South Central Texas Regional Water Planning Area

2011 Regional Water Plan

Volume II Technical Evaluations of Water Management Strategies

September 2010

Prepared by:

South Central Texas Regional Water Planning Group

http://www.regionltexas.org

With administration by:

San Antonio River Authority

With technical assistance by:

HDR Engineering, Inc.

Laura Raun Public Relations

Ximenes & Associates

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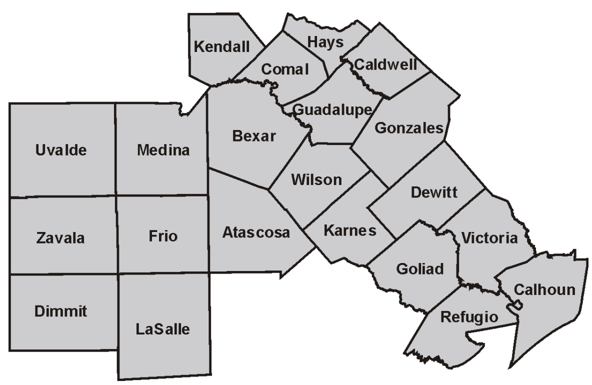

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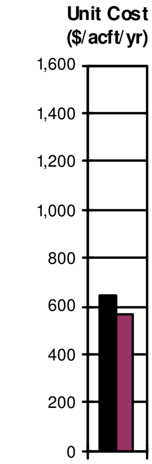
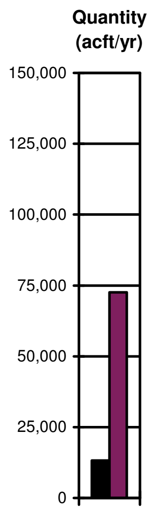
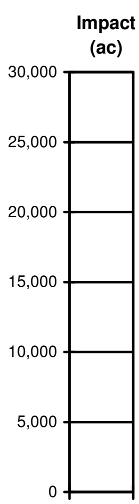
Appendices

2011 South Central Texas Regional Water Plan
Water Management Strategy Summary Sheet







Name: Municipal Water Conservation (Demand Reduction)

Description: Best Management Practices of plumbing fixture and clothes washer retrofit, and urban lawn and landscape irrigation efficiency improvements in residential, commercial, and institutional establishments to reduce municipal per capita water use in addition to reductions already incorporated into the TWDB municipal water demand projections.

***Decade Needed*:** 2000 – 2060.

Cost, Quantity of Water, and Land Impacted

Unit Cost of Water:	**648 – 566**	**$/acft/yr[1]**	**Water demand reduced.**
Quantity of Water:	**13,213 -72,570**	**acft/yr[2]**	**Reliability = Firm**
Land Impacted:	**0**	**acres**	**[1 & 2]Unit cost and quantity of water at 2010 and 2060**

Additional Considerations per Regional Water Planning Guidelines

Environmental Factors: Needs are met through municipal water demand reduction. Avoids water supply development that requires additional land and other resources.

Impacts on Water Resources: Slight reductions in treated effluent discharged from municipal systems are possible, depending upon relative rate of growth in demand and conservation effectiveness.

Impacts on Agricultural & Natural Resources: Needs are met through municipal water demand reduction (see Environmental Factors above), and would not affect quantity or quality of fresh water for agriculture and natural resources, with the possible exception of small reductions in discharge of treated municipal effluent that may result in reduced streamflows.

Other Relevant Factors per SCTRWPG: Water conservation is central to regional water plan, and is encouraged for all uses.

Comparison of Strategies to Meet Needs: Relatively low cost in comparison to conventional water supply strategies. No conflicts with other water management strategies.

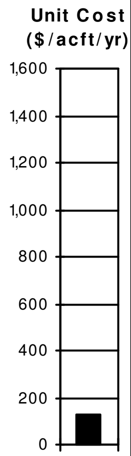
Interbasin Transfer Issues: Means of achieving highest practicable level of conservation for recipients of planned interbasin transfer.

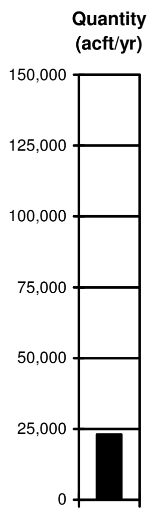
Third-Party Impacts of Voluntary Transfers: Not applicable.

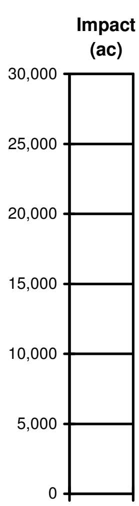
Regional Efficiency: Allows existing water supplies to serve more population. Water use efficiency is increased throughout the region.

Water Quality Considerations: None of significant concern.

2011 South Central Texas Regional Water Plan
Water Management Strategy Summary Sheet







Name: Irrigation Water Conservation (Demand Reduction)

Description: Best Management Practices of Low Energy Precision Application (LEPA) in conjunction with Furrow Dikes to reduce irrigation rates by 20 percent per acre on 75 percent of year 2000 irrigated acres in counties having irrigation needs.

***Decade Needed*:** 2000 – 2060: Applicable to major irrigation areas of the region.

Cost, Quantity of Water, and Land Impacted

Unit Cost of Water:	**143**	**$/acft/yr**[1]	**Water demand reduced.**
Quantity of Water:	**20,709**	**acft/yr**[2]	**Reliability = Firm**
Land Impacted:	**0**	**acres**	[1 & 2]**Unit cost and quantity of water at 2010 (Atascosa, Bexar, Medina, and Zavala Cos.)**

Additional Considerations per Regional Water Planning Guidelines

Environmental Factors: Needs are met through irrigation water demand reduction on acres equipped with LEPA, thereby freeing up water to irrigate acreages having water shortages. Avoids water supply development that requires additional land and other resources (see Impacts on Agricultural & Natural Resources below).

Impacts on Water Resources: Improved water application efficiency per acre irrigated results in reduced water demands per acre, thereby contributing to meeting projected needs for irrigation.

Impacts on Agricultural & Natural Resources: Needs are met through improved irrigation application efficiencies, and would allow existing quantity of fresh water used for irrigated agriculture to meet projected demands. This strategy would not affect the quantity or quality of fresh water for natural resources.

Other Relevant Factors per SCTRWPG: Water conservation is central to regional water plan, and is encouraged for all uses.

Comparison of Strategies to Meet Needs: Relatively low cost in comparison to conventional water supply strategies. No conflicts with other water management strategies.

Interbasin Transfer Issues: Not applicable.

Third-Party Impacts of Voluntary Transfers: Not applicable.

Regional Efficiency: Allows existing water supplies to meet projected demands in Atascosa, Bexar, and Medina Counties. Needs of Zavala County cannot be met through irrigation water conservation.

Water Quality Considerations: Through use of BMPs, there is potential to reduce runoff from irrigated land, thereby reducing instream nutrient and contaminant loading.

Section 4C
Technical Evaluations of Water Management Strategies

4C.1 Water Conservation (Demand Reduction)

A significant water management strategy is to increase water conservation and thereby reduce freshwater use within the planning area. The general methods to accomplish this objective are to: (1) reduce per capita water use in the municipal water use category; (2) recycle and reuse industrial water and substitute reclaimed water (treated municipal and industrial wastewater) for use in some industries, steam-electric power generation, and irrigation; and (3) improve irrigation efficiencies to reduce the quantity of water use in agriculture per acre irrigated. Best Management Practices (BMPs) for water conservation, as identified by the Water Conservation Implementation Task Force, will be used in the water conservation water management strategy.[1] In addition, estimates will be made of the water conservation potentials and associated costs of water conservation for municipal and irrigation water user groups.

4C.1.1 Municipal Water Conservation

For regional water planning purposes, municipal water use is defined as residential and commercial water use. Municipal water supply is used primarily for drinking, sanitation, cleaning, cooling, fire protection, and landscape watering for residential, commercial, and institutional establishments. Such water is supplied by both public and private utilities, and in areas not served by water utilities, is supplied by individual households. A key parameter of municipal water use within a typical city or water service area is the number of gallons used per person per day (per capita water use). The objective of municipal water conservation programs is to reduce the per capita water use parameter without adversely affecting the quality of life of the people involved. This can be achieved through:

- Use of low flow plumbing fixtures (e.g., toilets, shower heads, and faucets that are designed for low quantities of flow per unit of use);
- The selection and use of more efficient water-using appliances (e.g., clothes washers and dishwashers);
- Modifying and/or installing lawn and landscaping systems to use grass and plants that require less water;
- Repair of plumbing and water-using appliances to reduce leaks; and

[1] Water Conservation Implementation Task Force, Report to the 79th Legislature, Texas Water Development Board, Special Report, Austin, Texas, November 2004.

- Modification of personal behavior that controls the use of plumbing fixtures, appliances, and lawn watering methods.

With respect to plumbing fixtures, in 1991 the Texas Legislature enacted Senate Bill 587, which established minimum standards for plumbing fixtures sold in Texas.[2] The bill became effective on January 1, 1992, and allowed for wholesalers and retailers to clear existing inventories of pre-standards plumbing fixtures by January 1, 1993. The standards for new plumbing fixtures, as specified by Senate Bill 587, are shown in Table 4C.1-1. The Texas Commission on Environmental Quality (TCEQ) has promulgated rules requiring the labeling of both plumbing fixtures and water-using appliances sold in Texas. The labels must specify the rates of flow for plumbing fixtures and lawn sprinklers, and the amounts of water used per cycle for clothes washers and dishwashers.[3]

In 2009, the Texas Legislature enacted House Bill (HB) 2667 establishing new minimum standards for plumbing fixtures sold in Texas beginning in 2014. HB 2667 clarifies and sets out the national standards of the American Society of Mechanical Engineers and American National Standards Institute by which plumbing fixtures will be produced and tested. This bill establishes a phase-in of high efficiency plumbing fixtures brought into Texas, which will allow manufacturers the time to change their production, at the same time allowing retailers the opportunity to turn over their inventory. HB 2667 creates an exemption for those manufacturers that volunteer to register their products with the United States Environmental Protection Agency's WaterSense Program, which should result in additional water savings. This bill also repeals the Texas Commission on Environmental Quality certification process for plumbing fixtures since the plumbing fixtures must meet national certification and testing procedures. The Texas Commission on Environmental Quality (TCEQ) has promulgated rules to reflect this new change in law. The newly enacted standards for plumbing fixtures will be reflected in the 2016 Regional Water Plan.

[2] Senate Bill 587, Texas Legislature, Regular Session, 1991, Austin, Texas.
[3] Chapter 290, 30 TAC Sections 290.251, 290.253 - 290.256, 290.260, 290.265, 290.266, Water Hygiene, Texas Register, Page 9935, December 24, 1993.

Table 4C.1-1.
Standards for Plumbing Fixtures

Fixture	Standard
Wall-mounted Flushometer Toilets	2.00 gallons per flush
All Other Toilets	1.60 gallons per flush
Shower Heads	2.75 gallons per minute at 80 psi
Urinals	1.00 gallon per flush
Faucet Aerators	2.20 gallons per minute at 80 psi
Drinking Water Fountains	Shall be self-closing

The TWDB has estimated that the effect of the new plumbing fixtures in dwellings, offices, and public places will be a reduction in per capita water use of 18 gallons per capita per day (gpcd), in comparison to what would have occurred with previous generations of plumbing fixtures.[4] The estimated water conservation effect of 18 gpcd was obtained using the data found in Table 4C.1-2.

In 2001, the Texas Legislature amended the Texas Water Code to require Regional Water Planning Groups to consider water conservation and drought management measures for

Table 4C.1-2.
Water Conservation Potentials of
Low Flow Plumbing Fixtures[1]

Plumbing Fixture	Water Savings (gpcd)
Toilets – 1.6 gallons per flush	11.5
Shower Heads – 2.75 gallons per minute	4.0
Faucet Aerators – 2.2 gallons per minute	2.0
Urinals – 1.0 gallon per minute	0.3
Drinking Fountains (self-closing)	0.1
Total	17.9 (18 gpcd)
[1] Texas Water Development Board, 1992.	

each water user group with a need (projected water shortage). The Water Conservation Implementation Task Force has identified and described Water Conservation BMPs and

[4] "Water Conservation Impacts on Per Capita Water Use," Water Planning Information, Texas Water Development Board, Austin, Texas, 1992.

provided a BMP Guide for use by Regional Water Planning Groups in the development of the 2011 Regional Water Plans.[5] The list of BMPs for municipal water users is as follows:

1. System Water Audit and Water Loss;
2. Water Conservation Pricing;
3. Prohibition on Wasting Water;
4. Showerhead, Aerator, and Toilet Flapper Retrofit;
5. Residential Ultra-Low Flow Toilet Replacement Programs;
6. Residential Clothes Washer Incentive Program;
7. School Education;
8. Water Survey for Single-Family and Multi-Family Customers;
9. Landscape Irrigation Conservation and Incentives;
10. Water-Wise Landscape Design and Conversion Programs;
11. Athletic Field Conservation;
12. Golf Course Conservation;
13. Metering of all New Connections and Retrofitting of Existing Connections;
14. Wholesale Agency Assistance Programs;
15. Conservation Coordinator;
16. Reuse of Reclaimed Water;
17. Public Information;
18. Rainwater Harvesting and Condensate Reuse;
19. New Construction Graywater;
20. Park Conservation; and
21. Conservation Programs for Industrial, Commercial, and Institutional Accounts.

In addition to the list of BMPs, the Water Conservation Implementation Task Force recommends that a standardized methodology be used for determining per capita per day municipal water use in order to allow consistent evaluations of effectiveness of water conservation measures among cities that are located in the different climates and parts of Texas. The Task Force further recommends gpcd targets and goals that should be considered by retail public water suppliers when developing water conservation plans required by the state, as follows:

- "All public water suppliers that are required to prepare and submit water conservation plans should establish targets for water conservation, including specific goals for per capita water use and for water loss programs using appropriate water conservation BMPs.
- "Municipal Water Conservation Plans required by the state shall include per capita water-use goals, with targets and goals established by an entity giving consideration to a minimum annual reduction of one percent in total gpcd, based upon a five-year

[5] Water Conservation Implementation Task Force, Report to the 79th Legislature, Texas Water Development Board, Special Report, Austin, Texas, November 2004.

moving average, until such time as the entity achieves a total gpcd of 140 gpcd or less."

For the 2011 Regional Water Plan, The South Central Texas Regional Water Planning Group established the municipal water conservation goals, as follows:

- For municipal WUGs with water use of 140 gpcd and greater, the goal is to reduce per capita water use by one percent per year until the level of 140 gpcd is reached, after which, the goal is to reduce per capita water use by one-fourth percent per year for the remainder of the planning period; and
- For municipal WUGs having year 2000 water use of less than 140 gpcd, the goal is to reduce per capita water use by one-fourth percent per year (0.25% per year).

The 130 Municipal WUGs of Region L are listed in Table 4C.1-3, in the order of lowest to highest per capita water use in year 2000 together with projected per capita water use with expected effects of low flow plumbing fixtures upon per capita water use in 2010, 2020, 2030, 2040, 2050, and 2060. This table shows the water conservation effects of low flow plumbing fixtures that were included in the projected water demands for each WUG. The projected municipal water needs (shortages) were calculated for each WUG by subtracting projected municipal water demands from existing municipal water supplies, with the low flow plumbing fixture water conservation effects taken into account.

Table 4C.1-3.
Municipal Water User Groups
Projected Per Capita Water Use with Low Flow Plumbing Fixtures
South Central Texas Water Planning Region

County Number	Water User Group*	County	Per Capita Water Use with Low Flow Plumbing Fixtures 2000 (gpcd)	2010 (gpcd)	2020 (gpcd)	2030 (gpcd)	2040 (gpcd)	2050 (gpcd)	2060 (gpcd)
1	Calhoun County WS	Calhoun	71	66	64	62	61	60	60
2	County-Other	Wilson	81	78	76	75	74	74	74
3	Green Valley SUD	Guadalupe	85	80	77	76	74	74	74
4	Polonia WSC	Caldwell	87	82	79	77	76	75	75
5	County-Other	Victoria	91	87	84	82	80	79	79
6	Benton City WSC	Atascosa	94	90	88	87	86	86	86
7	County-Other	Dimmit	96	93	90	87	84	83	83
8	County-Other	Goliad	98	94	92	89	87	86	86
9	Creedmoor-Maha WSC	Caldwell	98	94	90	88	87	86	86
10	Goforth WSC	Hays	99	93	91	89	88	88	88
11	Crystal Clear WSC	Guadalupe	100	95	92	91	89	89	89
12	Martindale	Caldwell	100	97	93	90	87	86	86
13	Plum Creek Water Co.	Hays	100	95	92	90	89	89	89
14	County-Other	Refugio	101	99	96	93	89	87	87
15	McCoy WSC	Atascosa	101	97	95	93	92	92	92
16	Atascosa Rural WSC	Bexar	102	96	93	91	90	89	89
17	County-Other	Atascosa	102	102	102	99	93	88	88
18	County-Other	Kendall	102	96	94	92	91	91	91
19	Wimberley WSC	Hays	102	98	95	93	91	91	91
20	Kirby	Bexar	103	99	95	92	89	88	88
21	County-Other	Dewitt	105	102	99	96	93	91	91
22	County-Other	Frio	105	101	97	95	93	92	92
23	Karnes City	Karnes	108	104	101	98	96	95	95
24	Leon Valley	Bexar	108	105	102	99	96	94	94
25	Maxwell WSC	Caldwell	108	103	99	98	96	96	96
26	Live Oak	Bexar	110	106	102	99	96	95	95
27	SS WSC	Wilson	110	104	102	100	99	99	99
28	County-Other	Gonzales	111	110	108	105	100	97	97
29	County-Other	Guadalupe	112	110	107	104	100	98	98
30	Santa Clara	Guadalupe	114	110	108	108	107	107	107
31	County-Other	Bexar	115	113	111	109	107	106	106
32	East Medina WSC	Medina	115	111	108	106	104	103	103
33	Converse	Bexar	116	111	107	105	104	103	103
34	County-Other	Comal	116	112	109	106	103	102	102
35	Niederwald	Hays	116	113	111	111	110	110	110
36	Bexar Met Water District	Bexar	118	114	111	108	105	104	104
37	Kyle	Hays	118	114	113	112	111	111	111
38	Bulverde City	Comal	120	116	114	113	113	113	113
39	County-Other	Uvalde	122	118	115	113	112	111	111
40	East Central WSC	Bexar	122	116	113	111	110	109	109
41	St. Hedwig	Bexar	122	117	113	111	109	108	108

Table 4C.1-3 (Continued)

County Number	Water User Group*	County	Per Capita Water Use with Low Flow Plumbing Fixtures 2000 (gpcd)	2010 (gpcd)	2020 (gpcd)	2030 (gpcd)	2040 (gpcd)	2050 (gpcd)	2060 (gpcd)
42	Aqua WSC	Caldwell	123	118	115	112	111	110	110
43	Port Lavaca	Calhoun	123	120	117	114	111	110	110
44	Marion	Guadalupe	125	121	118	115	113	112	112
45	Waelder	Gonzales	125	122	119	116	115	114	114
46	County-Other	Medina	129	126	124	122	121	121	121
47	Water Ser Inc (APEX)	Bexar	129	124	121	119	118	117	117
48	Woodcreek	Hays	132	127	125	123	121	121	121
49	Elmendorf	Bexar	133	129	125	122	120	119	119
50	County-Other	La Salle	134	132	129	128	126	126	126
51	County-Other	Calhoun	135	131	128	125	122	121	121
52	Lacoste	Medina	135	131	127	125	122	121	121
53	Yorktown	Dewitt	135	132	129	126	123	121	121
54	County-Other	Hays	136	132	129	127	126	126	126
55	Canyon Lake WSC	Comal	137	134	133	132	132	132	132
56	Lockhart	Caldwell	138	134	131	129	128	127	127
57	Oak Hills WSC	Wilson	138	133	130	128	127	127	127
58	Universal City	Bexar	140	135	132	129	127	126	126
59	Balcones Heights	Bexar	142	138	135	132	129	128	128
60	Schertz	Guadalupe	143	138	136	134	133	133	133
61	Sunko WSC	Wilson	143	138	135	132	131	130	130
62	Woodsboro	Refugio	144	140	137	134	131	130	130
63	Olmos Park	Bexar	145	141	138	135	132	131	131
64	Terrell Hills	Bexar	145	140	137	134	131	130	130
65	San Antonio	Bexar	147	143	139	137	135	134	134
66	Yoakum	Dewitt	147	144	141	138	135	133	133
67	Mountain City	Hays	148	143	141	140	139	139	139
68	County Line WSC	Hays	149	144	142	141	140	140	140
69	County-Other	Zavala	150	146	143	141	139	138	138
70	Poth	Wilson	152	148	144	141	139	138	138
71	San Marcos	Hays	152	147	143	141	139	138	138
72	Charlotte	Atascosa	154	150	147	144	141	140	140
73	Encinal	La Salle	156	153	150	147	143	142	142
74	Luling	Caldwell	156	151	148	145	142	141	141
75	Natalia	Medina	156	152	149	147	145	144	144
76	Point Comfort	Calhoun	160	157	154	151	148	146	146
77	County-Other	Karnes	161	158	157	156	155	155	155
78	Runge	Karnes	161	158	154	151	148	147	147
79	Falls City	Karnes	162	157	154	151	149	148	148
80	Seadrift	Calhoun	163	160	156	153	150	149	149
81	Goliad	Goliad	165	161	158	155	152	151	151
82	Victoria	Victoria	166	162	159	156	153	152	152
83	Yancey WSC	Medina	168	164	161	159	158	157	157
84	Boerne	Kendall	169	163	160	158	156	156	156
85	Cuero	Dewitt	169	166	163	160	157	155	155
86	El Oso WSC	Karnes	169	165	162	159	157	156	156

Table 4C.1-3 (Concluded)

County Number	Water User Group*	County	Per Capita Water Use with Low Flow Plumbing Fixtures 2000 (gpcd)	2010 (gpcd)	2020 (gpcd)	2030 (gpcd)	2040 (gpcd)	2050 (gpcd)	2060 (gpcd)
87	Nixon	Gonzales	169	166	162	160	157	156	156
88	Refugio	Refugio	169	164	161	158	156	155	155
89	Springs Hill WSC	Guadalupe	172	168	164	162	160	159	159
90	County-Other	Caldwell	173	172	170	167	162	159	159
91	Lytle	Atascosa	174	171	167	164	161	160	160
92	Cibolo	Guadalupe	176	172	169	168	167	167	167
93	Helotes	Bexar	176	172	170	170	169	169	169
94	Jourdanton	Atascosa	177	173	169	166	164	163	163
95	Castle Hills	Bexar	178	174	171	168	165	163	163
96	Devine	Medina	179	175	172	168	165	164	164
97	Pearsall	Frio	179	176	173	170	166	165	165
98	Big Wells	Dimmit	180	176	173	170	167	166	166
99	Gonzales	Gonzales	181	177	174	171	169	168	168
100	Hondo	Medina	181	176	173	171	169	168	168
101	Seguin	Guadalupe	181	177	174	171	169	168	168
102	Asherton	Dimmit	182	177	174	171	168	167	167
103	Floresville	Wilson	183	179	175	172	170	169	169
104	Woodcreek Utilities Inc.	Hays	183	179	177	177	176	176	176
105	Somerset	Bexar	185	180	177	174	173	172	172
106	Kenedy	Karnes	194	190	186	183	180	179	179
107	Poteet	Atascosa	197	194	191	187	184	183	183
108	La Vernia	Wilson	198	194	191	189	187	187	187
109	Pleasanton	Atascosa	198	195	191	188	185	184	184
110	New Braunfels	Comal	204	200	196	194	193	192	192
111	Stockdale	Wilson	205	201	197	194	192	191	191
112	China Grove	Bexar	206	201	197	195	194	193	193
113	Castroville	Medina	208	204	200	197	195	194	194
114	Fairoaks Ranch	Bexar	209	207	206	205	204	203	203
115	Windcrest	Bexar	212	209	206	203	200	198	198
116	Garden Ridge	Comal	217	212	208	205	204	203	203
117	Mustang Ridge	Caldwell	222	217	213	211	210	209	209
118	Sabinal	Uvalde	232	229	226	223	220	218	218
119	Alamo Heights	Bexar	244	241	237	234	231	230	230
120	Dilley	Frio	253	250	247	244	243	242	242
121	Gonzales County WSC	Gonzales	264	260	256	254	252	251	251
122	Crystal City	Zavala	270	267	263	260	257	256	256
123	Carrizo Springs	Dimmit	275	271	268	265	262	261	261
124	Selma	Bexar	312	307	304	302	301	300	300
125	Cotulla	La Salle	314	310	307	304	301	300	300
126	Uvalde	Uvalde	363	359	356	353	350	348	348
127	Lackland AFB (CDP)	Bexar	393	389	386	383	380	378	378
128	Shavano Park	Bexar	408	405	402	398	395	394	394
129	Hollywood Park	Bexar	667	664	660	657	654	653	653
130	Hill Country Village	Bexar	731	728	725	722	719	717	717

* Some Water User Groups are located in more than one county and more than one river basin. The county in which the major part of the service area is located is named in this table. However, in later tables, water conservation estimates and costs are shown for service areas located in each county and river basin in which the WUG provides service.

In year 2000, in the South Central Texas Water Planning Region, 57 WUGs had per capita water use of less than 140 gpcd (Table 4C.1-4). WUGs with less than 140 gpcd represented 23.39 percent of the population of the Region in year 2000, and used 17.46 percent of the quantity of municipal water used in the Region in year 2000 (Table 4C.1-4). In 2000, 56.16 percent of the WUGs in the Region had per capita water use of 140 or more gpcd. This group represented 76.61 percent of the region's population in 2000, and accounted for 82.54 percent of the municipal water used in the Region in 2000 (Table 4C.1-4).

Table 4C.1-4.
Municipal Water User Groups
Number, Population and Water Use by Per Capita Water Use Levels
South Central Texas Water Planning Region

Per Capita Water Use in 2000 (gpcd)	*Number of WUGs*	*Percent of WUGs*	*Population*		*Water Use*	
			2000 (number)	*Percent of Total*	*2000 (acft)*	*Percent of Total*
Less than 140	57	43.84%	477,680	23.39%	59,372	17.46%
140 and Greater	73	56.16%	1,564,541	76.61%	280,651	82.54%
Totals	130	100.00%	2,042,221	100.00%	340,023	100.00%

For purposes of calculating the additional water conservation that needs to be included in the South Central Texas Regional Water Plan, for WUGS having projected needs, the projected per capita water use for municipal WUGs was calculated for the Region L municipal water conservation goals, as stated above, in comparison to the low flow plumbing fixtures per capita water use projections used in calculating municipal water demand (Table 4C.1-5). It is important to note that for the first few WUGs listed in Table 4C.1-5, the low flow plumbing fixtures had a greater effect than the Region L goal. For these WUGS, no additional water conservation is considered.

Additional plumbing fixtures water conservation potentials, in gpcd are shown in Table 4C.1-6 for each WUG of Region L, where the low flow plumbing fixtures effects that are already included in the water demand projections are deducted from the 18 gpcd plumbing fixtures potentials for municipal water demand reduction. In Table 4C.1-7, the per capita water conservation needed by each WUG to meet the Region L goals are tabulated for indoor (plumbing fixtures) and outdoor (lawn watering) water conservation.

Table 4C.1-5.
Municipal Water User Groups with Projected per Capita Water Use with Low Flow Pluming Fixtures and Region L Water Conservation Goals

No.	Water User Group *	County *	Year 2000 gpcd	Projected Per Capita Water Use with Low Flow Plumbing Fixtures *						Projected Per Capita Water Use with Region L Water Conservation Goals **					
				2010 gpcd	2020 gpcd	2030 gpcd	2040 gpcd	2050 gpcd	2060 gpcd	2010 gpcd	2020 gpcd	2030 gpcd	2040 gpcd	2050 gpcd	2060 gpcd
1	CALHOUN COUNTY WS	CALHOUN	71	66	64	62	61	60	60	69	68	66	64	63	61
2	COUNTY-OTHER	WILSON	81	78	76	75	74	74	74	79	77	75	73	71	70
3	GREEN VALLEY SUD	GUADALUPE	85	80	77	76	74	74	74	83	81	79	77	75	73
4	POLONIA WSC	CALDWELL	87	82	79	77	76	75	75	85	83	81	79	77	75
5	COUNTY-OTHER	VICTORIA	91	87	84	82	80	79	79	89	87	84	82	80	78
6	BENTON CITY WSC	ATASCOSA	94	90	88	87	86	86	86	92	89	87	85	83	81
7	COUNTY-OTHER	DIMMIT	96	93	90	87	84	83	83	94	91	89	87	85	83
8	COUNTY-OTHER	GOLIAD	98	94	92	89	87	86	86	96	93	91	89	86	84
9	CREEDMOOR-MAHA WSC	CALDWELL	98	94	90	88	87	86	86	96	93	91	89	86	84
10	GOFORTH WSC	HAYS	99	93	91	89	88	88	88	97	94	92	90	87	85
11	CRYSTAL CLEAR WSC	GUADALUPE	100	95	92	91	89	89	89	98	95	93	90	88	86
12	MARTINDALE	CALDWELL	100	97	93	90	87	86	86	98	95	93	90	88	86
13	PLUM CREEK WATER COMPANY	HAYS	100	95	92	90	89	89	89	98	95	93	90	88	86
14	COUNTY-OTHER	REFUGIO	101	99	96	93	89	87	87	99	96	94	91	89	87
15	MCCOY WSC	ATASCOSA	101	97	95	93	92	92	92	99	96	94	91	89	87
16	ATASCOSA RURAL WSC	BEXAR	102	96	93	91	90	89	89	99	97	95	92	90	88
17	COUNTY-OTHER	ATASCOSA	102	102	102	99	93	88	88	99	97	95	92	90	88
18	COUNTY-OTHER	KENDALL	102	96	94	92	91	91	91	99	97	95	92	90	88
19	WIMBERLEY WSC	HAYS	102	98	95	93	91	91	91	99	97	95	92	90	88
20	KIRBY	BEXAR	103	99	95	92	89	88	88	100	98	96	93	91	89
21	COUNTY-OTHER	DEWITT	105	102	99	96	93	91	91	102	100	97	95	93	90
22	COUNTY-OTHER	FRIO	105	101	97	95	93	92	92	102	100	97	95	93	90
23	KARNES CITY	KARNES	108	104	101	98	96	95	95	105	103	100	98	95	93
24	LEON VALLEY	BEXAR	108	105	102	99	96	94	94	105	103	100	98	95	93
25	MAXWELL WSC	CALDWELL	108	103	99	98	96	96	96	105	103	100	98	95	93
26	LIVE OAK	BEXAR	110	106	102	99	96	95	95	107	105	102	100	97	95
27	SS WSC	WILSON	110	104	102	100	99	99	99	107	105	102	100	97	95
28	COUNTY-OTHER	GONZALES	111	110	108	105	100	97	97	108	106	103	100	98	96
29	COUNTY-OTHER	GUADALUPE	112	110	107	104	100	98	98	109	107	104	101	99	96
30	SANTA CLARA	GUADALUPE	114	110	108	108	107	107	107	111	108	106	103	101	98
31	COUNTY-OTHER	BEXAR	115	113	111	109	107	106	106	112	109	107	104	101	99
32	EAST MEDINA SUD	MEDINA	115	111	108	106	104	103	103	112	109	107	104	101	99

Table 4C.1-5 (Continued)

No.	Water User Group *	County *	Year 2000 gpcd	Projected Per Capita Water Use with Low Flow Plumbing Fixtures *						Projected Per Capita Water Use with Region L Water Conservation Goals **					
				2010 gpcd	2020 gpcd	2030 gpcd	2040 gpcd	2050 gpcd	2060 gpcd	2010 gpcd	2020 gpcd	2030 gpcd	2040 gpcd	2050 gpcd	2060 gpcd
33	CONVERSE	BEXAR	116	111	107	105	104	103	103	113	110	108	105	102	100
34	COUNTY-OTHER	COMAL	116	112	109	106	103	102	102	113	110	108	105	102	100
35	NIEDERWALD	HAYS	116	113	111	111	110	110	110	113	110	108	105	102	100
36	BEXAR MET WATER DISTRICT	BEXAR	118	114	111	108	105	104	104	115	112	109	107	104	102
37	KYLE	HAYS	118	114	113	112	111	111	111	115	112	109	107	104	102
38	BULVERDE CITY	COMAL	120	116	114	113	113	113	113	117	114	111	109	106	103
39	COUNTY-OTHER	UVALDE	122	118	115	113	112	111	111	119	116	113	110	108	105
40	EAST CENTRAL WSC	BEXAR	122	116	113	111	110	109	109	119	116	113	110	108	105
41	ST. HEDWIG	BEXAR	122	117	113	111	109	108	108	119	116	113	110	108	105
42	AQUA WSC	CALDWELL	123	118	115	112	111	110	110	120	117	114	111	109	106
43	PORT LAVACA	CALHOUN	123	120	117	114	111	110	110	120	117	114	111	109	106
44	MARION	GUADALUPE	125	121	118	115	113	112	112	122	119	116	113	110	108
45	WAELDER	GONZALES	125	122	119	116	115	114	114	122	119	116	113	110	108
46	COUNTY-OTHER	MEDINA	129	126	124	122	121	121	121	126	123	120	117	114	111
47	WATER SER INC (APEX)	BEXAR	129	124	121	119	118	117	117	126	123	120	117	114	111
48	WOODCREEK	HAYS	132	127	125	123	121	121	121	129	126	122	119	116	114
49	ELMENDORF	BEXAR	133	129	125	122	120	119	119	130	127	123	120	117	114
50	COUNTY-OTHER	LA SALLE	134	132	129	128	126	126	126	131	127	124	121	118	115
51	COUNTY-OTHER	CALHOUN	135	131	128	125	122	121	121	132	128	125	122	119	116
52	LACOSTE	MEDINA	135	131	127	125	122	121	121	132	128	125	122	119	116
53	YORKTOWN	DEWITT	135	132	129	126	123	121	121	132	128	125	122	119	116
54	COUNTY-OTHER	HAYS	136	132	129	127	126	126	126	133	129	126	123	120	117
55	CANYON LAKE WSC	COMAL	137	134	133	132	132	132	132	134	130	127	124	121	118
56	LOCKHART	CALDWELL	138	134	131	129	128	127	127	135	131	128	125	122	119
57	OAK HILLS WSC	WILSON	138	133	130	128	127	127	127	135	131	128	125	122	119
58	UNIVERSAL CITY	BEXAR	140	135	132	129	127	126	126	137	133	130	127	124	120
59	BALCONES HEIGHTS	BEXAR	142	138	135	132	129	128	128	137	134	130	127	124	121
60	SCHERTZ	GUADALUPE	143	138	136	134	133	133	133	137	134	131	127	124	121
61	SUNKO WSC	WILSON	143	138	135	132	131	130	130	137	134	131	127	124	121
62	WOODSBORO	REFUGIO	144	140	137	134	131	130	130	138	134	131	128	124	121
63	OLMOS PARK	BEXAR	145	141	138	135	132	131	131	138	134	131	128	125	122
64	TERRELL HILLS	BEXAR	145	140	137	134	131	130	130	138	134	131	128	125	122
65	SAN ANTONIO	BEXAR	147	143	139	137	135	134	134	138	135	131	128	125	122
66	YOAKUM	DEWITT	147	144	141	138	135	133	133	138	135	131	128	125	122
67	MOUNTAIN CITY	HAYS	148	143	141	140	139	139	139	138	135	132	128	125	122

Table 4C.1-5 (Continued)

No.	Water User Group *	County *	Year 2000 gpcd	Projected Per Capita Water Use with Low Flow Plumbing Fixtures *						Projected Per Capita Water Use with Region L Water Conservation Goals **					
				2010 gpcd	2020 gpcd	2030 gpcd	2040 gpcd	2050 gpcd	2060 gpcd	2010 gpcd	2020 gpcd	2030 gpcd	2040 gpcd	2050 gpcd	2060 gpcd
68	COUNTY LINE WSC	HAYS	149	144	142	141	140	140	140	139	135	132	129	125	122
69	COUNTY-OTHER	ZAVALA	150	146	143	141	139	138	138	139	135	132	129	126	123
70	POTH	WILSON	152	148	144	141	139	138	138	139	136	133	129	126	123
71	SAN MARCOS	HAYS	152	147	143	141	139	138	138	139	136	133	129	126	123
72	CHARLOTTE	ATASCOSA	154	150	147	144	141	140	140	140	136	133	130	126	123
73	ENCINAL	LA SALLE	156	153	150	147	143	142	142	141	137	133	130	127	124
74	LULING	CALDWELL	156	151	148	145	142	141	141	141	137	133	130	127	124
75	NATALIA	MEDINA	156	152	149	147	145	144	144	141	137	133	130	127	124
76	POINT COMFORT	CALHOUN	160	157	154	151	148	146	146	145	138	134	131	128	125
77	COUNTY-OTHER	KARNES	161	158	157	156	155	155	155	146	138	134	131	128	125
78	RUNGE	KARNES	161	158	154	151	148	147	147	146	138	134	131	128	125
79	FALLS CITY	KARNES	162	157	154	151	149	148	148	147	138	135	131	128	125
80	SEADRIFT	CALHOUN	163	160	156	153	150	149	149	147	138	135	132	128	125
81	GOLIAD	GOLIAD	165	161	158	155	152	151	151	149	139	135	132	129	126
82	VICTORIA	VICTORIA	166	162	159	156	153	152	152	150	139	136	132	129	126
83	YANCEY WSC	MEDINA	168	164	161	159	158	157	157	152	139	136	133	129	126
84	BOERNE	KENDALL	169	163	160	158	156	156	156	153	140	136	133	129	126
85	CUERO	DEWITT	169	166	163	160	157	155	155	153	140	136	133	129	126
86	EL OSO WSC	KARNES	169	165	162	159	157	156	156	153	140	136	133	129	126
87	NIXON	GONZALES	169	166	162	160	157	156	156	153	140	136	133	129	126
88	REFUGIO	REFUGIO	169	164	161	158	156	155	155	153	140	136	133	129	126
89	SPRINGS HILL WSC	GUADALUPE	172	168	164	162	160	159	159	156	141	137	133	130	127
90	COUNTY-OTHER	CALDWELL	173	172	170	167	162	159	159	156	141	137	134	130	127
91	LYTLE	ATASCOSA	174	171	167	164	161	160	160	157	142	137	134	130	127
92	CIBOLO	GUADALUPE	176	172	169	168	167	167	167	159	144	137	134	131	128
93	HELOTES	BEXAR	176	172	170	170	169	169	169	159	144	137	134	131	128
94	JOURDANTON	ATASCOSA	177	173	169	166	164	163	163	160	145	138	134	131	128
95	CASTLE HILLS	BEXAR	178	174	171	168	165	163	163	161	146	138	134	131	128
96	DEVINE	MEDINA	179	175	172	168	165	164	164	162	146	138	135	131	128
97	PEARSALL	FRIO	179	176	173	170	166	165	165	162	146	138	135	131	128
98	BIG WELLS	DIMMIT	180	176	173	170	167	166	166	163	147	138	135	132	128
99	GONZALES	GONZALES	181	177	174	171	169	168	168	164	148	138	135	132	128
100	HONDO	MEDINA	181	176	173	171	169	168	168	164	148	138	135	132	128
101	SEGUIN	GUADALUPE	181	177	174	171	169	168	168	164	148	138	135	132	128

Table 4C.1-5 (Concluded)

No.	Water User Group *	County *	Year 2000 gpcd	Projected Per Capita Water Use with Low Flow Plumbing Fixtures *						Projected Per Capita Water Use with Region L Water Conservation Goals **					
				2010 gpcd	2020 gpcd	2030 gpcd	2040 gpcd	2050 gpcd	2060 gpcd	2010 gpcd	2020 gpcd	2030 gpcd	2040 gpcd	2050 gpcd	2060 gpcd
102	ASHERTON	DIMMIT	182	177	174	171	168	167	167	165	149	139	135	132	129
103	FLORESVILLE	WILSON	183	179	175	172	170	169	169	166	150	139	135	132	129
104	WOODCREEK UTILITIES INC	HAYS	183	179	177	177	176	176	176	166	150	139	135	132	129
105	SOMERSET	BEXAR	185	180	177	174	173	172	172	167	151	139	136	132	129
106	KENEDY	KARNES	194	190	186	183	180	179	179	175	159	144	137	134	131
107	POTEET	ATASCOSA	197	194	191	187	184	183	183	178	161	146	138	134	131
108	LA VERNIA	WILSON	198	194	191	189	187	187	187	179	162	146	138	135	131
109	PLEASANTON	ATASCOSA	198	195	191	188	185	184	184	179	162	146	138	135	131
110	NEW BRAUNFELS	COMAL	204	200	196	194	193	192	192	184	167	151	139	136	132
111	STOCKDALE	WILSON	205	201	197	194	192	191	191	185	168	152	139	136	132
112	CHINA GROVE	BEXAR	206	201	197	195	194	193	193	186	168	152	139	136	133
113	CASTROVILLE	MEDINA	208	204	200	197	195	194	194	188	170	154	140	136	133
114	FAIROAKS RANCH	BEXAR	209	207	206	205	204	203	203	189	171	155	140	136	133
115	WINDCREST	BEXAR	212	209	206	203	200	198	198	192	173	157	142	137	134
116	GARDEN RIDGE	COMAL	217	212	208	205	204	203	203	196	177	161	145	138	134
117	MUSTANG RIDGE	CALDWELL	222	217	213	211	210	209	209	201	182	164	149	139	135
118	SABINAL	UVALDE	232	229	226	223	220	218	218	210	190	172	155	140	137
119	ALAMO HEIGHTS	BEXAR	244	241	237	234	231	230	230	221	200	180	163	148	138
120	DILLEY	FRIO	253	250	247	244	243	242	242	229	207	187	169	153	140
121	GONZALES COUNTY WSC	GONZALES	264	260	256	254	252	251	251	239	216	195	177	160	144
122	CRYSTAL CITY	ZAVALA	270	267	263	260	257	256	256	244	221	200	181	163	148
123	CARRIZO SPRINGS	DIMMIT	275	271	268	265	262	261	261	249	225	203	184	166	150
124	SELMA	BEXAR	312	307	304	302	301	300	300	282	255	231	209	189	171
125	COTULLA	LA SALLE	314	310	307	304	301	300	300	284	257	232	210	190	172
126	UVALDE	UVALDE	363	359	356	353	350	348	348	328	297	269	243	220	199
127	LACKLAND AFB (CDP)	BEXAR	393	389	386	383	380	378	378	355	321	291	263	238	215
128	SHAVANO PARK	BEXAR	408	405	402	398	395	394	394	369	334	302	273	247	223
129	HOLLYWOOD PARK	BEXAR	667	664	660	657	654	653	653	603	546	493	446	404	365
130	HILL COUNTRY VILLAGE	BEXAR	731	728	725	722	719	717	717	661	598	541	489	442	400

*Water Conservation Effects, as estimated by the TWDB and used in computing municipal water demand for municipal WUGs.

**Region L water conservation goals for municipal WUGs with water use of 140 gpcd and greater in year 2000 are to reduce per capita water use by 1 percent per year until the level of 140 gpcd is reached, after which the goal is to reduce per capita water use by one-fourth percent per year for the remainder of the planning period. For Municipal WUGs having per capita water use less than 140 gpcd in year 2000, the goal is to reduce per capita water use by one-fourth percent per year.

Table 4C.1-6.
Projected per Capita Water Conservation Potential with Low Flow Pumping Fixtures and Additional Plumbing Fixtures and Clothes Washers Retrofit

No.	Water User Group *	County *	Plumbing Fixtures Potentials gpcd	Low Flow Plumbing Fixtures Water Conservation Potentials *						Additional Plumbing Fixtures and Clothes Washer Conservation Potentials					
				2010 gpcd	2020 gpcd	2030 gpcd	2040 gpcd	2050 gpcd	2060 gpcd	2010 gpcd	2020 gpcd	2030 gpcd	2040 gpcd	2050 gpcd	2060 gpcd
1	CALHOUN COUNTY WS	CALHOUN	18	5	7	9	10	11	11	13	11	9	8	7	7
2	COUNTY-OTHER	WILSON	18	3	5	6	7	7	7	15	13	12	11	11	11
3	GREEN VALLEY SUD	GUADALUPE	18	5	8	9	11	11	11	13	10	9	7	7	7
4	POLONIA WSC	CALDWELL	18	5	8	10	11	12	12	13	10	8	7	6	6
5	COUNTY-OTHER	VICTORIA	18	4	7	9	11	12	12	14	11	9	7	6	6
6	BENTON CITY WSC	ATASCOSA	18	4	6	7	8	8	8	14	12	11	10	10	10
7	COUNTY-OTHER	DIMMIT	18	3	6	9	12	13	13	15	12	9	6	5	5
8	COUNTY-OTHER	GOLIAD	18	4	6	9	11	12	12	14	12	9	7	6	6
9	CREEDMOOR-MAHA WSC	CALDWELL	18	4	8	10	11	12	12	14	10	8	7	6	6
10	GOFORTH WSC	HAYS	18	6	8	10	11	11	11	12	10	8	7	7	7
11	CRYSTAL CLEAR WSC	GUADALUPE	18	5	8	9	11	11	11	13	10	9	7	7	7
12	MARTINDALE	CALDWELL	18	3	7	10	13	14	14	15	11	8	5	4	4
13	PLUM CREEK WATER COMPANY	HAYS	18	5	8	10	11	11	11	13	10	8	7	7	7
14	COUNTY-OTHER	REFUGIO	18	2	5	8	12	14	14	16	13	10	6	4	4
15	MCCOY WSC	ATASCOSA	18	4	6	8	9	9	9	14	12	10	9	9	9
16	ATASCOSA RURAL WSC	BEXAR	18	6	9	11	12	13	13	12	9	7	6	5	5
17	COUNTY-OTHER	ATASCOSA	18	0	0	3	9	14	14	18	18	15	9	4	4
18	COUNTY-OTHER	KENDALL	18	6	8	10	11	11	11	12	10	8	7	7	7
19	WIMBERLEY WSC	HAYS	18	4	7	9	11	11	11	14	11	9	7	7	7
20	KIRBY	BEXAR	18	4	8	11	14	15	15	14	10	7	4	3	3
21	COUNTY-OTHER	DEWITT	18	3	6	9	12	14	14	15	12	9	6	4	4
22	COUNTY-OTHER	FRIO	18	4	8	10	12	13	13	14	10	8	6	5	5
23	KARNES CITY	KARNES	18	4	7	10	12	13	13	14	11	8	6	5	5
24	LEON VALLEY	BEXAR	18	3	6	9	12	14	14	15	12	9	6	4	4
25	MAXWELL WSC	CALDWELL	18	5	9	10	12	12	12	13	9	8	6	6	6
26	LIVE OAK	BEXAR	18	4	8	11	14	15	15	14	10	7	4	3	3
27	SS WSC	WILSON	18	6	8	10	11	11	11	12	10	8	7	7	7
28	COUNTY-OTHER	GONZALES	18	1	3	6	11	14	14	17	15	12	7	4	4
29	COUNTY-OTHER	GUADALUPE	18	2	5	8	12	14	14	16	13	10	6	4	4
30	SANTA CLARA	GUADALUPE	18	4	6	6	7	7	7	14	12	12	11	11	11
31	COUNTY-OTHER	BEXAR	18	2	4	6	8	9	9	16	14	12	10	9	9
32	EAST MEDINA SUD	MEDINA	18	4	7	9	11	12	12	14	11	9	7	6	6
33	CONVERSE	BEXAR	18	5	9	11	12	13	13	13	9	7	6	5	5
34	COUNTY-OTHER	COMAL	18	4	7	10	13	14	14	14	11	8	5	4	4
35	NIEDERWALD	HAYS	18	3	5	5	6	6	6	15	13	13	12	12	12

Table 4C.1-6 (Continued)

No.	Water User Group *	County *	Plumbing Fixtures Potentials gpcd	Low Flow Plumbing Fixtures Water Conservation Potentials * 2010 gpcd	2020 gpcd	2030 gpcd	2040 gpcd	2050 gpcd	2060 gpcd	Additional Plumbing Fixtures and Clothes Washer Conservation Potentials 2010 gpcd	2020 gpcd	2030 gpcd	2040 gpcd	2050 gpcd	2060 gpcd
36	BEXAR MET WATER DISTRICT	BEXAR	18	4	7	10	13	14	14	14	11	8	5	4	4
37	KYLE	HAYS	18	4	5	6	7	7	7	14	13	12	11	11	11
38	BULVERDE CITY	COMAL	18	4	6	7	7	7	7	14	12	11	11	11	11
39	COUNTY-OTHER	UVALDE	18	4	7	9	10	11	11	14	11	9	8	7	7
40	EAST CENTRAL WSC	BEXAR	18	6	9	11	12	13	13	12	9	7	6	5	5
41	ST. HEDWIG	BEXAR	18	5	9	11	13	14	14	13	9	7	5	4	4
42	AQUA WSC	CALDWELL	18	5	8	11	12	13	13	13	10	7	6	5	5
43	PORT LAVACA	CALHOUN	18	3	6	9	12	13	13	15	12	9	6	5	5
44	MARION	GUADALUPE	18	4	7	10	12	13	13	14	11	8	6	5	5
45	WAELDER	GONZALES	18	3	6	9	10	11	11	15	12	9	8	7	7
46	COUNTY-OTHER	MEDINA	18	3	5	7	8	8	8	15	13	11	10	10	10
47	WATER SER INC (APEX)	BEXAR	18	5	8	10	11	12	12	13	10	8	7	6	6
48	WOODCREEK	HAYS	18	5	7	9	11	11	11	13	11	9	7	7	7
49	ELMENDORF	BEXAR	18	4	8	11	13	14	14	14	10	7	5	4	4
50	COUNTY-OTHER	LA SALLE	18	2	5	6	8	8	8	16	13	12	10	10	10
51	COUNTY-OTHER	CALHOUN	18	4	7	10	13	14	14	14	11	8	5	4	4
52	LACOSTE	MEDINA	18	4	8	10	13	14	14	14	10	8	5	4	4
53	YORKTOWN	DEWITT	18	3	6	9	12	14	14	15	12	9	6	4	4
54	COUNTY-OTHER	HAYS	18	4	7	9	10	10	10	14	11	9	8	8	8
55	CANYON LAKE WSC	COMAL	18	3	4	5	5	5	5	15	14	13	13	13	13
56	LOCKHART	CALDWELL	18	4	7	9	10	11	11	14	11	9	8	7	7
57	OAK HILLS WSC	WILSON	18	5	8	10	11	11	11	13	10	8	7	7	7
58	UNIVERSAL CITY	BEXAR	18	5	8	11	13	14	14	13	10	7	5	4	4
59	BALCONES HEIGHTS	BEXAR	18	4	7	10	13	14	14	14	11	8	5	4	4
60	SCHERTZ	GUADALUPE	18	5	7	9	10	10	10	13	11	9	8	8	8
61	SUNKO WSC	WILSON	18	5	8	11	12	13	13	13	10	7	6	5	5
62	WOODSBORO	REFUGIO	18	4	7	10	13	14	14	14	11	8	5	4	4
63	OLMOS PARK	BEXAR	18	4	7	10	13	14	14	14	11	8	5	4	4
64	TERRELL HILLS	BEXAR	18	5	8	11	14	15	15	13	10	7	4	3	3
65	SAN ANTONIO	BEXAR	18	5	8	11	14	15	15	13	10	7	4	3	3
66	YOAKUM	DEWITT	18	3	6	9	12	14	14	15	12	9	6	4	4
67	MOUNTAIN CITY	HAYS	18	5	7	8	9	9	9	13	11	10	9	9	9
68	COUNTY LINE WSC	HAYS	18	5	7	8	9	9	9	13	11	10	9	9	9
69	COUNTY-OTHER	ZAVALA	18	4	7	9	11	12	12	14	11	9	7	6	6
70	POTH	WILSON	18	4	8	11	13	14	14	14	10	7	5	4	4
71	SAN MARCOS	HAYS	18	5	9	11	13	14	14	13	9	7	5	4	4
72	CHARLOTTE	ATASCOSA	18	4	7	10	13	14	14	14	11	8	5	4	4
73	ENCINAL	LA SALLE	18	3	6	9	13	14	14	15	12	9	5	4	4
74	LULING	CALDWELL	18	5	8	11	14	15	15	13	10	7	4	3	3

Table 4C.1-6 (Continued)

No.	Water User Group *	County *	Plumbing Fixtures Potentials gpcd	Low Flow Plumbing Fixtures Water Conservation Potentials *						Additional Plumbing Fixtures and Clothes Washer Conservation Potentials					
				2010 gpcd	2020 gpcd	2030 gpcd	2040 gpcd	2050 gpcd	2060 gpcd	2010 gpcd	2020 gpcd	2030 gpcd	2040 gpcd	2050 gpcd	2060 gpcd
75	NATALIA	MEDINA	18	4	7	9	11	12	12	14	11	9	7	6	6
76	POINT COMFORT	CALHOUN	18	3	6	9	12	14	14	15	12	9	6	4	4
77	COUNTY-OTHER	KARNES	18	3	4	5	6	6	6	15	14	13	12	12	12
78	RUNGE	KARNES	18	3	7	10	13	14	14	15	11	8	5	4	4
79	FALLS CITY	KARNES	18	5	8	11	13	14	14	13	10	7	5	4	4
80	SEADRIFT	CALHOUN	18	3	7	10	13	14	14	15	11	8	5	4	4
81	GOLIAD	GOLIAD	18	4	7	10	13	14	14	14	11	8	5	4	4
82	VICTORIA	VICTORIA	18	4	7	10	13	14	14	14	11	8	5	4	4
83	YANCEY WSC	MEDINA	18	4	7	9	10	11	11	14	11	9	8	7	7
84	BOERNE	KENDALL	18	6	9	11	13	13	13	12	9	7	5	5	5
85	CUERO	DEWITT	18	3	6	9	12	14	14	15	12	9	6	4	4
86	EL OSO WSC	KARNES	18	4	7	10	12	13	13	14	11	8	6	5	5
87	NIXON	GONZALES	18	3	7	9	12	13	13	15	11	9	6	5	5
88	REFUGIO	REFUGIO	18	5	8	11	13	14	14	13	10	7	5	4	4
89	SPRINGS HILL WSC	GUADALUPE	18	4	8	10	12	13	13	14	10	8	6	5	5
90	COUNTY-OTHER	CALDWELL	18	1	3	6	11	14	14	17	15	12	7	4	4
91	LYTLE	ATASCOSA	18	3	7	10	13	14	14	15	11	8	5	4	4
92	CIBOLO	GUADALUPE	18	4	7	8	9	9	9	14	11	10	9	9	9
93	HELOTES	BEXAR	18	4	6	6	7	7	7	14	12	12	11	11	11
94	JOURDANTON	ATASCOSA	18	4	8	11	13	14	14	14	10	7	5	4	4
95	CASTLE HILLS	BEXAR	18	4	7	10	13	15	15	14	11	8	5	3	3
96	DEVINE	MEDINA	18	4	7	11	14	15	15	14	11	7	4	3	3
97	PEARSALL	FRIO	18	3	6	9	13	14	14	15	12	9	5	4	4
98	BIG WELLS	DIMMIT	18	4	7	10	13	14	14	14	11	8	5	4	4
99	GONZALES	GONZALES	18	4	7	10	12	13	13	14	11	8	6	5	5
100	HONDO	MEDINA	18	5	8	10	12	13	13	13	10	8	6	5	5
101	SEGUIN	GUADALUPE	18	4	7	10	12	13	13	14	11	8	6	5	5
102	ASHERTON	DIMMIT	18	5	8	11	14	15	15	13	10	7	4	3	3
103	FLORESVILLE	WILSON	18	4	8	11	13	14	14	14	10	7	5	4	4
104	WOODCREEK UTILITIES INC	HAYS	18	4	6	6	7	7	7	14	12	12	11	11	11
105	SOMERSET	BEXAR	18	5	8	11	12	13	13	13	10	7	6	5	5
106	KENEDY	KARNES	18	4	8	11	14	15	15	14	10	7	4	3	3
107	POTEET	ATASCOSA	18	3	6	10	13	14	14	15	12	8	5	4	4
108	LA VERNIA	WILSON	18	4	7	9	11	11	11	14	11	9	7	7	7
109	PLEASANTON	ATASCOSA	18	3	7	10	13	14	14	15	11	8	5	4	4
110	NEW BRAUNFELS	COMAL	18	4	8	10	11	12	12	14	10	8	7	6	6
111	STOCKDALE	WILSON	18	4	8	11	13	14	14	14	10	7	5	4	4
112	CHINA GROVE	BEXAR	18	5	9	11	12	13	13	13	9	7	6	5	5
113	CASTROVILLE	MEDINA	18	4	8	11	13	14	14	14	10	7	5	4	4

Table 4C.1-6 (Concluded)

No.	Water User Group *	County *	Plumbing Fixtures Potentials gpcd	Low Flow Plumbing Fixtures Water Conservation Potentials *						Additional Plumbing Fixtures and Clothes Washer Conservation Potentials					
				2010 gpcd	2020 gpcd	2030 gpcd	2040 gpcd	2050 gpcd	2060 gpcd	2010 gpcd	2020 gpcd	2030 gpcd	2040 gpcd	2050 gpcd	2060 gpcd
114	FAIROAKS RANCH	BEXAR	18	2	3	4	5	6	6	16	15	14	13	12	12
115	WINDCREST	BEXAR	18	3	6	9	12	14	14	15	12	9	6	4	4
116	GARDEN RIDGE	COMAL	18	5	9	12	13	14	14	13	9	6	5	4	4
117	MUSTANG RIDGE	CALDWELL	18	5	9	11	12	13	13	13	9	7	6	5	5
118	SABINAL	UVALDE	18	3	6	9	12	14	14	15	12	9	6	4	4
119	ALAMO HEIGHTS	BEXAR	18	3	7	10	13	14	14	15	11	8	5	4	4
120	DILLEY	FRIO	18	3	6	9	10	11	11	15	12	9	8	7	7
121	GONZALES COUNTY WSC	GONZALES	18	4	8	10	12	13	13	14	10	8	6	5	5
122	CRYSTAL CITY	ZAVALA	18	3	7	10	13	14	14	15	11	8	5	4	4
123	CARRIZO SPRINGS	DIMMIT	18	4	7	10	13	14	14	14	11	8	5	4	4
124	SELMA	BEXAR	18	5	8	10	11	12	12	13	10	8	7	6	6
125	COTULLA	LA SALLE	18	4	7	10	13	14	14	14	11	8	5	4	4
126	UVALDE	UVALDE	18	4	7	10	13	15	15	14	11	8	5	3	3
127	LACKLAND AFB (CDP)	BEXAR	18	4	7	10	13	15	15	14	11	8	5	3	3
128	SHAVANO PARK	BEXAR	18	3	6	10	13	14	14	15	12	8	5	4	4
129	HOLLYWOOD PARK	BEXAR	18	3	7	10	13	14	14	15	11	8	5	4	4
130	HILL COUNTRY VILLAGE	BEXAR	18	3	6	9	12	14	14	15	12	9	6	4	4

* Water Conservation Effects, as estimated by the Texas Water Development Board, and used in computing municipal water ddemand for municipal WUGS.
** Region L water conservation goals for municipal WUGs with water use of 140 gpcd and greater in year 2000 are to reduce per capita water use by one percent per year until the level of 140 gpcd is reached, after which the goal is to reduce per capita water use by one -fourth percent per year for the remainder of the planning period. For municipal WUGs having per capita water use less than 140 gpcd in year 2000, the goal is to reduce per capita water use by one -fourth

Table 4C.1-7.
Projected per Capita Water Conservation Potentials of Region L Municipal Water Conservation Goals with Additional Plumbing Fixturs and Clothes Washers Retrofit and Lawn Irrigation Water Conservation

No.	Water User Group *	County *	Additional Plumbing Fixtures and Clothes Washers Retrofit Conservation						Lawn Irrigation Water Conservation					
			2010 gpcd	2020 gpcd	2030 gpcd	2040 gpcd	2050 gpcd	2060 gpcd	2010 gpcd	2020 gpcd	2030 gpcd	2040 gpcd	2050 gpcd	2060 gpcd
1	CALHOUN COUNTY WS	CALHOUN	0	0	0	0	0	0	0	0	0	0	0	0
2	COUNTY-OTHER	WILSON	0	0	0	1	3	4	0	0	0	0	0	0
3	GREEN VALLEY SUD	GUADALUPE	0	0	0	0	0	1	0	0	0	0	0	0
4	POLONIA WSC	CALDWELL	0	0	0	0	0	0	0	0	0	0	0	0
5	COUNTY-OTHER	VICTORIA	0	0	0	0	0	1	0	0	0	0	0	0
6	BENTON CITY WSC	ATASCOSA	0	0	0	1	3	5	0	0	0	0	0	0
7	COUNTY-OTHER	DIMMIT	0	0	0	0	0	0	0	0	0	0	0	0
8	COUNTY-OTHER	GOLIAD	0	0	0	0	0	2	0	0	0	0	0	0
9	CREEDMOOR-MAHA WSC	CALDWELL	0	0	0	0	0	2	0	0	0	0	0	0
10	GOFORTH WSC	HAYS	0	0	0	0	1	3	0	0	0	0	0	0
11	CRYSTAL CLEAR WSC	GUADALUPE	0	0	0	0	1	3	0	0	0	0	0	0
12	MARTINDALE	CALDWELL	0	0	0	0	0	0	0	0	0	0	0	0
13	PLUM CREEK WATER COMPANY	HAYS	0	0	0	0	1	3	0	0	0	0	0	0
14	COUNTY-OTHER	REFUGIO	0	0	0	0	0	0	0	0	0	0	0	0
15	MCCOY WSC	ATASCOSA	0	0	0	1	3	5	0	0	0	0	0	0
16	ATASCOSA RURAL WSC	BEXAR	0	0	0	0	0	1	0	0	0	0	0	0
17	COUNTY-OTHER	ATASCOSA	3	5	4	1	0	0	0	0	0	0	0	0
18	COUNTY-OTHER	KENDALL	0	0	0	0	1	3	0	0	0	0	0	0
19	WIMBERLEY WSC	HAYS	0	0	0	0	1	3	0	0	0	0	0	0
20	KIRBY	BEXAR	0	0	0	0	0	0	0	0	0	0	0	0
21	COUNTY-OTHER	DEWITT	0	0	0	0	0	1	0	0	0	0	0	0
22	COUNTY-OTHER	FRIO	0	0	0	0	0	2	0	0	0	0	0	0
23	KARNES CITY	KARNES	0	0	0	0	0	2	0	0	0	0	0	0
24	LEON VALLEY	BEXAR	0	0	0	0	0	1	0	0	0	0	0	0
25	MAXWELL WSC	CALDWELL	0	0	0	0	1	3	0	0	0	0	0	0
26	LIVE OAK	BEXAR	0	0	0	0	0	0	0	0	0	0	0	0
27	SS WSC	WILSON	0	0	0	0	2	4	0	0	0	0	0	0
28	COUNTY-OTHER	GONZALES	2	2	2	0	0	1	0	0	0	0	0	0
29	COUNTY-OTHER	GUADALUPE	1	0	0	0	0	2	0	0	0	0	0	0
30	SANTA CLARA	GUADALUPE	0	0	2	4	6	9	0	0	0	0	0	0
31	COUNTY-OTHER	BEXAR	1	2	2	3	5	7	0	0	0	0	0	0
32	EAST MEDINA SUD	MEDINA	0	0	0	0	2	4	0	0	0	0	0	0
33	CONVERSE	BEXAR	0	0	0	0	1	3	0	0	0	0	0	0
34	COUNTY-OTHER	COMAL	0	0	0	0	0	2	0	0	0	0	0	0
35	NIEDERWALD	HAYS	0	1	3	5	8	10	0	0	0	0	0	0
36	BEXAR MET WATER DISTRICT	BEXAR	0	0	0	0	0	2	0	0	0	0	0	0

Table 4C.1-7 (Continued)

No.	Water User Group *	County *	Additional Plumbing Fixtures and Clothes Washers Retrofit Conservation 2010 gpcd	2020 gpcd	2030 gpcd	2040 gpcd	2050 gpcd	2060 gpcd	Lawn Irrigation Water Conservation 2010 gpcd	2020 gpcd	2030 gpcd	2040 gpcd	2050 gpcd	2060 gpcd
37	KYLE	HAYS	0	1	3	4	7	9	0	0	0	0	0	0
38	BULVERDE CITY	COMAL	0	0	2	4	7	10	0	0	0	0	0	0
39	COUNTY-OTHER	UVALDE	0	0	0	2	3	6	0	0	0	0	0	0
40	EAST CENTRAL WSC	BEXAR	0	0	0	0	1	4	0	0	0	0	0	0
41	ST. HEDWIG	BEXAR	0	0	0	0	0	3	0	0	0	0	0	0
42	AQUA WSC	CALDWELL	0	0	0	0	1	4	0	0	0	0	0	0
43	PORT LAVACA	CALHOUN	0	0	0	0	1	4	0	0	0	0	0	0
44	MARION	GUADALUPE	0	0	0	0	2	4	0	0	0	0	0	0
45	WAELDER	GONZALES	0	0	0	2	4	6	0	0	0	0	0	0
46	COUNTY-OTHER	MEDINA	0	1	2	4	7	10	0	0	0	0	0	0
47	WATER SER INC (APEX)	BEXAR	0	0	0	1	3	6	0	0	0	0	0	0
48	WOODCREEK	HAYS	0	0	1	2	5	7	0	0	0	0	0	0
49	ELMENDORF	BEXAR	0	0	0	0	2	5	0	0	0	0	0	0
50	COUNTY-OTHER	LA SALLE	1	2	4	5	8	11	0	0	0	0	0	0
51	COUNTY-OTHER	CALHOUN	0	0	0	0	2	5	0	0	0	0	0	0
52	LACOSTE	MEDINA	0	0	0	0	2	5	0	0	0	0	0	0
53	YORKTOWN	DEWITT	0	1	1	1	2	5	0	0	0	0	0	0
54	COUNTY-OTHER	HAYS	0	0	1	3	6	9	0	0	0	0	0	0
55	CANYON LAKE WSC	COMAL	0	3	5	8	11	13	0	0	0	0	0	1
56	LOCKHART	CALDWELL	0	0	1	3	5	7	0	0	0	0	0	1
57	OAK HILLS WSC	WILSON	0	0	0	2	5	7	0	0	0	0	0	1
58	UNIVERSAL CITY	BEXAR	0	0	0	0	2	4	0	0	0	0	0	2
59	BALCONES HEIGHTS	BEXAR	1	1	2	2	4	4	0	0	0	0	0	3
60	SCHERTZ	GUADALUPE	1	2	3	6	8	8	0	0	0	0	1	4
61	SUNKO WSC	WILSON	1	1	1	4	5	5	0	0	0	0	1	4
62	WOODSBORO	REFUGIO	2	3	3	3	4	4	0	0	0	0	2	5
63	OLMOS PARK	BEXAR	3	4	4	4	4	4	0	0	0	0	2	5
64	TERRELL HILLS	BEXAR	2	3	3	3	3	3	0	0	0	0	2	5
65	SAN ANTONIO	BEXAR	4	4	5	4	3	3	0	0	0	1	4	7
66	YOAKUM	DEWITT	6	6	7	6	4	4	0	0	0	1	4	7
67	MOUNTAIN CITY	HAYS	5	6	8	9	9	9	0	0	0	2	5	8
68	COUNTY LINE WSC	HAYS	5	7	9	9	9	9	0	0	0	2	6	9
69	COUNTY-OTHER	ZAVALA	7	8	9	7	6	6	0	0	0	3	6	9
70	POTH	WILSON	9	8	7	5	4	4	0	0	1	3	8	11
71	SAN MARCOS	HAYS	8	7	7	5	4	4	0	0	1	5	8	11
72	CHARLOTTE	ATASCOSA	10	11	8	5	4	4	0	0	3	6	10	13
73	ENCINAL	LA SALLE	12	12	9	5	4	4	0	1	5	8	11	14
74	LULING	CALDWELL	10	10	7	4	3	3	0	1	5	8	11	14
75	NATALIA	MEDINA	11	11	9	7	6	6	0	1	5	8	11	14

Table 4C.1-7 (Continued)

No.	Water User Group *	County *	Additional Plumbing Fixtures and Clothes Washers Retrofit Conservation						Lawn Irrigation Water Conservation					
			2010 gpcd	2020 gpcd	2030 gpcd	2040 gpcd	2050 gpcd	2060 gpcd	2010 gpcd	2020 gpcd	2030 gpcd	2040 gpcd	2050 gpcd	2060 gpcd
76	POINT COMFORT	CALHOUN	12	12	9	6	4	4	0	4	8	11	14	17
77	COUNTY-OTHER	KARNES	12	14	13	12	12	12	0	5	9	12	15	18
78	RUNGE	KARNES	12	11	8	5	4	4	0	5	9	12	15	18
79	FALLS CITY	KARNES	10	10	7	5	4	4	0	6	9	13	16	19
80	SEADRIFT	CALHOUN	13	11	8	5	4	4	0	7	10	13	17	20
81	GOLIAD	GOLIAD	12	11	8	5	4	4	0	8	12	15	18	21
82	VICTORIA	VICTORIA	12	11	8	5	4	4	0	9	12	16	19	22
83	YANCEY WSC	MEDINA	12	11	9	8	7	7	0	11	14	17	21	24
84	BOERNE	KENDALL	10	9	7	5	5	5	0	11	15	18	22	25
85	CUERO	DEWITT	13	12	9	6	4	4	0	11	15	18	22	25
86	EL OSO WSC	KARNES	12	11	8	6	5	5	0	11	15	18	22	25
87	NIXON	GONZALES	13	11	9	6	5	5	0	11	15	18	22	25
88	REFUGIO	REFUGIO	11	10	7	5	4	4	0	11	15	18	22	25
89	SPRINGS HILL WSC	GUADALUPE	12	10	8	6	5	5	0	13	17	21	24	27
90	COUNTY-OTHER	CALDWELL	16	15	12	7	4	4	0	14	18	21	25	28
91	LYTLE	ATASCOSA	14	11	8	5	4	4	0	14	19	22	26	29
92	CIBOLO	GUADALUPE	13	11	10	9	9	9	0	14	21	24	27	30
93	HELOTES	BEXAR	13	12	12	11	11	11	0	14	21	24	27	30
94	JOURDANTON	ATASCOSA	13	10	7	5	4	4	0	14	21	25	28	31
95	CASTLE HILLS	BEXAR	13	11	8	5	3	3	0	14	22	26	29	32
96	DEVINE	MEDINA	13	11	7	4	3	3	0	15	23	26	30	33
97	PEARSALL	FRIO	14	12	9	5	4	4	0	15	23	26	30	33
98	BIG WELLS	DIMMIT	13	11	8	5	4	4	0	15	24	27	30	34
99	GONZALES	GONZALES	13	11	8	6	5	5	0	15	25	28	31	35
100	HONDO	MEDINA	12	10	8	6	5	5	0	15	25	28	31	35
101	SEGUIN	GUADALUPE	13	11	8	6	5	5	0	15	25	28	31	35
102	ASHERTON	DIMMIT	12	10	7	4	3	3	0	15	25	29	32	35
103	FLORESVILLE	WILSON	13	10	7	5	4	4	0	15	26	30	33	36
104	WOODCREEK UTILITIES INC	HAYS	13	12	12	11	11	11	0	15	26	30	33	36
105	SOMERSET	BEXAR	13	10	7	6	5	5	0	16	28	31	35	38
106	KENEDY	KARNES	14	10	7	4	3	3	1	17	32	39	42	45
107	POTEET	ATASCOSA	15	12	8	5	4	4	1	18	33	41	45	48
108	LA VERNIA	WILSON	14	11	9	7	7	7	1	18	34	42	45	49
109	PLEASANTON	ATASCOS A	15	11	8	5	4	4	1	18	34	42	45	49
110	NEW BRAUNFELS	COMAL	14	10	8	7	6	6	2	19	35	47	50	54
111	STOCKDALE	WILSON	14	10	7	5	4	4	2	19	35	48	51	55
112	CHINA GROVE	BEXAR	13	9	7	6	5	5	2	20	36	49	52	55
113	CASTROVILLE	MEDINA	14	10	7	5	4	4	2	20	36	50	54	57
114	FAIROAKS RANCH	BEXAR	16	15	14	13	12	12	2	20	36	51	55	58

Table 4C.1-7 (Concluded)

No.	Water User Group *	County *	Additional Plumbing Fixtures and Clothes Washers Retrofit Conservation						Lawn Irrigation Water Conservation					
			2010 gpcd	2020 gpcd	2030 gpcd	2040 gpcd	2050 gpcd	2060 gpcd	2010 gpcd	2020 gpcd	2030 gpcd	2040 gpcd	2050 gpcd	2060 gpcd
115	WINDCREST	BEXAR	15	12	9	6	4	4	2	21	37	52	57	60
116	GARDEN RIDGE	COMAL	13	9	6	5	4	4	3	22	38	54	61	65
117	MUSTANG RIDGE	CALDWELL	13	9	7	6	5	5	3	22	40	55	65	69
118	SABINAL	UVALDE	15	12	9	6	4	4	4	24	42	59	74	77
119	ALAMO HEIGHTS	BEXAR	15	11	8	5	4	4	5	26	46	63	78	88
120	DILLEY	FRIO	15	12	9	8	7	7	6	28	48	66	82	95
121	GONZALES COUNTY WSC	GONZALES	14	10	8	6	5	5	7	30	51	69	86	102
122	CRYSTAL CITY	ZAVALA	15	11	8	5	4	4	8	31	52	71	89	104
123	CARRIZO SPRINGS	DIMMIT	14	11	8	5	4	4	8	32	54	73	91	107
124	SELMA	BEXAR	13	10	8	7	6	6	12	39	63	85	105	123
125	COTULLA	LA SALLE	14	11	8	5	4	4	12	39	64	86	106	124
126	UVALDE	UVALDE	14	11	8	5	3	3	17	48	76	102	125	146
127	LACKLAND AFB (CDP)	BEXAR	14	11	8	5	3	3	20	54	84	112	137	160
128	SHAVANO PARK	BEXAR	15	12	8	5	4	4	21	56	88	117	143	167
129	HOLLYWOOD PARK	BEXAR	15	11	8	5	4	4	46	103	156	203	245	284
130	HILL COUNTRY VILLAGE	BEXAR	15	12	9	6	4	4	52	115	172	224	271	313

* Water Conservation Effects, as estimated by the Texas Water Development Board, and used in computing municipal water ddemand for municipal WUGS.

** Region L water conservation goals for municipal WUGs with water use of 140 gpcd and greater in yea r 2000 are to reduce per capita water use by one percent per year until the level of 140 gpcd is reached, after which the goal is to reduce per capita water use by one-fourth percent per year for the remainder of the planning period. For municipal WUGs having per capita water use less than 140 gpcd in year 2000, the goal is to reduce per capita water use by one-fourth percent per year.

The water conservation water management strategy for Municipal Water User Groups (WUGs) of Region L is based upon BMPs listed above, and quantities and costs of water conservation measures, as reported in, "Quantifying the Effectiveness of Various Water Conservation Techniques in Texas, Texas Water Development Board, GDS Associates, Austin, Texas, July 2003," and the Water Conservation Implementation Task Force guidelines for water-use targets and goals listed above. The purpose of the municipal water conservation water management strategy is to evaluate the potentials of additional municipal water conservation for inclusion in the Regional Water Plan to meet a part of the projected water needs (shortages) of each WUG for which a need (shortage) is projected.

The calculations for the municipal water conservation water management strategy for municipal WUGs is presented below, and includes both indoor (plumbing fixtures and clothes washers) and outdoor (lawn watering and landscape irrigation) water conservation methods. The underlying methods and assumptions are as follows:

1. Indoor plumbing fixture water conservation potentials are 18 gpcd.. a part of which has already been included in the per capita water use projections shown in Table 4C.1-3, and is taken into account in the computations of quantities and costs of the municipal water conservation water management strategy;
2. Outdoor (lawn and landscape) water conservation is used to meet the projected conservation that is needed in order to meet the Region L municipal water goals, as stated above; and
3. Costs of municipal water conservation were obtained from a TWDB study, and are as follows:

    - Plumbing fixture and clothes washer retrofit (Table 4C.1-8)[6]
        - Rural areas………………………………...$ 770 per acre-foot;
        - Suburban areas…………………………….$ 681 per acre-foot; and
        - Urban areas………………………………..$ 600 per acre-foot.
    - Lawn watering and landscape water conservation… $524 per acre-foot.

The per capita municipal water conservation potentials for indoor (plumbing fixtures and clothes washers) and outdoor (lawn and landscape irrigation) are tabulated for each WUG of Region L in Table 4C.1-5, and are shown in 3 parts as follows:

1. Low flow plumbing fixtures water conservation potentials, as provided by TWDB for use in the municipal water demand projections.
2. Additional plumbing fixtures and clothes washer water conservation calculated at 1.0 % and 0.25 % per year respectively, as stated in the goals, above.
3. Lawn and landscape irrigation conservation potentials.

[6] GDS Associates, "Quantifying the Effectiveness of Various Water Conservation Techniques in Texas; Appendix VI, Region L," Texas Water Development Board, Austin, Texas, July 2003.

Table 4C.1-8.
Water Conservation Potentials and Costs of Various Water Conservation Techniques in Rural, Suburban, and Urban Residential Housing
South Central Texas Water Planning Region

Water Conservation Techniques*	Life (Years)	Discount Factor at 6%	Potential Savings for Region L (acft)	Number of People Affected	Potential Savings (acft per person per year)	Total Costs (dollars)	Cost per acft of Water Saved Amortized at 6%*
Rural Areas							
SF Toilet Retrofit	25	0.0782	1,536	326,520	0.004705	12,300,668	626
SF Showerheads and Aerators	15	0.1029	805	326,520	0.002464	1,012,996	130
SF Clothes Washer Rebate	13	0.1129	1,843	326,520	0.005646	19,536,354	1,197
MF Toilet Retrofit	25	0.0782	65	11,083	0.005881	338,247	406
MF Showerheads and Aerators	15	0.1029	34	11,083	0.003080	18,040	54
MF Clothes Washer Rebate	8	0.1610	8	11,083	0.000754	39,086	753
Totals **			4,292	337,603	**0.012713**	33,245,391	**$770****
Suburban Areas							
SF Toilet Retrofit	25	0.0782	2,254	279,152	0.008075	16,144,438	560
SF Showerheads and Aerators	15	0.1029	1,181	279,152	0.004230	1,329,542	116
SF Clothes Washer Rebate	13	0.1129	2,705	279,152	0.009690	25,641,167	1,070
MF Toilet Retrofit	25	0.0782	222	37,787	0.005881	1,346,116	474
MF Showerheads and Aerators	15	0.1029	116	37,787	0.003080	71,793	63
MF Clothes Washer Rebate	8	0.1610	33	37,787	0.000880	155,551	753
Totals **			6,512	316,939	**0.020546**	44,688,607	**$681****
Urban Areas							
SF Toilet Retrofit	25	0.0782	4,406	936,489	0.004705	29,225,488	519
SF Showerheads and Aerators	15	0.1029	2,308	936,489	0.002464	2,406,805	107
SF Clothes Washer Rebate	13	0.1129	5,287	936,489	0.005646	46,416,952	991
MF Toilet Retrofit	25	0.0782	1,427	242,646	0.005881	8,420,679	461
MF Showerheads and Aerators	15	0.1029	747	242,646	0.003080	449,103	62
MF Clothes Washer Rebate	8	0.1610	208	242,646	0.000857	973,056	753
Totals **			14,383	1,179,135	**0.012198**	87,892,082	**$600****

* SF is Single Family and MF is Multi-family residential housing. Potentials for Water Conservation in Commercial Sector estimated at zero due to expected poor participation.

** Weighted average of measures included. Used to obtain cost per acre foot of municipal water conservation for use in calculating unit and total costs for water conservation water management strategy for Region L.

Source: "Quantifying the Effectiveness of Various Water Conservation Techniques in Texas," Texas Water Development Board, GDS Associates, Austin, Texas, July 2003.

The estimated quantities of water conservation potential (or water demand reduction) and associated costs for the WUGs of Region L for which additional water conservation is needed in order to reach the Region L water conservation goals are presented in Table 4C.1-9. The information shown in Table 4C.1-9 for each of the 73 WUGs for which water conservation estimates have been calculated is illustrated using the City of San Antonio (Number 65 on the list) as an example. For example, with additional water conservation through plumbing fixtures and clothes washers retrofit, the water conservation water management strategy would meet 5,752 acft/yr of projected need (shortages) in 2010; 8,795 acft/yr in 2030; and 7,113 acft/yr in 2060 (Table 4C.1-9). In order to meet the Region L water conservation goals, additional water conservation through lawn irrigation would provide 2,098 acft/yr in 2040; 8,970 acft/yr in 2050; and 16,598 acft/yr in 2060 (Table 4C.1-9).

Potential water conservation associated with implementation of the cited BMPs by each of the WUGs can be viewed in Table 4C.1-9. The projected water demand reductions shown in Table 4C.1-9 are the quantities for the water conservation water management strategy, and for WUGs with projected needs (shortages) will be included to meet a part the projected needs (shortages) of WUGs in the 2011 Regional Water Plan, respectively. Total projected water demand reduction through water conservation, needed to meet the Region L per capita water use goals is 13,231 acft/yr in 2010, 31,616 acft/yr in 2030, and 72,570 acft/yr in 2060 (Table 4C.1-10). The associated costs for the water conservation water management strategy are shown in Table 4C.1-7.

The estimated costs of municipal water conservation for each individual WUG are shown in Table 4C.1-11 for additional plumbing fixtures and clothes washers retrofit, Table 4C.1-12 for lawn irrigation, and Table 4C.1-13 for the total of plumbing fixtures and clothes washers retrofit and lawn irrigation. The costs depend upon quantity of water conservation potential, as well as location. For example, San Marcos (Number 71 on the list) has a potential of 417 acft/yr in 2010, with a cost $284,314, and a potential of 2,656 acft/yr in 2060 at a cost of $1,503,171 (Table 4C.1-10 and Table 4C.1-13, respectively). Total cost for implementation and administration of the municipal water conservation water management strategy to meet the Region L goals of reducing per capita water use at the 1 percent and 0.25 percent rates, as

Table 4C.1-9.
Projected Water Demand Reduction from Additional Plumbing Fixtures and Clothes Washers Retrofit and Lawn Irrigation Water Conservation

No.	Water User Group *	County *	Additional Plumbing Fixtures and Clothes Washers Retrofit Conservation						Lawn Irrigation Water Conservation					
			2010 acft/yr	2020 acft/yr	2030 acft/yr	2040 acft/yr	2050 acft/yr	2060 acft/yr	2010 acft/yr	2020 acft/yr	2030 acft/yr	2040 acft/yr	2050 acft/yr	2060 acft/yr
1	CALHOUN COUNTY WS	CALHOUN	0	0	0	0	0	0	0	0	0	0	0	0
2	COUNTY-OTHER	WILSON	0	0	0	14	58	116	0	0	0	0	0	0
3	GREEN VALLEY SUD	GUADALUPE	0	0	0	0	0	20	0	0	0	0	0	0
4	POLONIA WSC	CALDWELL	0	0	0	0	0	0	0	0	0	0	0	0
5	COUNTY-OTHER	VICTORIA	0	0	0	0	0	32	0	0	0	0	0	0
6	BENTON CITY WSC	ATASCOSA	0	0	0	24	85	153	0	0	0	0	0	0
7	COUNTY-OTHER	DIMMIT	0	0	0	0	0	0	0	0	0	0	0	0
8	COUNTY-OTHER	GOLIAD	0	0	0	0	0	16	0	0	0	0	0	0
9	CREEDMOOR-MAHA WSC	CALDWELL	0	0	0	0	0	11	0	0	0	0	0	0
10	GOFORTH WSC	HAYS	0	0	0	0	22	111	0	0	0	0	0	0
11	CRYSTAL CLEAR WSC	GUADALUPE	0	0	0	0	41	184	0	0	0	0	0	0
12	MARTINDALE	CALDWELL	0	0	0	0	0	0	0	0	0	0	0	0
13	PLUM CREEK WATER COMPANY	HAYS	0	0	0	0	12	54	0	0	0	0	0	0
14	COUNTY-OTHER	REFUGIO	0	0	0	0	0	0	0	0	0	0	0	0
15	MCCOY WSC	ATASCOSA	0	0	0	13	68	129	0	0	0	0	0	0
16	ATASCOSA RURAL WSC	BEXAR	0	0	0	0	0	22	0	0	0	0	0	0
17	COUNTY-OTHER	ATASCOSA	11	17	11	1	0	0	0	0	0	0	0	0
18	COUNTY-OTHER	KENDALL	0	0	0	0	73	264	0	0	0	0	0	0
19	WIMBERLEY WSC	HAYS	0	0	0	0	19	70	0	0	0	0	0	0
20	KIRBY	BEXAR	0	0	0	0	0	0	0	0	0	0	0	0
21	COUNTY-OTHER	DEWITT	0	0	0	0	0	6	0	0	0	0	0	0
22	COUNTY-OTHER	FRIO	0	0	0	0	0	18	0	0	0	0	0	0
23	KARNES CITY	KARNES	0	0	0	0	0	11	0	0	0	0	0	0
24	LEON VALLEY	BEXAR	0	0	0	0	0	12	0	0	0	0	0	0
25	MAXWELL WSC	CALDWELL	0	0	0	0	11	55	0	0	0	0	0	0
26	LIVE OAK	BEXAR	0	0	0	0	0	0	0	0	0	0	0	0
27	SS WSC	WILSON	0	0	0	0	84	221	0	0	0	0	0	0
28	COUNTY-OTHER	GONZALES	6	7	5	0	0	3	0	0	0	0	0	0
29	COUNTY-OTHER	GUADALUPE	2	0	0	0	0	0	0	0	0	0	0	0
30	SANTA CLARA	GUADALUPE	0	0	10	23	47	79	0	0	0	0	0	0
31	COUNTY-OTHER	BEXAR	49	96	140	191	310	505	0	0	0	0	0	0
32	EAST MEDINA SUD	MEDINA	0	0	0	0	19	54	0	0	0	0	0	0
33	CONVERSE	BEXAR	0	0	0	0	21	110	0	0	0	0	0	0
34	COUNTY-OTHER	COMAL	0	0	0	0	0	85	0	0	0	0	0	0
35	NIEDERWALD	HAYS	0	1	8	15	27	42	0	0	0	0	0	0
36	BEXAR MET WATER DISTRICT	BEXAR	0	0	0	0	0	293	0	0	0	0	0	0

Table 4C.1-9 (Continued)

37	KYLE	HAYS	0	27	96	167	302	443	0	0	0	0	0	0
38	BULVERDE CITY	COMAL	0	0	38	130	260	430	0	0	0	0	0	0
39	COUNTY-OTHER	UVALDE	0	0	0	33	73	137	0	0	0	0	0	0
40	EAST CENTRAL WSC	BEXAR	0	0	0	0	32	104	0	0	0	0	0	0
41	ST. HEDWIG	BEXAR	0	0	0	0	0	14	0	0	0	0	0	0
42	AQUA WSC	CALDWELL	0	0	0	0	6	19	0	0	0	0	0	0
43	PORT LAVACA	CALHOUN	0	0	0	0	30	89	0	0	0	0	0	0
44	MARION	GUADALUPE	0	0	0	0	3	10	0	0	0	0	0	0
45	WAELDER	GONZALES	0	0	0	3	7	11	0	0	0	0	0	0
46	COUNTY-OTHER	MEDINA	0	20	41	86	160	244	0	0	0	0	0	0
47	WATER SER INC (APE X)	BEXAR	0	0	0	18	50	105	0	0	0	0	0	0
48	WOODCREEK	HAYS	0	0	2	6	20	37	0	0	0	0	0	0
49	ELMENDORF	BEXAR	0	0	0	0	2	6	0	0	0	0	0	0
50	COUNTY-OTHER	LA SALLE	3	4	11	17	29	42	0	0	0	0	0	0
51	COUNTY-OTHER	CALHOUN	0	0	0	0	4	11	0	0	0	0	0	0
52	LACOSTE	MEDINA	0	0	0	0	4	11	0	0	0	0	0	0
53	YORKTOWN	DEWITT	0	2	2	2	5	13	0	0	0	0	0	0
54	COUNTY-OTHER	HAYS	0	0	12	49	112	184	0	0	0	0	0	0
55	CANYON LAKE WSC	COMAL	0	96	254	543	929	1,313	0	0	0	0	0	101
56	LOCKHART	CALDWELL	0	0	28	103	195	291	0	0	0	0	0	42
57	OAK HILLS WSC	WILSON	0	0	0	26	76	119	0	0	0	0	0	17
58	UNIVERSAL CITY	BEXAR	0	0	0	0	49	98	0	0	0	0	0	49
59	BALCONES HEIGHTS	BEXAR	4	6	7	9	20	21	0	0	0	0	0	16
60	SCHERTZ	GUADALUPE	22	87	182	365	617	725	0	0	0	0	77	363
61	SUNKO WSC	WILSON	3	6	10	29	45	51	0	0	0	0	9	41
62	WOODSBORO	REFUGIO	5	6	7	8	9	9	0	0	0	0	5	11
63	OLMOS PARK	BEXAR	9	11	13	14	14	15	0	0	0	0	7	18
64	TERRELL HILLS	BEXAR	14	18	21	24	24	24	0	0	0	0	16	41
65	SAN ANTONIO	BEXAR	5,752	7,318	8,795	8,392	6,728	7,113	0	0	0	2,098	8,970	16,598
66	YOAKUM	DEWITT	14	16	17	15	10	10	0	0	0	3	10	17
67	MOUNTAIN CITY	HAYS	1	3	6	8	10	12	0	0	0	2	6	11
68	COUNTY LINE WSC	HAYS	43	110	176	186	206	236	0	0	0	41	138	236
69	COUNTY-OTHER	ZAVALA	42	54	71	62	58	60	0	0	0	27	58	89
70	POTH	WILSON	20	22	22	17	15	17	0	0	3	10	31	47
71	SAN MARCOS	HAYS	417	554	713	641	625	708	0	0	102	641	1,250	1,948
72	CHARLOTTE	ATASCOSA	20	23	18	12	10	10	0	0	7	14	24	33
73	ENCINAL	LA SALLE	9	9	7	4	3	3	0	1	4	6	8	11
74	LULING	CALDWELL	70	82	63	39	32	34	0	8	45	78	116	158
75	NATALIA	MEDINA	24	28	25	22	20	22	0	3	13	24	37	51
76	POINT COMFORT	CALHOUN	18	25	30	27	18	18	0	9	26	51	65	80
77	COUNTY-OTHER	KARNES	68	88	95	97	101	102	0	32	62	96	127	156
78	RUNGE	KARNES	15	15	12	8	6	7	0	7	12	18	24	31
79	FALLS CITY	KARNES	8	8	6	5	4	4	0	5	8	12	15	19

Table 4C.1-9 (Continued)

80	SEADRIFT	CALHOUN	20	18	13	9	7	7	0	11	17	23	29	34
81	GOLIAD	GOLIAD	30	33	27	18	15	16	0	25	40	55	70	85
82	VICTORIA	VICTORIA	874	876	676	442	367	378	0	722	1,056	1,402	1,752	2,107
83	YANCEY WSC	MEDINA	61	69	67	67	65	71	0	67	105	147	194	244
84	BOERNE	KENDALL	98	123	126	108	123	137	0	156	268	394	529	679
85	CUERO	DEWITT	99	93	70	47	31	30	0	88	116	143	167	188
86	EL OSO WSC	KARNES	41	41	32	26	23	23	0	42	60	79	97	115
87	NIXON	GONZALES	35	31	27	19	16	16	0	32	45	57	68	77
88	REFUGIO	REFUGIO	44	44	32	24	20	20	0	50	68	89	109	124
89	SPRINGS HILL WSC	GUADALUPE	174	163	151	128	121	136	0	218	326	442	580	740
90	COUNTY-OTHER	CALDWELL	21	20	14	8	4	4	0	18	22	23	24	25
91	LYTLE	ATASCOSA	38	32	24	16	13	13	0	40	58	70	83	95
92	CIBOLO	GUADALUPE	65	77	92	102	124	147	0	99	189	272	375	498
93	HELOTES	BEXAR	115	159	199	212	239	263	0	186	340	462	593	729
94	JOURDANTON	ATASCOSA	60	51	39	29	24	25	0	73	117	144	171	197
95	CASTLE HILLS	BEXAR	61	52	38	24	14	14	0	68	104	121	136	152
96	DEVINE	MEDINA	63	54	36	21	16	16	0	72	117	138	159	180
97	PEARSALL	FRIO	116	100	77	43	35	35	0	122	195	228	259	289
98	BIG WELLS	DIMMIT	11	10	8	5	4	4	0	13	22	26	28	30
99	GONZALES	GONZALES	116	104	80	62	53	52	0	141	245	291	329	362
100	HONDO	MEDINA	125	116	103	84	76	81	0	173	317	393	475	559
101	SEGUIN	GUADALUPE	377	362	302	256	240	269	0	492	927	1,192	1,504	1,861
102	ASHERTON	DIMMIT	20	17	13	7	5	5	0	26	45	52	56	59
103	FLORESVILLE	WILSON	136	115	91	73	65	71	0	176	342	431	532	643
104	WOODCREEK UTILITIES INC	HAYS	56	78	106	123	155	180	0	99	231	332	464	591
105	SOMERSET	BEXAR	29	27	22	21	19	21	0	43	88	110	133	156
106	KENEDY	KARNES	56	44	33	20	16	17	2	77	155	196	226	251
107	POTEET	ATASCOSA	57	47	32	20	16	16	3	69	132	165	181	197
108	LA VERNIA	WILSON	20	21	22	21	25	29	1	35	82	125	160	199
109	PLEASANTON	ATASC OSA	147	113	86	56	46	47	9	186	362	467	520	569
110	NEW BRAUNFELS	COMAL	736	674	674	706	708	820	79	1,291	2,958	4,727	5,941	7,332
111	STOCKDALE	WILSON	24	20	15	12	11	12	3	38	78	116	137	159
112	CHINA GROVE	BEXAR	24	21	19	18	17	18	3	45	97	148	174	199
113	CASTROVILLE	MEDINA	47	37	29	22	19	20	6	74	147	220	251	282
114	FAIROAKS RANCH	BEXAR	111	105	99	93	87	87	14	141	258	366	394	422
115	WINDCREST	BEXAR	86	70	53	35	24	24	13	120	217	307	338	361
116	GARDEN RIDGE	COMAL	35	30	25	25	23	27	7	73	161	269	356	433
117	MUSTANG RIDGE	CALDWELL	8	8	7	7	7	8	2	19	41	67	91	108
118	SABINAL	UVALDE	27	21	16	11	7	7	7	43	76	105	131	138
119	ALAMO HEIGHTS	BEXAR	129	99	73	46	37	38	46	238	415	579	731	827
120	DILLEY	FRIO	74	68	57	55	51	53	30	160	305	455	601	719
121	GONZALES COUNTY WSC	GONZALES	94	78	69	55	47	47	49	234	436	638	811	955

Table 4C.1-9 (Concluded)

122	CRYSTAL CITY	ZAVALA	126	95	72	45	37	37	66	269	471	649	813	965
123	CARRIZO SPRINGS	DIMMIT	95	80	60	38	30	28	56	233	404	552	670	749
124	SELMA	BEXAR	71	70	69	61	52	52	64	274	547	740	914	1,070
125	COTULLA	LA SALLE	64	54	41	27	22	23	55	193	328	461	593	722
126	UVALDE	UVALDE	237	189	139	88	53	53	283	827	1,331	1,794	2,216	2,599
127	LACKLAND AFB (CDP)	BEXAR	112	88	64	40	24	24	156	427	673	894	1,095	1,276
128	SHAVANO PARK	BEXAR	30	25	17	11	9	9	43	117	188	254	315	373
129	HOLLYWOOD PARK	BEXAR	52	40	30	19	16	16	160	375	582	779	964	1,138
130	HILL COUNTRY VILLAGE	BEXAR	17	14	10	7	5	5	60	133	198	258	312	360
	Total		12,013	13,734	15,231	14,961	15,083	19,163	1,218	9,008	16,386	25,567	38,842	53,407

Table 4C.1-10.
Projected Municipal Water Demand Reduction from Additional Plumbing Fixtures and Clothes Washers Retrofit and Lawn Irrigation Water Conservation (Totals)
South Central Texas Water Planning Region

County Number	Water User Group*	County	Plumbing Fixtures and Clothes Washers Retrofit Plus Lawn Irrigation Conservation 2010 (acft/yr)	2020 (acft/yr)	2030 (acft/yr)	2040 (acft/yr)	2050 (acft/yr)	2060 (acft/yr)
1	Calhoun County WS	Calhoun	0	0	0	0	0	0
2	County-Other	Wilson	0	0	0	14	58	116
3	Green Valley SUD	Guadalupe	0	0	0	0	0	20
4	Polonia WSC	Caldwell	0	0	0	0	0	0
5	County-Other	Victoria	0	0	0	0	0	32
6	Benton City WSC	Atascosa	0	0	0	24	85	153
7	County-Other	Dimmit	0	0	0	0	0	0
8	County-Other	Goliad	0	0	0	0	0	16
9	Creedmoor-Maha WSC	Caldwell	0	0	0	0	0	11
10	Goforth WSC	Caldwell	0	0	0	0	22	111
11	Crystal Clear WSC	Guadalupe	0	0	0	0	41	184
12	Martindale	Caldwell	0	0	0	0	0	0
13	Plum Creek Water Co.	Hays	0	0	0	0	12	54
14	County-Other	Refugio	0	0	0	0	0	0
15	McCoy WSC	Atascosa	0	0	0	13	68	129
16	Atascosa Rural WSC	Bexar	0	0	0	0	0	22
17	County-Other	Atascosa	11	17	11	1	0	0
18	County-Other	Kendall	0	0	0	0	73	264
19	Wimberley WSC	Hays	0	0	0	0	19	70
20	Kirby	Bexar	0	0	0	0	0	0
21	County-Other	Dewitt	0	0	0	0	0	6
22	County-Other	Frio	0	0	0	0	0	18
23	Karnes City	Karnes	0	0	0	0	0	11
24	Leon Valley	Bexar	0	0	0	0	0	12
25	Maxwell WSC	Caldwell	0	0	0	0	11	55
26	Live Oak	Bexar	0	0	0	0	0	0
27	Ss WSC	Wilson	0	0	0	0	84	221
28	County-Other	Gonzales	6	7	5	0	0	3
29	County-Other	Guadalupe	2	0	0	0	0	0
30	Santa Clara	Guadalupe	0	0	10	23	47	79
31	County-Other	Bexar	49	96	140	191	310	505
32	East Medina SUD	Medina	0	0	0	0	19	54
33	Converse	Bexar	0	0	0	0	21	110
34	County-Other	Comal	0	0	0	0	0	85
35	Niederwald	Hays	0	1	8	15	27	42
36	Bexar Met Water District	Bexar	0	0	0	0	0	293
37	Kyle	Hays	0	27	96	167	302	443
38	Bulverde City	Comal	0	0	38	130	260	430
39	County-Other	Uvalde	0	0	0	33	73	137
40	East Central WSC	Bexar	0	0	0	0	32	104
41	St. Hedwig	Bexar	0	0	0	0	0	14
42	Aqua WSC	Caldwell	0	0	0	0	6	19

Table 4C-1-10 (Continued)

County Number	Water User Group*	County	*Plumbing Fixtures and Clothes Washers Retrofit Plus Lawn Irrigation Conservation* 2010 (acft/yr)	2020 (acft/yr)	2030 (acft/yr)	2040 (acft/yr)	2050 (acft/yr)	2060 (acft/yr)
43	Port Lavaca	Calhoun	0	0	0	0	30	89
44	Marion	Guadalupe	0	0	0	0	3	10
45	Waelder	Gonzales	0	0	0	3	7	11
46	County-Other	Medina	0	20	41	86	160	244
47	Water Ser Inc (APEX)	Bexar	0	0	0	18	50	105
48	Woodcreek	Hays	0	0	2	6	20	37
49	Elmendorf	Bexar	0	0	0	0	2	6
50	County-Other	La Salle	3	4	11	17	29	42
51	County-Other	Calhoun	0	0	0	0	4	11
52	Lacoste	Medina	0	0	0	0	4	11
53	Yorktown	Dewitt	0	2	2	2	5	13
54	County-Other	Hays	0	0	12	49	112	184
55	Canyon Lake WSC	Comal	0	96	254	543	929	1,414
56	Lockhart	Caldwell	0	0	28	103	195	333
57	Oak Hills WSC	Wilson	0	0	0	26	76	136
58	Universal City	Bexar	0	0	0	0	49	148
59	Balcones Heights	Bexar	4	6	7	9	20	37
60	Schertz	Guadalupe	22	87	182	365	694	1,088
61	Sunko WSC	Wilson	3	6	10	29	54	92
62	Woodsboro	Refugio	5	6	7	8	14	20
63	Olmos Park	Bexar	9	11	13	14	21	33
64	Terrell Hills	Bexar	14	18	21	24	39	65
65	San Antonio	Bexar	5,752	7,318	8,795	10,490	15,698	23,711
66	Yoakum	Dewitt	14	16	17	18	20	27
67	Mountain City	Hays	1	3	6	10	16	22
68	County Line WSC	Hays	43	110	176	227	344	473
69	County-Other	Zavala	42	54	71	89	115	149
70	Poth	Wilson	20	22	25	28	46	64
71	San Marcos	Hays	417	554	815	1,282	1,875	2,656
72	Charlotte	Atascosa	20	23	25	26	34	43
73	Encinal	La Salle	9	9	10	10	11	14
74	Luling	Caldwell	70	90	108	117	148	192
75	Natalia	Medina	24	31	38	46	58	73
76	Point Comfort	Calhoun	18	34	55	78	84	98
77	County-Other	Karnes	68	121	157	193	227	258
78	Runge	Karnes	15	22	24	26	31	37
79	Falls City	Karnes	8	13	14	16	19	23
80	Seadrift	Calhoun	20	29	30	32	36	41
81	Goliad	Goliad	30	59	67	73	85	100
82	Victoria	Victoria	874	1,597	1,733	1,844	2,118	2,485
83	Yancey WSC	Medina	61	136	171	214	259	316
84	Boerne	Kendall	98	280	394	502	652	816
85	Cuero	Dewitt	99	181	187	190	197	218
86	El Oso WSC	Karnes	41	83	92	105	120	139
87	Nixon	Gonzales	35	64	72	75	83	93

Table 4C-1-10 (Concluded)

County Number	Water User Group*	County	Plumbing Fixtures and Clothes Washers Retrofit Plus Lawn Irrigation Conservation 2010 (acft/yr)	2020 (acft/yr)	2030 (acft/yr)	2040 (acft/yr)	2050 (acft/yr)	2060 (acft/yr)
88	Refugio	Refugio	44	94	100	114	130	144
89	Springs Hill WSC	Guadalupe	174	381	477	571	701	877
90	County-Other	Caldwell	21	37	36	31	28	29
91	Lytle	Atascosa	38	72	82	86	96	108
92	Cibolo	Guadalupe	65	176	281	374	499	645
93	Helotes	Bexar	115	345	539	674	832	993
94	Jourdanton	Atascosa	60	123	156	173	195	222
95	Castle Hills	Bexar	61	120	142	144	151	166
96	Devine	Medina	63	127	152	159	175	196
97	Pearsall	Frio	116	223	272	271	294	324
98	Big Wells	Dimmit	11	23	30	30	32	33
99	Gonzales	Gonzales	116	245	325	353	381	414
100	Hondo	Medina	125	289	420	477	551	640
101	Seguin	Guadalupe	377	853	1,229	1,448	1,744	2,131
102	Asherton	Dimmit	20	43	58	59	62	64
103	Floresville	Wilson	136	291	433	504	596	714
104	Woodcreek Utilities Inc	Hays	56	177	337	455	619	771
105	Somerset	Bexar	29	70	110	131	152	177
106	Kenedy	Karnes	58	121	189	216	242	268
107	Poteet	Atascosa	60	116	163	185	198	213
108	La Vernia	Wilson	21	56	105	146	184	227
109	Pleasanton	Atascosa	156	300	448	523	565	615
110	New Braunfels	Comal	815	1,965	3,632	5,433	6,650	8,152
111	Stockdale	Wilson	27	57	93	128	147	171
112	China Grove	Bexar	28	66	116	166	190	217
113	Castroville	Medina	53	111	176	242	270	302
114	Fairoaks Ranch	Bexar	125	246	358	460	481	509
115	Windcrest	Bexar	99	189	270	343	362	385
116	Garden Ridge	Comal	42	103	187	294	379	460
117	Mustang Ridge	Caldwell	10	26	48	74	98	116
118	Sabinal	Uvalde	34	65	92	116	139	145
119	Alamo Heights	Bexar	175	337	488	625	769	865
120	Dilley	Frio	104	229	362	511	652	772
121	Gonzales County WSC	Gonzales	143	312	505	693	858	1,002
122	Crystal City	Zavala	192	364	543	695	850	1,002
123	Carrizo Springs	Dimmit	152	312	464	590	700	777
124	Selma	Bexar	135	344	617	801	966	1,122
125	Cotulla	La Salle	118	248	369	488	615	745
126	Uvalde	Uvalde	521	1,017	1,471	1,882	2,269	2,652
127	Lackland AFB (CDP)	Bexar	268	515	736	934	1,119	1,300
128	Shavano Park	Bexar	73	142	205	265	324	382
129	Hollywood Park	Bexar	212	414	612	798	980	1,154
130	Hill Country Village	Bexar	77	146	209	265	316	365
	Total		13,231	22,742	31,616	40,528	53,925	72,570

Table 4C.1-11. Estimated Costs for Projected Municipal Water Conservation from Additional Plumbing Fixtures and Clothes Washers Retrofit South Central Texas Water Planning Region

Water User Group *	County *	Area	Cost Per Acre Foot	Costs of Water Demand Reduction from Plumbing Fixtures and Clothes Washers Retrofit Conservation					
				2010 dollars	2020 dollars	2030 dollars	2040 dollars	2050 dollars	2060 dollars
CALHOUN COUNTY WS	CALHOUN	Rural	770	0	0	0	0	0	0
COUNTY-OTHER	WILSON	Rural	770	0	0	0	10,542	44,842	89,671
GREEN VALLEY SUD	GUADALUPE	Rural	770	0	0	0	0	0	15,704
POLONIA WSC	CALDWELL	Rural	770	0	0	0	0	0	0
COUNTY-OTHER	VICTORIA	Rural	770	0	0	0	0	0	24,722
BENTON CITY WSC	ATASCOSA	Rural	770	0	0	0	18,286	65,146	117,506
COUNTY-OTHER	DIMMIT	Rural	770	0	0	0	0	0	0
COUNTY-OTHER	GOLIAD	Rural	770	0	0	0	0	0	12,663
CREEDMOOR-MAHA WSC	CALDWELL	Rural	770	0	0	0	0	0	8,700
GOFORTH WSC	HAYS	Rural	770	0	0	0	0	17,198	85,581
CRYSTAL CLEAR WSC	GUADALUPE	Rural	770	0	0	0	0	31,476	141,432
MARTINDALE	CALDWELL	Rural	770	0	0	0	0	0	0
PLUM CREEK WATER CO	HAYS	Rural	770	0	0	0	0	9,431	41,541
COUNTY-OTHER	REFUGIO	Rural	770	0	0	0	0	0	0
MCCOY WSC	ATASCOSA	Rural	770	0	0	0	10,182	52,244	99,091
ATASCOSA RURAL WSC	BEXAR	Rural	770	0	0	0	0	0	17,081
COUNTY-OTHER	ATASCOSA	Rural	770	8,554	12,806	8,532	1,061	0	0
COUNTY-OTHER	KENDALL	Rural	770	0	0	0	0	56,422	203,520
WIMBERLEY WSC	HAYS	Rural	770	0	0	0	0	14,676	53,642
KIRBY	BEXAR	Rural	770	0	0	0	0	0	0
COUNTY-OTHER	DEWITT	Rural	770	0	0	0	0	0	4,961
COUNTY-OTHER	FRIO	Rural	770	0	0	0	0	0	13,845
KARNES CITY	KARNES	Rural	770	0	0	0	0	0	8,554
LEON VALLEY	BEXAR	Suburban	681	0	0	0	0	0	7,962
MAXWELL WSC	CALDWELL	Rural	770	0	0	0	0	8,599	42,527
LIVE OAK	BEXAR	Suburban	681	0	0	0	0	0	0
SS WSC	WILSON	Rural	770	0	0	0	0	64,588	169,800
COUNTY-OTHER	GONZALES	Rural	770	4,791	5,521	3,910	0	0	2,398
COUNTY-OTHER	GUADALUPE	Rural	770	1,449	0	0	0	0	162
SANTA CLARA	GUADALUPE	Rural	770	0	0	7,877	17,462	36,225	61,080
COUNTY-OTHER	BEXAR	Rural	770	37,759	73,618	107,959	147,203	238,677	389,088
EAST MEDINA SUD	MEDINA	Rural	770	0	0	0	0	14,753	41,817
CONVERSE	BEXAR	Suburban	681	0	0	0	0	14,150	74,857
COUNTY-OTHER	COMAL	Rural	770	0	0	0	0	0	65,700
NIEDERWALD	HAYS	Rural	770	0	877	5,986	11,172	20,827	32,038
BEXAR MET WD	BEXAR	Rural	770	0	0	0	0	0	225,525
KYLE	HAYS	Suburban	681	0	18,091	65,039	113,927	205,763	301,858
BULVERDE CITY	COMAL	Suburban	681	0	0	25,608	88,450	176,820	293,074
COUNTY-OTHER	UVALDE	Rural	770	0	0	0	25,734	56,398	105,635
EAST CENTRAL WSC	BEXAR	Rural	770	0	0	0	0	24,845	80,163

Table 4C.1-11 (Continued)

Water User Group *	County *	Area	Cost Per Acre Foot	Costs of Water Demand Reduction from Plumbing Fixtures and Clothes Washers Retrofit Conservation					
				2010 dollars	2020 dollars	2030 dollars	2040 dollars	2050 dollars	2060 dollars
ST. HEDWIG	BEXAR	Rural	770	0	0	0	0	0	10,763
AQUA WSC	CALDWELL	Rural	770	0	0	0	0	4,655	14,729
PORT LAVACA	CALHOUN	Rural	770	0	0	0	0	22,725	68,162
MARION	GUADALUPE	Rural	770	0	0	0	0	2,680	7,652
WAELDER	GONZALES	Rural	770	0	0	0	2,582	5,110	8,815
COUNTY-OTHER	MEDINA	Rural	770	0	15,020	31,826	66,279	123,399	187,503
WATER SER INC (APEX)	BEXAR	Rural	770	0	0	0	13,791	38,479	81,122
WOODCREEK	HAYS	Rural	770	0	0	1,323	4,535	15,573	28,752
ELMENDORF	BEXAR	Suburban	681	0	0	0	0	1,393	4,052
COUNTY-OTHER	LA SALLE	Rural	770	2,160	2,958	8,526	12,845	22,694	32,667
COUNTY-OTHER	CALHOUN	Rural	770	0	0	0	0	3,079	8,263
LACOSTE	MEDINA	Rural	770	0	0	0	0	3,178	8,617
YORKTOWN	DEWITT	Rural	770	0	1,215	1,594	1,801	3,871	9,753
COUNTY-OTHER	HAYS	Rural	770	0	0	9,433	37,534	86,547	141,576
CANYON LAKE WSC	COMAL	Rural	770	0	74,261	195,883	418,001	715,563	1,010,965
LOCKHART	CALDWELL	Suburban	681	0	0	18,838	70,011	132,630	198,360
OAK HILLS WSC	WILSON	Rural	770	0	0	0	20,004	58,480	91,687
UNIVERSAL CITY	BEXAR	Suburban	681	0	0	0	0	33,518	67,036
BALCONES HEIGHTS	BEXAR	Suburban	681	2,481	3,821	4,975	5,990	13,578	14,262
SCHERTZ	GUADALUPE	Suburban	681	15,118	59,574	123,652	248,424	419,886	493,964
SUNKO WSC	WILSON	Rural	770	2,522	4,800	7,421	22,111	34,647	39,283
WOODSBORO	REFUGIO	Rural	770	3,894	4,740	5,344	5,907	6,979	6,938
OLMOS PARK	BEXAR	Suburban	681	6,343	7,676	8,877	9,863	9,721	10,066
TERRELL HILLS	BEXAR	Suburban	681	9,495	12,125	14,510	16,484	16,005	16,610
SAN ANTONIO	BEXAR	Urban	600	3,451,336	4,390,988	5,276,772	5,035,174	4,036,585	4,267,981
YOAKUM	DEWITT	Rural	770	10,915	11,989	12,800	11,794	7,745	7,607
MOUNTAIN CITY	HAYS	Rural	770	1,109	2,321	4,477	6,202	7,832	9,113
COUNTY LINE WSC	HAYS	Rural	770	32,760	84,518	135,342	143,228	158,970	182,017
COUNTY-OTHER	ZAVALA	Rural	770	32,321	41,667	54,983	48,107	44,412	45,887
POTH	WILSON	Rural	770	15,634	16,790	16,603	13,287	11,820	13,052
SAN MARCOS	HAYS	Suburban	681	284,314	377,577	485,862	436,626	425,549	482,403
CHARLOTTE	ATASCOSA	Rural	770	15,490	17,386	13,869	9,061	7,514	7,707
ENCINAL	LA SALLE	Rural	770	6,568	6,707	5,092	2,864	2,312	2,329
LULING	CALDWELL	Rural	770	53,961	62,972	48,289	30,015	24,341	26,113
NATALIA	MEDINA	Rural	770	18,238	21,252	19,585	16,712	15,556	16,659
POINT COMFORT	CALHOUN	Rural	770	13,536	19,355	22,970	21,119	14,080	14,080
COUNTY-OTHER	KARNES	Rural	770	52,693	68,116	73,151	74,645	77,512	78,806
RUNGE	KARNES	Rural	770	11,749	11,471	8,929	5,895	4,985	5,185
FALLS CITY	KARNES	Rural	770	5,827	6,089	4,661	3,558	2,957	3,019
SEADRIFT	CALHOUN	Rural	770	15,284	13,842	10,343	6,577	5,303	5,330
GOLIAD	GOLIAD	Rural	770	23,424	25,711	20,942	14,007	11,768	12,123
VICTORIA	VICTORIA	Urban	681	595,101	596,248	460,449	301,103	249,637	257,350
YANCEY WSC	MEDINA	Rural	770	47,146	53,273	51,443	51,764	50,426	55,033

Table 4C.1-11 (Continued)

Water User Group *	County *	Area	Cost Per Acre Foot	Costs of Water Demand Reduction from Plumbing Fixtures and Clothes Washers Retrofit Conservation					
				2010 dollars	2020 dollars	2030 dollars	2040 dollars	2050 dollars	2060 dollars
BOERNE	KENDALL	Rural	770	75,359	94,766	96,994	83,172	94,553	105,683
CUERO	DEWITT	Rural	770	76,250	71,240	54,160	36,262	23,812	23,388
EL OSO WSC	KARNES	Rural	770	31,484	31,214	24,813	19,934	17,397	17,957
NIXON	GONZALES	Rural	770	26,707	24,051	20,757	14,356	12,088	12,049
REFUGIO	REFUGIO	Rural	770	33,794	33,923	24,663	18,820	15,642	15,449
SPRINGS HILL WSC	GUADALUPE	Rural	770	134,027	125,745	116,211	98,859	93,199	104,847
COUNTY-OTHER	CALDWELL	Rural	770	16,475	15,163	11,033	5,844	3,043	2,763
LYTLE	ATASCOSA	Suburban	681	26,007	21,984	16,636	10,718	8,791	8,952
CIBOLO	GUADALUPE	Suburban	681	44,008	52,729	62,673	69,656	84,355	100,186
HELOTES	BEXAR	Suburban	681	78,092	108,125	135,550	144,694	163,054	179,383
JOURDANTON	ATASCOSA	Rural	770	46,083	39,236	29,669	22,430	18,779	19,389
CASTLE HILLS	BEXAR	Suburban	681	41,783	35,334	25,722	16,088	9,660	9,664
DEVINE	MEDINA	Rural	770	48,304	41,878	27,459	16,091	12,361	12,622
PEARSALL	FRIO	Suburban	681	78,787	68,416	52,232	29,441	23,800	23,928
BIG WELLS	DIMMIT	Rural	770	8,603	7,647	5,775	3,623	2,836	2,698
GONZALES	GONZALES	Rural	770	89,431	80,028	61,583	48,009	40,447	40,309
HONDO	MEDINA	Rural	770	96,064	89,046	79,441	64,900	58,392	62,260
SEGUIN	GUADALUPE	Suburban	681	256,904	246,183	205,631	174,142	163,537	183,370
ASHERTON	DIMMIT	Rural	770	15,404	13,248	9,636	5,527	4,055	3,855
FLORESVILLE	WILSON	Rural	770	104,780	88,502	70,356	56,059	49,688	54,669
WOODCREEK UTIL INC	HAYS	Suburban	681	38,437	52,854	72,205	84,011	105,424	122,265
SOMERSET	BEXAR	Suburban	681	19,446	18,636	15,111	14,394	13,075	14,032
KENEDY	KARNES	Rural	770	43,289	34,199	25,756	15,601	12,402	12,808
POTEET	ATASCOSA	Rural	770	43,768	35,842	24,385	15,478	12,544	12,662
LA VERNIA	WILSON	Rural	770	15,456	16,271	17,031	16,054	18,976	22,007
PLEASANTON	ATASCOSA	Suburban	681	99,868	77,239	58,731	37,962	31,218	31,837
NEW BRAUNFELS	COMAL	Suburban	681	500,962	459,110	459,149	480,586	482,369	558,126
STOCKDALE	WILSON	Rural	770	18,753	15,068	11,834	9,345	8,221	8,991
CHINA GROVE	BEXAR	Suburban	681	16,571	14,225	12,976	12,454	11,374	12,258
CASTROVILLE	MEDINA	Rural	770	35,911	28,601	21,953	16,871	14,421	15,253
FAIROAKS RANCH	BEXAR	Suburban	681	75,440	71,754	67,697	63,546	59,051	59,536
WINDCREST	BEXAR	Suburban	681	58,848	47,426	35,823	24,056	16,153	16,266
GARDEN RIDGE	COMAL	Suburban	681	23,602	20,713	17,131	16,988	15,839	18,256
MUSTANG RIDGE	CALDWELL	Rural	770	6,223	5,791	5,500	5,574	5,369	6,059
SABINAL	UVALDE	Rural	770	20,545	16,457	12,358	8,244	5,499	5,503
ALAMO HEIGHTS	BEXAR	Suburban	681	87,774	67,455	49,724	31,424	25,420	25,701
DILLEY	FRIO	Rural	770	56,783	52,693	44,154	42,670	39,510	40,639
GONZALES COUNTY WSC	CALDWELL	Rural	770	72,451	59,936	52,958	42,487	36,208	36,208
CRYSTAL CITY	ZAVALA	Rural	770	97,214	73,178	55,518	35,009	28,263	28,518
CARRIZO SPRINGS	DIMMIT	Rural	770	73,272	61,423	46,403	29,114	22,781	21,663
SELMA	BEXAR	Suburban	681	48,106	47,989	47,179	41,383	35,471	35,471
COTULLA	LA SALLE	Rural	770	48,929	41,821	31,727	20,657	17,212	17,899
UVALDE	UVALDE	Rural	770	182,782	145,692	107,214	67,625	40,821	41,007

Table 4C.1-11 (Concluded)

Water User Group *	County *	Area	Cost Per Acre Foot	Costs of Water Demand Reduction from Plumbing Fixtures and Clothes Washers Retrofit Conservation					
				2010 dollars	2020 dollars	2030 dollars	2040 dollars	2050 dollars	2060 dollars
LACKLAND AFB (CDP)	BEXAR	Urban	600	67,022	52,660	38,298	23,936	14,362	14,362
SHAVANO PARK	BEXAR	Suburban	681	20,665	16,980	11,589	7,380	6,002	6,087
HOLLYWOOD PARK	BEXAR	Suburban	681	35,597	27,120	20,382	13,075	10,701	10,914
HILL COUNTRY VILLAGE	BEXAR	Suburban	681	11,763	9,410	7,058	4,705	3,137	3,137
Total				7,929,791	8,984,376	9,884,512	9,751,174	10,078,084	13,066,179

Table 4C.1-12.
Estimated Costs for Projected Municipal Water Conservation from Lawn Irrigation South Central Texas Water Planning Region

Water User Group*	County	Area	Cost per Acre foot	Costs of Water Demand Reduction from Lawn Irrigation Conservation					
				2010 dollars	2020 dollars	2030 dollars	2040 dollars	2050 dollars	2060 dollars
CALHOUN COUNTY WS	CALHOUN	Rural	524	0	0	0	0	0	0
COUNTY-OTHER	WILSON	Rural	524	0	0	0	0	0	0
GREEN VALLEY SUD	GUADALUPE	Rural	524	0	0	0	0	0	0
POLONIA WSC	CALDWELL	Rural	524	0	0	0	0	0	0
COUNTY-OTHER	VICTORIA	Rural	524	0	0	0	0	0	0
BENTON CITY WSC	ATASCOSA	Rural	524	0	0	0	0	0	0
COUNTY-OTHER	DIMMIT	Rural	524	0	0	0	0	0	0
COUNTY-OTHER	GOLIAD	Rural	524	0	0	0	0	0	0
CREEDMOOR-MAHA WSC	CALDWELL	Rural	524	0	0	0	0	0	0
GOFORTH WSC	HAYS	Rural	524	0	0	0	0	0	0
CRYSTAL CLEAR WSC	GUADALUPE	Rural	524	0	0	0	0	0	0
MARTINDALE	CALDWELL	Rural	524	0	0	0	0	0	0
PLUM CREEK WATER CO	HAYS	Rural	524	0	0	0	0	0	0
COUNTY-OTHER	REFUGIO	Rural	524	0	0	0	0	0	0
MCCOY WSC	ATASCOSA	Rural	524	0	0	0	0	0	0
ATASCOSA RURAL WSC	BEXAR	Rural	524	0	0	0	0	0	0
COUNTY-OTHER	ATASCOSA	Rural	524	0	0	0	0	0	0
COUNTY-OTHER	KENDALL	Rural	524	0	0	0	0	0	0
WIMBERLEY WSC	HAYS	Rural	524	0	0	0	0	0	0
KIRBY	BEXAR	Rural	524	0	0	0	0	0	0
COUNTY-OTHER	DEWITT	Rural	524	0	0	0	0	0	0
COUNTY-OTHER	FRIO	Rural	524	0	0	0	0	0	0
KARNES CITY	KARNES	Rural	524	0	0	0	0	0	0
LEON VALLEY	BEXAR	Suburban	524	0	0	0	0	0	0
MAXWELL WSC	CALDWELL	Rural	524	0	0	0	0	0	0
LIVE OAK	BEXAR	Suburban	524	0	0	0	0	0	0
SS WSC	WILSON	Rural	524	0	0	0	0	0	0
COUNTY-OTHER	GONZALES	Rural	524	0	0	0	0	0	0
COUNTY-OTHER	GUADALUPE	Rural	524	0	0	0	0	0	0
SANTA CLARA	GUADALUPE	Rural	524	0	0	0	0	0	0
COUNTY-OTHER	BEXAR	Rural	524	0	0	0	0	0	0
EAST MEDINA SUD	MEDINA	Rural	524	0	0	0	0	0	0
CONVERSE	BEXAR	Suburban	524	0	0	0	0	0	0
COUNTY-OTHER	COMAL	Rural	524	0	0	0	0	0	0
NIEDERWALD	HAYS	Rural	524	0	0	0	0	0	0
BEXAR MET WD	BEXAR	Rural	524	0	0	0	0	0	0
KYLE	HAYS	Suburban	524	0	0	0	0	0	0
BULVERDE CITY	COMAL	Suburban	524	0	0	0	0	0	0
COUNTY-OTHER	UVALDE	Rural	524	0	0	0	0	0	0
EAST CENTRAL WSC	BEXAR	Rural	524	0	0	0	0	0	0
ST. HEDWIG	BEXAR	Rural	524	0	0	0	0	0	0
AQUA WSC	CALDWELL	Rural	524	0	0	0	0	0	0
PORT LAVACA	CALHOUN	Rural	524	0	0	0	0	0	0
MARION	GUADALUPE	Rural	524	0	0	0	0	0	0

Table 4C.1-12 (Continued)

Water User Group*	County	Area	Cost per Acre foot	Costs of Water Demand Reduction from Lawn Irrigation Conservation					
				2010 dollars	2020 dollars	2030 dollars	2040 dollars	2050 dollars	2060 dollars
WAELDER	GONZALES	Rural	524	0	0	0	0	0	0
COUNTY-OTHER	MEDINA	Rural	524	0	0	0	0	0	0
WATER SER INC (APEX)	BEXAR	Rural	524	0	0	0	0	0	0
WOODCREEK	HAYS	Rural	524	0	0	0	0	0	0
ELMENDORF	BEXAR	Suburban	524	0	0	0	0	0	0
COUNTY-OTHER	LA SALLE	Rural	524	0	0	0	0	0	0
COUNTY-OTHER	CALHOUN	Rural	524	0	0	0	0	0	0
LACOSTE	MEDINA	Rural	524	0	0	0	0	0	0
YORKTOWN	DEWITT	Rural	524	0	0	0	0	0	0
COUNTY-OTHER	HAYS	Rural	524	0	0	0	0	0	0
CANYON LAKE WSC	COMAL	Rural	524	0	0	0	0	0	52,922
LOCKHART	CALDWELL	Suburban	524	0	0	0	0	0	21,804
OAK HILLS WSC	WILSON	Rural	524	0	0	0	0	0	8,914
UNIVERSAL CITY	BEXAR	Suburban	524	0	0	0	0	0	25,791
BALCONES HEIGHTS	BEXAR	Suburban	524	0	0	0	0	0	8,230
SCHERTZ	GUADALUPE	Suburban	524	0	0	0	0	40,385	190,042
SUNKO WSC	WILSON	Rural	524	0	0	0	0	4,716	21,386
WOODSBORO	REFUGIO	Rural	524	0	0	0	0	2,375	5,902
OLMOS PARK	BEXAR	Suburban	524	0	0	0	0	3,740	9,682
TERRELL HILLS	BEXAR	Suburban	524	0	0	0	0	8,210	21,301
SAN ANTONIO	BEXAR	Urban	524	0	0	0	1,099,346	4,700,379	8,697,196
YOAKUM	DEWITT	Rural	524	0	0	0	1,338	5,271	9,060
MOUNTAIN CITY	HAYS	Rural	524	0	0	0	938	2,961	5,513
COUNTY LINE WSC	HAYS	Rural	524	0	0	0	21,660	72,122	123,866
COUNTY-OTHER	ZAVALA	Rural	524	0	0	0	14,031	30,224	46,841
POTH	WILSON	Rural	524	0	0	1,614	5,425	16,087	24,425
SAN MARCOS	HAYS	Suburban	524	0	0	53,407	335,964	654,883	1,020,768
CHARLOTTE	ATASCOSA	Rural	524	0	0	3,539	7,399	12,784	17,046
ENCINAL	LA SALLE	Rural	524	0	380	1,925	3,118	4,326	5,547
LULING	CALDWELL	Rural	524	0	4,285	23,472	40,852	60,736	82,930
NATALIA	MEDINA	Rural	524	0	1,576	6,783	12,800	19,576	26,891
POINT COMFORT	CALHOUN	Rural	524	0	4,756	13,436	26,482	34,236	41,798
COUNTY-OTHER	KARNES	Rural	524	0	16,950	32,655	50,171	66,349	81,587
RUNGE	KARNES	Rural	524	0	3,633	6,477	9,510	12,802	16,105
FALLS CITY	KARNES	Rural	524	0	2,448	4,223	6,125	7,996	9,791
SEADRIFT	CALHOUN	Rural	524	0	5,733	8,898	12,038	15,066	18,021
GOLIAD	GOLIAD	Rural	524	0	13,161	20,848	28,688	36,658	44,327
VICTORIA	VICTORIA	Urban	524	0	378,083	553,569	734,410	917,977	1,104,070
YANCEY WSC	MEDINA	Rural	524	0	35,100	54,825	76,858	101,629	128,010
BOERNE	KENDALL	Rural	524	0	82,002	140,440	206,686	277,197	355,861
CUERO	DEWITT	Rural	524	0	46,233	60,993	75,093	87,262	98,441
EL OSO WSC	KARNES	Rural	524	0	22,099	31,436	41,281	51,002	60,467
NIXON	GONZALES	Rural	524	0	17,028	23,376	29,729	35,438	40,573
REFUGIO	REFUGIO	Rural	524	0	26,418	35,711	46,768	57,323	65,027
SPRINGS HILL WSC	GUADALUPE	Rural	524	0	113,982	170,980	231,825	304,068	387,941
COUNTY-OTHER	CALDWELL	Rural	524	0	9,288	11,324	12,206	12,830	13,165
LYTLE	ATASCOSA	Suburban	524	0	21,044	30,244	36,766	43,284	49,632

Table 4C.1-12 (Concluded)

Water User Group*	County	Area	Cost per Acre foot	Costs of Water Demand Reduction from Lawn Irrigation Conservation					
				2010 dollars	2020 dollars	2030 dollars	2040 dollars	2050 dollars	2060 dollars
CIBOLO	GUADALUPE	Suburban	524	0	51,816	98,913	142,389	196,342	260,882
HELOTES	BEXAR	Suburban	524	0	97,399	178,274	242,003	310,517	382,178
JOURDANTON	ATASCOSA	Rural	524	0	37,996	61,484	75,466	89,582	103,174
CASTLE HILLS	BEXAR	Suburban	524	0	35,623	54,734	63,211	71,492	79,562
DEVINE	MEDINA	Rural	524	0	37,812	61,214	72,119	83,200	94,254
PEARSALL	FRIO	Suburban	524	0	64,025	102,400	119,358	135,850	151,525
BIG WELLS	DIMMIT	Rural	524	0	6,991	11,663	13,390	14,711	15,487
GONZALES	GONZALES	Rural	524	0	74,061	128,599	152,308	172,358	189,630
HONDO	MEDINA	Rural	524	0	90,647	165,889	205,895	248,825	292,895
SEGUIN	GUADALUPE	Suburban	524	0	257,602	485,520	624,663	787,951	975,378
ASHERTON	DIMMIT	Rural	524	0	13,651	23,755	27,067	29,550	30,949
FLORESVILLE	WILSON	Rural	524	0	92,287	178,990	225,850	278,521	336,809
WOODCREEK UTIL INC	HAYS	Suburban	524	0	51,931	121,160	173,953	242,976	309,709
SOMERSET	BEXAR	Suburban	524	0	22,494	46,166	57,657	69,598	81,763
KENEDY	KARNES	Rural	524	1,157	40,323	81,374	102,501	118,198	131,693
POTEET	ATASCOSA	Rural	524	1,661	36,328	69,031	86,564	94,973	103,024
LA VERNIA	WILSON	Rural	524	700	18,174	43,191	65,422	83,628	104,107
PLEASANTON	ATASCOSA	Suburban	524	4,776	97,547	189,459	244,884	272,222	298,012
NEW BRAUNFELS	COMAL	Suburban	524	41,467	676,396	1,550,134	2,476,937	3,113,218	3,842,215
STOCKDALE	WILSON	Rural	524	1,460	19,820	40,681	60,694	71,560	83,393
CHINA GROVE	BEXAR	Suburban	524	1,665	23,729	50,807	77,538	91,009	104,432
CASTROVILLE	MEDINA	Rural	524	3,297	38,684	77,134	115,298	131,675	148,012
FAIROAKS RANCH	BEXAR	Suburban	524	7,198	73,827	135,444	191,995	206,384	220,960
WINDCREST	BEXAR	Suburban	524	6,855	62,656	113,883	160,971	177,182	189,016
GARDEN RIDGE	COMAL	Suburban	524	3,840	38,098	84,551	140,736	186,539	226,960
MUSTANG RIDGE	CALDWELL	Rural	524	1,051	9,819	21,275	35,077	47,820	56,790
SABINAL	UVALDE	Rural	524	3,899	22,627	39,610	54,978	68,897	72,436
ALAMO HEIGHTS	BEXAR	Suburban	524	24,002	124,714	217,667	303,555	383,265	433,317
DILLEY	FRIO	Rural	524	15,950	83,877	159,771	238,655	314,709	376,876
GONZALES COUNTY WSC	CALDWELL	Rural	524	25,508	122,659	228,484	334,391	425,187	500,449
CRYSTAL CITY	ZAVALA	Rural	524	34,475	141,090	246,904	340,108	426,251	505,883
CARRIZO SPRINGS	DIMMIT	Rural	524	29,544	121,886	211,504	289,395	351,226	392,623
SELMA	BEXAR	Suburban	524	33,692	143,319	286,847	387,934	478,718	560,821
COTULLA	LA SALLE	Rural	524	28,597	101,363	172,007	241,630	310,484	378,183
UVALDE	UVALDE	Rural	524	148,458	433,537	697,586	940,315	1,161,021	1,361,657
LACKLAND AFB (CDP)	BEXAR	Urban	524	81,853	223,939	352,439	468,652	573,754	668,805
SHAVANO PARK	BEXAR	Suburban	524	22,274	61,293	98,313	132,951	165,281	195,272
HOLLYWOOD PARK	BEXAR	Suburban	524	83,590	196,260	305,082	408,042	505,270	596,367
HILL COUNTRY VILLAGE	BEXAR	Suburban	524	31,314	69,456	103,951	135,148	163,362	188,878
Total				638,285	4,719,956	8,586,068	13,397,207	20,353,198	27,985,250

Table 4C.1-13.
Estimated Costs for Projected Municipal Water Conservation from Additional Plumbing Fixtures and Clothes Washers Retrofit and Lawn Irrigation South Central Texas Water Planning Region

Water User Group *	County *	Area	Costs of Water Demand Reduction from Plumbing Fixtures and Clothes Washers Retrofit plus Lawn Irrigation Conservation					
			2010 dollars	2020 dollars	2030 dollars	2040 dollars	2050 dollars	2060 dollars
CALHOUN COUNTY WS	CALHOUN	Rural	0	0	0	0	0	0
COUNTY-OTHER	WILSON	Rural	0	0	0	10,542	44,842	89,671
GREEN VALLEY SUD	GUADALUPE	Rural	0	0	0	0	0	15,704
POLONIA WSC	CALDWELL	Rural	0	0	0	0	0	0
COUNTY-OTHER	VICTORIA	Rural	0	0	0	0	0	24,722
BENTON CITY WSC	ATASCOSA	Rural	0	0	0	18,286	65,146	117,506
COUNTY-OTHER	DIMMIT	Rural	0	0	0	0	0	0
COUNTY-OTHER	GOLIAD	Rural	0	0	0	0	0	12,663
CREEDMOOR-MAHA WSC	CALDWELL	Rural	0	0	0	0	0	8,700
GOFORTH WSC	HAYS	Rural	0	0	0	0	17,198	85,581
CRYSTAL CLEAR WSC	GUADALUPE	Rural	0	0	0	0	31,476	141,432
MARTINDALE	CALDWELL	Rural	0	0	0	0	0	0
PLUM CREEK WATER CO	HAYS	Rural	0	0	0	0	9,431	41,541
COUNTY-OTHER	REFUGIO	Rural	0	0	0	0	0	0
MCCOY WSC	ATASCOSA	Rural	0	0	0	10,182	52,244	99,091
ATASCOSA RURAL WSC	BEXAR	Rural	0	0	0	0	0	17,081
COUNTY-OTHER	ATASCOSA	Rural	8,554	12,806	8,532	1,061	0	0
COUNTY-OTHER	KENDALL	Rural	0	0	0	0	56,422	203,520
WIMBERLEY WSC	HAYS	Rural	0	0	0	0	14,676	53,642
KIRBY	BEXAR	Rural	0	0	0	0	0	0
COUNTY-OTHER	DEWITT	Rural	0	0	0	0	0	4,961
COUNTY-OTHER	FRIO	Rural	0	0	0	0	0	13,845
KARNES CITY	KARNES	Rural	0	0	0	0	0	8,554
LEON VALLEY	BEXAR	Suburban	0	0	0	0	0	7,962
MAXWELL WSC	CALDWELL	Rural	0	0	0	0	8,599	42,527
LIVE OAK	BEXAR	Suburban	0	0	0	0	0	0
SS WSC	WILSON	Rural	0	0	0	0	64,588	169,800
COUNTY-OTHER	GONZALES	Rural	4,791	5,521	3,910	0	0	2,398
COUNTY-OTHER	GUADALUPE	Rural	1,449	0	0	0	0	162
SANTA CLARA	GUADALUPE	Rural	0	0	7,877	17,462	36,225	61,080
COUNTY-OTHER	BEXAR	Rural	37,759	73,618	107,959	147,203	238,677	389,088
EAST MEDINA SUD	MEDINA	Rural	0	0	0	0	14,753	41,817
CONVERSE	BEXAR	Suburban	0	0	0	0	14,150	74,857
COUNTY-OTHER	COMAL	Rural	0	0	0	0	0	65,700
NIEDERWALD	HAYS	Rural	0	877	5,986	11,172	20,827	32,038
BEXAR MET WD	BEXAR	Rural	0	0	0	0	0	225,525
KYLE	HAYS	Suburban	0	18,091	65,039	113,927	205,763	301,858
BULVERDE CITY	COMAL	Suburban	0	0	25,608	88,450	176,820	293,074
COUNTY-OTHER	UVALDE	Rural	0	0	0	25,734	56,398	105,635
EAST CENTRAL WSC	BEXAR	Rural	0	0	0	0	24,845	80,163
ST. HEDWIG	BEXAR	Rural	0	0	0	0	0	10,763
AQUA WSC	CALDWELL	Rural	0	0	0	0	4,655	14,729
PORT LAVACA	CALHOUN	Rural	0	0	0	0	22,725	68,162

Table 4C.1-13 (Continued)

Water User Group *	County *	Area	Costs of Water Demand Reduction from Plumbing Fixtures and Clothes Washers Retrofit plus Lawn Irrigation Conservation					
			2010 dollars	2020 dollars	2030 dollars	2040 dollars	2050 dollars	2060 dollars
MARION	GUADALUPE	Rural	0	0	0	0	2,680	7,652
WAELDER	GONZALES	Rural	0	0	0	2,582	5,110	8,815
COUNTY-OTHER	MEDINA	Rural	0	15,020	31,826	66,279	123,399	187,503
WATER SER INC (APEX)	BEXAR	Rural	0	0	0	13,791	38,479	81,122
WOODCREEK	HAYS	Rural	0	0	1,323	4,535	15,573	28,752
ELMENDORF	BEXAR	Suburban	0	0	0	0	1,393	4,052
COUNTY-OTHER	LA SALLE	Rural	2,160	2,958	8,526	12,845	22,694	32,667
COUNTY-OTHER	CALHOUN	Rural	0	0	0	0	3,079	8,263
LACOSTE	MEDINA	Rural	0	0	0	0	3,178	8,617
YORKTOWN	DEWITT	Rural	0	1,215	1,594	1,801	3,871	9,753
COUNTY-OTHER	HAYS	Rural	0	0	9,433	37,534	86,547	141,576
CANYON LAKE WSC	COMAL	Rural	0	74,261	195,883	418,001	715,563	1,063,887
LOCKHART	CALDWELL	Suburban	0	0	18,838	70,011	132,630	220,164
OAK HILLS WSC	WILSON	Rural	0	0	0	20,004	58,480	100,600
UNIVERSAL CITY	BEXAR	Suburban	0	0	0	0	33,518	92,827
BALCONES HEIGHTS	BEXAR	Suburban	2,481	3,821	4,975	5,990	13,578	22,492
SCHERTZ	GUADALUPE	Suburban	15,118	59,574	123,652	248,424	460,271	684,006
SUNKO WSC	WILSON	Rural	2,522	4,800	7,421	22,111	39,363	60,669
WOODSBORO	REFUGIO	Rural	3,894	4,740	5,344	5,907	9,354	12,840
OLMOS PARK	BEXAR	Suburban	6,343	7,676	8,877	9,863	13,461	19,748
TERRELL HILLS	BEXAR	Suburban	9,495	12,125	14,510	16,484	24,216	37,910
SAN ANTONIO	BEXAR	Urban	3,451,336	4,390,988	5,276,772	6,134,520	8,736,963	12,965,177
YOAKUM	DEWITT	Rural	10,915	11,989	12,800	13,132	13,016	16,667
MOUNTAIN CITY	HAYS	Rural	1,109	2,321	4,477	7,140	10,794	14,626
COUNTY LINE WSC	HAYS	Rural	32,760	84,518	135,342	164,888	231,092	305,884
COUNTY-OTHER	ZAVALA	Rural	32,321	41,667	54,983	62,138	74,636	92,728
POTH	WILSON	Rural	15,634	16,790	18,217	18,712	27,907	37,476
SAN MARCOS	HAYS	Suburban	284,314	377,577	539,269	772,590	1,080,431	1,503,171
CHARLOTTE	ATASCOSA	Rural	15,490	17,386	17,409	16,460	20,298	24,754
ENCINAL	LA SALLE	Rural	6,568	7,087	7,017	5,981	6,637	7,876
LULING	CALDWELL	Rural	53,961	67,257	71,761	70,867	85,077	109,043
NATALIA	MEDINA	Rural	18,238	22,828	26,368	29,512	35,132	43,549
POINT COMFORT	CALHOUN	Rural	13,536	24,111	36,406	47,601	48,315	55,877
COUNTY-OTHER	KARNES	Rural	52,693	85,066	105,807	124,816	143,861	160,393
RUNGE	KARNES	Rural	11,749	15,103	15,406	15,405	17,787	21,291
FALLS CITY	KARNES	Rural	5,827	8,537	8,884	9,683	10,953	12,810
SEADRIFT	CALHOUN	Rural	15,284	19,576	19,242	18,614	20,369	23,351
GOLIAD	GOLIAD	Rural	23,424	38,872	41,790	42,695	48,426	56,450
VICTORIA	VICTORIA	Urban	595,101	974,331	1,014,018	1,035,513	1,167,614	1,361,420
YANCEY WSC	MEDINA	Rural	47,146	88,373	106,268	128,622	152,055	183,043
BOERNE	KENDALL	Rural	75,359	176,767	237,434	289,858	371,749	461,545
CUERO	DEWITT	Rural	76,250	117,473	115,153	111,355	111,074	121,828
EL OSO WSC	KARNES	Rural	31,484	53,313	56,249	61,216	68,398	78,425
NIXON	GONZALES	Rural	26,707	41,079	44,133	44,084	47,526	52,622
REFUGIO	REFUGIO	Rural	33,794	60,341	60,375	65,588	72,966	80,476
SPRINGS HILL WSC	GUADALUPE	Rural	134,027	239,728	287,191	330,685	397,267	492,788
COUNTY-OTHER	CALDWELL	Rural	16,475	24,451	22,357	18,050	15,873	15,929

Table 4C.1-13 (Concluded)

Water User Group *	County *	Area	Costs of Water Demand Reduction from Plumbing Fixtures and Clothes Washers Retrofit plus Lawn Irrigation Conservation					
			2010 dollars	2020 dollars	2030 dollars	2040 dollars	2050 dollars	2060 dollars
LYTLE	ATASCOSA	Suburban	26,007	43,028	46,879	47,483	52,075	58,584
CIBOLO	GUADALUPE	Suburban	44,008	104,545	161,586	212,045	280,697	361,068
HELOTES	BEXAR	Suburban	78,092	205,524	313,824	386,697	473,570	561,561
JOURDANTON	ATASCOSA	Rural	46,083	77,232	91,153	97,895	108,361	122,564
CASTLE HILLS	BEXAR	Suburban	41,783	70,958	80,456	79,299	81,152	89,226
DEVINE	MEDINA	Rural	48,304	79,690	88,673	88,210	95,560	106,876
PEARSALL	FRIO	Suburban	78,787	132,441	154,632	148,799	159,650	175,453
BIG WELLS	DIMMIT	Rural	8,603	14,638	17,438	17,012	17,547	18,185
GONZALES	GONZALES	Rural	89,431	154,089	190,182	200,317	212,805	229,940
HONDO	MEDINA	Rural	96,064	179,692	245,330	270,796	307,217	355,156
SEGUIN	GUADALUPE	Suburban	256,904	503,785	691,151	798,805	951,488	1,158,748
ASHERTON	DIMMIT	Rural	15,404	26,899	33,391	32,594	33,605	34,805
FLORESVILLE	WILSON	Rural	104,780	180,789	249,346	281,909	328,209	391,478
WOODCREEK UTIL INC	HAYS	Suburban	38,437	104,785	193,365	257,964	348,401	431,974
SOMERSET	BEXAR	Suburban	19,446	41,130	61,277	72,051	82,673	95,795
KENEDY	KARNES	Rural	44,446	74,521	107,130	118,102	130,600	144,501
POTEET	ATASCOSA	Rural	45,430	72,170	93,416	102,042	107,518	115,685
LA VERNIA	WILSON	Rural	16,157	34,445	60,222	81,476	102,604	126,114
PLEASANTON	ATASCOSA	Suburban	104,645	174,786	248,190	282,846	303,440	329,849
NEW BRAUNFELS	COMAL	Suburban	542,429	1,135,506	2,009,283	2,957,523	3,595,588	4,400,341
STOCKDALE	WILSON	Rural	20,213	34,888	52,515	70,039	79,781	92,384
CHINA GROVE	BEXAR	Suburban	18,235	37,954	63,783	89,992	102,383	116,691
CASTROVILLE	MEDINA	Rural	39,208	67,285	99,086	132,169	146,096	163,265
FAIROAKS RANCH	BEXAR	Suburban	82,638	145,582	203,141	255,541	265,435	280,497
WINDCREST	BEXAR	Suburban	65,703	110,082	149,707	185,027	193,335	205,282
GARDEN RIDGE	COMAL	Suburban	27,442	58,811	101,682	157,724	202,378	245,216
MUSTANG RIDGE	CALDWELL	Rural	7,274	15,610	26,775	40,651	53,189	62,850
SABINAL	UVALDE	Rural	24,444	39,084	51,968	63,222	74,396	77,939
ALAMO HEIGHTS	BEXAR	Suburban	111,776	192,169	267,391	334,980	408,685	459,018
DILLEY	FRIO	Rural	72,733	136,570	203,925	281,326	354,219	417,515
GONZALES COUNTY WSC	CALDWELL	Rural	97,959	182,594	281,442	376,878	461,395	536,658
CRYSTAL CITY	ZAVALA	Rural	131,689	214,268	302,422	375,117	454,514	534,401
CARRIZO SPRINGS	DIMMIT	Rural	102,816	183,308	257,908	318,509	374,006	414,285
SELMA	BEXAR	Suburban	81,797	191,307	334,026	429,317	514,189	596,292
COTULLA	LA SALLE	Rural	77,526	143,185	203,733	262,287	327,697	396,081
UVALDE	UVALDE	Rural	331,239	579,229	804,800	1,007,941	1,201,842	1,402,664
LACKLAND AFB (CDP)	BEXAR	Urban	148,874	276,599	390,737	492,589	588,115	683,167
SHAVANO PARK	BEXAR	Suburban	42,938	78,273	109,901	140,332	171,283	201,359
HOLLYWOOD PARK	BEXAR	Suburban	119,187	223,380	325,464	421,117	515,971	607,281
HILL COUNTRY VILLAGE	BEXAR	Suburban	43,077	78,866	111,009	139,853	166,499	192,015
Total			8,568,075	13,704,332	18,470,580	23,148,381	30,431,282	41,051,428

described at the beginning of this analysis, in 2010 is $8,568,075 ($648/acft/yr), increasing to $18,470,580 ($584/acft/yr) in 2030, and to $41,051,428 in 2060 ($566/acft/yr) (Table 4C.1-13). As the quantity of water conservation (demand reduction) increases, the unit cost decreases from $648 per acre-foot in 2010, to $584 per acre-foot in 2030, and to $566 per acre-foot in 2060.

4C.1.2 Irrigation Water Conservation

Irrigation water use is the use of freshwater that is pumped from aquifers and/or diverted from streams and reservoirs of the planning area and applied directly to grow crops, orchards, and hay and pasture in the study area. In the case of groundwater in Region L, irrigation wells are usually located within the fields to be irrigated, such that the irrigation water is taken directly from the wells and applied to the land by: (1) flowing or flooding water down the furrows; and (2) with the use of sprinklers. In the case of surface water from planning area streams and reservoirs, water is diverted from the source and conveyed by canals and pipelines to the fields where it is then applied by: (1) flowing or flooding water down the furrows; and (2) with the use of sprinklers. In both the use of groundwater and surface water, the conservation objective is to reduce the quantity of water that is lost to deep percolation and evaporation between the originating points (wells in the case of groundwater, and stream diversion points in the case of surface water), and the irrigated crops in the fields. Thus, the focus is upon investments in irrigation application equipment, instruments, and conveyance facility improvements (canal lining and pipelines) to reduce seepage losses, deep percolation, and evaporation of water between the originating points of the water and the destination locations within the irrigated fields, and management of the irrigation processes to improve efficiencies of irrigation water use and reduce the quantities of water needed to accomplish irrigation.

The Water Conservation Implementation Task Force list of Best Management Practices (BMPs) for irrigation is as follows:[7]

1. Irrigation Scheduling;
2. Volumetric Measurement of Irrigation Water Use;
3. Crop Residue Management and Conservation Tillage;
4. On-farm Irrigation audit;
5. Furrow Dikes;
6. Land Leveling;
7. Contour Farming;

[7] Water Conservation Implementation Task Force, Report to the 79th Legislature, Texas Water Development Board, Special Report, Austin, Texas, November 2004.

8. Conservation of Supplemental Irrigated Farmland to Dry-Land Farmland;
9. Brush Control/Management;
10. Lining of On-Farm Irrigation ditches;
11. Replacement of On-/farm Irrigation Ditches with Pipelines;
12. Low Pressure Center Pivot Sprinkler Irrigation Systems;
13. Drip/Micro-Irrigation System;
14. Gated and Flexible Pipe for Field Water Distribution Systems;
15. Surge Flow Irrigation for Field Water Distribution Systems;
16. Linear Move Sprinkler Irrigation Systems;
17. Lining of District Irrigation Canals;
18. Replacement of District Irrigation canals and Lateral canals with Pipelines;
19. Tailwater Recovery and Use System; and
20. Nursery Production Systems.

Principal methods of irrigation water conservation on irrigation farms of Region L are: (1) low-pressure sprinklers (LESA); (2) low-energy precision application systems (LEPA); and (3) irrigation scheduling. In comparison to the irrigation method (furrow or flood irrigation) of releasing the water into the furrows at the ends of the rows and allowing it to flow across the fields until each furrow has been saturated throughout its entire length, the use of LESA, LEPA, and irrigation scheduling all improve application efficiency within the irrigated fields and thereby reduce the total quantity of water needed to produce an irrigated crop. The major irrigation water conservation techniques applicable in the South Central Texas Water Planning Region are described briefly below.

Low-pressure sprinklers spray water into the atmosphere above the crops as the sprinkler systems are moved across the fields. LEPA systems involve a sprinkler system that has been modified to discharge water directly into furrows at low pressure, thus reducing evaporation losses. When used in conjunction with furrow dikes, which hold both precipitation and sprinkler applied water behind small mounds of earth within the furrows, LEPA systems can accomplish the irrigation objective with less water than is required for the furrow irrigation and pressurized sprinkler methods. (Note: Furrow dikes are constructed by towing the furrow-diking implement behind planters or cultivators when these operations are performed. The furrow dikes hold water in place within the furrows, allowing it to infiltrate the soil profile as opposed to allowing the water to flow down the furrows and exit the fields. Furrow dikes have been demonstrated to be useful management tools on both irrigated and non-irrigated cropland.)

Low-pressure sprinklers (LESA) and surge valves improve irrigation application efficiency in comparison to furrow irrigation by reducing water requirements per acre in the

10 to 15 percent range, while LEPA combined with furrow diking can reduce water requirements per acre by 30 to 40 percent. In the Edwards Aquifer area of the Region (Bexar, Medina, and Uvalde Counties), conversion from furrow irrigation to LEPA systems with furrow diking would save about 0.8 acft/acre converted.[8] In the major irrigation counties of the Carrizo Aquifer area of the Region (Atascosa, Frio, and Zavala), the water savings through use of LEPA/Furrow Dike systems is estimated at 0.25 to 0.30 acft/acre. Use of LEPA and furrow dikes allows irrigation farmers to produce equivalent yields per acre at lower energy and labor costs of irrigation. It has been demonstrated that LEPA systems improve production and profitability of irrigation farming. The barriers to installation are high capital costs, with no assurance (at the present time) that the water saved in the Carrizo Aquifer from the investment would be available to the irrigation farmer who incurred the costs. However, under the Edwards Aquifer Authority's regulatory powers, the water conservation investor could be assured ownership of the conservation savings.

The TWDB irrigation water demand projections for the South Central Texas Region show significant decreases in irrigation usage in the future. For example, the TWDB estimates of irrigation water use in the 21 counties of the South Central Texas Region was 669,440 acft/yr in 1990 and are 383,332 acft/yr in 2000 (Table 2-8), with projections to 2030 of 344,777 acft/yr and to 2060 of 301,679 acft/yr (Section 2.6, Table 2-8). For the South Central Texas Region, irrigation water use declined between 1990 and 2000 by 286,108 acft/yr, with the projections showing further reductions between 2000 and 2030 of 38,555 acft/yr and between 2030 and 2060 of an additional 43,098 acft/yr (Section 2.6, Table 2-8).

Calculated irrigation water use rates for the Edwards Aquifer area counties showed a 46 percent decline from 2.39 acre-feet per acre in 1990 to 1.28 acre-feet per acre in 2000 (Table 4C.1-14). Water use rates for the Carrizo Aquifer area counties showed a 7.3 percent decline from 1.5 acre-feet per acre in 1990 to 1.39 acre-feet per acre in 2000 (Table 4C.1-14), Gulf Coast Aquifer area counties irrigation use rates declined 12.6 percent from 1.98 acre-feet per acre to 1.73 acre-feet per acre, Calhoun County, which uses surface water, showed a 24 percent decline from 5.71 acre-feet per acre in 1990 to 4.33 acre-feet per acre in 2000. Finally, Hill Country

[8] Pena, Jose G., and Robert Jenson, "Irrigation Water Use Conservation Potential and the Economic Implications of Adopting More Efficient Irrigation Technology, the Case in Uvalde County," Water for South Texas, Texas Agricultural Experiment Station, Texas A & M University, College Station, Texas, CPR - 5043-5046, October 1992.

**Table 4C.1-14.
Irrigated Acreages, Irrigation Water Use, and Irrigation Application Rates
South Central Texas Water Planning Region – 1990 and 2000**

County	1990			2000		
	Acres Irrigated	Irrigation Water Use (acft)	Irrigation Use Rate (acft/acre)	Acres Irrigated	Irrigation Water Use (acft)	Irrigation Use Rate (acft/acre)
Edward Aquifer Area Counties						
Bexar	18,420	36,051	1.96	7,885	15,865	2.01
Medina	55,600	149,412	2.69	44,755	56,422	1.26
Uvalde	66,020	140,669	2.13	48,940	58,061	1.19
Subtotal	140,040	326,132	2.33	101,580	130,348	1.28
Carrizo Aquifer Area Counties						
Atascosa	43,050	47,208	1.10	35,796	35,053	0.98
Caldwell	1,335	1,375	1.03	1,593	989	0.62
Dimmit	7,525	10,425	1.39	5,262	6,750	1.28
Frio	61,300	83,233	1.36	69,845	117,098	1.68
Gonzales	3,350	3,540	1.06	3,039	2,438	0.80
Guadalupe	2,780	2,646	0.95	665	875	1.32
La Salle	8,150	7,292	0.89	3,584	4,003	1.12
Wilson	12,820	13,697	1.07	14,122	20,883	1.48
Zavala	47,000	107,459	2.29	34,309	46,275	1.35
Subtotal	187,310	276,875	1.48	168,215	234,364	1.39
Gulf Coast Aquifer Area Counties						
DeWitt	620	285	0.46	467	102	0.22
Goliad	970	685	0.71	386	359	0.93
Karnes	1,915	2,034	1.06	1,350	1,916	1.42
Refugio	0	0	0.00	1,130	850	0.75
Victoria	4,920	13,699	2.78	2,411	6,708	2.78
Subtotal	8,425	16,703	1.98	5,744	9,935	1.73
Gulf Coast Surface Water Counties						
Calhoun	6,200	16,533	2.67	1,864	8,077	4.33
Subtotal	6,200	16,533	2.67	1,864	8,077	4.33
Hill Country Area Counties						
Comal	375	479	1.28	121	50	0.41
Hays (part)	274	298	1.09	176	162	0.92
Kendall	205	380	1.85	312	396	1.27
Subtotal	854	1,157	1.35	609	608	1.00
Region L Totals	**342,829**	**637,400**	**1.86**	**278,013**	**383,332**	**1.38**

* Texas Water Development Board.

counties showed a 26 percent decline from 1.95 acre-feet per acre in 1990 to 1.00 acre-feet per acre in 2000 (Table 4C.1-14). Overall, the South Central Texas Water Planning Region average irrigation use rate per acre declined 29 percent from 1.95 acre-feet per acre in 1990 to 1.38 acre-feet per acre in 2000 (Table 4C.1-14).

Given that the technological limits of irrigation conservation potential were in the range of 20 to 40 percent of the level of use in the 1990s, and that much of this potential appears to have been reached by year 2000 (Table 4C.1-14), the irrigation water conservation water management strategy appears to be quite limited insofar as utility for meeting projected irrigation needs (shortages). However, the irrigation water conservation water management strategy will be developed for Atascosa, Medina, and Zavala Counties, since these are the counties for which there are projected irrigation water needs (shortages) (Table 4C.1-15).

Table 4C.1-15.
Projected Irrigation Water Needs (Shortages)
South Central Texas Water Planning Region

County	2010 (acft)	2020 (acft)	2030 (acft)	2040 (acft)	2050 (acft)	2060 (acft)
Atascosa	6,095	4,734	3,413	2,141	924	291
Medina	7,770	5,878	4,067	2,332	670	0
Zavala	54,600	51,763	49,038	46,421	43,907	41,492
Total	55,109	49,548	44,602	40,632	38,087	35,635

The estimates of quantities and costs of the water conservation water management strategy for irrigation in Atascosa, Medina, and Zavala Counties are based upon the assumption that the irrigation water conservation method having the most potential is the LEPA System in conjunction with furrow dikes, and that the following conditions and assumptions apply:

- Conservation result is 20 percent of irrigation rate;
- Irrigation rate from which to estimate water savings from conservation is that calculated for year 2000, and is shown for each county in Table 4C.1-14; and
- Cost to install LEPA is $440 per acre.

In order to meet the projected irrigation needs (shortages) in Atascosa County, within the Carrizo Aquifer area by year 2010, it would be necessary to install LEPA systems with furrow dikes, or an equivalent conservation method, by year 2010 to approximately 31,095 acres, (87 percent of acres irrigated in year 2000) at a capital cost of approximately $13.68 million, resulting in annual cost per acre-foot of water of $176 (Table 4C.1-16). For Medina County, in order to meet the projected irrigation needs, it would be necessary to equip 26,853 of the 44,755 acres irrigated in year 2000, at a cost of $11.87 million, which when amortized at 6 percent interest rate for 20 years, results in annual cost of water of $137 per acre-foot.

Table 4C.1-16.
Estimated Irrigation Water Conservation Needed and Costs to meet Needs (Shortages) for Counties with Irrigation Needs South Central Texas Water Planning Region

County	Shortage in 2010 (acft)	Irrigation Rate in 2000* (acft/acre)	Water Conservation Potentials 20%** (acft/acre)	Acres Needing Conservation***	Acres Irrigated in 2000	Total Capital Cost ($440/acre)	Annual Cost at 6% per acre-foot	Estimated Cost per acre-foot
Atascosa	6,095	0.98	0.20	31,095	35,796	13,681,800	1,069,935	176
Medina	6,770	1.26	0.25	26,853	44,755	11,875,531	923,974	137
Zavala	54,600	1.35	0.27	201,179	34,309	88,518,760	6,922,167	127
Atascosa and Medina Subtotal	13,865			57,948	80,551	25,557,331	1,993,909	146
Total	**67,465**			**259,127**	**114,860**	**114,076,091**	**8,916,076**	**130**

* From Table 4C.1-14.
** Estimated for LEPA and Furrow Dikes.
*** Acres that need to be placed under LEPA and Furrow Dikes to obtain quantities sufficient to meet the projected needs (shortages in 2010 shown in column number 1 of Table 4-1.*

In the case of Zavala County, the projected acreages to which irrigation water conservation would need to be applied is 201,179, while year 2000 irrigated acreage was only 34,309 (Table 4C.1-16). Even though the water conservation strategy would not completely meet the projected needs in Zavala County, it is recommended that irrigation water conservation be practiced to the extent possible.

In the case of Atascosa, and Medina Counties, where the use of LEPA systems with furrow dikes have the potential to reduce irrigation water demands per acre in quantities sufficient to meet the projected needs of 13,865 acft/yr, the estimated annual cost of is $1,993,909, with a unit cost of $146/acft (Table 4C.1-16).

In the discussion above, estimates were presented of the acreages to which water conservation would need to be applied and the quantities of irrigation water conservation needed in order to meet the irrigation water needs (shortages) in Atascosa and Medina Counties.

Table 4C.1-17.
Estimated Irrigation Water Conservation Potentials and Costs
For Counties with Irrigation Needs (Shortages)
South Central Texas Water Planning Region

County	Shortage in 2010 (acft/yr)	Irrigation Rate in 2000* (acft/acre)	Water Conservation Potentials 20%** (acft/acre)	Acres Irrigated in 2000*	Estimated Acreages to which LEPA & Furrow Dikes Applicable***	Estimated Water Conservation via LEPA & Furrow Dikes (acft/yr)	Total Capital Cost $440/acre (dollars)	Annual Cost at 6% for 20 yrs. (dollars)	Estimated Cost per acre-foot (dollars)
Atascosa	6,095	0.98	0.20	35,796	26,847	5,369	11,812,680	923,752	172
Medina	6,770	1.26	0.25	44,755	33,566	8,392	14,769,150	1,154,948	138
Zavala	54,600	1.35	0.27	34,309	25,732	6,948	11,321,970	885,378	127
Total	**67,465**			**114,860**	**86,145**	**20,709**	**37,903,800**	**2,964,078**	**143**

* From Table 4C.1-14.
** Estimated for LEPA and Furrow Dikes.
*** Estimated that LEPA and Furrow Dikes can be used on 75 percent of acreages irrigated in 2000.

In the following discussion, estimates are presented of the irrigation water conservation potentials in counties with irrigation needs (shortages) in the South Central Texas Water Planning Region (Table 4C.1-17). Based upon estimates that irrigation water conservation practices of LEPA, with Furrow Dikes, can be applied to 75 percent of the acreages that were irrigated in year 2000 in the counties of the region for which water needs have been projected, it is estimated that 20,709 acft/yr of irrigation water conservation can be accomplished at an average cost of $143 per acft (Table 4C.1-17). Of this total, 5,369 acft/yr are in Atascosa County, 8,392 acft/yr are in Medina County, and 6,948 acft/yr are in Zavala County (Table 4C.1-17).

In the case Zavala County, it is not economically feasible for agricultural producers to pay for additional water supplies to meet projected irrigation water needs (shortages), even if such supplies were available. For example, in 2008, for irrigated cotton, the estimated income remaining after other production expenses had been paid was about $70 per acre, for grain crops was about $102 per acre, and for vegetables ranged between $719 per acre for cabbage to -$116 per acre.[9] The cost of water from other sources far exceeds these values. For example, cost estimates being made for use in this Regional Water Plan to meet projected municipal needs range from about $566/acft for municipal water conservation, to more than $1,000/acft for water from the Lower Guadalupe for the Bexar county area, and to more than $1,760/acft for desalted

[9] "Crop Enterprise Budgets," Texas Agricultural Extension Service, Uvalde, Texas.

seawater for the Bexar County area, and these cost estimates do not include the additional cost of transporting water from these sources to Zavala County.

4C.1.3 Industrial, Steam-Electric Power Generation and Mining Water Conservation

In industry, steam-electric power generation, and mining activities water is used for several different purposes, including as an integral part of manufactured products, cleaning and waste removal, waste heat removal, dust control, and landscaping. In the South Central Texas Water Planning Region, the projected need (shortage) of water for manufacturing, steam-electric power generation and mining is 8,493 acft/yr in 2010 and is projected to increase to 70,465 acft/yr in 2060. Water conservation should be considered by industry, steam-electric power generation, and mining water user groups, as a means to meet a part of the projected water needs.

The Water Conservation Implementation Task Force list of Best Management Practices (BMPs) for industry is as follows:[10]

1. Industrial Water Audit;
2. Industrial Water Waste Reduction;
3. Industrial Submetering;
4. Cooling Towers;
5. Cooling Systems Other than Cooling Towers;
6. Industrial Alternative Sources and Reuse of Process Water;
7. Rinsing/Cleaning;
8. Water Treatment;
9. Boiler and Steam Systems;
10. Refrigeration (including Chilled Water);
11. Once-through Cooling;
12. Management and Employee Programs;
13. Industrial Landscape; and
14. Industrial Site Specific Conservation.

The BMPs listed above can be expected to improve the efficiency of water use in individual industrial and steam-electric power plants, and mining sites, and/or function as alternative ways to accomplish the purposes for which water is used, and thereby lower the quantity of water that has been projected to be needed by these water user groups. For example, air cooling instead of use of water for cooling in electric power generation and some industrial processes could meet a part of the water needs of these water user group. The collection and use

[10] Water Conservation Implementation Task Force, Report to the 79th Legislature, Texas Water Development Board, Special Report, Austin, Texas, November 2004.

of precipitation runoff at mining sites is a potential way to meet some of the mining water needs, as opposed to drilling wells and/or obtaining water from other sources for dust control and washing purposes. Another source of water for industrial, steam-electric power, and mining is the treatment and reuse of municipal and industrial wastewater.

Although the BMPs listed above, if used by individual establishments of the industrial, steam-electric power, and mining water users of the South Central Texas Region have potentials to meet a part of the projected water needs (shortages), data are not available to the public with which to compute estimates of quantities and costs of these measures.

4C.1.4 Environmental Issues

Municipal water conservation operates to reduce the quantities of water required for a given population, and thereby reduces the quantities of land and other resources needed to supply the population of an individual city with water. For this reason, this water management strategy has little, if any adverse effects upon fish and wildlife habitat, and cultural resources which might otherwise be impacted by development and delivery of the larger quantities of water that would be needed for the lower conservation scenario. However, a potential environmental impact of municipal water conservation might result from reduced quantities of reclaimed water available for established uses, or discharge to streams in the short term. In the South Central Texas Region, significant quantities of the wastewater effluent are being reused for non-potable purposes; therefore, increased municipal water conservation could reduce the quantities of water available for these uses, as well as for discharge to streams in the Region.

The irrigation water conservation methods of this water management option have been developed and tested through public and private sector research, and have been adopted and applied within the Region. Hundreds of LEPA systems have been installed, and are in operation today, and experience has shown that there are not any significant environmental issues associated with this water management strategy. For example, this method improves water use efficiency without making changes to wildlife habitat. This method of application, when coupled with furrow dikes reduces runoff of both applied irrigation water and rainfall. The results are reduced transport of sediment and any fertilizers or other chemicals that have been applied to the crops. Thus, the proposed conservation practices do not have potential adverse effects, and in fact have potential beneficial environmental effects.

In the case of use of BMPs for water conservation in industrial, steam-electric power generation, and mining, the potential improvement in water use efficiencies that result in lower water demands can be expected to reduce the quantities of land and other resources needed to supply water for these purposes.

4C.1.5 Implementation Issues

Demand reduction through water conservation is being implemented throughout the South Central Texas Region (see description of the region). However, the rate of adoption of efficient water-using practices is dependent upon public knowledge of the benefits, information about how to implement water conservation measures, and financing.

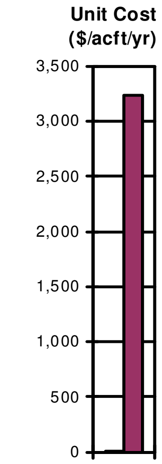
There is widespread public support for both municipal and irrigation water conservation. Cities of the South Central Texas Region have water conservation programs in place. The principal methods of municipal water conservation are public information and education, increasing block water rates, plumbing retrofit, the promotion of low water-using landscapes, and efficient lawn irrigation practices. Irrigation water conservation is being implemented at a steady pace, and as water markets for conserved water expand, this practice will likely reach its maximum potential.

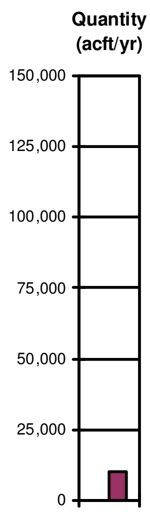
A major barrier to implementation of water conservation in the municipal and irrigation water user groups is financing. Cities can and are giving rebates for plumbing retrofit and the TWDB has low-interest loans for irrigation water conservation equipment. Industry has found water conservation through recycling and reuse to be cost-effective, in that the costs of wastewater treatment are lowered more than enough to pay the recycling and reuse costs.

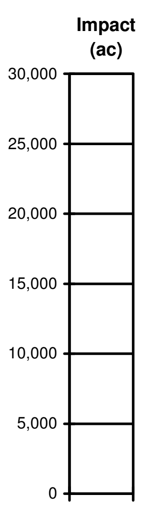
Uncertainty about the effect of demand reduction is present due to the somewhat uncertain rate at which water conservation practices will be implemented, and failure by the public to recognize and realize the magnitude of the water saved and the cost reductions to water users. The implementation of municipal demand reduction will reduce the volume of return flows, creating uncertainty for the planning of reclaimed water treatment facilities, as well as the future availability of return flows for instream flow and freshwater inflow to bays and estuaries.

Industrial, steam-electric power, and mining water conservation through the use of Best Management Practices in these water user groups has potentials to improve water use efficiencies, and thereby contribute to meeting a part of the needs (shortages) projected for these water user groups. However, water conservation in these water user groups will have to be tailored to individual establishments, since each individual water user is a unique factory, power plant, or mining operation.

2011 South Central Texas Regional Water Plan
Water Management Strategy Summary Sheet







Name: Drought Management

Description: The periodic activation of approved drought contingency plans resulting in short-term demand reduction. This reduction in demand is then considered a "supply" source. Using this approach, an entity may make the conscious decision not to develop firm water supplies greater than or equal to projected water demands with the understanding that demands will have to be reduced or go unmet during times of drought.

Decade Needed: 2010 – 2020.

Cost, Quantity of Water, and Land Impacted

Unit Cost of Water:	**9 – 3,239**	**$/acft/yr[1]**	**Water demand reduced.**
Quantity of Water:	**6 – 9,883**	**acft/yr[2]**	**Reliability = Firm**
Land Impacted:	**0**	**acres**	**[1 & 2]Unit cost and quantity of water for a 5% reduction scenario**

Additional Considerations per Regional Water Planning Guidelines

Environmental Factors: Needs are met through municipal water demand reduction. Avoids water supply development that requires additional land and other resources.

Impacts on Water Resources: Slight reductions in treated effluent discharged from municipal systems are possible, depending upon effectiveness of drought management plans.

Impacts on Agricultural & Natural Resources: Needs are met through municipal water demand reduction (see Environmental Factors above), and would not affect quantity or quality of fresh water for agriculture and natural resources, with the possible exception of small reductions in discharge of treated municipal effluent that may result in reduced streamflows.

Other Relevant Factors per SCTRWPG: Drought management is an interim strategy to meet near-term needs through demand reduction until such time as economically viable long-term water supplies can be developed.

Comparison of Strategies to Meet Needs: Relatively low to moderate cost (for most utilities) in comparison to conventional water supply strategies. No conflicts with other water management strategies.

Interbasin Transfer Issues: None anticipated.

Third-Party Impacts of Voluntary Transfers: Not applicable.

Regional Efficiency: Allows existing water supplies to serve more population. Water use efficiency is increased throughout the region.

Water Quality Considerations: None of significant concern.

4C.2 Drought Management

4C.2.1 Description of Water Management Strategy

Texas Administrative Code (TAC), Chapter 357 Regional Water Planning Guidelines, states that "Regional water plan development shall include an evaluation of all water management strategies the regional water planning group determines to be potentially feasible, including drought management measures including water demand management [357.7(a)(7)(B)]." As defined here, drought management means the periodic activation of approved drought contingency plans resulting in short-term demand reduction. This reduction in demand is then considered a "supply" source. Using this approach, an entity may make the conscious decision not to develop firm water supplies greater than or equal to projected water demands with the understanding that demands will have to be reduced or go unmet during times of drought. Using this rationale, an economic impact of not meeting projected water demands can be estimated and compared with the costs of other potentially feasible water management strategies in terms of annual unit costs.

Figure 4C.2-1 shows how water supply planning was done in the 2007 State Water Plan and 2006 Regional Water Plans. For each Water User Group (WUG) with an identified shortage or need during the planning period, a future water supply plan was developed consisting of one or more water management strategies. In each case, the planned future water supply was greater than the projected dry weather demand to allow for drought more severe than the drought of record, uncertainty in water demand projections, and/or available supply from recommended water management strategies. This difference between planned water supply and projected dry weather demand is called management supply in Region L.

Figure 4C.2-2 illustrates how a drought management water management strategy (WMS) could alter the planning paradigm for WUGs with projected needs. Instead of identifying water management strategies to meet the projected need, planned water supply remains below the projected dry weather water demand. The difference between these two lines represents the drought management WMS. Under this concept, a WUG's water demand would be reduced by activating a drought contingency plan to reduce demands, resulting in unmet needs. This strategy of demand reduction could negate the need for water management strategies to meet the full projected need of the WUG. Basically, using this approach,

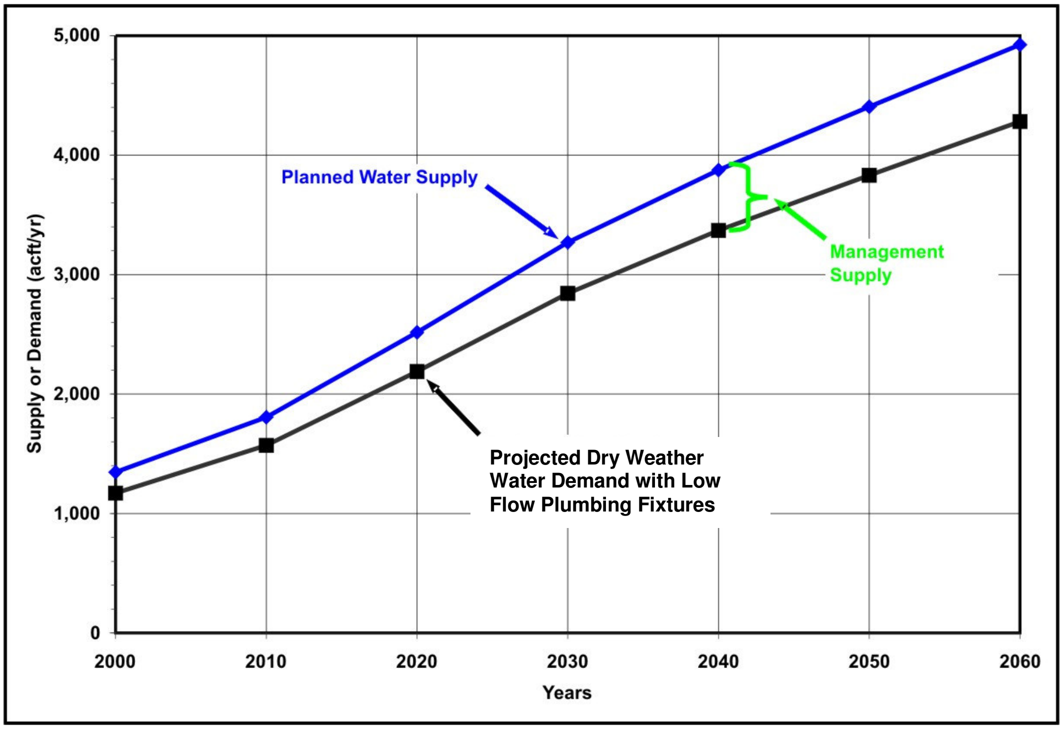


Figure 4C.2-1. Typical Planning in 2006 Regional Water Plan

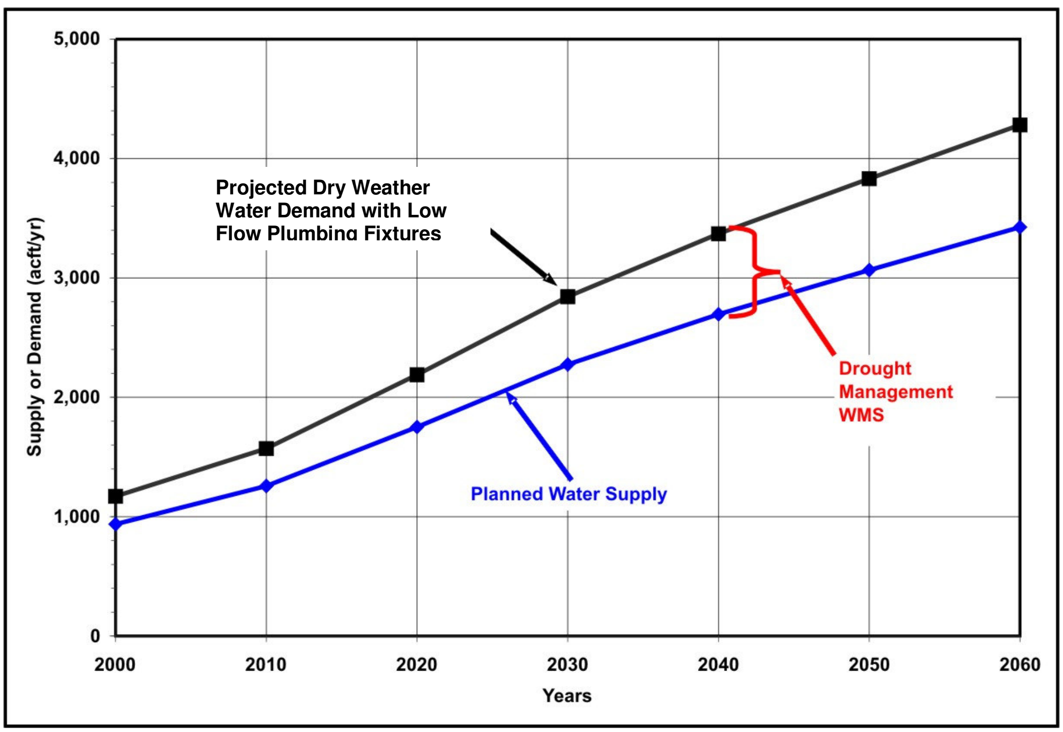


Figure 4C.2-2. Planning with Drought Management Water Management Strategy

the WUG is planning to manage water shortages through drought contingency plan activation. This concept is more fully illustrated in Figure 4C.2-3, which shows that, in any given year, the actual demand may be above or below the planned supply. During times in which the demand exceeds supply, the WUG would experience shortages and incur associated economic impacts.

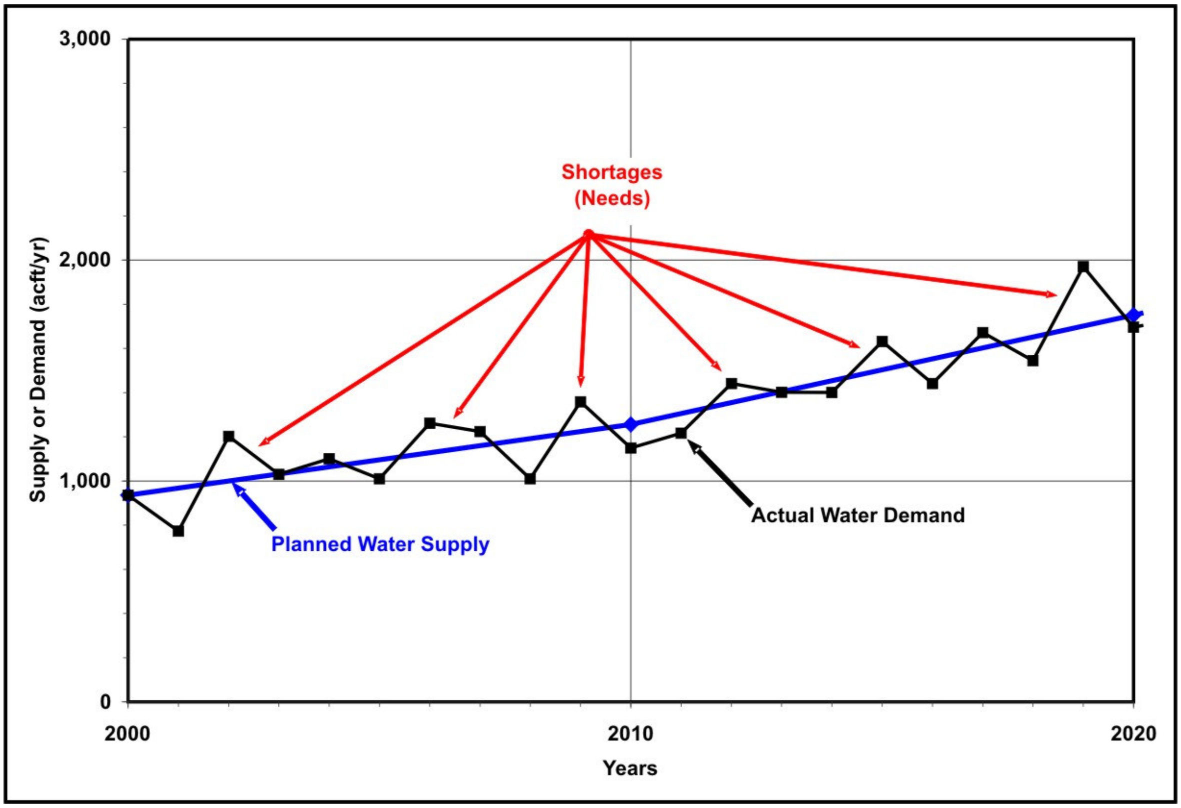


Figure 4C.2-3. Example Drought Management Water Management Strategy

4C.2.2 Drought Management Strategy Methodology

As shown in Figure 4C.2-4, there are a number of incremental steps to calculating a unit cost for this strategy so that it can be compared to other strategies. The first step in the process is to calculate a risk factor for the 5% reduction, 10% reduction, 15% reduction, and 20% reduction cases. Figure 4C.2-5 illustrates the 5% reduction scenario. The risk factor is defined as the integrated chance of occurrence of potential annual demands in excess of planned supply based on historical per capita variations for each entity. A 5% Drought Management WMS, for example, equates to planned supply that is 95% of projected demand.

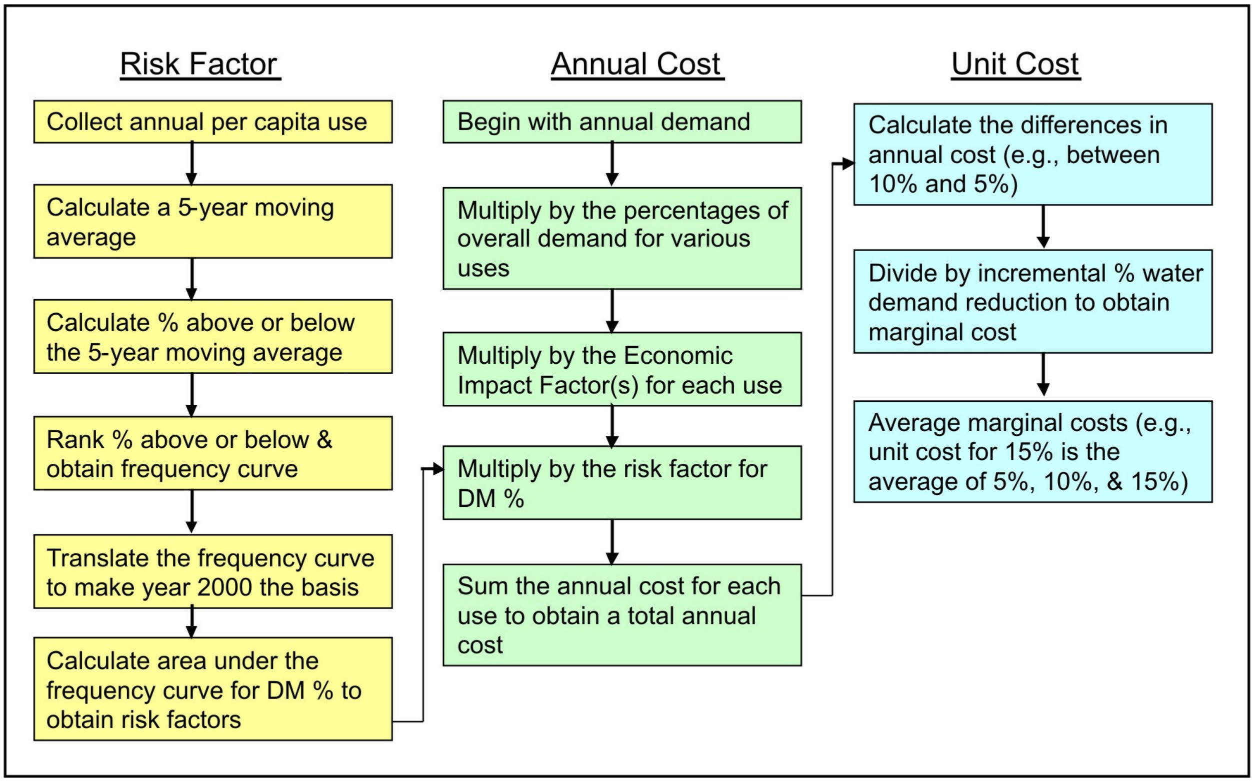


Figure 4C.2-4. Methodology Flowchart

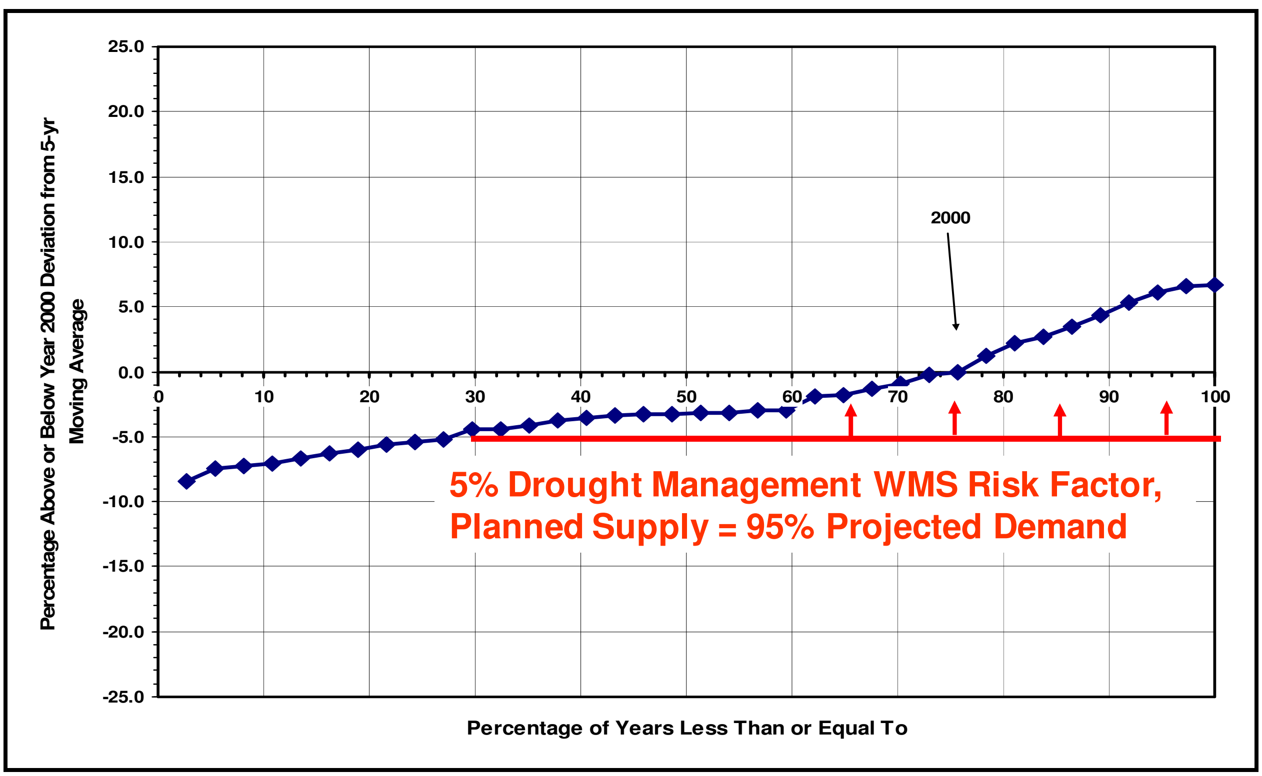


Figure 4C.2-5. Frequency of Per Capita Water Use Variations Adjusted to Basis of Demand Projections

The first step in determining the risk factors was to obtain historical annual per capita water use values. These data were obtained from the TWDB for the period 1964 to 2004, if available. From these data, a 5-year moving per capita water use average was calculated in order to limit the effects of trends in per capita water use rates. Next, an annual percentage above or below the 5-year moving average was calculated. These values were then ranked lowest to highest. A frequency curve was then developed using these data with the percentage above or below the 5-year moving average on the y-axis and the percentage of years less than or equal to that value on the x-axis. Finally, this curve was translated so that the year 2000 value was placed at 0 on the y-axis (Figure 4C.2-5) because year 2000 was used by the TWDB as the basis for demand projections in the 2011 regional water plans. From a plot like Figure 4C.2-5, the integrated area under the frequency curve was calculated as the risk factor. Using formulas developed in Excel, a chart of risk factors was developed for each WUG for each ½% reduction in water use. Using data supplied by the TWDB which shows the % of water use for each WUG that is considered to be residential/domestic, the % reduction in this use type was determined for each of the determined drought management levels (5%, 10%, 15%, and 20%). In other words, reductions in use were focused on residential use first. In this case, all reductions in residential use are attributed to outdoor water use and no reductions in indoor residential water use were assumed to occur. For example, a 10% reduction in overall water use for a WUG may reflect a 12% reduction in residential water use, depending on the amount of water used for other purposes. Using the chart developed above, the risk factor associated with a 12% reduction in use (10% overall) was determined. If an overall 20% reduction in water use could be obtained without exceeding a 25% reduction in residential use, the use for other water users was not affected. If however, for certain WUGs (Kyle, New Braunfels, BMWD, and SAWS) this was not the case. For these WUG, residential water use was reduced by 25% with the remaining reduction being split evenly between commercial and industrial use.

After risk factors for each scenario were calculated, an annual cost was then calculated using the following formula:

(Demand) X (%Demand) X (Risk Factor) X ($ Impact Factor) = DM WMS Annual Cost

where:

- Demand (acft/yr) = Projected "dry year" demand from TWDB based on year 2000 per capita use rate (projected demand in year 2010 was used);

- % Demand = Proportion of water demand associated with various use types (i.e., residential, commercial, and manufacturing);
- Risk Factor = Integrated chance of occurrence of potential annual demands in excess of planned supply based on historical per capita use variations for each entity;
- $ Impact Factor ($/acft) = Economic impact factors used by TWDB (see Table 4C.2-1) to calculate economic impacts of not meeting needs. TWDB factors used include (a) lost sales for water-intensive commercial users; (b) costs to non-water-intensive commercial businesses and households; and (c) lost sales for manufacturing; and
- DM WMS Annual Cost ($/yr) = Typical annual economic impacts of adhering to the Drought Management WMS for that water use type. The annual cost for each use type (i.e., domestic, commercial, and manufacturing) were then summed to obtain a total annual cost.

The final step in this process was to convert the annual cost to a unit cost so that this strategy could be compared to other potentially feasible water management strategies. In order to do this, the difference between the annual cost for each scenario were first calculated (i.e., between 10% and 5%). This value was then divided by a 5% water demand reduction from the year 2010 demand to obtain a marginal cost. Finally, the marginal cost values were averaged to obtain a unit cost (i.e., the unit cost for 15% is the average of 5%, 10%, and 15%).

An example cost calculation for the City of Uvalde is provided in Tables 4C.2-2 and 4C.2-3. Using data supplied by the TWDB (Table 4C.2-1), the "Share of WUG's Need Applied to Factor" row is populated. In this case, 80% of the demand is applied to Domestic/Residential use and 20% to Commercial use. There is no demand associated with Manufacturing for the City of Uvalde. Next, the demand associated with each water use is determined by multiplying the total year 2010 demand times the percentage associated with each use type (i.e., 6,087 acft x .80 = 4,870 acft for domestic/residential demand). Using the methodology described above, the risk factor was determined for each scenario. Next, the economic impact factor was determined for each use type using the data supplied by the TWDB and shown in Table 4C.2-1. These factors are constant from one drought management scenario to the next, with the exception of the factors for Domestic/Residential which were determined by interpolating between the values

Table 4C.2-1.
Texas Water Development Board Economic Impact Factors

		Residential/Domestic										Non-Residential		Distribution by Category				
		Outdoor				Indoor												
		% of Total Household Monthly Use Restricted																
WUG	County	5%	10%	20%	30%	40%	50%	60%	70%	80%	>90%	Com-mercial	Indus-trial (Utility Serviced)	Domestic (%)	Domestic Outdoor (%)	Domestic Indoor (%)	Com-mercial	Indus-trial (Utility Serviced)
ALAMO HEIGHTS	BEXAR	$920	$1,030	$1,290	$2,130	$5,780	$7,040	$8,950	$12,120	$18,460	$24,070	$47,680	$0	85%	30%	70%	15%	0%
AQUA WSC	CALDWELL	$1,070	$1,230	$1,580	$2,900	$9,010	$10,970	$13,910	$18,800	$24,070	$24,070	$7,090	$0	95%	30%	70%	5%	0%
ATASCOSA RURAL WSC	BEXAR	$920	$1,030	$1,290	$2,130	$5,780	$7,040	$8,950	$12,120	$18,460	$24,070	$34,980	$0	95%	30%	70%	5%	0%
BENTON CITY WSC	FRIO	$1,070	$1,230	$1,580	$2,900	$9,010	$10,970	$13,910	$18,800	$24,070	$24,070	$0	$0	100%	30%	70%	0%	0%
BEXAR MET WATER DISTRICT	MEDINA	$1,070	$1,230	$1,580	$2,900	$9,010	$10,970	$13,910	$18,800	$24,070	$24,070	$80,920	$0	65%	30%	70%	35%	0%
BULVERDE CITY	COMAL	$920	$1,030	$1,290	$2,130	$5,780	$7,040	$8,950	$12,120	$18,460	$24,070	$29,350	$0	85%	30%	70%	15%	0%
CASTLE HILLS	BEXAR	$1,070	$1,230	$1,580	$2,900	$9,010	$10,970	$13,910	$18,800	$24,070	$24,070	$40,140	$0	85%	30%	70%	15%	0%
CASTROVILLE	MEDINA	$1,070	$1,230	$1,580	$2,900	$9,010	$10,970	$13,910	$18,800	$24,070	$24,070	$33,540	$54,000	90%	30%	70%	9%	1%
COUNTY LINE WSC	CALDWELL	$1,070	$1,230	$1,580	$2,900	$9,010	$10,970	$13,910	$18,800	$24,070	$24,070	$19,380	$0	100%	30%	70%	0%	0%
CRYSTAL CLEAR WSC	COMAL	$1,070	$1,230	$1,580	$2,900	$9,010	$10,970	$13,910	$18,800	$24,070	$24,070	$16,100	$175,240	95%	30%	70%	5%	0%
EAST MEDINA SUD	MEDINA	$920	$1,030	$1,290	$2,130	$5,780	$7,040	$8,950	$12,120	$18,460	$24,070	$46,820	$0	90%	30%	70%	10%	0%
GARDEN RIDGE	COMAL	$1,070	$1,230	$1,580	$2,900	$9,010	$10,970	$13,910	$18,800	$24,070	$24,070	$13,680	$0	95%	30%	70%	5%	0%
GONZALES COUNTY WSC	CALDWELL	$1,070	$1,230	$1,580	$2,900	$9,010	$10,970	$13,910	$18,800	$24,070	$24,070	$0	$120,700	98%	30%	70%	0%	2%
GREEN VALLEY SUD	COMAL	$1,070	$1,230	$1,580	$2,900	$9,010	$10,970	$13,910	$18,800	$24,070	$24,070	$11,640	$151,370	77%	30%	70%	15%	8%
HILL COUNTRY VILLAGE	BEXAR	$1,070	$1,230	$1,580	$2,900	$9,010	$10,970	$13,910	$18,800	$24,070	$24,070	$39,280	$0	90%	30%	70%	10%	0%
HOLLYWOOD PARK	BEXAR	$1,070	$1,230	$1,580	$2,900	$9,010	$10,970	$13,910	$18,800	$24,070	$24,070	$28,450	$0	90%	30%	70%	10%	0%
HONDO	MEDINA	$920	$1,030	$1,290	$2,130	$5,780	$7,040	$8,950	$12,120	$18,460	$24,070	$69,360	$405,000	90%	30%	70%	9%	1%
JOURDANTON	ATASCOSA	$1,070	$1,230	$1,580	$2,900	$9,010	$10,970	$13,910	$18,800	$24,070	$24,070	$64,940	$0	90%	30%	70%	10%	0%
KIRBY	BEXAR	$920	$1,030	$1,290	$2,130	$5,780	$7,040	$8,950	$12,120	$18,460	$24,070	$32,750	$0	85%	30%	70%	15%	0%
KYLE	HAYS	$920	$1,030	$1,290	$2,130	$5,780	$7,040	$8,950	$12,120	$18,460	$24,070	$62,790	$0	75%	30%	70%	25%	0%
LACOSTE	MEDINA	$1,070	$1,230	$1,580	$2,900	$9,010	$10,970	$13,910	$18,800	$24,070	$24,070	$13,420	$0	95%	30%	70%	5%	0%
LOCKHART	CALDWELL	$920	$1,030	$1,290	$2,130	$5,780	$7,040	$8,950	$12,120	$18,460	$24,070	$35,230	$0	80%	30%	70%	20%	0%
LULING	CALDWELL	$920	$1,030	$1,290	$2,130	$5,780	$7,040	$8,950	$12,120	$18,460	$24,070	$25,500	$0	90%	30%	70%	10%	0%
LYTLE	BEXAR	$1,070	$1,230	$1,580	$2,900	$9,010	$10,970	$13,910	$18,800	$24,070	$24,070	$44,190	$0	90%	30%	70%	10%	0%
MARTINDALE	CALDWELL	$1,070	$1,230	$1,580	$2,900	$9,010	$10,970	$13,910	$18,800	$24,070	$24,070	$7,570	$0	95%	30%	70%	5%	0%
MARTINDALE WSC	GUADALUPE	$1,070	$1,230	$1,580	$2,900	$9,010	$10,970	$13,910	$18,800	$24,070	$24,070	$0	$0	100%	30%	70%	0%	0%
MCCOY WSC	WILSON	$1,070	$1,230	$1,580	$2,900	$9,010	$10,970	$13,910	$18,800	$24,070	$24,070	$0	$0	100%	30%	70%	0%	0%
MUSTANG RIDGE	CALDWELL	$1,070	$1,230	$1,580	$2,900	$9,010	$10,970	$13,910	$18,800	$24,070	$24,070	$0	$0	100%	30%	70%	0%	0%
NATALIA	MEDINA	$1,070	$1,230	$1,580	$2,900	$9,010	$10,970	$13,910	$18,800	$24,070	$24,070	$22,790	$0	100%	30%	70%	0%	0%
NEW BRAUNFELS	COMAL	$920	$1,030	$1,290	$2,130	$5,780	$7,040	$8,950	$12,120	$18,460	$24,070	$81,750	$81,488	75%	30%	70%	24%	1%
NIEDERWALD	CALDWELL	$1,070	$1,230	$1,580	$2,900	$9,010	$10,970	$13,910	$18,800	$24,070	$24,070	$0	$0	100%	30%	70%	0%	0%
PLUM CRK WC/MONARCH UTILITIES	HAYS	$920	$1,030	$1,290	$2,130	$5,780	$7,040	$8,950	$12,120	$18,460	$24,070	$0	$0	100%	30%	70%	0%	0%
POINT COMFORT	CALHOUN	$1,070	$1,230	$1,580	$2,900	$9,010	$10,970	$13,910	$18,800	$24,070	$24,070	$0	$0	95%	30%	70%	5%	0%
SABINAL	UVALDE	$1,070	$1,230	$1,580	$2,900	$9,010	$10,970	$13,910	$18,800	$24,070	$24,070	$36,360	$0	95%	30%	70%	5%	0%
SAN ANTONIO (BMWD)	BEXAR	$920	$1,030	$1,290	$2,130	$5,780	$7,040	$8,950	$12,120	$18,460	$24,070	$80,920	$0	65%	30%	70%	35%	0%
SAN ANTONIO (SAWS)	BEXAR	$820	$910	$1,110	$1,700	$4,190	$5,110	$6,500	$8,820	$13,460	$24,070	$86,280	$268,840	65%	30%	70%	33%	2%
SANTA CLARA	GUADALUPE	$1,070	$1,230	$1,580	$2,900	$9,010	$10,970	$13,910	$18,800	$24,070	$24,070	$0	$0	100%	30%	70%	0%	0%
SCHERTZ	COMAL	$1,070	$1,230	$1,580	$2,900	$9,010	$10,970	$13,910	$18,800	$24,070	$24,070	$87,580	$0	80%	30%	70%	20%	0%
SELMA	GUADALUPE	$1,070	$1,230	$1,580	$2,900	$9,010	$10,970	$13,910	$18,800	$24,070	$24,070	$43,000	$0	80%	30%	70%	20%	0%
SHAVANO PARK	BEXAR	$1,070	$1,230	$1,580	$2,900	$9,010	$10,970	$13,910	$18,800	$24,070	$24,070	$40,190	$0	90%	30%	70%	10%	0%
SS WSC	WILSON	$920	$1,030	$1,290	$2,130	$5,780	$7,040	$8,950	$12,120	$18,460	$24,070	$0	$0	100%	30%	70%	0%	0%
UNIVERSAL CITY	BEXAR	$920	$1,030	$1,290	$2,130	$5,780	$7,040	$8,950	$12,120	$18,460	$24,070	$63,100	$0	80%	30%	70%	20%	0%
UVALDE	UVALDE	$920	$1,030	$1,290	$2,130	$5,780	$7,040	$8,950	$12,120	$18,460	$24,070	$52,120	$0	80%	30%	70%	20%	0%
WATER SERVICES INC.	GUADALUPE	$1,070	$1,230	$1,580	$2,900	$9,010	$10,970	$13,910	$18,800	$24,070	$24,070	$0	$0	100%	30%	70%	0%	0%
WIMBERLEY WSC	HAYS	$920	$1,030	$1,290	$2,130	$5,780	$7,040	$8,950	$12,120	$18,460	$24,070	$0	$0	100%	30%	70%	0%	0%
WOODCREEK	HAYS	$1,070	$1,230	$1,580	$2,900	$9,010	$10,970	$13,910	$18,800	$24,070	$24,070	$0	$0	100%	30%	70%	0%	0%
WOODCREEK UTILITIES	HAYS	$1,070	$1,230	$1,580	$2,900	$9,010	$10,970	$13,910	$18,800	$24,070	$24,070	$0	$0	100%	30%	70%	0%	0%

Table 4C.2-2.
5% Drought Management Scenario (City of Uvalde)

	Domestic/ Residential	Com- mercial	Manu- facturing	Total/ Combined
Share of WUG's Need Applied to Factor (%)	80%	20%	0%	
Proportional Demand (acft)	4,870	1,217	0	
5% DM WMS Risk Factor	0.0007	0.0000	0.0000	
5% Reduction Economic Impact Factor ($/acft)	$949	$52,120	-	
5% DM WMS - Total Economic Impact ($)	$3,375	$0		$3,375

Table 4C.2-3.
10% Drought Management Scenario (City of Uvalde)

	Domestic/ Residential	Com- mercial	Manu- facturing	Total/ Combined
Share of WUG's Need Applied to Factor (%)	80%	20%	0%	
Proportional Demand (acft)	4,870	1,217	0	
10% DM WMS Risk Factor	0.0038	0.0000	0.0000	
10% Reduction Economic Impact Factor ($/acft)	$1,095	$52,120	-	
10% DM WMS - Total Economic Impact ($)	$20,363	$0		$20,363

supplied by the TWDB for the risk factor associated with scenario. For example, for the 5% drought management scenario (a 6.3% reduction in residential/domestic use) for the City of Uvalde, the associated economic impact factor for domestic/residential is $949; however, for the 10% reduction scenario (a 12.5% reduction in residential/domestic use), the economic impact factor is $1,095. Next the total economic impact for each use type is calculated by multiplying the proportional demand times the risk factor times the economic impact factor (i.e., 4,870 acft x 0.0038 x $1,095/acft = $20,363 for the residential sector with a 10% reduction). This same formula was used to determine the economic impact for each use type. Note, that the only WUGs for which commercial and manufacturing water use was reduced are Kyle, New Braunfels, BMWD, and SAWS, and only for the 20% reduction scenario. Next, the economic impacts for each use type were summed to obtain a total economic impact (in this case and most cases just for domestic/residential). This type of process was used to determine the total economic impact for each of the drought management scenarios.

To determine the unit cost for the 10% drought management scenario for Uvalde, the following steps were completed. First, marginal costs for both the 5% and 10% scenarios were calculated. For the 5% scenario, this is simply the total economic impact divided by 5% of the total year 2010 demand (i.e., $3,375 / 304 acft = $11/acft). For the 10% scenario, a marginal cost must first be calculated. This is calculated as the difference in total economic impact between the 10% and 5% drought management scenarios, divided by 5% of the total year 2010 demand (i.e., ($20,263 - $3,375) / 304 acft = $56/acft). To calculate the unit cost for the 10% drought management scenario, the marginal costs of the 5% and the 10% scenario are averaged (i.e., ($11 + $56) / 2 = $33/acft).

4C.2.3 Yield from Drought Management Strategy

The yield associated with drought management is simply the year 2010 projected demand times the appropriate percentage depending upon which scenario is used (5%, 10%, 15% or 20%). These values are summarized below in Table 4C.2-4.

4C.2.4 Drought Management Strategy Costs

For each selected WUG, risk factors for 5%, 10%, 15%, and 20% drought management scenario reductions were calculated (Table 4C.2-5). For the 5% reduction scenario, the risk factors ranged from 0.0005 for the City of Point Comfort, indicating there is very little risk of a higher per capita use rate occurring than what occurred in the year 2000, to 0.1652 for the City of Castroville, indicating a much greater risk of demand being greater than supply. For the 20% scenario, the risk factors ranged from a low of 0.0136 for the City of Point Comfort to a high of 0.3113 for Atascosa Rural WSC. The risk factors associated with the commercial and manufacturing uses in Kyle, New Braunfels, BMWD, and SAWA are 0.0713, 0.0170, 0.1730, and 0.0820 respectively.

As described above, these risk factors were then used to determine an annual cost for a planned supply less than demand for the year 2010 (Table 4C.2-6). For the 5% reduction scenario, the annual cost ranged from $106 for the City of Point Comfort to a cost of almost $5.7 million for SAWS. For the 20% reduction scenario, the annual cost ranged from $4,979 for the

Table 4C.2-4.
Drought Management Yield

Entity	Yield (acft)			
	5%	10%	15%	20%
Alamo Heights	104	207	311	414
Aqua WSC	13	27	40	53
Atascosa Rural WSC	47	94	141	188
Castle Hills	41	82	123	164
Castroville	34	68	102	136
County Line WSC	58	115	173	230
East Medina SUD	44	88	132	176
Garden Ridge	28	57	85	113
Hill Country Village	42	84	126	168
Hollywood Park	116	231	347	463
Hondo	89	178	268	357
Jourdanton	40	80	120	160
Kirby	50	101	151	201
Kyle	137	274	411	548
La Coste	10	21	31	41
Lockhart	123	245	368	490
Luling	53	107	160	213
Lytle	24	48	72	96
Martindale	6	13	19	25
Martindale WSC	9	19	28	38
Natalia	17	33	50	66
New Braunfels	525	1,051	1,576	2,102
Point Comfort	11	22	34	45
Sabinal	20	41	61	81
San Antonio (BMWD)	1,233	2,465	3,698	4,931
San Antonio (SAWS)	9,883	19,767	29,650	39,534
Shavano Park	41	82	123	164
SS WSC	78	156	234	313
Universal City	130	261	391	522
Uvalde	304	609	913	1,217
Water Services, Inc.	48	95	143	190
Woodcreek	12	25	37	49

Table 4C.2-5.
Risk Factors

Entity	Risk Factors			
	5%	10%	15%	20%
Alamo Heights	0.1254	0.1765	0.2280	0.2853
Aqua WSC	0.1439	0.1918	0.2445	0.2924
Atascosa Rural WSC	0.1620	0.2100	0.2631	0.3113
Castle Hills	0.0939	0.1465	0.1976	0.2551
Castroville	0.1652	0.2088	0.2569	0.3090
County Line WSC	0.0077	0.0121	0.0175	0.0287
East Medina SUD	0.0785	0.1245	0.1762	0.2293
Garden Ridge	0.0202	0.0365	0.0573	0.0933
Hill Country Village	0.0162	0.0236	0.0325	0.0462
Hollywood Park	0.0145	0.0250	0.0422	0.0727
Hondo	0.1242	0.1724	0.2250	0.2785
Jourdanton	0.0833	0.1157	0.1519	0.1916
Kirby	0.0473	0.0886	0.1419	0.1990
Kyle	0.0820	0.1332	0.1867	0.2328
La Coste	0.0299	0.0589	0.1077	0.1531
Lockhart	0.1143	0.1711	0.2342	0.2926
Luling	0.0338	0.0632	0.1049	0.1541
Lytle	0.0308	0.0597	0.1024	0.1473
Martindale	0.0229	0.0461	0.0829	0.1237
Martindale WSC	0.0475	0.0780	0.1136	0.1528
Natalia	0.0832	0.1162	0.1535	0.1950
New Braunfels	0.0233	0.0653	0.1243	0.1730
Point Comfort	0.0005	.0..17	0.0067	0.0136
Sabinal	0.0397	0.0574	0.0813	0.1146
San Antonio (BMWD)	0.1449	0.2199	0.2902	0.3089
San Antonio (SAWS)	0.0530	0.1307	0.2037	0.2231
Shavano Park	0.0188	0.0364	0.0650	0.1032
SS WSC	0.0600	0.1048	0.1498	0.1948
Universal City	0.0592	0.1133	0.1762	0.2342
Uvalde	0.0007	0.0038	0.0184	0.0458
Water Services, Inc.	0.0214	0.0491	0.0884	0.1358
Woodcreek	0.0468	0.0863	0.1302	0.1756

Table 4C.2-6.
Total Annual Cost

Entity	Total Annual Cost			
	5%	10%	15%	20%
Alamo Heights	$207,467	$334,603	$492,848	$795,557
Aqua WSC	$39,415	$60,714	$88,873	$127,948
Atascosa Rural WSC	$134,283	$195,817	$277,718	$384,550
Castle Hills	$71,926	$131,986	$206,066	$363,087
Castroville	$110,122	$162,132	$234,565	$353,656
County Line WSC	$9,453	$17,170	$31,834	$95,670
East Medina SUD	$58,052	$104,559	$172,803	$268,225
Garden Ridge	$11,735	$24,473	$44,092	$86,421
Hill Country Village	$13,281	$22,545	$36,933	$65,164
Hollywood Park	$32,969	$65,928	$135,465	$283,804
Hondo	$186,065	$293,119	$444,307	$659,526
Jourdanton	$65,394	$105,840	$164,152	$258,230
Kirby	$37,944	$85,364	$148,882	$269,313
Kyle	$161,234	$305,472	$495,428	$4,106,244
La Coste	$6,279	$14,324	$30,044	$51,436
Lockhart	$212,699	$367,325	$578,264	$981,151
Luling	$30,282	$64,242	$126,289	$218,304
Lytle	$14,479	$34,571	$70,064	$126,262
Martindale	$2,943	$6,839	$14,099	$25,334
Martindale WSC	$9,615	$18,122	$33,911	$83,733
Natalia	$29,368	$47,150	$80,054	$186,586
New Braunfels	$176,029	$574,252	$1,264,094	$6,174,754
Point Comfort	$106	$445	$2,042	$4,979
Sabinal	$16,587	$27,700	$45,067	$76,464
San Antonio (BMWD)	$2,272,791	$4,122,408	$7,207,795	$132,531,960
San Antonio (SAWS)	$5,681,497	$17,092,861	$33,833,350	$627,263,236
Shavano Park	$15,091	$34,067	$73,354	$142,175
SS WSC	$86,255	$168,677	$301,988	$648,445
Universal City	$117,148	$258,925	$462,754	$835,451
Uvalde	$3,375	$20,363	$112,875	$186,182
Water Services, Inc.	$21,809	$57,433	$132,763	$374,501
Woodcreek	$12,309	$26,109	$50,588	$125,279

City of Point Comfort to a cost of almost $627.3 million for SAWS. The two most important factors driving the annual cost are the risk factor and whether or not that WUG supplies water for commercial and manufacturing purposes (at the 20% reduction level), as these uses have high impact factors.

Finally, the annual cost data were used to calculate a unit cost so that comparisons could be made with other potentially feasible water management strategies (Table 4C.2-7). For the 5% scenario (supply equal to 95% of dry condition demand), the unit costs ranged from $9/acft/yr for the City of Point Comfort to a high of $3,239/acft/yr for the City of Castroville. For the 20% scenario (supply equal to 80% of dry condition demand), the unit costs ranged from $111 for the City of Point Comfort to a high of $26,878 for BMWD. Again, the high unit costs for BMWD are primarily due to the high risk factors (i.e., the year 2000 per capita was lower than in many previous years) and the high economic impact factors associated with commercial and manufacturing uses.

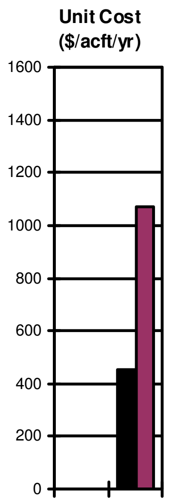
The SCTRWPG has found, and the San Antonio Water System (SAWS) has demonstrated, that water user groups having sufficient flexibility to focus on discretionary outdoor water use first and avoid water use reductions in the commercial and manufacturing use sectors may find some degrees of drought management to be economically viable and cost-competitive with other water management strategies. Recognizing that implementation of appropriate water management strategies is a matter of local choice, the SCTRWPG recommends due consideration of economically viable drought management as an interim strategy to meet near-term needs through demand reduction until such time as economically viable long-term water supplies can be developed. Hence, new demand reductions associated with the 5 percent drought management scenario are shown as recommended at year 2010 for each municipal water user group with projected needs for additional water supply at year 2010[1].

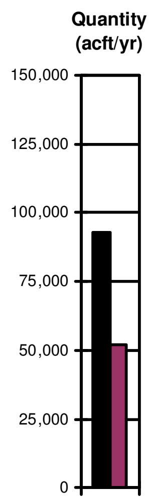
[1] In accordance with the SAWS 2009 Water Management Plan Update, 37,622 acft/yr is the drought management supply (demand reduction) shown for SAWS in year 2010. This quantity is between the 15 and 20 percent drought management scenarios presented in Table 4C.2-4.

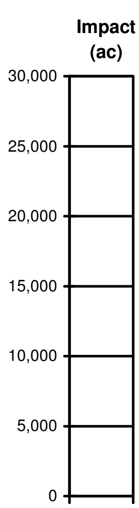
Table 4C.2-7.
Average Unit Cost

Entity	Average Unit Cost			
	5%	10%	15%	20%
Alamo Heights	$2,004	$1,616	$1,587	$1,921
Aqua WSC	$2,952	$2,274	$2,219	$2,396
Atascosa Rural WSC	$2,854	$2,081	$1,968	$2,043
Castle Hills	$1,754	$1,610	$1,675	$2,214
Castroville	$3,239	$2,384	$2,300	$2,600
County Line WSC	$164	$149	$184	$416
East Medina SUD	$1,318	$1,187	$1,308	$1,522
Garden Ridge	$415	$433	$520	$765
Hill Country Village	$317	$269	$294	$389
Hollywood Park	$285	$285	$390	$613
Hondo	$2,086	$1,643	$1,660	$1,848
Jourdanton	$1,633	$1,321	$1,366	$1,612
Kirby	$755	$849	$988	$1,340
Kyle	$1,177	$1,115	$1,205	$7,493
La Coste	$613	$699	$977	$1,255
Lockhart	$1,736	$1,499	$1,573	$2,002
Luling	$568	$602	$789	$1,023
Lytle	$605	$722	$975	$1,318
Martindale	$471	$547	$752	$1,013
Martindale WSC	$1,017	$959	$1,196	$2,215
Natalia	$1,780	$1,429	$1,617	$2,827
New Braunfels	$335	$546	$802	$2,938
Point Comfort	$9	$20	$61	$111
Sabinal	$815	$681	$738	$939
San Antonio (BMWD)	$1,844	$1,672	$1,949	$26,878
San Antonio (SAWS)	$575	$865	$1,141	$15,867
Shavano Park	$369	$416	$597	$868
SS WSC	$1,104	$1,079	$1,288	$2,074
Universal City	$898	$993	$1,183	$1,602
Uvalde	$11	$33	$124	$153
Water Services, Inc.	$459	$604	$931	$1,969
Woodcreek	$1,001	$1,061	$1,371	$2,546

2011 South Central Texas Regional Water Plan
Water Management Strategy Summary Sheet







Name: Edwards Transfers

Description: The Edwards Aquifer Authority Act (SB 1477) regulates the quantity of pumpage from the Edwards Aquifer and establishes a withdrawal permit system which allows an irrigation permit holder to lease up to 50 percent of irrigation permits. This water management strategy considers quantities potentially available for transfer and the associated effects of planned transfers.

***Decade Needed*:** 2000 – 2060

Cost, Quantity of Water, and Land Impacted

Unit Cost of Water:	**$454**	**$/acft/yr**	**Lease Permits: firm supply**
	$1072	**$/acft/yr**	**Buy Permits: firm supply.**
Quantity of Water:	**92,727**	**acft/yr**	**Permits at IRP Value**
	51,875	**acft/yr**	**Firm Supply**
Land Impacted:	**0**	**acres**	

Additional Considerations per Regional Water Planning Guidelines

Environmental Factors:
To the extent that the quantities of water transferred are from improved efficiencies in irrigation application methods, there would not be a change in land use, and therefore would not produce environmental effects. Conversion from irrigated to dryland crops would result in changes of vegetation from irrigated to dryland crops. Where lands are converted to grazing and wildlife uses, long-term conservation of soil and natural resources may be increased, due to grass cover versus row crops.

Impacts on Water Resources:
Potential impacts due to pumpage nearer to major springs.

Impacts on Agricultural & Natural Resources:
Voluntary transfers may result in reduced projected irrigation demand/use in source counties.

Other Relevant Factors per SCTRWPG:
SB 1477 restricts transfer via pipeline from Uvalde County. Transfers are subject to critical period and other rules of the Edwards Aquifer Authority.

Comparison of Strategies to Meet Needs:
No significant conflicts with other recommended water management strategies.

Interbasin Transfer Issues:
Not applicable.

Third-Party Impacts of Voluntary Transfers:
Reduction in irrigation lowers demands for farm supply and farm marketing services and support industries thereby reducing local area economic activity. Estimated economic impact of water converted from production of cotton, grain sorghum, wheat and other grains is $448 per acft/yr. For vegetables, the estimated economic impact is $3,378 per acft/yr. The estimates presented here are based upon 2004 farm and purchased input prices, and will change as farm prices change.

Regional Efficiency:
This water management strategy contributes to meeting municipal needs without the construction of traditional water supply facilities.

Water Quality Considerations:
None anticipated.

4C.3 Edwards Transfers

The purposes of this section are to: (1) estimate the quantity of Edwards irrigation water eligible and available for transfer to municipal and industrial use by purchase or lease, and (2) estimate potential impacts of transfers included in the 2011 Regional Water Plan upon the local economies of Uvalde, Medina, and Bexar Counties. This water management strategy is based upon the provisions of Senate Bill 1477 (SB 1477), 1993 Regular Session, Texas Legislature, as amended (The Edwards Aquifer Act).

4C.3.1 Provisions for Purchase (or Lease) of Edwards Irrigation Water

Senate Bill 3 of the 80th Texas Legislature (SB3) established a maximum annual amount of permitted withdrawals from the aquifer of 572,000 acft/yr, specific critical period management plan provisions, interim minimum annualized rates for permitted withdrawals in critical period of 320,000 acft/yr, and a Recovery Implementation Program for protection of endangered species. For purposes of water supply analyses for the 2011 South Central Texas Regional Water Plan, the permitted supply from the Edwards Aquifer is assumed to be 320,000 acft/yr.[1] The Edwards Aquifer Authority (EAA) has adopted Demand Management and Critical Period rules that are consistent with SB3 and establish trigger conditions for recognition of drought and specify reductions in withdrawals from the Edwards Aquifer when these trigger conditions are met. Subject to permitted withdrawals totaling 572,000 acft/yr, these rules reflect staged reductions in permitted withdrawals ranging from five to 40 percent during periods in which water levels in representative monitoring wells in Bexar and Uvalde Counties or discharges at Comal or San Marcos Springs have fallen below specified trigger levels. Tables 4C.3-1 and 4C.3-2 summarize the factors specific to the Edwards Aquifer in determining whether to initiate a drought response and the reductions in withdrawal expected as part of the response. For comprehensive information supplementing that shown in Tables 4C.3-1 and 4C.3-2, please refer to the rules of the EAA.

[1] For planning purposes, an estimate of 320,000 acft/yr of available supply during a drought of record from the Edwards Aquifer was agreed upon by the SCTRWPG and the staff of the TWDB. This quantity is adopted as a placeholder number until the EAA obtains approval of a Habitat Conservation Plan (HCP) from the U.S. Fish and Wildlife Service.

Table 4C.3-1.
Senate Bill 3 Critical Period Withdrawal Reduction Stages for the San Antonio Pool

Reduction Stage	Triggers Initiating Drought Response				San Antonio Pool Withdrawal Reduction
	J-17 (ft-msl)	Springflows (cfs) San Marcos	Springflows (cfs) Comal	J-27 (ft-msl)	
I	660	96	225	N/A	20 %
II	650	80	200	N/A	30 %
III	640	N/A	150	N/A	35 %
IV	630	N/A	100	N/A	40 %

Table 4C.3-2.
Senate Bill 3 Critical Period Withdrawal Reduction Stages for the Uvalde Pool

Reduction Stage	Triggers Initiating Drought Response				Uvalde Pool Withdrawal Reduction
	J-17 (ft-msl)	Springflows (cfs) San Marcos	Springflows (cfs) Comal	J-27 (ft-msl)	
I	N/A	N/A	N/A		N/A
II	N/A	N/A	N/A	850	5 %
III	N/A	N/A	N/A	845	20 %
IV	N/A	N/A	N/A	842	35 %

Section 1.15 of The Edwards Aquifer Act provides that the Edwards Aquifer Authority shall manage withdrawals and points of withdrawal from the aquifer by granting permits, and Section 1.34 of The Edwards Aquifer Act specifies the manner in which water rights may be transferred, as follows:

"(a) Water withdrawn from the aquifer must be used within the boundaries of the authority.
(b) The authority by rule may establish a procedure by which a person who installs water conservation equipment may sell the water conserved.
(c) A permit holder may lease permitted water rights, but a holder of a permit for irrigation use may not lease more than 50 percent of the irrigation water rights initially permitted. The user's remaining irrigation water rights must be used in accordance with the original permit and must pass with transfer of the irrigated land."

The Edwards Aquifer Act, Section 1.16(e), provides that, "An existing irrigation user shall receive a permit for not less than 2 aft/yr for each acre of land the user actually irrigated in any one calendar year during the historical period."

In accordance with provisions of The Edwards Aquifer Act, the EAA has issued Initial Regular Permits (IRPs) for municipal, industrial, and irrigation water use. The total quantity permitted for municipal, industrial, and irrigation uses was 569,699 acft/yr. The total of the unrestricted transfer potentials for the EAA six-county area is 451,274 acft/yr, of which 283,674 is in Bexar County, 55,580 acft/yr is in Medina County, and 80,364 acft/yr is in Uvalde County (Table 4C.3-3). Due to permanent transfers to date, there is 377,909 acft/yr of remaining unrestricted transfer potential, and 118,425 acft/yr of remaining restricted transfer potential (Table 4C.3-3). In the case of "restricted" permits, only the quantity that is saved through irrigation water conservation can be transferred (i.e., that part of the 50 percent of the irrigation permit that by The Edwards Aquifer Act must remain with the land).

Under the provisions of the act allowing for transfer of "restricted" permits, as of June 2005, SAWS has participated in the installation of irrigation water conservation equipment through cost-sharing with the US Department of Agriculture's Environmental Quality Incentives Program (EQIP). Under this irrigation water conservation program, center pivots for irrigation application were installed on approximately 6,000 acres that had previously been irrigated using the flooding application method. It has been estimated that this effort has resulted in about 2,000 acft/yr, of water conservation on the 6,000 acres, and SAWS has applied to the EAA for transfer of the 2,000 acre-feet of irrigation "restricted" permits to municipal and industrial permits.

For Bexar, Medina, and Uvalde Counties, the remaining unrestricted irrigation permit quantity that is potentially available for transfer to municipal and industrial uses is 77,551 acft/yr, and the restricted transfer potential is 116,995 acft/yr (Table 4C.3-3). When adjusted to the 320,000 acft/yr pumping cap and accounting for reductions during critical periods, these quantities are 43,351 acft/yr and 65,401 acft/yr, respectively, for unrestricted and restricted permits (Table 4C.3-3).

In the 2011 Regional Water Plan, irrigation transfers are included to meet projected needs of 17 municipal water user groups, in 2010 of 45,896 acft/yr, increasing to 48,931 acft/yr in 2030, and to 51,875 acft/yr in 2060 (quantities are part of the 320,000 acft/yr of firm yield used in the development of the 2011 plan) (Table 4C.3-4). IRP value of permits needed to obtain these quantities of firm yield increase from 82,039 acft/yr in 2010 to 87,464 acft/yr in 2030, and 92,727 acft/yr in 2060 (Table 4C.3-4).

Table 4C.3-3.
Edwards Aquifer Water Use Permits by Purpose of Use by County
South Central Texas Region

County	*Use Type*	*EAA Initial Regular Permits (acft/yr)*	*Unrestricted Transfer Potential[1] (acft/yr)*	*Permanent Transfers[2] (acft/yr)*	*Remaining Unrestricted Transfer Potential[3] (acft/yr)*	*320K Cap Drought Supply Equivalent[4] (acft/yr)*	*Remaining Restricted Transfer Potential[5] (acft/yr)*	*320K Cap Drought Supply Equivalent[4] (acft/yr)*
Atascosa	Municipal	384	384	0	384	215	0	0
	Industrial	0	0	0	0	0	0	0
	Irrigation	924	462	125	337	188	462	258
	Subtotal	**1,308**	**846**	**125**	**721**	**403**	**462**	**258**
Bexar	Municipal	237,343	237,343	548	236,795	132,369	0	0
	Industrial	30,866	30,866	34,786	0	0	0	0
	Irrigation	30,930	15,465	8,152	7,313	4,088	15,465	8,645
	Subtotal	**299,140**	**283,674**	**43,486**	**244,108**	**136,457**	**15,465**	**8,645**
Comal	Municipal	9,083	9,083	0	9,083	5,077	0	0
	Industrial	10,447	10,447	2,005	8,442	4,719	0	0
	Irrigation	966	483	8	475	266	483	270
	Subtotal	**20,496**	**20,012**	**2,013**	**17,999**	**10,062**	**483**	**270**
Guadalupe	Municipal	0	0	0	0	0	0	0
	Industrial	284	284	0	284	159	0	0
	Irrigation	0	0	0	0	0	0	0
	Subtotal	**284**	**284**	**0**	**284**	**159**	**0**	**0**
Hays	Municipal	7,243	7,243	72	7,171	4,009	0	0
	Industrial	2,786	2,786	0	2,786	1,557	0	0
	Irrigation	969	485	10	475	265	485	271
	Subtotal	**10,999**	**10,514**	**82**	**10,432**	**5,831**	**485**	**271**
Medina	Municipal	13,801	13,801	6	13,795	7,711	0	0
	Industrial	2,338	2,338	35	2,303	1,287	0	0
	Irrigation	78,882	39,441	12,400	27,041	15,116	39,441	22,048
	Subtotal	**95,021**	**55,580**	**12,441**	**43,139**	**24,115**	**39,441**	**22,048**
Uvalde	Municipal	15,827	15,827	0	15,827	8,847	0	0
	Industrial	2,448	2,448	245	2,203	1,231	0	0
	Irrigation	124,178	62,089	18,893	43,197	24,147	62,089	34,708
	Subtotal	**142,453**	**80,364**	**19,138**	**61,226**	**34,225**	**62,089**	**34,708**
Bexar, Medina, and Uvalde Counties Subtotals								
	Municipal	**266,970**	**266,970**	**554**	**266,416**	**148,927**	**0**	**0**
	Industrial	**35,652**	**35,652**	**35,066**	**4,506**	**2,519**	**0**	**0**
	Irrigation	**233,991**	**116,995**	**39,445**	**77,551**	**43,351**	**116,995**	**65,401**
	Subtotal	**536,613**	**419,618**	**75,064**	**348,473**	**194,797**	**116,995**	**65,401**
Edwards Aquifer Area Totals								
	Municipal	**283,680**	**283,680**	**626**	**283,054**	**158,228**	**0**	**0**
	Industrial	**49,168**	**49,168**	**37,071**	**16,017**	**8,953**	**0**	**0**
	Irrigation	**236,851**	**118,425**	**39,588**	**78,838**	**44,070**	**118,425**	**66,200**
	EAA Total	**569,699**	**451,274**	**77,284**	**377,909**	**211,251**	**118,425**	**66,200**

1 Calculated as 50% of irrigation and 100% of municipal & industrial Initial Regular Permit amounts.
2 Data provided by SAWS in March 2004 in yellow. Data provided by EAA and consist of sales from 1/1/2005 to 12/16/2009 in dark green. Light green is a combination of both SAWS and EAA data.
3 Unrestricted transfer potential net of permanent transfers.
4 Calculated as the pro-ration of Initial Regular Permits based on a 320,000 acft/yr cap.
5 Maximum amount potentially transferable with conversion of base to unrestricted irrigation groundwater by installation of water conservation equipment.

Table 4C.3-4.
Edwards Aquifer Water Transfers by County
South Central Texas Region

Entity	County	Year 2010 (acft)	2020 (acft)	2030 (acft)	2040 (acft)	2050 (acft)	2060 (acft)
Lytle	Atascosa	141	152	162	169	179	188
Subtotal		141	152	162	169	179	188
Alamo Heights	Bexar	592	655	657	653	667	691
Atascosa Rural WSC	Bexar	546	717	869	996	1,106	1,218
Kirby	Bexar	335	334	337	331	343	364
Universal City	Bexar	113	421	680	630	606	606
Water Ser Inc (Apex Water Ser)	Bexar	587	723	844	945	1,031	1,116
Windcrest	Bexar	235	235	235	235	235	235
Subtotal		2,408	3,085	3,622	3,790	3,988	4,230
Castroville	Medina	294	357	416	468	522	575
East Medina SUD	Medina	0	104	214	303	397	491
Hondo	Medina	319	536	740	910	1,083	1,252
La Coste	Medina	92	109	126	138	152	168
Natalia	Medina	194	238	279	314	349	383
Yancey WSC	Medina	214	395	562	710	851	985
County-Other	Medina	0	236	528	787	1,055	1,296
Subtotal		1,113	1,975	2,865	3,630	4,409	5,150
Sabinal	Uvalde	127	123	118	113	109	109
Uvalde	Uvalde	3,172	3,209	3,229	3,233	3,235	3,263
Subtotal		3,299	3,332	3,347	3,346	3,344	3,372
Subtotals		6,961	8,544	9,996	10,935	11,920	12,940
SAWS		35,935	35,935	35,935	35,935	35,935	35,935
BMWD		3,000	3,000	3,000	3,000	3,000	3,000
TOTAL Firm Supply (320,000 acft/yr)		**45,896**	**47,479**	**48,931**	**49,870**	**50,855**	**51,875**
IRP Value Permits Needed*		82,039	84,869	87,464	89,143	90,903	92,727

* IRP value of permits needed is 572,000/320,000 times the Firm Supply needed.

Given the quantities of transfers, as shown in Table 4C.3-4, the quantities of projected irrigation surpluses, irrigation water conservation potentials, and quantities of irrigation water conservation needed to meet projected irrigation needs in Bexar, Medina, and Uvalde Counties (Table 4C.3-5), there is a projected transfer of irrigation water to municipal and industrial uses in Bexar, Medina, and Uvalde Counties of 11,973 acft/yr in 2010, 1,362 acft/yr in 2030, and surpluses of 2,921 acft/yr, 6,416 acft/yr, and 9,696 acft/yr in 2040, 2050, and 2060, respectively (Table 4C.3-5); e.g.; the Edwards transfer water management strategies of the 2011 Regional

Table 4C.3-5.
Summary of Sources of Edwards Aquifer Water for Transfer
South Central Texas Region

Source of Supply	Year					
	2010 (acft)	2020 (acft)	2030 (acft)	2040 (acft)	2050 (acft)	2060 (acft)
Irrigation Surpluses						
Bexar County	9,737	10,369	10,215	10,790	11,340	11,868
Medina County	-4,994	-2,723	-549	1,534	3,529	5,441
Uvalde County	14,680	16,862	18,958	20,973	22,908	24,768
Subtotal	19,423	24,508	28,624	33,297	37,777	42,077
Irrigation Water Conservation Potentials						
Bexar County	2,366	2,366	2,366	2,366	2,366	2,366
Medina County	8,392	8,392	8,392	8,392	8,392	8,392
Uvalde County	8,736	8,736	8,736	8,736	8,736	8,736
Subtotal	19,494	19,494	19,494	19,494	19,494	19,494
Irrigation Water Conservation to Meet Needs						
Bexar County	0	0	0	0	0	0
Medina County	4,994	2,723	549	0	0	0
Uvalde County	0	0	0	0	0	0
Subtotal	4,994	2,723	549	0	0	0
Total Available						
(Surpluses + Cons Potential - Cons to Meet Needs)	33,923	41,279	47,569	52,791	57,271	61,571
Firm Supply Transfers	45,896	47,479	48,931	49,870	50,855	51,875
Change in Supply for Irrigation *	-11,973	-6,200	-1,362	2,921	6,416	9,696
Projected Irrigation Demand						
Bexar County	15,273	14,628	14,010	13,417	12,850	12,306
Medina County	54,450	52,179	50,005	47,922	45,927	44,015
Uvalde County	55,791	53,609	51,513	49,498	47,563	45,703
Subtotal	125,514	120,416	115,528	110,837	106,340	102,024
Transfer as Percent of Projected Irrigation Demand	9.54%	5.15%	1.18%	2.64%	6.03%	9.50%

* Irrigation surpluses plus irrigation conservation potentials minus irrigation conservation to meet projected needs minus Firm Supply Transfers equals net quantities of transfers from irrigation to municipal uses.

Water Plan result in transfers of projected irrigation water surpluses, a part of the quantities of irrigation water conservation, and water that was projected to be used in irrigation in the quantities shown in Table 4C.3-5. The quantity that would be transferred from irrigation uses is 9.54 percent of the projected irrigation demand in 2010, 1.18 percent in 2030, and 6.03 percent in 2050 (Table 4C.3-5). In 2060, there is an estimated 9,696 acft/yr of unused irrigation water that is not projected to be transferred (Table 4C.3-5).

4C.3.2 Edwards Aquifer Irrigation Water Supply and Water Cost Information

In the Edwards Aquifer area, irrigation with water from the aquifer and from the Medina Lake System supplements annual precipitation, which averages 25 inches in the west and 28 inches in the east.[2] The quantity of irrigation water applied per acre can vary from a few inches when precipitation is above average to as much as 42 inches on some high water demand crops during drought years.

Water from the Edwards Aquifer is used in Bexar, Medina, and Uvalde Counties for irrigation of crops such as corn, cotton, grain sorghum, wheat, vegetables, and forage for livestock. Although cotton, corn, grain sorghum, wheat and forage for livestock, can be produced in Bexar, Medina, and Uvalde Counties without irrigation, the yields per acre are only about one-third to one-half those on irrigated acres (Table 4C.3-6). In the case of vegetables and oil seed crops, dryland production is not possible in most years. Thus, without a supply of irrigation water, the total value of agricultural commodities marketed in this part of the South Central Texas Region would be reduced, and agricultural marketing establishments' business levels could be lowered.

Average annual irrigated acreage in the Bexar, Medina, and Uvalde Counties area for the 1996 through 2000 period was approximately 104,022 acres, with average annual irrigation water use of 170,746 acft, of which approximately 122,100 acft/yr was from the Edwards Aquifer (Table 4C.3-7).[3] Of total water use of 170,746 acft/yr, approximately 7.9 percent was applied to cotton, 8.3 percent was used for the production of Grain Sorghum, 48.62 percent was used to grow corn, 6.19 percent was used to produce wheat and other small grains, 11.23 percent was used to grow hay, forage, and pasture, 11.67 percent was used to produce vegetables, and 6.09 percent was used for all other crops (Table 4C.3-7).

[2] Texas Department of Water Resources, "Climatic Atlas of Texas," LP-192, December 1983.

[3] "Edwards Aquifer Authority Hydrologic Data Report for 2003," Edwards Aquifer Authority, San Antonio, Texas, June 2004.

Table 4C.3-6
Dryland and Irrigated Crop Yields*
Bexar, Medina and Uvalde Counties
South Central Texas Region

Crop	*Dryland*	*Irrigated*
Corn	60 bu/acre	115 bu/acre
Cotton	350 lbs/acre	960 lbs/acre
Grain Sorghum	3,000 lbs/acre	5,000 lbs/acre
Guar	800 lbs/acre	1,850 lbs/acre
Peanuts	**	3,500 lbs/acre
Sesame	**	1,250 lbs/acre
Winter Wheat/Grain	20 bu/acre	40 bu/acre
Winter Wheat/Grazing	45 days/acre	90 days/acre
Spring Wheat/Grain	10 bu/acre	50 bu/acre
Beets/Processing	**	14 tons/acre
Cabbage	**	16 tons/acre
Cantaloupe	**	300 cartons/acre
Carrots/Fresh	**	12 tons/acre
Carrots/Processing	**	14 tons/acre
Cucumbers/Fresh	**	6.25 tons/acre
Cucumbers/Pickles	**	8 tons/acre
Lettuce	**	12.5 tons/acre
Onions	**	18.75 tons/acre
Spinach/Fresh	**	450 bu/acre
Spinach/Processing	**	11 tons/acre
Forage		
Coastal Bermuda/Pasture	200 days/acre***	600 days/acre***
Coastal Bermuda/Hay	**	10 tons/acre
Forage Sorghum/Grazing	**	600 days/acre***
Forage Sorghum/Hay	4.5 tons/acre	10 tons/acre

*Source: “Texas Crop Enterprise Budgets, Southwest Texas District;” Peña, Jose G.; Texas Agricultural Extension Service, Texas A&M University System; Uvalde, Texas, 1997. The yields per acre listed here are indications of potential yields for high level farm and ranch management and favorable weather conditions, as opposed to projections of yields for average conditions.

** Not produced dryland.

*** May stock more than one animal unit per acre.

Table 4C.3-7.
Estimated Differences between Dryland and Irrigated Income and Costs of Purchased Inputs*
Bexar, Medina, and Uvalde Counties
South Central Texas Region

Major Crop Irrigated	Acres Irrigated 1996--2000** Average	Percent of Total Acres (%)	Irrigation Water Applied **		Total Income per Acre		Purchased Inputs per Acre		Difference per Acre		Region Difference Total		Irrigation Water Used (%)
			(acft)	(acft/acre)	Dryland (dollars)	Irrigated (dollars)	Dryland (dollars)	Irrigated (dollars)	Income (dollars)	Inputs (dollars)	Income (dollars)	Inputs (dollars)	
Field Crops													
Cotton	7,717	7.42	13,503	(1.75)	270	811	248	590	541	342	4,175,005	2,639,282	7.91
Grain Sorghum	10,788	10.37	14,168	(1.31)	142	308	122	207	166	85	1,790,742	916,946	8.30
Corn	48,060	46.20	83,017	(1.73)	165	342	142	266	177	124	8,506,620	5,959,440	48.62
Wheat & Other Grain	9,796	9.42	10,570	(1.08)	140	220	88	157	80	69	783,680	675,924	6.19
Subtotal	76,361	73.41	121,258	(1.59)	169	369	143	276	200	133	15,256,047	10,191,592	71.02
Hay, Forage & Past[1]	10,431	10.03	19,180	(1.84)	167	553	174	457	386	283	4,026,212	2,951,860	11.23
Subtotal (Field & Forage)	86,792	83.43	140,438	(1.62)							19,282,258	13,143,452	82.25
Vegetables													
Shallow Rooted[2]	6,387	6.14	9,472	(1.48)	***	3,560	***	2,944	3,560	2,944	22,737,008	18,802,739	5.55
Deep Rooted[3]	6,849	6.58	10,446	(1.53)	***	1,068	***	760	1,068	760	7,314,305	5,204,936	6.12
Subtotal Vegetables	13,236	12.72	19,918	(1.50)					2,271	1,814	30,051,313	24,007,675	11.67
All Other Crops	3,995	3.84	10,390	(2.60)	***	772	***	264	772	264	3,084,294	1,054,733	6.09
Total for All Crops	104,022	100.00	170,746	(1.64)							52,417,866	38,205,860	100.00

* Source: "Texas Crop Enterprise Budgets, Southwest Texas District," Peña, Jose G.: Texas Agricultural Extension Service, Texas A&M University System, Uvalde, Texas , 2004. All income and input dollars are in 2004 prices.

** Annual Irrigation Surveys, Texas Water Development Board, Austin, Texas. For the 1996 through 2000 period, according to the EAA Hydrologic Data Report of 3003, average annual irrigation water use from the Edwards Aquifer was 122,100 acre-feet per year. The total Edwards Aquifer water use for Bexar, Medina, and Uvalde Counties in year 2000 was reported at 78,600 acre-feet.

1 Coastal Bermuda, Alfalfa, and Forage Sorghum.

2 Shallow Rooted Vegetables (cabbage, lettuce, onions, and spinach).

3 Deep Rooted Vegetables (beets, cantaloupes, carrots, and cucumbers).

*** Not produced dryland.

4C.3.3 Regional Economic Effects of Edwards Irrigation Water Transfer

Any reduction in irrigation that would occur due to lease or sale of Edwards Aquifer irrigation permits would result in reduced value of production of crops, that in turn would result in reduced demand for agricultural production inputs and agricultural marketing and processing services, and of course, farm incomes would be lower. Reduced irrigation would result in lower irrigated agriculture purchases of production inputs from other sectors of the economy, including seed, fertilizer, herbicides, insecticides, fuel, machinery, equipment, labor, transportation, and financial and business services. In addition, of course, there would be less grain, fiber, and vegetables sold to the agriculture processing sectors, thereby reducing business for the agricultural marketing, food and fiber processing, transportation, storage, warehousing, and related non-farm sectors of the economy. These economic impacts associated with reductions in irrigation are estimated below.

The sale or lease of irrigation permits for which the water is used to produce cotton, grain sorghum, and wheat and other grain, with the acreage affected being converted to dryland production of the same crops, would reduce gross farm income by $200 per acre and reduce purchased inputs by $133 per acre of irrigated land for which the irrigation water is sold or leased. On a per acre-foot of water basis, the farm income effect is $126, and the purchased inputs effect is $84. (The computations are from data in Table 4C.3-5 and are as follows: regional difference between irrigation and dryland income for cotton, grain sorghum, corn and wheat and other grains is $15,282,047; regional difference in purchased inputs is $10,191,592, and quantity of irrigation water is 121,258 acft. $15,282,047 ÷ 121,258 = $126 per acft for the income effect, and $10,191,592 ÷ 121,258 = $84 for the purchased inputs effects.)

The total output multiplier for crop production in the region is estimated at 2.24, which means that for each dollar of crop value at the farm, the total business effect within the area is $2.24.[4] Given this multiplier, the impact of a change of 1 acft in irrigation water use to produce cotton, grain sorghum, and wheat and other grains has an estimated economy-wide business effect of $448 per acft/year ($200 per acft x 2.24 = $448).

[4] Unpublished Output Multipliers; Lonnie L. Jones, Ph.D., Department of Agricultural Economics, Texas A&M University, College Station, Texas, April 1994.

In the case of vegetable production, the gross income effect per acft of water used is $1,508 per year (Table 4C.3-5), resulting in an estimated economy-wide business effect of $3,378 per acft/yr ($1,508 per acft x 2.24 = $3,378), of which $1,508 is the farm value and $1,870 is the off-farm gross business value.

The estimated farm income effect of the projected transfer of water from irrigation to municipal and industrial uses is estimated at $1.51 million per year in 2010, $0.78 million per year in 2020, and $0.17 million per year in 2030 (Table 4C.3-8). The reduction in value of purchased inputs in 2010 is $1.01 million per year, $0.52 million per year in 2020, and $0.11 million per year in 2030 (Table 4C.3-8). The total economic impact of the transfers is estimated at $3.38 million annually in 2010, $1.75 million in 2020, and $0.38 million annually in 2030 (Table 4C.3-8).

Recently, sales and leases of irrigation IRPs for municipal and industrial use have been made, with lease rates for 5 to 10 year terms at rates of $100/acft/yr to $128/acft/yr. In 2009, fee simple purchase price of Edwards IRPs has been in the range of $5,500 to $6,500 per acre foot.[5] An IRP lease price of $127.50/acft/yr is equivalent to a firm supply lease price of $228/acft/yr ($127.50 x 572,450/320,000). Similarly, an IRP purchase price of $5,500/acft amortized at 6 percent interest for 20 years is equivalent to a firm supply purchase price of $845.87/acft/yr. In addition, there are integration costs associated with facility upgrades on the buyer's facilities that add an additional $226/acft/yr to the cost. Therefore, cost estimates for Edwards Transfers in the 2011 SCTRWP are based on the lease price of $454/acft/yr. The annual cost of planned firm supply transfers of 51,875 acft/yr is estimated at $23,551,250.

4C.3.4 Environmental Issues

The primary environmental concerns associated with Edwards Irrigation Transfers are the conversion of irrigated land to dryland crops or grassland, or a combination of dryland crops and grassland. Since both dryland crop and range grasslands are present within the area, demonstrating that dryland and range grasslands are possible for the region, the major concern is with establishment of vegetation upon acreages to be returned to grassland or range vegetation. An additional concern involves potential reductions in discharge at Comal and San Marcos Springs associated with increased pumpage from municipal wells closer to the springs.

[5] Actual prices paid by San Antonio Water System and City of New Braunfels in 2009.

Table 4C.3-8.
Estimated Economic Effects of Irrigation Water Transfer
Bexar, Medina and Uvalde Counties
South Central Texas Region

Factors	Units	Year					
		2010	2020	2030	2040	2050	2060
Irrigation Transfers (Unused Irrigation)*	Acre-Feet	11,973	6,200	1,362	0	0	0
Economic Effects Per Unit							
Farm Income Per Acre-Foot	Dollars	126	126	126	126	126	126
Purchased Inputs Per Acre-Foot	Dollars	84	84	84	84	84	84
Total Output Multiplier	Dollars	2.24	2.24	2.24	2.24	2.24	2.24
Regional Economic Effects							
Total Farm Income	Million Dollars	1.51	0.78	0.17	0.00	0.00	0.00
Total Purchased Inputs	Million Dollars	1.01	0.52	0.11	0.00	0.00	0.00
Total Economic Impact	Million Dollars	3.38	1.75	0.38	0.00	0.00	0.00

* Irrigation surpluses plus irrigation conservation potentials minus irrigation conservation to meet projected needs minus Firm Supply Transfers equals net quantities of transfers from irrigation to municipal and industrial uses (Table 4C.3-3).

It is expected that dryland crop production can be carried out on acreages that were previously irrigated. However, fallow farmland to be converted to grassland with no native grass plantings could become infested with opportunistic weeds, followed by slower growing native thornbrush plants characteristic of the surrounding unimproved rangelands. Recovery of the land could take two decades or more, depending on use for cattle grazing and brush management practices. These lands, along with lands converted to improved rangeland, would eventually provide additional native species habitat. A program of converting cropland to native grasses would speed the process of reaching a mature native plant community and reduce the opportunity for soil erosion through water and winds. Such a program could provide habitat for native Texas wildlife, including the horned toad, tortoises, deer, hawks, and other dessert grassland species. The cost of seeding is not included in the purchase or lease price of the water.

No impacts to cultural resources are anticipated since this strategy does not involve construction.

4C.3.5 Water Quality and Treatability

No change is expected in water quality, since this water management strategy would reduce pumpage of Edwards Water for irrigation and allow equivalent quantities to be pumped for municipal and industrial purposes.

4C.3.6 Implementation Issues

The leasing and purchasing of Edwards Irrigation Water for municipal and industrial uses is being done to at the present time. Further implementation of this strategy will involve:

1. Willingness of Edwards Irrigation Permit holders to sell or lease permits issued for irrigation.
2. Approval by EAA of permit transfer and/or leases and compliance with critical period and other rules of the EAA.
3. Further evaluation of potential economic effects associated with the conversion from irrigated to other types of land use.
4. Further evaluation of potential effects of relocation of pumpage centers on discharges from Comal and San Marcos Springs and/or on species dependent upon Edwards Aquifer or spring habitats.

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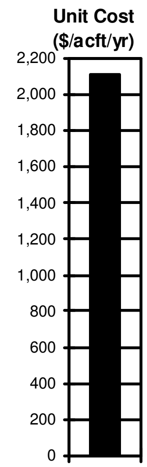
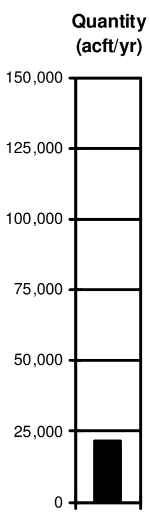
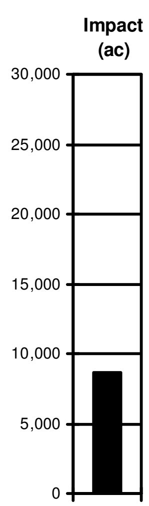
2011 South Central Texas Regional Water Plan
Water Management Strategy Summary Sheet







Name: **Edwards Aquifer Recharge — Type 2 Projects, Program 2A**

Description: Recharge enhancement structures (dams) located atop the Edwards Aquifer recharge zone on streams that are often dry. Structures impound flood waters that recharge the aquifer by direct percolation with the reservoir surface falling at rates on the order of 2 to 3 ft/day. Planned projects include: Indian Creek (with supplemental transmission system to the Dry Frio River), Lower Frio, Lower Sabinal, Lower Hondo, Lower Verde, San Geronimo, Northern Bexar / Medina County Projects, Salado Creek FRS, Cibolo Dam No. 1, Dry Comal, and Lower Blanco (with supplemental transmission system to the upper San Marcos watershed). The SCTRWPG recommends Program 2C for implementation by year 2020 with potential expansion to include the additional projects in Program 2A by year 2060. The SCTRWPG further recognizes that development of alternative projects at some or all of these sites is consistent with the 2006 Regional Water Plan.

***Decade Needed*:** 2050 – 2060

Cost, Quantity of Water, and Land Impacted

Unit Cost of Water:	**2,005**	**$/acft/yr**	**Raw Water in Aquifer**
Quantity of Water:	**21,577**	**acft/yr[1]**	**Reliability = Firm**
Land Impacted:	**8,713**	**acres**	

[1]**Quantity of water based on increase in sustained yield computed using the GWSIM-IV model of the Edwards Aquifer.**

Additional Considerations per Regional Water Planning Guidelines

Environmental Factors:

Enhanced springflows support endangered species at Comal & San Marcos Springs. Periodic inundation of reservoir areas may affect endangered arthropods (spiders, beetles, & harvestman) and local terrestrial habitat. Nueces (Indian Creek), Frio, Sabinal, and Blanco sites are located in Ecologically Significant River & Stream Segments per TPWD.

Impacts on Water Resources:

Edwards recharge enhancement increases regional aquifer levels, increases discharge from major springs (e.g., Comal, San Marcos, Leona), and reduces water available to some downstream water rights (e.g., Corpus Christi Reservoir System). Small reductions in Carrizo Aquifer recharge, primarily in the Nueces River Basin.

Impacts on Agricultural & Natural Resources:

Typically higher aquifer levels in Uvalde and Medina Counties.

Other Relevant Factors per SCTRWPG:

EAA aquifer storage and recharge recovery rules. Mitigation of impacts on firm yield of Corpus Christi Reservoir System. Ongoing feasibility studies by USACE in cooperation with SAWS, SARA, GBRA, NRA, EAA, Corpus Christi, TWDB, TPWD, and TCEQ.

Comparison of Strategies to Meet Needs:

Broad range of unit costs among potential recharge programs and individual projects (e.g., Program 2C provides 13,451 acft/yr at a unit cost of $888/acft/yr. The incremental unit cost of new supply between Programs 2C and 2A is $3,855/acft/yr. No conflicts with other recommended water management strategies.

Interbasin Transfer Issues: Not applicable.

Third-Party Impacts of Voluntary Transfers: Not applicable.

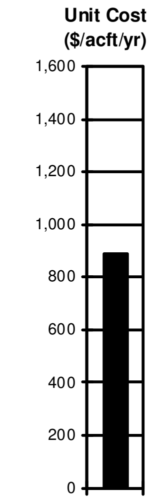
Regional Efficiency:

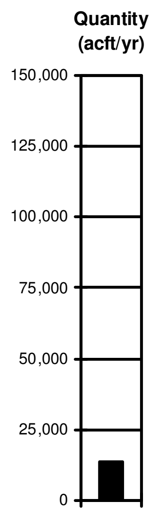
Enhanced Recharge can be recovered using existing wells.

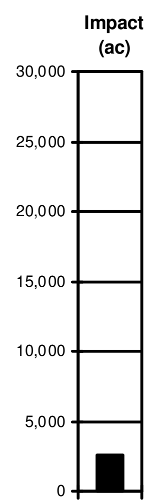
Water Quality Considerations:

Projects in urbanizing watersheds may increase risk of introducing contaminants to aquifer.

2011 South Central Texas Regional Water Plan
Water Management Strategy Summary Sheet







Name: Edwards Aquifer Recharge — Type 2 Projects, Program 2C

Description: Recharge enhancement structures (dams) located atop the Edwards Aquifer recharge zone on streams that are often dry. Structures impound flood waters that recharge the aquifer by direct percolation with the reservoir surface falling at rates on the order of 2 to 3 ft/day. Planned projects include: Lower Frio, Lower Sabinal, Lower Hondo, Lower Verde, Salado Creek FRS, and Cibolo Dam No. 1. The SCTRWPG recommends Program 2C for implementation by year 2020 with potential expansion to include the additional projects in Program 2A by year 2060. The SCTRWPG further recognizes that development of alternative projects at some or all of these sites is consistent with the 2006 Regional Water Plan.

***Decade Needed*:** 2010 – 2020

Cost, Quantity of Water, and Land Impacted

Unit Cost of Water:	**888**	**$/acft/yr**	**Raw Water in Aquifer**
Quantity of Water:	**13,451**	**acft/yr[1]**	**Reliability = Firm**
Land Impacted:	**2,595**	**acres**	

[1]Quantity of water based on increase in sustained yield computed using the GWSIM-IV model of the Edwards Aquifer.

Additional Considerations per Regional Water Planning Guidelines

Environmental Factors:

Enhanced springflows support endangered species at Comal & San Marcos Springs. Periodic inundation of reservoir areas may affect endangered arthropods (spiders, beetles, & harvestman) and local terrestrial habitat. Frio and Sabinal sites are located in Ecologically Significant River & Stream Segments per TPWD.

Impacts on Water Resources:

Edwards recharge enhancement increases regional aquifer levels, increases discharge from major springs (e.g., Comal, San Marcos, Leona), and reduces water available to some downstream water rights (e.g., Corpus Christi Reservoir System). Small reductions in Carrizo Aquifer recharge, primarily in the Nueces River Basin.

Impacts on Agricultural & Natural Resources:

Typically higher aquifer levels in Uvalde and Medina Counties.

Other Relevant Factors per SCTRWPG:

EAA aquifer storage and recharge recovery rules. Mitigation of impacts on firm yield of Corpus Christi Reservoir System. Ongoing feasibility studies by USACE in cooperation with SAWS, SARA, GBRA, NRA, EAA, Corpus Christi, TWDB, TPWD, and TCEQ.

Comparison of Strategies to Meet Needs:

Broad range of unit costs among potential recharge programs and individual projects (e.g., Program 2C provides 13,451 acft/yr at a unit cost of $888/acft/yr. The incremental unit cost of new supply between Programs 2C and 2A is $3,855/acft/yr. No conflicts with other recommended water management strategies.

Interbasin Transfer Issues: Not applicable.

Third-Party Impacts of Voluntary Transfers: Not applicable.

Regional Efficiency:

Enhanced Recharge can be recovered using existing wells.

Water Quality Considerations:

Projects in urbanizing watersheds may increase risk of introducing contaminants to aquifer.

4C.4 Edwards Aquifer Recharge — Type 2 Projects

4C.4.1 Description of Water Management Strategy

Two types of recharge enhancement reservoirs have been analyzed and optimized in a series of studies[1,2,3,4,5,6] sponsored by the Edwards Underground Water District and others beginning in 1990. This water management strategy deals with the potential construction of Type 2 projects, which are immediate recharge structures located within the Edwards Aquifer recharge zone. Type 2 structures are, generally speaking, normally dry and impound water for only a few days or weeks following storm events. These structures recharge water very quickly to the aquifer, typically draining at a rate of 2 to 3 feet per day. This large recharge rate minimizes evaporation losses and maximizes recharge.

The approximate location of each of the major Type 2 recharge projects recommended for development is shown in Figure 4C.4-1. Five of the projects are located in the Nueces River Basin and affect inflows to the CCR/LCC System and the Nueces Estuary. These five projects include Indian Creek, Lower Frio, Lower Sabinal, Lower Hondo, and Lower Verde. Other previously identified Type 2 sites in the Nueces River Basin are not recommended because the quantity of enhanced recharge during the drought is extremely small and the associated unit costs are extremely high.

In the Guadalupe-San Antonio River Basin, up to nine new recharge projects are being considered for development or further study. These include San Geronimo, Cibolo Dam No. 1, Dry Comal, Lower Blanco, and up to five small Soil Conservation Service (SCS) type reservoirs in northern Bexar and Medina Counties. Other previously identified recharge enhancement projects in the Guadalupe-San Antonio River Basin recommended for development or further

[1] HDR Engineering, Inc. and Geraghty and Miller, Inc., "Nueces River Basin Regional Water Supply Planning Study, Phase I," Vols. 1, 2, and 3, Nueces River Authority, et al., May 1991.
[2] HDR, "Nueces River Basin Regional Water Supply Planning Study, Phase III – Recharge Enhancement," Nueces River Authority, November 1991.
[3] HDR, "Nueces River Basin, Edwards Aquifer Recharge Enhancement Project, Phase IVA," Edwards Underground Water District, June 1994.
[4] HDR, "Nueces River Basin, Edwards Aquifer Recharge Enhancement Project, Phase IVB, Technical Memorandum, Combined Impacts of Frio, Sabinal, Hondo, and Verde Recharge Enhancement Projects on Downstream Water Rights," December 12, 1995.
[5] HDR, "Guadalupe-San Antonio River Basin Recharge Enhancement Study," Vols. I, II, and III, Edwards Underground Water District, September 1993.
[6] HDR, "Guadalupe-San Antonio River Basin Recharge Enhancement Study Feasibility Assessment," Trans-Texas Water Program, West Central Study Area, Phase II, Edwards Aquifer Recharge Analyses, San Antonio River Authority, et al., March 1998.

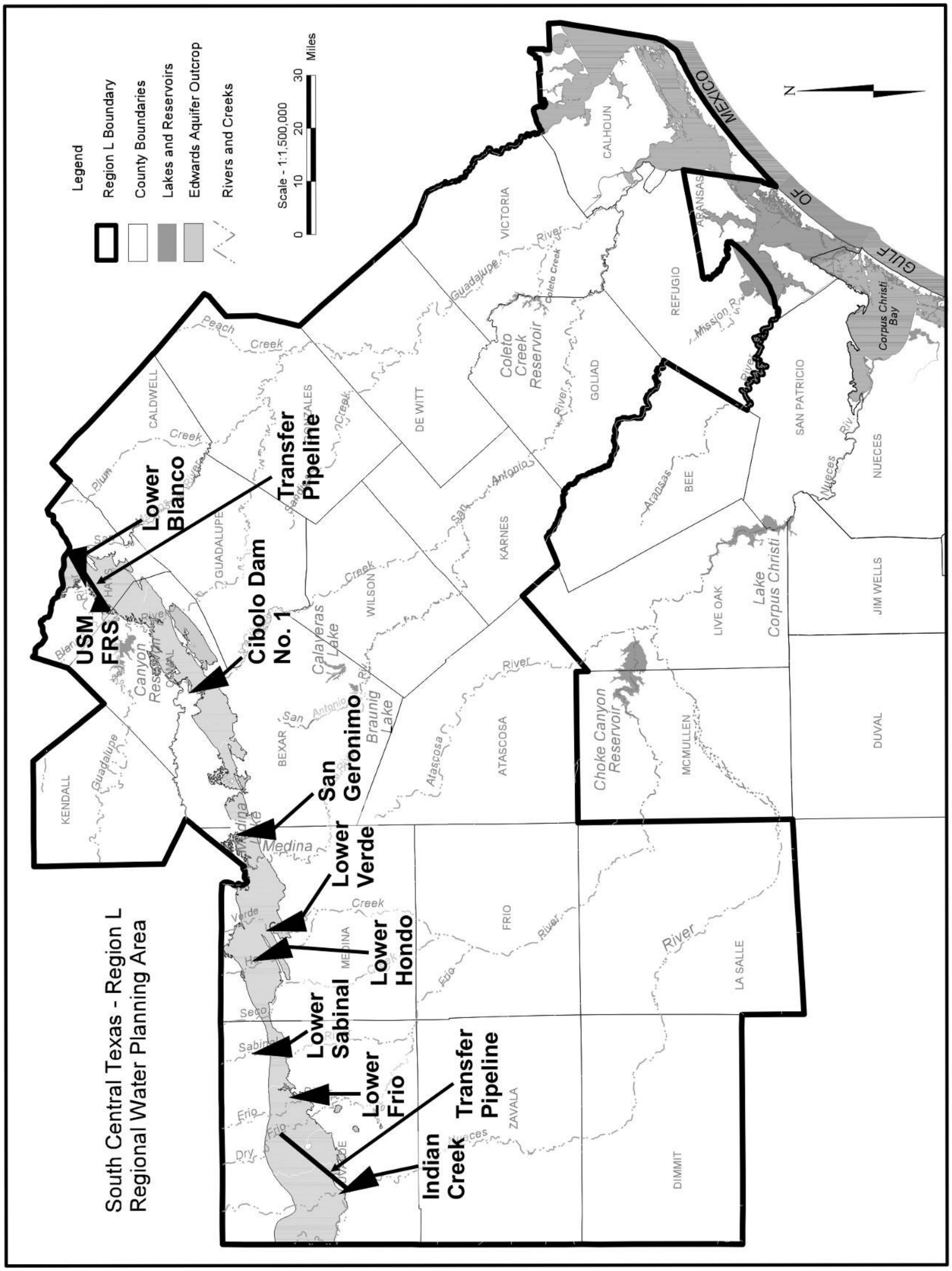


Figure 4C.4-1. Edwards Aquifer Recharge - Type 2 Projects study include projects to modify the outlets on some existing SCS Floodwater Retarding Structures (SCS-FRS) in the Salado Creek watershed. These modifications would either close or restrict the outlets on existing SCS-FRS dams resulting in additional recharge.

The Type 2 projects in the Nueces and Guadalupe-San Antonio River Basins have all been considered in previous studies that included some fairly detailed cost analyses. For these projects, an optimum size has previously been determined for each project. Three Type 2 Programs consisting of up to 14 potential new storage projects and two modifications to existing dams to increase recharge are presented herein. The projects included in each of the three programs are identified below.

4C.4.1.1 Program 2A

- Nueces River Basin:
  - Indian Creek (with recharge diversions to Dry Frio River),
  - Lower Frio,
  - Lower Sabinal,
  - Lower Hondo, and
  - Lower Verde.
- Guadalupe-San Antonio River Basin:
  - Lower Blanco (with recharge diversions to San Marcos FRS),
  - Cibolo Dam No. 1,
  - San Geronimo, and
  - Northern Bexar/Medina County Projects:
    - Limekiln,
    - Culebra,
    - Government Canyon,
    - Deep Creek, and
    - Salado Dam No. 3.
- Dry Comal, and
- Salado Creek FRS:
  - Modifications to spillways at existing dams 11 and 13B.

4C.4.1.2 Program 2B

- Nueces River Basin:
  - Lower Frio,
  - Lower Sabinal,
  - Lower Hondo, and
  - Lower Verde.

- Guadalupe-San Antonio River Basin:
  - Lower Blanco (with recharge diversions to San Marcos FRS),
  - Cibolo Dam No. 1,
  - San Geronimo, and
  - Salado Creek FRS:
    - Modifications to spillways at existing dams 11 and 13B.

4C.4.1.3 Program 2C

- Nueces River Basin:
  - Lower Frio,
  - Lower Sabinal,
  - Lower Hondo, and
  - Lower Verde.
- Guadalupe-San Antonio River Basin:
  - Cibolo Dam No. 1, and
  - Salado Creek FRS:
    - Modifications to spillways at existing dams 11 and 13B.

The projects in Program 2A would impound a combined maximum recharge pool storage of 170,309 acft and periodically inundate 8,448 acres, as shown in Table 4C.4-1. At the other extreme, Program 2C would impound up to 42,650 acft in the combined recharge storage pools for projects in this program and periodically inundate about 2,595 acres. The South Central Texas Regional Water Planning Group (SCTRWPG) has chosen to recommend Program 2C for implementation by year 2020 with potential expansion to include the additional projects in Program 2A by year 2060. The SCTRWPG further recognizes that development of alternative projects at some or all of these sites (either larger or smaller in capacity) is consistent with the 2006 Regional Water Plan.

4C.4.2 Available Yield

Available yield or recharge enhancement volumes were calculated for the Type 2 structures using the Nueces River Basin Model and the Guadalupe-San Antonio River Basin Model, subject to average and drought conditions. <u>Average conditions</u> represent the average annual recharge enhancement rate for the entire 56-year simulation period (1934 to 1989). <u>Drought conditions</u> represent the average annual recharge enhancement rate for the 10-year period from 1947 through 1956, which is when the most severe drought on record occurred. Analyses of recharge enhancement projects presented in this study were performed honoring all existing water rights to the maximum extent possible, with one exception. This exception involves the water rights of the CCR/LCC System, in which case impacts were not mitigated by releases, but were assumed to be mitigated by remuneration and/or development of additional water supply for the Corpus Christi service area.

Table 4C.4-1.
Summary of Recharge Enhancement Potential for Type 2 Recharge Programs

Type 2 Project Program	Capacity (acft)	Surface Area (acres)	Recharge Enhancement: 1934 to 1989 Average Conditions (acft/yr)	Recharge Enhancement: 1947 to 1956 Drought Conditions (acft/yr)	Reduction in Average Nueces Estuary Inflow (acft/yr)	Reduction in CCR/LCC System Yield (acft/yr)	Reduction in Drought Average Guadalupe Estuary Inflow (acft/yr)
Program 2A	170,309	8,448	134,434	50,032	14,590	4,308	13,269
Program 2B	96,150	4,186	108,003	34,788	11,592	1,355	13,026
Program 2C	42,650	2,595	54,471	10,034	11,592	1,355	500

1 Estuarine inflow reduction and CCR/LCC System yield reductions estimated by the addition of Indian Creek Project impacts from "Edwards Aquifer Recharge Enhancement Project, Phase IVA" and the analysis in footnote 2 below.
2 Estimates of estuarine inflow reduction and CCR/LCC System yield reduction quantities were taken from "Nueces River Basin, Edwards Aquifer Recharge Enhancement Project, Phase IVB, Technical Memorandum, Combined Impacts of Frio, Sabinal, Hondo, and Verde Recharge Enhancement Projects on Downstream Water Rights," December 12, 1995, prepared by HDR Engineering, Inc.
3 Estimates of drought average (1947 to 1956) estuarine inflow reductions for all Guadalupe-San Antonio River Basin Projects were taken from "Guadalupe-San Antonio River Basin Recharge Enhancement Study Feasibility Assessment," West Central Study Area, Trans-Texas Water Program, Phase II, Edwards Aquifer Recharge Analysis.

For the Type 2 Recharge Program 2A, recharge could be enhanced by 134,434 acft/yr for average conditions and 50,032 acft/yr for drought conditions as shown in Table 4C.4-1. The impact on the CCR/LCC System totals 4,308 acft/yr for the Type 2 Program 2A, which represents about 2 percent of the system firm yield. Estimates indicate that Type 2 Recharge Program 2B could enhance recharge by 108,003 acft/yr for average conditions and 34,788 acft/yr during drought. Program 2B impacts CCR/LCC System yield by 1,355 acft/yr (less than 1 percent). Program 2C could enhance recharge in the Nueces and Guadalupe-San Antonio River Basins by 54,471 acft/yr and 10,034 acft/yr, during average and drought conditions, respectively. Impacts to CCR/LCC System yield under Program 2C are the same as under Program 2B.

Application of the Consensus Criteria for Environmental Flow Needs (CCEFN) for reservoir pass-throughs for instream flows was included in this analysis for the Type 2 recharge projects. The only potential recharge dams that required reservoir pass-throughs were Indian Creek and Lower Blanco. Tables 4C.4-2 and 4C.4-3 contain the streamflow statistics used to

Table 4C.4-2
Daily Naturalized Streamflow Statistics for
Indian Creek Edwards Recharge - Type II Project

Month	Median Flows - Zone 1 Pass-Through Requirement (cfs)	25th Percentile Flows - Zone 2 Pass-Through Requirement (cfs)
January	25.2	22.2*
February	23.7	22.2*
March	22.2*	22.2*
April	23.2	22.2*
May	26.2	22.2*
June	28.2	22.2*
July	29.2	22.2*
August	28.2	22.2*
September	24.7	22.2*
October	30.8	22.2*
November	30.2	22.2*
December	27.2	22.2*
Zone 3 Pass-Through Requirement (cfs)		22.2
** Zone 3 Pass-Through Requirement exceeds 25th Percentile Flow and Median Flow.*		

Table 4C.4-3
Daily Naturalized Streamflow Statistics for
Lower Blanco Edwards Recharge - Type II Project

Month	Median Flows - Zone 1 Pass-Through Requirement (cfs)	25th Percentile Flows - Zone 2 Pass-Through Requirement (cfs)
January	40.3	14.6*
February	51.4	14.6*
March	45.4	14.6*
April	67.6	15.1
May	76.1	23.2
June	68.1	27.7
July	37.3	14.6*
August	16.6	14.6*
September	24.2	14.6*
October	29.2	14.6*
November	29.2	14.6*
December	40.3	14.6*
Zone 3 Pass-Through Requirement (cfs)		14.6
** Zone 3 Pass-Through Requirement exceeds 25th Percentile Flow and Median Flow.*		

apply CCEFN for Indian Creek and Lower Blanco, respectively. The criteria were not significant at other sites because, under normal weather conditions, the streams on which these sites are located do not contribute flows downstream of the recharge zone. The maximum impact on the average inflow to the Nueces Estuary due to the five Nueces River Basin projects (Program 2A) is a reduction of about 14,590 acft/yr, or about 6 percent. The impact of the remaining sites on the average inflow to the Guadalupe Estuary (as measured at the Guadalupe River Saltwater Barrier) would be a reduction of about 13,300 acft/yr, or about 1 percent under Program 2A during drought (1947 to 1956). The impact of Program 2C on average inflows to the Nueces Estuary is about 11,590 acft/yr, or about 4.5 percent, and to the Guadalupe Estuary, is 500 acft/yr.

Once monthly recharge enhancement amounts were computed for each potential project, they were added to the baseline recharge for the GWSIM-IV Model of the Edwards Aquifer at the spatial locations representing the proposed recharge enhancement projects. Figure 4C.4-2 shows the Edwards Aquifer GWSIM-IV Model cell grid with an overlay of the streams and major reservoirs in the model area. Also shown in this figure are the approximate locations of the recharge enhancement projects modeled. Recharge enhancement estimates from the surface water models for Program 2A, Program 2B, and Program 2C were distributed into the appropriate recharge zone cells in the GWSIM-IV Model. Application of the GWSIM-IV Model provides a basis for determining additional groundwater that could potentially be withdrawn under a recharge recovery permit[7] for each Type 2 Recharge Enhancement Program (Appendix C). It is noted, however, that rules governing recharge recovery have yet to be applied at this scale by the Edwards Aquifer Authority. A summary of the sustained yield pumpage increase associated with each Type 2 Recharge Enhancement Program is presented in Table 4C.4-4. Quantification of an increase in sustained yield of the Edwards Aquifer during the drought of record provides a means for direct comparison of recharge enhancement strategies with surface water supply strategies under TWDB rules for regional water supply planning.

Figure 4C.4-3 summarizes the results of the GWSIM-IV Model runs used to determine the change in sustained yield associated with enhanced recharge for Program 2A. With long-term average enhanced recharge of 134,434 acft/yr, the sustained yield pumpage was found to increase by 21,577 acft/yr (16 percent of the average annual enhancement). The majority of the

[7] HDR, "Introduction to Technical Application Requirements for Artificial Recharge Contracts and Recharge Recovery Permits," Edwards Aquifer Authority, December 1998.

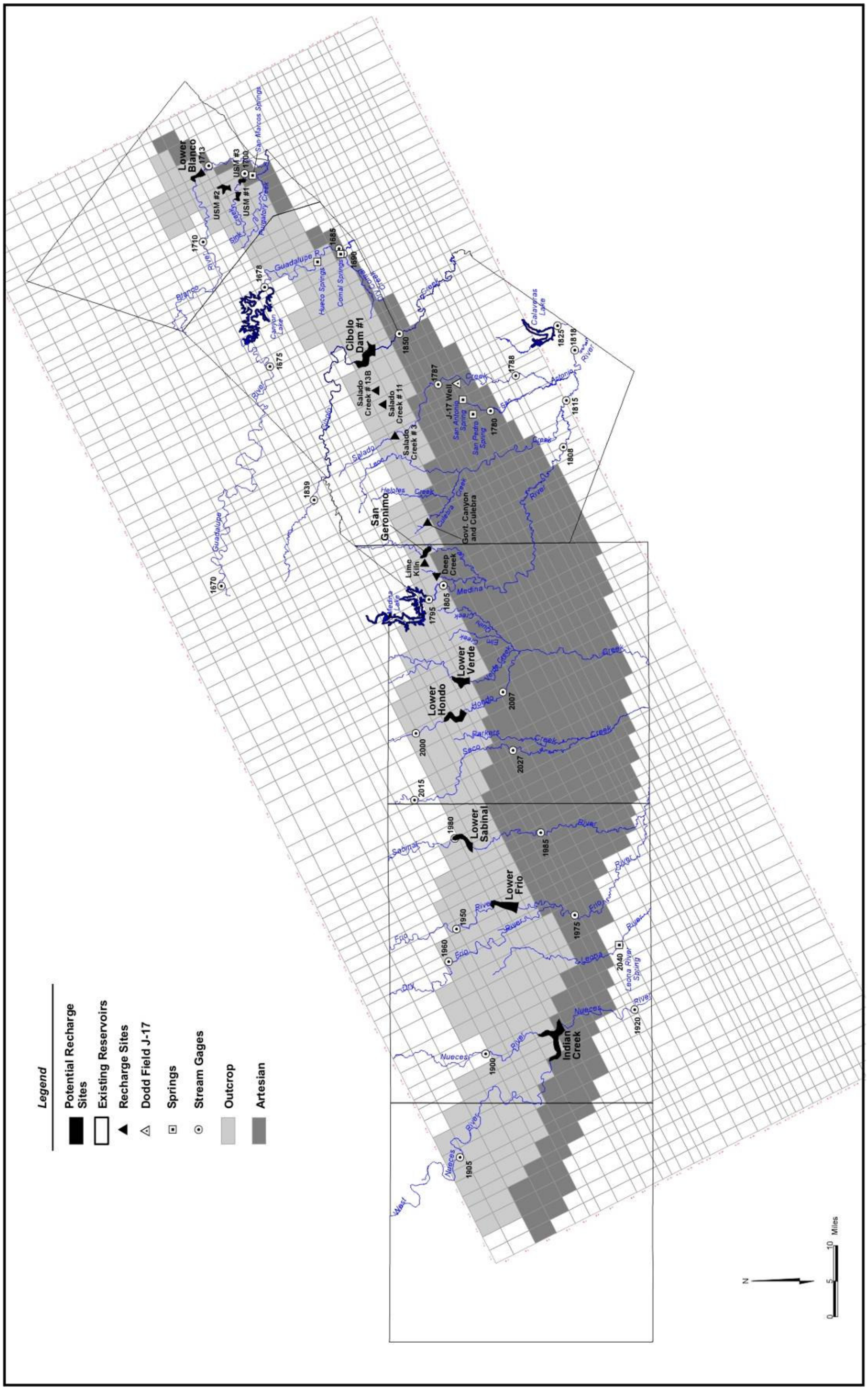
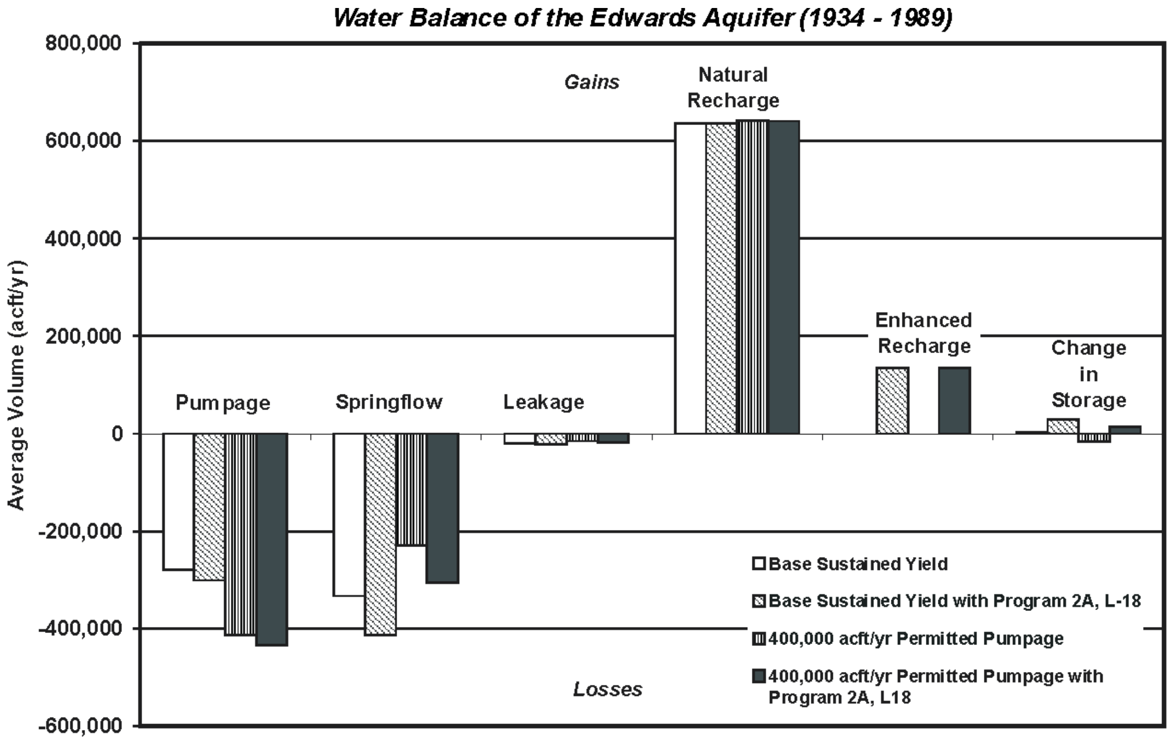


Figure 4C.4-2. Edwards Recharge — Type 2 Projects



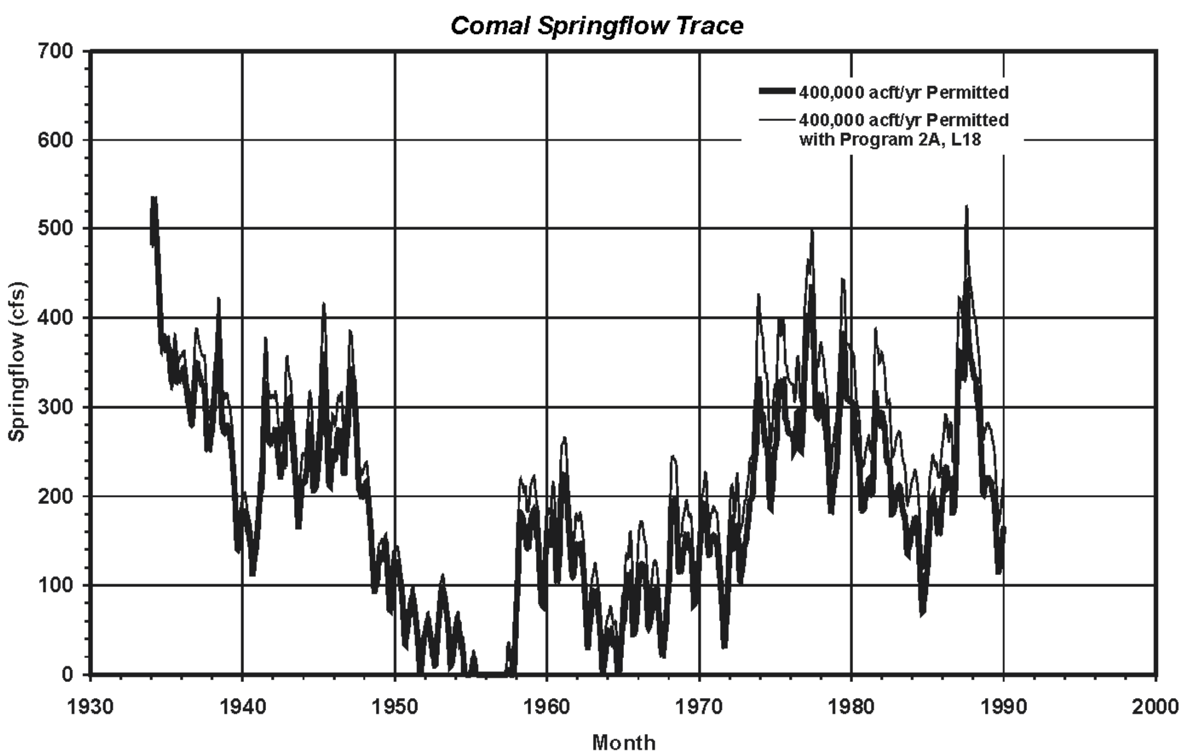


Figure 4C.4-3. Enhanced Recharge from Type 2 Recharge Projects — Program 2A

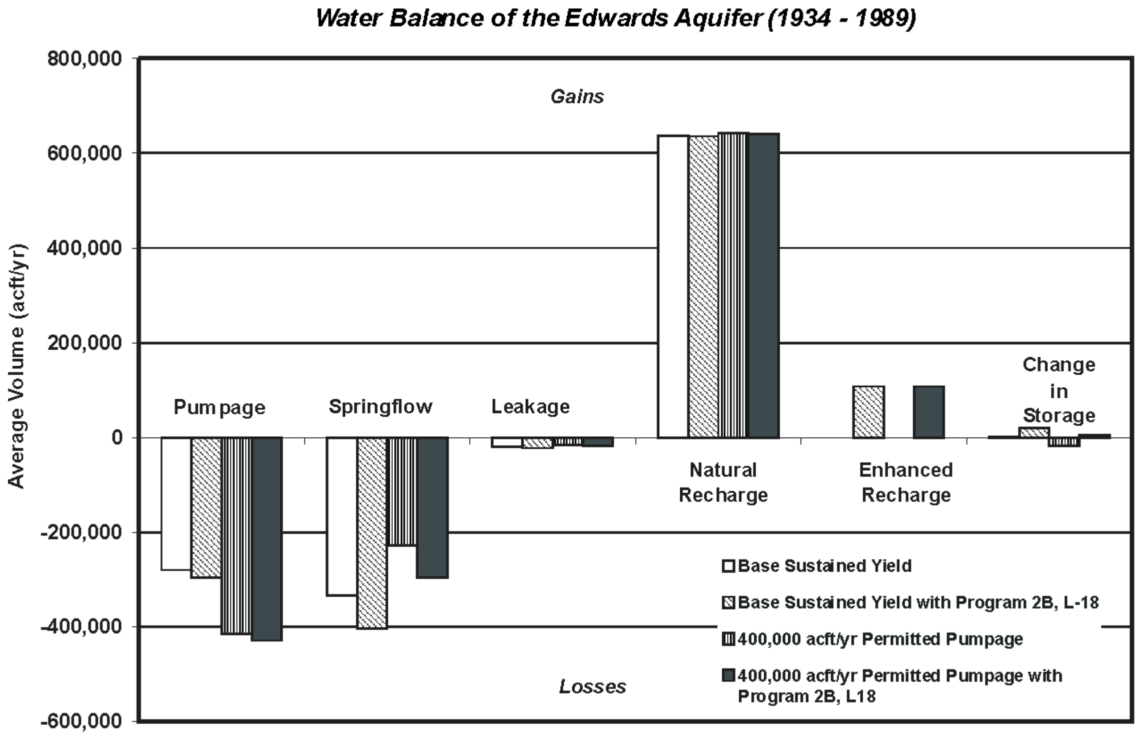
average annual recharge enhancement becomes springflow. As shown in Table 4C.4-4, 80,189 acft/yr (60 percent) of the 134,434 acft/yr recharge enhancement becomes increased springflow. This increase in springflow is shown in the lower chart in Figure 4C.4-3. This chart shows the Comal Springs flow patterns under the 400,000 acft/yr management plan pumpage with and without a recharge recovery permit pumpage of 21,577 acft/yr. As seen in this figure, the close proximity of the Lower Blanco and Cibolo Dam No. 1 recharge projects to Comal and San Marcos Springs serve to enhance springflow more than increase dependable supply for municipal pumpage.

Table 4C.4-4.
Summary of Sustained Yield Enhancement for Type 2 Reservoir Programs

Type 2 Project Program	Recharge Enhancement		Sustained Yield Pumpage Increase (acft/yr)	Increase in Springflow (acft/yr)
	1934 to 1989 Average Conditions	1947 to 1956 Drought Conditions		
Program 2A	134,434	50,032	21,577	80,189
Program 2B	108,003	34,788	15,980	69,971
Program 2C	54,471	10,034	13,451	24,401

[1] Sustained yield increase based on comparison of GWSIM-IV Model runs in which aquifer pumpage was maximized while maintaining a minimum flow from Comal Springs of 60 cfs in one and only one month with and without recharge enhancement from the associated Type 2 Program.

Program 2B was analyzed in a similar fashion and the results indicate similar increases, on a percentage basis, to sustained yield and springflow. Under Program 2B, 15,980 acft/yr (15 percent) of the 108,003 acft/yr average annual recharge enhancement is potentially available for recovery on a firm basis, while 69,971 acft/yr (65 percent) becomes increased springflow. The primary difference between Programs 2A and 2B is the exclusion of the Indian Creek recharge project in Program 2B. The Lower Blanco and Cibolo Dam No. 1 projects remain and thus Comal and San Marcos springflow enhancement remains high. The results for Program 2B are shown in Figure 4C.4-4.



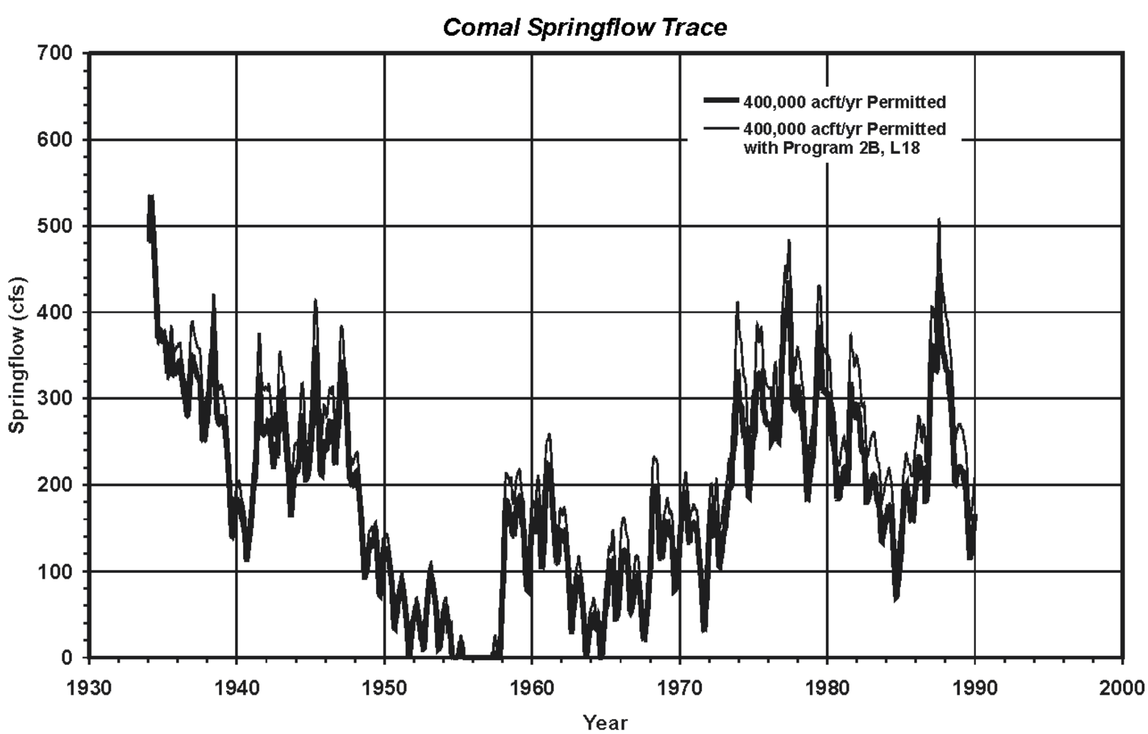


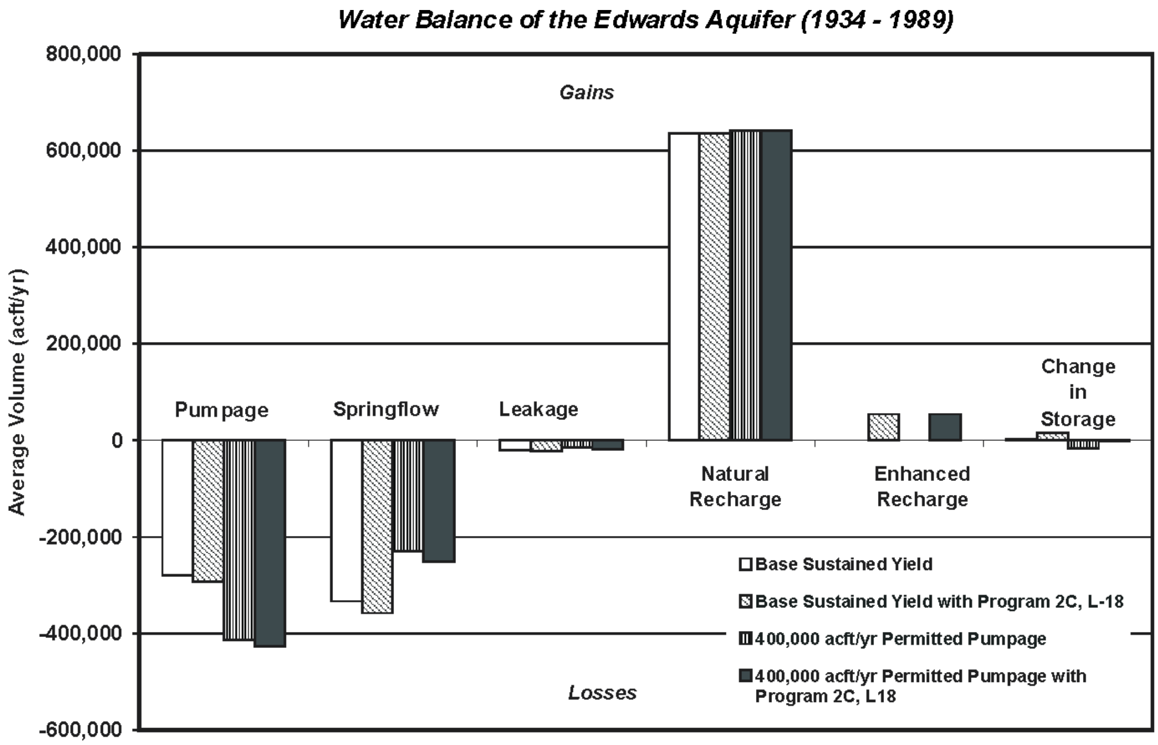
Figure 4C.4-4. Enhanced Recharge from Type 2 Recharge Projects — Program 2B

In Program 2C, the Indian Creek, Lower Blanco, and San Geronimo recharge enhancement projects were removed from the program. As shown in Table 4C.4-4 and Figure 4C.4-5, the increase in sustained yield pumpage of the aquifer is 13,451 acft/yr, approximately 25 percent of the average annual recharge enhancement. This is the only program considered herein with a sustained yield greater than the drought average recharge enhancement. Figure 4C.4-5 and Table 4C.4-4 also indicate that the removal of the Lower Blanco project from the Program 2C analysis decreased the percentage of average annual enhancement that became increased springflow. For Program 2C, 24,401 acft/yr (or 45 percent) of the annual average recharge enhancement becomes springflow. For these reasons, Program 2C appears to be, in a hydrologic sense, the most efficient Type 2 recharge project enhancement program.

Potential Edwards Aquifer recharge enhancement projects could negatively impact natural recharge of the Carrizo-Wilcox Aquifer. Previous studies[8] have estimated recharge to the Carrizo-Wilcox Aquifer by breaking recharge into three components: baseflow recharge in the stream, flood flow recharge in overbanks of the stream, and areal recharge in the tributaries and soils in the watershed outside the main channel. Of these three components, flood flow recharge is the component most likely to be negatively impacted by recharge dams on the Edwards Aquifer outcrop, upstream of the Carrizo-Wilcox outcrop. Flood flow recharge is defined as the recharge that occurs along the main channel during flood events due to the inundation of overbanks adjacent to the river. Previous estimates of total recharge in the Winter Garden Area[9] (the Carrizo-Wilcox from the Rio Grande to the San Marcos River) tabulated flood flow recharge to the Carrizo-Wilcox as approximately 25 percent (51,500 acft/yr) of the total average annual recharge to the aquifer. Total average annual recharge in the Winter Garden Area was estimated to be 207,700 acft/yr.

Average annual flood flow recharge in the area was estimated to be 51,500 acft/yr, of which 17,700 acft/yr occurs on streams which could potentially be impacted by Type 2 Edwards Aquifer recharge enhancement projects. Therefore, in the most extreme case (no flood flow recharge to the Carrizo-Wilcox downstream of potential Type 2 projects) average annual Carrizo-Wilcox natural recharge could be reduced by about 8.5 percent (17,700 ÷ 207,700) under

[8] LBG-Guyton Associates and HDR Engineering, Inc., "Interaction between Ground Water and Surface Water in the Carrizo-Wilcox Aquifer," Texas Water Development Board, August 1998.
[9] Ibid.



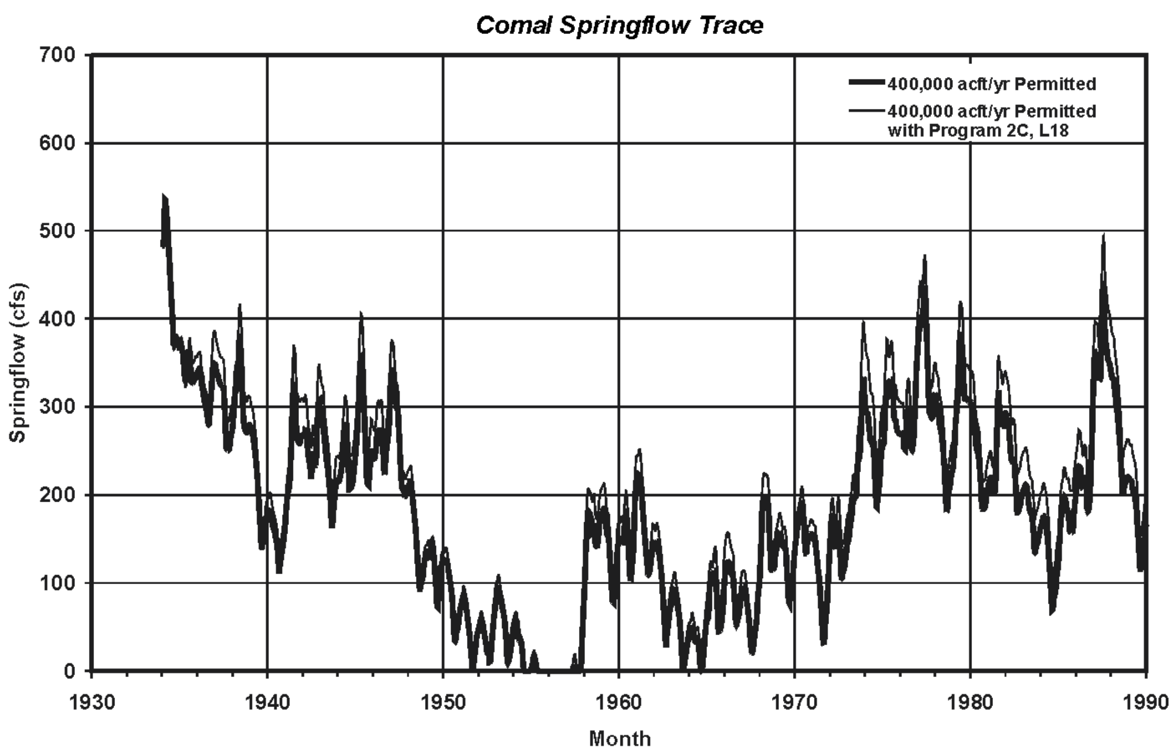


Figure 4C.4-5. Enhanced Recharge from Type 2 Recharge Projects — Program 2C

Program 2A. Similarly, under Program 2B, the removal of an Edwards Project on the Nueces River would decrease the potential impact to Carrizo-Wilcox recharge down to 5 percent of the total average annual recharge. Likewise, Program 2C could cause a decrease in Carrizo-Wilcox average annual recharge of at most 4 percent. It should be noted that these estimates of impacts, while relatively small, are essentially the maximum attainable assuming the Edwards Aquifer recharge projects completely control all floods on their respective streams. The proposed Type 2 projects, however, are not large enough to control floods to this extent. Therefore, impacts to Carrizo-Wilcox recharge across the region will most certainly be considerably less than the potential impacts presented above.

4C.4.3 Environmental Issues

Type 2 reservoirs are immediate recharge (direct percolation) structures that drain from the bottom of the reservoir into the recharge zone until the entire volume is exhausted, usually within a period of less than 1 month. Type 2 reservoirs are intended to impound flows that would have otherwise passed across the recharge zone.

Suitable sites for the Type 2 reservoirs are located in the area encompassing the headwaters of the Nueces River Basin along the southern margin of the Edwards Plateau in Medina and Uvalde Counties, and the headwaters of the San Antonio and Guadalupe rivers along the southeastern margin of the Edwards Plateau in Bexar, Comal and Hays Counties, respectively (Figure 4C.4-1). There are three Type 2 reservoir sites in Uvalde County (Indian Creek, Lower Frio and Lower Sabinal), five Type 2 reservoir sites in Medina County (Lower Hondo, Lower Verde, San Geronimo, Deep Creek, and Limekiln), four Type 2 reservoir sites in Bexar County (Culebra, Government Canyon, Salado Dam #3, and Cibolo Dam #1), one Type 2 reservoir site in Comal County (Dry Comal), and one Type 2 reservoir site in Hays County (Lower Blanco). In addition, there are proposals for modifying outlets on existing floodwater retarding structures in the Salado Creek watershed. Portions of the Frio, Sabinal, and Blanco Rivers have been designated by Texas Parks and Wildlife Department as Ecologically Significant River and Stream Segments.

All of the Type 2 recharge project sites are located near the southern edge of Omernik's Central Texas Plateau Ecoregion and the corresponding ecotones of Gould, Blair and Correll and

Johnston.[10,11,12,13] Downstream of the Edwards recharge area, the streams enter Omernik's Texas Blackland Prairie or Southern Texas Plains ecoregions.

The terrestrial habitat impacts of the Type 2 reservoirs will depend on the amount of clearing done, frequency of inundation, and the rapidity of pool drainage following capture of run-off. Operation of a Type 2 recharge structure on Parker's Creek in Medina County for 20 years has resulted in little or no impact to terrestrial vegetation beyond an approximately 20 acre cleared area immediately upstream of the dam. Conservation (recharge) pool levels and major types of habitat that would be inundated as a result of operation of the Type 2 reservoirs being studied here are listed in Table 4C.4-5.

Table 4C.4-5.
Habitats Affected by Operation of Type 2 Recharge Reservoirs (L-18)

Reservoir	Recharge Pool[1] (acres)	Grassland (%)	Brush (%)	Developed (%)	Crops (%)	Woodlands (%)	Wetland (acres)
Indian Creek	3,657	20%	80%				10.4
Lower Frio	1,099	20%	80%				7.4
Lower Sabinal	454						
Lower Hondo	232	70%				30%	5.5
Lower Verde	334	3%				97%	8.2
San Geronimo	183		45%			40%	5
Government Canyon	216	No information available					
Cibolo Dam #1	476	10%				40%	50
Dry Comal	265[E]	5%	10%	5%	50%	20%	10

[1] Corresponds to conservation pool of a conventional reservoir.
E = estimated

Because Type 2 reservoirs are immediate recharge (direct percolation) structures that drain directly into karst features (fractures, holes, and/or caves) present below the stream channel, disturbance of the local karst system and its fauna is a possibility. The fauna inhabiting these caves are usually small in both species diversity and population size, and are adapted to relatively stable physical habitats, which presumably makes them particularly sensitive to disturbances outside of the natural regime. Both terrestrial and aquatic communities are

[10] Omernik, James M., "Ecoregions of the Conterminous United States," Annals of the Association of American Geographers, 77(1) pp. 118-125, 1987.
[11] Correll, D.S., and M.C. Johnston, "Manual of the Vascular Plants of Texas," Texas Research Foundation, Renner, Texas, 1979.
[12] Blair, W. F., "The Biotic Provinces of Texas," Texas Journal of Science 2(1): pp. 93-117, 1950.
[13] Gould, F.W., "The Grasses of Texas," Texas A & M University Press, College Station, Texas, 1975.

extensive in the karst openings associated with the Edwards limestone, and significant threats to these habitats presently exist as a result of human activities in many areas, including northern Bexar County.[14,15]

The extent of intermittently flooded karst zones that would be affected hydrologically by the proposed Type 2 structures is unknown. The extent to which these zones are inhabited by protected species is largely limited to Bexar County, but similar Karst communities exist throughout the Edwards recharge area. The effects of hydrologic changes on resident Karst communities will depend on the extent, frequency, and duration of inundation. While karst openings in stream beds are generally devoid of established terrestrial communities as a result of flooding, scour and deposition, Karst openings in the vicinity of the recharge structures that presently experience periodic flooding may be inundated for longer periods, or experience an increase in the maximum elevation to which the water rises following a runoff event.

The types of dissolved and suspended materials entering the Edwards aquifer are not expected to be altered by the Type 2 reservoirs. As only brief impoundment and immediate recharge will take place there will be no opportunity for thermal stratification to set up or for oxidation of entrained organic material to deplete dissolved oxygen levels. The presence of the dams will increase sediment deposition in the inundated reach upstream of the dam. Openings in the stream bank would be exposed to successively smaller organic matter that could alter the oligotrophic conditions typical of protected karst species.

Operation of the recharge structures will result in additional yield to be available for human use, but modeling has shown a large proportion (averaging 45-65% depending on the projects constructed) of the recharged water appearing as enhanced Edwards springflow. Modeling also demonstrated springflow enhancement even during the drought of record. Operation of the recharge structures will also result in a reduction in the frequency and magnitude of flood flows that make it completely across the recharge zone. Presumably, this will affect channel morphology downstream of the recharge dam as a result of flood peak and frequency reduction. On the other hand, interception of the bed load in the recharge reservoir will tend to mitigate the extent of aggradation in the stream channel below the dam and sediment

[14] Ibid.

[15] Longley, G., "The Edwards Aquifer: Earth's Most Diverse Ground Water Ecosystem?" International. J. Speleol. 11:123-128, 1981.

transport across the recharge zone. Effects on downstream aquatic communities will be mediated through the extent to which perennial aquatic habitats (pools and flowing reaches) persist in the stream reaches immediately below the recharge zone. The upstream limits of perennial pools or flowing reaches may be expected to decrease to some extent as a result of recharge structure operation.

The USFWS lists as endangered several new species of invertebrates with limited distribution in caves of northern Bexar County (Table 4C.4-6). These species are identified as inhabiting specific caves, although an effort is being made to identify additional habitat areas. All of the Type 2 recharge sites are in areas that have a potential for caves containing endangered species.[16]

Table 4C.4-6
Arthropods Listed as Endangered by USFWS

Common Name	Scientific Name	Summary of Habitat Preference	Cave Location Known to Exist	County
Government Cave Spider	*Neoleptoneta microps*	Small, eyeless or essentially eyeless troglobitic spider; karst features in N and NW Bexar Co.	Government Canyon Bat Cave	Bexar
Cokendolpher Cave Harvestman	*Texella Cokendolpheri*	Small, eyeless or essentially eyeless troglobitic harvestman; karst features in N and NW Bexar Co.	Robber Baron Cave	Bexar
Madla's Cave Spider	*Cicurina madla*	Small, eyeless or essentially eyeless troglobitic spider; karst features in N and NW Bexar Co.	Madla's Cave	Bexar
Govt. Canyon Bat Cave Meshweaver	*Cicurina vespera*	Small, eyeless or essentially eyeless troglobitic spider; karst features in N and NW Bexar Co.	Bracken Bat Cave	Bexar
Robber Baron Cave Spider	*Cicurina baronia*	Small, eyeless or essentially eyeless troglobitic spider; karst features in N and NW Bexar Co.	Robber Baron Cave	Bexar
Braken Bat Cave Meshweaver	*Cicurina venii*	Small, eyeless or essentially eyeless spider; karst features in N and NW Bexar Co. troglobitic	Government Canyon Bat Cave	Bexar
Ground Beetle 1	*Rhadine exilius*	Small, essentially eyeless ground beetle; karst features in N and NW Bexar Co.	John Wagner Ranch Cave No. 3 (Marnock Cave)	Bexar
Ground Beetle 2	*Rhadine infernalis*	Small, essentially eyeless ground beetle; karst features in N and NW Bexar Co.	Government Canyon Bat Cave, Cave of the Woods, Genesis Cave, Helotes Blowhole, Isopit, Kamikaze Cricket Cave, Poison Ivy Pit, and Wurzbach Cave	Bexar
Helotes Mold Beetle	*Bastrisodes venyivi*	Small, essentially eyeless mold beetle; karst features in N and NW Bexar Co.	Helotes Hilltop Cave	Bexar

[16] Ibid.

Government Canyon Bat Cave is located in the immediate vicinity of the potential recharge site on that stream. Although the known opening of this cave is located well above the impoundment elevation, the depth to which *Cicurina venii*, habitat extends is not known, and additional site surveys would be required to determine whether it might be affected by an increase in the duration of inundation events, or by an increase in the maximum inundation elevation within the cave. On-site surveys of the reservoir and surrounding areas and mitigation or relocation of the project may be required if caves with protected species are found and will be affected by project development. Government Canyon, including the Government Canyon Bat Cave site, is the location of a new State park. The Government Canyon State Park plan includes environmental resource preservation, a preserve for nesting Golden-Cheeked Warblers and Black-Capped Vireos, and some recreational facilities. Natural recharge in the canyon may not conflict with preserving the area's environmental resources and the park development plan, although extensive dam construction may conflict.

Protected and threatened species known or thought to occur in the study areas of Uvalde, Bexar, Hays, Comal, and Medina Counties are listed in Table 2C.4-7. The Natural Diversity Database, which is maintained by TPWD, reports the occurrence of endangered, threatened, or rare species near the proposed Type 2 projects. The Lower Frio recharge project area includes occurrences of the endangered Black-capped Vireo. Black-capped Vireos are insectivorous songbirds that nest in low shrubland thickets where vegetation extends to ground level. Two rare plants including bracted twistflower (*Strepthanthus bracteatus*), and Texas largeseed bittercress (*Cardamine macrocarpa* var *texana*) are also found within this area.

Areas near the Lower Sabinal recharge project include habitat preferred by the Black-capped Vireo. The Lower Hondo project area has a number of occurrences of the Texas mock orange (*Philadelphus texensis*). The Golden-cheeked Warbler (*Dendroica chrysoparia*) a species listed as endangered is found within the area of the Lower Verde project. Golden-cheeked Warblers prefer habitat consisting of mature oak-juniper woodlands located along steep escarpments and canyons. Occurrences of significant species around the San Geronimo site include Bracted Twistflower, (*Stretanthus bracteatus*), Texas mock orange (*Philadelphus texensis*), and Golden-cheeked Warbler (*Dendroica chrysoparia*).

Table 4C.4-7.
Endangered, Threatened, and Species of Concern for Bexar, Comal, Hays, Medina, and Uvalde Counties

Common Name	Scientific Name	Impact Value	Multiplier Based On Status	Adjusted Impact	Summary of Habitat Preference	Listing Entity		Potential Occurrence in County
						USFWS[1]	TPWD[1]	
A cave obligate crustacean	*Monodella texana*	0	1	0	Subaquatic, underground freshwater aquifers			Resident
A mayfly	*Pseudocentroptiloides morihari*	0	1	0	Aquatic larval stage, adults generally found in shoreline vegetation.			Resident
A mayfly	*Procloeon distinctum*	0	1	0	Distinguished by their aquatic larval stage, adults are generally found in shoreline vegetation.			Resident
A mayfly	*Allenhyphes michaeli*	0	1	0	Found in the Texas Hill Country. Distinguished by an aquatic larval stage, with adults generally found in shoreline vegetation.			Resident
American Peregrine Falcon	*Falco peregrinus anatum*	0	3	0	Open country; cliffs	DL	E	Nesting/Migrant
Arctic Peregrine Falcon	*Falco peregrinus tundrius*	0	2	0	Open country; cliffs	DL	T	Nesting/Migrant
Baird's Sparrow	*Ammodramus bairdii*	0	1	0	Found in shortgrass prairie areas. Migratory in the western half of Texas.			Migrant
Balcones Cave Amphipod	*Stygobromus balconies*	0	1	0	Found in cave pools.			Resident
Bald eagle	*Haliaeetus leucoephalus*	0	2	0	Found primarily near rivers and large lakes.	DL	T	Possible Migrant
Bandit Cave spider	*Cicurina bandida*	1	1	1	Small subterranean obligate spider.			Resident
Big Red Sage	*Salvia penstemonoides*	1	1	1	Moist Creek and stream bed edges; historic; introduced in native plant nursery trade			Resident
Black Bear	*Usus americanus*	1	2	2	Mountains, broken country, woods, brushlands, forests	T/SA; NL	T	Resident
Black-capped Vireo	*Vireo atricapillus*	1	3	3	oak-juniper woolands with distinctive patchy, two-layered aspect; shrub and tree layer with open, grassy spaces	LE	E	Nesting/Migrant
Blanco Blind Salamander	*Eurycea robusta*	0	2	0	Troglobitic, water-filled subterranean caverns, may inhabit deep levels of Balcones Aquifer		T	Resident
Blanco River Springs Salamander	*Eurycea pterophila*	0	1	0	Subaquatic, springs and caves in the Blanco River drainage in Blanco, Hays and Kendall			Resident
Blue Sucker	*Clycleptus elongatus*	1	2	2	Large rivers throughout Mississippi River Basin south and west in major streams of Texas to Rio Grand River		T	Resident
Braken Bat Cave Meshweaver	Cicurina venii	1	3	3	Small eyeless spider, in Karst features in western Bexar County.	LE		Resident

Table 4C.4-7 (Continued)

Common Name	Scientific Name	Impact Value	Multiplier Based On Status	Adjusted Impact	Summary of Habitat Preference	Listing Entity		Potential Occurrence in County
						USFWS[1]	TPWD[1]	
Bracted twistflower	*Streptanthus bracteatus*	2	1	2	endemic, openings in juniper-oak woodlands, rocky slopes			Resident
Cagle's Map Turtle	*Graptemys caglei*	1	2	2	Guadalupe River System, transition areas between riffles and pools, nests within 30 ft of water's edges		T	Resident
Canyon mock-orange	*Philadelphus ernestii*	2	1	2	Endemic: found in shallow well-drained clays in woodlands.			Resident
Cascade Caverns Salamander	*Eurycea latitans*	1	2	2	Endemic; subaquatic, springs and caves in Comal Co.		T	Resident
Cave Myotis Bat	*Myotis velifer*	2	1	2	colonial, and cave dwelling; hibernates in limestone caves of Edwards Plateau			Resident
Coahuila giant skipper	*Agathymus remingtoni valverdiensis*	0	1	0	Found with the Lechugilla plant in desert hills and thorn forests.			Resident
Cokendolpher Cave Harvestman	*Texella cokendolpheri*	1	3	3	Small eyeless harvestman, karst features in north-central Bexar county.	LE		Resident
Comal Blind Salamander	*Eurycea tridentifera*	1	2	2	Endemic; semi-troglobitic; found in springs and waters of caves in Bexar and Comal Co		T	Resident
Comal Snakewood	*Colubrina stricta*	1	1	1	Shrub.			Resident
Comal Springs Diving Beetle	*Comaldessus stygius*	0	1	0	Outflow at Comal Springs.			Resident
Correll's false dragon-head	*Physostegia correllii*	1	1	1	Found in wet, silty clay loams on sides of streams and other wet areas.			Resident
Creeper (squawfoot)	*Strophitus undulates*	0	1	0	Small to large streams			Resident
Edwards Aquifer Diving Beetle	*Haideoporus texanus*	1	1	1	Known from an artesian well in Hays Co.			Resident
Edwards Plateau Spring Salamander	*Eurycea sp. 7*	2	1	2	Endemic; troglobitic; springs, seeps, cave streams, and creek headwaters			Resident
Edwards Plateau Shiner	*Cyprinella sp.2*	0	1	0	Edwards Plateau portion of Nueces basin.			Resident
Elmendorf's Onion	*Allium elmendorfii*	1	1	1	Endemic; deep sands derived from Queen City and similar Eocene formations			Resident
Ezell's Cave Amphipod	*Stygobromus flagellatus*	0	1	0	Known only from artesian wells			Resident
False spike mussel	*Quincuncina mitchelli*	0	2	0	Substrates of cobble and mud with water lilies present. Rio Grande, Brazos, Colorado and Guadalupe river basins.		T	Resident
Flint's net-spinning caddisfly	*Cheumatopsyche flinti*	1	1	1	Occupies spring habitat.			Resident

Table 4C.4-7 (Continued)

Common Name	Scientific Name	Impact Value	Multiplier Based On Status	Adjusted Impact	Summary of Habitat Preference	Listing Entity USFWS[1]	Listing Entity TPWD[1]	Potential Occurrence in County
Fountain Darter	*Etheostoma fonticola*	1	3	3	Known only from the San Marcos and Comal rivers; springs and spring-fed streams in dense vegetation	LE	E	Resident
Frio Pocket Gopher	*Geomys texensis bakeri*	1	1	1	Associated with nearly level Atoc soil, which is well drained and consists of sandy surface layers with loam extending to as deep as 2m.			Resident
Ghost-faced Bat	*Mormoops megalophylla*	0	1	0	Roosts in caves.			Resident
Glass Mountain coral root	*Hexalectrisnitida*	1	1	1	Mesic woodlands in canyons, lower elevations, under oaks			Resident
Golden-cheeked Warbler	*Dendrpoica chrysoparia*	2	3	6	Juniper-oak woodlands; dependent on mature Ashe juniper (cedar) for nests	LE	E	Nesting/Migrant
Golden orb	*Quadrula aurea*	0	2	0	Sand and gravel, Guadalupe, San Antonio, and Nueces River basins		T	Resident
Government Canyon Bat Cave Spider	*Neoleptoneta microps*	1	3	3	Small, eyeless or essentially eyeless spider; karst features in N and NW Bexar Co.	LE		Resident
Government Canyon Bat Cave Meshweaver	*Cicurina vespera*	0	3	0	Small, eyeless spider, karst features in northwestern Bexar County.	LE		Resident
Gray Wolf	*Canis lupus*	0	3	0	Extirpated.	LE	E	Historic Resident
Ground Beetle #1	*Rhadine exilis*	0	3	0	Eyeless beetle, karst features in northern Bexar County.	LE		Resident
Ground Beetle #2	*Rhadine infernalis*	0	3	0	Small eyeless ground beetle; karst features in northern and western Bexar County.	LE		Resident
Guadalupe Bass	*Micropterus treculi*	2	1	2	Perennial streams of the Edward's plateau region			Resident
Guadalupe Darter	*Percina sciera apristis*	1	1	1	Raceways of medium streams and rivers.			Resident
Headwater catfish	*Ictalurus lupus*	0	1	0	Clear Streams			Historic in Uvalde
Helotes Mold Beetle	*Bastrisodes venyivi*	1	3	3	Small, essentially eyeless mold beetle; karst features in N and NW Bexar Co.	LE		Resident
Henslow's Sparrow	*Ammodramus henslowii*	1	1	1	Weedy fields or cut over areas; bare ground for running and walking			Nesting/Migrant
Hill Country Wild Mercury	*Argythamnia aphoroides*	1	1	1	In grasslands.			Resident
Horseshoe Liptooth snail	*Daedalochila hippocrepis*	1	1	1	Terrestrial snail.			Resident
Indigo Snake	*Drymarchon corais erebennus*	1	2	2	Grass prairies and sand hills; usually thornbush woodland and mesquite savannah of coastal plain		T	Resident
Interior Least Tern	*Sterna antillarum athalassos*	1	3	3	Inland river sandbars for nesting and shallow water for foraging	LE	E	Nesting/Migrant

Table 4C.4-7 (Continued)

Common Name	Scientific Name	Impact Value	Multiplier Based On Status	Adjusted Impact	Summary of Habitat Preference	Listing Entity: USFWS[1]	Listing Entity: TPWD[1]	Potential Occurrence in County
Jaguarundi	*Felis yagouaroudi*	1	3	3	South Texas thick brushlands, favors areas near water	LE	E	Resident
Keeled Earless Lizard	*Holbrookia propinqua*	1	1	1	Coastal dunes, Barrier islands and sandy areas			Resident
Leonora's dancer damselfly	*Argia leonorae*	1	1	1	Found near small streams and seepages.			Resident
Long-legged Cave Amphipod	Stygobromus longipes	1	1	1	Found in subterranean streams.			Resident
Madla Cave Spider	*Cicurina madla*	2	3	2	Small, eyeless or essentially eyeless spider; karst features in N and NW Bexar Co.	LE		Resident
Manfreda Giant-skipper	*Stallingsia maculosus*	0	1	0	Small insect.			Resident
Mimic Cavesnail	*Phreatodrobia imitata*	1	1	1	Sub aquatic found in two wells penetrating the Edwards Aquifer			Resident
Mountain Plover	*Charadrius montanus*	1	1	1	Non-breeding-shortgrass plains and fields, plowed fields and sandy deserts			Nesting/Migrant
Nueces River Shiner	*Cyprinella sp.2*	0	1	0	Edwards Plateau portion of Nueces basin.			Resident
Nueces Roundnose Minnow	*Dionda serena*	0	1	0	Edwards Plateau portion of Nueces basin.			Resident
Ocelot	*Felis pardalis*	1	3	3	Dense chaparral thickets; mesquite-thorn scrub and live oak mottes; avoids open areas	LE	E	Resident
Parks' Jointweed	*Polygonella parksii*	1	1	1	South Texas Plains; sub herbaceous annual in deep loose sands, spring-summer			Resident
Peck's Cave Amphipod	*Stygobromus pecki*	0	3	0	Small, aquatic crustacean; lives underground in Edwards Aquifer	LE	E	Resident
Pistolgrip	*Tritogonia verrucosa*	0	1	0	Aquatic, stable substrate. Red through San Antonio river basins.			Resident
Plains Spotted Skunk	*Spilogale putorius interrupta*	0	1	0	Prefers wooded, brushy areas and tallgrass prairie, fields, prairies, croplands, fence rows, farmyards, forest edges			Resident
Rawson's metalmark	*Calephelis rawsoni*	1	1	1	Moist areas in shaded limestone outcrops			Resident
Red Wolf	*Canis rufus*	0	3	0	Extirpated.	LE	E	
Reticulate Collared Lizard	*Crotaphytus reticulatus*	1	2	2	Endemic grass prairies of South Texas Plains; usually thornbush, mesquite-blackbrush		T	Resident
Robber Baron Cave Meshweaver	*Cicurina baronia*	1	3	3	Small, eyeless or essentially eyeless spider; karst features in N and NW Bexar Co.	LE		Resident
Sage sphinx	*Sphinx eremitoides*	1	1	1	Found in desert, grassland and sandy prairie with sage.			Resident

Table 4C.4-7 (Continued)

Common Name	Scientific Name	Impact Value	Multiplier Based On Status	Adjusted Impact	Summary of Habitat Preference	Listing Entity USFWS[1]	Listing Entity TPWD[1]	Potential Occurrence in County
San Marcos Gambusia	*Gambusia georgei*	0	3	0	Endemic, extinct.	LE	E	
San Marcos Saddle Case Caddisfly	*Protoptila arca*	0	1	0	Known from an artesian well in Hays Co.; 1-2m deep water			Resident
San Marcos Salamander	*Eurycea nana*	0	2	0	Headwaters of San Marcos River, downstream to 1/2 mile past IH-35	LT	T	Resident
Sabinal prairie-clover	*Dalea sabinalis*	2	1	2	Rocky soils.			Resident
Sandhill woolywhite	*Hymenopappuscarrizoanus*	1	1	1	Endemic, deep loose sands of Carrizo, disturbed areas			Resident
Sennett's Hooded Oriole	*Icterus cucullatus sennetti*	0	1	0	This species often builds nests of Spanish moss.			Resident
Spot-tailed earless Lizard	*Holbrookia lacerata*	1	1	1	Central & Southern Texas; oak-juniper woodlands and mesquite-prickly pear			Resident
Springrun whitehead	*Trichocoronis rivularis*	0	1	0	Found in shallow, slow-moving water in spring-fed streams and rivers.			Resident
Texas austrotinodes caddisfly	*Austrotinodes texensis*	0	1	0	Endemic to Karst Springs and spring runs of the Edward Plateau region.			Resident
Texas Blind Salamander	*Eurycea rathbuni*	0	3	0	Troglobitic, water-filled subterranean caverns, along San Marcos Spring Fault	LE	E	Resident
Texas Cave Shrimp	*Palaemonetes antrorum*	1	1	1	Subterranean sluggish streams and pools			Resident
Texas fatmucket	*Lampsilis bracteata*	0	1	0	Streams and rivers on sand, mud and gravel, Colorado and Guadalupe River basins.		T	Resident
Texas Garter Snake	*Thamnophis sirtalis annectens*	2	1	2	Varied, especially wet areas; bottomlands and pastures			Resident
Texas Grease Bush	*Glossopetalon texense*	2	1	2	Dry limestone ledges.			Resident
Texas Horned Lizard	*Phrynosoma cornutum*	1	2	2	Varied, sparsely vegetated uplands, grass, cactus, brush		T	Resident
Texas Largeseed bittercress	*Cardamine macrocarpa var. texana*	2	1	2	Moist loam soils in pine-oak woodlands.			Resident
Texas Mock-Orange	*Philadelphus texensis*	2	1	2	On limestone bluffs and among boulders on the Edwards Plateau			Resident
Texas pimpleback	*Quadrula petrina*	0	2	0	Mud, gravel and sand substrates, Colorado and Guadalupe river basins		T	Resident
Texas Salamander	*Eurycea neotenes*	2	1	2	Endemic, in caves, springs and seeps.			Resident
Texas Tortoise	*Gopherus berlandieri*	1	2	2	Open brush with grass understory; open grass and bare ground avoided; occupies shallow depressions at base of bush or cactus, underground burrows, under objects; active March-Nov		T	Resident

Table 4C.4-7 (Concluded)

Common Name	Scientific Name	Impact Value	Multiplier Based On Status	Adjusted Impact	Summary of Habitat Preference	Listing Entity USFWS[1]	Listing Entity TPWD[1]	Potential Occurrence in County
Timber Rattlesnake	*Crotalus horridus*	1	2	2	Floodplains, upland pine, deciduous woodlands, riparian zones, abandoned farms, dense ground cover		T	Resident
Texas wild-rice	*Zizania texana*	0	3	0	Perennial, emergent, aquatic grass known from San Marcos River	LE	E	Resident
Tobusch fishhook Cactus	*Sclerocactus brevehamatus var tobuschii*	0	3	0	Endemic, shallow gravelly soil in shortgrass grasslands.	LE	E	Resident
Toothless Blindcat	*Trogloglanis pattersoni*	0	2	0	Troglobitic, blind catfish endemic to the San Antonio pool of the Edward's Aquifer		T	Resident
Valdina Farms Sinkhole Salamander	*Eurycea troglodytes*	1	1	1	Isolated, intermittent pools of a subterranean stream; sinkhole found in Medina Co.			Resident
Warnock's coral root	*Hexalectric warnockii*	0	1	0	In oak juniper woodlands.			Resident
Western Burrowing Owl	*Athene cunicularia hypugaea*	1	1	1	Open grasslands, especially prairie, plains and savanna			Resident
White-faced Ibis	*Pelagis chihi*	1	2	2	Prefers freshwater marshes, sloughs, and irrigated rice fields		T	Migrant
White-nosed coati	*Nasua narica*	1	2	2	woodlands, rocky and riparian areas		T	Resident
Whooping Crane	*Grus americana*	0	3	0	Potential migrant	LE	E	Migrant
Widemouth Blindcat	*Satan eurystomus*	0	2	0	Troglobitic, blind catfish endemic to the San Antonio pool of the Edward's Aquifer		T	Resident
Wood Stork	*Mycteria americana*	1	2	2	Forages in prairie ponds, ditches, and shallow standing water formerly nested in TX		T	Migrant
Zone-tailed Hawk	*Buteo albonotatus*	1	2	2	Arid, open country including deciduous or pine-oak woodland; nests in various habitats and sites		T	Nesting/Migrant

[1] Source: TPWD, Annotated County List of Rare Species, Bexar, Comal, Hays, Medina and Uvalde Counties, January 2010.
* LE/LT=Federally Listed Endangered/Threatened E/SA, T/SA=Federally Listed Endangered/Threatened by Similarity of Appearance
C1=Federal Candidate for Listing DL, PDL=Federally Delisted/Proposed for Delisting NL=notFederally Listed E, T=State Listed Endangered/Threatened
PE, PT=Federally Proposed Endangered/ Threatened Blank = Rare, but no regulatory listing status

The Cibolo Dam #1 site could impact the Guadalupe bass (*Micropterus treculi*), and a rare plant, Texas mock orange (*Philadelphus texensis*). Species listed as occurring near the Lower Blanco project area include the Guadalupe bass (*Micropterus treculi*), and Blanco blind salamander (*Eurycea robusta*).

The Government Creek area is known to contain numerous prehistoric sites and a 17th century Spanish colonial trail. Cultural resources protection on public lands in Texas is afforded by the Antiquities Code of Texas (Title 9, Chapter 191, Texas Natural Resource Code of 1977), the National Historic Preservation Act (Pl96-515), and the Archeological and Historic Preservation Act (PL93-291). Based on the review of available records housed at the Texas Archeological Research Laboratory in Austin, sixteen cultural resource sites appear to occur within the proposed project area. Table 4C.4-8 lists archeological sites within a one-mile corridor of the proposed project areas. Considering that the owner or controller of the project will likely be a political subdivision of the State of Texas (i.e. river authority, municipality, county, etc.), they will be required to coordinate with the Texas Historical Commission regarding if the project will affect waters of the United States or wetlands, the project sponsor will also be required to coordinate with the U.S. Army Corps of Engineers regarding impacts to cultural resources. All areas to be disturbed during construction will be first surveyed by qualified professionals for the presence of significant cultural resources. Additional measures to mitigate impacts may be required by the presence of significant cultural deposits that cannot be avoided.

4C.4.4 Engineering and Costing

Preliminary cost estimates for all Type 2 recharge enhancement projects located in the Nueces River Basin were prepared in 1994 by HDR,[17] and preliminary cost estimates for the Type 2 recharge enhancement projects located in the Guadalupe-San Antonio River Basin were prepared in 1998 by HDR.[18,19] These costs were then updated to second quarter 1999 prices for the 2001 Regional Water Plan. The costs presented in Table 4C.4-9 are based on the 1999 costs and have been adjusted to September 2008 prices in accordance with TWDB guidance for regional water planning. The land component of each project cost was updated based on the data

[17] HDR Engineering, Inc., "Nueces River Basin Edwards Aquifer Recharge Study, Phase IVA," Edwards Underground Water District, May 1994.
[18] HDR, Op. Cit., March 1998.
[19] HDR, "Modification of Principal Spillways at Existing Flood Control Projects for Recharge Enhancement," Trans-Texas Water Program, West Central Study Area, Phase II, Edwards Aquifer Recharge Analyses, San Antonio River Authority, et al., March 1998.

provided in "Texas Rural Land Value Trends 2008."[20] In addition, pumping power costs were added to the estimates where applicable, and the debt service period for non-reservoir items was updated from 30 to 20 years. Lastly, the water rights mitigation costs used in the estimates are derived from unit values of $359.00, $17.95 and $5.00 per acft for the CCR/LCC System, the Nueces Estuary, and the Guadalupe Estuary, respectively. The CCR/LCC unit cost is based on the City of Corpus Christi's July 2009 estimate of Garwood supply costs prorated back to September 2008 dollars; the Nueces Estuary unit cost is estimated as 5% of the CCR/LCC unit cost; and Guadalupe Estuary unit cost is estimated as approximately 5% of GBRA's current rate for run of the river supply in the costal area.

Table 4C.4-8
Previously Recorded Sites within 1-mile Distance
from the proposed Edwards Recharge-Type 2 projects.

Reservoir	*Sites*
Indian Creek	41UV371
Lower Frio	41UV249
	41UV251
	41UV258
	41UV259
Lower Sabinal	No sites
Lower Hondo	No sites
Lower Verde	No sites
San Geronimo	41ME7
	41ME8
	41ME108
Cibolo Dam No. 1	No sites
Lower Blanco	41HY11
	41HY51
	41HY104
	41HY139
	41HY229
	41HY230
	41HY231
	41HY232

[20] American Society of Farm Managers and Rural Appraisers, Texas Chapter, "Texas Rural Land Value Trends 2008," 2008.

Table 4C.4-9.
Summary of Costs for
Edwards Aquifer Recharge Programs — Type 2 Projects (L-18)
September 2008 Prices

Item	*Program 2A*[1]	*Program 2B*[2]	*Program 2C*[3]
Capital Costs			
Dams and Reservoirs	$224,626,000	$116,637,000	$72,250,000
Outlet Modifications	29,000	29,000	29,000
Transmission Pipeline	29,435,000	5,547,000	0
Relocations and Others	8,279,000	8,279,000	6,695,000
Total Capital Cost	**$262,369,000**	**$130,492,000**	**$78,974,000**
Engineering, Legal Costs and Contingencies	$90,356,000	$45,393,000	$27,640,000
Environmental & Archaeology Studies and Mitigation	71,888,000	39,030,000	$18,663,000
Land Acquisition	72,645,000	39,355,000	$18,878,000
Interest During Construction	$30,385,000	$14,201,000	$5,770,000
Total Project Cost	**$527,643,000**	**$268,471,000**	**$149,925,000**
Annual Costs			
Debt Service (6 percent for 20 years)	$4,519,000	$1,703,000	$823,000
Reservoir Debt Service (6 percent for 40 years)	$31,622,000	$16,544,000	$9,337,000
Operation and Maintenance	$5,251,000	$2,103,000	$1,083,000
Water Rights Mitigation	$1,875,000	$761,000	$697,000
Total Annual Cost	**$43,267,000**	**$21,111,000**	**$11,940,000**
Available Project Yield (acft/yr)	**21,577**	**15,980**	**13,451**
Annual Cost of Water ($ per acft) Raw Water in Aquifer[4]	$2,005	$1,321	$888
Annual Cost of Water ($ per 1,000 gallons)	$6.15	$4.05	$2.72

1 Program 2A includes Indian Creek, Lower Frio, Lower Sabinal, Lower Hondo, Lower Verde, Lower Blanco, Cibolo Dam No. 1, San Geronimo, Northern Bexar/Medina County Projects, Dry Comal, and Salado Creek FRS outlet modifications.

2 Program 2B includes Lower Frio, Lower Sabinal, Lower Hondo, Lower Verde, Lower Blanco, Cibolo Dam No. 1, San Geronimo, and Salado Creek FRS outlet modifications.

3 Program 2C includes Lower Frio, Lower Sabinal, Lower Hondo, Lower Verde, Cibolo Dam No. 1, and Salado Creek FRS outlet modifications.

4 Reported Annual Cost of Water is for additional water supply in the Edwards Aquifer.

As seen in Table 4C.4-9, the Type 2 Recharge Program 2A has a total cost of $527,643,000 and a total annual cost of $43,267,000. Under this Program, sustained yield pumpage is enhanced by about 21,577 acft/yr, which results in an estimated unit cost of water of $2,005/acft/yr.

The Program 2B total cost was computed as $268,471,000 with a total annual cost of $21,111,000. Sustained yield pumpage for Program 2B is 15,980 acft/yr, which results in an estimated unit cost of $1,321/acft/yr.

Table 4C.4-9 shows that Program 2C appears to be the most efficient program from both a hydrologic and a unit cost standpoint. Its total project cost of $149,925,000 equates to an annual cost of $11,940,000 per year. With a sustained yield increase of 13,451 acft/yr, the resulting annual unit cost of water under Program 2C is $888/acft/yr. Table 4C.4-10 provides the costs broken down by individual project. The incremental cost of the additional 2,529 acft/yr provided by Program 2B, as compared to Program 2C, is $3,626/acft/yr. The incremental cost of the additional 5,597 acft/yr provided by Program 2A, as compared to Program 2B, is $3,959 per acft.

4C.4.5 Implementation Issues

An institutional arrangement may be needed to implement this project including financing on a regional basis.

- Necessary permits could include:
  - TCEQ Water Right and Storage permits;
  - USACE Sections 10 and 404 dredge and fill permits for the reservoir and pipelines;
  - TWDB Sand, Gravel, and Marl Removal permits;
  - GLO Easement for use of state-owned land; and
  - Edwards Aquifer Authority aquifer storage and recharge recovery permits.
- Permitting, at a minimum, will require these studies:
  - Assessment of changes in instream flow and freshwater inflows to bays and estuaries;
  - Habitat mitigation plan;
  - Environmental studies;
  - Cultural resource studies; and
  - Study of impact on karst geology organisms.
- Land and/or easements must be acquired through either negotiations or condemnation.
- Relocations and crossings:
  - Highways and railroad; and
  - Other utilities.

Table 4C.4-10.
Summary of Costs for
Edwards Aquifer Recharge Projects Type 2 Projects (L-18)
September 2008 Prices

Project	Program(s)			Capa-city (acft)	Long-Term Average Recharge Enhance-ment (acft/yr)	Drought Average Recharge Enhance-ment (acft/yr)	Sus-tained Yield (acft/yr)	Project Cost	Annual Cost	Long-term Average Unit Cost ($/acft/yr)	Drought Average Unit Cost ($/acft/yr)	Sustained Yield Unit Cost ($/acft/yr)	Incremental Sustained Yield Unit Cost ($/acft/yr)
Lower Frio	2C	2B	2A	17,500	16,614	3634		$69,819,000	$5,465,000	$329	$1,504		
Lower Sabinal	2C	2B	2A	8,750	16,616	2501		$21,990,000	$1,908,000	$115	$763		
Lower Hondo	2C	2B	2A	2,800	6,455	952		$24,169,000	$2,007,000	$ 311	$2,108		
Lower Verde	2C	2B	2A	3,600	4,613	1484		$16,422,000	$1,226,000	$266	$826		
Cibolo	2C	2B	2A	10,000	9,870	1490		$27,510,000	$2,004,000	$203	$1,345		
Salado FRS	2C	2B	2A	n/a	303	0		$40,000	$3,000	$10	n/a		
Program 2C Total				**42,650**	**54,471**	**10,061**	**13,451**	**$159,950,000**	**$12,613,000**	**$232**	**$1,254**	**$938**	
Lower Blanco		2B	2A	50,000	50,246	24,020		$116,751,000	$8,987,000	$179	$374		
San Geronimo		2B	2A	3,500	3,286	707		$10,226,000	$762,000	$232	$1,078		
Program 2B Total				**96,150**	**108,003**	**34,788**	**15,980**	**$286,927,000**	**$22,362,000**	**$207**	**$643**	**$1,399**	**$3,855**
Indian Creek			2A	61,750	23,506	14,444		$219,739,000	$19,103,000	$813	$1,323		
N. Bexar/Medina			2A	12,409	2,224	562		$35,014,000	$2,599,000	$1,169	$4,625		
Dry Comal			2A	n/a	701	238		$20,077,000	$1,495,000	$2,133	$6,282		
Program 2A Total				**170,309**	**134,434**	**50,032**	**21,577**	**$561,757,000**	**$45,559,000**	**$339**	**$911**	**$2,111**	**$4,145**

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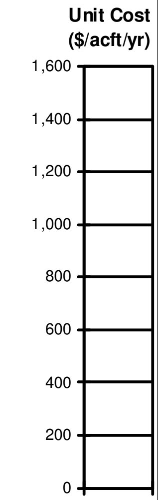
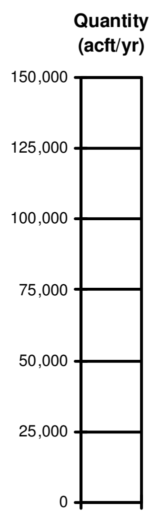
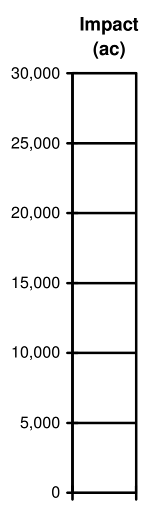
2011 South Central Texas Regional Water Plan
Water Management Strategy Summary Sheet







Name: ***Recycled Water Programs***

Description: The water management strategy includes recommended uses of recycled water for non-potable use for the following WUGs: Bexar County Industrial (17,734 acft/yr in 2060) and Comal County Industrial (9,022 acft/yr in 2060). Supply of the recycled water will come from SAWS, SARA, CCMA, and/or New Braunfels Utilities waste water treatment plants. The unit cost of water and yield resulting from implementing the projects is dependent upon the individual project.

***Decade Needed*:** 2000 - 2060

Cost, Quantity of Water, and Land Impacted

Unit Cost of Water:	**Dependent upon project**	**$/acft/yr**	**Recycled Water Delivered**
Quantity of Water:	**Dependent upon project**	**acft/yr**	**Reliability = Firm**
Land Impacted:	**N/A**	**acres**	

Additional Considerations per
Regional Water Planning Guidelines

Environmental Factors:

It is likely that implementation or expansion of current water recycling programs will have minimal effects on the environment due to project areas being contained within urban areas.

Impacts on Water Resources:

Effluent discharges are likely to increase throughout the planning period, even after considering recycled water programs.

Impacts on Agricultural & Natural Resources:

Implementation will occur in predominantly urban areas and likely be concentrated in existing utility easements and previously disturbed floodplains not located on the outcrop of the Edwards Aquifer. Hence, impacts to agricultural and natural resources are expected to be minimal.

Other Relevant Factors per SCTRWPG:

Encourages beneficial use of available resource.

Comparison of Strategies to Meet Needs:

Relatively low unit cost. No conflicts with other recommended water management strategies.

Interbasin Transfer Issues:

Not applicable.

Third-Party Impacts of Voluntary Transfers:

Not applicable.

Regional Efficiency:

New supply proximate to points of need.

Water Quality Considerations:

At current levels of treatment, recycled water must be used for non-potable purposes only.

4C.5 Recycled Water Programs

4C.5.1 Description of Water Management Strategy

Recycled Water Programs is defined as projects that utilize treated wastewater effluent as a replacement for potable water where non-potable water could be used (irrigation, industrial cooling, etc), thereby reducing the overall demand for fresh water supply. Recycled water typically involves a capital project connecting the treatment plant discharge facilities to an individual area that has a relatively high, localized use that can be met with non-potable water. Examples most frequently include the irrigation of golf courses and other public lands and specific industries or industrial use areas. Few entities, if any, would be capable of utilizing their entire effluent capacity for recycled water at present. However, for the long term, it is likely that increased pressure on water supplies will result in an increased emphasis on recycled water. Downstream needs, both water rights and environmental instream uses, would have to be met. Any remaining flows after these needs are met could potentially be utilized. Virtually any water supply entity with a wastewater treatment plant could pursue a recycled water alternative, provided that downstream water rights do not have a claim for the entire return flow.

Recycled water can be classified into two forms, defined by how the effluent water is handled:

1. Direct Reuse – Pipe treated wastewater directly from wastewater plant to place of use (also called "flange-to-flange").
2. Indirect Reuse – Discharge treated wastewater to river, stream, or lake for subsequent diversion downstream (also called "bed and banks").

All possible recycled water projects considered for implementation within Region L and described in the following section are classified as direct reuse projects. All direct reuse water supply options assume that treated wastewater remains under the control (in pipelines or storage tanks) at all times from treatment to point of use by the entity treating the wastewater and/or supplying recycled water.

Recycled water quality and system design requirements are regulated by the Texas Commission on Environmental Quality (TCEQ) by 30 TAC §210. TCEQ allows two types of recycled water as defined by the use of the water and the required water quality:

- Type 1 – Public or food crops generally can come in contact with recycled water; and
- Type 2 – Public or food crops cannot come in contact with recycled water.

Current TCEQ criteria for recycled water are shown in Table 4C.5-1. Trends across the country indicate that criteria for unrestricted recycled water will likely tend to become more stringent over time. The water quality required for Type 1 recycled water is more stringent with lower requirements for oxygen demand (BOD_5 or $CBOD_5$), turbidity, and fecal coliform levels.

Table 4C.5-1.
TCEQ Quality Standards for Recycled Water

Parameter	*Allowable Level*
Type 1 Recycled Water	
BOD_5 or $CBOD_5$	5 mg/L
Turbidity	3 NTU
Fecal Coliform	20 CFU / 100 ml[1]
Fecal Coliform (not to exceed)	75 CFU / 100 ml[2]
Type 2 Recycled Water	
For a system other than a pond system	
BOD_5	20 mg/L
or $CBOD_5$	15 mg/L
Fecal Coliform	200 CFU / 100 ml[1]
Fecal Coliform (not to exceed)	800 CFU / 100 ml[2]
Type 2 Recycled Water	
For a pond system	
BOD_5	30 mg/L
Fecal Coliform	200 CFU / 100 ml[1]
Fecal Coliform (not to exceed)	800 CFU / 100 ml[2]

[1] geometric mean
[2] single grab sample

A general evaluation of recycled water for multiple water user groups (WUGs) with needs and potential wastewater sources were utilized to evaluate a broad range of potential recycled water supplies.

4C.5.2 General Evaluation of Direct Reuse Potential for Multiple Water User Groups

4C.5.2.1 Potential Recycled Water Needs

A number of water user groups with needs have the potential to utilize recycle water as a water management strategy. These include:

- Bexar County Industrial;
- Comal County Industrial;
- Bexar County Mining;
- Comal County Mining;
- Hays County Mining;
- SAWS;
- San Marcos;
- City of Marion;
- City of Floresville;
- SS WSC; and
- County Line WSC.

The needs of two water user groups can be completely met with the Recycle Water Programs water management strategy (Table 4C.5-2) in the 2011 South Central Texas Regional Water Plan. Three WUGs (Bexar County Mining, Comal County Mining, and Hays County Mining) were also considered for this strategy, but because the mining operations are located over the Edwards Aquifer Outcrop, the use of recycle water is discrouraged. Each of the other WUGs could use recycled water to meet the non-potable portion of their needs, however for regional planning purposes, it is assumed that their needs will be met by other projects. Table 4C.5-2 lists the water user groups with potential needs for recycled water by decade for 2010 through 2060 and their corresponding possible source of recycled water.

Table 4C.5-2.
General Recycled Water Potential

WUG	Proximate WW Treatment Facility	2010 Projected Need (acft/yr)	2020 Projected Need (acft/yr)	2030 Projected Need (acft/yr)	2040 Projected Need (acft/yr)	2050 Projected Need (acft/yr)	2060 Projected Need (acft/yr)
Bexar County Industrial	SAWS, SARA and CCMA	1,500	5,048	8,396	11,689	14,587	17,734
Comal County Industrial	New Braunfels Utilities	5,199	6,033	6,784	7,514	8,141	9,022

4C.5.2.2 Potential Recyecled Water Supply

The supply from recycled water that would be potentially available for any entity would be that portion of their wastewater effluent stream that is over and above any currently planned recycled water and any commitments made to downstream water rights and environmental flows. Of this potential, the amount that can actually be recognized depends on the availability of suitable users within an economical distance from the treatment plant. If individual high water use industrial plants or open land that benefits from irrigation, such as golf courses, are located relatively close to the plant, then recycled water can provide a substantial benefit to water supplies.

Information regarding each of the water utility districts with an available or projected supply of recycled water within an economical distance of a WUG with recycled water needs is listed in Table 4C.5-3.

Table 4C.5-3.
Possible Recycled Water Supply

Proximate WW Treatment Facility	2010 Projected Supply (acft/yr)	2020 Projected Supply (acft/yr)	2030 Projected Supply (acft/yr)	2040 Projected Supply (acft/yr)	2050 Projected Supply (acft/yr)	2060 Projected Supply (acft/yr)
SAWS	0	15,127	15,127	15,127	15,127	15,127
SARA	0	2,241	2,241	2,241	2,241	2,241
CCMA	6,722	9,859	16,580	16,580	16,580	16,580
New Braunfels Utilities	5,933	7,414	9,142	10,853	12,609	14,558
San Marcos Utilities	1,127	3,023	4,927	6,998	9,239	10,967

4C.5.2.3 Meeting Demands

The recycled water supply is sufficient to meet the projected needs for the two industrial WUGs in the region. Utilization of this water source is contingent on whether a potential use for the wastewater effluent exists within an economical distance from the treatment plant. Tables 4C.5-4 and 4C.5-5 itemize the projected supplies to meet the projected demands by decade for each water user group.

Table 4C.5-4.
Bexar County Industrial Recycled Water Needs, Supply, and Shortages

	2010 (acft/yr)	2020 (acft/yr)	2030 (acft/yr)	2040 (acft/yr)	2050 (acft/yr)	2060 (acft/yr)
Projected Needs	1,500	5,048	8,396	11,689	14,587	17,734
Supply from SAWS	0	15,127	15,127	15,127	15,127	15,127
Supply from SARA	0	2,241	2,241	2,241	2,241	2,241
Supply from CCMA	6,722	9,859	16,580	16,580	16,580	16,580
Shortages	0	0	0	0	0	0

Table 4C.5-6.
Comal County Industrial Recycled Water Needs, Supply, and Shortages

	2010 (acft/yr)	2020 (acft/yr)	2030 (acft/yr)	2040 (acft/yr)	2050 (acft/yr)	2060 (acft/yr)
Projected Needs	5,199	6,033	6,784	7,514	8,141	9,022
Supply from NBU	5,933	7,414	9,142	10,853	12,609	14,558
Shortages	0	0	0	0	0	0

4C.5.3 Environmental Issues

A summary of environmental issues is presented in Table 4C.5-7.

Table 4C.5-7.
Environmental Issues: General Recycled Water

Implementation Measures	Development of additional wastewater treatment plant facilities, distribution pipelines, and pump stations. Avoidence of project locations on the Edwards Aquifer recharge zone is desirable.
Environmental Water Needs / Instream Flows	Possible low impact on in-stream flows due to decreased effluent.
Bays and Estuaries	Possible low impact on freshwater inflows during drought dut to decreased effluent.
Fish and Wildlife Habitat	Possible impacts depending on changes in volume of effluent and locations of recycled water projects.
Cultural Resources	No impact anticipated.
Threatened and Endangered Species	Possible impacts depending on project location and habitat for listed species.
Comments	Assumes needed infrastructure will be in urbanized areas.

4C.5.4 Engineering and Costing

The required improvements to implement a recycled water supply would be expected to vary considerably between entities based on the upgrades required both in treatment and integration. Therefore, general cost estimates were developed for varying recycled water scenarios as described in Table 4C.5-8. To provide more flexibility in the types of recycled water applications possible, the scenarios assume the use of a type 1 wastewater effluent.

Table 4C.5-8.
Recycled Water Scenarios

Scenario #	Treatment	Integration
1	Existing WWTP is achieving treatment that meets the Type 1 effluent requirements. Treatment upgrade includes only the addition of chlorine for distribution.	Treated wastewater is supplied to demand location(s) from central WWTP by addition of piping and pump station.
2	Existing WWTP is nearly achieving treatment that meets the Type 1 effluent requirements. Treatment upgrade includes tertiary treatment and chlorine.	Treated wastewater is supplied to demand location(s) from central WWTP by addition of piping and pump station.

Scenarios 1 and 2, include central storage at the wastewater plant with recycled water delivered to demand location on an as needed basis. An alternate delivery option not included here is a more decentralized recycled water system with storage located at the point of use. Providing storage at the point of use may decrease required pipeline and pump station size because the water can be transported at a more uniform rate to fill storage tanks at the point of use. However, installation of storage tanks at the point of use may be problematic in highly urbanized areas or undesirable near high public use areas.

Cost estimates were developed for each of the scenarios with required facilities for each scenario shown in Table 4C.5-8. The demand for recycled water used for irrigation of golf courses, parks, schools, crops, or other landscapes will vary seasonally. For planning purposes, the application rates in Table 4C.5-9 are assumed to determine the available project yield for varying sizes of recycled water facilities. Recycled water facilities are sized for the peak usage periods, and consequently, the average annual rate of usage may be considerably lower than the peak usage. For a recycled water system with typical application rates, as shown in Table 4C.5-10, the annual available project yield is 57 percent of the recycled water system capacity. Available project yield may be higher than 57 percent of maximum capacity for systems supplying a large portion of the recycled water to industrial or other users that have a more uniform recycled water demand.

Table 4C.5-9. Recycled Water Scenarios 1, and 2 Required Distribution Facilities

Facility	Maximum Capacity (MGD)				Description
	0.5	1	5	10	
Pump Station, HP	127	248	1,209	2,332	Capacity to deliver maximum daily demand in 6 hours
Storage Tank, MG	0.5	1	5	10	Store one days treated recycled water at WWTP
Pipeline, Size in Inches (Length in Miles)	12 (2)	16 (2)	33 (3) 18 (2) 12 (1)	48 (4) 18 (3) 12 (2)	Capacity to deliver maximum daily demand in 6 hours
Available Project Yield, acft/yr (MGD)	319 (0.28)	638 (0.57)	3,193 (2.85)	6,385 (5.7)	Yield is 57 percent of maximum treatment capacity based on seasonal use shown in Table 4C.5-7

Table 4C.5-10. Recycled Water Irrigation Application Rate

Use Level	Application Rate	Duration
Peak	1.25 in/week	4 months
Normal	0.75 in/week	3 months
Below Normal	0.25 in/week	5 months
Average	0.71 in/week	weighted
Average/Peak	0.71 / 1.25 = 0.57	

Irrigation water for landscapes such as golf courses and parks will generally be applied during periods when these areas are not being utilized, typically at night. Therefore, the distribution facilities are sized to deliver the total daily demand in a 6-hour period. Pumping facilities are sized to provide a residual pressure of 60 psi at the delivery point.

Table 4C.5-11 shows annual cost of recycled water per 1,000 gallons for a range of project scenarios and capacities. These costs are for general planning purposes and will vary significantly depending on the specific circumstances of an individual water user group. Tables 4C.5-12 and 4C.5-13 show the total project capital costs and total operations and maintenance costs for recycled water supplies, respectively.

Table 4C.5-11.
General Recycled Water Annual Cost of Water
($ per 1,000 gal available project yield)
September 2008 Prices

Scenario	Capacity (MGD)			
	0.5	1	5	10
1	$4.00	$2.94	$1.91	$1.69
2	$7.61	$5.57	$3.47	$3.04
Debt Service (6 percent for 20 years)				

Table 4C.5-12.
General Recycled Water Total Project Capital Cost
($ per gallon maximum capacity)
September 2008 Prices

	Maximum Capacity (MGD)			
Scenario	0.5	1	5	10
1	$7.91	$5.67	$3.73	$1.87
2	$11.10	$7.96	$4.97	$2.48

Table 4C.5-13.
General Recycled Water Total Operations and Maintenance Cost
($ per 1,000 gallons)
September 2008 Prices

	Maximum Capacity (MGD)			
Scenario	0.5	1	5	10
1	$0.69	$0.56	$0.35	$0.30
2	$2.95	$2.23	$1.39	$1.23

The general recycled water costs are utilized to develop the cost estimates for individual water user groups shown in Table 4C.5-14. The recycled water project maximum capacity (MGD) for each water user group was developed based on the "2060 Projected Need" and "2060 Potential Recycled Water," as shown in Tables 4C.5-2 and 4C.5-3.

Table 4C.5-14.
Unit Cost Estimate Summaries
Recycled Water as a Water Management Strategy for Multiple Water User Groups
September 2008 Prices

Water User Group	Costing Scenario	Unit Cost ($/acft)					
		2010	2020	2030	2040	2050	2060
Bexar County Industrial	1	$580	$580	$98	$881	$881	$205
Comal County Industrial	1	$580	$580	$98	$98	$98	$98

4C.5.5 Implementation Issues

This water supply option has been compared to the plan development criteria, as shown in Table 4C.5-16, and the option meets each criterion. Each community that pursues recycled water will need to investigate concerns that would include at a minimum:

- Amount of treated effluent available, taking into consideration downstream water commitments and discharge permit restrictions.
- Potential users, primarily individual large-scale users that could utilize non-potable water (e.g., certain industries) and irrigated lands (e.g., golf courses and park areas).
- Capital costs of constructing needed distribution systems connecting the treatment facilities to the areas of recycled water.

Recycled water requires a TCEQ permit. Requirements specific to pipelines needed to link wastewater treatment facilities to recycled water customers may include:

- U.S. Army Corps of Engineers Section 404 permit(s) for pipeline stream crossings; discharges of fill into wetlands and waters of the United States for construction; and other activities;
- TPDES Storm Water Pollution Prevention Plan; and
- TPWD Sand, Shell, Gravel and Marl permit for construction in state-owned streambeds.

Table 4C.5-16.
Comparison of General Recycled Water Option to Plan Development Criteria

Impact Category	Comment(s)
A. Water Supply 1. Quantity 2. Reliability 3. Cost	 1. Potentially important source, up to 25 percent of demand 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. Produces instream flows—low to moderate impact 2. Possible low impact 3. None or low impact 4. None or low impact 5. Possible impact 6. None or low impact
C. Impact on Other State Water Resources	No apparent negative impacts on state water resources; benefit accrues to demand centers by more efficient use of available water supplies; no effect on navigation
D. Threats to Agriculture and Natural Resources	Generally positive effect to agriculture and natural resources by avoiding need for new supplies
E. Equitable Comparison of Strategies Deemed Feasible	Option is considered to meet municipal and industrial shortages
F. Requirements for Interbasin Transfers	Not applicable
G. Third Party Social and Economic Impacts from Voluntary Redistribution	Could offset the need for voluntary redistribution of other supplies

2011 South Central Texas Regional Water Plan
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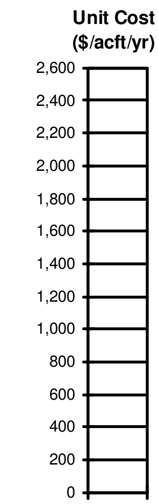

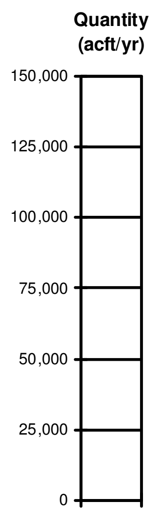

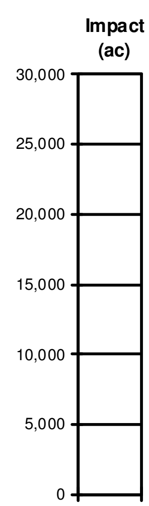

Name: Facilities Expansions

Description: Facilities Expansions is an activity to identify known or projected system improvements to continue to provide a safe and reliable water supply to the utility's customers. These improvements commonly add pipelines, pump stations and/or storage, interconnection with nearby utilities, and water treatment plants. The improvements were identified by the water utilities and not by a review of each facilities' infrastructure by Region L. Ten utilities in six counties have identified needed improvements.

***Decade Needed*:** 2010 – 2060

Cost, Quantity of Water, and Land Impacted

Unit Cost of Water:	**N/A**		**Treated Water Delivered**
Quantity of Water:	**N/A**	**acft/yr**	**Reliability = Firm**
Land Impacted:	**N/A**	**acres**	

Additional Considerations per Regional Water Planning Guidelines

Environmental Factors:

The water utility improvements are to be constructed in developed areas of the water utilities.
No significant impacts on wildlife and cultural features are expected.

Impacts on Water Resources:

None.

Impacts on Agricultural & Natural Resources:

None.

Other Relevant Factors per SCTRWPG:

None.

Comparison of Strategies to Meet Needs:

None.

Interbasin Transfer:

None.

Issues:

None.

Third-Party Impacts of Voluntary Transfers:

None anticipated.

Regional Efficiency:

None.

Water Quality Considerations:

None.

4C.6 Facilities Expansions

4C.6.1 Description of the Water Management Strategy

Several Water User Groups (WUGs) are interested in projects to expand major components of their existing infrastructure (facilities) so they can continue to provide a safe and reliable water supply to their customers during the planning period. These facilities expansions are considered to be independent of any potential water management strategies to acquire a new water supply, and instead are intended to address expected future improvements to the water system, such as the installation of new water transmission facilities or additional water treatment.

The identification of the facilities expansions is based on responses from WUGs or representatives of the South Central Texas Regional Water Planning Group only. This water management strategy does not include an environmental assessment, as any environmental issues would likely be localized. Furthermore, cost estimates for each of these facilities expansions are not included, as they will be based on preliminary engineering designs by the entities' engineer.

4C.6.2 Available Yield

The Facilities Expansions water management strategy (WMS) does not provide additional new firm supply. It is intended to document the expansion of existing facilities for WUGs that notified the South Central Texas Regional Planning Group about their plans during the request for information on their future water supply plans. The Facilities Expansions WMS allows these WUGs to better utilize their existing supplies and facilitate the implementation of new supplies from other WMSs.

4C.6.3 Environmental Issues

Facilities expansions typically include adding or expanding water treatment plants, pipelines, pump station, and ground or elevated storage, many of which are on land and easements already owned by the WUG. In the permitting process some of these facilities expansions may require habitat studies and surveys for protected species and a cultural review. If a significant negative impact appears likely, some modifications to the project may be required. Mitigation may include compensation for net losses of wetlands where impacts are unavoidable.

4C.6.4 Engineering and Costing

Preliminary engineering and costing have been completed for all facilities expansions not already included in other strategies. Cost estimates were developed using regional planning procedures, and all connections are assumed to be made by 12 in. dia. transmission pipelines. The annual costs include debt service for a 20-year loan at 6 percent interest and operation and maintenance costs. A description of the facilities expansions requested by each WUG is presented by county below.

4C.6.4.1 Atascosa County

4C.6.4.1.1 City of Charlotte

The City of Charlotte is interested in constructing new water transmission facilities that would establish interconnects between their water utility and Benton City WSC, City of Poteet, City of Jourdanton, and City of Pleasanton. These interconnects would greatly increase the reliability of potable water for the City of Charlotte and the other small utilities. The cost estimate for facilities expansion for the City of Charlotte includes four 12-inch interconnection transmission pipelines and is summarized in Table 4C.6-1.

4C.6.4.1.2 City of Pleasanton

In addition to installing new wells that were identified in the Local Groundwater WMS, the City of Pleasanton is interested in installing two new elevated water tanks - one in the northwest sector of the service area and another one in the northeast sector of the service area. The expansion is planned to address increased demands for potable water in these areas and to improve water system pressure. No cost estimates were prepared for the City of Pleasanton facilities expansion projects as they are distribution system improvements and not part of the regional planning process.

4C.6.4.1.3 Atascosa Rural WSC

The Atascosa Rural WSC is interested in water transmission facilities for interconnects with Benton City WSC, Bexar Metropolitan Water District (BMWD), City of Poteet, City of Jourdanton, and City of Pleasanton. This interconnect would greatly increase the reliability of the utility and facilitate the implementation of potential WMSs, including Medina Lake Firm-up and Aquifer Storage and Recovery projects. The cost estimate for facilities expansion for the Atascosa Rural WSC includes four 12-inch interconnection transmission pipelines and is summarized in Table 4C.6-1.

4C.6.4.2 Bexar County

4C.6.2.2.1 City of Helotes

The City of Helotes is interested in integrating their water system with SAWS by installing new water main pipelines, pump stations, and/or storage. The area of greatest interest is along State Highway 16 within the commercial corridor of the city. The cost estimate for facilities expansion for the City of Helotes includes a 12-inch interconnection transmission pipeline and is summarized in Table 4C.6-1.

4C.6.4.3 Caldwell County

4C.6.4.3.1 Tri-Community WSC

The Tri-Community WSC is interested in constructing an emergency and/or long-term interconnect with the Maxwell WSC and the City of Luling. The interconnects are to be designed to provide, at least, an interim supply of treated water during emergencies. These interconnects would require new pipelines, pump stations, and/or storage facilities. The cost estimate for facilities expansion for the Tri-Community WSC (Caldwell County Rural) includes two 12-inch interconnection transmission pipelines and is summarized in Table 4C.6-1.

4C.6.4.4 Gonzales County

4C.6.4.4.1 Gonzales County WSC

The Gonzales County WSC is interested in a facilities expansion that includes: (1) an interconnection with the Schertz-Seguin Local Government Corporation (SSLGC) and (2) an interconnection with the Texas Water Alliance. These interconnects would require new pipelines, pump stations, and/or storage facilities. Costs associated with Gonzales County WSC facilities expansion are included in the TWA Regional Carrizo water management strategy.

4C.6.4.5 Guadalupe County

4C.6.4.5.1 City of Seguin

The City of Seguin is interested in a facilities expansion that includes an interconnection with Texas Water Alliance. The interconnection would require new pipelines, pump stations, and/or storage facilities. In addition, the City foresees the need for additional transmission facilities (pipelines, pump stations ,and storage) for their SSLGC project. Costs associated with the City of Seguin facilities expansion are included in the TWA Regional Carrizo water management strategy.

4C.6.4.5.2 Springs Hill WSC

The Springs Hill WSC is interested in expanding their Lake Placid Water Treatment Plant from the current 1 MGD capacity to 2 MGD so that they can fully utilize their surface water rights. In addition, other improvements may include new pipelines, pump stations, and/or storage. The cost estimate is summarized in Table 4C.6-1.

4C.6.4.6 Medina County

4C.6.4.6.1 City of Castroville

The City of Castroville is interested in an expansion that includes an interconnection with the South Texas Regional Water Alliance. This interconnection would require new pipelines, pump stations, and/or storage facilities. The cost estimate for facilities expansion for the City of Castroville includes a 12-inch interconnection transmission pipeline and is summarized in Table 4C.6-1.

4C.6.4.6.2 Yancey WSC

The Yancey WSC is interested in adding an element to their Local Groundwater WMS that includes an expansion of water transmission facilities such as new pipelines, pump stations, and/or storage facilities. No cost estimates were prepared for the City of Pleasanton facilities expansion projects as they are distribution system improvements and not part of the regional planning process.

Table 4C.6-1.
Facilities Expansion Preliminary Costs

WUG	Description	Total Capacity of Facilities Expansion (acft/yr)	Project Cost	Annual Cost
City of Charlotte	(4) 12-in. dia. transmission pipeline connection	11,372	$38,356,000	$3,586,000
Atascosa Rural WSC	(4) 12-in. dia. transmission pipeline connection	11,372	$72,433,000	$6,772,000
City of Helotes	12-in. dia. transmission pipeline connection	2,843	$2,863,000	$269,000
Tri-Community WSC	(2) 12-in. dia. transmission pipeline connection	5,686	$17,584,000	$774,000
City of Castroville	12-in. dia. transmission pipeline connection	2,843	$11,046,000	$1,033,000
Springs Hill WSC	Expansion of Lake Placid WTP capacity from 1 MGD to 2MGD	1,120	$2,277,000	$722,000

4C.6.5 Implementation Issues

The facilities expansions are not expected to have significant implementation issues.

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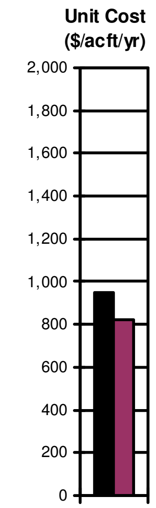
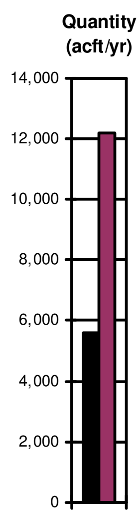
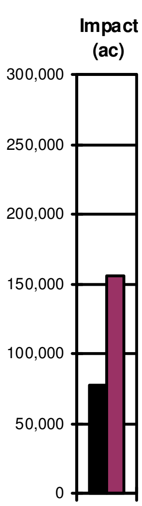
2011 South Central Texas Regional Water Plan
Water Management Strategy Summary Sheet







Name: Brush Management (Above Canyon Reservoir)

Description: Selective removal of brush from rangeland watersheds in counties of the South Central Texas Water Planning Region located in the watershed upstream of Canyon Reservoir that contributes runoff and thereby enhances the firm yield of the reservoir.

***Decade Needed*:** 2010 – 2060

Cost, Quantity of Water, and Land Impacted

Unit Cost of Water:	**949**	**$/acft/yr**	**Treated w/ 25% Participation**
	823	**$/acft/yr**	**Treated w/ 50% Participation**
Quantity of Water:	**5,590**	**acft/yr**	**Reliability = Firm**
	12,180	**acft/yr**	**Reliability = Firm**
Land Impacted:	**~78,000**	**acres**	
	~156,000	**acres**	

Additional Considerations per Regional Water Planning Guidelines

Environmental Factors: May increase runoff and instream flows. Brush management may adversely impact existing wildlife population. Chemical brush control methods may result in residual chemicals in aquifers and streams.

Impacts on Water Resources: Benefit to Canyon Reservoir due to increased water for runoff.

Impacts on Agricultural & Natural Resources: Potential threats to wildlife habitat due to removal of brush.

Other Relevant Factors per SCTRWPG: Additional water supply and costs are only applicable to enhanced firm yield of Canyon Reservoir. Costs and additional water supply would be different for other reservoirs and watersheds. Permitting such a project with TCEQ will be difficult. The outcome of GMA 9, specifically the Desired Future Conditions (DFC) and associated pumpage could affect the potential supply associated with a Brush Management project in the watershed above Canyon Reservoir.

Comparison of Strategies to Meet Needs: Moderate unit costs. No conflicts with other recommended water management strategies.

Interbasin Transfer Issues: Not applicable.

Third-Party Impacts of Voluntary Transfers: Not applicable

Regional Efficiency: Effective implementation of brush management strategy requires coordination and participation by many local land owners.

Water Quality Considerations: Chemical brush control methods may result in residual chemicals to aquifers and streams

4C.7 Brush Management (Above Canyon Reservoir)

4C.7.1 Description of Water Management Strategy

The interest in brush management as a means to increase water supply has its roots in (1) the observation that Texas rangelands changed after settlement and use by Europeans from predominantly open grasslands to increasing domination of brush, and (2) the significantly greater interception of water by brush than grasses. The former suggests that the "natural" character of Texas rangelands would be grasslands. The latter suggests the possibility of increasing aquifer recharge and streamflow by controlling and limiting growth of brush and trees in areas where grasslands would have naturally dominated. For this brush management option, brush management methods will be described, and estimates of cost and potential water supply effects will be presented.

Documentation of early European settlers described Texas rangelands as grasslands. Prior to settlement by Europeans, with its associated grazing, significant brush growth was inhibited due to several natural conditions. Tree seeds commonly die following germination in grass cover because they cannot compete with grasses for sunlight and moisture. Also, any surviving seedlings are typically destroyed in periodic wildfires that occur in natural grasslands. Heavy grazing lessens the competitiveness of grass relative to brush and removes the fuel (grass) from rangeland wildfires. The result of heavy grazing is the increased dominance of trees and brush in grasslands. This pattern of vegetation was common worldwide with the advent of European settlement of rangelands.

In view of the consequences of heavy grazing on rangelands, ranchers have a compelling interest in controlling brush (i.e., the livestock-carrying capacity of rangeland is reduced by large increases in woody cover). The effect on livestock-carrying capacity results from the noxious-tasting seedlings common in Texas, like juniper and mesquite. Livestock avoid grazing these plants and, thus, provide these brush species a competitive advantage over the grasses preferred by livestock. For a unit grazing area, fewer livestock can be supported as the percentage of brush increases. This suggests there would be some economic incentive for ranchers to control brush and, to the extent that reductions in brush cover on rangeland results in larger quantities of recharge to aquifers and run-off to streams, brush control may result in increased water supplies for municipal, industrial, irrigation and other uses.

Brush management is one of many land management practices, collectively referred to as "voluntary land stewardship", that can provide water supply at its origin. Voluntary land stewardship includes (but is not limited to) absorbing rainfall, reducing run-off, using prescribed fire properly, planning and managing grazing, brush management, managing erosion, wildlife and habitat management, and protecting springs and creek banks. With an optimal, voluntary land stewardship program, floods are reduced, aquifers are replenished, and water is released more slowly and steadily into streams, rivers, lakes and bays. Although this water management strategy specifically addresses supplies attributable to brush management, additional water supply benefits, including additional inflow to reservoir systems, may be achieved with a comprehensive land stewardship program.

More problematic for brush control, however, is the evidence that more Texas ranches are being purchased for reasons other than grazing. A survey of the Edwards Plateau found that ranch owners who are not dependent on livestock income are less interested in investing in brush control. Some within this group of ranchers may practice brush control, but they do so for reasons other than agricultural economics. According to previous studies, brush management may have detrimental effects on certain types of wildlife. Brush species constitute a significant portion (>58 percent) of nutritious forage for white tailed deer, and provide shelter and hiding cover for wildlife. In 1996, hunting and wildlife watching contributed approximately $2.6 billion to the Texas economy. Hunting is popular in South Texas. Previous studies recommend maintaining 40 to 60 percent brush to provide good deer habitat. Consequently, it may provide greater regional benefits to leave more untreated brush to maintain diversity essential to good wildlife habitat and hunting.

4C.7.2 Water Availability

A hydrologic model was developed for the study watershed using U.S. Environmental Protection Agency's (EPA) Hydrologic Simulation Program – Fortran (HSPF) model in conjunction with the EPA BASINS suite of tools. HSPF is a set of computer codes that can simulate the hydrologic and associated water quality processes on pervious and impervious land surfaces, and in streams and well-mixed impoundments. HSPF uses continuous rainfall and other meteorological records to compute streamflow hydrographs and pollutographs. It simulates several parameters including interception, soil moisture, surface runoff, interflow, base flow, evapo-transpiration, and groundwater recharge. HSPF can simulate one or multiple pervious or impervious unit areas discharging to one or multiple river reaches or reservoirs. Using a post-processing tool (WDMUtil), frequency-duration analysis can be done for any timeseries. HSPF can be used to assess the effects of land-use change, reservoir operations, point and non-point source discharges, and flow diversions on streamflow conditions.

4C.7.2.1 Hydrologic Data and Inputs

Figure 4C.7-1 shows the study watershed that includes the entire drainage area (1,314 square miles) above the USGS streamgage #08167500 (Guadalupe River near Spring Branch), located upstream Canyon Reservoir. For this study, the watershed was divided into two sub-watersheds:

- Upper basin based on the USGS streamgage #08167000 (Guadalupe River at Comfort), with a drainage area of 839 square miles; and
- Lower basin based on the Guadalupe River near Spring Branch streamgage, with a drainage area of 475 square miles.

A daily time step was chosen for the simulation of the January 1934 through December 1998 period of record, which includes the drought of record (1947 through 1956).

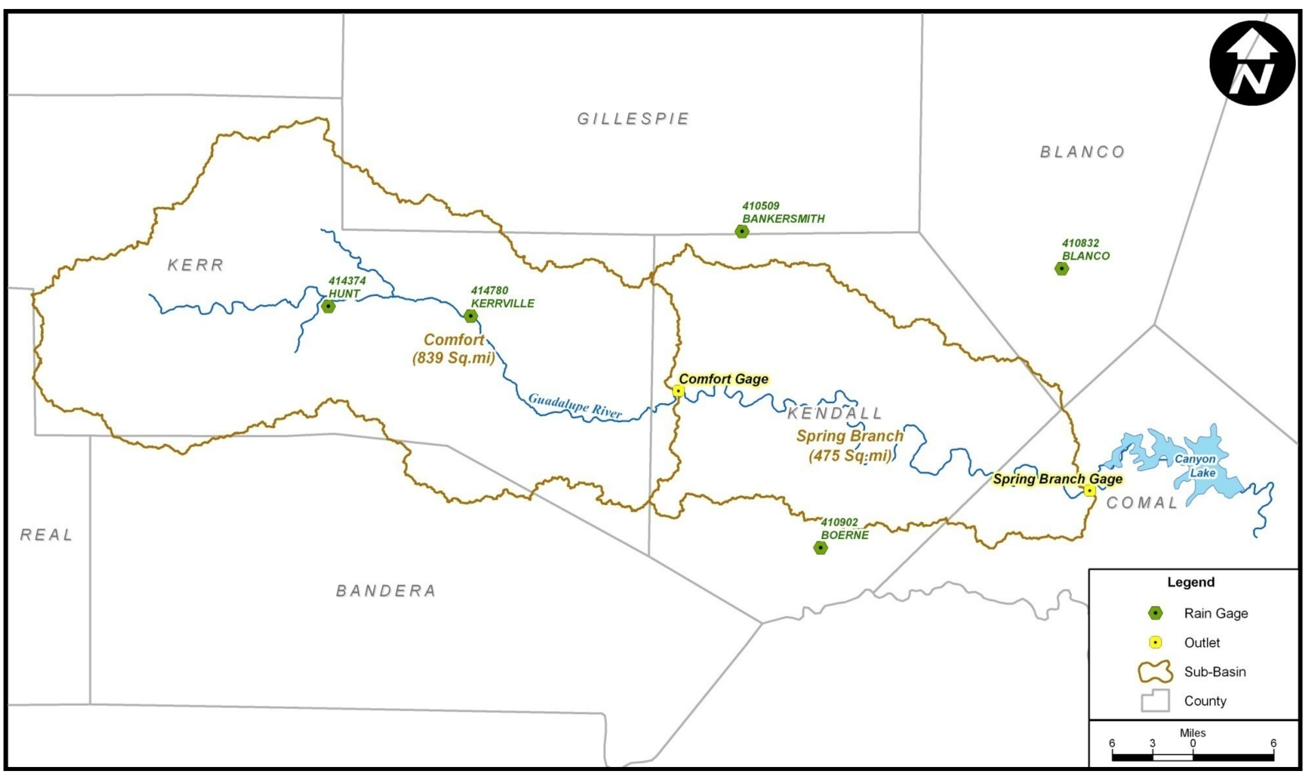


Figure 4C.7-1. Brush Management Study Area Watershed

Observed streamflows at the Guadalupe River near Spring Branch streamgage was acquired from the USGS website[1] for the simulation period for use in calibration. Daily precipitation data from five gages in and around the study area (Figure 4C.7-1) were obtained from the National Weather Service (NWS) and combined into one timeseries for input to HSPF using Thiessen polygon area weighting methodology. A monthly gross evaporation dataset was obtained from the Texas Water Development Board. The 2001 USGS National Landcover Dataset (NLCD), USGS Digital Elevation Model (DEM), and the delineated sub-watersheds were overlaid to obtain a breakdown of the landcover categories and the average slope within the sub-watersheds. The average land-surface slope in a sub-watershed was applied to all land segments within the sub-watershed. Furthermore, one pervious (PERLND) and one impervious (IMPLND) land segment for each of the two sub-watersheds was created in HSPF. Input parameters were derived based on landcover, and then averaged for the entire sub-watershed for input into the HSPF model.

Table 4C.7-1 summarizes the average streamflow, precipitation and evaporation for existing ("Baseline") long-term (1934-1998) and drought (1947-1956) as used in this study. The data shows that there is a 20 percent decrease in rainfall during the drought period with a corresponding 20 percent increase in evaporation. This translates into a more pronounced 70 percent decrease in runoff within the watershed.

Table 4C.7-1.
Watershed above Canyon Reservoir – Hydrologic Data

Period	*Average Annual Streamflow – Spring Branch Gage (cfs)*	*Average Annual Rainfall (in)*	*Average Annual Evaporation (in)*
Period of Record (1934-1998)	378.0	28.0	62.8
Drought of Record (1947-1956)	113.0	22.4	75.4

All of the spatial information necessary for to represent the watershed is included in the main input (UCI) file and consists of the land segment (PERLND/IMPLND), river reach (RCHRES), length and hydraulic capacity and connectivity. There are 17 parameter values

[1] http://waterdata.usgs.gov/usa/nwis/uv?site_no=08167500

within the UCI files that are used to describe the hydrologic characteristics of each land segment in the Spring Branch watershed. Initial parameters values were chosen primarily from two earlier reports.[2,3]

Two key model parameters for Brush Management within HSPF are Lower Zone Evapo-transpiration (LZETP) and Interception (CEPSC). LZETP is an index to the density of deep rooted vegetation and varies monthly based on vegetative cover, with slightly higher evapo-transpiration for Juniper species and grasses. Grasses have a broader range of seasonal LZETP increase from 0.1 in January to 0.8 from May-September than juniper species, which ranges from 0.3 in January to 0.7 in May as shown in Table 4C.7-2.

Table 4C.7-2.
Typical Monthly Lower Zone Evapo-transpiration Parameter (LZETP) Values for Various Landcovers

Landcover	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Average
Open Water	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00
Developed, Open Space	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.05
Developed, Low Intensity	0.1	0.1	0.3	0.7	0.8	0.9	0.9	0.9	0.8	0.4	0.3	0.1	0.53
Developed, Medium Intensity	0.1	0.1	0.3	0.7	0.8	0.9	0.9	0.9	0.8	0.4	0.3	0.1	0.53
Developed, High Intensity	0.1	0.1	0.3	0.7	0.8	0.9	0.9	0.9	0.8	0.4	0.3	0.1	0.53
Barren Land (Rock/Sand/Clay)	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.05
Deciduous Forest	0.3	0.3	0.5	0.5	0.6	0.7	0.7	0.7	0.7	0.6	0.4	0.3	0.53
Evergreen Forest	0.3	0.3	0.4	0.6	0.7	0.7	0.7	0.7	0.7	0.6	0.4	0.3	0.53
Mixed Forest	0.1	0.1	0.3	0.6	0.6	0.7	0.7	0.7	0.7	0.5	0.3	0.2	0.46
Shrub/Scrub	0.1	0.2	0.3	0.6	0.8	0.8	0.8	0.8	0.8	0.4	0.3	0.1	0.50
Grassland/Herbaceous	0.1	0.1	0.3	0.7	0.8	0.9	0.9	0.9	0.8	0.4	0.3	0.1	0.53
Pasture/Hay	0.1	0.1	0.3	0.7	0.8	0.9	0.9	0.9	0.8	0.4	0.3	0.1	0.53
Cultivated Crops	0.1	0.1	0.3	0.7	0.8	0.9	0.9	0.9	0.8	0.4	0.3	0.1	0.53
Woody Wetlands	0.1	0.1	0.3	0.7	0.8	0.9	0.9	0.9	0.8	0.4	0.3	0.1	0.53

[2] Brush Management: 2006 South Central Texas Regional Water Plan Volume II – January 2006
[3] Pilot Recharge Models of the Nueces and Blanco River Basins, HDR, June 2002

In addition to distinctly different LZETP trends based on types of vegetation, the water use of various trees, brush, and grasses, measured using an interception storage capacity (CEPSC) parameter, has been studied by the USGS and simulated in hydrologic programs (specifically Hydrologic Simulation Program- Fortran)[4]. Interception storage is a function of cover density and is best estimated with vegetation and land use cover distribution maps. Interception values vary according to types of land coverage as shown in Table 4C.7-3.

Table 4C.7-3.
Typical Interception Values for Various Landcovers

Landcover	*Interception (in)*
Open Water	0.00
Developed, Open Space	0.05
Developed, Low Intensity	0.12
Developed, Medium Intensity	0.12
Developed, High Intensity	0.12
Barren Land (Rock/Sand/Clay)	0.05
Deciduous Forest	0.30
Evergreen Forest	0.40
Mixed Forest	0.15
Shrub/Scrub	0.12
Grassland/Herbaceous	0.15
Pasture/Hay	0.12
Cultivated Crops	0.12
Woody Wetlands	0.15

4C.7.2.2 HSPF Calibration

After selecting an initial set of parameters as mentioned in the previous section, the HSPF model was calibrated by adjusting the parameters listed in Table 4C.7-4.

[4] ibid

Table 4C.7-4.
Key HSPF Calibration Parameters

Parameter Group	Parameter	Description
PWAT-PARM2	LZSN	Lower zone nominal storage (inches)
	INFILT	Infiltration capacity of the soil (inches/hour)
	KVARY	GW recession parameter enabling it to be non-exponential in its decay (1/inch)
	AGWRC	GW recession rate; if KVARY =0, no inflow to GW (1/day)
PWAT-PARM3	DEEPFR	Fraction of GW lost to deep percolation
	BASETP	Fraction. of remaining pot. ET which can be satisfied from baseflow
	AGWETP	Fraction of remaining pot. ET which can be satisfied from active GW Storage
PWAT-PARM4	UZSN	Upper zone nominal storage (inches)
	CEPSC	Interception storage capacity (inches)
	INTFW	Interflow inflow parameter
	LZETP	Lower zone E-T parameter (used monthly values)
	IRC	Interflow recession parameter (1/day)

The initial LZETP values were based on Table 4C.7-2. These values corresponding to the landcover categories within the study area were weighted with the individual sub-watershed areas (Comfort gage and Spring Branch gage). The calculated weighting factors were then applied to the initial values to calculate a "Baseline LZETP" for each landcover and month. This set of Baseline LZETP was used as a starting point for HSPF calibration. During the process of calibration, these values were further adjusted resulting in a new set of "Calibrated LZETP" values. The calibrated LZETP then formed the basis for further adjustment during the brush management scenario simulations. This approach provides both spatial and temporal variability in LZETP across the model domain.

A similar area-weighting approach was taken for the interception parameter (CEPSC). However, the initial set of values (Table 4C.7-3) available for this parameter varied only by land cover and not by month. Therefore, the same set of values was repeated for all the months. This approach (as opposed to using a single CEPSC value and no variability) provides spatial variability but no temporal variability in the model.

The main calibration goals were to match the annual volumes with observed volumes at the Spring Branch gage and the recession limb of the hydrograph. In general, the model parameters were adjusted for the for the entire simulation period of 1934-1998 during calibration so as to avoid having multiple sets of calibration parameters for different time periods. In addition, two dry years, two average years, and two wet years were examined closer to assess the calibration. Specifically, the following time periods/years were examined.

- Two Dry Years = 1954 and 1963
- Two Average Years = 1971 and 1976
- Two Wet Years = 1987 and 1992

Figure 4C.7-2 shows a graph of total annual observed streamflow volumes at the Spring Branch gage during the simulation period. The dotted line indicates the overall long-term average (273,500 acft) for the simulation period. Figures 4C.7-3 through 4C.7-9 show the plots comparing observed streamflow at Spring Branch gage with modeled flows for Baseline (calibrated) Conditions and the entire simulation period, the two dry, average and wet years.

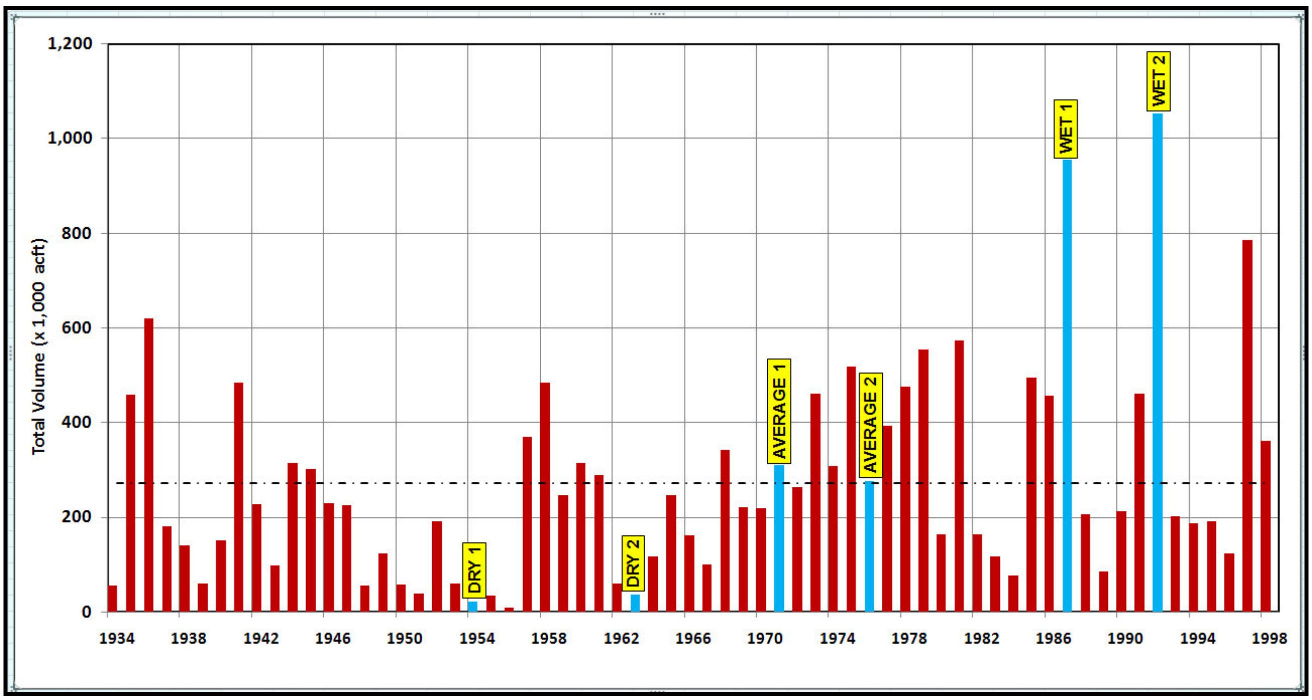


Figure 4C.7-2. Annual Runoff Volume at Spring Branch Gage

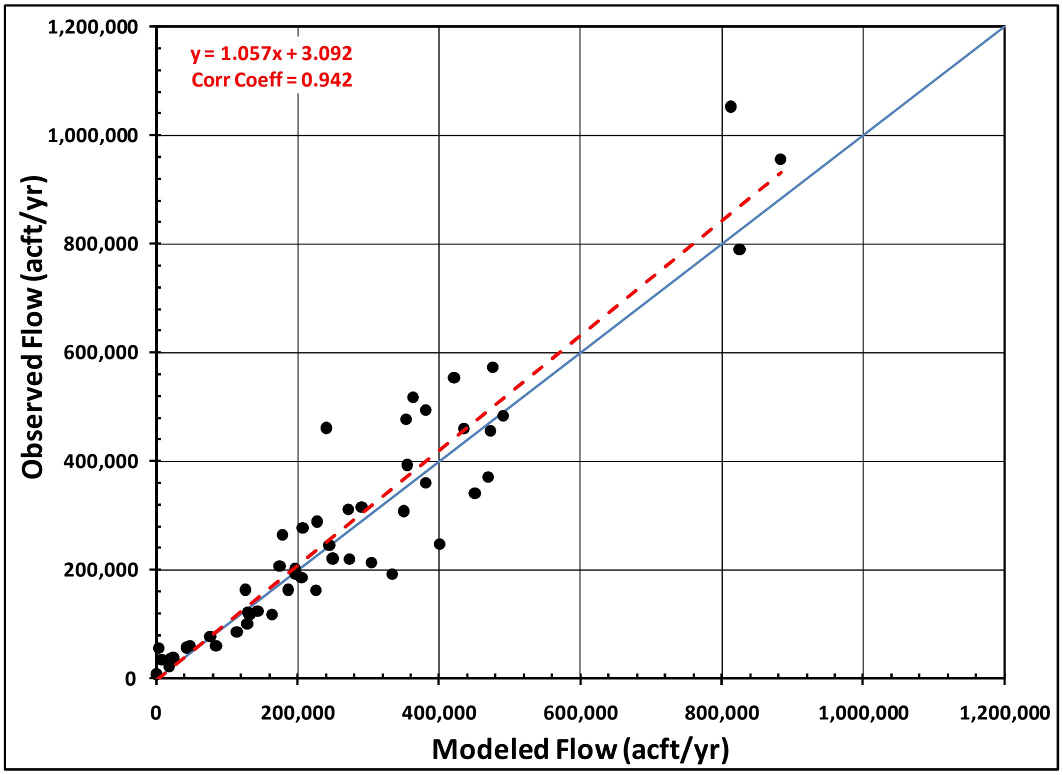


Figure 4C.7-3a. Annual Observed Streamflow vs. Simulated (Baseline) Streamflows

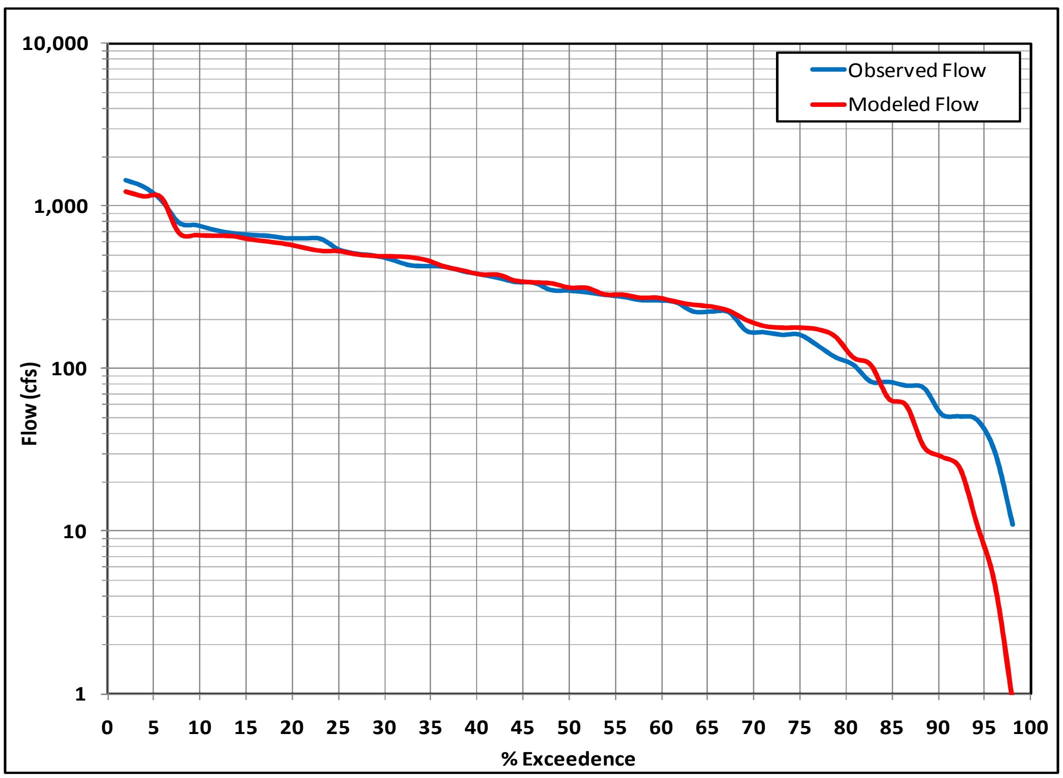


Figure 4C.7-3b Annual Observed Streamflow vs. Simulated (Baseline) Streamflows

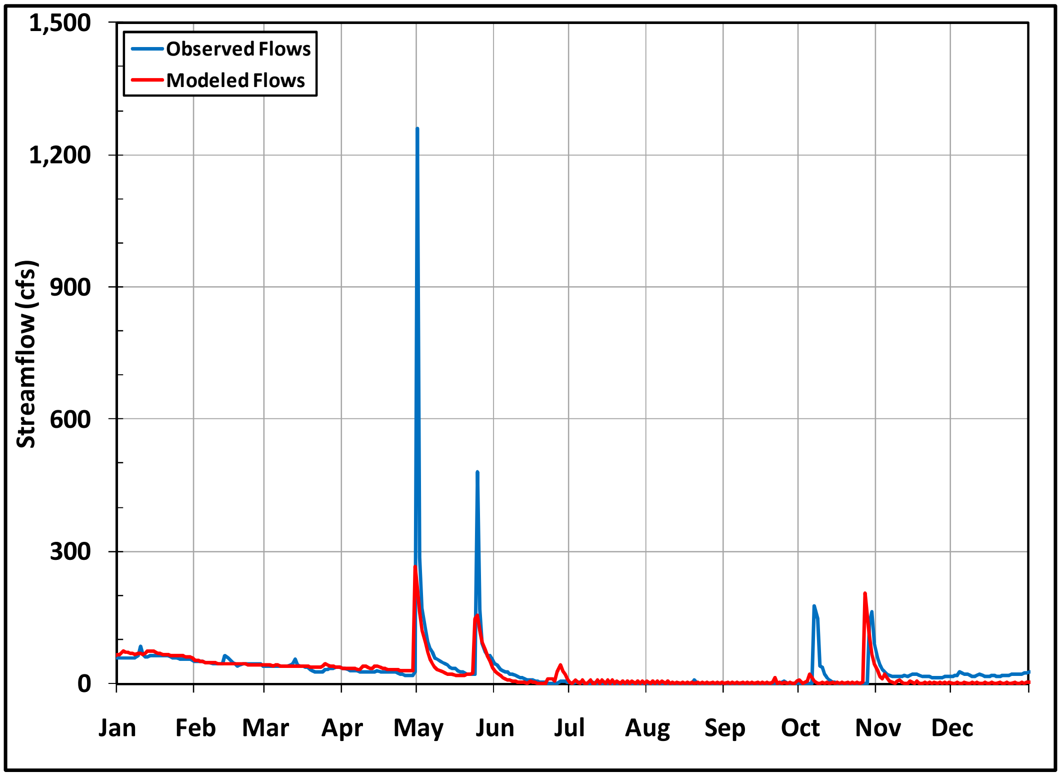


Figure 4C.7-4. Daily Observed Streamflow vs. Simulated (Baseline) Streamflow (1954)

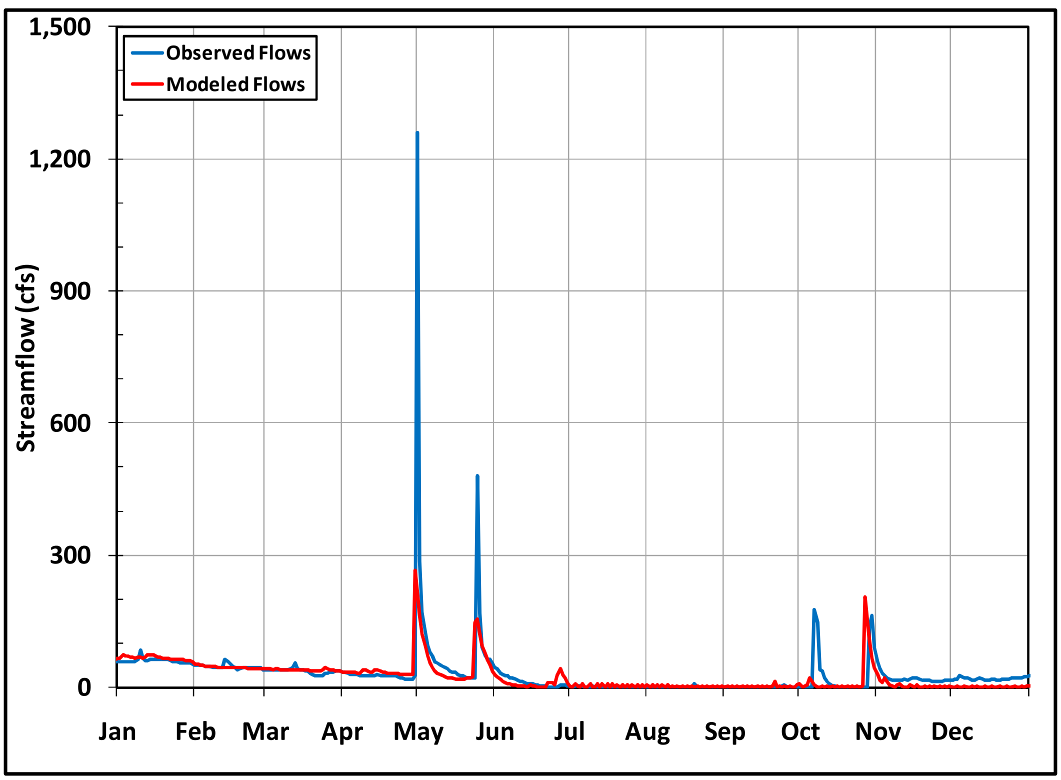


Figure 4C.7-5. Daily Observed Streamflow vs. Simulated (Baseline) Streamflow (1963)

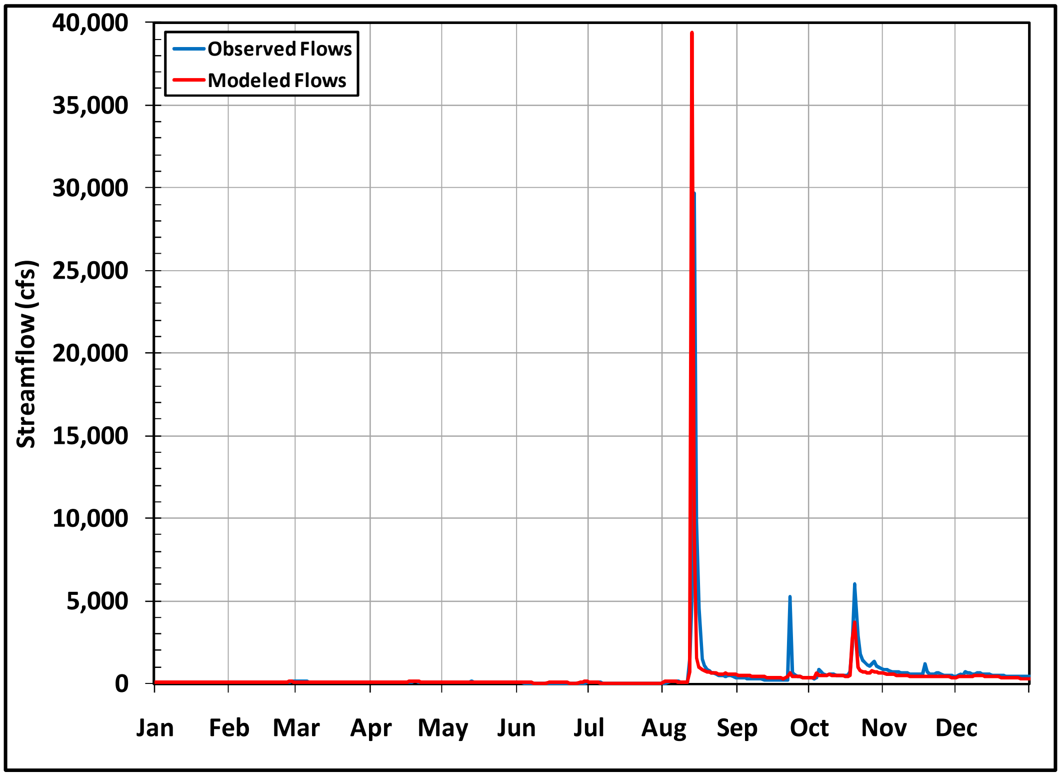


Figure 4C.7-6. Daily Observed Streamflow vs. Simulated (Baseline) Streamflow (1971)

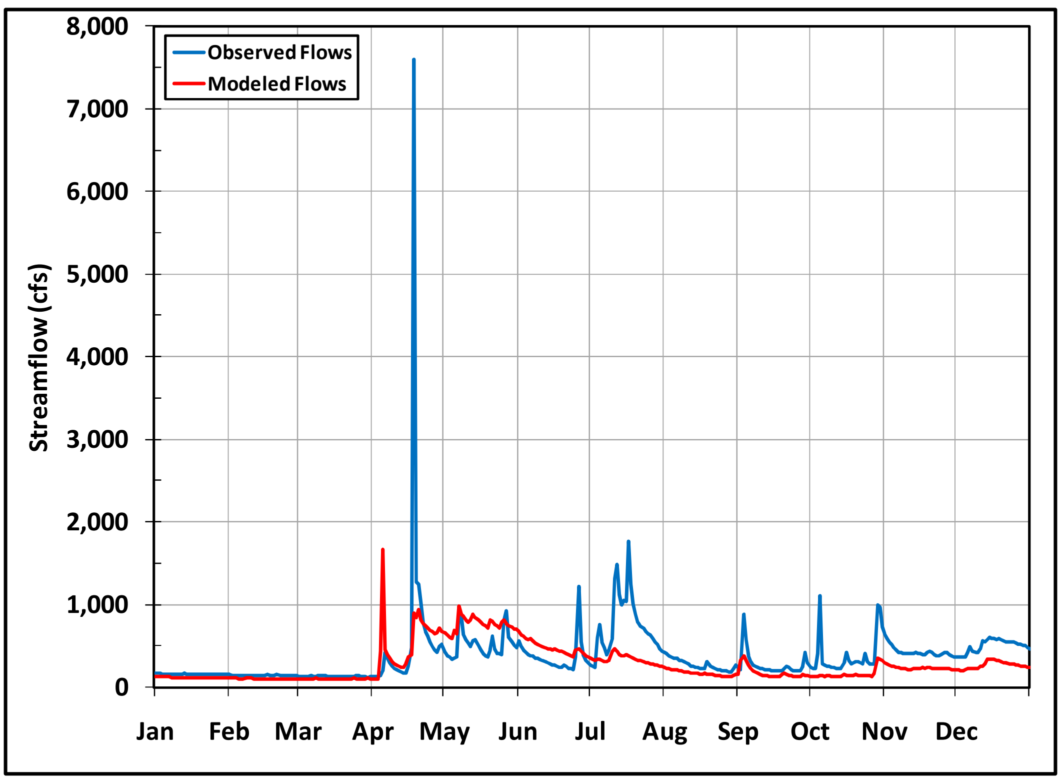


Figure 4C.7-7. Daily Observed Streamflow vs. Simulated (Baseline) Streamflow (1976)

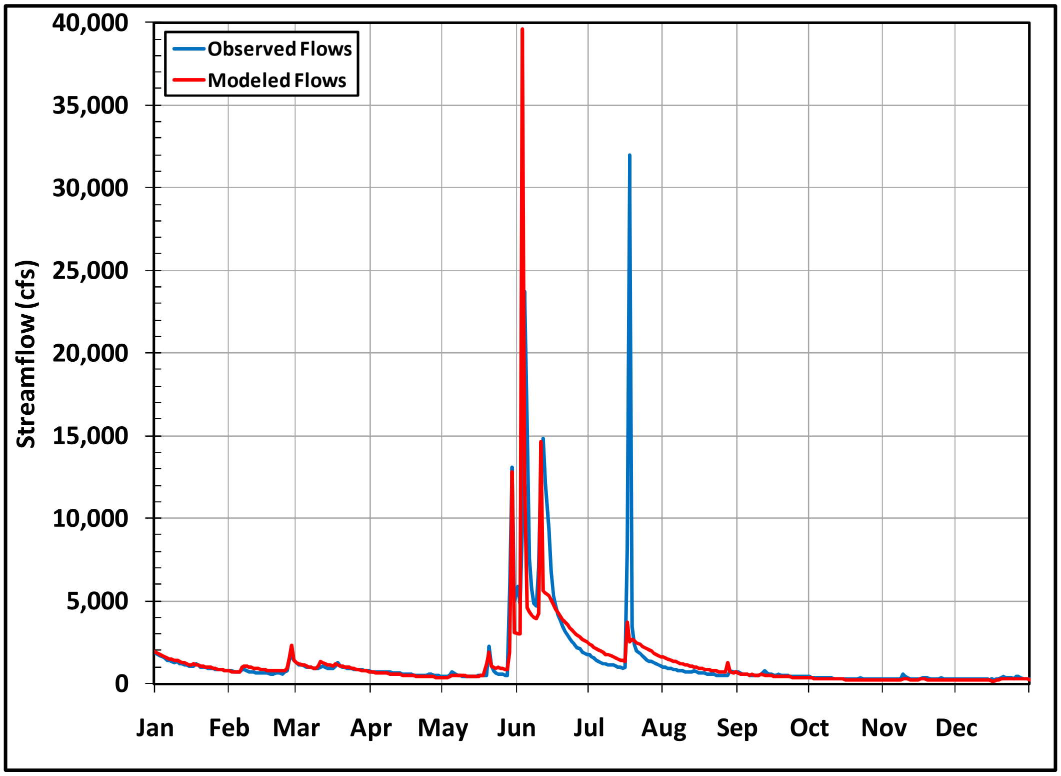


Figure 4C.7-8. Daily Observed Streamflow vs. Simulated (Baseline) Streamflow (1987)

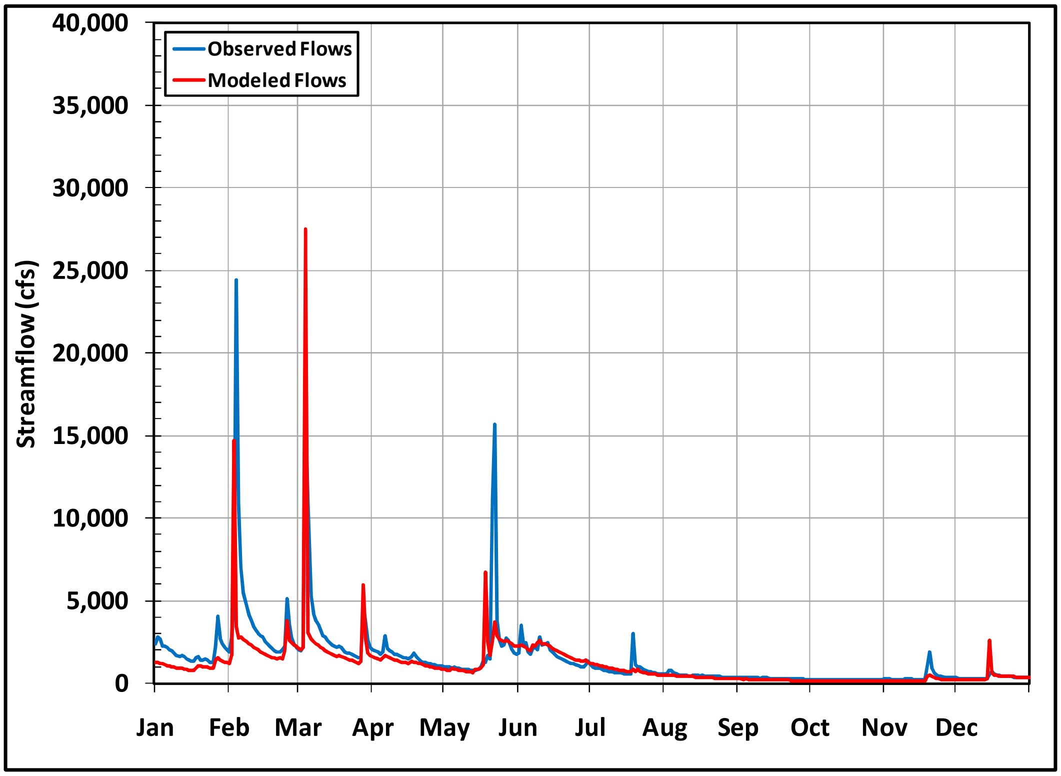


Figure 4C.7-9. Daily Observed Streamflow vs. Simulated (Baseline) Streamflow (1992)

The overall results indicate a reasonable match with the observed flows at Spring Branch gage. The model was found to be extremely sensitive to three parameters in particular i.e, LZETP, the evapo-transpiration potential from near the ground surface, AGWRC, the Active Groundwater Recession Coefficient that determines the rate of flow to groundwater (recession limb of the hydrograph) and KVARY which is related to AGWRC and enables it to decay non-exponentially with time. The effect of LZETP can be seen in the flow-duration plot where the higher LZETP during the summer months causes an underestimation of percent exceedence during low flows. Increasing the AGWRC lowers the hydrograph peaks by increasing the rate of transfer of surface runoff to active groundwater and vice-versa. On the other hand, increasing KVARY decreases the slope of the recession limb of the hydrograph and vice-versa. Thus while AGWRC affects the total runoff volume, KVARY can be used to adjust the hydrograph shape. The combination of these parameter values and the dynamics of their interaction with each other were found to be very sensitive to the overall calibration.

4C.7.2.3 Application of Brush Management in the Watershed

Texas A&M University (TAMU) performed an analysis of the watershed above Canyon Reservoir to determine the potential suitable lands for a Brush Management program[5]. The TAMU analysis was based on landcover, slope, tract size, and endangered species habitat. The total acreage by county that is suitable for brush management is summarized in Table 4C.7-6.

Table 4C.7-6.
Suitable Areas for Brush Management

Sub-Watershed	***County***	***Area (acres)***	***Area (sq. mi)***
Comfort	Kerr	172,931	270
	Bandera	2,678	4
	Gillespie	10,272	16
	SUBTOTAL	**185,881**	**290**
Spring Branch	Kendall	77,953	122
	Comal	47,684	75
	SUBTOTAL	**125,637**	**197**
TOTAL		**311,518**	**487**

[5] Texas A&M University, "DRAFT – The Influence of Juniper Control in the Upper Guadalupe Watershed of Region L on Water Yield and Costs", November 2009. (See Volume II, Appendix D)

Table 4C.7-7 shows a breakdown of landcover categories and their areas within each sub-watershed. Brush Management was simulated within HSPF primarily by converting the appropriate acreage of Evergreen Forest landcover into Grassland landcover.

Table 4C.7-7.
Existing Landcover Categories and Areas

Sub-Watershed	Area (sq. mi)	Landcover	Area (sq. mi)
Comfort	838	Open Water	1.80
		Developed, Open Space	23.53
		Developed, Low Intensity	5.71
		Developed, Medium Intensity	2.29
		Developed, High Intensity	0.83
		Barren Land (Rock/Sand/Clay)	0.05
		Deciduous Forest	53.39
		Evergreen Forest	262.58
		Mixed Forest	0.31
		Shrub/Scrub	432.49
		Grassland/Herbaceous	49.85
		Pasture/Hay	2.67
		Cultivated Crops	2.83
		Woody Wetlands	0.14
Spring Branch	475	Open Water	0.44
		Developed, Open Space	5.38
		Developed, Low Intensity	1.03
		Developed, Medium Intensity	0.14
		Developed, High Intensity	0.02
		Barren Land (Rock/Sand/Clay)	0.03
		Deciduous Forest	37.39
		Evergreen Forest	140.12
		Mixed Forest	0.07
		Shrub/Scrub	210.01
		Grassland/Herbaceous	74.82
		Pasture/Hay	2.17
		Cultivated Crops	2.65
		Woody Wetlands	0.29

Based on this approach, scenarios for a brush management program with a 25 percent, 50 percent, 75 percent, and 100 percent land owner participation were simulated. In each of these scenarios, the appropriate percentage of evergreen landcover area for each sub-watershed was converted to grassland. All the other areas remained unchanged. The resulting areas were then weighted with the calibrated LZETP and CEPSC (interception) values and new LZETP and CEPSC values were calculated. Table 4C.7-8 shows the LZETP and CEPSC values in comparison to their Baseline values. The changes in calculated monthly LZETP with brush management vary monthly and have different seasonal trends. During the fall/winter months (October-March), brush management decreases evapo-transpiration (Table 4C.7-8). In the spring/summer months (April-September), however, evapo-transpiration increases with brush management. This means that by replacing evergreen forests (i.e. Ashe Juniper) with grasses and other vegetative species, less evapo-transpiration occurs during the winter months and more evapo-transpiration occurs in the summer months.

Table 4C.7-8.
LZETP and CEPSC Values for Brush Management Simulations

Month	***Baseline***		***Brush Management***							
	CEPSC	***LZETP***	***25% Participation***		***50% Participation***		***75% Participation***		***100% Participation***	
			CEPSC	***LZETP***	***CEPSC***	***LZETP***	***CEPSC***	***LZETP***	***CEPSC***	***LZETP***
Jan	0.13	0.0814	0.13	0.0705	0.11	0.0626	0.10	0.0547	0.09	0.0468
Feb	0.13	0.1057	0.13	0.0911	0.11	0.0828	0.10	0.0746	0.09	0.0664
Mar	0.13	0.1577	0.13	0.1442	0.11	0.1401	0.10	0.1361	0.09	0.1321
Apr	0.13	0.1746	0.13	0.1652	0.11	0.1678	0.10	0.1703	0.09	0.1729
May	0.13	0.2746	0.13	0.2574	0.11	0.2607	0.10	0.2640	0.09	0.2672
Jun	0.13	0.3746	0.13	0.3561	0.11	0.3649	0.10	0.3737	0.09	0.3824
Jul	0.13	0.6086	0.13	0.5785	0.11	0.5928	0.10	0.6070	0.09	0.6211
Aug	0.13	0.6086	0.13	0.5785	0.11	0.5928	0.10	0.6070	0.09	0.6211
Sep	0.13	0.6086	0.13	0.5708	0.11	0.5781	0.10	0.5852	0.09	0.5925
Oct	0.13	0.2188	0.13	0.1981	0.11	0.1900	0.10	0.1819	0.09	0.1738
Nov	0.13	0.1551	0.13	0.1415	0.11	0.1375	0.10	0.1334	0.09	0.1294
Dec	0.13	0.0814	0.13	0.0705	0.11	0.0626	0.10	0.0547	0.09	0.0468

The four scenarios were then run with their new LZETP and CEPSC values to quantify the impacts of varying degrees of brush management. Streamflow data from the HSPF model were evaluated for the entire 65 year simulation (1934-1998) and the 1950s drought (1947-1956) to determine the amount of increased flows that might be seen at the Spring Branch gage with brush management within land segments of the Spring Branch watershed. Table 4C.7-9 summarizes this increase in average annual volumes resulting from brush management for both long-term and the 1950s drought period as compared to the Baseline scenario.

Table 4C.7-9.
Increased Streamflows at Spring Branch Gage due to Brush Management

Scenario	Long-Term (1934-1998)			Drought (1947-1956)		
	Average Annual Streamflow (cfs)	Average Annual Volume (acft/yr)	% Increase	Average Annual Streamflow (cfs)	Average Annual Volume (acft/yr)	% Increase
Baseline	291.4	210,732		72.3	52,232	
25% Participation	307.4	222,310	5%	80.4	58,159	11%
50% Participation	324.8	234,784	11%	90.3	65,334	25%
75% Participation	335.5	242,637	15%	96.9	69,979	34%
100% Participation	347.5	251,300	19%	104.6	75,539	45%

When compared to the Baseline Conditions, (no brush management), a 25 percent land participation results in a 11,578 acft/yr (5 percent) average increase in runoff during long-term and 5,927 acft/yr (11 percent) increase during the drought period. A 50 percent land participation results in a 24,052 acft/yr (11 percent) average increase in runoff during long-term and a 13,102 acft/yr (25 percent) increase during the drought period. Based on the TAMU research, it is unlikely that land owner participation greater than about 60 percent is possible.

4C.7.2.4 Water Availability Modeling

The Guadalupe-San Antonio River Basin Water Availability Model (GSAWAM, as modified for regional water planning purposes) is used to quantify water available for diversion under the GBRA Mid-Basin (Surface Water) WMS. Hydrologic simulations and calculations are performed subject to the General Assumptions for Applications of Hydrologic Models, as adopted by the SCTRWPG for the 2011 Regional Water Plan. Application of the GSAWAM, with a period of record from January 1934 to December 1989, the Baseline firm yield of Canyon Reservoir was calculated as 86,900 acft/yr. For the Brush Management scenarios, the timeseries of increased streamflow at the Spring Branch gage relative to Baseline were calculated for the entire simulation period and were input into GSAWAM flow adjustment (FAD) file. The

Canyon Reservoir firm yield with the Brush Management scenarios and the enhanced firm yield due to the increase streamflows associated with the Brush Management scenarios were calculated and are presented in Table 4C.7-10.

Table 4C.7-10.
Brush Management – Enhanced Firm Yield

Scenario	*Firm Yield (acft/yr)*	*Enhanced Firm Yield Due to Brush Management (acft/yr)*
Baseline	86,900	-
25%	92,490	5,590
50%	99,080	12,180
75%	103,355	16,455
100%	107,790	20,890

4C.7.3 Environmental Issues

In general, brush management encompasses the control of junipers, mesquites and other woody species that compete with native grasses for water, light and nutrients, but whose growth may be encouraged by conventional land use practices. In the context of water supplies for Region L, brush management means reduction of juniper cover on Edwards Plateau watersheds upstream of the Edwards Aquifer recharge zone to increase runoff that might percolate to the Edwards Aquifer. Environmental concerns with brush control projects focus primarily on the reduction or removal of the wildlife habitat provided by the brush cover, and secondarily on the potential for soil erosion from exposed, disturbed soils where mechanical clearing methods are used, or the effects of herbicides on non-target species when chemical methods are employed.

Chaining, cabling, disking and other mechanical methods that strip brush displace resident wildlife populations, remove the habitat on which they depend and expose soil surfaces to erosion by wind and water. Brush management guidelines applicable to Edwards Plateau habitats are available from the Texas Parks and Wildlife Department and the Texas State Soil and Water Conservation Board that can be used to avoid or minimize potential impacts, but individual management plans should be developed for specific locations that take into account the topography of the site, the character of the brushy cover and the vegetation intended to replace it, local and regional wildlife needs, and the potential for impacts to endangered species. Management practices may include limitation of clearings to slopes of less than 10 percent, avoiding disturbance to riparian areas, limiting the size of cleared areas and limiting the proportion of open to wooded habitat to about 2:1. Low impact hand techniques that clear brush in a patchwork fashion, leaving brush berms to control erosion and provide protection for wildlife, may be necessary where soils on slopes are thin and droughty.

Chemical methods of brush control carry some risk of chemical runoff into streams and subsequent percolation into the underlying aquifers. The chemicals to be used should be applied strictly according to the label directions to avoid toxicity to aquatic organisms. Where large areas are to receive herbicide treatments, stream monitoring (particularly storm flows) above the recharge zone for those substances may be necessary to evaluate potential exposures to water users and endangered species resident in the aquifer and its large spring openings.

4C.7.4 Engineering and Costing

The Texas A&M University (TAMU) study provided a cost estimate for brush control for the watershed upstream of Canyon Reservoir, as well as a cost for the associated monitoring program. TAMU estimates an initial application cost of $200/acre for each acre participating in the Brush Management program, and a $25/acre maintenance costs every three to five years. Using this information, a cost estimate was developed for the 25 percent and 50 percent land owner participation scenarios. It was assumed that the $200/acre cost for the initial Brush Management application, along with engineering, legal, and contingencies at 35 percent, treatment, and integration, would be financed for a 20 year period at a 6 percent interest rate. The maintenance cost was assumed to be $5/year based on a $25/acre maintenance costs every 5 years.

The monitoring program (see Volume II, Appendix D for details) consists of three parts; 1) a wide-scale remote sensing program, 2) a mid-scale streamflow monitoring program, and 3) a small-scale example catchment program. In total, the three-part monitoring program lasts between three and ten years with an estimated cost of $2,910,150. Assuming that TCEQ would require a continuous monitoring program, it is assumed that this estimate was averaged to an annual cost ($291,015/yr) and would be part of the operation and maintenance cost associated with is project. Long-term monitoring program costs could be less as the initial field data would be used to calibrate models and wide-scale remote sensing technology improves.

The total project cost for the 25 percent land owner scenario is $41,917,000, and the associated annual cost is $5,308,000/yr. With an enhanced firm yield of 5,590 acft/yr, the annual unit cost for a Brush Management program based on 25 percent land owner participation (of the suitable land area) is $949/acft/yr.

The total project cost for the 50 percent land owner scenario is $82,134,000, and the associated annual cost is $10,026,000/yr. With an enhanced firm yield of 12,180 acft/yr, the annual unit cost for a Brush Management program based on 50 percent land owner participation (of the suitable land area) is $823/acft/yr.

4C.7.5 Implementation Issues

Several implementation issues pertain to this potential water management strategy. *In situ* brush control studies have been effective for catchment-level examples of areas of 1,000 acres or less. To make a significant impact upon increasing the firm yield of a large reservoir like Canyon Reservoir, brush control would have to be practiced over a considerable area. The watershed above Canyon Reservoir (Figure 4C.7-1), covering about 840,000 acres, is significantly larger than typical brush control study areas and will require significant participation from stakeholders and state and federal agencies to achieve program goals for additional water supply. It is not proven that a large-scale brush control program would be practical because it would require the cooperation of many different landowners having different interests in their property. In a specific target watershed, there may be property owners who are not dependent on grazing income and therefore have limited interest in brush control. To ensure cooperation of these ranch owners, additional subsidies or other considerations may be required which could alter the cost profiles for brush control.

Another issue is that most of the assumptions and results presented above are based on computer modeling rather than *in situ* examples that have the benefit of several years of performance to demonstrate results. It would be recommended that much more research be performed *in situ* at specific sites before public funds are invested in major projects.

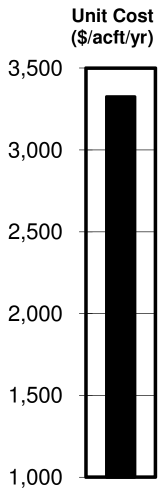
One critical implementation issue is how the increase in runoff resulting from brush control would be related to water supply yield in a permit application with the Texas Commission on Environmental Quality. Key questions that need answers are:

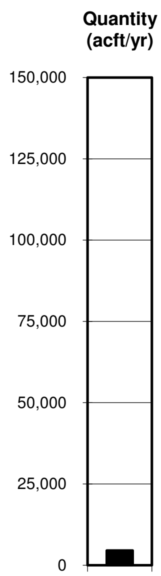
- How is the increased runoff verified?
- How much of the increased runoff results in yields of affected aquifers? and

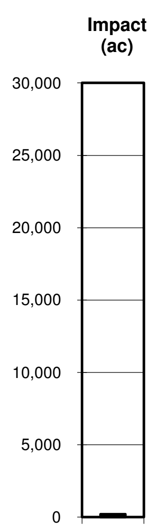
- How is the increased yield of the affected reservoir verified?

Finally, it is important to note that the outcome of GMA 9, specifically the Desired Future Conditions (DFC) and associated pumpage could affect the potential supply associated with a Brush Management project in the watershed above Canyon Reservoir.

2011 South Central Texas Regional Water Plan
Water Management Strategy Summary Sheet







Name: Wimberley and Woodcreek Water Supply Project

Description: There are three delivery options to bring new water supplies to Wimberley and Woodcreek considered herein. Each option includes a pipeline sized for ultimate capacity of 4,480 acft/yr to deliver treated water from the San Marcos Water Treatment Plant along Ranch Road 12 or Farm-to-Market 150. The RR12 route is recommended and the FM150 route is considered an alternative in this plan. The facilities required for each of the pipeline routes would include a water treatment plant expansion, a pump station, a treated water transmission line from the plant to Wimberley/Woodcreek, and a terminal storage tank located near Wimberley and Woodcreek.

***Decade Needed*:** 2010 - 2020

Cost, Quantity of Water, and Land Impacted

Unit Cost of Water:	**2,275 – 3,324**	**$/acft/yr**	**Treated Water Delivered**
Quantity of Water:	**1,120 – 4,480**	**acft/yr**	**Reliability = Firm**
Land Impacted:	**211**	**acres**	

Additional Considerations per Regional Water Planning Guidelines

Environmental Factors:

The Golden-cheeked Warbler has been documented along or immediately adjacent to pipeline routes for Options B and C. Fountain darter, Texas blind salamander, and San Marcos salamander have been documented along or immediately adjacent to the pipeline route for Option B.

Impacts on Water Resources:

None anticipated. Near-term supplies are available from existing sources and impacts of long-term supplies are associated with other strategies.

Impacts on Agricultural & Natural Resources:

None anticipated.

Other Relevant Factors per SCTRWPG:

In the short-term, this strategy would rely on previously allocated, but not fully used, contracts from Canyon Reservoir and/or other supplies potentially available through San Marcos. Long-term water sources for this strategy will likely be obtained from the GBRA Mid-Basin Project and/or the Hays/Caldwell PUA Project.

Comparison of Strategies to Meet Needs:

Options are limited; cost estimates indicate that this strategy has a high unit cost.

Interbasin Transfer Issues:

None.

Third-Party Impacts of Voluntary Transfers:

None anticipated.

Regional Efficiency:

Project meets needs in area with limited alternatives of new supply.

Water Quality Considerations:

These options occur within the Edwards Aquifer recharge zone and would be subject to requirements of Edwards Aquifer Protection Program.

4C.8 Wimberley and Woodcreek Water Supply Project

4C.8.1 Description of Water Management Strategy

The communities of Wimberley and Woodcreek are located next to each other near the Blanco River, within the Guadalupe River Basin, in Hays County (Figure 4C.8-1). Historically, water has been obtained from wells in the Trinity Aquifer and supplied by water supply corporations or other retail entities. Municipal water supplies for Wimberley and Woodcreek are provided by Wimberley Water Supply Corporation (WSC) and Woodcreek Utilities, Inc. (Aqua Texas). As supplies from the Trinity Aquifer are expected to be inadequate to meet all of the projected demands for these entities, strategies have been developed to provide additional short-term water supply from Canyon Reservoir and long-term supply from the GBRA Mid-Basin Project or the Hays/Caldwell PUA Project. Short-term supplies may be made available through leasing of committed supplies from Canyon Reservoir that are not currently being taken. Once Canyon contract holders grow into their purchased water supplies, Wimberley and Woodcreek will rely on long-term water supplies expected to be obtained from one of the projects identified above, each of which includes delivery to the San Marcos Water Treatment Plant (WTP) area located 18 miles from Wimberley. There are three delivery options to bring water supplies to Wimberley/Woodcreek. Each option includes a pipeline sized for an ultimate capacity of 4,480 acft/yr to deliver treated water from the San Marcos Water Treatment Plant along RR 12 or FM 150. This supply could be accessed by purchasing water from a wholesale water provider or, more specifically, entering into a water supply contract with the Guadalupe-Blanco River Authority (GBRA), the City of San Marcos, and/or the Hays/Caldwell PUA and constructing a pipeline that could bring water to the entities for retail distribution.

In 2000, total water use in the Wimberley and Woodcreek communities was 1,166 acft, all of which was obtained from the Trinity Aquifer. Comparison of projected water demands and existing supplies from the Trinity Aquifer indicates projected needs for additional water supplies ranging from 697 acft/yr in 2010 to 4,376 acft/yr in 2060. Hence, this water management strategy has been sized and a cost estimate prepared to provide a near-term supply of 1,120 acft/yr (1.0 mgd) and a long-term supply of 4,480 acft/yr (4.0 mgd) with transmission through the same infrastructure.

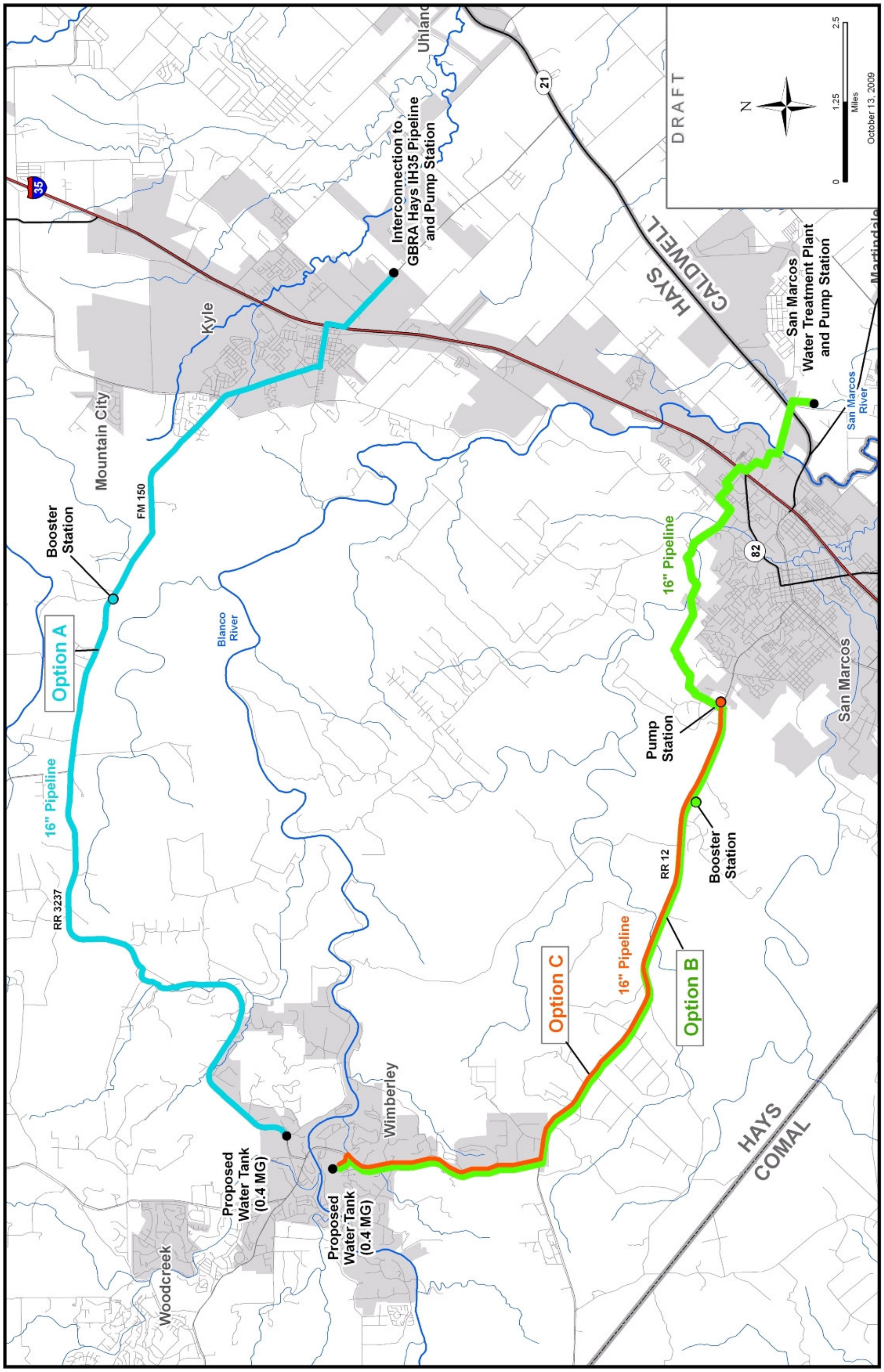


Figure 4C.8-1. Wimberely and Wodcreek Water Supply Options

4C.8.2 Available Yield

The year 2030 and 2060 projected water needs for the Wimberley/Woodcreek area are 2,100 and 4,376 acft/yr, respectively. Although, all supplies in Canyon Reservoir are fully allocated as of 2008, some contract holders are not using their full allocation and may be willing to lease a portion of their contract to Wimberley and Woodcreek as a short-term supply until long-term supplies may be made available. One potential long-term supply, the GBRA Mid-Basin Project will provide a firm yield of approximately 25,000 acft/yr of supplemental water supplies to customers in Hays and Caldwell Counties and long-term water supplies throughout the GBRA statutory district. Additional information on the GBRA Mid-Basin Project can be found in Sections 4C.15 through 4C.17. Another potential long-term supply is the Hays/Caldwell PUA Project which is expected to provide a firm yield of approximately 35,000 acft/yr to project participants including the City of San Marcos. Additional information on the Hays/Caldwell PUA Project can be found in Section 4C.20.

4C.8.3 Environmental Issues

The Wimberley and Woodcreek communities are located about 12 miles northeast of Canyon Reservoir in Hays County on a tributary of the Blanco River at about 800 to 900 ft-msl (Figure 4.2-1). Spring-fed Cypress Creek flows through the center of the town of Wimberley. Large cypress trees line Cypress Creek and a portion of the nearby Blanco River. The scenic Wimberley area on the eastern Edwards Plateau is a popular tourist destination, and both the Blanco River and Cypress Creek are heavily used recreational resources. Both have been nominated by Texas Parks and Wildlife Department as Ecologically Significant River and Stream Segments.

The three proposed pipeline routes are located in eastern Hays County; Option B extends slightly into western Caldwell County. The three proposed pipeline routes are primarily within the Edwards Plateau ecoregion; however, Options A and B lie on the ecotone between the Edwards Plateau and the Blackland Prairies ecoregions.[1] The three pipeline routes are on the edge of the Balconian and Texan biotic provinces.[2]

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[1] TPWD, "Texas Partners in Flight; Ecological Region 7 – Edwards Plateau"http://www.tpwd.state.tx.us/huntwild/wild/birding/pif/assist/pif_regions/region_7.phtml accessed July 20, 2009.

[2] Blair, W.F., "The Biotic Provinces of Texas, "Tex. J. Sci. 2:93-117, 1950.

Important species known to occur in Hays and Caldwell Counties are listed in Table 4C.8-1. Although the species listed in this table do not necessarily occur at the specific locations that would be disturbed during development of water supply facilities, this list of species and their preferred habitats would need to be investigated, or considered during a route finalization. In the case of migratory or transient species, a field survey should attempt to identify and evaluate habitat that may be attractive to migrating species, such as the endangered Whooping Crane.

The endangered species listed for Hays and Caldwell counties includes one amphibian, four birds, two fishes, two insects, one crustacean, and one plant. The Texas blind salamander a troglobitic (cave-dwelling) salamander occurs in subterranean caverns in the vicinity of San Marcos and may be present in the area of Option B. The Golden-cheeked Warbler and Black-capped Vireo, are known to nest in Hays County in areas with appropriate habitat.[3] The Golden-cheeked Warbler and the Black-capped Vireo are upland woodland/brushland species. The endangered Whooping Crane is migratory through the project area. The fountain darter, an endangered fish, is found only in the San Marcos and Comal Rivers; the other endangered fish, the San Marcos gambusia is listed as extinct. The Comal Springs dryopid beetle can be found clinging to objects or crawling on stream bottoms or along shores in the area. The endangered Comal Springs riffle beetle is only found in Comal and San Marcos Springs. Peck's Cave amphipod, a crustacean has only been collected from Comal Springs in New Braunfels and would not likely be impacted by the project. Texas wild-rice occurs in spring-fed river water that is mostly less than one meter deep. Additionally, there are several state and federally-listed threatened and rare species that may occur in the vicinity of Options A, B, and C.

The three options are present over the Edwards Aquifer Recharge Zone. As such, the project would be subject to the Edwards Aquifer Protection Program and would be required to submit a water pollution abatement plan to the Texas Commission on Environmental Quality.

Land use in Wimberley and Woodcreek is rural residential, suburban residential and recreational. Most of the surrounding land use is rangeland. This report discusses three alternatives: Option A, Option B, and Option C. Options B and C share most of their alignment.

[3] Texas Parks and Wildlife Department (TPWD), 2009. Annotated County Lists of Rare Species – Hays County. Last Revision 7/16/2009. Accessed online http://www.tpwd.state.tx.us/

**Table 4C.8-1.
Endangered, Threatened, and Species of Concern in
Caldwell, and Hays Counties**

Common Name	Scientific Name	Impact Value	Multiplier Based on Status	Adjusted Impact	Summary of Habitat Preference	Listing Entity		Potential Occurrence in County
						USFWS[1]	TPWD[1]	
A cave obligate crustacean	Monodella texana	1	1	1	Subaquatic, subterranean obligate; underground freshwater aquifers			Resident
A mayfly	Procloeon distinctum	1	1	1	Aquatic larval state; adult stage generally found in shoreline vegetation.			Resident
American Peregrine Falcon	Falco peregrinus anatum	0	2	0	Open country; cliffs	DL	T	Nesting/Migrant
Arctic Peregrine Falcon	*Falco peregrinus tundrius*	0	1	0	Open country; cliffs	DL		Nesting/Migrant
Balcones Cave Amphipod	*Stygobromus balconies*	1	1	1	Small subterranean amphipod found in cave pools.			Resident
Bald Eagle	*Haliaeetus leucocephalus*	0	2	0	Primarily near rivers and large lakes.	DL	T	Resident
Bandit Cave spider	*Cicurina bandida*	0	1	0	Very small, subterrestrial, subterranean obligate.			Resident
Black-capped Vireo	*Vireo atricapillus*	2	3	6	Semi-open broad-leaved shrublands	LE	E	Nesting/Migrant
Blanco Blind Salamander	*Eurycea robusta*	1	2	2	Troglobitic; Stream bed of the Blanco River		T	Resident
Blanco River Springs Salamander	*Eurycea pterophila*	1	1	1	Subaquatic; Springs and caves of the Blanco River			Resident
Cagle's Map Turtle	*Graptemys caglei*	1	2	2	Waters of the Guadalupe River Basin		T	Resident
Canyon Mock-Orange	*Philadelphus ernestii*	1	1	1	Edwards Plateau			Resident

Table 4C.8-1 (Continued)

Common Name	Scientific Name	Impact Value	Multiplier Based on Status	Adjusted Impact	Summary of Habitat Preference	Listing Entity		Potential Occurrence in County
						USFWS[1]	TPWD[1]	
Cave Myotis Bat	*Myotis velifer*	0	1	0	Colonial & cave dwelling; hibernates in limestone caves of Edwards Plateau			Resident
Comal Springs Dryopid Beetle	*Stygoparnus comalensis*	0	3	0	Cling to objects in streams; adults fly especially at night	LE		Resident
Comal Springs Riffle Beetle	*Heterelmis comalensis*	0	3	0	Comal and San Marcos Springs	LE		Resident
Creeper (squawfoot)	*Strophitus undulates*	1	1	1	Small to large streams Colorado, Guadalupe, San Antonio, Neches (historic), and Trinity (historic) River basins.			Resident
Edwards Aquifer Diving Beetle	*Haideoporus texanus*	0	1	0	Habitat poorly known; known from artesian well			Resident
Ezell's Cave Amphipod	*Stygobromus flagelloatus*	0	1	0	Known from artesian wells			Resident
False Spike Mussel	*Quincuncina mitchelli*	1	1	1	Substrates of cobble and mud with water lilies present. Rio Grande, Brazos, Colorado, and Guadalupe (historic) river basins.			Resident
Flint's Net-Spinning Caddisfly	*Cheumatopsyche flinti*	1	1	1	Poorly known species with habitat listed as spring.			Resident
Fountain Darter	*Etheostoma fonticola*	0	3	0	San Marcos and Comal rivers; springs and spring-fed streams	LE	E	Resident
Golden-Cheeked Warbler	*Dendroica chrysoparia*	2	3	6	Woodlands with oaks and old juniper	LE	E	Nesting/Migrant
Golden Orb	*Quadrula aurea*	1	2	2	Guadalupe, San Antonio, and Nueces River basins.		T*	Resident

Table 4C.8-1 (Continued)

Common Name	Scientific Name	Impact Value	Multiplier Based on Status	Adjusted Impact	Summary of Habitat Preference	Listing Entity		Potential Occurrence in County
						USFWS[1]	TPWD[1]	
Guadalupe Bass	*Micropterus treculi*	1	1	1	Streams of eastern Edwards Plateau			Resident
Guadalupe Darter	*Percina sciera apristis*	0	1	0	Typically found over gravel or gravel and sand raceways of medium streams, rivers and pools.			Resudent
Hill Country Wild-Mercury	*Argythamnia aphoroides*	1	1	1	Shallow to moderately deep clays; live oak woodlands			Resident
Ironcolor Shiner	*Notropis chalybaeus*	0	1	0	Big Cypress Bayou and Sabine River basins. Pools and slow runs.			Resident
Leonora's Dancer Damselfly	*Argia leonorae*	1	1	1	South central and western Texas. Small streams and seepages.			Resident
Mountain Plover	*Charadrius montanus*	0	1	0	Breeding, nests on ground in shallow depression.			Migrant
Pistolgrip	*Tritogonia verrucosa*	1	1	1	Stable substrate, rock, hard mud, silt and soft bottoms, often deeply buried. Red through San Antonio River basins in east and central Texas.			Resident
Plains Spotted Skunk	*Spilogale putorius interrupta*	1	1	1	Catholic; Wooded, brushy areas and tallgrass prairies			Resident
Rawson's Metalmark	*Calephelis rawsoni*	1	1	1	Moist areas in shaded limestone outcrops in central Texas. Along rivers elsewhere.			Resident

Table 4C.8-1 (Continued)

Common Name	Scientific Name	Impact Value	Multiplier Based on Status	Adjusted Impact	Summary of Habitat Preference	Listing Entity USFWS[1]	Listing Entity TPWD[1]	Potential Occurrence in County
Red Wolf	*Canis rufus*	0	3	0	Extirpated	LE	E	Extirpated
Rock Pocketbook	*Arcidens confragosus*	1	1	1	Mud, sand, and gravel substrates of medium to large rivers. east Texas, Red through Guadalupe River basins			Resident
San Marcos Gambusia (extirpated)	*Gambusia georgei*	0	3	0	Endemic; upper San Marcos River	LE	E	Resident
San Marcos Saddle-case Caddisfly	*Protoptila arca*	0	1	0	Swift; well-oxygenated warm water 1-2 m deep			Resident
San Marcos Salamander	*Eurycea nana*	0	2	0	Headwaters of the San Marcos River	LT	T	Resident
Spot-tailed Earless Lizard	*Holbrookia lacerata*	1	1	1	Oak-juniper woodlands and mesquite-prickly pear			Resident
Texas Austrotinodes Caddisfly	*Austrotinodes texensis*	1	1	1	Appears endemic to karst springs and spring runs in Edwards Plateau region.			Resident
Texas Blind Salamander	*Eurycea rathbuni*	1	3	3	Troglobitic; Caverns along 6 mile stretch of San Marcos Springs Fault	LE	E	Resident
Texas Cave Shrimp	*Palamonetes antrorum*	0	1	0	Subterranean sluggish streams and pools			Resident
Texas Fatmucket	*Lampsilis bracteata*	1	2	2	Sand, mud and gravel substrates; Colorado and Guadalupe River basins.		T	Resident
Texas Garter Snake	*Thamnophis sirtalis annectens*	1	1	1	Varied, especially wet areas; bottomlands and pastures			Resident
Texas Horned Lizard	*Phrynosoma cornutum*	1	2	2	Varied, sparsely vegetated uplands		T	Resident

Table 4C.8-1 (Concluded)

Common Name	Scientific Name	Impact Value	Multiplier Based on Status	Adjusted Impact	Summary of Habitat Preference	Listing Entity USFWS[1]	Listing Entity TPWD[1]	Potential Occurrence in County
Texas Pimpleback	*Quadrula petrina*	1	2	2	Mud, gravel and sand substrates in areas with slow flow rates. Colorado and Guadalupe River basins.		T	Resident
Texas Troglobitic Water Slater	*Lirceolus smithii*	1	1	1	Subaquatic, subterranean obligate, aquifer.			Resident
Texas Wild-Rice	*Zizania texana*	0	3	0	Upper 2.5 km of the San Marcos River	LE	E	Resident
Warnock's Coral Root	*Hexalectris warnockii*	2	1	2	Oak-juniper woodlands in mountain canyons; terraces along creekbeds			Resident
Western Burrowing Owl	*Athene cunicularia hypugaea*	0	1	0	Open grasslands.			Resident
Whooping Crane	*Grus americana*	0	3	3	Potential migrant	LE	E	Migrant
Zone-tailed Hawk	*Buteo albonotatus*	1	2	2	Arid, open country including deciduous or pine-oak woodland; nests in various habitats and sites		T	Nesting/Migrant

[1] Texas Parks and Wildlife Department (TPWD), Annotated Lists of Rare Species, Last revision 7/16/2009. Accessed online: http://www.tpwd.state.tx.us.

** LE/LT=Federally Listed Endangered/Threatened E/SA, T/SA=Federally Listed Endangered/Threatened by Similarity of Appearance C1=Federal Candidate for Listing*
DL, PDL=Federally Delisted/Proposed for Delisting NL=not Federally Listed E, T=State Listed Endangered/Threatened
PE, PT=Federally Proposed Endangered/ Threatened Blank = Rare, but no regulatory listing status

4C.8.3.1 Option A

Vegetation[4] on this proposed pipeline route consists primarily of live oak-ashe juniper parks (71 percent). Live oak-ashe juniper woodlands (six percent), crops (3.5 percent) and other (20 percent) comprise the remainder of the pipeline route. Option A would cross a tributary to

[4] McMahan, C.A., R.G. Frye, K.L. Brown, "The Vegetation Types of Texas Including Cropland," TPWD, Austin, Texas, 1982.

Plum Creek in Kyle and would parallel and cross Lone Man Creek, a tributary to the Blanco River.

If the waterline to Wimberley and Woodcreek from Kyle is assumed to mostly parallel existing roadways, it would be about 19 miles long (Figure 4C.8-1). The waterline would require a construction corridor of about 100 feet and a maintenance corridor of about 30 feet. Construction would involve the disturbance of soils and vegetation on up to approximately 240 acres, and the long-term impacts of maintaining the right-of-way free of woody vegetation would affect about 70 acres.

The Natural Diversity Database, maintained by TPWD, documents occurrences of endangered, threatened, or rare species in the state. There are no mapped occurrences of important species along or immediately adjacent to the proposed Option A pipeline route. Reported occurrences near the proposed pipeline route include the endangered Golden-cheeked warbler within one mile, the endangered Black-capped Vireo within 2.5 miles, and the state threatened Cagle's map turtle within two miles. Additionally, the rare Blanco River Springs salamander, and three rare plant species including Warnock's Coral Root, canyon mock-orange, and Hill Country wild-mercury were also documented near the pipeline route.

Resource conflicts can generally be avoided or minimized by careful site and alignment selection, avoiding, for example, springs and vegetated wetlands where the pipeline crosses a stream channel, and mesic, wooded slopes. Any future detailed assessment should include a complete review of important species with appropriate habitat including spring and karst associated species. Where right-of-way clearing and construction activity cannot avoid affecting a federally protected species, consultation with the USFWS concerning the need for a permit for the incidental take of that species should be conducted.

Cultural resources protection on public lands in Texas is afforded by the Antiquities Code of Texas (Title 9, Chapter 191, Texas Natural Resource Code of 1977), the National Historic Preservation Act (Pl96-515), and the Archeological and Historic Preservation Act (PL93-291). Based on the review of available Geographic Information System (GIS) files from the Texas Historical Commission, five historical sites are along or immediately adjacent to the proposed pipeline route. Table 4C.8-2 lists these sites. Archeological records are housed at the Texas Archeological Research Laboratory in Austin; their records should be searched for previously recorded archeological sites within the project corridor. Considering that the owner or controller of the project will likely be a political subdivision of the State of Texas (i.e. river authority, municipality, county, etc.), they will be required to coordinate with the Texas Historical Commission regarding if the project will affect waters of the United States or wetlands, the project sponsor will also be required to coordinate with the U.S. Army Corps of Engineers regarding impacts to cultural resources.

Table 4C.8-2
Historic Sites Along or Adjacent to the Pipeline Route for Option A.

Site	*Database*
D.A. Young	State Historical Marker
Kyle Auction Oak	State Historical Marker
Kyle City Hall	National Register of Historic Places
Katherine Anne Porter House	National Register of Historic Places
M.G. Michaelis Ranch	National Register Historic District

4C.8.3.2 Option B

Vegetation[5] on this proposed pipeline route consists of live oak-ashe juniper parks (34 percent), live oak-ashe juniper woodlands (26 percent), live oak-mesquite-ashe juniper parks (23 percent), and crops (17 percent). Option B would cross the San Marcos River and tributaries to the San Marcos River and the Blanco River.

If the waterline to Wimberley and Woodcreek from the San Marcos Water Treatment Plant and Pump Station is assumed to mostly parallel existing roadways, it would be about 18.3 miles long (Figure 4C.8-1). The waterline would require a construction corridor of about 100 feet and a maintenance corridor of about 30 feet. Construction would involve the disturbance of soils and vegetation on up to approximately 225 acres, and the long-term impacts of maintaining the right-of-way free of woody vegetation would affect about 67 acres.

The Natural Diversity Database, maintained by TPWD, documents occurrences of endangered, threatened, or rare species in the state. There are several mapped occurrences of important species along or immediately adjacent to the proposed Option B pipeline route

[5] McMahan, C.A., R.G. Frye, K.L. Brown, "The Vegetation Types of Texas Including Cropland," TPWD, Austin, Texas, 1982.

including the endangered Golden-cheeked warbler, the endangered fountain darter, the endangered Texas blind salamander, the threatened San Marcos salamander and the rare plants Hill Country wild-mercury and Warnock's coral-root. Reported occurrences near the proposed Option B pipeline route include the endangered Black-capped Vireo within 1.5 miles, the endangered plant Texas wild-rice within 0.5 miles, the state threatened Blanco blind salamander within 1.5 miles, and the state threatened Cagle's map turtle within approximately 1.5 miles. Additionally, the rare Guadalupe bass was also documented within 3 miles of the proposed pipeline route.

Resource conflicts can generally be avoided or minimized by careful site and alignment selection, avoiding, for example, springs and vegetated wetlands where the pipeline crosses a stream channel, and mesic, wooded slopes. Any future detailed assessment should include a complete review of important species with appropriate habitat including spring and karst associated species. Where right-of-way clearing and construction activity cannot avoid affecting a federally protected species, consultation with the USFWS concerning the need for a permit for the incidental take of that species should be conducted.

Cultural resources protection on public lands in Texas is afforded by the Antiquities Code of Texas (Title 9, Chapter 191, Texas Natural Resource Code of 1977), the National Historic Preservation Act (Pl96-515), and the Archeological and Historic Preservation Act (PL93-291). Based on the review of available Geographic Information System (GIS) files from the Texas Historical Commission, two historical sites are along or immediately adjacent to the proposed pipeline route. Table 4C.8-3 lists these sites. Archeological records are housed at the Texas Archeological Research Laboratory in Austin; their records should be searched for previously recorded archeological sites within the project corridor. Considering that the owner or controller of the project will likely be a political subdivision of the State of Texas (i.e. river authority, municipality, county, etc.), they will be required to coordinate with the Texas Historical Commission regarding if the project will affect waters of the United States or wetlands, the project sponsor will also be required to coordinate with the U.S. Army Corps of Engineers regarding impacts to cultural resources.

Table 4C.8-3
Historic Sites Along or Adjacent to the Pipeline Route for Option B.

Site	Database
Cen-Tex Wool Mill	National Register Historic District
Belger-Cahill Lime Kiln	National Register of Historic Places

4C.8.3.3 Option C

Option C follows the alignment of Option B until just west of the City of San Marcos. Vegetation[6] on this proposed pipeline route consists primarily of live oak-ashe juniper parks (53 percent) and live oak-mesquite-ashe juniper parks (39 percent). Live oak-ashe juniper woodlands (eight percent) comprise the remainder of the pipeline route. Option C would cross tributaries to the San Marcos River and the Blanco River.

If the waterline to Wimberley and Woodcreek from just west of San Marcos is assumed to mostly parallel existing roadways, it would be about 12 miles long (Figure 4C.8-1). The waterline would require a construction corridor of about 100 feet and a maintenance corridor of about 30 feet. Construction would involve the disturbance of soils and vegetation on up to approximately 150 acres, and the long-term impacts of maintaining the right-of-way free of woody vegetation would affect about 45 acres.

The Natural Diversity Database, maintained by TPWD, documents occurrences of endangered, threatened, or rare species in the state. There are several mapped occurrences of important species along or immediately adjacent to the proposed Option C pipeline route including the endangered Golden-cheeked warbler and the rare plants Hill Country wild-mercury and Warnock's coral-root. Reported occurrences near the proposed Option C pipeline route include the endangered Black-capped Vireo within 1.5 miles, the state threatened Cagle's map turtle within approximately 1.5 miles, and the rare Blanco River springs salamander within 1.0 miles. Within 2.5 miles of the proposed Option C pipeline route the following endangered, threatened or rare species have been documented: Texas blind salamander, the Blanco blind salamander, the San Marcos salamander, fountain darter, and Texas wild-rice.

[6] McMahan, C.A., R.G. Frye, K.L. Brown, "The Vegetation Types of Texas Including Cropland," TPWD, Austin, Texas, 1982.

Resource conflicts can generally be avoided or minimized by careful site and alignment selection, avoiding, for example, springs and vegetated wetlands where the pipeline crosses a stream channel, and mesic, wooded slopes. Any future detailed assessment should include a complete review of important species with appropriate habitat including spring and karst associated species. Where right-of-way clearing and construction activity cannot avoid affecting a federally protected species, consultation with the USFWS concerning the need for a permit for the incidental take of that species should be conducted.

Cultural resources protection on public lands in Texas is afforded by the Antiquities Code of Texas (Title 9, Chapter 191, Texas Natural Resource Code of 1977), the National Historic Preservation Act (Pl96-515), and the Archeological and Historic Preservation Act (PL93-291). Based on the review of available Geographic Information System (GIS) files from the Texas Historical Commission, no historical sites are along or immediately adjacent to the proposed pipeline route. Archeological records are housed at the Texas Archeological Research Laboratory in Austin; their records should be searched for previously recorded archeological sites within the project corridor. Considering that the owner or controller of the project will likely be a political subdivision of the State of Texas (i.e. river authority, municipality, county, etc.), they will be required to coordinate with the Texas Historical Commission regarding if the project will affect waters of the United States or wetlands, the project sponsor will also be required to coordinate with the U.S. Army Corps of Engineers regarding impacts to cultural resources.

4C.8.4 Engineering and Costing

There are three delivery options for this water management strategy, surface water supply for the Wimberley/Woodcreek area as shown in Figure 4C.8-1. The facilities required for each of the pipeline routes would include a 4 MGD water treatment plant expansion at the existing San Marcos Water Treatment Plant, a pump station, a treated water transmission line from the plant to Wimberley/Woodcreek, and a terminal storage tank located near Wimberley and Woodcreek.

For conceptual design, costing, and environmental analyses, the treatment and transmission systems are sized for delivery of 4,480 acft/yr to meet the 2060 need. Costs are summarized under three options for both a short-term supply (1 MGD) and a long-term supply (4 MGD) scenario as indicated in Table 4C.8-3. The short-term supply scenario under each option represents a delivery of 1 MGD of treated water through the 4 MGD system. This would meet the immediate need of 1 MGD for the Wimberley area and provide additional capacity in the system for the full 2060 demand. Capital costs are nearly identical under the short-term and long-term scenarios except for the water treatment plant expansion costs for the long term supply; however, short term supply annual costs vary significantly due to the raw water costs, water treatment plant operation and maintenance and pumping costs.

Option A includes a pipeline that would deliver up to 4.0 MGD beginning near Kyle, TX and terminating at a new water tank in Wimberley. The preferred alignment for this 19 mile pipeline utilizes the right-of-way along FM 150 and RR 3237 into Wimberley. System components include the interconnect with the existing 30-inch diameter GBRA Hays-IH35 pipeline, a 4 MGD pump station, 16 inch diameter pipeline, one booster station, and a 400,000 gallon storage tank in Wimberley. Treated water costs for this option are estimated at $2.34/kgal and include the raw water cost, cost to deliver water to San Marcos, treatment and integration to the interconnection. Costs for treated water as a long term supply is assumed to increase to $5.69/kgal based on an average cost for long term raw water at $1000/acft. Total project cost for the long-term supply for Option A is estimated at $33,848,000 with annual cost of $2,610/acft.

A second optional pipeline route (Option B) would deliver water from the San Marcos WTP to Wimberley/Woodcreek using right-of-way along RR 12. The project would include an 18 mile, 16-inch diameter pipeline, and would require a pump station and a booster station to deliver the treated supply. Treated water costs for this option are estimated at $1.70/kgal and include the raw water cost, cost to deliver water to San Marcos, and treatment and integration to the interconnection. Costs for treated water as a long term supply is assumed to increase to $4.45/kgal based on an average cost for long term raw water at $1000/acft. Total project cost for the long-term supply for Option B is estimated at $33,771,000 with annual cost of $2,429/acft (Table 4C.8-3).

Option C would deliver water from the edge of San Marcos distribution system 10 miles to Wimberley/Woodcreek along RR 12. Water from the San Marcos WTP would be wheeled through the City of San Marcos delivery system to an existing water storage tank at the intersection of Wonder World Dr. and RR 12. A pump station and a 16 inch diameter pipeline would be constructed from the storage tank to deliver the supplies to Wimberley / Woodcreek. San Marcos has additional water that it may be willing to sell to Wimberley as a short term supply until other supplies may be developed. The treated water costs ($2.94/kgal) for the short term supply under this option represent the current San Marcos fee to treat and wheel the water through the City's distribution system. Costs for treated water as a long term supply is assumed to increase to $5.69/kgal based on an average cost for long term raw water at $1000/acft. Total project cost for the long-term supply for Option B is estimated at $19,936,000 with annual cost of $2,453/acft (Table 4C.8-3).

A fourth option of delivering water to Wimberley directly from Canyon Reservoir was also considered. This option was previously described in the 2006 Regional Plan as a potential strategy for meeting Wimberley area water supply needs. However, the remaining available water supplies from Canyon Reservoir have been contracted and there is significant resistance to adding a new intake in the Reservoir. Although, interim supplies could be leased, without available long-term supplies at Canyon Reservoir, it is not recommended to finance the associated treatment and transmission facilities for interim supplies.

4C.8.5 Implementation Issues

Requirements Specific to Treatment and Transmission

1. Necessary permits:
   a. USACE Sections 10 and 404 dredge and fill permits for stream crossings.
   b. TCEQ discharge of water treatment plant settling basin blowdown and filter backwash.
   c. GLO Sand and Gravel Removal permits.
   d. TPWD Sand, Gravel, and Marl permit for river crossing.
2. Right-of-way and easement acquisition.
3. Crossings:
   a. Highways,
   b. Creeks and river, and
   c. Other utilities.
4. Financing:
   a. Sponsoring entity must be identified and be able to incur debt to finance project.
   b. Participating entities must negotiate water purchase contract with GBRA, San Marcos, and/or the Hays/Caldwell PUA and establish rate structures.

Table 4C.8-3.
Cost Estimate Summaries for Wimberley and Woodcreek Water Supply
(September 2008 Prices)

Item	Option A** FM 150 Route 19 miles		Option B** RR 12 Route Around San Marcos System 18 miles		Option C** RR 12 Route Through San Marcos System 10 miles	
	Short-Term Supply (1 MGD)	Long-Term Supply (4 MGD)	Short-Term Supply (1 MGD)	Long-Term Supply (4 MGD)	Short-Term Supply (1 MGD)	Long-Term Supply (4 MGD)
Capital Costs						
Intake and Pump Station (4 MGD)	$0	$0	$0	$0	$0	$0
Transmission Pipeline (16 inch diameter)	$11,536,000	$11,536,000	$11,060,000	$11,060,000	$5,135,000	$5,135,000
Transmission Pump Station(s)	$6,491,000	$6,491,000	$6,978,000	$6,978,000	$3,220,000	$3,220,000
Water Treatment Plant or Plant Expansion (4 MGD)	$0	$5,135,000	$0	$5,135,000	$0	$5,135,000
Terminal Storage Tank (0.4 MG)	$375,000	$375,000	$375,000	$375,000	$375,000	$375,000
Interconnection to GBRA Hays IH35 Pipeline	$50,000	$50,000	$0	$0	$0	$0
Total Capital Cost	**$18,452,000**	**$23,587,000**	**$18,413,000**	**$23,548,000**	**$8,730,000**	**$13,865,000**
Engineering, Legal Costs, and Contingencies	$7,678,000	$7,678,000	$7,689,000	$7,689,000	$4,596,000	$4,596,000
Environmental & Archaeology Studies and Mitigation	$543,000	$543,000	$524,000	$524,000	$302,000	$302,000
Land Acquisition and Surveying	$738,000	$738,000	$711,000	$711,000	$406,000	$406,000
Interest During Construction (1 years)	$1,302,000	$1,302,000	$1,299,000	$1,299,000	$767,000	$767,000
Total Project Cost	**$28,713,000**	**$33,848,000**	**$28,636,000**	**$33,771,000**	**$14,801,000**	**$19,936,000**
Annual Costs						
Debt Service (6 percent, 20 years)	$2,503,000	$2,951,000	$2,497,000	$2,944,000	$1,290,000	$1,738,000
Operation and Maintenance						
Intake, Pipeline, Pump Station	$273,000	$273,000	$282,000	$282,000	$136,000	$136,000
Water Treatment Plant	$0	$487,000	$0	$487,000	$0	$487,000
Pumping Energy Costs ($0.09/kW-hr)	$93,000	$554,000	$116,000	$678,000	$49,000	$329,000
Raw Water Rate ($/acft)[1]	$105	$1,000	$105	$1,000	$105	$1,000
Purchase of Raw Water						
Treated Water Rate ($/kgal)[2,3]	$2.34	$5.09	$1.70	$4.45	$2.94	$5.69
Purchase of Treated Water	$854,000	$7,426,000	$620,000	$6,491,000	$1,073,000	$8,301,000
Total Annual Cost	**$3,723,000**	**$11,691,000**	**$3,515,000**	**$10,882,000**	**$2,548,000**	**$10,991,000**
Available Project Yield (acft/yr)	1,120	4,480	1,120	4,480	1,120	4,480
Annual Cost of Water ($/acft/yr)	$3,324	$2,610	$3,138	$2,429	$2,275	$2,453
Annual Cost of Water ($/kgal)	$10.20	$8.01	$9.63	$7.45	$6.98	$7.53

* System facilities are sized for uniform delivery to Wimberley at 4 MGD. No peaking capacity has been included.
** Summary information descriptive of each option follows:
Option A: Short-Term = Committed, but presently unused, water from Canyon Reservoir available on a short -term basis. Treated water delivery from the existing San Marcos WTP via the GBRA Hays IH35 Pipeline.
Long-Term = Water from a new project (e.g., GBRA Mid -Basin, Hays/Caldwell PUA, etc.) available on a long-term basis. Treated water delivery from an expanded San Marcos WTP via the GBRA Hays IH35 Pipeline.
Option B: Short-Term = Committed, but presently unused, water from Canyon Reservoir available on a short -term basis. Treated water delivery from the existing San Marcos WTP in a new pipeline bypassing the San Marcos distribution system.
Long-Term = Water from a new project (e.g., GBRA Mid -Basin, Hays/Caldwell PUA, etc.) available on a long-term basis. Treated water delivery from an expanded San Marcos WTP in a new pipeline bypassing the San Marcos distribution system.
Option B -1 : Alternate cross country route for Option B.
Option C: Short-Term = Committed, but presently unused, water (GBRA/Canyon and/or Edwards) that San Marcos believes it can serve on a short-term basis. Treated water delivery from the existing San Marcos WTP through the San Marcos distribution system.
Long-Term = Water from a new project (e.g., GBRA Mid-Basin, Hays/Caldwell PUA, etc.) available on a long-term basis. Treated water delivery from an expanded San Marcos WTP through the San Marcos distribution system.
Expansion of transmission capacity within the San Marcos distribution system has not been evaluated.
Option C -1 : Alternate cross country route for Option C.
[1] $1000/acft is preliminary estimate of cost of raw water at the San Marcos WTP provided through development of a new project.
[2] Treated water rates include raw water cost, treatment, O&M, pumping, and wheeling costs per GBRA for Options A and B and per San Marcos for Option C.
[3] Treated water rates are adjusted to account for increase in raw water rate for long-term supply (Options A-C).

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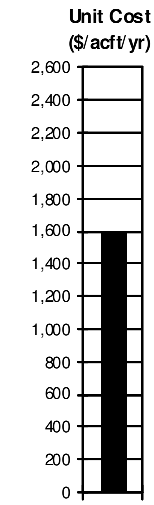
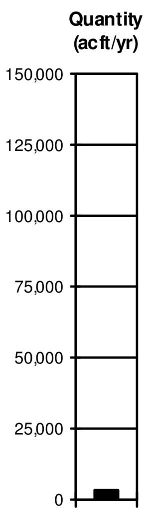
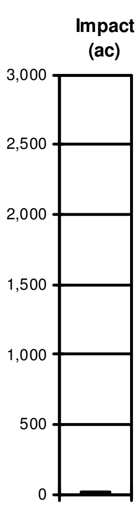
2011 South Central Texas Regional Water Plan
Water Management Strategy Summary Sheet







Name: Storage above Canyon Reservoir – Aquifer Storage and Recovery

Description: Water management strategies of the 2011 South Central Texas Regional Water Plan are sized and scheduled to meet seasonal and daily variations of demand, but, without storage, some current and proposed supplies may not be fully reliable during extended droughts. This strategy involves construction of a large-scale Aquifer Storage and Recovery (ASR) system in the watershed upstream of Canyon Reservoir. The capability of the Trinity Aquifer to store surface water available under a new appropriation in Comal, Kendall, and/or Kerr Counties in two areas was assessed and the firm supply of this option evaluated.

***Decade Needed*:** 2020 – 2030

Cost, Quantity of Water, and Land Impacted

Unit Cost of Water:	**$1,599**	**$/acft/yr**	**Treated Water Delivered**
Quantity of Water:	**3,140**	**acft/yr**	**Reliability = Firm**
Land Impacted:	**23**	**acres**	

Additional Considerations per
Regional Water Planning Guidelines

Environmental Factors:

The Cascade Cavern salamander, a state threatened species has been documented within 2.5-miles of the proposed site and the state and federally-listed endangered Golden-cheeked Warbler has been documented within four miles of the proposed site.

Impacts on Water Resources:

A modification of the streamflow regime on the Guadalupe River at Spring Branch would be anticipated on reservoir filling.

Impacts on Agricultural & Natural Resources:

Conversion of existing land uses and habitats to open water.

Other Relevant Factors per SCTRWPG:

None.

Comparison of Strategies to Meet Needs:

No conflicts with other recommended water management strategies.

Interbasin Transfer Issues:

None anticipated.

Third-Party Impacts of Voluntary Transfers:

None anticipated.

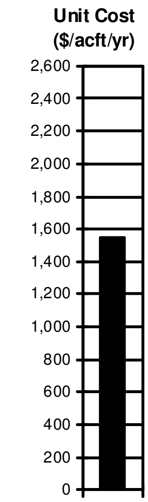
Regional Efficiency:

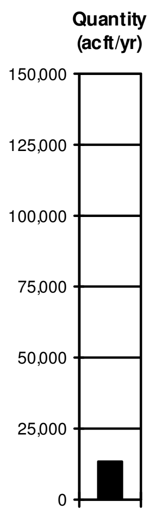
Project could meet needs in area with limited alternatives of new supply.

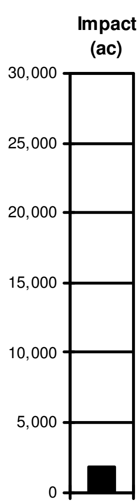
Water Quality Considerations:

None anticipated.

2011 South Central Texas Regional Water Plan
Water Management Strategy Summary Sheet







Name: Storage above Canyon Reservoir – Site 3

Description: Water management strategies of the 2011 South Central Texas Regional Water Plan are sized and scheduled to meet seasonal and daily variations of demand, but, without storage, some current and proposed supplies may not be fully reliable during extended droughts. This strategy involves construction of an off channel reservoir in the watershed upstream of Canyon Reservoir. For Site 3, dam construction and inundation of approximately 1,816 acres along approximately two miles of Krause Creek and approximately two miles of Simmons Creek would occur. These two creeks converge prior to entering Curry Creek, a tributary of the Guadalupe River.

***Decade Needed*:** 2020-2030

Cost, Quantity of Water, and Land Impacted

Unit Cost of Water:	**$1,616**	**$/acft/yr**	**Treated Water Delivered**
Quantity of Water:	**13,500**	**acft/yr**	**Reliability = Firm**
Land Impacted:	**1,837**	**acres**	

Additional Considerations per
Regional Water Planning Guidelines

Environmental Factors:

The Cascade Cavern salamander, a state threatened species has been documented within 2.5-miles of the proposed site and the state and federally-listed endangered Golden-cheeked Warbler has been documented within four miles of the proposed site.

Impacts on Water Resources:

Modification of the streamflow regime on the Guadalupe River at Spring Branch would be anticipated on reservoir filling.

Impacts on Agricultural & Natural Resources:

Conversion of existing land uses and habitats to open water.

Other Relevant Factors per SCTRWPG:

None.

Comparison of Strategies to Meet Needs:

No conflicts with other recommended water management strategies.

Interbasin Transfer Issues:

None anticipated.

Third-Party Impacts of Voluntary Transfers:

None anticipated.

Regional Efficiency:

Project could meet needs in area with limited alternatives of new supply.

Water Quality Considerations:

The off-channel reservoir will aid in suspending river diversions to avoid poor water quality during flood events and facilitate maintenance of diversion facilities without stopping reservoir deliveries.

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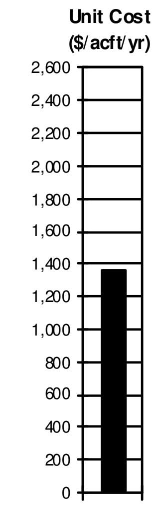


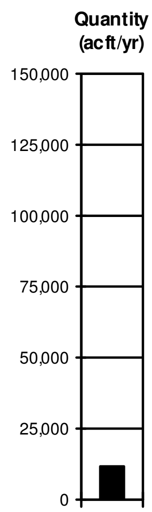
Name: Storage above Canyon Reservoir – Site 8

Description: Water management strategies of the 2011 South Central Texas Regional Water Plan are sized and scheduled to meet seasonal and daily variations of demand, but, without storage, some current and proposed supplies may not be fully reliable during extended droughts. This strategy involves construction of an off channel reservoir in the watershed upstream of Canyon Reservoir. For Site 8, dam construction and inundation of approximately 737 acres along an approximately 2.5-mile reach of Flat Rock Creek, a tributary of the Guadalupe River, would occur.

***Decade Needed*:** 2020 – 2030

Cost, Quantity of Water, and Land Impacted

Unit Cost of Water:	**$1,423**	**$/acft/yr**	**Treated Water Delivered**
Quantity of Water:	**11,390**	**acft/yr**	**Reliability = Firm**
Land Impacted:	**748**	**acres**	



Additional Considerations per
Regional Water Planning Guidelines

Environmental Factors:

No threatened or endangered species have been documented within the immediate study area.

Impacts on Water Resources:

A modification of the streamflow regime on the Guadalupe River at Comfort would be anticipated on reservoir filling.

Impacts on Agricultural & Natural Resources:

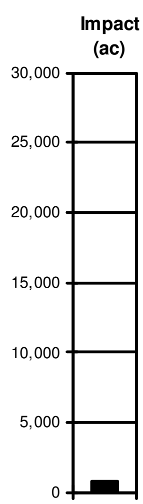
Conversion of existing land uses and habitats to open water.

Other Relevant Factors per SCTRWPG:

None.

Comparison of Strategies to Meet Needs:

No conflicts with other recommended water management strategies.



Interbasin Transfer Issues:

None anticipated.

Third-Party Impacts of Voluntary Transfers:

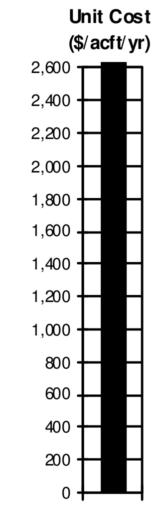
None anticipated.

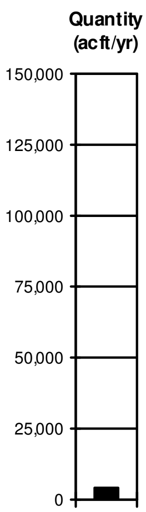
Regional Efficiency:

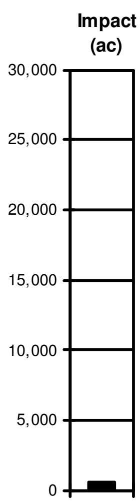
None.

Water Quality Considerations:

The off-channel reservoir will aid in suspending river diversions to avoid poor water quality during flood events and facilitate maintenance of diversion facilities without stopping reservoir deliveries.







Name: Storage above Canyon Reservoir – Site 15

Description: Water management strategies of the 2011 South Central Texas Regional Water Plan are sized and scheduled to meet seasonal and daily variations of demand, but, without storage, some current and proposed supplies may not be fully reliable during extended droughts. This strategy involves construction of an off channel reservoir in the watershed upstream of Canyon Reservoir. Dam construction and inundation of approximately 629 acres that lie west of the Guadalupe River between Mountain Creek to the north and Bear Creek to the south would occur to construct Site 15. For this strategy, unappropriated flow would be diverted from the flood pool of Canyon Reservoir.

***Decade Needed*:** 2020 – 2030

Cost, Quantity of Water, and Land Impacted

Unit Cost of Water:	**$2,957**	**$/acft/yr**	**Treated Water Delivered**
Quantity of Water:	**4,255**	**acft/yr**	**Reliability = Firm**
Land Impacted:	**635**	**acres**	

Additional Considerations per Regional Water Planning Guidelines

Environmental Factors:

No occurrences of threatened, endangered or rare species were documented within or surrounding the OCR area.

Impacts on Water Resources:

Only flood water from Canyon Reservoir would be diverted so downstream impacts to water resources are not anticipated.

Impacts on Agricultural & Natural Resources:

Conversion of existing land uses and habitats to open water.

Other Relevant Factors per SCTRWPG:

None.

Comparison of Strategies to Meet Needs:

No conflicts with other recommended water management strategies.

Interbasin Transfer Issues:

None anticipated.

Third-Party Impacts of Voluntary Transfers:

None anticipated.

Regional Efficiency:

Project could meet needs in area with limited alternatives of new supply.

Water Quality Considerations:

The off-channel reservoir will aid in suspending river diversions to avoid poor water quality during flood events and facilitate maintenance of diversion facilities without stopping reservoir deliveries.

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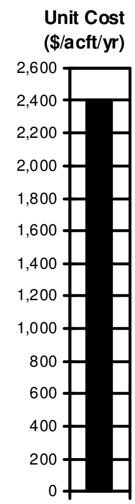


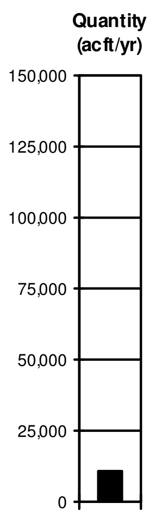
Name: Storage above Canyon Reservoir – Site 17A

Description: Water management strategies of the 2011 South Central Texas Regional Water Plan are sized and scheduled to meet seasonal and daily variations of demand, but, without storage, some current and proposed supplies may not be fully reliable during extended droughts. This strategy involves construction of an off channel reservoir in the watershed upstream of Canyon Reservoir. Approximately 1,046 acres east of Canyon Reservoir between two unnamed tributaries of the Guadalupe River would be inundated and a dam would be constructed for Site 17A. For this strategy, unappropriated flow would be diverted from the flood pool of Canyon Reservoir.

***Decade Needed*:** 2020 – 2030

Cost, Quantity of Water, and Land Impacted

Unit Cost of Water:	**$2,405**	**$/acft/yr**	**Treated Water Delivered**
Quantity of Water:	**11,130**	**acft/yr**	**Reliability = Firm**
Land Impacted:	**1,061**	**acres**	



Additional Considerations per Regional Water Planning Guidelines

Environmental Factors:

No protected species have been documented within or surrounding the OCR area.

Impacts on Water Resources:

Only flood water from Canyon Reservoir would be diverted so downstream impacts to water resources are not anticipated.

Natural Resources:

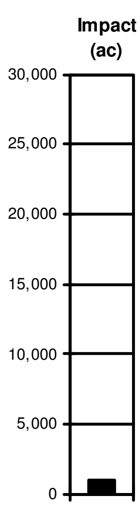
Conversion of existing land uses and habitats to open water.

Other Relevant Factors per SCTRWPG:

None.

Comparison of Strategies to Meet Needs:

No conflicts with other recommended water management strategies.



Interbasin Transfer Issues:

None anticipated.

Third-Party Impacts of Voluntary Transfers:

None anticipated.

Regional Efficiency:

None.

Water Quality Considerations:

The off-channel reservoir will aid in suspending river diversions to avoid poor water quality during flood events and facilitate maintenance of diversion facilities without stopping reservoir deliveries.

4C.9 Storage above Canyon Reservoir

4C.9.1 Description of Water Management Strategy

The alternatives for new water supplies in the watershed above Canyon Reservoir are limited, particularly to Water User Groups (WUGs) in Kendall and Comal Counties. One such potential water supply is the Storage above Canyon Reservoir water management strategy, which involves diverting streamflows from the Guadalupe River above Canyon Reservoir during wet periods and storing them either in an off-channel reservoir (OCR) or a large-scale Aquifer Storage and Recovery (ASR) system. In the Storage above Canyon Reservoir water management strategy, potential surface water storage sites and ASR well fields in the watershed upstream of Canyon Reservoir are assessed, and the firm supply is determined using the storage to firm up run-of-river water available under a new appropriation.

4C.9.1.1 Off-channel Reservoir Screening Criteria and Site Selection

Screening criteria to be used to determine adequate off-channel reservoir sites were identified based on critical issues to be considered in meeting the goals of the strategy. Eight criteria were used in the screening process. Nineteen sites for surface storage were identified in the watershed above Canyon Reservoir or in the Canyon Reservoir flood pool. For the planning-level purposes, these sites are meant to be illustrative only of potential sites and do not exclude other sites that may be identified upon further study. A list of the preliminary screening criteria includes the following:

- Amount of development in reservoir footprint and surrounding area;
- Straight-line distance from Canyon Lake and/or Guadalupe River;
- Natural topography;
- Site efficiency (i.e. average depth: reservoir volume/reservoir area);
- Stream classification (perennial versus intermittent) based on USGS topographic maps;
- Environmental/cultural issues;
- Water availability/accessibility and related infrastructure needs; and
- Geology (not coincident with Edwards Aquifer outcrop).

The reservoir site efficiency criterion provides a relative measure of reservoir site efficiency with respect to inflow, topography, and evaporation losses. Preference is given to reservoir sites for which available inflow is efficiently stored and evaporation losses are minimized, thereby maximizing firm yield.

Based on the screening criteria, four OCR sites shown in Figure 4C.9-1 were chosen for firm yield analyses. The OCR sites are identified by the initial numbering system of sites identified and include Sites 3, 8, 15, and 17A. Sites 3 and 8 are upstream of Canyon Reservoir on tributaries of the Guadalupe River. Sites 15 and 17A are on tributaries near Canyon Reservoir and would include diversion of flood flows from the Canyon Reservoir flood pool.

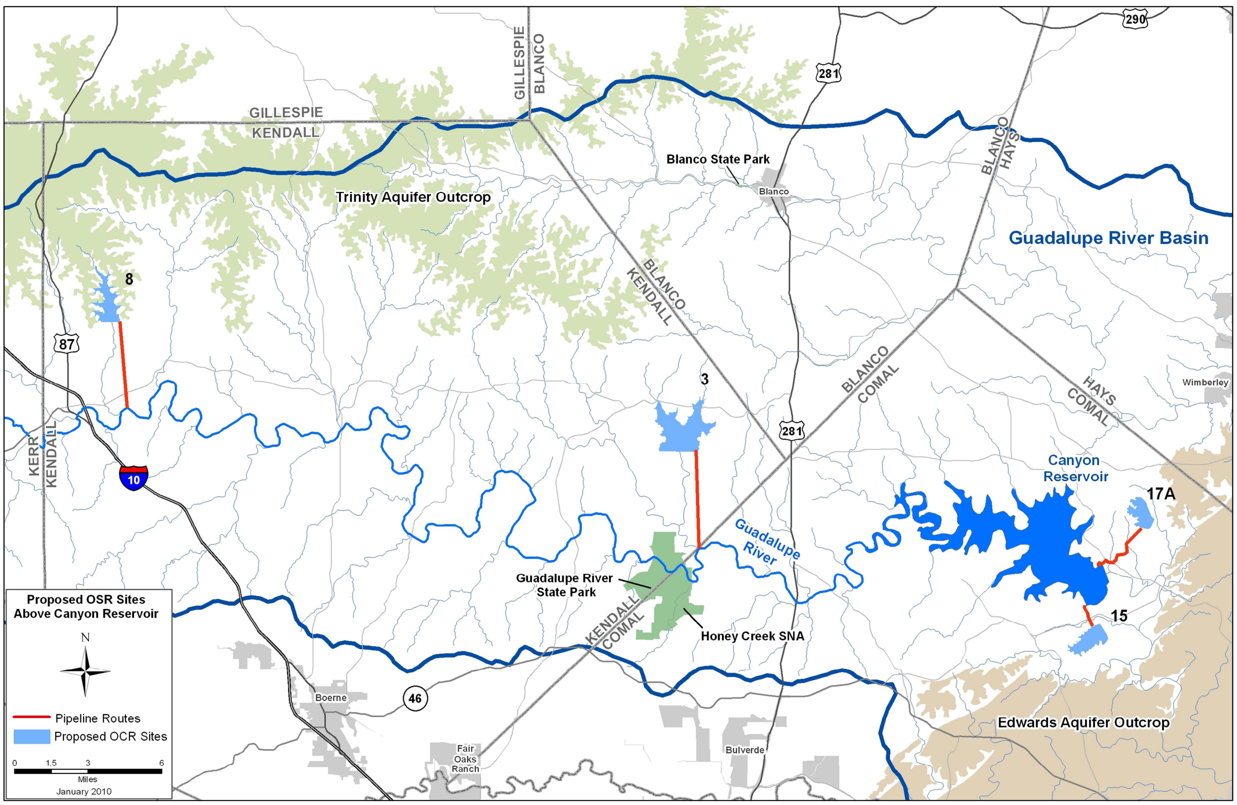


Figure 4C.9-1. Potential Off-Channel Reservoir Sites

Off-channel reservoir characteristics are shown in Table 4C.9-1. Site 3 has a storage capacity of 75,984 acft at a conservation pool elevation of 1,320 ft-msl and would use a 96-in, 4-mile pipeline to divert water from the Guadalupe River at Spring Branch. Site 8 has a storage capacity of 51,086 acft at a conservation pool elevation of 1,740 ft-msl and would utilize a 96-in, 2-mile pipeline to transport water diverted from the Guadalupe River downstream of Comfort, TX. Site 15 has a storage capacity of 55,187 acft at a conservation pool elevation of 1,100 ft-msl and would utilize a 96-in, 1-mile pipeline to transport water from the Canyon Reservoir flood pool. Site 17A has a storage capacity of 140,153 acft at a conservation pool elevation of 1,200 ft-msl and would implement a 120-in, 3-mile pipeline to transport water from the Canyon Reservoir flood pool.

Table 4C.9-1.
Off-channel Reservoir Characteristics

	Off-channel Reservoir Site			
	Site 3	**Site 8**	**Site 15**	**Site 17A**
Reservoir Capacity (acft)	75,984	51,086	55,817	140,153
Surface Area (acres)	1,816	737	629	1,046
Average Depth (ft)	42	69	89	134
Transmission Pipeline Diameter (inches)	96	96	96	120
Transmission Pipeline Length (miles)	4	2	1	3

4C.9.1.2 Identification of Aquifer Storage and Recovery Sites

Aquifer Storage and Recovery (ASR), or underground storage of water, could be used to firm-up interruptible run-of-river water available under a new appropriation to meet demands in Kendall and/or Comal Counties. In nearby Kerr County, which has similar geography and geology to Kendall and Comal Counties, a large-scale ASR system has been successfully implemented with little or no dissipation of the injected ASR water. Potential ASR sites above Canyon Reservoir were identified based on proximity to the Guadalupe River and the geology of the area. The area identified for potential ASR implementation shown in Figure 4C.9-2 was chosen based on an analysis of existing well yields and depth to the Trinity Aquifer in the immediate area and is not meant to exclude other areas that may be identified as potential ASR sites in future studies. The identified area follows the Guadalupe River and Block Creek northeast of Comfort to minimize pumping costs from the Guadalupe River to the ASR well field site.

The basic assumptions made to determine the size and characteristics of the components of the ASR site are listed in Table 4C.9-2. For the ASR site, an aquifer storage capacity of 10,000 acft for the ASR site and an injection rate of 350 gpm for ten wells were assumed. Any water injected into an ASR well field is treated to drinking water standards prior to injection into the aquifer. Facilities would include an intake(s) and pump station(s) at the Guadalupe River, transmission pipeline to the ASR wells, treatment plant, and ten ASR wells.

Table 4C.9-2.
Engineering Assumptions for ASR Option

Parameter	*Assumption*	*Description*
Aquifer Storage Capacity	10,000 acft	-
Number of ASR wells	10	Injection and Recovery
Injection Rate	350 gpm	Pumps used to meet demand are turned on automatically for injection when water is available.
Monthly Demand Pattern	Municipal	Municipal demand pattern from GSA Model

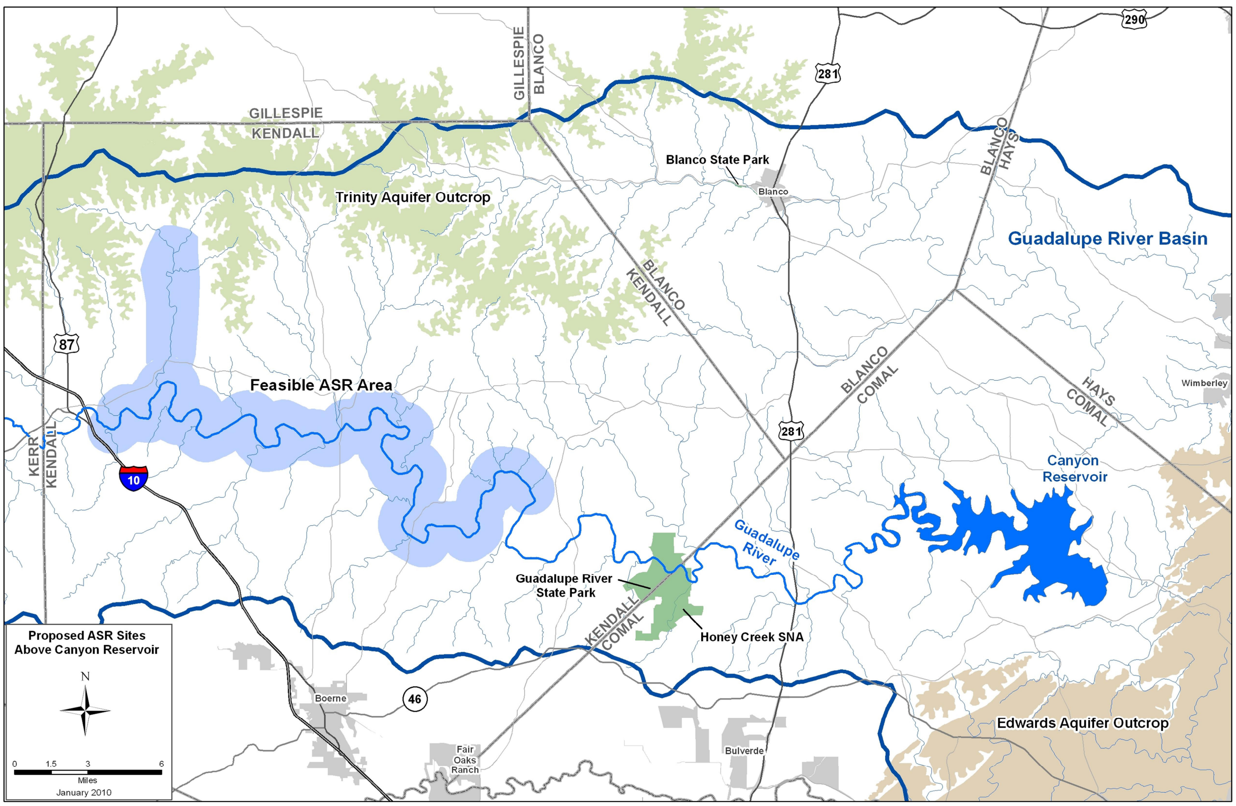


Figure 4C.9-2. Potential Aquifer Storage and Recovery Area

4C.9.2 Water Availability

4C.9.2.1 Off-Channel Reservoir Water Availability

The Guadalupe-San Antonio River Basin Water Availability Model (GSAWAM, as modified for regional water planning purposes) is used to quantify water available for diversion under a new appropriation on the Guadalupe River above Canyon Reservoir, to determine water available for OCR Sites 3 and 8. Hydrologic simulations and calculations are performed subject to the General Assumptions for Applications of Hydrologic Models, as adopted by the SCTRWPG for the 2011 Regional Water Plan. Canyon Reservoir was subordinated to the diversions from the Guadalupe River for Sites 3 and 8.

During the simulation period from 1934-1989, streamflow availability was derived using Consensus Criteria for Environmental Flow Needs (CCEFN). Tables 4C.9-3 and 4C.9-4 list the monthly natural streamflow statistics used to derive the environmental flow restrictions for diversion from the Guadalupe River at Spring Branch for OCR 8 and diversions from the Guadalupe River near Comfort for OCR 3, respectively. The GSAWAM is a monthly timestep model, however, the GSAWAM, as modified for regional water planning purposes, has a subroutine designed specifically to perform supplemental calculations that quantify water availability for a new water right subject to daily flow variations, senior water rights, instantaneous instream flow restrictions, and an instantaneous maximum diversion rate.

Table 4C.9-3.
Environmental Flow Restrictions for Diversion from the Guadalupe River at Spring Branch

Month	Natural Median Flow (cfs)	Natural Quartile Flow (cfs)	Natural 7Q2 Flow (cfs)
JAN	5.61	2.99	1.73
FEB	5.89	3.22	1.73
MAR	6.30	3.07	1.73
APR	5.98	3.38	1.73
MAY	7.77	3.13	1.73
JUN	6.35	2.62	1.73
JUL	3.90	1.73*	1.73
AUG	2.91	1.73*	1.73
SEP	3.78	1.73*	1.73
OCT	4.85	2.02	1.73
NOV	4.87	2.41	1.73
DEC	5.59	2.81	1.73

**Natural 7Q2 exceeds natural quartile flow*

Table 4C.9-4.
Environmental Flow Restrictions for Diversions from the Guadalupe River near Comfort

Month	Natural Median Flow (cfs)	Natural Quartile Flow (cfs)	Natural 7Q2 Flow (cfs)
JAN	3.63	2.14	0.96
FEB	3.92	2.16	0.96
MAR	3.79	2.05	0.96
APR	3.67	2.11	0.96
MAY	4.17	1.86	0.96
JUN	3.33	1.50	0.96
JUL	2.35	1.01	0.96
AUG	1.95	0.96*	0.96
SEP	2.50	1.12	0.96
OCT	3.17	1.48	0.96
NOV	3.47	1.73	0.96
DEC	3.71	2.01	0.96
**Natural 7Q2 exceeds natural quartile flow*			

For OCR Sites 15 and 17A, the GSAWAM was used to estimate water available from the flood pool of Canyon Reservoir for diversion to the OCR sites by calculating monthly spill volumes. Water captured in the flood pool of Canyon Reservoir is to be released at a rate of 5,000 cfs, thus limiting the time available for diversion to Sites 15 and 17A. A daily spreadsheet analysis was performed to determine number of days the monthly spill flow volumes would remain in the flood pool and calculate pumping volumes to the OCR sites during these days.

All inflows to the OCR sites from contributing drainage areas were passed through downstream and were not assumed to contribute to water available for impoundment/diversion. Application of the GSAWAM, with a period of record from January 1934 to December 1989, demonstrates that the calculated firm yields of the four OCR options range from 4,255 acft/yr to 13,500 acft/yr (Table 4C.9-5).

There are three delivery possibilities associated with the Storage above Canyon Reservoir – OCR option water management strategy. One possibility is to deliver the water via pipeline to a nearby WUG. Another possibility is includes making releases out of the off-channel reservoir and allowing the water to flow downstream in the Guadalupe River for WUGs to subsequently divert downstream. Finally, water could be released out of the off-channel reservoir, allowed to flow downstream to Canyon Reservoir, and used by GBRA customers either via the Western Canyon Pipeline or through subsequent downstream releases from Canyon Reservoir.

Table 4C.9-5.
Off-Channel Reservoir Capacities and Firm Yields

	Off-channel Reservoir Site			
	Site 3	*Site 8*	*Site 15*	*Site 17A*
Reservoir Capacity (acft)	75,984	51,086	55,817	140,153
Firm Yield (acft/yr)	13,500	11,390	4,255	11,130

4C.9.2.2 Aquifer Storage and Recovery Water Availability

The amount of water available for injection into an ASR system was estimated using daily results from the GSAWAM for the period of record of 1934 to 1989, and using the same assumptions as described above for OCR Sites 3 and 8. The firm yield supply of the ASR system of 3,140 acft/yr was estimated using an iterative spreadsheet-based model. The model incorporates a municipal demand pattern and first meets demands before any remaining available water is injected into the subsurface. The spreadsheet model assumes that the ASR system is full at a capacity of 10,000 acft in 1934. Then the firm yield is estimated based on the storage in the aquifer reaching nearly 0 acft after meeting municipal demand.

4C.9.3 Environmental Issues

Four proposed sites, Site 3, Site 8, Site 15 and Site 17A, have been identified for the OCR above Canyon Reservoir as described in the subsections below. Implementation of any of these OCR alternatives would require field surveys by qualified professionals to document vegetation/habitat types and cultural resources that may be impacted by the proposed reservoir or water diversion pipelines. Where impacts to protected species habitat or significant cultural resources cannot be avoided, additional studies would be necessary to evaluate habitat use and/or value, or eligibility for inclusion in the National Register of Historic Places, respectively. Compensation would be required for unavoidable adverse impacts involving net losses of wetlands.

The Texas Parks & Wildlife Department (TPWD) has identified a number of stream segments throughout the state as ecologically significant on the basis of biological function, hydrologic function, riparian conservation, exceptional aquatic life uses, and/or threatened or endangered species. Currently, 21 stream segments in Region L have been designated as ecologically significant by the Regional Water Planning Group.[1] Subject to this criterion, reservoir sites that do not conflict with identified ecologically significant stream segments are scored more favorably. None of the creeks potentially affected by the proposed OCR above Canyon Reservoir Site 3, Site 8, Site 15, or Site 17A are included on the list of ecologically significant streams. However, the Guadalupe River in this area, from which water would be diverted, is on the list of ecologically significant streams.

Cultural resources protection on public lands in Texas is afforded by the Antiquities Code of Texas (Title 9, Chapter 191, Texas Natural Resource Code of 1977), the National Historic Preservation Act (Pl96-515), and the Archeological and Historic Preservation Act (PL93-291). Based on the review of available GIS datasets, no documented cemeteries, historic markers, or historic places are within the proposed project area for any of the four alternative sites. Cultural resource occurrences within this project area are expected to be present due to the reservoirs locations on creeks. Coordination with the Texas Historical Commission will need to be initiated prior to project construction. If the project will affect waters of the United States or wetlands, the project sponsor will also be required to coordinate with the U.S. Army Corps of Engineers regarding any impacts to cultural resources.

4C.9.3.1 Site 3

Site 3 involves dam construction and inundation of approximately 1,815 acres along approximately two miles of Krause Creek and approximately two miles of Simmons Creek. These two creeks converge prior to entering Curry Creek, a tributary of the Guadalupe River. The proposed reservoir site is located in eastern Kendall County within the Edwards Plateau ecoregion,[2] and in the Balconian biotic province.[3] Vegetation within the project area is a mixture

[1] TPWD, "Ecologically Significant Stream Segments," http://www.tpwd.state.tx.us/landwater/water/environconcerns/water_quality/sigsegs/index.phtml accessed July 20, 2009.
[2] TPWD, "Texas Partners in Flight; Ecological Region 7 – Edwards Plateau"http://www.tpwd.state.tx.us/huntwild/wild/birding/pif/assist/pif_regions/region_7.phtml accessed July 20, 2009.
[3] Blair, W.F., "The Biotic Provinces of Texas, "Tex. J. Sci. 2:93-117, 1950.

of live oak – ashe juniper woodlands and parklands and live oak – mesquite – ashe juniper parklands[4].

Seven soils types underlie the proposed OCR Site 3 area. Eckrant-Comfort association soils, gently undulating is the most abundant soil association in the project area. This association consists of shallow, cobbly and stony soils on broad upland hilltops. Slopes range from 1-5 percent. These soils are well drained and are potential rangeland or wildlife habitat. Doss-Brackett association, undulating soils are also prevalent in the project area. This association consists of shallow, loamy and clayey soils on uplands with slopes of 1 to 8 percent. The soils in this association are well drained and suited to rangeland. Denton silty clay with 1 to 3 percent slopes is moderately deep soils on uplands. This soil is well drained and may be used as cropland, rangeland and improved pasture. Doss silty clay with 1 to 5 percent slopes is shallow gently sloping soils on uplands. This soil is well drained and moderately well suited to crop and pastureland. Krum silty clay soils are deep, gently sloping soils found at the base of limestone hills. Slopes range from 1 to 3 percent. This soil is well drained and is used as cropland and rangeland. Nuvalde silty clay, 0 to 1 percent slopes are found on terraces near floodplains of streams. This soil type is well drained and is well suited to crops and improved pasture. The final soil type found within the project is Oakalla silty clay loam. These soils are deep, nearly level soils on floodplains of major streams.

The primary impacts that would result from construction of the proposed OCR above Canyon Reservoir at Site 3 include conversion of existing habitats and land uses within the conservation pool to open water, and potential downstream effects due to modification of the existing flow regime. Site 3 would permanently inundate 1,815 acres below 1,320 ft-msl. According to land use and land cover data[5], approximately 1,764 acres of evergreen forest land and 51 acres of cropland and pastureland would be converted to open water upon reservoir filling. Based on available information, no communities or other special resources are located within the reservoir area. Indirect effects of reservoir construction may include land use changes in the area surrounding the reservoir and in mitigation areas that may be converted to alternate uses to compensate for losses of terrestrial habitat.

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[4] McMahan, C. A., R. G. Frye and K. L. Brown, " The Vegetation Types of Texas -- Including Cropland," Texas Parks and Wildlife Department − PWD Bulletin 7000-120. 1984.
[5] [5] USGS, 1990. "A Land Use and Land Cover Classification System for Use with Remote Sensor Data," Reston, VA 1990.

Potential downstream impacts would include modification of the streamflow regime on the Guadalupe River at Spring Branch. With the project, monthly median streamflow on the Guadalupe River at Spring Branch would be reduced by a maximum of 3,200 acre-feet/month in October, over without a project conditions. Streamflow reductions for other months would range from 800 to 2,400 acre-feet/month over without a project conditions.

In addition to long-term impacts within the conservation pool, minor changes to existing resources situated between the conservation pool elevation and flood pool elevation could be anticipated due to occasional temporary inundation during flood events.

Plant and animal species listed by USFWS, and TPWD, as endangered or threatened in Kendall County are listed in Table 4C.9-6. According to the TPWD Natural Diversity Database, no protected species have been recorded within the immediate study area, although the area may provide potential habitat to endangered or threatened species found in Kendall County. The Cascade Cavern salamander, a state threatened species has been documented within 2.5-miles of the proposed site and the state and federally-listed endangered Golden-cheeked Warbler has been documented within four miles of the proposed site. A survey of the reservoir site may be required prior to dam construction to determine whether populations of or potential habitats used by listed species occur in the area to be affected.

4C.9.3.2 Site 8

Site 8 involves dam construction and inundation of approximately 740 acres along an approximately 2.5-mile reach of Flat Rock Creek, a tributary of the Guadalupe River. The proposed reservoir site is located in western Kendall County within the Edwards Plateau ecoregion,[6] and in the Balconian biotic province.[7] Vegetation within the project area is classified as live oak – Ashe juniper woodlands.

Three main soil types occur within the proposed OCR Site 8. Shallow, loamy, undulating Brackett association soils are found on ridges and foot slopes. Slopes range from 1 to 8 percent. These soils are well drained and are primarily used as rangeland. Brackett-Real association soils,

[6] TPWD, "Texas Partners in Flight; Ecological Region 7 – Edwards Plateau"http://www.tpwd.state.tx.us/huntwild/wild/birding/pif/assist/pif_regions/region_7.phtml accessed July 20, 2009.
[7] Blair, W.F., "The Biotic Provinces of Texas, "Tex. J. Sci. 2:93-117, 1950.

Table 4C.9-6.
Endangered, Threatened, and Species of Concern Listed for Kendall County

Common Name	Scientific Name	Summary of Habitat Preference	Listing Entity		Potential Occurrence in County
			USFWS	TPWD	
AMPHIBIANS					
Blanco River springs salamander	*Eurycea pterophila*	Subaquatic species found in spring and caves in the Blanco River drainage.	—	—	Resident
Cascade Caverns salamander	*Eurycea latitans complex*	Endemic, subaquatic in Edwards Aquifer Area	—	T	Resident
Comal Blind Salamander	*Eurycea tridentifera*	Endemic; found in springs and waters of caves.	—	T	Resident
Texas Salamander	*Eurycea neotenes*	Endemic; springs, seeps, cave streams, Helotes and Leon Creek drainages.	—	—	Resident
BIRDS					
Bald eagle	*Haliaeetus leucoephalus*	Found primarily near rivers and large lakes.	DL	T	Possible Migrant
Black-capped Vireo	*Vireo atricapillus*	Oak-juniper woodlands,	LE	E	Resident
Golden-cheeked Warbler	*Dendroica chrysoparia*	*Juniper-oak woodlands.*	LE	E	Resident
Interior least tern	*Sterna antillarum athalassos*	Nests along sand and gravel bars in braided streams	LE	E	Resident
Mountain Plover	*Charadrius montanus*	Non-breeding, shortgrass plains and fields	—	—	Nesting/Migrant
Peregrine falcon	Falco peregrinus anatum (American)	Open county; cliffs	T	DL	Nesting/Migrant
	Falco peregrinus tundrius (Arctic)	Open county; cliffs	—	DL	Nesting/Migrant
Western Burrowing Owl	*Athene cunicularia hypugaea*	Open grasslands, especially prairie, plains and savanna	—	—	Resident
Whooping Crane	*Grus americana*	Potential migrant	LE	E	Potential Migrant
Zone-tailed Hawk	*Buteo albonotatus*	Arid open country, often near watercourses	—	T	Resident
CRUSTACEANS					
Cascade Cave amphipod	*Stygobromus dejectus*	Subaquatic crustacean, subterranean obligate found in underground streams.	—	—	Resident

Table 4C.9-6 (Continued)

Common Name	Scientific Name	Summary of Habitat Preference	Listing Entity		Potential Occurrence in County
			USFWS	TPWD	
Long-legged cave amphipod	*Stygobromus longipes*	Subaquatic crustacean found in subterranean streams.	—	—	Resident
FISHES					
Guadalupe Bass	*Micropterus treculi*	Endemic to perennial streams of the Edwards Plateau region.	—	—	Resident
Guadalupe Darter	*Percina sciera apristis*	Guadalupe River Basin. Usually found over gravel or gravel and sand raceways of larger streams and rivers.	—	—	Resident
Headwater catfish	*Ictalurus lupus*	Originally found throughout streams of the Edwards Plateau and Rio Grande basin.	—	—	Resident
MAMMALS					
Black Bear	*Ursus americanus*	Inhabits bottomland hardwoods	T/SA;NL	T	Historic Resident
Cave Myotis Bat	*Myotis velifer*	Roosts colonially in caves, rock crevices	—		Resident
Gray wolf	*Canis lupus*	Extirpated, forests, brushlands or grasslands	LE	E	Historic resident
Plains Spotted Skunk	*Spilogale putorius interrupta*	Prefers wooded, brushy areas.	—	—	Resident
Red Wolf	*Canis rufus*	Extirpated.	LE	E	Historic Resident
MOLLUSKS					
Creeper (squawfoot)	*Strophitus undulates*	Small to large streams	—	—	Resident
False spike mussel	*Quincuncina mitchelli*	Substrates of cobble and mud with water lilies present. Rio Grande, Brazos, Colorado and Guadalupe river basins.	—	T*	Resident
Golden orb	*Quadrula aurea*	Sand and gravel, Guadalupe, San Antonio, and Nueces River basins	—	T*	Resident
Pistolgrip	*Tritogonia verrucosa*	Aquatic, stable substrate. Red through San Antonio river basins.	—	—	Resident

Table 4C.9-6 (Concluded)

Common Name	***Scientific Name***	***Summary of Habitat Preference***	***Listing Entity***		***Potential Occurrence in County***
			USFWS	***TPWD***	
Texas fatmucket	*Lampsilis bracteata*	Streams and rivers on sand, mud and gravel, Colorado and Guadalupe River basins.	__	T*	Resident
Texas pimpleback	*Quadrula petrina*	Mud, gravel and sand substrates, Colorado and Guadalupe river basins	__	T*	Resident
PLANTS					
Basin bellflower	*Campanula reverchonii*	Endemic, found among scattered vegetation on loose gravel and other areas.	—	—	Resident
Big red sage	*Salvia penstemonoides*	Endemic; moist to seasonally wet clay or silt soils in creek beds.	—	—	Resident
Canyon mock-orange	*Philadelphus ernestii*	Endemic, usually found on limestone outcrops.	—	—	Resident
Hill country wild-mercury	*Argythamnia aphoroides*	Endemic, found primarily in grasslands associated with oak woodlands.	—	—	Resident
Texas mock-orange	*Philadelphus texensis*	Found primarily on limestone outcrops on cliffs and rocky slopes.	—	—	Resident
REPTILES					
Cagle's map turtle	*Graptemys caglei*	Endemic to Guadalupe River System. Found within 30 feet of waters' edge.	__	T	Resident
Spot-tailed earless lizard	*Holbrookia lacerata*	Moderately open prairie-brushland.	—	—	Resident
Texas Garter Snake	*Thamnophis sirtalis annectens*	Wet or moist microhabitats	—	—	Resident
Texas Horned Lizard	*Phrynosoma cornutum*	Varied habitat including sparsely vegetated uplands.	__	T	Resident

LE/LT=Federally Listed Endangered/Threatened
DL, PDL=Federally Delisted/Proposed for Delisting
T/SA=Listed as Threatened by Similarity of Appearance
E, T=State Listed Endangered/Threatened T*= in process of being listed as threatened by State
-- = Species of concern, but no regulatory listing status
Source: TPWD, Annotated County List of Rare Species, Kendall County, revised May 4, 2009.

hilly consist of shallow, gravelly and loamy soils with convex slopes ranging from 8 to 30 percent. The soils in this association are well drained and are poorly suited to cropland uses. The final soil type underlying the project area is Krum silty clay soils with 3 to 5 percent slopes. This deep, gently sloping soil is found of foot slopes of limestone hills. This soil is well drained and is well suited to cropland and improved pasture.

The primary impacts that would result from construction and operation of the proposed OCR above Canyon Reservoir at this site include conversion of existing habitats and land uses within the conservation pool to open water, and potential downstream effects due to modification of the existing flow regime. Site 8 would permanently inundate 740 acres below 1,740 ft-msl. According to land use and land cover data[8], the entire 740 acre site would be converted from evergreen forest land to open water upon reservoir filling. Based on available information, no communities or other special resources are located within the reservoir area. Indirect effects of reservoir construction may include land use changes in the area surrounding the reservoir and in mitigation areas that may be converted to alternate uses to compensate for losses of terrestrial habitat.

Potential downstream impacts would include modification of the streamflow regime on the Guadalupe River at Comfort. With the project, monthly median streamflow on the Guadalupe River at Comfort would be reduced over without a project conditions by a maximum of approximately 1,600 acre-feet/month for March, May, July and October. Monthly median streamflow reductions for other months would range from 800 to 1,400 acre-feet/month over without a project conditions.

In addition to long-term impacts within the conservation pool, minor changes to existing resources situated between the conservation pool elevation and flood pool elevation could be anticipated due to occasional temporary inundation during flood events.

Plant and animal species listed by USFWS, and TPWD, as endangered or threatened in Kendall County are previously listed in Table 4C.9-6. According to the TPWD Natural Diversity Database, no protected species have been recorded within the immediate study area, although the area may provide potential habitat to endangered or threatened species found in Kendall County. Other protected species may use habitats in the area during migration. A survey of the reservoir site may be required prior to dam construction to determine whether populations of or potential habitats used by listed species occur in the area to be affected.

4C.9.3.3 Site 15

Site 15 involves dam construction and inundation of approximately 630 acres that lie west of the Guadalupe River between Mountain Creek to the north and Bear Creek to the south. The proposed reservoir site is located in east-central Comal County within the Edwards Plateau ecoregion,[9] and in the Balconian biotic province.[10] Vegetation within the project area is classified as live oak – Ashe juniper woodlands.

Soils underlying the proposed OCR Site 15 area are composed of two soil complexes. Found in the Edwards Plateau, the Brackett-Rock outcrop-Real complex has slopes ranging from eight to 30 percent. This complex consists of shallow, loamy and clayey soils and Rock outcrop on uplands such as ridges and plateaus. The soils in this complex are well drained, potentially highly erodible, and are well suited to rangeland and wildlife habitat. Comfort-rock outcrop complex soils consist of shallow, clayey soils and Rock outcrop on side slopes and on hilltops and ridgetops on uplands in the Edwards Plateau. Comfort soils are well drained; the soils in this complex are used as rangeland and as habitat for wildlife.

The primary impacts that would result from construction and operation of the proposed OCR above Canyon Reservoir at this site include conversion of existing habitats and land uses within the conservation pool to open water, and potential downstream effects due to modification of the existing flow regime. Site 15 would permanently inundate 630 acres below 1,100 ft-msl. According to land use and land cover data[11], the entire 630 acre site would be converted from evergreen forest land to open water upon reservoir filling. Based on available information, no communities or other special resources are located within the reservoir area. Indirect effects of reservoir construction may include land use changes in the area surrounding the reservoir and in mitigation areas that may be converted to alternate uses to compensate for losses of terrestrial habitat.

Site 15 would only divert flood water from Canyon Reservoir. As such, this alternative would not alter the streamflow regime on the Guadalupe River.

[8] USGS, 1990. "A Land Use and Land Cover Classification System for Use with Remote Sensor Data," Reston, VA 1990.
[9] TPWD, "Texas Partners in Flight; Ecological Region 7 – Edwards Plateau"http://www.tpwd.state.tx.us/huntwild/wild/birding/pif/assist/pif_regions/region_7.phtml accessed July 20, 2009.
[10] Blair, W.F., "The Biotic Provinces of Texas, "Tex. J. Sci. 2:93-117, 1950.
[11] USGS, 1990. "A Land Use and Land Cover Classification System for Use with Remote Sensor Data," Reston, VA 1990.

In addition to long-term impacts within the conservation pool, minor changes to existing resources situated between the conservation pool elevation and flood pool elevation could be anticipated due to occasional temporary inundation during flood events.

Plant and animal species listed by USFWS, and TPWD, as endangered or threatened with potential habitat in Comal County are listed in Table 4C.9-7. According to the TPWD Natural Diversity Database, no protected species have been recorded within the immediate study area, although the area may provide potential habitat to endangered or threatened species found in Comal County. Other protected species may use habitats in the area during migration. A survey of the reservoir site may be required prior to dam construction to determine whether populations of or potential habitats used by listed species occur in the area to be affected.

4C.9.3.4 Site 17A

Site 17A involves dam construction and inundation of approximately 1,045 acres east of Canyon Reservoir between two unnamed tributaries of the Guadalupe River. The proposed reservoir site is located in northeastern Comal County within the Edwards Plateau ecoregion,[12] and in the Balconian biotic province.[13] Vegetation within the project area is a mixture of live oak – Ashe juniper woodlands and parklands.[14]

The majority of the soils within the OCR Site 17A area are composed of Brackett-Rock outcrop-Real complex, steep. This complex consists of shallow, loamy soils and Rock outcrop on uplands in the Edwards Plateau. Slopes are convex and range from 8 to 30 percent. The soils in this complex are well drained; water erosion is a severe hazard. The soils in this complex are typically used as rangeland and as wildlife habitat. Bolar clay loam soils with 1 to 3 percent slopes comprise the remainder of the soils underlying Site 17A. These soils are moderately deep, gently sloping and found on concave valley slopes and foot slopes of hills on uplands. This soil is well drained and is primarily used as rangeland.

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[12] TPWD, "Texas Partners in Flight; Ecological Region 7 – Edwards Plateau"http://www.tpwd.state.tx.us/huntwild/wild/birding/pif/assist/pif_regions/region_7.phtml accessed July 20, 2009.
[13] Blair, W.F., "The Biotic Provinces of Texas, "Tex. J. Sci. 2:93-117, 1950.
[14] McMahan, C. A., R. G. Frye and K. L. Brown, " The Vegetation Types of Texas -- Including Cropland," Texas Parks and Wildlife Department − PWD Bulletin 7000-120. 1984.

**Table 4C.9-7.
Endangered, Threatened, and Species of Concern Listed for Comal County**

Common Name	Scientific Name	Summary of Habitat Preference	Listing Entity		Potential Occurrence in County
			USFWS	TPWD	
AMPHIBIANS					
Cascade Caverns salamander	*Eurycea latitans complex*	Endemic, subaquatic in Edwards Aquifer Area	—	T	Resident
Comal Blind Salamander	*Eurycea tridentifera*	Endemic; found in springs and waters of caves.	—	T	Resident
Comal Springs salamander	*Eurycea sp.8*	Endemic, found only in Comal Springs.	—	—	Resident
Edwards Plateau spring salamander	*Eurycea sp.7*	Endemic, found in springs and waters of some caves of this region.	—	—	Resident
BIRDS					
Bald eagle	*Haliaeetus leucoephalus*	Found primarily near rivers and large lakes.	DL	T	Possible Migrant
Black-capped Vireo	*Vireo atricapillus*	Oak-juniper woodlands,	LE	E	Resident
Golden-cheeked Warbler	*Dendroica chrysoparia*	*Juniper-oak woodlands.*	LE	E	Resident
Mountain Plover	*Charadrius montanus*	Non-breeding, shortgrass plains and fields	—	—	Nesting/Migrant
Peregrine falcon	Falco peregrinus anatum (American)	Open county; cliffs	T	DL	Nesting/Migrant
	Falco peregrinus tundrius (Arctic)	Open county; cliffs	—	DL	Nesting/Migrant
Western Burrowing Owl	*Athene cunicularia hypugaea*	Open grasslands, especially prairie, plains and savanna	—	—	Resident
Whooping Crane	*Grus americana*	Potential migrant	LE	E	Potential Migrant
Zone-tailed Hawk	*Buteo albonotatus*	Arid open country, often near watercourses	—	T	Resident
CRUSTACEANS					
Ezell's cave amphipod	*Stygobromus flagellates*	This species only known from artesian wells.	—	—	Resident
Long-legged cave amphipod	*Stygobromus longipes*	Subaquatic crustacean found in subterranean streams.	—	—	Resident
Peck's cave amphipod	*Stygobromus pecki*	Small aquatic species, collected at Comal Springs and Hueco Springs.	—	—	Resident

Table 4C.9-7 (Continued)

Common Name	***Scientific Name***	***Summary of Habitat Preference***	***Listing Entity***		***Potential Occurrence in County***
			USFWS	***TPWD***	
FISHES					
Fountain darter	*Etheostoma fonticola*	Known only from the San Marcos and Comal Rivers.	LE	E	Resident
Guadalupe Bass	*Micropterus treculi*	Endemic to perennial streams of the Edwards Plateau region.	—	—	Resident
Guadalupe Darter	*Percina sciera apristis*	Guadalupe River Basin. Usually found over gravel or gravel and sand raceways of larger streams and rivers.	—	—	Resident
INSECTS					
A mayfly	*Pseudocentroptiloides morihari*	Species with aquatic larval stage, adults generally found in shoreline vegetation.	—	—	Resident
Comal Springs diving beetle	*Comaldessus stygius*	Known only from the outflows at Comal Springs.	—	—	Resident
Comal Springs dryopid beetle	*Stygoparnus comalensis*	Beetles usually found clinging to objects in streams. Larvae live in soil or decaying wood.	LE	—	Resident
Comal Springs riffle beetle	*Heterelmis comalensis*	Beetle found in Comal and San Marcos Springs.	LE	—	Resident
Edwards Aquifer diving beetle	*Haideoporus texanus*	Known only from an atesian well in Hays County.	—	—	Resident
Rawson's metalmark	*Calephelis rawsoni*	Butterfly found in moist areas in shaded limestone outcrops, within woodlands or along rivers.	—	—	Resident
MAMMALS					
Black Bear	*Ursus americanus*	Inhabits bottomland hardwoods	T/SA;NL	T	Historic Resident
Cave Myotis Bat	*Myotis velifer*	Roosts colonially in caves, rock crevices	—		Resident
Jaguarundi	*Herpailurus yaguarondi*	Favors thick brushlands near water.	LE	E	Resident
Plains Spotted Skunk	*Spilogale putorius interrupta*	Prefers wooded, brushy areas.	—	—	Resident
Red Wolf	*Canis rufus*	Extirpated.	LE	E	Historic Resident

Table 4C.9-7 (Continued)

Common Name	Scientific Name	Summary of Habitat Preference	Listing Entity		Potential Occurrence in County
			USFWS	TPWD	
MOLLUSKS					
Creeper (squawfoot)	*Strophitus undulates*	Small to large streams	—	—	Resident
False spike mussel	*Quincuncina mitchelli*	Substrates of cobble and mud with water lilies present. Rio Grande, Brazos, Colorado and Guadalupe river basins.	—	T*	Resident
Golden orb	*Quadrula aurea*	Sand and gravel, Guadalupe, San Antonio, and Nueces River basins	—	T*	Resident
Horseshoe liptooth snail	*Daedalochila hippocrepis*	Terrestrial snail known only from Landa Park.	—	—	Resident
Pistolgrip	*Tritogonia verrucosa*	Aquatic, stable substrate. Red through San Antonio river basins.	—	—	Resident
Rock pocketbook	*Arcidens confragosus*	Found within the Red through Guadalupe River basins.	—	—	Resident
Texas fatmucket	*Lampsilis bracteata*	Streams and rivers on sand, mud and gravel, Colorado and Guadalupe River basins.	—	T*	Resident
PLANTS					
Bracted twistflower	*Streptanthus bracteatus*	Endemic, generally found on shallow, well-drained gravelly clays over limestone.	—	—	Resident
Canyon mock-orange	*Philadelphus ernestii*	Endemic, usually found on limestone outcrops.	—	—	Resident
Comal snakewood	*Colubrina stricta*	Historic in Comal County.	—	—	Resident
Hill country wild-mercury	*Argythamnia aphoroides*	Endemic, found primarily in grasslands associated with oak woodlands.	—	—	Resident
Texas mock-orange	*Philadelphus texensis*	Found primarily on limestone outcrops on cliffs and rocky slopes.	—	—	Resident

Table 4C.9-7 (Concluded)

Common Name	***Scientific Name***	***Summary of Habitat Preference***	***Listing Entity***		***Potential Occurrence in County***
			USFWS	***TPWD***	
REPTILES					
Cagle's map turtle	*Graptemys caglei*	Endemic to Guadalupe River System. Found within 30 feet of waters' edge.	__	T	Resident
Spot-tailed earless lizard	*Holbrookia lacerata*	Moderately open prairie-brushland.	—	—	Resident
Texas Garter Snake	*Thamnophis sirtalis annectens*	Wet or moist microhabitats	—	—	Resident
Texas Horned Lizard	*Phrynosoma cornutum*	Varied habitat including sparsely vegetated uplands.	__	T	Resident

LE/LT=Federally Listed Endangered/Threatened
DL, PDL=Federally Delisted/Proposed for Delisting
T/SA=Listed as Threatened by Similarity of Appearance
E, T=State Listed Endangered/Threatened T*= in process of being listed as threatened by State
-- = Species of concern, but no regulatory listing status
Source: TPWD, Annotated County List of Rare Species, Comal County, revised September 24, 2009.

The primary impacts that would result from construction and operation of the proposed OCR above Canyon Reservoir at Site 17A include conversion of existing habitats and land uses within the conservation pool to open water, and potential downstream effects due to modification of the existing flow regime. Site 3 would permanently inundate 1,045 acres below 1,200 ft-msl. According to land use and land cover data,[15] the entire 1,045-acre site would be converted from evergreen forest land to open water upon reservoir filling. Based on available information, no communities or other special resources are located within the reservoir area. Indirect effects of reservoir construction may include land use changes in the area surrounding the reservoir and in mitigation areas that may be converted to alternate uses to compensate for losses of terrestrial habitat.

Site 17A would only divert flood water from Canyon Reservoir. As such, this alternative would not alter the streamflow regime on the Guadalupe River.

In addition to long-term impacts within the conservation pool, minor changes to existing resources situated between the conservation pool elevation and flood pool elevation could be anticipated due to occasional temporary inundation during flood events.

[15] USGS, 1990. "A Land Use and Land Cover Classification System for Use with Remote Sensor Data," Reston, VA 1990.

Plant and animal species listed by USFWS, and TPWD, as endangered or threatened in Comal County are previously listed in Table 4C.9-7. According to the TPWD Natural Diversity Database, no protected species have been recorded within the immediate study area, although the area may provide potential habitat to endangered or threatened species found in Comal County. A survey of the reservoir site may be required prior to dam construction to determine whether populations of or potential habitats used by listed species occur in the area to be affected.

4C.9.3.5 ASR

Potential environmental issues associated with implementation of the ASR water management strategy include consideration and mitigation of affected aquatic and terrestrial habitats, cultural resources, and threatened and endangered species, in accordance with applicable state and federal requirements. Field surveys by qualified professionals to document vegetation/habitat types, waters of the U.S. including wetlands, and cultural resources that may be impacted by the ASR system would be required. Where impacts to protected species habitat or significant cultural resources cannot be avoided, additional studies would be necessary to evaluate habitat use and/or value, or eligibility for inclusion in the National Register of Historic Places, respectively. Compensation would be required for unavoidable adverse impacts involving net losses of wetlands.

Unappropriated flows from the Guadalupe River above Canyon Reservoir would be diverted into a pipeline for storage within the Trinity Aquifer. The Guadalupe River, where unappropriated flows would be diverted for the ASR system has been identified by the TPWD as ecologically significant. The potential well field area is along the Guadalupe River in Kendall County within the Edwards Plateau ecoregion[16] within the Balconian biotic province of Texas.[17] Vegetation within the project area is primarily live oak – Ashe juniper parks and live oak – mesquite – Ashe juniper parks.[18]

Based on a review of available GIS datasets from the Texas Historical Commission, there are several cemeteries, historical markers and National Register properties located within

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[16] TPWD, "Texas Partners in Flight; Ecological Region 7 – Edwards Plateau"http://www.tpwd.state.tx.us/huntwild/wild/birding/pif/assist/pif_regions/region_7.phtml accessed July 20, 2009.
[17] Blair, W.F., "The Biotic Provinces of Texas, "Tex. J. Sci. 2:93-117, 1950.
[18] McMahan, C. A., R. G. Frye and K. L. Brown, "The Vegetation Types of Texas -- Including Cropland," Texas Parks and Wildlife Department − PWD Bulletin 7000-120. 1984.

1 mile of the potential ASR well field area. Coordination with the Texas Historical Commission (THC) will need to be initiated prior to project construction. No review of archaeological resources has been completed. It is likely that there would be buried archaeological resources within the potential well field area due to its proximity to the Guadalupe River. A study of the pipeline diversion routes and well areas, as well as any other areas that would be disturbed would likely be required by the THC to determine impacts to archaeological resources. If the project will affect waters of the United States or wetlands, the project sponsor will also be required to coordinate with the U.S. Army Corps of Engineers regarding any impacts to cultural resources.

The primary impacts that would result from construction and operation of the proposed ASR include the diversion of unappropriated flows from the Guadalupe River and conversion of existing habitats along the pipeline route and within the well field area to maintained right-of-way. Land use in the surrounding area would not be anticipated to change due to this project.

Unappropriated flows from the Guadalupe River would be diverted for the ASR option. As such, this alternative would not be expected to alter the streamflow regime on the Guadalupe River and potential downstream impacts would not be likely.

Plant and animal species listed by USFWS, and TPWD, as endangered or threatened with potential habitat in Kendall County are listed in Table 4C.9-7. According to the TPWD Natural Diversity Database, the Golden-cheeked Warbler, a federal and state listed endangered species, and the Cascade Caverns salamander, a state threatened species have been documented within or near the potential well field area in Kendall County. Additionally, the headwater catfish and four plant species, big red sage, basin bellflower, Texas mock orange, and canyon mock, all species of concern, have been documented within or within one mile of the potential ASR well field area. A survey of the potential well field area may be required prior to construction to determine whether populations of or potential habitats used by listed species occur in the area to be affected.

4C.9.4 Engineering and Costing

The cost estimates for the different options of this water management strategy are shown in Table 4C.9-8. Included in the costs for the off-channel reservoirs and ASR scenarios are raw water intakes and pump stations and transmission pipelines. The ASR option also includes the cost of a water treatment plant and ASR injection/recovery wells. The OCR options also include costs of the reservoir and dam. Depending upon the location(s) and type(s) of use for water supplies associated with an off-channel reservoir or ASR, additional facilities and costs could include additional pipelines to customers. Inundated land and mitigation land acquisition and operation and maintenance costs were developed in accordance with the standard cost estimating procedures summarized in Appendix A. Costs include land purchased within the spillway design flood pools for the off-channel reservoirs. The annual costs, including debt service and operation and maintenance, range from $5,019,000 for the ASR option to $26,763,000 for the off-channel reservoir Site 17A. For annual firm yields ranging from 3,140 acft to 13,500 acft, the resulting unit cost of treated water ranges from $1,423 to $2,957 per acft (Table 4C.9-8).

4C.9.5 Implementation Issues

An institutional arrangement may be needed to implement these projects, including financing on a regional basis.

1. It will be necessary to obtain these permits:
   a. TCEQ Water Right and Storage permits.
   b. TCEQ Interbasin Transfer approval depending upon location(s) of use.
   c. USACE Sections 10 and 404 dredge and fill permits for the reservoir and pipelines.
   d. GLO Sand and Gravel Removal permits.
   e. GLO Easement for use of state-owned land.
   f. Coastal Coordination Council review.
   g. TPWD Sand, Gravel, and Marl permit.

2. Permitting, at a minimum, will require these studies:
   a. Assessment of instream flow and bay and estuary inflow changes.
   b. Habitat mitigation plan.
   c. Environmental studies.
   d. Cultural resources.

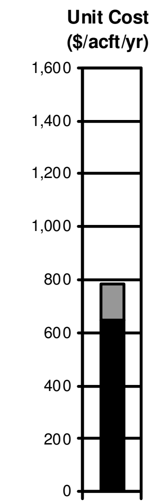
3. Land will need to be acquired through either negotiations or condemnation (see Section 8.10).

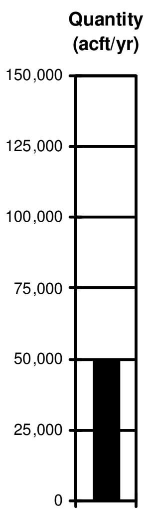
4. Relocations for the reservoir may include:
   a. County roads.
   b. Utilities.
   c. Structures of historical significance.
   d. Cemeteries.

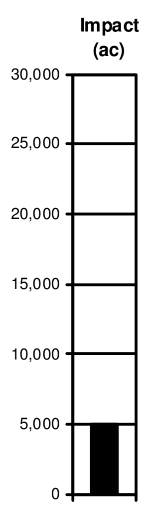
Table 4C.9-8. Cost Estimate Summary for Storage above Canyon Reservoir (September 2008 Prices)

Item	*Estimated Costs for Facilities*				
	Site 3	*Site 8*	*Site 15*	*Site 17A*	*ASR*
Capital Costs					
Off-Channel Storage	$87,075,000	$64,835,000	$68,498,000	$144,391,000	$0
Intake and Pump Station	$32,170,000	$34,943,000	$24,136,000	$43,771,000	$4,487,000
Transmission Pipeline	$22,540,000	$10,340,000	$5,057,000	$20,674,000	$1,088,000
Well Fields	$0	$0	$0	$0	$4,306,000
Water Treatment Plant	$0	$0	$0	$0	$16,416,000
Total Capital Cost	**$141,785,000**	**$110,118,000**	**$97,691,000**	**$208,836,000**	**$26,297,000**
Engineering, Legal Costs and Contingencies	$48,497,000	$38,024,000	$33,939,000	$72,059,000	$9,150,000
Environmental & Archaeology Studies and Mitigation	$17,710,000	$7,207,000	$2,638,000	$4,414,000	$214,000
Land Acquisition and Surveying	$17,889,000	$7,289,000	$2,690,000	$4,527,000	$229,000
Interest During Construction (2 years)	$15,149,000	$10,580,000	$9,388,000	$19,741,000	$1,436,000
Total Project Cost	**$241,030,000**	**$173,218,000**	**$146,346,000**	**$309,577,000**	**$37,326,000**
Annual Costs					
Debt Service (6 percent, 20 years)	$6,624,000	$5,513,000	$3,558,000	$7,815,000	$3,254,000
Reservoir Debt Service (6 percent, 40 years)	$10,969,000	$7,310,000	$7,014,000	$14,618,000	$0
Operation and Maintenance					
Intake, Pipeline, Pump Station	$1,030,000	$977,000	$654,000	$1,301,000	$166,000
Dam and Reservoir	$1,306,000	$973,000	$1,027,000	$2,166,000	$0
Water Treatment Plant	$0	$0	$0	$0	$1,291,000
Pumping Energy Costs	$909,000	$789,000	$328,000	$863,000	$308,000
Purchase of Water	$977,000	$650,000	$0	$0	$0
Total Annual Cost	**$21,815,000**	**$16,212,000**	**$12,581,000**	**$26,763,000**	**$5,019,000**
Available Project Yield (acft/yr)	13,500	11,390	4,255	11,130	3,140
Annual Cost of Water ($ per acft)	$1,616	$1,423	$2,957	$2,405	$1,598
Annual Cost of Water ($ per 1,000 gallons)	$4.96	$4.37	$9.07	$7.38	$4.90

2011 South Central Texas Regional Water Plan
Water Management Strategy Summary Sheet







Name: GBRA-Exelon Project

Description: The Exelon Generation Company, LLC (Exelon) is presently investigating the feasibility of constructing a nuclear power plant in Victoria County south of Victoria, Texas. The availability of a reliable supply of cooling water is critical to the development of a power plant at this location. Two concepts for supplying raw water to the plant are being considered: the river diversion option, which involves diversion from the Guadalupe River at the GBRA Saltwater Barrier, and the canal diversion option, which involves diversion from the GBRA Calhoun Canal system. Both options would supply up to 75,000 acft/yr from existing GBRA/Dow Lower Basin Water Rights to Exelon's Victoria County Site.

Facilities that would be constructed under the river diversion option include a new canal and pump station at the Guadalupe River near the Saltwater Barrier and 11 miles of 90-inch transmission pipeline. Facilities that would be constructed under the canal diversion option include conveyance improvements to existing canals, an expansion of the Main Pump Station, a new pump station on the Main Canal located adjacent to the existing Relift #1 Pump Station, and 18 miles of 90-inch transmission pipeline. Both options include construction of a 101,300 acft cooling reservoir at the Exelon power plant site.

Decade Needed: 2010 – 2020

Cost, Quantity of Water, and Land Impacted

Unit Cost of Water (River Diversion Option):	**$646**	**$/acft/yr**	**Raw Water**
Unit Cost of Water (Canal Diversion Option):	**$782**	**$/acft/yr**	**Raw Water**
Quantity of Water:	**49,126**	**acft/yr**	**Reliability = Firm**
Land Impacted (River Diversion Option):	**4,991**	**acres**	
Land Impacted (Canal Diversion Option):	**5,028**	**acres**	

Additional Considerations per Regional Water Planning Guidelines

Environmental Factors:

Wintering population of endangered Whooping Cranes at Aransas National Wildlife Refuge located adjacent to Lower San Antonio Bay. Surface water diversions from a Ecologically Significant Stream Segment per TPWD.

Impacts on Water Resources:

Some reductions in freshwater inflows to the Guadalupe Estuary associated with greater utilization of existing water rights.

Impacts on Agricultural & Natural Resources:

Minimal, if any.

Other Relevant Factors per SCTRWPG:

None.

Comparison of Strategies to Meet Needs:

The GBRA-Exelon Project and the LGWSP for Upstream GBRA Needs (Firm Yield = 60,000 acft/yr) use portions of the same water. Should the GBRA-Exelon Project be recommended, then the LGWSP for Upstream GBRA Needs at Reduced Capacity (Firm Yield = 35,000 acft/yr) would be available.

Interbasin Transfer Issues:

Since this specific strategy is intended to serve water user groups within the GBRA district, no inter-basin transfer issues are anticipated.

Third-Party Impacts of Voluntary Transfers:

None anticipated.

Regional Efficiency:

Opportunity to provide water supply to industrial sites between Canal Diversion Option and Victoria Barge Canal.

Water Quality Considerations:

The off-channel reservoir will aid in suspending river diversions to avoid poor water quality during flood events and facilitate maintenance of diversion facilities without stopping reservoir deliveries.

4C.10 GBRA-Exelon Project

4C.10.1 Description of Water Management Strategy

The Exelon Generation Company, LLC (Exelon) is presently investigating the feasibility of constructing a nuclear power plant in Victoria County south of Victoria, Texas. The availability of a reliable supply of cooling water is critical to the development of a power plant at this location. Two concepts for supplying raw water to the plant are being considered: the river diversion option, which involves diversion from the Guadalupe River at the GBRA Saltwater Barrier, and the canal diversion option, which involves diversion from the GBRA Calhoun Canal system. Both options would supply up to 75,000 acft/yr from existing GBRA/Dow Lower Basin Water Rights to Exelon's Victoria County Site.

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4C.10.1.1 River Diversion Option

The river diversion pipeline route extends from a proposed 121 MGD pump station located approximately 3,000 feet southwest of the GBRA Saltwater Barrier and Diversion Dam to the Exelon delivery point, crossing the San Antonio River. A new canal would be constructed from the Guadalupe River to the pump station site located above the floodplain on the southwest side of the river. Conventional direct-bury/lay construction techniques are suitable for the installation of most of the pipeline along the route; however, horizontal directional drilling (HDD) is recommended (and likely required) at two locations.

The 90-inch pipeline route is approximately 59,600 LF (11 miles) in length and extends southwest from the pump station for 13,800 LF and then turns northwest. The route includes two borings, one extending underneath a bluff and the other crossing under the San Antonio River.

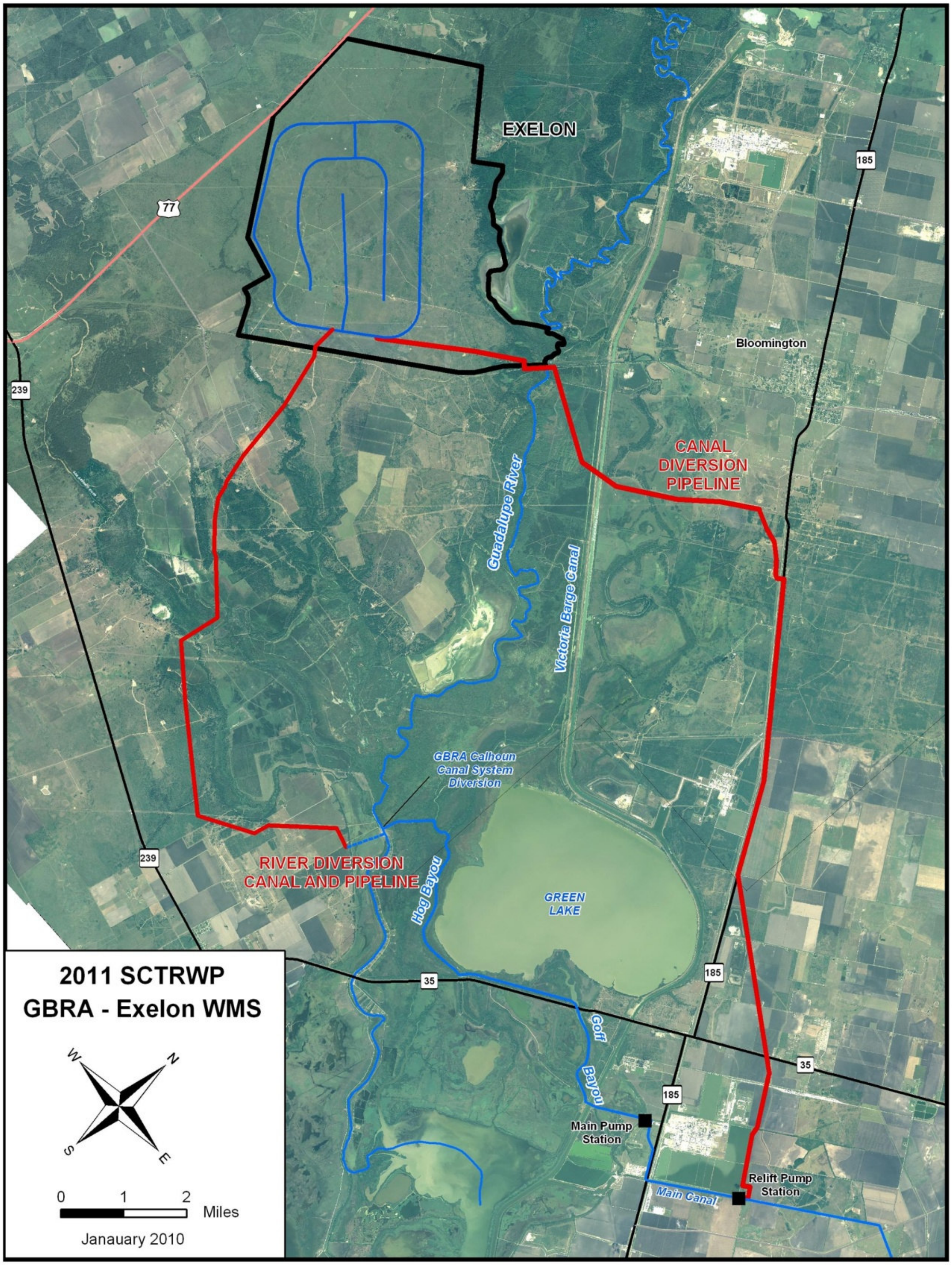

Figure 4C.10-1. Location of GBRA-Exelon Project

The pipeline terminus is located near the southernmost portion of the proposed cooling reservoir embankment on the Exelon site.

4C.10.1.2 Canal Diversion Option

The GBRA Calhoun Canal System currently supplies water from the Guadalupe River to a Dow Chemical Company (Dow) facility (formerly owned by Union Carbide Corporation), the GBRA Port Lavaca Water Treatment Plant, and various municipal, industrial, and irrigation customers of the GBRA. Under the canal diversion option, the existing GBRA Calhoun Canal System will be improved and used to convey raw water from the Guadalupe River at the GBRA Saltwater Barrier to a proposed 121 MGD GBRA-Exelon Pump Station located on the Main Canal adjacent to the existing GBRA Relift#1 Pump Station (Figure 4C.10-1). Subsequent to diversion from the Main Canal at the proposed pump station, raw water will be delivered to the proposed reservoir on the Exelon nuclear power plant site for use by Exelon and GBRA via a proposed 90-inch, 18 mile transmission pipeline. Conventional direct-bury/lay construction techniques are suitable for the installation of most of the pipeline along the route; however, horizontal directional drilling (HDD) is recommended (and likely required) at the Victoria Barge Canal and the Guadalupe River. The pipeline terminus is located near the easternmost portion of the proposed cooling reservoir embankment on the Exelon site.

The Gravity Conveyance System (GCS) refers to the gravity flow components of the GBRA Calhoun Canal System. More specifically, the GCS is comprised of two gravity sub-systems, one for conveyance of water diverted from the Guadalupe River to the Goff Bayou Siphon intake adjacent to the Victoria Barge Canal, and the other for conveyance of water from the Main Pump Station discharge structure to the Relift#1 Pump Station site via a canal and conduits on Dow property and the Main Canal. The GCS will be improved to provide the increased capacity necessary to supply water to the Exelon project in addition to existing customers. The associated work will include the following:

- Modification of the existing diversion structure at the Guadalupe River to increase its capacity;
- Construction of two bridges providing access to the north side of the existing diversion canal running between the Guadalupe River and Hog Bayou to allow access for enhanced maintenance (clearing) of the north canal bank;
- Modification to the Green Lake spillway;

- Increasing the height of the levees on the Dow Canal, which is located between the Main Pump Station and the Main Canal;
- Adding capacity to the Main Canal, including excavating a new channel parallel to the existing canal, associated land acquisition, levee construction, and construction of a maintenance access bridge; and
- Upgrading the existing dirt access road to the Relift #1 Pump Station.

In addition to the new pump station, new pipeline, and GCS improvements, the canal diversion option will also require modifications to the existing Main Pump Station to increase its capacity.

4C.10.2 Water Availability

The Guadalupe River Saltwater Barrier was constructed in the early 1960s at a location immediately downstream of the confluence of the Guadalupe and San Antonio Rivers and creates a reservoir pool extending some distance up both rivers. Diversions from this reservoir pool, under existing rights, flow into GBRA's Calhoun Canal System and are dependent upon waters originating in both the Guadalupe and San Antonio Rivers and their respective tributaries.

Maximum reported water use under the GBRA lower basin water rights totaling 175,501 acft/yr at the Guadalupe River Saltwater Barrier did not exceed 63,000 acft/yr during the 1991 through 2006 historical period[1]. It is estimated by GBRA that up to 75,000 acft/yr under one or more of these rights is available for periods of time into the future leaving 100,000 acft/yr available for lower basin uses. Certificate of Adjudication (CA) #18-5178 is the least senior of GBRA's lower basin water rights and it has a priority date of January 7, 1952. Authorized annual diversions under CA# 18-5178 total 106,000 acft for municipal, industrial, and irrigation uses.

The Guadalupe-San Antonio River Basin Water Availability Model (GSAWAM, as modified for regional water planning purposes) was used to quantify water available for diversion under CA# 18-5178. Hydrologic simulations and calculations were performed subject to the General Assumptions for Applications of Hydrologic Models, as adopted by the SCTRWPG for the 2011 Regional Water Plan. Additional assumptions used in the GSA-WAM to quantify water available to Exelon include:

[1] GBRA, Personal Communication, 2007.

- Exelon supplies are from the most junior portion of CA# 18-5178 and are subordinated to Canyon Reservoir and run-of-river diversions to Coleto Creek Reservoir.
- Water available to Exelon is not constrained by annual or instantaneous maximum diversion rates in the GSA-WAM. Maximum diversion rate constraints are applied as described below.

Using the total monthly regulated streamflow and historical daily streamflow patterns, the monthly streamflow values from the GSA-WAM were disaggregated to daily values in a specially-designed Microsoft Excel workbook. The historical daily streamflow patterns representative of the Guadalupe River near Tivoli were obtained from project files for a 1998 study[2] for the 1934 through 1989 period. These daily streamflow values were then used, along with the monthly amount of water designated for senior water rights, to determine the daily amount that must be reserved for the senior water rights. This daily senior water right reservation was then subtracted from the daily streamflow to establish maximum daily availability to Exelon under CA# 18-5178. Actual quantities of water available to Exelon under CA# 18-5178 are limited by an instantaneous maximum diversion rate of 187 cfs.

Available water for the GBRA-Exelon Project as computed in the analysis described above and limited by the maximum diversion rate of 187 cfs is summarized in Table 4C.10-1. Water availability is sufficient to support normal power plant and cooling reservoir operations including maximum forced evaporation of approximately 49,126 acft/yr.

4C.10.3 Environmental Issues

4C.10.3.1 River Diversion Option

The primary environmental issue related to the development of the river diversion option pipeline is the construction of the transmission pipeline, and the cooling reservoir at the Exelon power plant. Raw water transported through the approximately 11-mile river diversion pipeline route will facilitate water delivery from a pump station site near the GBRA saltwater barrier and diversion dam in Refugio County to the Exelon project site in Victoria County. This 90-inch diameter pipeline originates approximately 3 miles northwest of the City of Tivoli in Refugio

[2] HDR Engineering, Inc., "Guadalupe - San Antonio River Basin Model Modifications & Enhancements," Trans-Texas Water Program, West Central Study Area, Texas Water Development Board, San Antonio River Authority, et.al., March 1998.

Table 4C.10-1.
Water Available to Exelon

Year	Month												Grand Total
	1	2	3	4	5	6	7	8	9	10	11	12	
1934	11,498	10,386	11,498	11,127	11,498	11,127	11,498	11,498	11,127	11,498	11,127	11,498	135,384
1935	11,498	10,386	11,498	11,127	11,498	11,127	11,498	11,498	11,127	11,498	11,127	11,498	135,384
1936	11,498	10,757	11,498	11,127	11,498	11,127	11,498	11,498	11,127	11,498	11,127	11,498	135,755
1937	11,498	10,386	11,498	11,127	11,498	11,127	11,498	11,498	11,127	11,498	11,127	11,498	135,384
1938	11,498	10,386	11,498	11,127	11,498	11,127	11,498	11,498	11,127	11,498	11,127	11,498	135,384
1939	11,498	10,386	11,498	11,127	11,498	11,127	11,498	11,498	11,127	11,189	11,127	11,498	135,075
1940	11,498	10,757	11,498	11,127	11,498	11,127	11,498	11,498	11,127	11,498	11,127	11,498	135,755
1941	11,498	10,386	11,498	11,127	11,498	11,127	11,498	11,498	11,127	11,498	11,127	11,498	135,384
1942	11,498	10,386	11,498	11,127	11,498	11,127	11,498	11,498	11,127	11,498	11,127	11,498	135,384
1943	11,498	10,386	11,498	11,127	11,498	11,127	11,498	11,498	11,127	11,498	11,127	11,498	135,384
1944	11,498	10,757	11,498	11,127	11,498	11,127	11,498	11,498	11,127	11,498	11,127	11,498	135,755
1945	11,498	10,386	11,498	11,127	11,498	11,127	11,498	11,498	11,127	11,498	11,127	11,498	135,384
1946	11,498	10,386	11,498	11,127	11,498	11,127	11,498	11,498	11,127	11,498	11,127	11,498	135,384
1947	11,498	10,386	11,498	11,127	11,498	11,127	11,498	11,498	11,127	11,498	11,127	11,498	135,384
1948	11,498	10,757	11,498	11,127	11,498	9,373	11,434	11,498	11,127	11,498	11,127	11,498	133,936
1949	11,498	10,386	11,498	11,127	11,498	11,127	11,498	11,498	11,127	11,498	11,127	11,498	135,384
1950	11,498	10,386	11,498	11,127	11,498	11,127	11,498	11,088	11,127	9,807	9,737	11,498	131,891
1951	11,498	10,386	11,480	10,735	11,498	11,127	3,821	0	11,127	11,160	11,115	10,595	114,543
1952	11,402	10,757	11,498	11,127	11,498	11,127	10,417	89	8,031	11,498	11,127	11,498	120,071
1953	11,498	10,386	11,498	11,127	11,498	5,296	2,491	11,498	11,127	11,498	11,127	11,498	120,545
1954	11,498	10,386	11,458	10,679	11,498	2,146	0	0	0	11,498	6,663	4,795	80,621
1955	8,973	10,386	8,801	4,269	7,470	9,013	596	10,056	11,127	9,693	4,142	5,458	89,984
1956	5,746	5,836	5,190	2,885	7,201	0	0	0	1,867	4,384	4,594	5,493	43,197
1957	5,623	7,625	11,498	11,127	11,498	11,127	11,498	7,509	10,839	11,498	11,127	11,498	122,469
1958	11,498	10,386	11,498	11,127	11,498	11,127	11,498	11,498	11,127	11,498	11,127	11,498	135,384
1959	11,498	10,386	11,498	11,127	11,498	11,127	11,498	11,498	11,127	11,498	11,127	11,498	135,384
1960	11,498	10,757	11,498	11,127	11,498	11,127	11,498	11,498	11,127	11,498	11,127	11,498	135,755
1961	11,498	10,386	11,498	11,127	11,498	11,127	11,498	11,498	11,127	11,498	11,127	11,498	135,384
1962	11,498	10,386	11,498	11,127	11,498	11,127	11,436	7,442	11,127	11,498	11,127	11,498	131,265
1963	11,498	10,386	11,498	11,127	11,413	10,679	6,647	0	1,943	5,503	11,127	11,498	103,320
1964	11,498	10,757	11,498	11,127	11,498	11,127	4,815	11,478	11,127	11,498	11,127	11,498	129,051
1965	11,498	10,386	11,498	11,127	11,498	11,127	11,498	11,498	11,127	11,498	11,127	11,498	135,384
1966	11,498	10,386	11,498	11,127	11,498	11,127	11,498	11,498	11,127	11,498	11,127	11,498	135,384
1967	11,498	10,386	11,498	11,127	11,498	11,127	4,570	7,435	11,127	11,498	11,127	11,498	124,392
1968	11,498	10,757	11,498	11,127	11,498	11,127	11,498	11,498	11,127	11,498	11,127	11,498	135,755
1969	11,498	10,386	11,498	11,127	11,498	11,127	11,498	11,498	11,127	11,498	11,127	11,498	135,384
1970	11,498	10,386	11,498	11,127	11,498	11,127	11,498	11,498	11,127	11,498	11,127	11,498	135,384
1971	11,498	10,386	11,498	11,127	11,498	10,662	9,527	11,438	11,127	11,498	11,127	11,498	132,886
1972	11,498	10,757	11,498	11,127	11,498	11,127	11,498	11,498	11,127	11,498	11,127	11,498	135,755
1973	11,498	10,386	11,498	11,127	11,498	11,127	11,498	11,498	11,127	11,498	11,127	11,498	135,384
1974	11,498	10,386	11,498	11,127	11,498	11,127	11,498	11,498	11,127	11,498	11,127	11,498	135,384
1975	11,498	10,386	11,498	11,127	11,498	11,127	11,498	11,498	11,127	11,498	11,127	11,498	135,384
1976	11,498	10,757	11,498	11,127	11,498	11,127	11,498	11,498	11,127	11,498	11,127	11,498	135,755
1977	11,498	10,386	11,498	11,127	11,498	11,127	11,498	11,498	11,127	11,498	11,127	11,498	135,384

Table 4C.10-1 (Concluded)

Year	Month 1	2	3	4	5	6	7	8	9	10	11	12	Grand Total
1978	11,498	10,386	11,498	11,127	11,498	11,127	11,498	11,498	11,127	11,498	11,127	11,498	135,384
1979	11,498	10,386	11,498	11,127	11,498	11,127	11,498	11,498	11,127	11,498	11,127	11,498	135,384
1980	11,498	10,757	11,498	11,127	11,498	11,127	11,498	11,498	11,127	11,498	11,127	11,498	135,755
1981	11,498	10,386	11,498	11,127	11,498	11,127	11,498	11,498	11,127	11,498	11,127	11,498	135,384
1982	11,498	10,386	11,498	11,127	11,498	11,127	11,498	11,498	11,127	11,498	11,127	11,498	135,384
1983	11,498	10,386	11,498	11,127	11,498	11,127	11,498	11,498	11,127	11,498	11,127	11,498	135,384
1984	11,498	10,757	11,498	11,127	11,498	9,869	1,429	4,054	887	10,869	11,127	11,498	106,113
1985	11,498	10,386	11,498	11,127	11,498	11,127	11,498	11,498	11,127	11,498	11,127	11,498	135,384
1986	11,498	10,386	11,498	11,127	11,498	11,127	11,498	11,498	11,127	11,498	11,127	11,498	135,384
1987	11,498	10,386	11,498	11,127	11,498	11,127	11,498	11,498	11,127	11,498	11,127	11,498	135,384
1988	11,498	10,757	11,498	11,127	11,498	11,127	11,498	11,498	11,127	11,498	11,127	11,498	135,755
1989	11,498	10,386	11,498	11,127	11,498	11,127	7,446	7,990	3,703	10,702	11,127	11,498	119,602
MAX	**11,498**	**10,757**	**11,498**	**11,127**	**11,498**	**11,127**	**11,498**	**11,498**	**11,127**	**11,498**	**11,127**	**11,498**	**135,755**
AVG	**11,244**	**10,341**	**11,336**	**10,843**	**11,348**	**10,556**	**9,956**	**10,027**	**10,223**	**11,165**	**10,781**	**11,147**	**128,969**
MIN	**5,623**	**5,836**	**5,190**	**2,885**	**7,201**	**0**	**0**	**0**	**0**	**4,384**	**4,142**	**4,795**	**43,197**

County initially paralleling the Refugio/Victoria County line and subsequently crossing the San Antonio River near its confluence with Cross Bayou. The pipeline route then runs in a primarily northwesterly direction terminating at the proposed Exelon project site approximately 2 miles south of Lynn Lake in Victoria County. Larger water sources crossed by this pipeline include the San Antonio River, Cross Bayou, Cushman Bayou, and Kuy Creek.

The project area is located in the Gulf Coastal Plains of Texas Physiographic Province, specifically in the subprovince of the Coastal Prairies.[3] This area is locally characterized as a nearly flat prairie composed of deltaic sands and muds which terminates at the Gulf of Mexico and includes topography changes of less than 1 foot per mile. Elevation levels in the Coastal Prairies range from 0 to 300 feet above mean sea level.

Land uses found within the area crossed by the river diversion option pipeline include primarily farm, pasture, and range areas with some heavier vegetated areas found primarily near stream and river crossings.

The river diversion pipeline is found within the Gulf Prairies and Marshes Vegetational Area.[4] Gulf Prairies have slow surface drainage and elevations that range from sea level to 250 feet. These areas include nearly level and virtually undissected plains. Originally the Gulf

[3] Bureau of Economic Geology. 1996. Physiographic map of Texas., The University of Texas at Austin, Austin, Texas.
[4] Gould, F. W., 1975. "The Grasses of Texas," Texas A&M University Press, College Station, Texas.

Prairies were composed of tallgrass prairie and post oak savannah. However tree species such as honey mesquite, and acacia, along with other trees and shrubs have increased in this area forming dense thickets in many places. Typical oak species found in this area include live oak (*Quercus virginiana*) and post oak (*Q. stellata*), in addition to huisache (*Acacia smallii*), black-brush (*A. rigidula*), and a dwarf shrub; bushy sea-ox-eye (*Borrichia frutescens*). Principal climax grasses of the Gulf Prairies include gulf cordgrass (*Spartina spartinae*), indiangrass (*Sorghastrum nutans*), and big bluestem (*Andropogon gerardii* var. *gerardii*). Prickleypear (*Opunita* sp.) are common within this area along with forbs including asters (*Aster* sp.), poppy mallows (*Callirhoe* sp.), bluebonnets (*Lupinus* sp.), and evening primroses (*Oenothera* sp.). Gulf Marshes range from sea level to a few feet in elevation, and include low, wet marshy coast areas commonly covered with saline water. These salty areas support numerous species of sedges (*Carex* and *Cyperus* sp.), bulrushes (*Scirpus* sp.), rushes (*Juncus* sp.), and grasses. Aquatic forbs found in these areas generally include pepperweeds (*Lepidium* sp.), smartweeds (*Polygonum* sp.), cattails (*Typha domingensis*) and spiderworts (Tradescantia sp.) among others. Upland game and waterfowl find these low marshy areas to be excellent natural wildlife habitat.

The federal Endangered Species Act of 1973, as amended, prohibits the “take” of any threatened or endangered species. The term “take” under the ESA means “to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or attempt to engage in any such conduct.” The term “harm” was further defined to include “significant habitat modification or degradation where it actually kills or injures wildlife by significantly impairing essential behavioral patterns, including breeding, feeding or sheltering.” Designation of critical habitat areas has been established for the public knowledge where the publishing of such information would not cause harm to the species. Additional federal protection is extended to migratory birds, and bald and golden eagles under the Migratory Bird Treaty Act (MBTA) as amended, and the Bald and Golden Eagle Protection Act. Protection is also afforded to Texas state-listed species. The Texas Parks and Wildlife Department (TPWD) enforces the state regulations.

The MBTA protects most bird species, including, but not limited to, cranes, ducks, geese, shorebirds, hawks, and songbirds. Migratory bird pathways, stopover habitats, wintering areas, and breeding areas may occur within and adjacent to the pipeline area, and may be associated with wetlands, ponds, shorelines, riparian corridors, fallow fields and grasslands, and woodland and forested areas. Pipeline construction activities could disturb migratory bird habitats and/or species’ activities.

Reasonable and prudent measures should be taken to avoid and minimize the potential effects of the proposed project's activities on threatened and endangered species as well as bald eagles. Species' locations, activities, and habitat requirements should be considered based on U.S. Fish and Wildlife Service (USFWS) and TPWD recommendations.

In Refugio and Victoria Counties there may occur 37 state-listed endangered or threatened species and 16 federally-listed endangered or threatened wildlife species, according to the county lists of rare species published by the TPWD. A list of these species, their preferred habitat and potential occurrence in the two county areas is provided in Table 4C.10-2.
Inclusion in Table 4C.10-2 does not imply that a species will occur within the project area, but only acknowledges the potential for occurrence in the project area counties. A more intensive field reconnaissance would be necessary to confirm and identify specific suitable habitat that may be present in the project area. In addition to the county lists, the Texas Natural Diversity Database (TXNDD) map data was also reviewed for known occurrences of listed species within or near the proposed project. This information indicated that there were reported sightings of the bald eagle (*Haliaeetus leucoephalus*), listed as a threatened species by the State within the pipeline route and in the surrounding area. No other specific sightings of any endangered or threatened species were documented near the pipeline route. Two plants that are species of concern have been documented within one mile of the pipeline corridor, the coastal gayfeather (*Liatris* bracteata), and Welder machaeranthera (*Psilactis heterocarpa*).

Five bird species federally or state listed as endangered are included in the project area. These include Attwater's greater prairie chicken (*Tympanuchus cupido attwateri*), brown pelican (*Pelecanus occidentalis*), northern aplomado falcon (*Falco femoralis septentrionalis*), interior least tern (*Sterna antillarum athalassos*), and whooping crane (*Grus americana*). While the Attwater's greater prairie chicken is a historic resident of the area, the northern aplomado falcon and the brown pelican are current residents. The brown pelican is listed as endangered by the state, but has recently been delisted by USFWS. The whooping crane and interior least tern are seasonal migrants which could pass through the project area. The main whooping crane flock nests in Canada and migrates annually to their wintering grounds in and around the Aransas National Wildlife Refuge near Rockport on the Texas coast. Whooping cranes occasionally utilize wetlands as an incidental rest stop during this migration. Habitat elements which are attractive to several of these bird species may be present on or adjacent to the proposed pipeline route or cooling reservoir.

**Table 4C.10-2.
Federal- and State-Listed Threatened, Endangered, and
Species of Concern Listed for Refugio and Victoria Counties**

Common Name	Scientific Name	Impact Value	Multiplier Based on Status	Adjusted Impact	Summary of Habitat Preference	Potential Occurrence in County	Federal Status	State Status
BIRDS								
Attwater's greater prairie-chicken	*Tympanuchus cupido attwateri*	*0*	*3*	*0*	Coastal Prairies of Gulf Coastal Plain	Endemic: within historic range	LE	E
Bald eagle	*Haliaeetus leucoephalus*	*1*	*2*	*2*	Large bodies of water with nearby resting sites	Nesting/Migrant	DL	T
Brown pelican	*Pelecanus occidentalis*	*1*	*3*	*3*	Coastal inlands for nesting, shallow gulf and bays for foraging	Resident	DL	E
Henslow's sparrow	*Ammodramus henslowii*	*1*	*1*	*1*	Wintering individuals found in weedy fields	Migrant	—	—
Interior least tern	*Sterna antillarum athalassos*	*1*	*3*	*3*	Inland river sandbars for nesting and shallow water for foraging	Nesting/Migrant	LE	E
Mountain plover	*Charadrius montanus*	*1*	*1*	*1*	Breeding, nesting on shortgrass prairie.	Resident	—	—
Northern Aplomado falcon	*Falco femoralis septentrionalis*	*1*	*3*	*3*	Found in open country especially in savanna and open woodland areas.	Resident	LE	E
Peregrine falcon	*Falco peregrinus anatum* (American)	0	2	0	Open county; cliffs	Nesting/Migrant	DL	T
	Falco peregrinus tundrius (Arctic)	0	1	0	Open county; cliffs	Nesting/Migrant	DL	—
Piping plover	*Charadrius melodus*	*1*	*2*	*2*	Beaches and flats of coastal Texas	Migrant	LT	T
Reddish egret	*Egretta rufescens*	*1*	*2*	*2*	Coastal inlands for nesting, coastal marshes for foraging	Resident	—	T

Table 4C.10-2 (Continued)

Common Name	Scientific Name	Impact Value	Multiplier Based on Status	Adjusted Impact	Summary of Habitat Preference	Potential Occurrence in County	Federal Status	State Status
Snowy plover	*Charadrius alexandrinus*	1	1	1	Potential migrant, wintering along the coast	Migrant	—	—
Sooty Tern	*Sterna fuscata*	1	2	2	Catches small fish as it hovers or flies over water	Resident	—	T
Western burrowing owl	*Athene cunicularia hypugaea*	1	1	1	Open grasslands, especially prairie.	Resident	—	—
White-faced ibis	*Plegadis chihi*	1	2	2	Prefers freshwater marshes	Resident	—	T
White-tailed hawk	*Buteo albicaudatus*	0	2	0	Coastal prairies, savannahs and marshes in Gulf Coastal Plain	Nesting/Migrant	—	T
Whooping crane	*Grus Americana*	1	3	3	Winters in coastal marshes	Migrant	LE	E
Wood stork	*Mycteria Americana*	1	2	2	Forages in prairie ponds, ditches and shallow standing water; formerly nested in Texas	Migrant	—	T
MAMMALS								
Louisiana black bear	*Ursus americanus luteolus*	0	2	0	Within historical range	Possible as transient in bottomland hardwoods and inaccessible forested areas	LT	T
Ocelot	*Leopardus pardalis*	1	3	3	Dense chaparral thickets; mesquite-thorn shrub and live oak stands.	Resident	LE	E
Plains spotted skunk	*Spilogale putorius interrupta*	1	1	1	Open fields, and prairies.	Resident	—	—
Red wolf	*Canis rufus*	0	3	0	Extirpated	Historic	LE	E
West Indian manatee	*Trichechus manatus*	0	3	0	Gulf and bay system; opportunistic, aquatic herbivore	Aquatic Resident	LE	E

Table 4C.10-2 (Continued)

Common Name	Scientific Name	Impact Value	Multiplier Based on Status	Adjusted Impact	Summary of Habitat Preference	Potential Occurrence in County	Federal Status	State Status
White-nosed coati	*Nasua narica*	1	2	2	Woodlands, riparian corridors and canyons	Transient	—	T
AMPHIBIANS								
Black-spotted newt	*Notophthalmus meridionalis*	1	2	2	Ponds and resacas in south Texas	Resident	—	T
Sheep frog	*Hypopachus variolosus*	1	2	2	Predominantly found in grassland and savannas; moist sites in arid areas	Resident	—	T
FISH								
American eel	*Anguilla rostrata*	1	1	1	Coastal waterways to Gulf.	Resident	—	—
Opossum pipefish	*Microphis brachyurus*	1	2	2	Brooding adults found in fresh or low salinity waters and young in more saline waters; Southern coastal areas	Aquatic Resident	—	T
Smalltooth sawfish	*Pristis pectinata*	1	3	3	Young sawfish are found very close to shore in muddy and sandy bottoms. Adults prefer various habitat types.	Aquatic Resident	LE	E
INSECTS								
A mayfly	*Tortopus circumfluus*	0	1	0	Adults found in shoreline vegetation.	Resident	—	—
Texas asaphomyian tabanid fly	*Asaphomyia texensis*	0	1	0	Globally historic, found near slow-moving water.	Historic Resident	—	—
MOLLUSKS								
Creeper	*Strophitus undulates*	1	1	1	Small to large streams.	Aquatic Resident	—	—
False spike mussel	*Quincuncina mitchelli*	1	2	2	Substrates of cobble and mud.	Aquatic Resident	—	T
Golden Orb	*Quadrula aurea*	1	2	2	Sand and gravel areas in river basins.	Aquatic Resident	—	T

Table 4C.10-2 (Continued)

Common Name	Scientific Name	Impact Value	Multiplier Based on Status	Adjusted Impact	Summary of Habitat Preference	Potential Occurrence in County	Federal Status	State Status
Pistolgrip	*Tritogonia verrucosa*	*1*	*1*	*1*	Stable substrate in river basins.	Aquatic Resident	—	—
Rock pocketbook	*Arcidens confragosus*	*1*	*1*	*1*	Substrates of medium to large rivers.	Aquatic Resident	—	—
Texas pimpleback	*Quadrula petrina*	*1*	*2*	*2*	Generally in areas with slow flow rates.	Aquatic Resident	—	T
REPTILES								
Atlantic hawksbill sea turtle	*Eretmochelys imbricate*	*0*	*3*	*0*	Gulf and bay systems; warm shallow waters in rocky marine environments.	Aquatic Resident	LE	E
Cagle's map turtle	*Graptemys caglei*	*1*	*2*	*2*	Endemic to Guadalupe River System	Resident	—	T
Green sea turtle	*Chelonia mydas*	*0*	*2*	*0*	Gulf and bay systems; shallow water seagrass beds	Aquatic Resident	LT	T
Gulf saltmarsh snake	*Nerodia clarkii*	*1*	*1*	*1*	Saline flats and river mouths	Resident	—	—
Indigo snake	*Drymarchon corais*	*1*	*2*	*2*	South of the Guadalupe River and Balcones Escarpment; mainly in dense riparian corridors	Resident	—	T
Kemp's Ridley sea turtle	*Lepidochelys kempii*	*0*	*3*	*0*	Gulf and bay systems; shallow waters of the Gulf of Mexico	Aquatic Resident	LE	E
Leatherback sea turtle	*Dermochelys coriacea*	*0*	*3*	*0*	Gulf and bay systems; forages in Gulf of Mexico	Aquatic Resident	LE	E
Loggerhead sea turtle	*Caretta caretta*	*0*	*2*	*0*	Gulf and bay systems for juveniles, adults prefer open waters	Aquatic Resident	LT	T
Spot-tailed earless lizard	*Holbrookia lacerate*	*1*	*1*	*1*	Open prairie-brushland.	Resident	—	—
Texas diamondback terrapin	*Malaclemys terrapin littoralis*	*1*	*1*	*1*	Coastal marshes and tidal flats.	Resident	—	—

Table 4C.10-2 (Continued)

Common Name	Scientific Name	Impact Value	Multiplier Based on Status	Adjusted Impact	Summary of Habitat Preference	Potential Occurrence in County	Federal Status	State Status
Texas horned lizard	*Phrynosoma cornutum*	1	2	2	Varied; sparsely vegetated uplands, grass, cactus, brush	Resident	—	T
Texas scarlet snake	*Cemophora coccinea lineri*	1	2	2	Mixed hardwood scrub on sandy soils	Resident	—	T
Texas tortoise	*Gopherus berlandieri*	1	2	2	Open brush with grass understory; open grass and bare ground avoided	Resident	—	T
Timber/Canebrake rattlesnake	*Crotalus horridus*	1	2	2	Floodplains, riparian zones with dense ground cover	Resident	—	T
PLANTS								
Black lace cactus	*Echinocereus reichenbachii* var. *albertii*	1	3	3	Endemic; grasslands, shrublands, and woodlands on coastal prairie	Resident	LE	E
Coastal gay-feather	*Liatris bracteata*	2	1	2	Endemic to black clay soils of prairie.	Resident	—	—
Elmendorf's onion	*Allium elmendorfii*	1	1	1	Endemic to grassland openings in woodlands	Resident	—	—
Plains gumweed	*Grindelia oolepis*	1	1	1	Coastal prairies on heavy clay soils.	Resident	—	—
Shinner's sunflower	*Helianthus occidentalis ssp plantagineus.*	1	1	1	Prairies on the Coastal Plain.	Resident	—	—
Tharp's rhododon	*Rhododon angulatus*	1	1	1	Deep sandy soils among dunes.	Resident	—	—
Three-flower broomweed	*Thurovia triflora*	1	1	1	Endemic, remnant grasslands and tidal flats	Resident	—	—

Table 4C.10-2 (Concluded)

Common Name	Scientific Name	Impact Value	Multiplier Based on Status	Adjusted Impact	Summary of Habitat Preference	Potential Occurrence in County	Federal Status	State Status
Welder machaeranthera	*Psilactis heterocarpa*	2	1	2	Endemic to grasslands and adjacent scrub flats.	Resident	—	—

Source: TPWD, Annotated County List of Rare Species, Refugio County, revised December 18, 2009 and Victoria County revised December 18, 2009.
DL Delisted
PDL Proposed for Delisting
LE Federally listed endangered
LT Federally listed threatened
--- Not Federally Listed
E State Endangered
T State Threatened

Avian species in the area which are federally or state listed as threatened include the peregrine falcon (*Falco peregrinus*), sooty tern (*Sterna fuscata*), white-faced ibis (*Plegadis chihi*), white-tailed hawk (*Buteo albicaudatus*), wood stork (*Mycteria Americana*), piping plover (*Charadrius melodus*), and bald eagle (*Haliaeetus leucocephalus*). The peregrine falcon includes two subspecies which migrate across the state from more northern breeding areas in the U.S. and Canada to winter along the coast. The majority of nesting bald eagle pairs currently reported are found along major rivers and near reservoirs in Texas. Bald eagles are opportunistic predators, feeding primarily on fish captured in the shallow water of both lakes and streams or scavenged food sources. These birds may utilize tall trees near perennial water as roosting or nesting sites. Bald eagles occur as migrants within south Texas. The remaining bird species excluding the white-tailed hawk prefer marshy or wet habitats.

Two mammal species, the ocelot (*Leopardus pardalis*) which is a federal and state listed endangered species, and the white-nosed coati (*Nasua narica*), a state threatened species, may occur within wooded areas which are found primarily along riparian corridors within the project area.

Reptile species which are state listed as threatened within the area include the Texas tortoise (*Gopherus berlandieri*), Indigo snake (*Drymarchon corais*), Cagle's map turtle (*Graptemys caglei*), Texas scarlet snake (*Cemophora coccinea lineri*), timber/canebrake rattlesnake (*Crotalus horridus*), and the Texas horned lizard (*Phrynosoma cornutum*). Cagle's map turtle is endemic to the Guadalupe River system. The indigo snake is normally found within riparian habitats while the Texas scarlet snake prefers areas of mixed hardwood scrub on sandy soils. Although suitable habitat for the state threatened Texas horned lizard may exist within the project area, no impact to this species is anticipated due to the abundance of similar habit near the project area and this species' ability to relocate to those areas if necessary. The Timber/Canebrake Rattlesnake may be found in the riparian woody vegetation of the area. The Texas tortoise prefers areas of open brush with grass understories. Destruction of the potential habitats for these species can be minimized by selecting a corridor through previously disturbed areas, such as croplands.

The only plant listed as endangered or threatened is the black lace cactus which is documented in Refugio County. This species prefers grasslands, shrub lands, and woodlands within coastal prairie areas.

After a review of the habitat requirements for each listed species, it is anticipated that this project will have no adverse effect on any federally listed threatened or endangered species, its habitat, or designated habitat, nor would it adversely affect any state endangered species. The presence or absence of potential habitat within an area does not confirm the presence or absence of a listed species. No species specific surveys were conducted in the project area for this report.

Potential wetland impacts are expected to primarily include pipeline river and stream crossings, which can be minimized by right-of-way selection and appropriate construction methods, including erosion controls and revegetation procedures. The pipeline will be bored under its crossing of the San Antonio River, thereby reducing any probable impacts to that major water source. Compensation for net losses of wetland would be required where impacts are unavoidable.

A review of the Texas Historical Commission Texas Historic Sites Atlas data base indicated that there are no historical markers, National Register Properties or cemeteries listed near the river diversion pipeline route or within the boundary of the Exelon cooling reservoir site.

Archeological site records from the Texas Historical Commission's (THC) restricted Texas Archeological Sites Atlas indicates that there are no recorded archeological sites found near the river diversion pipeline route. Although no sites have been recorded within the pipeline route project area, this does not mean that sites are not present. Site records were not reviewed for the cooling reservoir at the Exelon power plant site.

4C.10.3.2 Canal Diversion Option

Construction of the river diversion pipeline, improvements to the existing GBRA Calhoun Canal System, expansion of the main pump station, installation of a new pump station on the Main Canal adjacent to the existing GBRA Relift#1 Pump Station, and the cooling reservoir at the Exelon power plant are the primary environmental issues related to this option. The approximately 18-mile canal diversion option pipeline for water delivery from the GBRA Calhoun Canal System to the proposed Exelon site is located near the city of Bloomington in southern coastal Texas, within Calhoun and Victoria Counties. This 90-inch diameter pipeline originates approximately 13-miles southeast of Bloomington and runs in a northwesterly direction, primarily through agricultural areas, with a portion of the route paralleling State Highway 185. Water crossings within this section of the route include Black Bayou and a tributary of Black Bayou. The pipeline then turns to the northwest about two miles northeast of Bloomington and follows the Victoria-Calhoun County line, crossing the Victoria Barge Canal and the Guadalupe River, and terminating at the proposed cooling reservoir on the Exelon power plant site. Landuse within the lower portions of the route include marshy and more heavily vegetated floodplain areas near the canal and river.

The project area is located in the Gulf Coastal Plains of Texas Physiographic Province, specifically in the subprovince of the Coastal Prairies.[5] This area is locally characterized as a nearly flat prairie which terminates at the Gulf of Mexico, and includes topography changes of less than 1 foot per mile. Elevation levels in the project area range from 0 to 100 feet above mean sea level.

The canal diversion option is located within the Gulf Prairies and Marshes Vegetational Area.[6] Gulf Prairies have slow surface drainage and elevations that range from sea level to 250 feet. These areas include nearly level and virtually undissected plains. Originally, the Gulf Prairies were composed of tallgrass prairie and post oak savannah. However, tree species such as honey mesquite, and acacia, along with other trees and shrubs, have increased in this area forming dense thickets in many places. Typical oak species found in this area include live oak (*Quercus virginiana*) and post oak (*Q. stellata*), in addition to huisache (*Acacia smallii*), blackbrush (*A. rigidula*), and a dwarf shrub, bushy sea-ox-eye (*Borrichia frutescens*). Principal

[5] Bureau of Economic Geology. 1996. Physiographic map of Texas., The University of Texas at Austin, Austin, Texas.
[6] Gould, F. W., 1975. "The Grasses of Texas," Texas A&M University Press, College Station, Texas.

climax grasses of the Gulf Prairies include gulf cordgrass (*Spartina spartinae*), indiangrass (*Sorghastrum nutans*), and big bluestem (*Andropogon gerardii* var. *gerardii*). Prickleypear (*Opunita* spp.) are common within this area along with forbs including asters (*Aster* spp.), poppy mallows (*Callirhoe* sp.), bluebonnets (*Lupinus* spp.), and evening primroses (*Oenothera* sp.). Gulf Marshes range from sea level to a few feet in elevation, and include low, wet marshy coast areas commonly covered with saline water. These salty areas support numerous species of sedges (*Carex* and *Cyperus* sp.), bulrushes (*Scirpus* sp.), rushes (*Juncus* sp.), and grasses. Aquatic forbs found in these areas generally include pepperweeds (*Lepidium* sp.), smartweeds (*Polygonum* sp.), cattails (*Typha domingensis*) and spiderworts (*Tradescantia* sp.) among others. Upland game and waterfowl find these low marshy areas to be excellent natural wildlife habitat.

The federal Endangered Species Act (ESA) of 1973, as amended, prohibits the "take" of any threatened or endangered species. The term "take" under the ESA means "to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or attempt to engage in any such conduct." The term "harm" was further defined to include "significant habitat modification or degradation where it actually kills or injures wildlife by significantly impairing essential behavioral patterns, including breeding, feeding or sheltering." Designation of critical habitat areas has been established for the public knowledge where the publishing of such information would not cause harm to the species. Additional federal protection is extended to migratory birds, and bald and golden eagles under the Migratory Bird Treaty Act (MBTA) as amended, and the Bald and Golden Eagle Protection Act. Protection is also afforded to Texas state-listed species. The TPWD enforces state regulations concerning this act.

The MBTA protects most bird species, including, but not limited to, cranes, ducks, geese, shorebirds, hawks, and songbirds. Migratory bird pathways, stopover habitats, wintering areas, and breeding areas may occur within and adjacent to the pipeline area, and may be associated with wetlands, ponds, shorelines, riparian corridors, fallow fields and grasslands, and woodland and forested areas. Pipeline construction activities could disturb migratory bird habitats and/or species' activities.

Reasonable and prudent measures should be taken to avoid and minimize the potential effects of proposed project activities on threatened and endangered species as well as bald eagles. Species' locations, activities, and habitat requirements should be considered based on USFWS and TPWD recommendations.

In Calhoun and Victoria Counties, 38 state-listed endangered or threatened species and 17 federally-listed endangered or threatened wildlife species may occur, according to the county lists of rare species published by TPWD. Two of the species listed as endangered are considered extinct in Texas, the Eskimo curlew (*Numenius borealis*), and red wolf (*Canis rufus*). A list of species, their preferred habitat, and potential occurrence in the two county areas is provided in Table 4C.10-3.

Inclusion in Table 4C.10-3 does not imply that a species will occur within the project area, but only acknowledges the potential for occurrence in the project area counties. A more intensive field reconnaissance is necessary to confirm and identify specific suitable habitat that may be present in the project area. In addition to county lists, the Texas Natural Diversity Database (TXNDD) map data has been reviewed for known occurrences of listed species within or near the proposed pipeline route. This information indicates that there are reported sightings of the bald eagle (*Haliaeetus leucoephalus*) along the pipeline route and in the surrounding area. No other specific sightings of any endangered or threatened species were documented along the pipeline route. A plant species of concern, the three-flower broomweed (*Thurovia triflora*) has been recorded north of the proposed pipeline. A documented rookery with a nesting colony of olivaceous cormorants and cattle egrets occurs in a cypress swamp south of the Guadalupe River crossing.

Five bird species federally or state listed as endangered are included in the project area. The Eskimo curlew (*Numenius borealis*) is extinct, but was once a historic resident of this area. The four active endangered bird species include the Attwater's greater prairie chicken (*Tympanuchus cupido attwateri*), brown pelican (*Pelecanus occidentalis*), northern aplomado falcon (*Falco femoralis septentrionalis*), interior least tern (*Sterna antillarum athalassos*), and whooping crane (*Grus americana*). While the Attwater's greater prairie chicken is a historic resident of the area, the northern aplomado falcon and the brown pelican are current residents. The brown pelican is listed as endangered by the state, but has recently been delisted by USFWS. The whooping crane and interior least tern are seasonal migrants which could pass through the project area. The main whooping crane flock nests in Canada and migrates annually to their wintering grounds in and around the Aransas National Wildlife Refuge near Rockport on the Texas coast. Whooping cranes occasionally utilize wetlands as an incidental rest stop during this migration. Habitat elements which are attractive to several of these bird species may be present on or adjacent to the proposed pipeline route or cooling reservoir.

Table 4C.10-3.
Federal- and State-Listed Threatened, Endangered, and Species of Concern Listed for Calhoun and Victoria Counties

Common Name	Scientific Name	Impact Value	Multiplier Based on Status	Adjusted Impact	Summary of Habitat Preference	Potential Occurrence in County	Federal Status	State Status
				BIRDS				
Attwater's greater prairie-chicken	*Tympanuchus cupido attwateri*	0	3	0	Coastal Prairies of Gulf Coastal Plain	Endemic: within historic range	LE	E
Bald eagle	*Haliaeetus leucoephalus*	1	2	2	Large bodies of water with nearby resting sites	Nesting/Migrant	DL	T
Brown pelican	*Pelecanus occidentalis*	1	3	3	Coastal inlands for nesting, shallow gulf and bays for foraging	Resident	DL	E
Eskimo curlew	*Numenius borealis*	0	3	0	Historic, nonbreeding in grasslands and pastures.	Historic Resident	LE	E
Henslow's sparrow	*Ammodramus henslowii*	1	1	1	Wintering individuals found in weedy fields	Migrant	—	—
Interior least tern	*Sterna antillarum athalassos*	1	3	3	Inland river sandbars for nesting and shallow water for foraging	Nesting/Migrant	LE	E
Mountain plover	*Charadrius montanus*	1	1	1	Breeding, nesting on shortgrass prairie.	Resident	—	—
Northern Aplomado falcon	*Falco femoralis septentrionalis*	1	3	3	Found in open country especially in savanna and open woodland areas.	Resident	LE	E
Peregrine falcon	*Falco peregrinus anatum* (American)	0	2	0	Open county; cliffs	Nesting/Migrant	DL	T
	Falco peregrinus tundrius (Arctic)	0	1	0	Open county; cliffs	Nesting/Migrant	DL	—
Piping plover	*Charadrius melodus*	1	2	2	Beaches and flats of coastal Texas	Migrant	LT	T
Reddish egret	*Egretta rufescens*	1	2	2	Coastal inlands for nesting, coastal marshes for foraging	Resident	—	T
Snowy plover	*Charadrius alexandrinus*	1	1	1	Potential migrant, wintering along the coast	Migrant	—	—
Sooty tern	*Sterna fuscata*	1	2	2	Catches small fish as it hovers or flies over water	Resident	—	T

Table 4C.10-3 (Continued)

Common Name	Scientific Name	Impact Value	Multiplier Based on Status	Adjusted Impact	Summary of Habitat Preference	Potential Occurrence in County	Federal Status	State Status
Southeastern snowy plover	*Charadrius alexandrines tenuirostris*	0	1	0	Wintering migrant along the Texas Gulf Coast.	Migrant	—	—
Western burrowing owl	*Athene cunicularia hypugaea*	1	1	1	Open grasslands, especially prairie.	Resident	—	—
Western Snowy Plover	*Charadrius alexandrines nivosus*	0	1	0	Potential migrant, wintering along the coast.	Migrant	—	—
White-faced ibis	*Plegadis chihi*	1	2	2	Prefers freshwater marshes	Resident	—	T
White-tailed hawk	*Buteo albicaudatus*	0	2	0	Coastal prairies, savannahs and marshes in Gulf Coastal Plain	Nesting/Migrant	—	T
Whooping crane	*Grus Americana*	1	3	3	Winters in coastal marshes	Migrant	LE	E
Wood stork	*Mycteria Americana*	1	2	2	Forages in prairie ponds, ditches and shallow standing water; formerly nested in Texas	Migrant	—	T
				MAMMALS				
Black bear	*Ursus americanus*	0	2	0	Found in bottomland hardwoods and large tracts of inaccessible forested areas.	Transient	T/SA;NL	T
Jaguarundi	*Herpailurus yaguarondi*	1	3	3	Favors thick brushlands near water.	Resident	LE	E
Louisiana black bear	*Ursus americanus luteolus*	0	2	0	Within historical range	Possible as transient in bottomland hardwoods and inaccessible forested areas	LT	T
Ocelot	*Leopardus pardalis*	1	3	3	Dense chaparral thickets; mesquite-thorn shrub and live oak stands.	Resident	LE	E
Plains spotted skunk	*Spilogale putorius interrupta*	1	1	1	Open fields, and prairies.	Resident	—	—
Red wolf	*Canis rufus*	0	3	0	Extirpated	Historic	LE	E
West Indian manatee	*Trichechus manatus*	0	3	0	Gulf and bay system; opportunistic, aquatic herbivore	Aquatic Resident	LE	E
White-nosed coati	*Nasua narica*	1	2	2	Woodlands, riparian corridors and canyons	Transient	—	T

Table 4C.10-3 (Continued)

Common Name	Scientific Name	Impact Value	Multiplier Based on Status	Adjusted Impact	Summary of Habitat Preference	Potential Occurrence in County	Federal Status	State Status
AMPHIBIANS								
Black-spotted newt	*Notophthalmus meridionalis*	1	2	2	Ponds and resacas in south Texas	Resident	—	T
Sheep frog	*Hypopachus variolosus*	1	2	2	Predominantly found in grassland and savannas; moist sites in arid areas	Resident	—	T
FISH								
American eel	*Anguilla rostrata*	1	1	1	Coastal waterways to Gulf.	Resident	—	—
Opossum pipefish	*Microphis brachyurus*	1	2	2	Brooding adults found in fresh or low salinity waters and young in more saline waters; Southern coastal areas	Aquatic Resident	—	T
Smalltooth sawfish	*Pristis pectinata*	1	3	3	Young sawfish are found very close to shore in muddy and sandy bottoms. Adults prefer various habitat types.	Aquatic Resident	LE	E
INSECTS								
A mayfly	*Tortopus circumfluus*	0	1	0	Adults found in shoreline vegetation.	Resident	—	—
Texas asaphomyian tabanid fly	*Asaphomyia texensis*	0	1	0	Globally historic, found near slow-moving water.	Historic Resident	—	—
MOLLUSKS								
Creeper	*Strophitus undulates*	1	1	1	Small to large streams.	Aquatic Resident	—	—
False spike mussel	*Quincuncina mitchelli*	1	2	2	Substrates of cobble and mud.	Aquatic Resident	—	T*
Golden Orb	*Quadrula aurea*	1	2	2	Sand and gravel areas in river basins.	Aquatic Resident	—	T*
Pistolgrip	*Tritogonia verrucosa*	1	1	1	Stable substrate in river basins.	Aquatic Resident	—	—
Rock pocketbook	*Arcidens confragosus*	1	1	1	Substrates of medium to large rivers.	Aquatic Resident	—	—
Texas pimpleback	*Quadrula petrina*	1	2	2	Generally in areas with slow flow rates.	Aquatic Resident	—	T*
REPTILES								
Atlantic hawksbill sea turtle	*Eretmochelys imbricate*	0	3	0	Gulf and bay systems; warm shallow waters in rocky marine environments.	Aquatic Resident	LE	E

Table 4C.10-3 (Continued)

Common Name	Scientific Name	Impact Value	Multiplier Based on Status	Adjusted Impact	Summary of Habitat Preference	Potential Occurrence in County	Federal Status	State Status
Cagle's map turtle	*Graptemys caglei*	*1*	*2*	*2*	Endemic to Guadalupe River System	Resident	—	T
Green sea turtle	*Chelonia mydas*	*0*	*2*	*0*	Gulf and bay systems; shallow water seagrass beds	Aquatic Resident	LT	T
Gulf saltmarsh snake	*Nerodia clarkii*	*1*	*1*	*1*	Saline flats and river mouths	Resident	—	—
Kemp's Ridley sea turtle	*Lepidochelys kempii*	*0*	*3*	*0*	Gulf and bay systems; shallow waters of the Gulf of Mexico	Aquatic Resident	LE	E
Leatherback sea turtle	*Dermochelys coriacea*	*0*	*3*	*0*	Gulf and bay systems; forages in Gulf of Mexico	Aquatic Resident	LE	E
Loggerhead sea turtle	*Caretta caretta*	*0*	*2*	*0*	Gulf and bay systems for juveniles, adults prefer open waters	Aquatic Resident	LT	T
Texas diamondback terrapin	*Malaclemys terrapin littoralis*	*1*	*1*	*1*	Coastal marshes and tidal flats.	Resident	—	—
Texas horned lizard	*Phrynosoma cornutum*	*1*	*2*	*2*	Varied; sparsely vegetated uplands, grass, cactus, brush	Resident	—	T
Texas scarlet snake	*Cemophora coccinea lineri*	*1*	*2*	*2*	Mixed hardwood scrub on sandy soils	Resident	—	T
Texas tortoise	*Gopherus berlandieri*	*1*	*2*	*2*	Open bush with grass understory; open grass and bare ground avoided	Resident	—	T
Timber/Canebrake rattlesnake	*Crotalus horridus*	*1*	*2*	*2*	Floodplains, riparian zones with dense ground cover	Resident	—	T
PLANTS								
Shinner's sunflower	*Helianthus occidentalis ssp plantagineus.*	*1*	*1*	*1*	Prairies on the Coastal Plain.	Resident	—	—
Three-flower broomweed	*Thurovia triflora*	*1*	*1*	*1*	Endemic, remnant grasslands and tidal flats	Resident	—	—

Table 4C.10-3 (Concluded)

Common Name	Scientific Name	Impact Value	Multiplier Based on Status	Adjusted Impact	Summary of Habitat Preference	Potential Occurrence in County	Federal Status	State Status
Welder machaeranthera	*Psilactis heterocarpa*	2	1	2	Endemic to grasslands and adjacent scrub flats.	Resident	—	—

Source: TPWD, Annotated County List of Rare Species, Calhoun County, December 18, 2009 and Victoria County December 18, 2009.
DL Delisted
PDL Proposed for Delisting
LE Federally listed endangered
LT Federally listed threatened
T/SA Threatened by similarity of appearance
--- Not Federally Listed
E State Endangered
T State Threatened
T* In process of being designated as state Threatened.

Avian species in the area which are federally or state listed as threatened include the peregrine falcon (*Falco peregrinus*), reddish egret (*Egretta rufescens*), sooty tern (*Sterna fuscata*), white-faced ibis (*Plegadis chihi*), white-tailed hawk (*Buteo albicaudatus*), wood stork (*Mycteria Americana*), piping plover (*Charadrius melodus*), and bald eagle (*Haliaeetus leucocephalus*). The peregrine falcon includes two subspecies which migrate across the state from more northern breeding areas in the U.S. and Canada to winter along the coast. The majority of nesting bald eagle pairs currently reported are found along major rivers and near reservoirs in Texas. Bald eagles are opportunistic predators, feeding primarily on fish captured in the shallow water of both lakes and streams or scavenged food sources. These birds may utilize tall trees near perennial water as roosting or nesting sites. Bald eagles occur as migrants within south Texas. The remaining bird species excluding the white-tailed hawk prefer marshy or wet habitats.

Three mammal species, the jaguarundi (*Herpailurus yaguarondi*) and ocelot (*Leopardus pardalis*) which are both federal and state listed endangered species, and the white-nosed coati (*Nasua narica*), a state threatened species, may occur within brushy or wooded areas which are found primarily along riparian corridors within the project area.

Reptile species which are state listed as threatened within the area include the Texas tortoise (*Gopherus berlandieri*), Cagle's map turtle (*Graptemys caglei*), Texas scarlet snake (*Cemophora coccinea lineri*), timber/canebrake rattlesnake (*Crotalus horridus*), and the Texas horned lizard (*Phrynosoma cornutum*). Cagle's map turtle is endemic to the Guadalupe River system. The Texas scarlet snake is normally found in areas of mixed hardwood scrub on sandy soils. Although suitable habitat for the state threatened Texas horned lizard may exist within the project area, no impact to this species is anticipated due to the abundance of similar habit near the project area and this species' ability to relocate to those areas if necessary. The Timber/Canebrake rattlesnake may be found in the riparian woody vegetation of the area. The Texas tortoise prefers areas of open brush with grass understories. Destruction of potential habitats for these species can be minimized by selecting a corridor through previously disturbed areas, such as croplands.

Potential wetland impacts are expected to primarily include pipeline river and stream crossings, which can be minimized by right-of-way selection and appropriate construction methods, including erosion controls and revegetation procedures. The pipeline will be bored under its crossings of the Victoria Barge Canal and Guadalupe River, thereby reducing any probable impacts to these water sources. Compensation for net losses of wetland would be required where impacts are unavoidable.

A review of the Texas Historical Commission Texas Historic Sites Atlas data base indicates that there are no historical markers, National Register Properties, or cemeteries listed along the proposed canal diversion pipeline route or within the boundary of the Exelon cooling reservoir site.

Archeological site records from the Texas Historical Commission's (THC) restricted Texas Archeological Sites Atlas indicate that there is one recorded site along the pipeline route on the Green Lake Quad near West Coloma Creek. This site, according to site descriptions provided, does not occur within 150 feet of the project area. However, there are additional sites recorded within 0.31 miles of the proposed pipeline route, especially on the Green Lake Quad. Site records were not reviewed for the cooling reservoir at the Exelon power plant site.

4C.10.4 Engineering and Costing

Major facilities required to implement the river diversion option include:

- New 121 MGD pump station at the Guadalupe River near the GBRA Saltwater Barrier;
- Diversion canal from the Guadalupe River to the pump station;
- 11-miles of 90-inch transmission pipeline, including two borings; and
- 101,300 acft cooling pond on the Exelon site.

Major facilities required to implement the canal diversion option include:

- Gravity conveyance system improvements;

- Expansion of the Main Pump Station;
- New 121 MGD pump station on the Main Canal adjacent to the existing GBRA Relift#1 Pump Station;
- 18-miles of 90-inch transmission pipeline, including two borings; and
- 101,300 acft cooling pond on the Exelon site.

The estimated costs of the two GBRA-Exelon Project river diversion and canal diversion WMS options are presented in Tables 4C.10-4 and 4C.10-5, respectively, in September 2008 dollars. The estimated total project cost, which includes contingencies, is $280,598,000 for the river diversion option and $353,091,000 for the canal diversion option. With total annual costs of $31,711,000 and $38,421,000 (September 2008 dollars) and an available project yield of 49,126 acft/yr, the resulting unit cost is $646 per acft for the river diversion option and $782 per acft for the canal diversion option. The long-term, post-debt service cost of the project is $224 per acft for the river diversion option and $232 per acft for the canal diversion option.

4C.10.5 Implementation Issues

Institutional arrangements may be needed to implement the project.

1. It will be necessary to obtain the following:
    a. Combined Operating License from Nuclear Regulatory Commission;
    b. Final Water Supply Agreement with GBRA;
    c. TCEQ Storage Permits;
    d. USCE Sections 10 and 404 Dredge and Fill Permits for the reservoir and pipelines;
    e. GLO Sand and Gravel Removal permits;
    f. GLO Easement for use of state-owned land;
    g. Coastal Coordination Council review; and
    h. TPWD Sand, Gravel, and Marl permit.
2. Permitting may require these studies:
    a. Assessment of changes in freshwater inflows to bays and estuaries;
    b. Habitat mitigation plan;
    c. Environmental studies; and
    d. Cultural resource studies and mitigation.

Table 4C.10-4.
Cost Estimate Summary for GBRA-Exelon Project - River Diversion

Item	Estimated Costs for Facilities
Capital Costs	
Diversion Canal, Intake, and Pump Station (120.9 MGD)	$15,233,000
Transmission Pipeline (90 in dia., 11 miles)	$55,025,000
Off-Channel Storage (Conservation Pool 101,300 acft, 4,938 acres, 90.5 ft. msl)	$103,000,000
Total Capital Cost	**$173,258,000**
Engineering, Legal Costs and Contingencies	$57,889,000
Environmental & Archaeology Studies and Mitigation	$14,096,000
Land Acquisition and Surveying (4,991 acres)	$14,570,000
Interest During Construction (2 years)	$20,785,000
Total Project Cost	**$280,598,000**
Annual Costs	
Debt Service (6 percent, 20 years)	$8,744,000
Reservoir Debt Service (6 percent, 40 years)	$11,983,000
Operation and Maintenance	
Intake, Pipeline, Pump Station	$891,000
Dam and Reservoir	$1,545,000
Pumping Energy Costs (11,643,600 kW-hr @ 0.09 $/kW-hr)	$1,048,000
Purchase of Water (75,000 acft/yr @ 100 $/acft)	$7,500,000
Total Annual Cost	**$31,711,000**
Available Project Yield (acft/yr)	49,126
Annual Cost of Water ($ per acft)	$646
Annual Cost of Water ($ per 1,000 gallons)	$1.98

Table 4C.10-5.
Cost Estimate Summary for GBRA-Exelon Project - Canal Diversion

Item	Estimated Costs for Facilities
Capital Costs	
Main Pump Station Upgrades	$11,033,000
Canal Upgrades	$2,795,000
Intake and Pump Station (120.9 MGD)	$15,358,000
Transmission Pipeline (90 in dia., 18 miles)	$91,751,000
Off-Channel Storage (Conservation Pool 101,300 acft, 4,938 acres, 90.5 ft-msl)	$103,000,000
Total Capital Cost	**$223,937,000**
Engineering, Legal Costs and Contingencies	$73,790,000
Environmental & Archaeology Studies and Mitigation	$14,286,000
Land Acquisition and Surveying (5,028 acres)	$14,923,000
Interest During Construction (2 years)	$26,155,000
Total Project Cost	**$353,091,000**
Annual Costs	
Debt Service (6 percent, 20 years)	$15,064,000
Reservoir Debt Service (6 percent, 40 years)	$11,983,000
Operation and Maintenance	
Intake, Pipeline, Pump Station	$1,412,000
Dam and Reservoir	$1,545,000
Pumping Energy Costs (10,194,043 kW-hr @ 0.09 $/kW-hr)	$917,000
Purchase of Water (75,000 acft/yr @ 100 $/acft)	$7,500,000
Total Annual Cost	**$38,421,000**
Available Project Yield (acft/yr)	49,126
Annual Cost of Water ($ per acft)	$782
Annual Cost of Water ($ per 1,000 gallons)	$2.40

3. Land will need to be acquired through either negotiations or condemnation.
4. Relocations for the off-channel storage facilities may include:
    a. County roads;
    b. Other utilities;
    c. Product transmission pipelines; and
    d. Power transmission lines.

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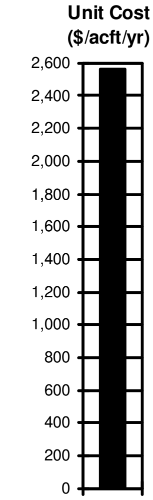
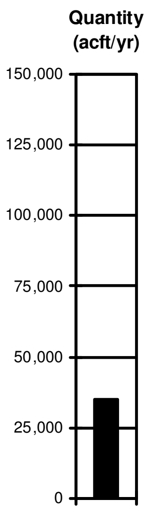
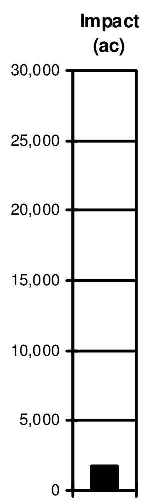
2011 South Central Texas Regional Water Plan
Water Management Strategy Summary Sheet







Name: Lower Guadalupe Water Supply Project for Upstream GBRA Needs at Reduced Capacity

Description: The project includes the diversion of underutilized surface water from the Guadalupe-Blanco River Authority (GBRA) Calhoun Canal System water rights to portions of Caldwell, Hays, Guadalupe, Comal, and Kendall Counties. Facilities include a 70 cfs canal intake and pump station; a 3-mile, 48-inch diameter diversion pipeline from the Canal System to a 16,500 acft off-channel reservoir in Calhoun County; a 160-mile transmission pipeline from the reservoir to the northwest delivery points, including a 48 inch, 112 mile transmission pipeline to Luling; a 42 inch, 27 mile transmission pipeline to Lake Dunlap; a 33 inch, 6 mile transmission pipeline to New Braunfels; and a 20 inch, 15 mile transmission pipeline to Western Canyon Project. The SCTRWPG has developed the following statement with regard to the LGWSP for Upstream GBRA Needs and environmental flows:

> *"As part of the development and implementation of the Lower Guadalupe Water Supply Project for Upstream GBRA needs, the Guadalupe-Blanco River Authority recognizes and supports the need to address inflow amounts necessary to protect and preserve a healthy ecosystem in the San Antonio Bay - Guadalupe Estuary system in conjunction with the development of water supplies to meet human water needs. The specifics of the inflow requirements will be determined through the state-mandated Senate Bill 3 environmental flows process which is intended to 1) determine the water needs of the environment based on science and other factors such as future changes in projected human needs, 2) reserve from new surface water appropriation, water needed for the environment as established in the environmental flows process and 3) encourage voluntary efforts to provide water for the environment from existing water rights.*
>
> *The Guadalupe-Blanco River Authority will work with Region L participants and other public and private water rights holders in the basin toward the development of a voluntary strategy to promote environmental stewardship and provide for the prudent management of the water and environmental resources of the San Antonio and Guadalupe Rivers and the San Antonio Bay-Guadalupe Estuary system within the framework of existing and future surface water rights, as well as existing and future alternative sources of supply. Any effort to develop a voluntary strategy will recognize and work in concert with the environmental flows process set out in Senate Bill 3."*

***Decade Needed*:** 2010 – 2020

Cost, Quantity of Water, and Land Impacted

Unit Cost of Water:	**$2,565**	**$/acft/yr**	**Treated Water Delivered**
Quantity of Water:	**35,000**	**acft/yr**	**Reliability = Firm**
Land Impacted:	**1,688**	**acres**	

Additional Considerations per Regional Water Planning Guidelines

Environmental Factors:

Wintering population of endangered Whooping Cranes at Aransas National Wildlife Refuge located adjacent to Lower San Antonio Bay.

Impacts on Water Resources:

Some reductions in freshwater inflows to the Guadalupe Estuary associated with greater utilization of existing water rights.

Impacts on Agricultural & Natural Resources:

Minimal, if any.

Other Relevant Factors per SCTRWPG:

Encourages beneficial use of available rights. Protects instream flows and recreational opportunities through lower basin diversion. If fresh groundwater from the lower Guadalupe Basin is added to this strategy, then the plan must be amended in order for the modified strategy to be recommended for implementation.

Lower Guadalupe Water Supply Project for Upstream GBRA Needs (cont'd)

Comparison of Strategies to Meet Needs:

No conflicts with other recommended water management strategies.

Interbasin Transfer Issues:

Since this specific strategy is intended to serve water user groups within the GBRA district, no inter-basin transfer issues are anticipated.

Third-Party Impacts of Voluntary Transfers:

None anticipated.

Regional Efficiency:

Provides long-term water supplies through out the GBRA statutory district.

Water Quality Considerations:

The off-channel reservoir will aid in suspending river diversions to avoid poor water quality during flood events and facilitate maintenance of diversion facilities without stopping reservoir deliveries.

4C.11 Lower Guadalupe Water Supply Project (LGWSP) for Upstream GBRA Needs at Reduced Capacity

4C.11.1 Description of Water Management Strategy

The Lower Guadalupe Water Supply Project (LGWSP) for Upstream GBRA Needs at Reduced Capacity water management strategy presented herein involves the diversion of up to 60,000 acft/yr of presently underutilized surface water rights from the Guadalupe-Blanco River Authority (GBRA) Calhoun Canal System. If fresh groundwater from the lower Guadalupe River Basin is added to this strategy, its character would be changed and an amendment process would be required for it to become a recommended strategy in the 2011 Regional Water Plan. The project includes a 3-mile diversion pipeline from the Canal System to an off-channel reservoir, from which transmission pipeline segments totaling 160 miles in length would deliver raw water to treatment plants at Luling, Lake Dunlap and/or San Marcos, New Braunfels, and the Western Canyon Project (Figure 4C.11-1). Treated water is then integrated into the municipal water supply systems of present and future GBRA customers.

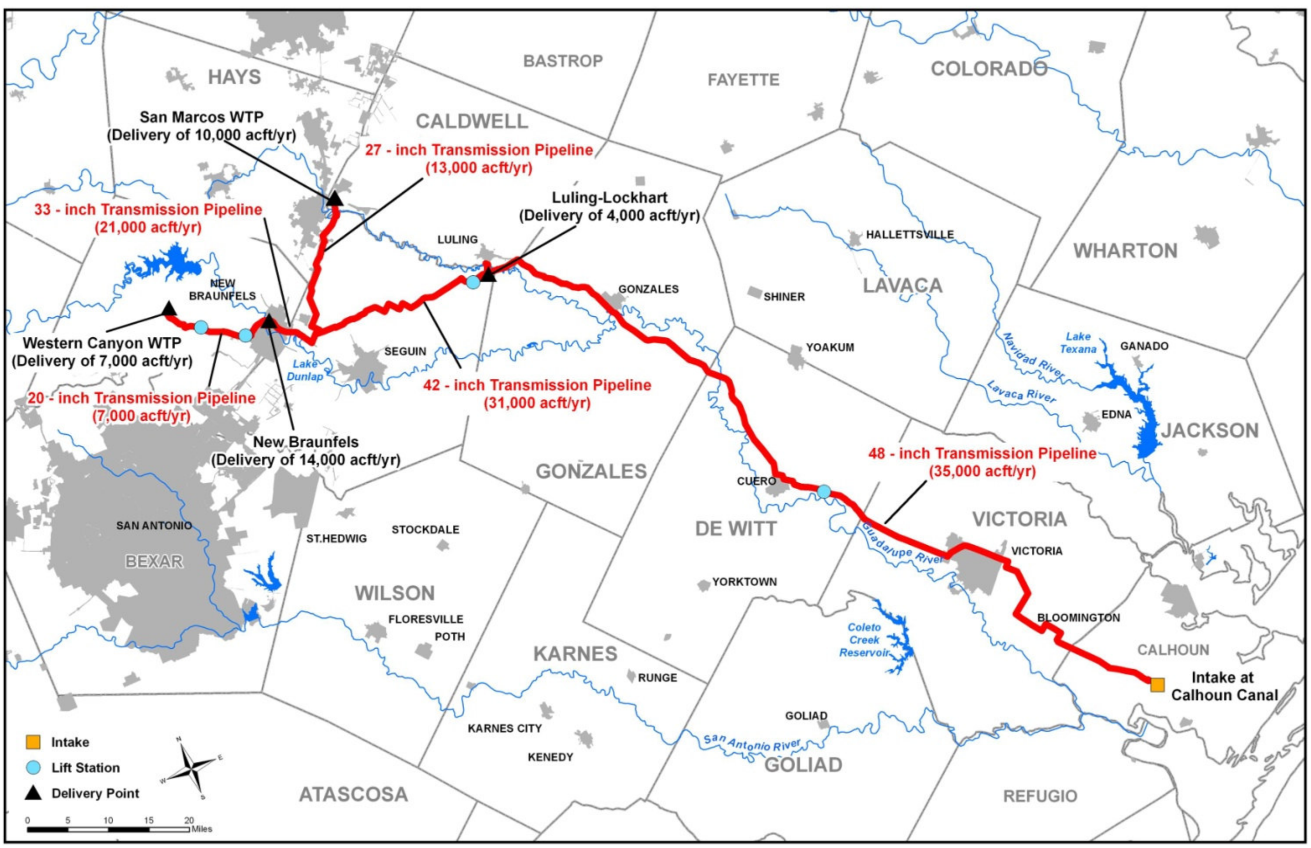


Figure 4C.11-1. LGWSP for Upstream GBRA Needs — Location Map

The GBRA lower basin water rights total 175,501 acft/yr and represent about 30 percent of all surface water rights in the Guadalupe-San Antonio River Basin authorized for consumptive use. A majority of these rights are jointly held with the Dow Chemical Company/Union Carbide Corporation. These GBRA water rights are quite reliable, as the upstream watershed encompasses approximately 10,128 square miles and includes the two largest springs in Texas. In addition, substantial volumes of treated effluent are discharged upstream of the proposed diversion point. In all years, there is unappropriated streamflow passing the Guadalupe River Saltwater Barrier and entering the Guadalupe Estuary. However, junior portions of the GBRA rights committed to the LGWSP may not be "firm" (i.e., 100 percent reliable) during each month of a repeat of the most severe drought on record. Hence, this strategy includes off-channel storage facilities that serve to "firm-up" (increase the reliability of) run-of-river diversions to be used for municipal and industrial purposes.

The water management strategy presented herein differs from the one presented in the 2006 South Central Texas Regional Water Plan (SCTRWP) adopted January 19, 2006 in that it was formulated in response to legislation set forth in HB 3776 of the 80th Texas Legislature. A sub-section of HB 3776 includes provisions for approving the 2006 SCTRWP so long as the LGWSP for Upstream GBRA Needs (at Reduced Capacity) water management strategy is revised to include the following conditions:

1. Include a transmission pipeline for the diversion of up to 60,000 acre-feet per year of surface water available under water rights held by the Guadalupe-Blanco River Authority as of December 31, 2006;
2. At least 100,000 acre-feet per year of surface water must be reserved for lower basin needs;
3. Prohibit use of fresh groundwater for the project;
4. Require the consent of appropriate property owner(s) before off-channel storage or an off-channel reservoir may be developed as part of the project; and
5. Require freshwater inflows in an amount sufficient to meet the Texas Parks and Wildlife Department, Texas Commission on Environmental Quality, and Texas Water Development Board's environmental consensus criteria for San Antonio Bay to be identified and included in the project.

Interpretation of the language in HB 3776 has been debated, as the bill references only the 2006 SCTRWP, and not any future Regional Water Plans. The South Central Texas Regional

Water Planning Group (SCTRWPG) has evaluated the LGWSP for Upstream GBRA Needs to ensure that long-term, reliable, and renewable surface water supplies will be available throughout the GBRA statutory district. Furthermore, the SCTRWPG has developed the following statement with regard to the LGWSP for Upstream GBRA Needs and environmental flows:

> *"As part of the development and implementation of the Lower Guadalupe Water Supply Project for Upstream GBRA needs, the Guadalupe-Blanco River Authority recognizes and supports the need to address inflow amounts necessary to protect and preserve a healthy ecosystem in the San Antonio Bay - Guadalupe Estuary system in conjunction with the development of water supplies to meet human water needs. The specifics of the inflow requirements will be determined through the state-mandated Senate Bill 3 environmental flows process which is intended to 1) determine the water needs of the environment based on science and other factors such as future changes in projected human needs, 2) reserve from new surface water appropriation, water needed for the environment as established in the environmental flows process and 3) encourage voluntary efforts to provide water for the environment from existing water rights.*
>
> *The Guadalupe-Blanco River Authority will work with Region L participants and other public and private water rights holders in the basin toward the development of a voluntary strategy to promote environmental stewardship and provide for the prudent management of the water and environmental resources of the San Antonio and Guadalupe Rivers and the San Antonio Bay-Guadalupe Estuary system within the framework of existing and future surface water rights, as well as existing and future alternative sources of supply. Any effort to develop a voluntary strategy will recognize and work in concert with the environmental flows process set out in Senate Bill 3."*

The LGWSP for Upstream GBRA Needs at Reduced Capacity, as defined by the SCTRWPG, is described below:

1. Modeling Assumptions:
   a. Diversion of up to 60,000 acft/yr under GBRA water rights per the Certificates of Adjudication;
   b. Edwards Aquifer pumpage consistent with SB3 (80^{th} Texas Legislature);
   c. Off-channel storage as necessary;
   d. No use of fresh groundwater supplies; and
   e. Delivery amount of 35,000 acft/yr.
2. Cost Estimate Assumptions:
   a. Diversion pump station at existing GBRA Relift #1 Pump Station site on Calhoun Canal System;
   b. Off-channel storage in Lower Basin;
   c. Transmission through GBRA District and delivery to Luling, Lake Dunlap, New Braunfels, and the Western Canyon Project in the amounts shown Figure 4C.11-2; and
   d. Treatment and integration facilities.

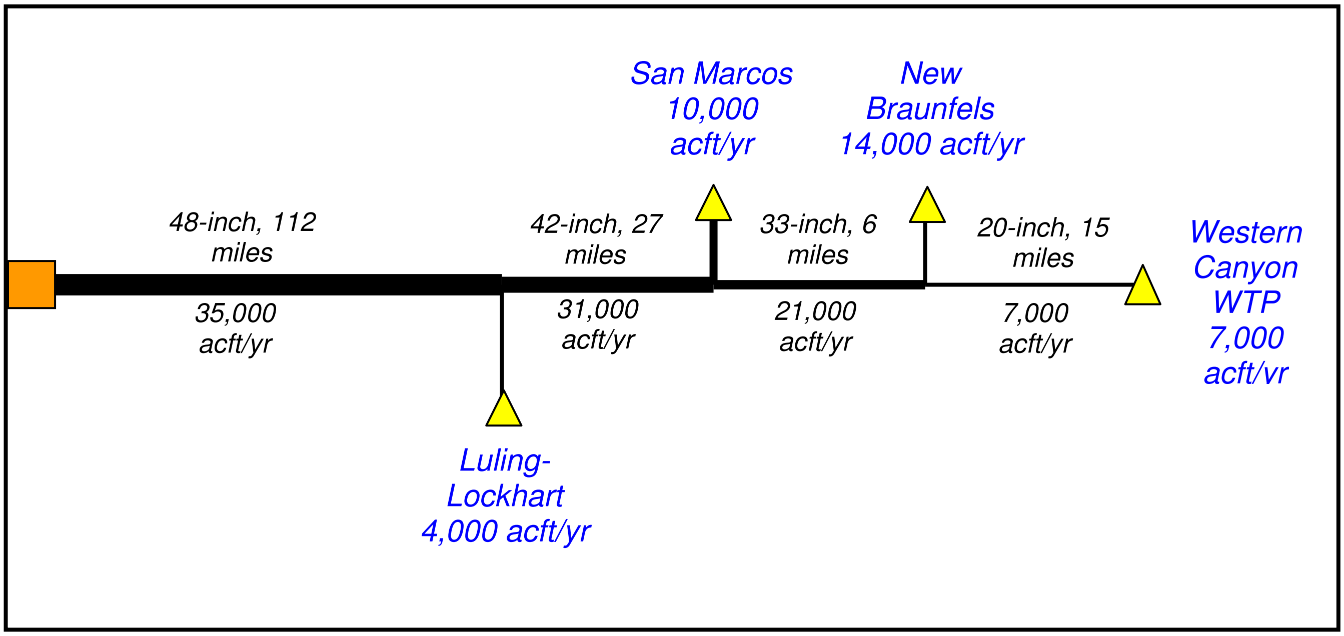


Figure 4C.11-2. LGWSP for Upstream GBRA Needs at Reduced Capacity — Schematic of Delivery Amounts

Inclusion of off-channel storage has certain operational advantages in addition to increasing firm water availability. These advantages include the capability of suspending river diversions to avoid poor water quality during flood events and/or facilitate maintenance of diversion facilities without curtailing deliveries from the reservoir. Off-channel storage will not be developed as part of this project without the consent of affected property owners.

4C.11.2 Water Availability

The Guadalupe River Saltwater Barrier was constructed in the early 1960s at a location immediately downstream of the San Antonio River confluence and creates a reservoir pool extending some distance up both rivers. Diversions from this reservoir pool, under existing rights, flow into GBRA's Calhoun Canal System and are dependent upon waters originating in both the Guadalupe and San Antonio Rivers and their respective tributaries. Since the end users of the LGWSP for Upstream GBRA Needs at Reduced Capacity are customers within the 10-county GBRA statutory district and part of each of the 10 counties is within the Guadalupe River Basin, this version of the LGWSP is not subject to many provisions of Section 11.085 of the Texas Water Code regarding inter-basin transfers.

Maximum reported water use under the GBRA lower basin water rights totaling 175,501 acft/yr at the Guadalupe River Saltwater Barrier did not exceed 63,000 acft/yr during the 1991 through 2006 historical period[1]. It is estimated by GBRA that up to 75,000 acft/yr under one or more of these rights is available for periods of time into the future leaving 100,000 acft/yr available for lower basin uses. Certificate of Adjudication (CA) #18-5178 is the least senior of GBRA's lower basin water rights and it has a priority date of January 7, 1952. Authorized annual diversions under CA# 18-5178 total 106,000 acft for municipal, industrial, and irrigation uses. Should the GBRA-Exelon WMS go forward and be included in the 2011 South Central Texas Regional Water Plan (SCTRWP), the full LGWSP for Upstream GBRA Needs (at 60,000 acft/yr) can not be included. However, it is possible to include this water management strategy (LGWSP for Upstream GBRA Needs at Reduced Capacity) as a recommended water management strategy in the 2011 SCTRWP along with the GBRA-Exelon WMS, should the planning group choose to do so.

The Guadalupe-San Antonio River Basin Water Availability Model (GSAWAM, as modified for regional water planning purposes) is used to quantify water available for diversion under CA# 18-5178. Hydrologic simulations and calculations are performed subject to the General Assumptions for Applications of Hydrologic Models, as adopted by the SCTRWPG for the 2011 Regional Water Plan. A maximum diversion rate of 70 cfs is used. A specifically-designed MS Excel model is then used to simulate off-channel storage operations, while meeting the 35,000 acft/yr delivery to GBRA customers. Results obtained using both the GSAWAM and the Excel model to evaluate the project are presented in the following paragraphs.

Application of the GSAWAM, with a period of record from January 1934 to December 1989, demonstrates that water availability from the Guadalupe River, via the Calhoun Canal System, is very reliable. Figure 4C.11-3 shows the water available for diversion of 60,000 acft/yr under the junior 75,000 acft/yr portion of CA# 18-5178 on an annual basis, limited only by a maximum diversion rate of 70 cfs (50,678 acft/yr). Actual diversions from the Guadalupe River to the off-channel reservoir are further limited by amounts necessary to keep the reservoir full. Subject to a uniform seasonal diversion pattern, the full monthly portion of 50,678 acft/yr is available in about 97 percent of the months simulated. Water available from the Calhoun Canal System was used in the Excel model to maintain storage in the off-channel storage facility sized to meet the specified 35,000 acft/yr delivery requirement.

[1] GBRA, Personal Communication, 2007.

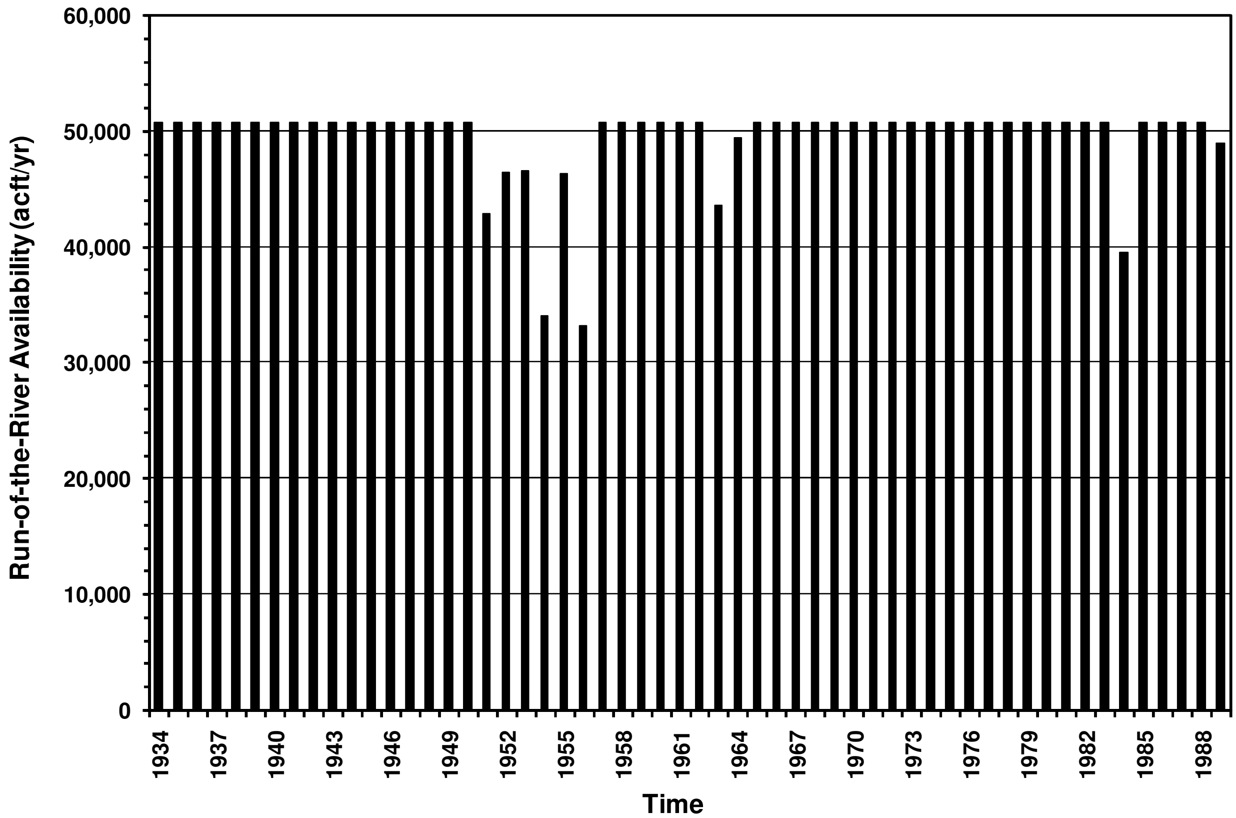


Figure 4C.11-3. Availability from Guadalupe River under Junior Portion of CA# 18-5178, Limited by Maximum Diversion Rate of 187 cfs

During relatively short periods during the 1934 – 1989 period of record, water is not available under CA# 18-5178, and diversions must be made from storage. It is assumed that the off-channel storage facility would be located in Calhoun County. Through an iterative process in the Excel model, it was determined that the storage necessary to sustain uniform delivery of 35,000 acft/yr is approximately 16,500 acft, based on a ring dike type structure limited to about 20-feet deep. An off-channel storage reservoir of this size would inundate approximately 825 acres. The long-term average net evaporative loss associated with a reservoir of this size in the lower Guadalupe River Basin is expected to be 1,870 acft/yr (5.3 percent of firm yield). The maximum annual diversion under CA# 18-5178 is 46,223 acft/yr in this project.

It is noted that GBRA could provide most, if not all, of the 35,000 acft/yr delivery amount using firm senior water rights, rather than the junior portion of CA# 18-5178. This project would substantially reduce or eliminate off-channel requirements, but would require occasional suspension of water rights used for irrigation.

4C.11.3 Environmental Issues

The LGWSP for Upstream GBRA Needs at Reduced Capacity includes a 3-mile diversion pipeline from the GBRA Calhoun Canal System to an off-channel storage facility in Calhoun County and a 160-mile long transmission pipeline from the off-channel storage facility to delivery points in the middle and upper Guadalupe River Basin. The transmission pipeline originates in Calhoun County and runs in a northwesterly direction through portions of Calhoun, Victoria, De Witt, Gonzales, Caldwell, Guadalupe, and Comal Counties.

A construction right-of-way approximately 140-feet wide would affect a total area of approximately 2,700 acres. The construction of the pipelines would include the clearing and removal of woody vegetation within and maintenance of a 40-foot wide right-of-way free of woody vegetation for the life of the project (1,943 acres of temporarily disturbed construction corridor).

The project area is located primarily in the Gulf Coastal Plains of Texas Physiographic Province. This area is locally characterized as a nearly flat prairie which terminates at the Gulf of Mexico, and includes topography changes of less than one foot per mile. Elevation levels in this area range from 0 to 300 feet above mean sea level. Vegetation types found within the pipeline corridor are primarily live oak and post oak woodlands, with crops as the second largest type and the remaining portions containing grasslands and urban areas.

The pipeline route encompasses four different vegetational areas, The Gulf Prairies and Marshes, Post Oak Savannah, Blackland Prairies, and Edwards Plateau. The portion of the pipeline route found within Calhoun County and the majority of Victoria County crosses the Gulf Prairies and Marshes Vegetational Area. Gulf Prairies have slow surface drainage and elevations that range from sea level to 250 feet. These areas include nearly level and virtually undissected plains. Originally the Gulf Prairies were composed of tallgrass prairie and post oak savannah. However, tree species such as honey mesquite and acacia, along with other trees and shrubs, have increased in this area, forming dense thickets in many places.

Typical oak species found in this area include live oak (*Quercus virginiana*) and post oak (Q. *stellata*), in addition to huisache (*Acacia smallii*), black-brush (*A. rigidula*), and a dwarf shrub, bushy sea-ox-eye (*Borrichia frutescens*). Principal climax grasses of the Gulf Prairies include gulf cordgrass (*Spartina spartinae*), indiangrass (*Sorghastrum nutans*), and big bluestem (*Andropogon gerardii var. gerardii*). Prickleypear (*Opunita*) are common within this area along with forbs including asters (*Aster*), poppy mallows (*Callirhoe*), bluebonnets (*Lupinus*), and evening primroses (*Oenothera*). Gulf Marshes range from sea level to a few feet in elevation, and include low, wet marshy coast areas commonly covered with saline water. These salty areas support numerous species of sedges (*Carex* and *Cyperus*), bulrushes (*Scirpus*), rushes (*Juncus*), and grasses. Aquatic forbs found in these areas generally include pepperweeds (*Lepidium*), smartweeds (*Polygonum*), cattails (*Typha domingensis*) and spiderworts (*Tradescantia*) among others. Upland game and waterfowl find these low marshy areas to be excellent natural wildlife habitat.

The Post Oak Savannah vegetational area of Texas includes portions of De Witt, Guadalupe, Gonzales, and Caldwell counties. The Post Oak Savannah refers to the gently rolling, moderately dissected, wooded plain that lies to the west of the Pineywoods in east-central Texas and intermingles with the Blackland Prairie in south-central Texas. The elevation in this area ranges from 300-800 feet. This vegetation area includes the entire Claypan land resource area of Texas, which is considered part of the Southern Coastal Plains. Vegetation is typified by post oak (*Quercus stellata*) and blackjack oak (*Quercus marilandica*) in association with tallgrasses. Dense thickets may occur within this area in the absence of fire or other methods of woody plant suppression. The Post Oak Savannah was extensively cultivated until the 1940's, but numerous acres have since been restored to native vegetation or converted to tame pastures.

In addition to post oak and blackjack oak, associated trees of the Post Oak Savannah include elms (*Ulmus* spp.), junipers (*Juniperus* spp.), hackberries (*Celtis* spp.), and hickories (*Carya* spp.). Understory vegetation includes shrubs such as yaupon (*Ilex vomitoria*), American beautyberry (*Callicarpa americana*), coralberry (*Symphoricarpos orbiculatus*), and vines such as greenbriars (*Smilax* spp.) and grapes (*Vitis* spp.). Common climax grasses include little bluestem (*Schizachyrium scoparium*), indiangrass (*Sorghastrum nutans*), switchgrass (*Panicum virgatum*), silver bluestem (*Bothriochloa laguroides*), Texas wintergrass (*Nassella leucotricha*), brownseed paspalum (*Paspalum plicatulum*) purpletop (*Tridens flavus*), narrow leaf woodoats (*Chasmanthium laxum*), and beaked panicum (*Panicum anceps*). Forbs occurring in the area include wild indigos (*Baptisia* spp.), indigobush (*Amorpha fruticosa*), sennas (*Senna* spp.), tickclovers (*Desmodium* spp.), lespedezas (*Lespedeza* spp.), prairie clovers (*Dalea* spp.), western ragweed (*Ambrosia psilostachya*), crotons (*Croton* spp.), and sneezeweeds (*Helenium* spp.).

The Blackland Prairies refers to rolling hills of well-dissected prairie in west-central Texas and represents the southern extension of the true prairie that occurs from Texas to Canada.

Portions of this type of vegetational area are included in De Witt, Guadalupe, Gonzales, Comal, and Caldwell counties. The region was once a tallgrass prairie dominated by little bluestem (*Schizachyrium scoparium*), big bluestem (*Andropogon gerardii*), indiangrass (Sorghastrum nutans), tall dropseed (*Sporobolus compositus*), and Silver dropseed (*Sporobolus silveanus*). Oaks (*Quercus* spp.), elms (*Ulmus* spp.), cottonwood (*Populus deltoides*), and native pecan (*Carya illinoinensis*) are common along streams in this region. About 98 percent of the Blackland Prairies were cultivated to produce crops such as cotton, corn, and wheat in the late 19th and early 20th centuries. Since the 1950s, the region has been increasingly used for pasture and forage crops for the production of livestock, and now only about 50 percent of the area is used as cropland.

The Edwards Plateau vegetational area occurs within the western portions of Comal and Hays counties. This area includes rapidly drained stony plains with broad flat divides. The original vegetation within this area was grassland or open savannah-type plains with most tree or brushy species found along rocky slopes and stream bottoms. The Edwards plateau is currently primarily rangeland with short grasses. Along rocky outcrops and protected areas with good soil moisture you will still find tallgrasses such as cane bluestem (*Bothriochloa barbinodis var. barbinodis*), indiangrass (*Sorghastrum nutans*), and switchgrass (*Panicum* spp.) Common woody species include live oak (*Quercus virginiana*), sand shin oak (*Quercus havardii*), mesquite (*Prosopis glandulosa*) and ashe juniper (*Juniperus ashei*).

In Calhoun, Victoria, De Witt, Guadalupe, Gonzales, Caldwell, and Comal Counties, 41 state-listed endangered or threatened species and 22 federally-listed endangered or threatened wildlife species, may occur according to the county lists of rare species published by Texas Parks and Wildlife Department (TPWD). A list of these species is provided in Table 4C.11-1.

Inclusion in Table 4C.11-1 does not imply that a species will occur within the study area, but only acknowledges the potential for occurrence in the study area counties. A more intensive field reconnaissance would be necessary to confirm and identify specific suitable habitat that may be present in the project area. In addition to county lists, HDR also reviewed Texas Natural Diversity Database (TXNDD) map data for known occurrences of listed species within or near the proposed pipeline route. This information indicated that there were reported sightings of Cagle's map turtle (*Graptemys caglei*), a state listed threatened species; the fountain darter fish (*Etheostoma fonticola*), listed by both the state and federal government as endangered; the

Table 4C.11-1
Important Species Having Habitat or Known to Occur in Calhoun, Caldwell, Comal, De Witt, Gonzales, Guadalupe and Victoria Counties

Common Name	Scientific Name	Summary of Habitat Preference	Listing Entity		Potential Occurrence in Counties
			USFWS[1]	TPWD[1]	
A mayfly	Campsurus decoloratus	TX and MX; possibly clay substrates;			Resident
A mayfly	Tortopus circumfluus	Generally found in shoreline vegetation			Resident
American Eel	*Anguilla rostrata*	Moist aquatic habitats			Resident
Atlantic Hawksbill Sea turtle	*Eretmochelys imbricata*	Gulf and bay systems	LE	E	Migrant
Attwater's Greater Prairie-chicken	*Tympanuchus cupido attwateri*	Endemic, open prairies and coastal plains	LE	E	Resident
Bald Eagle	*Haliaeetus leucocephalus*	Large bodies of water with nearby resting sites	DL	T	Nesting/ Migrant
Big red sage	*Salvia penstemonoides*	Endemic; moist to seasonally wet clay or silt soils in creek beds.			Resident
Black Bear	*Usus americanus*	Mountains, broken country, woods, brushlands, forests	T/SA; NL	T	Historic Resident
Black-capped Vireo	*Vireo atricapillus*	Semi-open broad-leaved shrublands	LE	E	Nesting/ Migrant
Black-Spotted Newt	*Notophthalmus meridionalis*	Ponds and resacas in south Texas		T	Resident
Blue sucker	Cycleptus elongatus	Larger portions of major rivers in Texas;		T	Resident
Bracted Twistflower	*Streptanthus bracteatus*	Endemic; Shallow clay soils over limestone; rocky slopes			Resident
Brown Pelican	*Pelecanus occidentalis*	Coastal inlands for nesting, shallow gulf and bays for foraging	LE	E	Nesting/ Migrant
Canyon mock-orange	*Philadelphus ernestii*	Endemic, outcrops of limestone			Resident
Cagle's map turtle	*Graptemys caglei*	Endemic; Guadalupe River System		T	Resident
Cascade Caverns salamander	*Eurycea latitans complex*	Endemic: subaquatic, springs and caves in Medina and Guadalupe River and Cibolo Creek Watersheds		T	Resident
Cave myotis bat	*Myotis velifer*	Colonial and cave-dwelling;			Resident
Comal Blind Salamander	*Eurycea tridentifera*	Endemic; Semi-troglobitic; Springs and waters of caves		T	Resident

Table 4C.11-1 (Continued)

Common Name	Scientific Name	Summary of Habitat Preference	Listing Entity		Potential Occurrence in Counties
			USFWS[1]	TPWD[1]	
Comal snakewood	*Colubria stricta*	Rock outcrops			Resident
Comal Springs diving beetle	*Comaldessus stygius*	Aquatic, at outflow at Comal Springs			Resident
Comal Springs dryopid beetle	*Stygoparnus comalensis*	Aquatic, cling to objects in streams	LE		Resident
Comal Springs riffle beetle	*Heterelmis comalensis*	Comal and San Marcos Springs	LE		Resident
Comal Springs salamander	*Eurycea* sp. 8	Endemic; Comal Springs			Resident
Creeper (squawfoot)	*Strophitus undulates*	Small to large streams			Resident
Edwards Aquifer diving beetle	*Haideoporus texanus*	Artesian well in Hays County			Resident
Edwards Plateau Spring Salamander	*Eurycea sp. 7*	Endemic; springs and waters of caves within region			Resident
Elmendorf's onion	*Allium elmendorfii*	Endemic, in deep sands			Resident
Eskimo curlew	*Numenius borealis*	Historic; grasslands, pastures	LE	E	Nonbreeding Historic Resident
Ezell's cave amphipod	*Stygobromus flagellatus*	Known from artesian wells			Resident
False spike mussel	*Quincuncina mitchelli*	Substrates of cobble and mud with water lilies present. Rio Grande, Brazos, Colorado and Guadalupe river basins.			Resident
Fountain darter	*Etheostoma fonticola*	Sam Marcos and Comal Rivers	LE	E	Resident
Golden-Cheeked Warbler	*Dendroica chrysoparia*	Woodlands with oaks and old juniper	LE	E	Nesting/ Migrant
Golden orb	*Quadrula aurea*	Sand and gravel, Guadalupe, San Antonio, and Nueces river basins			Resident
Green Sea Turtle	*Chelonia mydas*	Gulf and bay system.	LT	T	Migrant
Guadalupe bass	Micropterus treculii	Endemic to perennial streams of the Edward's Plateau region			Resident
Guadalupe darter	Percina sciera apristis	Guadalupe River basin; large streams and rivers			Resident
Gulf Saltmarsh Snake	Nerodia clarkii	Brackish to saline coastal waters			Resident
Henslow's Sparrow	*Ammodramus henslowii*	Weedy fields, cut over areas.			Nesting/ Migrant
Hill County wild-mercury	*Argythamnia aphoroides*	Shallow clays and limestone			Resident

Table 4C.11-1 (Continued)

Common Name	Scientific Name	Summary of Habitat Preference	Listing Entity		Potential Occurrence in Counties
			USFWS[1]	TPWD[1]	
Horseshoe liptooth snail	*Daedalochila hippocrepis*	Snal known only from Landa Park in New Braunfels			Resident
Jaguarundi	*Herpailurus yaguarondi*	South Texas thick brushlands, favors areas near water	LE	E	Resident
Kemp's Ridley Sea Turtle	*Lepidochelys kempii*	Gulf and bay system.	LE	E	Migrant
Leonora's dancer damselfly	Argia leonorae	South central and western Texas; small streams and seepages			Resident
Leatherback Sea Turtle	*Dermochelys coriacea*	Gulf and bay system.	LE	E	Migrant
Loggerhead Sea Turtle	*Caretta caretta*	Gulf and bay system.	LT	T	Migrant
Long-legged cave amphipod	*Stygobromus longipes*	Subaquatic obligate			Resident
Louisiana Black Bear	*Ursus americanus luteolus*	Within historical range.	LT	T	Historic Resident
Mountain Plover	*Charadrius montanus*	Non-breeding-shortgrass plains and fields, plowed fields and sandy deserts			Nesting/ Migrant
Ocelot	*Leopardus pardalis*	Dense chaparral thickets; mesquite-thorn scrub and live oak mottes	LE	E	Resident
Opossum Pipefish	*Microphis brachyurus*	Brooding adults found in fresh or low salinity waters.		T	Resident
Palmetto pill snail	Euchemotrema leai cheatumi	One known population, from moist palmetto woodlands of Palmetto State Park;			Resident
Park's jointweed	*Polygonella parksii*	Endemic; deep loose sands of Carrizo and similar Eocene formations.			Resident
Peck's cave amphipod	*Stygobromus pecki*	Aquatic crustacean, Comal Springs and Hueco Springs	LE	E	Resident
Peregrine falcon	*Falco peregrinus anatum (American)*	Open county; cliffs	DL	E	Nesting/ Migrant
	Falco peregrinus tundrius *(Arctic)*		DL	T	
Pistolgrip	*Tritogonia verrucosa*	Aquatic, stable substrate			Resident

Table 4C.11-1 (Continued)

Common Name	Scientific Name	Summary of Habitat Preference	Listing Entity		Potential Occurrence in Counties
			USFWS[1]	TPWD[1]	
Plains Spotted Skunk	*Spilogale putorius interrupta*	Prefers wooded, brushy areas and tallgrass prairie.			Resident
Rawson's metalmark	*Calephelis rawsoni*	Moist areas in limestone outcrops.			Resident
Red Wolf	*Canis rufus*	Extirpated	LE	E	Historic Resident
Reddish Egret	Egretta rufescens	Coastal inlands for nesting, coastal marshes for foraging		T	Migrant
Rock pocketbook	*Arcidens confragosus*	Mud and sand, Red through Guadalupe river basins			Resident
Sandhill woolywhite	*Hymenopappus carrizoanus*	Endemic; open areas in deep sands derived from Carrizo and similar Eocene formations			Resident
Sheep Frog	*Hypopachus variolosus*	Deep sandy soils of Southeast Texas		T	Resident
Shinner's sunflower	Helianthus occidentalis ssp plantagineus	Mostly in prairies on the Coastal Plain			Resident
Snowy Plover	*Charadrius alexandrinus*	Wintering Migrant on mud flats			Migrant
Sooty Tern	*Sterna fuscata*	Catches small fish		T	Resident
Southeastern Snowy Plover	*Charadrius alexandrinus tenuirostris*	Texas Gulf Coast beaches and bayside mud or salt flats			Wintering Migrant
Spot-tailed earless lizard	*Holbrookia lacerata*	Moderately open prairie-brushland			Resident
Texas asaphomyian tabanid fly	Asaphomyia texensis	Adults of tabanid spp. found near slow-moving water			Resident
Texas Diamondback Terrapin	*Malaclemys terrapin littoralis*	Bays, coastal marshes of the upper two-thirds of Texas Coast			Resident
Texas fatmucket	*Lampsilis bracteata*	Streams and rivers on sand, mud and gravel, Colorado and Guadalupe River basins			Resident
Texas Garter Snake	*Thamnophis sirtalis annectens*	Wet or moist microhabitats			Resident
Texas Horned Lizard	*Phrynosoma cornutum*	Varied, sparsely vegetated uplands, grass, cactus, brush		T	Resident
Texas mock-orange	*Philadelphus texensis*	Endemic, limestone cliffs and boulders			Resident

Table 4C.11-1 (Concluded)

Common Name	Scientific Name	Summary of Habitat Preference	Listing Entity		Potential Occurrence in Counties
			USFWS[1]	TPWD[1]	
Texas pimpleback	*Quadrula petrina*	Mud, gravel and sand substrates, Colorado and Guadalupe river basins			Resident
Texas Scarlet Snake	*Cemophora coccinea lineri*	Mixed hardwood scrub		T	Resident
Texas Tortoise	*Gopherus berlandieri*	Open brush w/ grass understory; open grass/bare ground avoided		T	Resident
Timber/Canebrake Rattlesnake	*Crotalus horridus*	Floodplains, upland pine, deciduous woodlands, riparian zones		T	Resident
Welder machaeranthera	*Psilactis heterocarpa*	Endemic, grasslands and adjacent scrub flats on clay			Resident
West Indian manatee	*Trichechus manatus*	Aquatic	LE	E	Resident
Timber/Canebrake Rattlesnake	*Crotalus horridus*	Floodplains, upland pine, deciduous woodlands, riparian zones		T	Resident
Western Burrowing Owl	*Athene cunicularia hypugaea*	Open grasslands, especially prairie, plains and savanna			Resident
Western Snowy Plover	*Charadrius alexandrinus nivosus*	Winters along coast			Migrant
White-faced Ibis	*Plegadis chihi*	Prefers freshwater marshes		T	Resident
White-nosed coati	*Nasua narica*	Woodlands, riparian corridors		T	Transient
White-tailed Hawk	*Buteo albicaudatus*	Coastal prairies, savannahs and marshes in Gulf coastal plain		T	Nesting/ Migrant
Whooping Crane	*Grus americana*	Potential migrant	LE	E	Migrant
Wood Stork	*Mycteria americana*	Forages in prairie ponds, ditches, and shallow standing water formerly nested in TX		T	Migrant
Zone-tailed Hawk	*Buteo albonotatus*	Arid open county near watercourse		T	Nesting/ Migrant

Source: TPWD, Annotated County List of Rare Species, Calhoun County, August 14, 2007, Victoria County November 20, 2007, De Witt County, November 20, 2007, Gonzales County August 8, 2007, Guadalupe County, August 8, 2007, and Caldwell County, November 20, 2007.
LE/LT=Federally Listed Endangered/Threatened
E/SA, T/SA=Federally Listed Endangered/Threatened by Similarity of Appearance
DL, PDL=Federally Delisted/Proposed for Delisting
E, T=State Listed Endangered/Threatened
Blank = Rare, but no regulatory listing status

Comal Springs dryopid beetle (*Stygoparnus comalensis*), which is federally listed as endangered; within a one mile radius of the pipeline area. Two rare species are also documented, the Guadalupe bass (*Micropterus teculii*) and the mountain plover (*Charadrius montanus*). The presence or absence of potential habitat within an area does not confirm the presence or absence of a listed species. No species specific surveys were conducted in the study area for this report.

Many migratory birds are dependent on estuarine environments like those located near Calhoun County in order to complete their foraging and nesting requirements during migration. One of the most well known of these migratory birds is the whooping crane (*Grus Americana*), which is listed as endangered by both United States Fish and Wildlife Service (USFWS) and TPWD. A growing population of whooping cranes winter in and near the Aransas National Wildlife Refuge, located adjacent to the Mesquite Bay and the southern and western portions of San Antonio Bay. This wintering population has grown from a low of only 16 birds in 1941 to a high of 257 birds in December 2007. Detailed research studies by Texas A&M University are underway at this time to identify and better understand factors affecting whooping crane population. Three other migratory birds known to the San Antonio Bay area are listed as threatened by TPWD: the reddish egret (*Egretta rufescens*), wood stork (*Mycteria Americana*), and piping plover (*Charadrius melodus*). The piping plover is also listed as threatened by USFWS.

Endangered and threatened species listed for Comal County include the Black-capped Vireo, Golden-cheeked Warbler, and four additional migratory bird species, two salamanders, an amphipod, and two beetles. Some care may be necessary should water pipelines traverse preferred habit for these endemic species. Black-capped Vireos are insectivorous songbirds that nest in low shrubland thickets where vegetation extends to ground level. Golden-cheeked Warblers prefer habitat consisting of mature oak-juniper woodlands located along steep escarpments and canyons. The listed invertebrate species (amphipod and beetles) are all endemic to karst features or springs, as is the Cascade Cavers salamander. The listed migratory bird species tend to avoid areas of concentrated human development.

Several species listed as threatened by the state may possibly be affected by the project. These include the Texas horned lizard (*Phrynosoma cornutum*), Texas scarlet snake (*Cemophora coccinea lineri*), Texas tortoise (*Gopherus berlandieri*), and timber/canebrake rattlesnake (*Crotalus horridus*). Many of these reptile species are dependent on shrubland or riparian habitat.

Habitat studies and surveys for protected species and cultural resources may need to be conducted at the proposed lift station sites and along any pipeline routes. Potential wetland impacts, which are limited to pipeline stream crossings, can be minimized by right-of-way selection and appropriate construction methods, including horizontal directional drilling, erosion controls, and revegetation procedures. Compensation for net losses of wetlands would be required where impacts are unavoidable.

All areas to be disturbed during construction would first be surveyed by qualified professionals to determine the presence or absence of significant cultural resources. Cultural resources protection on public lands in Texas is afforded by the Antiquities Code of Texas (Title 9, Chapter 191, Texas Natural Resource Code of 1977), the National Historic Preservation Act (Pl96-515), and the Archeological and Historic Preservation Act (PL93-291).

A specific site for the off-channel reservoir has not been chosen. In choosing a site, key considerations will include minimizing construction and long-term operations costs and minimizing conflicts with streams, highways/roadways, railroads, transmission facilities (water, product, and power), petroleum production, and environmental/cultural resources (e.g., endangered & threatened species habitat, wetlands, and historical/archaeological sites).

The LGWSP for Upstream GBRA Needs at Reduced Capacity relies on existing surface water rights and does not involve any new surface water appropriations. Therefore, freshwater inflows to the Guadalupe Estuary would be the same as the "full water rights use" baseline that is used when calculating surface water supply and evaluating the cumulative effects of regional water plan implementation. Thus graphics showing median inflow and flow frequency are not necessary, as the median values for both Baseline and Lower Guadalupe Water Supply Project for Upstream GBRA Needs at Reduced Capacity would be equal in all months.

4C.11.4 Engineering and Costing

The firm yield diversion from the off-channel reservoir used for costing purposes is assumed to be a uniform rate throughout the year. Major facilities required to implement this water management strategy include:

- Canal Intake and Pump Station;
- Transmission Pipeline to Off-Channel Storage;
- Off-Channel Storage;
- Reservoir Intake and Pump Station at Off-Channel Storage;

- Raw Water Transmission Pipeline to Luling;
- Raw Water Pipeline to Lake Dunlap;
- Raw Water Pipeline to New Braunfels;
- Raw Water Pipeline to Western Canyon Project;
- Transmission Lift Stations;
- New or Expanded Water Treatment Plants (Level 3) at Luling, near Lake Dunlap, near San Marcos, at New Braunfels, and at the Western Canyon Project;
- Treated or Raw Water Pipeline from Lake Dunlap to San Marcos; and
- Integration.

The canal intake and pump station are sized to deliver up to 70 cfs through a 3-mile, 48-inch diameter pipeline to an off-channel storage facility in Calhoun County. While a specific off-channel storage facility site has not been selected, it is assumed that an off-channel storage site could be located within three miles of the Calhoun Canal System.

It is important to note that, according to the 2011 Initially Prepared Plan (IPP), Year 2060 water needs in the upper and middle Guadalupe Basin total about 44,000 acft/yr. The estimated costs of the LGWSP for Upstream GBRA Needs at Reduced Capacity are presented in Table 4C.11-2, both in September 2008 dollars. The estimated total project cost, which includes contingencies, is $750,352,000. With a total annual cost of $89,778,000 and an available project yield of 35,000 acft/yr, the resulting unit cost is $2,565 per acft. The long-term, post-debt service cost of the project is $726 per acft.

Table 4C.11-2.
Cost Estimate Summary for Lower Guadalupe Water Supply Project for Upstream GBRA Needs at Reduced Capacity
September 2008 Prices

Item	Estimated Costs for Facilities
Capital Costs	
Canal Intake and Pump Station	$6,354,000
Transmission Pipeline to OCS (48 in dia., 3 miles)	$4,921,000
Off-Channel Storage Reservoir (Conservation Pool 16,500 acft, 825 acres, 20 ft. depth)	$32,906,000
Intake and Pump Station at OCS (45 MGD)	$15,777,000
Transmission Pipeline to Luling (48 in dia., 112 miles)	$199,480,000
Transmission Pipeline to Lake Dunlap (42 in dia., 27 miles)	$37,864,000
Transmission Pipeline to New Braunfels (33 in dia., 6 miles)	$6,572,000
Transmission Pipeline to Western Canyon Project (20 in dia., 15 miles)	$10,818,000
Transmission Booster Stations	$42,800,000
	-
Spur Pipeline to Luling WTP (16 in dia., 1 mile)	$446,000
Spur Pipeline to San Marcos WTP (27 in dia., 20 miles)	$13,986,000
Spur Pipeline to New Braunfels WTP (27 in dia., 1 mile)	$614,000
	-
Luling WTP Expansion (4 MGD)	$5,897,000
San Marcos WTP Expansion (11 MGD)	$12,119,000
New Braunfels WTP Expansion (14 MGD)	$15,723,000
Western Canyon WTP Expansion (6 MGD)	$6,387,000
Integration (31.2 MGD)	$41,441,000
Relocations & Other	$43,545,000
Total Capital Cost	**$497,650,000**
Engineering, Legal Costs and Contingencies	$158,265,000
Environmental & Archaeology Studies and Mitigation	$7,009,000
Land Acquisition and Surveying (1,688 acres)	$10,538,000
Interest During Construction (3 years)	$76,890,000
Total Project Cost	**$750,352,000**
Annual Costs	
Debt Service (6 percent, 20 years)	$60,968,000
Reservoir Debt Service (6 percent, 40 years)	$3,393,000
Operation and Maintenance	
Intake, Pipeline, Pump Station	$5,091,000
Dam and Reservoir	$494,000
Water Treatment Plant	$6,821,000
Pumping Energy Costs (106,045,082 kW-hr @ 0.09 $/kW-hr)	$9,544,000
Purchase of Water (46,223 acft/yr @ 75 $/acft)	$3,467,000
Total Annual Cost	**$89,778,000**
Available Project Yield (acft/yr)	35,000
Annual Cost of Water ($ per acft)	$2,565
Annual Cost of Water ($ per 1,000 gallons)	$7.87

4C.11.5 Implementation Issues

Institutional arrangements may be needed to implement the project, potentially including financing on a regional basis.

1. It will be necessary to obtain the following:
    a. TCEQ Storage Permits;
    b. USCE Sections 10 and 404 Dredge and Fill Permits for the reservoir and pipelines;
    c. GLO Sand and Gravel Removal permits;
    d. GLO Easement for use of state-owned land;
    e. Coastal Coordination Council review; and
    f. TPWD Sand, Gravel, and Marl permit.
2. Permitting may require these studies:
    a. Assessment of changes in freshwater inflows to bays and estuaries;
    b. Habitat mitigation plan;
    c. Environmental studies; and
    d. Cultural resource studies and mitigation.
3. Land will need to be acquired through either negotiations or condemnation.
4. Relocations for the off-channel storage facilities may include:
    a. County roads;
    b. Other utilities;
    c. Product transmission pipelines; and
    d. Power transmission lines.

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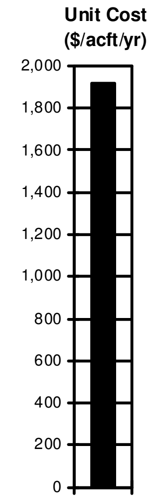
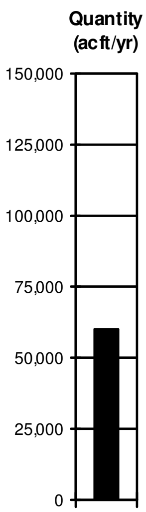
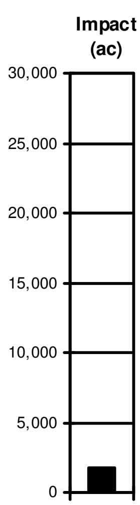
2011 South Central Texas Regional Water Plan
Water Management Strategy Summary Sheet







Name: Lower Guadalupe Water Supply Project for Upstream GBRA Needs

Description: The project includes the diversion of underutilized surface water from the Guadalupe-Blanco River Authority (GBRA) Calhoun Canal System water rights to portions of Caldwell, Hays, Guadalupe, Comal, and Kendall Counties. Facilities include a 187 cfs canal intake and pump station; a 3-mile, 96-inch diameter diversion pipeline from the Canal System to a 19,000 acft off-channel reservoir in Calhoun County; a 160-mile transmission pipeline from the reservoir to the northwest delivery points, including a 60 inch, 112 mile transmission pipeline to Luling; a 54 inch, 27 mile transmission pipeline to Lake Dunlap; a 33 inch, 6 mile transmission pipeline to New Braunfels; and a 20 inch, 15 mile transmission pipeline to Western Canyon Project. The SCTRWPG has developed the following statement with regard to the LGWSP for Upstream GBRA Needs and environmental flows:

> "*As part of the development and implementation of the Lower Guadalupe Water Supply Project for Upstream GBRA needs, the Guadalupe-Blanco River Authority recognizes and supports the need to address inflow amounts necessary to protect and preserve a healthy ecosystem in the San Antonio Bay - Guadalupe Estuary system in conjunction with the development of water supplies to meet human water needs. The specifics of the inflow requirements will be determined through the state-mandated Senate Bill 3 environmental flows process which is intended to 1) determine the water needs of the environment based on science and other factors such as future changes in projected human needs, 2) reserve from new surface water appropriation, water needed for the environment as established in the environmental flows process and 3) encourage voluntary efforts to provide water for the environment from existing water rights.*
>
> *The Guadalupe-Blanco River Authority will work with Region L participants and other public and private water rights holders in the basin toward the development of a voluntary strategy to promote environmental stewardship and provide for the prudent management of the water and environmental resources of the San Antonio and Guadalupe Rivers and the San Antonio Bay-Guadalupe Estuary system within the framework of existing and future surface water rights, as well as existing and future alternative sources of supply. Any effort to develop a voluntary strategy will recognize and work in concert with the environmental flows process set out in Senate Bill 3.*"

***Decade Needed*:** 2010 – 2020

Cost, Quantity of Water, and Land Impacted

Unit Cost of Water :	**$1,921**	**$/acft/yr**	**Treated Water Delivered**
Quantity of Water:	**60,000**	**acft/yr**	**Reliability = Firm**
Land Impacted:	**1,817**	**acres**	

Environmental Factors:

Wintering population of endangered Whooping Cranes at Aransas National Wildlife Refuge located adjacent to Lower San Antonio Bay.

Impacts on Water Resources:

Some reductions in freshwater inflows to the Guadalupe Estuary associated with greater utilization of existing water rights.

Impacts on Agricultural & Natural Resources:

Minimal, if any.

Lower Guadalupe Water Supply Project for Upstream GBRA Needs (cont'd)

Additional Considerations per Regional Water Planning Guidelines

Other Relevant Factors per SCTRWPG:

Project developed by SCTRWPG in association with GBRA (HB3776).

Project includes facilities for diversion of up to 75,000 acre-feet per year (below the City of Victoria) and transmission, treatment, and delivery of up to 60,000 acre-feet per year of surface water, provided however that at least 100,000 acre-feet per year of surface water must be reserved for lower basin needs (HB3776).

Project includes no use of fresh groundwater (HB3776).

Consent of affected property owners must be obtained before an off-channel reservoir may be developed as part of the project (HB3776).

GBRA and SCTRWPG have adopted language that recognizes and supports the need to address inflow amounts necessary to protect and preserve a healthy ecosystem in the San Antonio Bay - Guadalupe Estuary system in conjunction with the development of water supplies to meet human water needs (HB3776).

Project encourages beneficial use of available rights.

Project maintains instream flows and recreational opportunities throughout the basin through lower basin diversion.

If fresh groundwater from the lower Guadalupe Basin is added to this strategy, then the plan must be amended in order for the modified strategy to be recommended for implementation.

Comparison of Strategies to Meet Needs:

No conflicts with other recommended water management strategies.

Interbasin Transfer Issues:

Since this specific strategy is intended to serve water user groups within the GBRA district, no inter-basin transfer issues are anticipated.

Third-Party Impacts of Voluntary Transfers:

None anticipated.

Regional Efficiency:

Provides long-term water supplies through out the GBRA statutory district.

Water Quality Considerations:

The off-channel reservoir will aid in suspending river diversions to avoid poor water quality during flood events and facilitate maintenance of diversion facilities without stopping reservoir deliveries.

4C.12 Lower Guadalupe Water Supply Project (LGWSP) for Upstream GBRA Needs

4C.12.1 Description of Water Management Strategy

The Lower Guadalupe Water Supply Project (LGWSP) for Upstream GBRA Needs water management strategy presented herein involves the diversion of up to 75,000 acft/yr of presently underutilized surface water rights from the Guadalupe-Blanco River Authority (GBRA) Calhoun Canal System. If fresh groundwater from the lower Guadalupe River Basin is added to this strategy, its character would be changed and an amendment process would be required for it to become a recommended strategy in the 2011 Regional Water Plan. The project includes a 3-mile diversion pipeline from the Canal System to an off-channel reservoir, from which transmission pipeline segments totaling 160 miles in length would deliver raw water to treatment plants at Luling, Lake Dunlap and/or San Marcos, New Braunfels, and the Western Canyon Project (Figure 4C.12-1). Treated water is then integrated into the municipal water supply systems of present and future GBRA customers. To the extent that supplies in excess of those being used by GBRA's municipal customers are available, water supplies associated with this strategy may also be used to meet projected needs of GBRA's non-municipal customers. Such uses are deemed consistent with the 2006 SCTRWP if any necessary supplemental authorizations are obtained pursuant to Texas Commission on Environmental Quality (TCEQ) rules and applicable law.

The GBRA lower basin water rights total 175,501 acft/yr and represent about 30 percent of all surface water rights in the Guadalupe-San Antonio River Basin authorized for consumptive use. A majority of these rights are jointly held with the Dow Chemical Company/Union Carbide Corporation. These GBRA water rights are quite reliable, as the upstream watershed encompasses approximately 10,128 square miles and includes the two largest springs in Texas. In addition, substantial volumes of treated effluent are discharged upstream of the proposed diversion point. In all years, there is unappropriated streamflow passing the Guadalupe River Saltwater Barrier and entering the Guadalupe Estuary. However, junior portions of the GBRA rights committed to the LGWSP may not be "firm" (i.e., 100 percent reliable) during each month of a repeat of the most severe drought on record. Hence, this strategy includes off-channel storage facilities that serve to "firm-up" (increase the reliability of) run-of-river diversions to be used for municipal and industrial purposes.

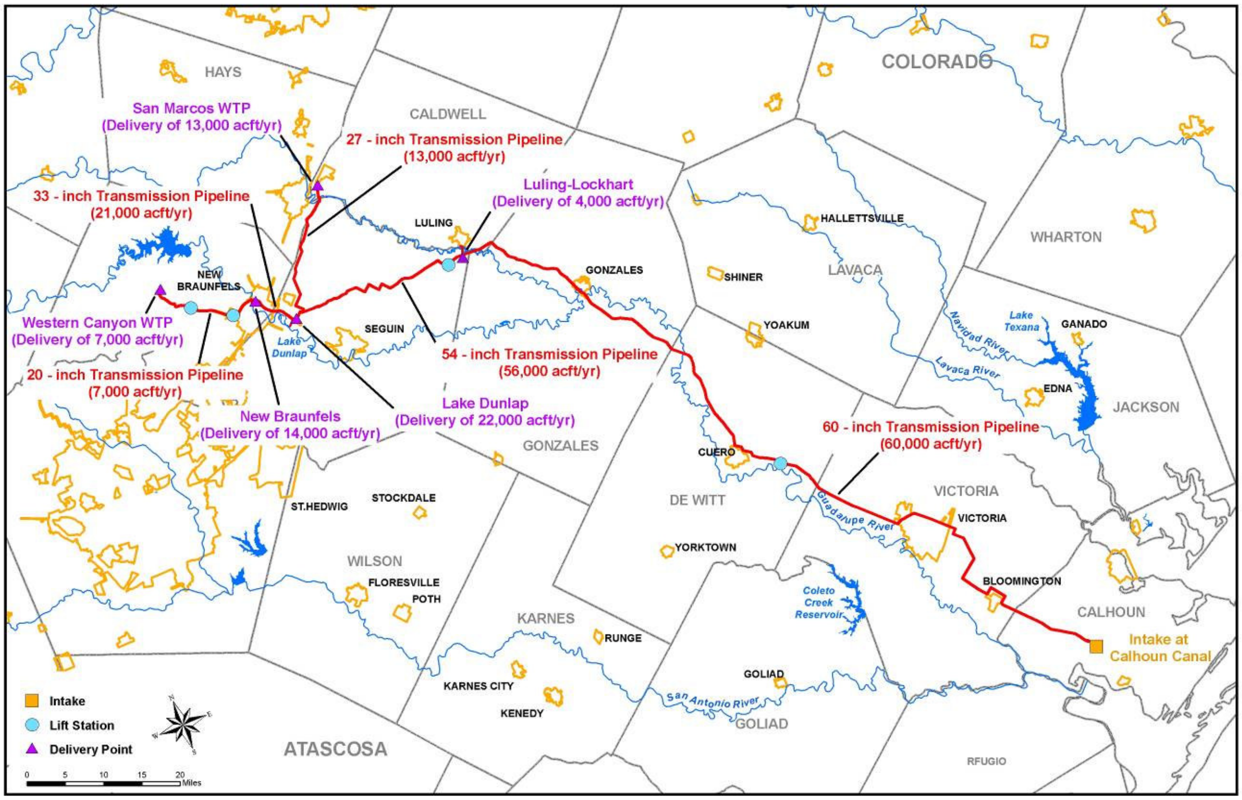


Figure 4C.12-1. LGWSP for Upstream GBRA Needs — Location Map

The water management strategy presented herein differs from the one presented in the 2006 South Central Texas Regional Water Plan (SCTRWP) adopted January 19, 2006 in that it was formulated in response to legislation set forth in HB 3776 of the 80th Texas Legislature. A sub-section of HB 3776 includes provisions for approving the 2006 SCTRWP so long as the LGWSP for Upstream GBRA Needs water management strategy is revised to include the following conditions:

1. Include a transmission pipeline for the diversion of up to 60,000 acre-feet per year of surface water available under water rights held by the Guadalupe-Blanco River Authority as of December 31, 2006;
2. At least 100,000 acre-feet per year of surface water must be reserved for lower basin needs;
3. Prohibit use of fresh groundwater for the project;
4. Require the consent of appropriate property owner(s) before off-channel storage or an off-channel reservoir may be developed as part of the project; and

5. Require freshwater inflows in an amount sufficient to meet the Texas Parks and Wildlife Department, Texas Commission on Environmental Quality, and Texas Water Development Board's environmental consensus criteria for San Antonio Bay to be identified and included in the project.

Interpretation of the language in HB 3776 has been debated, as the bill references only the 2006 SCTRWP, and not any future Regional Water Plans. The South Central Texas Regional Water Planning Group (SCTRWPG) has evaluated the LGWSP for Upstream GBRA Needs to ensure that long-term, reliable, and renewable surface water supplies will be available throughout the GBRA statutory district. Furthermore, the SCTRWPG has developed the following statement with regard to the LGWSP for Upstream GBRA Needs and environmental flows:

> *As part of the development and implementation of the Lower Guadalupe Water Supply Project for Upstream GBRA needs, the Guadalupe-Blanco River Authority recognizes and supports the need to address inflow amounts necessary to protect and preserve a healthy ecosystem in the San Antonio Bay - Guadalupe Estuary system in conjunction with the development of water supplies to meet human water needs. The specifics of the inflow requirements will be determined through the state-mandated Senate Bill 3 environmental flows process which is intended to 1) determine the water needs of the environment based on science and other factors such as future changes in projected human needs, 2) reserve from new surface water appropriation, water needed for the environment as established in the environmental flows process and 3) encourage voluntary efforts to provide water for the environment from existing water rights.*
>
> *The Guadalupe-Blanco River Authority will work with Region L participants and other public and private water rights holders in the basin toward the development of a voluntary strategy to promote environmental stewardship and provide for the prudent management of the water and environmental resources of the San Antonio and Guadalupe Rivers and the San Antonio Bay-Guadalupe Estuary system within the framework of existing and future surface water rights, as well as existing and future alternative sources of supply. Any effort to develop a voluntary strategy will recognize and work in concert with the environmental flows process set out in Senate Bill 3.*

The LGWSP for Upstream GBRA Needs, as defined by the SCTRWPG, is described below:

1. Modeling Assumptions:
   a. Diversion of up to 75,000 acft/yr under GBRA water rights per the Certificates of Adjudication.
   b. Edwards Aquifer pumpage consistent with SB3 (80^{th} Texas Legislature).
   c. Off-channel storage as necessary.
   d. No use of fresh groundwater supplies.
   e. Delivery amount of 60,000 acft/yr.

2. Cost Estimate Assumptions:
   a. Diversion pump station at existing GBRA Relift #1 Pump Station site on Calhoun Canal System.
   b. Off-channel storage in Lower Basin.
   c. Transmission through GBRA District and delivery to Luling, Lake Dunlap, New Braunfels, and the Western Canyon Project in the amounts shown Figure 4C.12-1.
   d. Treatment and integration facilities.

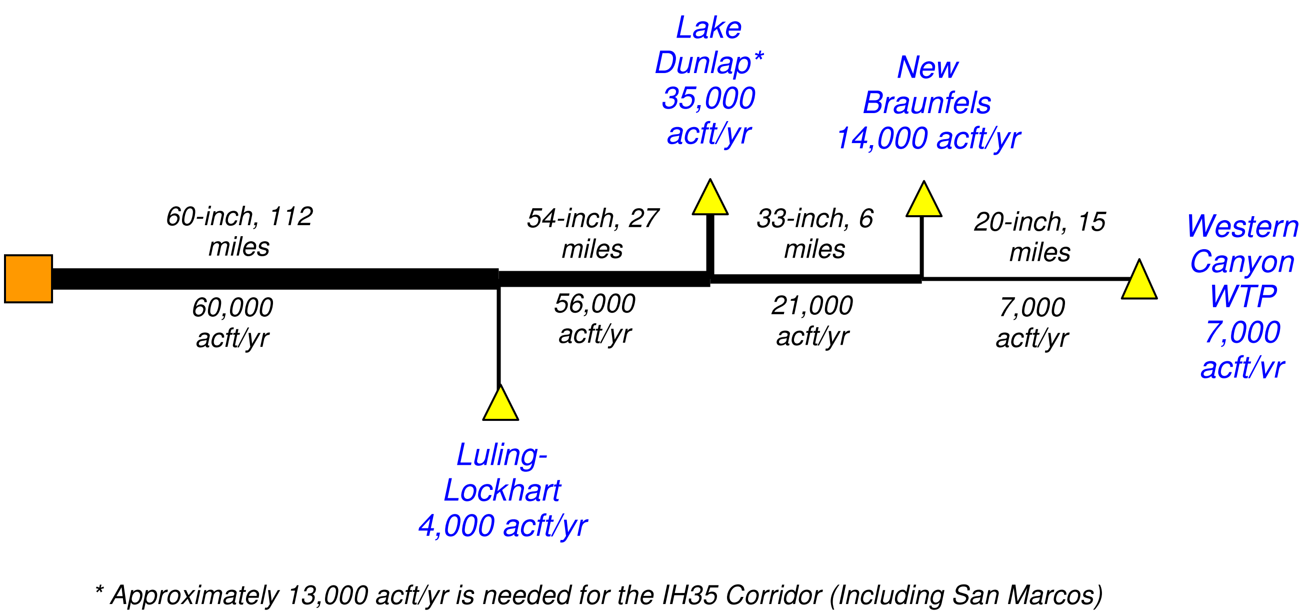


Figure 4C.12-2. LGWSP for Upstream GBRA Needs — Schematic of Delivery Amounts

Inclusion of off-channel storage has certain operational advantages in addition to increasing firm water availability. These advantages include the capability of suspending river diversions to avoid poor water quality during flood events and/or facilitate maintenance of diversion facilities without curtailing deliveries from the reservoir. Off-channel storage will not be developed as part of this project without the consent of affected property owners.

4C.12.2 Water Availability

The Guadalupe River Saltwater Barrier was constructed in the early 1960s at a location immediately downstream of the San Antonio River confluence and creates a reservoir pool extending some distance up both rivers. Diversions from this reservoir pool, under existing rights, flow into GBRA's Calhoun Canal System and are dependent upon waters originating in both the Guadalupe and San Antonio Rivers and their respective tributaries. Since the end users of the LGWSP for Upstream GBRA Needs are customers within the 10-county GBRA statutory district and part of each of the 10 counties is with in the Guadalupe River Basin, this version of the LGWSP is not subject to many provisions of Section 11.085 of the Texas Water Code regarding inter-basin transfers.

Maximum reported water use under the GBRA lower basin water rights totaling 175,501 acft/yr at the Guadalupe River Saltwater Barrier did not exceed 63,000 acft/yr during the 1991 through 2006 historical period[1]. It is estimated by GBRA that up to 75,000 acft/yr under one or more of these rights is available for periods of time into the future leaving 100,000 acft/yr available for lower basin uses. Certificate of Adjudication (CA) #18-5178 is the least senior of GBRA's lower basin water rights and it has a priority date of January 7, 1952. Authorized annual diversions under CA# 18-5178 total 106,000 acft for municipal, industrial, and irrigation uses.

The Guadalupe-San Antonio River Basin Water Availability Model (GSAWAM, as modified for regional water planning purposes) was used to quantify water available for diversion under CA# 18-5178. Hydrologic simulations and calculations were performed subject to the General Assumptions for Applications of Hydrologic Models, as adopted by the SCTRWPG for the 2006 Regional Water Plan, with a modification to include the latest Edwards Aquifer permitted pumping capacity and Critical Period provisions as set forth in SB3. A maximum diversion rate of 187 cfs (the pro-rata share of the maximum diversion rate in CA# 18-5178 or [264.35 cfs * 75,000 acft / 106,000 acft] = 187.0 cfs) was used. A specifically-designed MS Excel model was then used to simulate off-channel storage operations, while meeting the

[1] GBRA, Personal Communication, 2007.

60,000 acft/yr delivery to GBRA customers. Results obtained using both the GSAWAM and the Excel model to evaluate the project are presented in the following paragraphs.

Application of the GSAWAM, with a period of record from January 1934 to December 1989, demonstrates that water availability from the Guadalupe River, via the Calhoun Canal System, is very reliable. Figure 4C.12-3 shows the water available for diversion under the junior 75,000 acft/yr portion of CA# 18-5178 on an annual basis, limited only by a maximum diversion rate of 187 cfs. Actual diversions from the Guadalupe River to the off-channel reservoir are further limited by amounts necessary to keep the reservoir full. Subject to a uniform seasonal diversion pattern, the full monthly portion of 75,000 acft/yr is available in about 96 percent of the months simulated. Water available from the Calhoun Canal System was used in the Excel model to maintain storage in the off-channel storage facility sized to meet the specified 60,000 acft/yr delivery requirement.

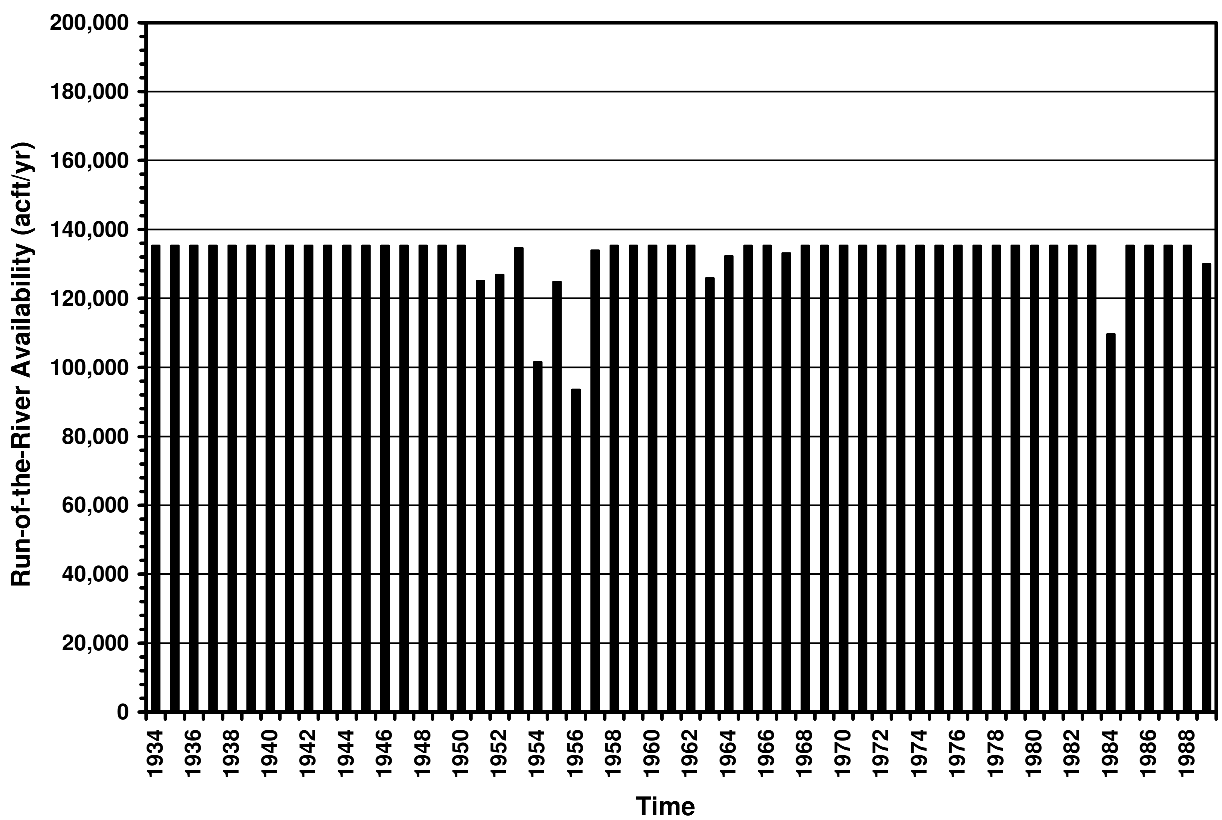


Figure 4C.12-3. Availability from Guadalupe River under Junior Portion of CA# 18-5178, Limited by Maximum Diversion Rate of 187 cfs

During relatively short periods during the 1934 – 1989 period of record, water is not available under CA# 18-5178, and diversions must be made from storage. It is assumed that the off-channel storage facility would be located in Calhoun County. Through an iterative process in the Excel model, it was determined that the storage necessary to sustain uniform delivery of 60,000 acft/yr is approximately 19,000 acft, based on a ring dike type structure limited to about 20-feet deep. An off-channel storage reservoir of this size would inundate approximately 950 acres. The long-term average net evaporative loss associated with a reservoir of this size in the lower Guadalupe River Basin is expected to be 2,160 acft/yr (3.6 percent of firm yield). The maximum annual diversion under CA# 18-5178 is 64,198 acft/yr in this project.

It is noted that GBRA could provide most, if not all, of the 60,000 acft/yr delivery amount using CA# 18-5176, CA# 18-5177, and/or more senior portions of CA# 18-5178, rather than the junior portion of CA# 18-5178. This would substantially reduce off-channel storage requirements, but could necessitate occasional suspension of water use for irrigation.

4C.12.3 Environmental Issues

The LGWSP for Upstream GBRA Needs includes a 3-mile diversion pipeline from the GBRA Calhoun Canal System to an off-channel storage facility in Calhoun County and a 160-mile long transmission pipeline from the off-channel storage facility to delivery points in the middle and upper Guadalupe River Basin. The transmission pipeline originates in Calhoun County and runs in a northwesterly direction through portions of Calhoun, Victoria, De Witt, Gonzales, Caldwell, Guadalupe, and Comal Counties.

A construction right-of-way approximately 140-feet wide would affect a total area of approximately 2,700 acres. The construction of the pipelines would include the clearing and removal of woody vegetation within and maintenance of a 40-foot wide right-of-way free of woody vegetation for the life of the project (1,943 acres of temporarily disturbed construction corridor).

The project area is located primarily in the Gulf Coastal Plains of Texas Physiographic Province. This area is locally characterized as a nearly flat prairie which terminates at the Gulf of Mexico, and includes topography changes of less than one foot per mile. Elevation levels in this area range from 0 to 300 feet above mean sea level. Vegetation types found within the pipeline corridor are primarily live oak and post oak woodlands, with crops as the second largest type and the remaining portions containing grasslands and urban areas.

The pipeline route encompasses four different vegetational areas, The Gulf Prairies and Marshes, Post Oak Savannah, Blackland Prairies, and Edwards Plateau. The portion of the pipeline route found within Calhoun County and the majority of Victoria County crosses the Gulf Prairies and Marshes Vegetational Area. Gulf Prairies have slow surface drainage and elevations that range from sea level to 250 feet. These areas include nearly level and virtually undissected plains. Originally the Gulf Prairies were composed of tallgrass prairie and post oak savannah. However, tree species such as honey mesquite and acacia, along with other trees and shrubs, have increased in this area, forming dense thickets in many places.

Typical oak species found in this area include live oak (*Quercus virginiana*) and post oak (*Q. stellata*), in addition to huisache (*Acacia smallii*), black-brush (*A. rigidula*), and a dwarf shrub, bushy sea-ox-eye (*Borrichia frutescens*). Principal climax grasses of the Gulf Prairies include gulf cordgrass (*Spartina spartinae*), indiangrass (*Sorghastrum nutans*), and big bluestem (*Andropogon gerardii var. gerardii*). *Prickleypear (Opunita*) are common within this area along with forbs including asters (*Aster*), poppy mallows (*Callirhoe*), bluebonnets (*Lupinus*), and evening primroses (*Oenothera*). Gulf Marshes range from sea level to a few feet in elevation, and include low, wet marshy coast areas commonly covered with saline water. These salty areas support numerous species of sedges (*Carex* and *Cyperus*), bulrushes (*Scirpus*), rushes (*Juncus*), and grasses. Aquatic forbs found in these areas generally include pepperweeds (*Lepidium*), smartweeds (*Polygonum*), cattails (*Typha domingensis*) and spiderworts (*Tradescantia*) among others. Upland game and waterfowl find these low marshy areas to be excellent natural wildlife habitat.

The Post Oak Savannah vegetational area of Texas includes portions of De Witt, Guadalupe, Gonzales, and Caldwell counties. The Post Oak Savannah refers to the gently rolling, moderately dissected, wooded plain that lies to the west of the Pineywoods in east-central Texas and intermingles with the Blackland Prairie in south-central Texas. The elevation in this area ranges from 300-800 feet. This vegetation area includes the entire Claypan land resource area of Texas, which is considered part of the Southern Coastal Plains. Vegetation is typified by post oak (*Quercus stellata*) and blackjack oak (*Quercus marilandica*) in association with tallgrasses. Dense thickets may occur within this area in the absence of fire or other methods of woody plant suppression. The Post Oak Savannah was extensively cultivated until the 1940's, but numerous acres have since been restored to native vegetation or converted to tame pastures.

In addition to post oak and blackjack oak, associated trees of the Post Oak Savannah include elms (*Ulmus spp*.), junipers (*Juniperus spp*.), hackberries (*Celtis spp*.), and hickories (*Carya spp*.). Understory vegetation includes shrubs such as yaupon (*Ilex vomitoria*), American beautyberry (*Callicarpa americana*), coralberry (*Symphoricarpos orbiculatus*), and vines such as greenbriars (*Smilax spp*.) and grapes (*Vitis spp*.). Common climax grasses include little bluestem (*Schizachyrium scoparium*), indiangrass (*Sorghastrum nutans*), switchgrass (*Panicum virgatum*), silver bluestem (*Bothriochloa laguroides*), Texas wintergrass (*Nassella leucotricha*), brownseed paspalum (*Paspalum plicatulum*) purpletop (*Tridens flavus*), narrow leaf woodoats (*Chasmanthium laxum*), and beaked panicum (*Panicum anceps*). Forbs occurring in the area include wild indigos (*Baptisia spp*.), indigobush (*Amorpha fruticosa*), sennas (*Senna spp*.), tickclovers (*Desmodium spp*.), lespedezas (*Lespedeza spp*.), prairie clovers (*Dalea spp*.), western ragweed (*Ambrosia psilostachya*), crotons (*Croton spp*.), and sneezeweeds (*Helenium spp*.).

The Blackland Prairies refers to rolling hills of well-dissected prairie in west-central Texas and represents the southern extension of the true prairie that occurs from Texas to Canada. Portions of this type of vegetational area are included in De Witt, Guadalupe, Gonzales, Comal, and Caldwell counties. The region was once a tallgrass prairie dominated by little bluestem (*Schizachyrium scoparium*), big bluestem (*Andropogon gerardii*), indiangrass (*Sorghastrum nutans*), tall dropseed (*Sporobolus compositus*), and Silver dropseed (*Sporobolus silveanus*). Oaks (*Quercus spp*.), elms (*Ulmus spp*.), cottonwood (*Populus deltoides*), and native pecan (*Carya illinoinensis*) are common along streams in this region. About 98 percent of the Blackland Prairies were cultivated to produce crops such as cotton, corn, and wheat in the late 19th and early 20th centuries. Since the 1950s, the region has been increasingly used for pasture and forage crops for the production of livestock, and now only about 50 percent of the area is used as cropland.

The Edwards Plateau vegetational area occurs within the western portions of Comal and Hays counties. This area includes rapidly drained stony plains with broad flat divides. The original vegetation within this area was grassland or open savannah-type plains with most tree or brushy species found along rocky slopes and stream bottoms. The Edwards plateau is currently primarily rangeland with short grasses. Along rocky outcrops and protected areas with good soil moisture you will still find tallgrasses such as cane bluestem (*Bothriochloa barbinodis var. barbinodis*), indiangrass (*Sorghastrum nutans*), and switchgrass (*Panicum spp*.) Common woody species include live oak (*Quercus virginiana*), sand shin oak (*Quercus havardii*), mesquite (*Prosopis glandulosa*) and ashe juniper (*Juniperus ashei*).

In Calhoun, Victoria, De Witt, Guadalupe, Gonzales, Caldwell, and Comal Counties, 41 state-listed endangered or threatened species and 22 federally-listed endangered or threatened wildlife species, may occur according to the county lists of rare species published by Texas Parks and Wildlife Department (TPWD). A list of these species is provided in Table 4C.12-1.

Inclusion in Table 4C.12-1 does not imply that a species will occur within the study area, but only acknowledges the potential for occurrence in the study area counties. A more intensive field reconnaissance would be necessary to confirm and identify specific suitable habitat that may be present in the project area. In addition to county lists, HDR also reviewed Texas Natural Diversity Database (TXNDD) map data for known occurrences of listed species within or near the proposed pipeline route. This information indicated that there were reported sightings of Cagle's map turtle (Graptemys caglei), a state listed threatened species; the fountain darter fish (*Etheostoma fonticola*), listed by both the state and federal government as endangered; the Comal Springs dryopid beetle (*Stygoparnus comalensis*), which is federally listed as endangered; within a one mile radius of the pipeline area. Two rare species are also documented, the Guadalupe bass (*Micropterus teculii*) and the mountain plover (*Charadrius montanus*). The presence or absence of potential habitat within an area does not confirm the presence or absence of a listed species. No species specific surveys were conducted in the study area for this report.

Many migratory birds are dependent on estuarine environments like those located near Calhoun County in order to complete their foraging and nesting requirements during migration. One of the most well known of these migratory birds is the whooping crane (*Grus Americana*), which is listed as endangered by both United States Fish and Wildlife Service (USFWS) and TPWD. A growing population of whooping cranes winter in and near the Aransas National Wildlife Refuge, located adjacent to the Mesquite Bay and the southern and western portions of San Antonio Bay. This wintering population has grown from a low of only 16 birds in 1941 to a high of 257 birds in December 2007. Detailed research studies by Texas A&M University are underway at this time to identify and better understand factors affecting whooping crane population. Three other migratory birds known to the San Antonio Bay area are listed as threatened by TPWD: the reddish egret (*Egretta rufescens*), wood stork (*Mycteria Americana*), and piping plover (*Charadrius melodus*). The piping plover is also listed as threatened by USFWS.

Table 4C.12-1
Important Species Having Habitat or Known to Occur in
Calhoun, Caldwell, Comal, DeWitt, Gonzales, Guadalupe, and Victoria Counties

Common Name	Scientific Name	Summary of Habitat Preference	Listing Entity		Potential Occurrence in Counties
			USFWS[1]	TPWD[1]	
A mayfly	Campsurus decoloratus	TX and MX; possibly clay substrates;			Resident
A mayfly	Tortopus circumfluus	Generally found in shoreline vegetation			Resident
American Eel	*Anguilla rostrata*	Moist aquatic habitats			Resident
Atlantic Hawksbill Sea turtle	*Eretmochelys imbricata*	Gulf and bay systems	LE	E	Migrant
Attwater's Greater Prairie-chicken	*Tympanuchus cupido attwateri*	Endemic, open prairies and coastal plains	LE	E	Resident
Bald Eagle	*Haliaeetus leucocephalus*	Large bodies of water with nearby resting sites	DL	T	Nesting/ Migrant
Big red sage	*Salvia penstemonoides*	Endemic; moist to seasonally wet clay or silt soils in creek beds.			Resident
Black Bear	*Usus americanus*	Mountains, broken country, woods, brushlands, forests	T/SA; NL	T	Historic Resident
Black-capped Vireo	Vireo atricapillus	Semi-open broad-leaved shrublands	LE	E	Nesting/ Migrant
Black-Spotted Newt	*Notophthalmus meridionalis*	Ponds and resacas in south Texas		T	Resident
Blue sucker	Cycleptus elongatus	Larger portions of major rivers in Texas;		T	Resident
Bracted Twistflower	*Streptanthus bracteatus*	Endemic; Shallow clay soils over limestone; rocky slopes			Resident
Brown Pelican	*Pelecanus occidentalis*	Coastal inlands for nesting, shallow gulf and bays for foraging	LE	E	Nesting/ Migrant
Canyon mock-orange	*Philadelphus ernestii*	Endemic, outcrops of limestone			Resident
Cagle's map turtle	*Graptemys caglei*	Endemic; Guadalupe River System		T	Resident
Cascade Caverns salamander	*Eurycea latitans complex*	Endemic: subaquatic, springs and caves in Medina and Guadalupe River and Cibolo Creek Watersheds		T	Resident
Cave myotis bat	*Myotis velifer*	Colonial and cave-dwelling;			Resident
Comal Blind Salamander	*Eurycea tridentifera*	Endemic; Semi-troglobitic; Springs and waters of caves		T	Resident
Comal snakewood	*Colubria stricta*	Rock outcrops			Resident

Table 4C.12-1 (Continued)

Common Name	Scientific Name	Summary of Habitat Preference	Listing Entity USFWS[1]	Listing Entity TPWD[1]	Potential Occurrence in Counties
Comal Springs diving beetle	*Comaldessus stygius*	Aquatic, at outflow at Comal Springs			Resident
Comal Springs dryopid beetle	*Stygoparnus comalensis*	Aquatic, cling to objects in streams	LE		Resident
Comal Springs riffle beetle	*Heterelmis comalensis*	Comal and San Marcos Springs	LE		Resident
Comal Springs salamander	*Eurycea* sp. 8	Endemic; Comal Springs			Resident
Creeper (squawfoot)	*Strophitus undulates*	Small to large streams			Resident
Edwards Aquifer diving beetle	*Haideoporus texanus*	Artesian well in Hays County			Resident
Edwards Plateau Spring Salamander	*Eurycea sp. 7*	Endemic; springs and waters of caves within region			Resident
Elmendorf's onion	*Allium elmendorfii*	Endemic, in deep sands			Resident
Eskimo curlew	*Numenius borealis*	Historic; grasslands, pastures	LE	E	Nonbreeding Historic Resident
Ezell's cave amphipod	*Stygobromus flagellatus*	Known from artesian wells			Resident
False spike mussel	*Quincuncina mitchelli*	Substrates of cobble and mud with water lilies present. Rio Grande, Brazos, Colorado and Guadalupe river basins.			Resident
Fountain darter	Etheostoma fonticola	Sam Marcos and Comal Rivers	LE	E	Resident
Golden-Cheeked Warbler	*Dendroica chrysoparia*	Woodlands with oaks and old juniper	LE	E	Nesting/ Migrant
Golden orb	*Quadrula aurea*	Sand and gravel, Guadalupe, San Antonio, and Nueces river basins			Resident
Green Sea Turtle	*Chelonia mydas*	Gulf and bay system.	LT	T	Migrant
Guadalupe bass	*Micropterus treculii*	Endemic to perennial streams of the Edward's Plateau region			Resident
Guadalupe darter	*Percina sciera apristis*	Guadalupe River basin; large streams and rivers			Resident
Gulf Saltmarsh Snake	Nerodia clarkii	Brackish to saline coastal waters			Resident
Henslow's Sparrow	*Ammodramus henslowii*	Weedy fields, cut over areas.			Nesting/ Migrant
Hill County wild-mercury	*Argythamnia aphoroides*	Shallow clays and limestone			Resident

Table 4C.12-1 (Continued)

Common Name	Scientific Name	Summary of Habitat Preference	Listing Entity		Potential Occurrence in Counties
			USFWS[1]	TPWD[1]	
Horseshoe liptooth snail	*Daedalochila hippocrepis*	Snal known only from Landa Park in New Braunfels			Resident
Jaguarundi	*Herpailurus yaguarondi*	South Texas thick brushlands, favors areas near water	LE	E	Resident
Kemp's Ridley Sea Turtle	*Lepidochelys kempii*	Gulf and bay system.	LE	E	Migrant
Leonora's dancer damselfly	Argia leonorae	South central and western Texas; small streams and seepages			Resident
Leatherback Sea Turtle	*Dermochelys coriacea*	Gulf and bay system.	LE	E	Migrant
Loggerhead Sea Turtle	*Caretta caretta*	Gulf and bay system.	LT	T	Migrant
Long-legged cave amphipod	*Stygobromus longipes*	Subaquatic obligate			Resident
Louisiana Black Bear	*Ursus americanus luteolus*	Within historical range.	LT	T	Historic Resident
Mountain Plover	*Charadrius montanus*	Non-breeding-shortgrass plains and fields, plowed fields and sandy deserts			Nesting/ Migrant
Ocelot	*Leopardus pardalis*	Dense chaparral thickets; mesquite-thorn scrub and live oak mottes	LE	E	Resident
Opossum Pipefish	*Microphis brachyurus*	Brooding adults found in fresh or low salinity waters.		T	Resident
Palmetto pill snail	Euchemotrema leai cheatumi	One known population, from moist palmetto woodlands of Palmetto State Park;			Resident
Park's jointweed	*Polygonella parksii*	Endemic; deep loose sands of Carrizo and similar Eocene formations.			Resident
Peck's cave amphipod	*Stygobromus pecki*	Aquatic crustacean, Comal Springs and Hueco Springs	LE	E	Resident
Peregrine falcon	*Falco peregrinus anatum (American)*	Open county; cliffs	DL	E	Nesting/ Migrant
	Falco peregrinus tundrius (Arctic)		DL	T	
Pistolgrip	*Tritogonia verrucosa*	Aquatic, stable substrate			Resident
Plains Spotted Skunk	*Spilogale putorius interrupta*	Prefers wooded, brushy areas and tallgrass prairie.			Resident

Table 4C.12-1 (Continued)

Common Name	Scientific Name	Summary of Habitat Preference	Listing Entity		Potential Occurrence in Counties
			USFWS[1]	TPWD[1]	
Rawson's metalmark	*Calephelis rawsoni*	Moist areas in limestone outcrops.			Resident
Red Wolf	*Canis rufus*	Extirpated	LE	E	Historic Resident
Reddish Egret	Egretta rufescens	Coastal inlands for nesting, coastal marshes for foraging		T	Migrant
Rock pocketbook	*Arcidens confragosus*	Mud and sand, Red through Guadalupe river basins			Resident
Sandhill woolywhite	*Hymenopappus carrizoanus*	Endemic; open areas in deep sands derived from Carrizo and similar Eocene formations			Resident
Sheep Frog	*Hypopachus variolosus*	Deep sandy soils of Southeast Texas		T	Resident
Shinner's sunflower	Helianthus occidentalis ssp plantagineus	Mostly in prairies on the Coastal Plain			Resident
Snowy Plover	*Charadrius alexandrinus*	Wintering Migrant on mud flats			Migrant
Sooty Tern	*Sterna fuscata*	Catches small fish		T	Resident
Southeastern Snowy Plover	*Charadrius alexandrinus tenuirostris*	Texas Gulf Coast beaches and bayside mud or salt flats			Wintering Migrant
Spot-tailed earless lizard	*Holbrookia lacerata*	Moderately open prairie-brushland			Resident
Texas asaphomyian tabanid fly	*Asaphomyia texensis*	Adults of tabanid spp. found near slow-moving water			Resident
Texas Diamondback Terrapin	*Malaclemys terrapin littoralis*	Bays, coastal marshes of the upper two-thirds of Texas Coast			Resident
Texas fatmucket	*Lampsilis bracteata*	Streams and rivers on sand, mud and gravel, Colorado and Guadalupe River basins			Resident
Texas Garter Snake	*Thamnophis sirtalis annectens*	Wet or moist microhabitats			Resident
Texas Horned Lizard	*Phrynosoma cornutum*	Varied, sparsely vegetated uplands, grass, cactus, brush		T	Resident
Texas mock-orange	*Philadelphus texensis*	Endemic, limestone cliffs and boulders			Resident
Texas pimpleback	*Quadrula petrina*	Mud, gravel and sand substrates, Colorado and Guadalupe river basins			Resident
Texas Scarlet Snake	*Cemophora coccinea lineri*	Mixed hardwood scrub		T	Resident

Table 4C.12-1 (Concluded)

Common Name	**Scientific Name**	**Summary of Habitat Preference**	**Listing Entity**		**Potential Occurrence in Counties**
			USFWS[1]	**TPWD[1]**	
Texas Tortoise	*Gopherus berlandieri*	Open brush w/ grass understory; open grass/bare ground avoided		T	Resident
Timber/Canebrake Rattlesnake	*Crotalus horridus*	Floodplains, upland pine, deciduous woodlands, riparian zones		T	Resident
Welder machaeranthera	*Psilactis heterocarpa*	Endemic, grasslands and adjacent scrub flats on clay			Resident
West Indian manatee	*Trichechus manatus*	Aquatic	LE	E	Resident
Timber/Canebrake Rattlesnake	*Crotalus horridus*	Floodplains, upland pine, deciduous woodlands, riparian zones		T	Resident
Western Burrowing Owl	*Athene cunicularia hypugaea*	Open grasslands, especially prairie, plains and savanna			Resident
Western Snowy Plover	*Charadrius alexandrinus nivosus*	Winters along coast			Migrant
White-faced Ibis	*Plegadis chihi*	Prefers freshwater marshes		T	Resident
White-nosed coati	*Nasua narica*	Woodlands, riparian corridors		T	Transient
White-tailed Hawk	*Buteo albicaudatus*	Coastal prairies, savannahs and marshes in Gulf coastal plain		T	Nesting/ Migrant
Whooping Crane	*Grus americana*	Potential migrant	LE	E	Migrant
Wood Stork	*Mycteria americana*	Forages in prairie ponds, ditches, and shallow standing water formerly nested in TX		T	Migrant
Zone-tailed Hawk	*Buteo albonotatus*	Arid open county near watercourse		T	Nesting/ Migrant

Source: TPWD, Annotated County List of Rare Species, Calhoun County, August 14, 2007, Victoria County November 20, 2007, De Witt County, November 20, 2007, Gonzales County August 8, 2007, Guadalupe County, August 8, 2007, and Caldwell County, November 20, 2007.

LE/LT=Federally Listed Endangered/Threatened
E/SA, T/SA=Federally Listed Endangered/Threatened by Similarity of Appearance
DL, PDL=Federally Delisted/Proposed for Delisting
E, T=State Listed Endangered/Threatened
Blank = Rare, but no regulatory listing status

Endangered and threatened species listed for Comal County include the Black-capped Vireo, Golden-cheeked Warbler, and four additional migratory bird species, two salamanders, an amphipod, and two beetles. Some care may be necessary should water pipelines traverse preferred habit for these endemic species. Black-capped Vireos are insectivorous songbirds that nest in low shrubland thickets where vegetation extends to ground level. Golden-cheeked Warblers prefer habitat consisting of mature oak-juniper woodlands located along steep escarpments and canyons. The listed invertebrate species (amphipod and beetles) are all endemic to karst features or springs, as is the Cascade Cavers salamander. The listed migratory bird species tend to avoid areas of concentrated human development.

Several species listed as threatened by the state may possibly be affected by the project. These include the Texas horned lizard (Phrynosoma cornutum), Texas scarlet snake (Cemophora coccinea lineri), Texas tortoise (Gopherus berlandieri), and timber/canebrake rattlesnake (Crotalus horridus). Many of these reptile species are dependent on shrubland or riparian habitat.

Habitat studies and surveys for protected species and cultural resources may need to be conducted at the proposed lift station sites and along any pipeline routes. Potential wetland impacts, which are limited to pipeline stream crossings, can be minimized by right-of-way selection and appropriate construction methods, including horizontal directional drilling, erosion controls, and revegetation procedures. Compensation for net losses of wetlands would be required where impacts are unavoidable.

All areas to be disturbed during construction would first be surveyed by qualified professionals to determine the presence or absence of significant cultural resources. Cultural resources protection on public lands in Texas is afforded by the Antiquities Code of Texas (Title 9, Chapter 191, Texas Natural Resource Code of 1977), the National Historic Preservation Act (Pl96-515), and the Archeological and Historic Preservation Act (PL93-291).

A specific site for the off-channel reservoir has not been chosen. In choosing a site, key considerations will include minimizing construction and long-term operations costs and minimizing conflicts with streams, highways/roadways, railroads, transmission facilities (water, product, and power), petroleum production, and environmental/cultural resources (e.g., endangered & threatened species habitat, wetlands, and historical/archaeological sites).

The LGWSP for Upstream GBRA Needs relies on existing surface water rights and does not involve any new surface water appropriations. Therefore, freshwater inflows to the Guadalupe Estuary would be the same as the "full water rights use" baseline that is used when calculating surface water supply and evaluating the cumulative effects of regional water plan implementation. Thus graphics showing median inflow and flow frequency are not necessary, as the median values for both Baseline and Lower Guadalupe Water Supply Project for Upstream GBRA needs would be equal in all months.

4C.12.4 Engineering and Costing

The firm yield diversion from the off-channel reservoir used for costing purposes is assumed to be a uniform rate throughout the year. Major facilities required to implement this water management strategy include:

- Canal Intake and Pump Station;
- Transmission Pipeline to Off-Channel Storage;
- Off-Channel Storage;
- Reservoir Intake and Pump Station at Off-Channel Storage;
- Raw Water Transmission Pipeline to Luling;
- Raw Water Pipeline to Lake Dunlap;
- Raw Water Pipeline to New Braunfels;
- Raw Water Pipeline to Western Canyon Project;
- Transmission Lift Stations;
- New or Expanded Water Treatment Plants (Level 3) at Luling, near Lake Dunlap, near San Marcos, at New Braunfels, and at the Western Canyon Project;
- Treated or Raw Water Pipeline from Lake Dunlap to San Marcos; and
- Integration.

The canal intake and pump station are sized to deliver up to 187 cfs through a 3-mile, 96-inch diameter pipeline to an off-channel storage facility in Calhoun County. While a specific off-channel storage facility site has not been selected, it is assumed that an off-channel storage site could be located within three miles of the Calhoun Canal System.

It is important to note that, according to the 2011 Initially Prepared Plan (IPP), Year 2060 water needs in the upper and middle Guadalupe Basin total about 44,000 acft/yr. The LGWSP for Upstream GBRA Needs project is sized to deliver up to 60,000 acft/yr, approximately 22,000 acft/yr more than the projected needs. This 22,000 acft/yr, delivered as raw water to Lake Dunlap, is held in reserve to meet needs beyond the Year 2060 projected timeline. For consistency, however, cost estimates include treatment and integration for this 22,000 acft/yr.

The estimated costs of the LGWSP for Upstream GBRA Needs are presented in Table 4C.12-2 in September 2008 dollars. The estimated total project cost, which includes contingencies, is $1,003,219,000. With a total annual cost of $115,258,000 and an available project yield of 60,000 acft/yr, the resulting unit cost is $1,921 per acft. The long-term, post-debt service cost of the project is $476 per acft.

4C.12.5 Implementation Issues

Institutional arrangements may be needed to implement the project, potentially including financing on a regional basis.

1. It will be necessary to obtain the following:
   a. TCEQ Storage Permits;
   b. USCE Sections 10 and 404 Dredge and Fill Permits for the reservoir and pipelines;
   c. GLO Sand and Gravel Removal permits;
   d. GLO Easement for use of state-owned land;
   e. Coastal Coordination Council review; and
   f. TPWD Sand, Gravel, and Marl permit.
2. Permitting may require these studies:
   a. Assessment of changes in freshwater inflows to bays and estuaries;
   b. Habitat mitigation plan;
   c. Environmental studies; and
   d. Cultural resource studies and mitigation.
3. Land will need to be acquired through either negotiations or condemnation.
4. Relocations for the off-channel storage facilities may include:
   a. County roads;
   b. Other utilities;
   c. Product transmission pipelines; and
   d. Power transmission lines.

Table 4C.12-2.
Cost Estimate Summary for
Lower Guadalupe Water Supply Project for Upstream GBRA Needs
September 2008 Prices

Item	Estimated Costs for Facilities
Capital Costs	
Canal Intake and Pump Station	$12,490,000
Transmission Pipeline to OCS (96 in dia., 3 miles)	$14,022,000
Off-Channel Storage Reservoir (Conservation Pool 19,000 acft, 950 acres, 52 ft. msl)	$23,179,000
Intake and Pump Station at OCS (56.3 MGD)	$20,812,000
Transmission Pipeline to Luling (60 in dia., 112 miles)	$325,397,000
Transmission Pipeline to Lake Dunlap (54 in dia., 27 miles)	$54,901,000
Transmission Pipeline to New Braunfels (33 in dia., 6 miles)	$6,572,000
Transmission Pipeline to Western Canyon Project (20 in dia., 15 miles)	$10,818,000
Transmission Booster Stations	$44,494,000
Spur Pipeline to Luling WTP (16 in dia., 1 mile)	$446,000
Spur Pipeline to San Marcos WTP (27 in dia., 20 miles)	$13,986,000
Spur Pipeline to New Braunfels WTP (27 in dia., 1 mile)	$614,000
Luling WTP Expansion (4 MGD)	$5,787,000
San Marcos WTP Expansion (11 MGD)	$11,893,000
New Braunfels WTP Expansion (14 MGD)	$15,430,000
Western Canyon WTP Expansion (6 MGD)	$6,268,000
New WTP at Lake Dunlap (20 MGD)*	$31,369,000
Integration (53.6 MGD)	$69,263,000
Total Capital Cost	**$667,741.000**
Engineering, Legal Costs and Contingencies	$212,371,000
Environmental & Archaeology Studies and Mitigation	$7,352,000
Land Acquisition and Surveying (1,817 acres)	$10,885,000
Interest During Construction (3 years)	$104,870,000
Total Project Cost	**$1,003,219,000**
Annual Costs	
Debt Service (6 percent, 20 years)	$84,141,000
Reservoir Debt Service (6 percent, 40 years)	$2,534,000
Operation and Maintenance	
Intake, Pipeline, Pump Station	$6,821,000
Dam and Reservoir	$348,000
Water Treatment Plant	$2,743,000
Pumping Energy Costs (153,952,955 kW-hr @ 0.09 $/kW-hr)	$13,856,000
Purchase of Water (64,198 acft/yr @ 75 $/acft)	$4,815,000
Total Annual Cost	**$115,258,000**
Available Project Yield (acft/yr)	60,000
Annual Cost of Water ($ per acft)	$1,921
Annual Cost of Water ($ per 1,000 gallons)	$5.89

**The 20 MGD WTP at Dunlap is a placeholder for the treatment plant necessary once the need for the water exists.*

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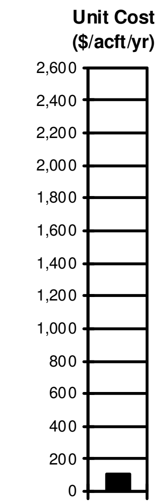
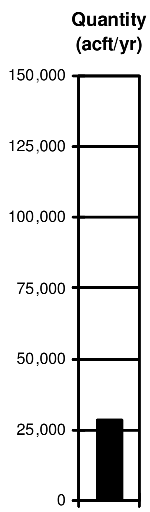
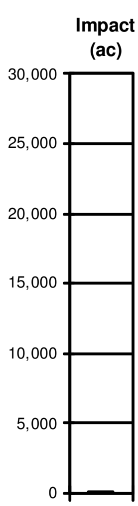
2011 South Central Texas Regional Water Plan
Water Management Strategy Summary Sheet







Name: GBRA Lower Basin Storage (100-acre Site)

Description: To firm up the existing interruptible GBRA/Dow Lower Basin Water Rights, a 100 acre, 2,500 acft off-channel reservoir (OCR) is recommended for implementation. The potential OCR site would be located approximately 3 miles east of Green Lake near the Dow Chemical Company. The off-channel reservoir would have a maximum water depth of 25-ft and be capable of impounding 2,500 ac-ft. A 42-in diameter pipeline would transport water diverted from the GBRA Main Canal System to the OCR site, and a 72-in diameter outlet pipeline would discharge the water.

***Decade Needed*:** 2030

Cost, Quantity of Water, and Land Impacted

Unit Cost of Water:	**$104**	**$/acft/yr**	**Raw Water Delivered**
Quantity of Water:	**28,369**	**acft/yr**	**Reliability = Firm**
Land Impacted:	**125**	**acres**	

Additional Considerations per Regional Water Planning Guidelines

Environmental Factors:

No specific sightings of any endangered or threatened species were documented within the proposed reservoir sites.

Impacts on Water Resources:

None anticipated.

Impacts on Agricultural & Natural Resources:

Conversion of existing land uses and habitats to open water.

Other Relevant Factors per SCTRWPG:

Project encourages beneficial use of available rights.

Comparison of Strategies to Meet Needs:

No conflicts with other recommended water management strategies.

Interbasin Transfer Issues:

Since this specific strategy is intended to serve water user groups within the GBRA district, no inter-basin transfer issues are anticipated.

Third-Party Impacts of Voluntary Transfers:

None anticipated.

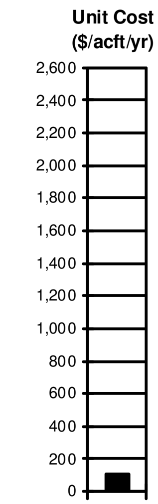
Regional Efficiency:

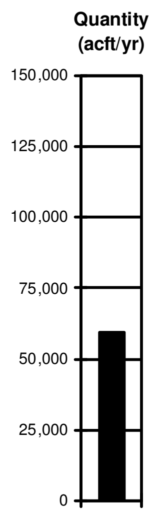
Increases long-term firm water supplies for the GBRA statutory district, particularly in Calhoun, Refugio, and Victoria Counties.

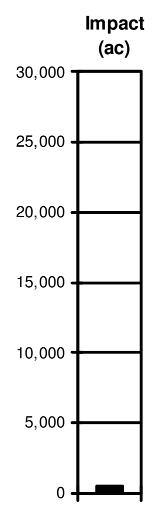
Water Quality Considerations:

The off-channel reservoir will aid in suspending river diversions to avoid poor water quality during flood events and facilitate maintenance of diversion facilities without stopping reservoir deliveries.

2011 South Central Texas Regional Water Plan
Water Management Strategy Summary Sheet







Name: GBRA Lower Basin Storage (500-acre Site)

Description: To firm up the existing interruptible GBRA/Dow Lower Basin Water Rights, a 500 acre, 12,500 acft off-channel reservoir (OCR) is considered for implementation. The potential OCR site would be located approximately 3 miles east of Green Lake near the Dow Chemical Company. The off-channel reservoir would have a maximum water depth of 25-ft and be capable of impounding 12,500 ac-ft. A 42-in diameter pipeline would transport water diverted from the GBRA Main Canal System to the OCR site, and a 72-in diameter outlet pipeline would discharge the water.

***Decade Needed*:** 2030

Cost, Quantity of Water, and Land Impacted

Unit Cost of Water:	**$109**	**$/acft/yr**	**Raw Water Delivered**
Quantity of Water:	**59,569**	**acft/yr**	**Reliability = Firm**
Land Impacted:	**625**	**acres**	

Additional Considerations per Regional Water Planning Guidelines

Environmental Factors:

No specific sightings of any endangered or threatened species were documented within the proposed reservoir sites.

Impacts on Water Resources:

None anticipated.

Impacts on Agricultural & Natural Resources:

Conversion of existing land uses and habitats to open water.

Other Relevant Factors per SCTRWPG:

Project encourages beneficial use of available rights.

Comparison of Strategies to Meet Needs:

No conflicts with other recommended water management strategies.

Interbasin Transfer Issues:

Since this specific strategy is intended to serve water user groups within the GBRA district, no inter-basin transfer issues are anticipated.

Third-Party Impacts of Voluntary Transfers:

None anticipated.

Regional Efficiency:

Increases long-term firm water supplies for the GBRA statutory district, particularly in Calhoun, Refugio, and Victoria Counties.

Water Quality Considerations:

The off-channel reservoir will aid in suspending river diversions to avoid poor water quality during flood events and facilitate maintenance of diversion facilities without stopping reservoir deliveries.

4C.13 GBRA Lower Basin Storage Project

4C.13.1 Description of Water Management Strategy

The Guadalupe-Blanco River Authority (GBRA) and Dow Chemical Company (Dow), individually and collectively, own surface water rights in the lower Guadalupe – San Antonio River Basin (the GBRA Lower Basin Water Rights) authorizing diversions totaling 175,501 acre-feet per year (acft/yr). Table 4C.13-1 lists the individual water rights owned by GBRA and Dow and provides their individual permit number, certificate of adjudication number, priority date, annual diversion, authorized uses, and ownership. Water available for diversion under these rights is governed by the complex interactions of natural, anthropogenic, and legal factors including rainfall, runoff, springflow, evaporation, aquifer recharge, diversions by other water right owners, reservoir operations, off-channel storage, treated effluent from municipal and industrial water users, terms and conditions of the water rights, and the prior appropriation doctrine as enforced by the South Texas Watermaster of the Texas Commission on Environmental Quality (TCEQ). Given that the GBRA Lower Basin Water Rights point of diversion near Tivoli is below the San Antonio River confluence and that they are senior in priority to most upstream water rights, it is recognized that they are quite reliable but not firm.

Table 4C.13-1. GBRA Lower Basin Water Rights

<table>
<tr><th>Certificate of Adjudication</th><th>Priority Date</th><th>Annual Diversion (acft/yr)</th><th>Authorized Uses</th><th>Ownership</th></tr>
<tr><td>18-5173</td><td>2/3/1941</td><td>2,500</td><td>Irrigation/Industrial</td><td>GBRA/Dow</td></tr>
<tr><td>18-5174</td><td>6/15/1944</td><td>1,870</td><td>Irrigation/Industrial</td><td>GBRA/Dow</td></tr>
<tr><td>18-5175</td><td>2/13/1951</td><td>940</td><td>Irrigation/Industrial/ Mining/Livestock</td><td>GBRA/Dow</td></tr>
<tr><td>18-5176</td><td>6/21/1951</td><td>9,944</td><td>Irrigation/Industrial/ Municipal</td><td>GBRA/Dow</td></tr>
<tr><td rowspan="3">18-5177</td><td>1/3/1944</td><td>10,000</td><td>Irrigation/Industrial/ Municipal</td><td>Dow</td></tr>
<tr><td>1/3/1944</td><td>32,615</td><td>Irrigation/Industrial/ Municipal</td><td>GBRA/Dow</td></tr>
<tr><td>1/26/1948</td><td>8,632</td><td>Irrigation/Industrial</td><td>GBRA/Dow</td></tr>
<tr><td>18-5178</td><td>1/7/1952</td><td>106,000</td><td>Irrigation/Industrial/ Municipal</td><td>GBRA/Dow</td></tr>
<tr><td>18-3863</td><td>3/1/1951</td><td>3,000</td><td>Irrigation/Industrial/ Municipal</td><td>GBRA</td></tr>
<tr><td>18-5484</td><td>5/15/1964</td><td>N/A</td><td>Diversion Dam & Salt Water Barrier</td><td>GBRA</td></tr>
</table>

To firm up the existing interruptible GBRA Lower Basin Water Rights, a 100 acre or 500 acre off-channel reservoir (OCR) is considered for implementation. Two potential OCR sites are located approximately 3 miles east of Green Lake adjacent to Dow facilities. The locations of the two sites are illustrated in Figure 4C.13-1. The off-channel reservoirs have an assumed maximum water depth of 25-ft and would be capable of impounding 2,500 ac-ft and 12,500 ac-ft of water at the 100 acre and 500 acre OCR sites, respectively. A 42-in diameter pipeline would transport water diverted from the GBRA Main Canal System to the OCR sites and a 72-in diameter outlet pipeline would discharge the water.

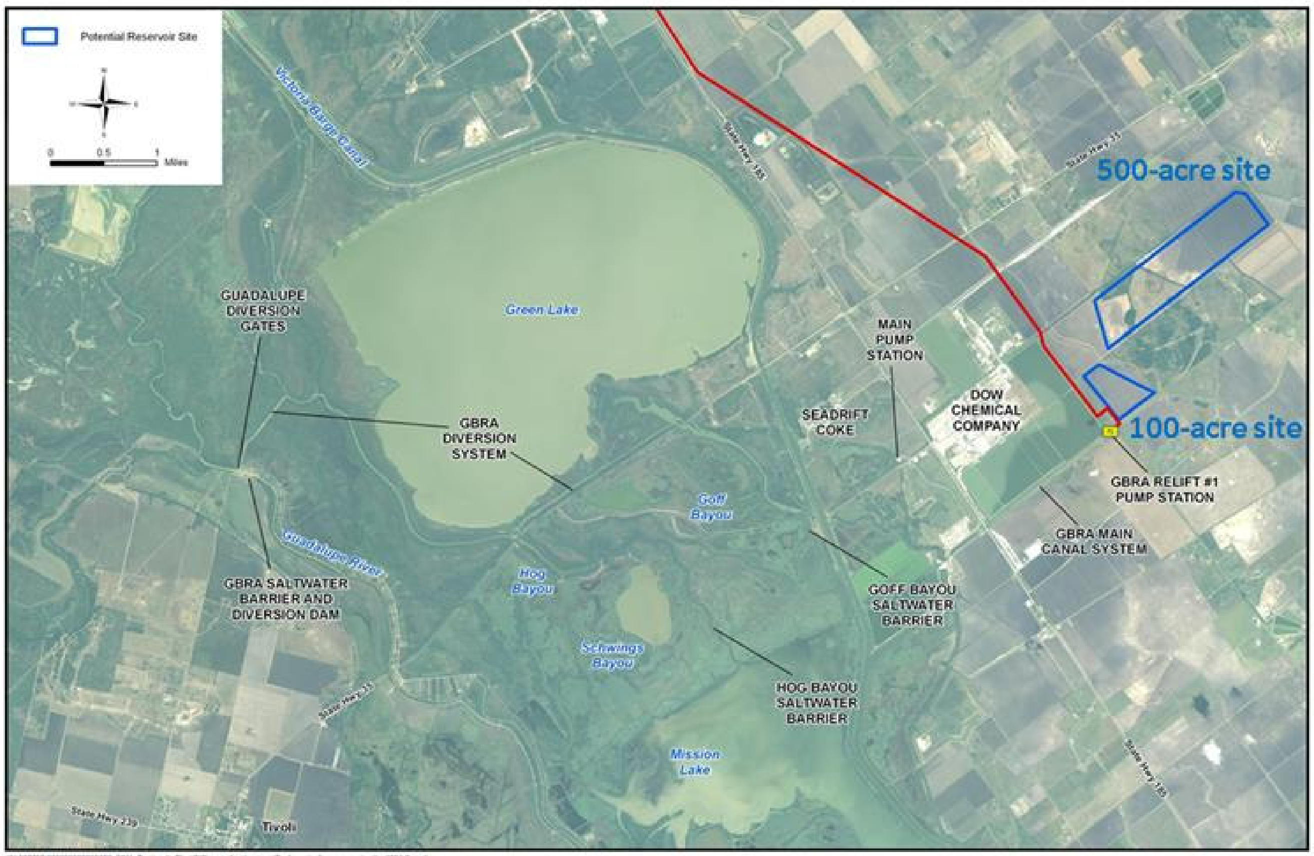


Figure 4C.13-1. GBRA Lower Basin Storage Off-Channel Storage Locations

4C.13.2 Water Availability

4C.13.2.1 Technical Assumptions for Water Availability Calculations

Initial water availability calculations were performed using the Guadalupe – San Antonio River Basin Water Availability Model (GSA WAM)[1] as modified and refined for use in development of the 2001, 2006, and 2011 South Central Texas Regional Water Plans[2,3] and water supply analyses for a proposed nuclear power plant in Victoria County.[4] The GSA WAM is a monthly time-step computer model used to estimate regulated streamflow and water available for diversion under existing water rights on a priority basis subject to technical assumptions regarding natural, anthropogenic, and legal factors. Technical assumptions used for the applications of the GSA WAM summarized herein include:

a) Surface water rights modeled at full consumptive amounts per certificates of adjudication and permits.
b) Permitted Edwards Aquifer pumpage of 572,000 acft/yr with critical period withdrawal reductions as outlined in SB3 of the 80th Texas Legislature.
c) Subordination of all senior Guadalupe River hydropower water rights to Canyon Reservoir.
d) 1934-2006 historical simulation period for the GSA WAM using simplified approximation techniques to extend basic hydrologic data from 1990 through 2006.[5]
e) Treated effluent quantities throughout the river basin reported for calendar year 1997 after accounting for San Antonio Water System (SAWS) direct reuse contracts under their recycled water program. These effluent quantities were used in surface water availability analyses for the 2006 South Central Texas Regional Water Plan and differ very little from those for the 2011 Plan.
f) Multiple regulated streamflow extractions from each GSA WAM simulation were necessary to account for the effects of diversions by Invista/DuPont (CA# 18-3861) on firm supply available to the GBRA Lower Basin Water Rights on a daily basis. The only large non-GBRA water right in the lower basin having a priority date senior to some (and junior to other) GBRA Lower Basin Water Rights is held by Invista/DuPont.

[1] HDR Engineering, Inc., "Water Availability in the Guadalupe – San Antonio River Basin," Texas Natural Resource Conservation Commission (Contract# 9880059200), December 1999.
[2] South Central Texas Regional Water Planning Group, "South Central Texas Regional Water Planning Area, 2001 Regional Water Plan," Texas Water Development Board, San Antonio River Authority, HDR Engineering, Inc., et al., January 2001.
[3] South Central Texas Regional Water Planning Group, "South Central Texas Regional Water Planning Area, 2006 Regional Water Plan," Texas Water Development Board, San Antonio River Authority, HDR Engineering, Inc., et al., January 2006.
[4] HDR Engineering, Inc., "Simplified Extension of Hydrologic Data in the Guadalupe – San Antonio River Basin and Approximate Daily Estimates of Water Availability," Guadalupe-Blanco River Authority, Exelon Generation Company, February 12, 2009.
[5] Ibid.

4C.13.2.2 Monthly Assessments of Reliability and Water Available

The combined annual water available under the GBRA Lower Basin Water Rights calculated by the GSA WAM is summarized in Figure 4C.13-2. As shown in Figure 4C.13-2, the full annual amount of 175,501 acft/yr is reliable in 85 percent of the years during the simulation period and the minimum annual amount of water available under the GBRA Lower Basin Water Rights is 145,665 acft/yr in 1956. The reliability of the GBRA Lower Basin Water Rights is summarized in Figure 4C.13-3 in terms of the percentage of time (months during the simulation period) that a percentage of the desired monthly amount of the total 175,501 acft/yr authorized diversion is available. As shown in Figure 4C.13-3, desired diversions are available in more than 97 percent of the months during the simulation period.

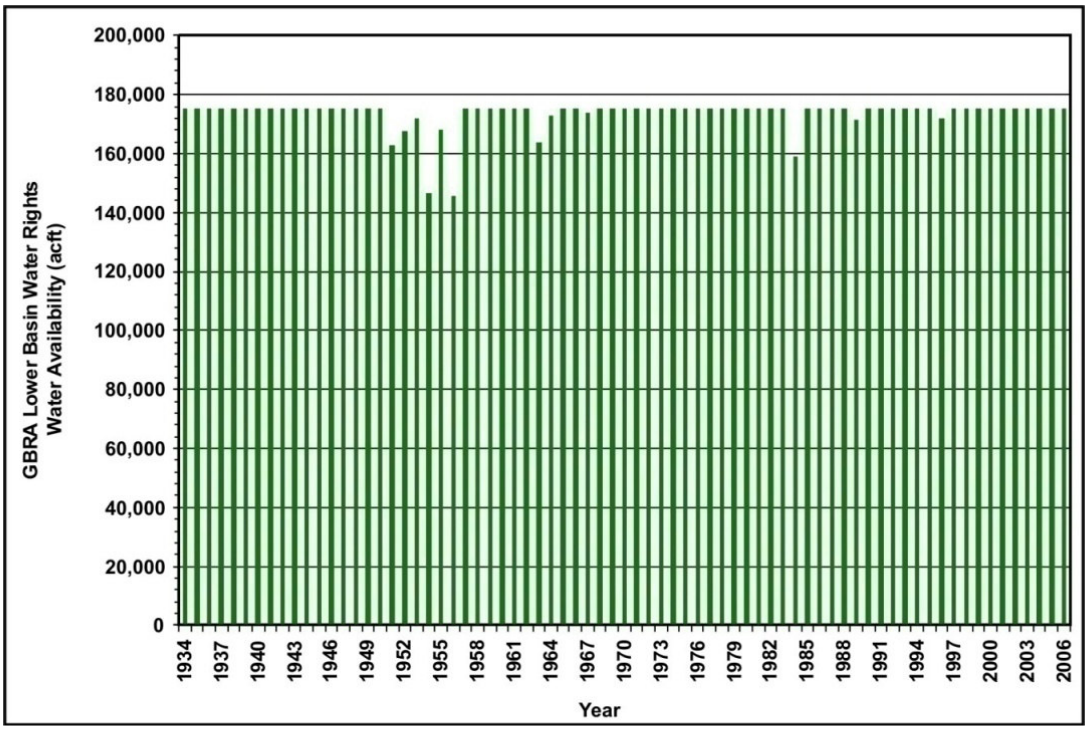


Figure 4C.13-2. GBRA Lower Basin Water Rights Annual Water Availability

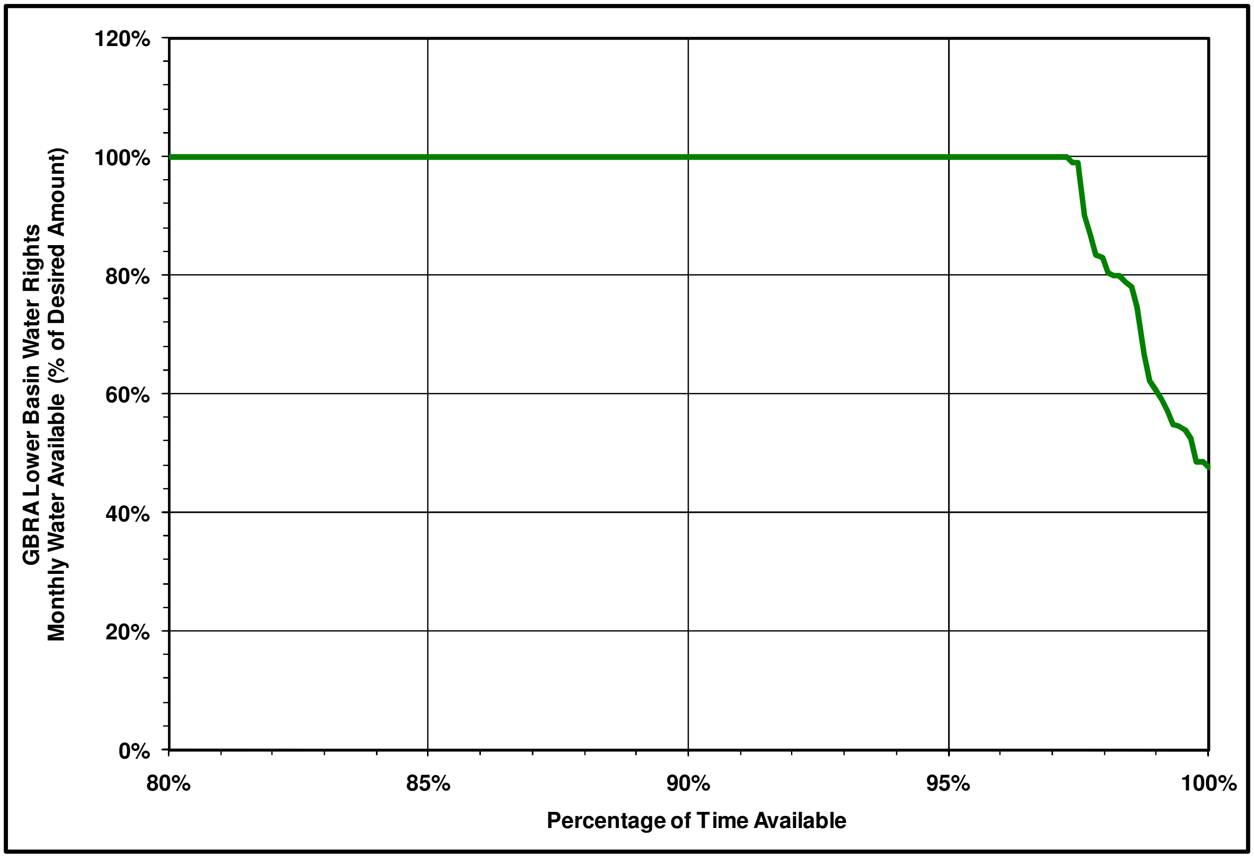


Figure 4C.13-3. GBRA Lower Basin Water Rights Monthly Reliability

4C.13.2.3 Firm Water Supply

As the GSA WAM is a monthly time-step model and flows in the lower Guadalupe River can, at times, be quite variable from day to day, it is important for GBRA planning purposes to refine the monthly estimates of water availability presented in Section 4C.13.2.2 and quantify water supplies that are reliable or firm on a daily basis. A specially-designed Microsoft Excel workbook was developed and applied to disaggregate monthly regulated streamflow values from the GSA WAM to daily values using historical daily streamflow patterns and obtain estimates of firm water supply available under the GBRA Lower Basin Water Rights on a daily basis. Historical daily streamflow patterns representative of the Guadalupe River near Tivoli are based on flows for the Guadalupe River at Victoria (USGS# 08176500), Coleto Creek near Victoria (USGS# 08177500), and the San Antonio River at Goliad (USGS# 08188500) during the 1990 through 2006 period and obtained from project files for a 1998 study[6] for the 1934 through 1989 period. These daily streamflow values were then used, along with applicable seasonal diversion patterns associated with type of use, to determine the firm supply available under the GBRA Lower Basin Water Rights on a daily basis. The firm water supply that is reliable on a daily basis throughout the most severe drought on record is shown in Figure 4C.13-4, along with comparable annual and monthly amounts based solely on monthly GSA WAM output. It is important to note that the firm supply in Figure 4C.13-4 does not account for any storage between diversion from the Guadalupe River and ultimate users. Dow, Seadrift Coke, Ineous Nitriles, and the Port Lavaca Water Treatment Plant do, however, have on-site storage that could be drawn upon for relatively short periods during which water from the river is limited or unavailable. Hence, firm water supply on a daily basis is actually incrementally greater than the amount shown in Figure 4C.13-4.

4C.13.2.4 Firm Water Supply Enhancement with Off-Channel Storage

Firm water supplies available on a daily basis under the GBRA Lower Basin Water Rights can be enhanced with development and integration of off-channel storage. Analyses of potential enhancement of firm water supplies with off-channel storage are based on:

a) Water availability calculated on a daily basis.

b) Simplified off-channel reservoir operations simulations assuming maximum and minimum water depths of 25 feet and 3.5 feet, respectively.

c) Delivery of water into the off-channel reservoir at a maximum rate of 50 cfs.

d) Historical net evaporation from the GSA WAM.

Firm water supply could be increased from 41,548 acft/yr to 69,917 acft/yr (28,369 acft/yr increase) with the addition of the 100 acre, 2,500 acft off-channel storage reservoir. The 500 acre, 12,500 acft off-channel reservoir could increase the firm water supply from 41,548 acft/yr to 101,117 acft/yr (59,569 acft/yr increase).

[6] HDR Engineering, Inc., "Guadalupe - San Antonio River Basin Model Modifications & Enhancements," Trans-Texas Water Program, West Central Study Area, Texas Water Development Board, San Antonio River Authority, et. al., March 1998.

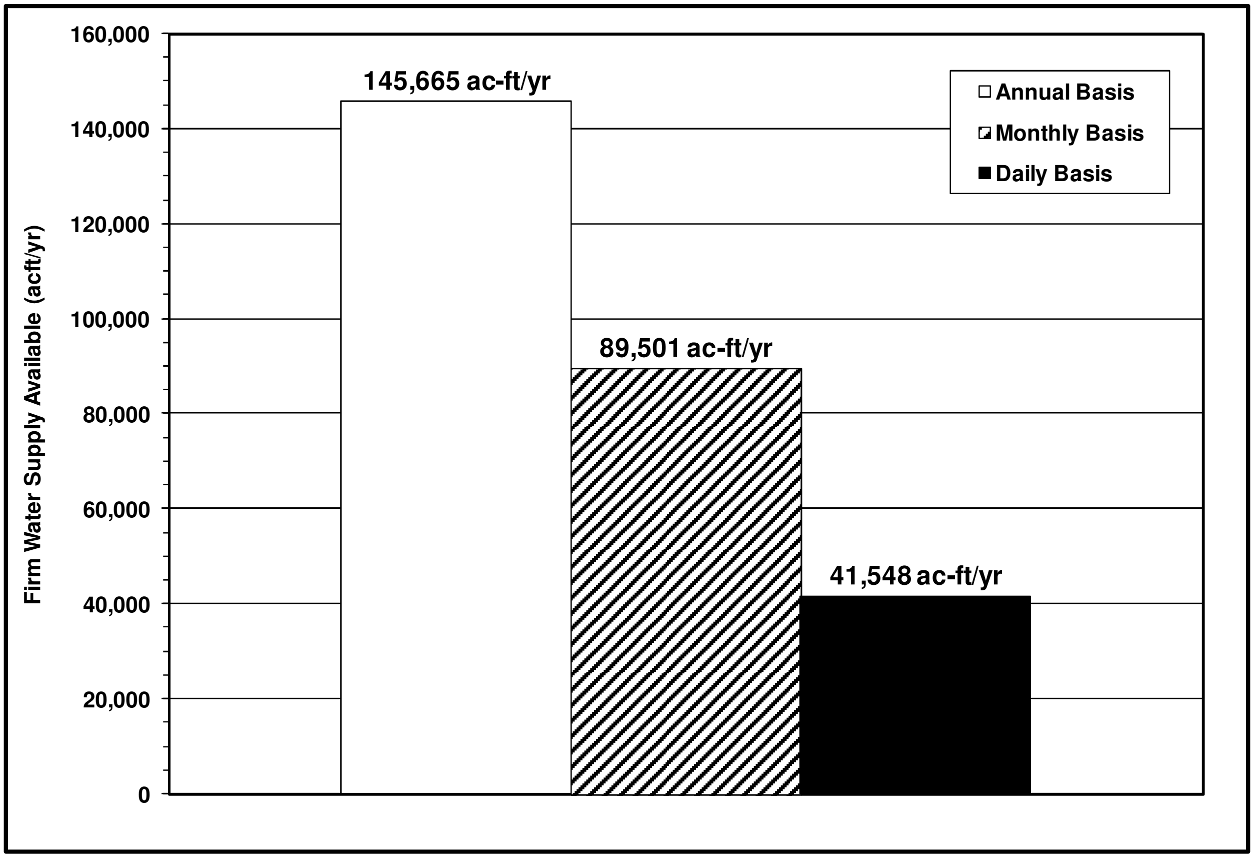


Figure 4C.13-4. Firm Water Supply on a Time-Step Basis

4C.13.3 Environmental Issues

The potential off-channel storage reservoir sites are located in Calhoun County, approximately two miles east of the intersection of State Highway (SH) 35 and SH 185. The approximate surface areas of these reservoirs are 100 and 500 acres. The total areas disturbed by the reservoir, embankments, and appurtenant facilities are approximately 125 and 625 acres, respectively.

Land uses found within the project areas include primarily farm, pasture, and range areas. U.S. Geological Survey land use and land cover data indicates that the project area contains approximately 65 percent cropland and pasture, and 35 percent shrub and brush rangeland.

The potential reservoir sites are located in the Gulf Coastal Plains of Texas Physiographic Province, specifically in the subprovince of the Coastal Prairies. This area is locally characterized as a nearly flat prairie composed of deltaic sands and muds which terminates at the

Gulf of Mexico and includes topography changes of less than one foot per mile. Elevation levels in the Coastal Prairies range from 0 to 300 feet above mean sea level.

4C.13.3.1 Vegetation

The potential reservoir sites are located within the Gulf Prairies and Marshes Vegetational Area. Gulf Prairies have slow surface drainage and elevations that range from sea level to 250 feet. These areas include nearly level and virtually undissected plains. Originally the Gulf Prairies were composed of tallgrass prairie and post oak savannah. However, tree species such as honey mesquite, and acacia, along with other trees and shrubs have increased in this area forming dense thickets in many places. Typical oak species found in this area include live oak (*Quercus virginiana*) and post oak (*Q. stellata*), in addition to huisache (*Acacia smallii*), black-brush (*A. rigidula*), and a dwarf shrub; bushy sea-ox-eye (*Borrichia frutescens*). Principal climax grasses of the Gulf Prairies include gulf cordgrass (*Spartina spartinae*), indiangrass (*Sorghastrum nutans*), and big bluestem (*Andropogon gerardii var. gerardii*). Prickly pear (*Opunita*) are common within this area along with forbs including asters (*Aster sp.*), poppy mallows (*Callirhoe sp.*), bluebonnets (*Lupinus sp.*), and evening primroses (*Oenothera sp.*). Gulf Marshes range from sea level to a few feet in elevation, and include low, wet marshy coast areas commonly covered with saline water. These salty areas support numerous species of sedges (*Carex* and *Cyperus sp.*), bulrushes (*Scirpus sp.*), rushes (*Juncus sp.*), and grasses. Aquatic forbs found in these areas generally include pepperweeds (*Lepidium sp.*), smartweeds (*Polygonum sp.*), cattails (*Typha domingensis*) and spiderworts (*Tradescantia sp.*) among others. Upland game and waterfowl find these low marshy areas to be excellent natural wildlife habitat.

4C.13.3.2 Threatened and Endangered Species

The Federal Endangered Species Act of 1973, as amended, prohibits the "take" of any threatened or endangered species. The term "take" under the ESA means "to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or attempt to engage in any such conduct." The term "harm" was further defined to include "significant habitat modification or degradation where it actually kills or injures wildlife by significantly impairing essential behavioral patterns, including breeding, feeding or sheltering." Designation of critical habitat areas has been established for the public knowledge where the publishing of such information would not cause harm to the species. Additional federal protection is extended to migratory birds, and bald and golden eagles under the Migratory Bird Treaty Act (MBTA) as amended, and the Bald and Golden Eagle Protection Act. Protection is also afforded to Texas state-listed species. The Texas Parks and Wildlife Department (TPWD) enforces the state regulations.

The MBTA protects most bird species, including, but not limited to, cranes, ducks, geese, shorebirds, hawks, and songbirds. Migratory bird pathways, stopover habitats, wintering areas, and breeding areas may occur within and adjacent to the proposed reservoir sites, and may be associated with wetlands, ponds, shorelines, riparian corridors, fallow fields and grasslands, and woodland and forested areas. Construction activities could disturb migratory bird habitats and/or species' activities.

Reasonable and prudent measures should be taken to avoid and minimize the potential effects of project activities on threatened and endangered species as well as bald eagles. Species' locations, activities, and habitat requirements should be considered based on U.S. Fish and Wildlife Service and TPWD recommendations.

4C.13.3.3 County-Listed Species

In Calhoun County, there may occur 32 state-listed endangered or threatened species and 17 federally-listed endangered or threatened wildlife species, according to the county lists of rare species published by the TPWD. A list of these species, their preferred habitat, and potential occurrence in Calhoun County is provided in Table 4C.13-2.

Inclusion in Table 4C.13-2 does not imply that a species will occur within the project area, but only acknowledges the potential for occurrence in Calhoun County. A more intensive field reconnaissance would be necessary to confirm and identify specific suitable habitat that may be present in the project area. In addition to county lists, HDR also reviewed the Texas Natural Diversity Database (TXNDD) map data for known occurrences of listed species within or near the proposed reservoir sites. This information indicated that there were reported sightings of the bald eagle (*Haliaeetus leucoephalus*), listed as a threatened species by the State within the surrounding area. No specific sightings of any endangered or threatened species were documented within the proposed reservoir sites. The presence or absence of potential habitat within an area does not confirm the presence or absence of a listed species. No species specific surveys were conducted in the project area for this report.

Table 4C.13-2.
Endangered, Threatened, and Species of Concern for Calhoun County

Common Name	***Scientific Name***	***Impact Value***	***Multiplier Based on Status***	***Adjusted Impact***	***Summary of Habitat Preference***	***Listing Entity***		***Potential Occurrence in County***
						USFWS	**TPWD**	
AMPHIBIANS								
Black-spotted newt	*Notophthalmus meridionalis*	*1*	*2*	*2*	Usually found in wet or sometimes wet areas in the Gulf Coastal Plain south of the San Antonio River.		T	Resident
Sheep frog	*Hypopachus variolosus*	*1*	*2*	*2*	Found in grassland and savanna; moist sites in arid areas.		T	Resident
BIRDS								
Bald eagle	*Haliaeetus leucoephalus*	*0*	*2*	*0*	Found primarily near rivers and large lakes.	DL	T	Possible Migrant
Brown pelican	*Pelecanus occidentalis*	*0*	*3*	*0*	*Largely coastal and near shore areas.*	DL	E	Resident
Eskimo curlew	*Numenius borealis*	*0*	*3*	*0*	Historic, nonbreeding.	LE	E	Historic Resident
Henslow's Sparrow	*Ammodramus henslowii*	*1*	*1*	*1*	Found in weedy fields or cut-over areas			Resident
Mountain Plover	*Charadrius montanus*	*1*	*1*	*1*	Non-breeding, shortgrass plains and fields			Nesting/Migrant
Northern Aplomado Falcon	*Falco femoralis septentrionalis*	*0*	*3*	*0*	Found in open country, especially savanna and open woodland.	LE	E	Resident
American Peregrine Falcon	*Falco peregrinus anatum*	*0*	*2*	*0*	Migrant and local breeder in West Texas.	DL	T	Possible Migrant
Arctic Peregrine Falcon	*Falco peregrinus tundrius*	*0*	*1*	*0*	Migrant throughout the state.	DL		Possible Migrant
Piping plover	*Charadrius melodus*	*0*	*2*	*0*	Wintering migrant along the Texas Gulf Coast.	LT	T	Migrant
Reddish Egret	*Egretta rufescens*	*1*	*2*	*2*	Resident of Texas Gulf coast.		T	Resident
Snowy Plover	*Charadrius alexandrines*	*0*	*1*	*0*	Potential migrant, winters along coast			Migrant
Sooty Tern	*Sterna fuscata*	*1*	*2*	*2*	Usually flies or hovers over water.		T	Resident
Southeastern Snowy Plover	*Charadrius alexandrines tenuirostris*	*0*	*1*	*0*	Wintering migrant along the Texas Gulf Coast.			Migrant
Western Burrowing Owl	*Athene cunicularia hypugaea*	*1*	*1*	*1*	Open grasslands, especially prairie, plains and savanna			Resident
White-faced Ibis	*Plegadis chihi*	*1*	*2*	*2*	Prefers freshwater marshes.		T	Resident
White-tailed Hawk	*Buteo albicaudatus*	*0*	*2*	*0*	Found near the coast on prairies.		T	Resident
Whooping Crane	*Grus americana*	*1*	*3*	*3*	Potential migrant	LE	E	Potential Migrant

Table 4C.13-2 (Continued)

Common Name	Scientific Name	Impact Value	Multiplier Based on Status	Adjusted Impact	Summary of Habitat Preference	Listing Entity		Potential Occurrence in County
						USFWS	TPWD	
Wood Stork	*Mycteria americana*	1	2	2	Forages in prairie ponds, ditches, and shallow standing water formerly nested in TX		T	Migrant
FISH								
American eel	*Anguilla rostrata*	1	1	1	Coastal waterways below reservoirs to gulf.			Resident
Opossum pipefish	*Microphis brachyurus*	1	2	2	Adults found in fresh or low salinity waters.		T	Resident
Smalltooth sawfish	*Pristis pectinata*	1	3	3	Found in bays, estuaries or river mouths.	LE	E	Resident
MAMMALS								
Black Bear	*Ursus americanus*	0	2	0	Inhabits bottomland hardwoods	T/SA;NL	T	Historic Resident
Jaguarundi	*Herpailurus yaguarondi*	0	3	0	Found in thick brushlands near water.	LE	E	Resident
Louisiana black bear	*Ursus americanus luteolus*	0	2	0	Possible transient.	LT	T	Transient
Ocelot	*Leopardus pardalis*	0	3	0	Found in dense chaparral thrickets; mesquite-thorn scrub and live oak motts.	LE	E	Resident
Plains Spotted Skunk	*Spilogale putorius interrupta*	1	1	1	Prefers wooded, brushy areas.			Resident
Red Wolf	*Canis rufus*	0	3	0	Extirpated.	LE	E	Historic Resident
West Indian manatee	*Trichechus manatus*	0	3	0	Gulf and bay systems.	LE	E	Resident
MUSSELS								
Creeper (squawfoot)	*Strophitus undulates*	1	1	1	Small to large streams			Resident
Pistolgrip	*Tritogonia verrucosa*	1	1	1	Aquatic, stable substrate. Red through San Antonio river basins.			Resident
PLANTS								
Threeflower broomweed	*Thurovia triflora*	1	1	1	Endemic: near coast.			Resident
REPTILES								
Atlantic hawksbill sea turtle	*Eretmochelys imbricate*	0	3	0	Found in Gulf and bay systems.	LE	E	Resident
Green sea turtle	*Chelonia mydas*	0	2	0	Gulf and bay systems.	LT	T	Resident
Gulf Saltmarsh snake	*Nerodia clarkii*	1	1	1	Found on saline flats.			Resident
Kemp's Ridley sea turtle	*Lepidochelys kempii*	0	3	0	Found in gulf and bay systems.	LE	E	Resident
Leatherback sea turtle	*Dermochelys coriacea*	0	3	0	Gulf and bay systems.	LE	E	Resident
Loggerhead sea turtle	*Caretta caretta*	0	2	0	Gulf and bay systems for juveniles, ocean for adults.	LT	T	Resident

Table 4C.13-2 (Concluded)

Common Name	Scientific Name	Impact Value	Multiplier Based on Status	Adjusted Impact	Summary of Habitat Preference	Listing Entity		Potential Occurrence in County
						USFWS	TPWD	
Texas diamondback terrapin	*Malaclemys terrapin littoralis*	1	1	1	Found in coastal marshes and tidal flats.			Resident
Texas Horned Lizard	*Phrynosoma cornutum*	1	2	2	Varied, sparsely vegetated uplands.		T	Resident
Texas scarlet snake	*Cemophora coccinea lineri*	1	2	2	Mixed hardwood scrub on sandy soils.		T	Resident
Texas Tortoise	*Gopherus berlandieri*	1	2	2	Open brush w/ grass understory.		T	Resident
Timber/Canebrake Rattlesnake	*Crotalus horridus*	1	2	2	Floodplains, upland pine, deciduous woodlands, riparian zones.		T	Resident

Source: TPWD, Annotated County List of Rare Species, Calhoun County, Updated May 4, 2009.

DL Delisted
PDL Proposed for Delisting
LE Federally listed endangered
LT Federally listed threatened
T/SA;NL Threatened by similarity of appearance but not listed
--- Not Federally or State Listed but considered a species of concern
E State Endangered
T State Threatened

4C.13.3.4 Cultural Resources

A review of the Texas Historical Commission Texas Historic Sites Atlas data base indicated that there are no historical markers, National Register Properties, or cemeteries listed within 500 feet of or within the proposed reservoir sites.

A request was made for archeological site records recorded within 500 feet of the proposed reservoir sites from the Texas Historical Commission's (THC) restricted Texas Archeological Sites Atlas. Information received from the THC indicates that there are no recorded sites found within the project area on the Green Lake, or Port Lavaca West quad maps. Although no sites have been recorded within the project area, this does not necessarily mean that sites are not present.

4C.13.4 Engineering and Costing

The cost estimates for the two off-channel reservoir sites of this water management strategy are shown in Tables 4C.13-3 and 4C.13-4. Included in the costs for the off-channel

Table 4C.13-3.
Cost Estimate Summary
GBRA Lower Basin Storage Project for 100 acre, 2,500 ac-ft OCR
September 2008 Prices

Item	Estimated Costs for Facilities (September 2008)
Capital Costs	
Off-Channel Reservoir (2,500 acft, 100 acres)	$12,938,000
Intake and Pump Station (360 HP, 34 MGD)	$7,897,000
Transmission Pipeline (42-in dia., 994 ft)	$1,566,000
Outlet Pipeline (72-in dia., 994 ft)	$786,000
Total Capital Cost	**$23,187,000**
Engineering, Legal Costs and Contingencies	$7,998,000
Environmental & Archaeology Studies and Mitigation	$317,000
Land Acquisition and Surveying (100 acres)	$ 304,000
Interest During Construction (2 years)	$1,994,000
Total Project Cost	**$33,800,000**
Annual Costs	
Debt Service (6 percent, 20 years)	$1,249,000
Reservoir Debt Service (6 percent, 40 years)	$1,294,000
Operation and Maintenance	
Intake, Pipeline, Pump Station	$221,000
Off-Channel Reservoir	$194,000
Pumping Energy Costs (46,592 kW-hr @ 0.09 $/kW-hr)	$4,000
Total Annual Cost	**$ 2,962,000**
Available Project Yield (acft/yr)	28,369
Annual Cost of Water ($ per acft)	$104
Annual Cost of Water ($ per 1,000 gallons)	$0.32

Table 4C.13-4.
Cost Estimate Summary
GBRA Lower Basin Storage Project for 500 acre, 12,500 ac-ft OCR
September 2008 Prices

Item	Estimated Costs for Facilities (September 2008)
Capital Costs	
Off-Channel Reservoir (12,500 acft, 100 acres)	$34,230,000
Intake and Pump Station (360 HP, 34 MGD)	$7,897,000
Transmission Pipeline (42-in dia., 6,979 ft)	$5,440,000
Outlet Pipeline (72-in dia., 994 ft)	$4,660,000
Total Capital Cost	**$52,227,000**
Engineering, Legal Costs and Contingencies	$17,774,000
Environmental & Archaeology Studies and Mitigation	$1,473,000
Land Acquisition and Surveying (100 acres)	$1,520,000
Interest During Construction (2 years)	$4,882,000
Total Project Cost	**$77,876,000**
Annual Costs	
Debt Service (6 percent, 20 years)	$2,172,000
Reservoir Debt Service (6 percent, 40 years)	$3,520,000
Operation and Maintenance	
Intake, Pipeline, Pump Station	$298,000
Off-Channel Reservoir	$513,000
Pumping Energy Costs (46,592 kW-hr @ 0.09 $/kW-hr)	$16,000
Total Annual Cost	**$6,519,000**
Available Project Yield (acft/yr)	59,569
Annual Cost of Water ($ per acft)	$109
Annual Cost of Water ($ per 1,000 gallons)	$0.34

reservoirs are raw water intakes and pump stations, transmission pipelines, and outlet pipelines. The OCR options also include cost of the reservoir and dam. Depending upon the location(s) and type(s) of use for water supplies associated with the off-channel reservoir, additional facilities and costs could include pipelines to customers and treatment. Inundated land and mitigation land acquisition and operation and maintenance costs were developed in accordance with the standard cost estimating procedures summarized in Appendix A.

The costs presented in Tables 4C.13-3 and 4C.13-4 are based on the firm yield increase associated with the implementation of each off-channel reservoir. The total project and annual costs, including debt service and operation and maintenance are $33,800,000 and $2,962,000 for the 2,500 acft OCR and $77,876,000 and $6,519,000 for the 12,500 acft OCR, respectively. These annual costs translate to unit costs of $104 per acft and $109 per acft for the 2,500 acft and 12,500 acft off-channel reservoirs, respectively.

4C.13.5 Implementation Issues

An institutional arrangement may be needed to implement this project including financing on a regional basis.

1. It will be necessary to obtain this permit:
   a. TCEQ storage permit.
2. Permitting, at a minimum, will require these studies:
   a. Habitat mitigation plan.
   b. Environmental studies.
   c. Cultural resources.
3. Land will need to be acquired through either negotiations or condemnation.
4. Relocations for these reservoir sites are expected to minimal, if any.

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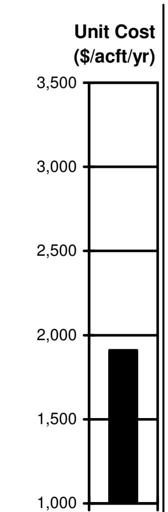
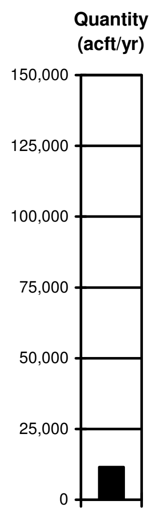
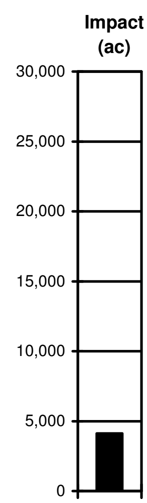
2011 South Central Texas Regional Water Plan
Water Management Strategy Summary Sheet







Name: **GBRA New Appropriation (Lower Basin)**

Description: Diversion and storage of water under a new appropriation in the lower basin from the Guadalupe River via the Calhoun Canal System. Facilities include Main Pump Station and Canal Upgrades (from 355 cfs to 500 cfs); New Intake and Pump Station from Main Canal (~250 cfs); 10-mile, 96-inch diameter Diversion Pipeline; Off-Channel Storage between 25,000 acft and 200,000 acft; and Integration.

***Decade Needed*:** 2020 - 2030

Cost, Quantity of Water, and Land Impacted

Unit Cost of Water:	**1,910**	**$/acft/yr**	**Raw Water at Reservoir with Integration**
Quantity of Water:	**11,300**	**acft/yr**	**Reliability = Firm**
Land Impacted:	**4,111**	**acres**	

Additional Considerations per Regional Water Planning Guidelines

Environmental Factors:

Wintering population of endangered Whooping Cranes at Aransas National Wildlife Refuge located adjacent to Lower San Antonio Bay. Surface water diversions from a Ecologically Significant Stream Segment per TPWD.

Impacts on Water Resources:

Some reductions in freshwater inflows to the Guadalupe Estuary associated with scalping high flows by the new appropriation.

Impacts on Agricultural & Natural Resources:

Not applicable.

Other Relevant Factors per SCTRWPG:

Project subject to senior water rights, full application of environmental flow standards adopted pursuant to Section 11.1471 of the Texas Water Code, and the TCEQ permitting process. If fresh groundwater from the lower Guadalupe Basin is added to this strategy, then the plan must be amended in order for the modified strategy to be recommended for implementation.

Comparison of Strategies to Meet Needs:

No conflicts with other recommended water management strategies.

Interbasin Transfer Issues:

Not applicable.

Third-Party Impacts of Voluntary Transfers:

Not applicable.

Regional Efficiency:

Provides short-term water supplies to GBRA's lower basin customers and long-term water supplies through out the GBRA statutory district.

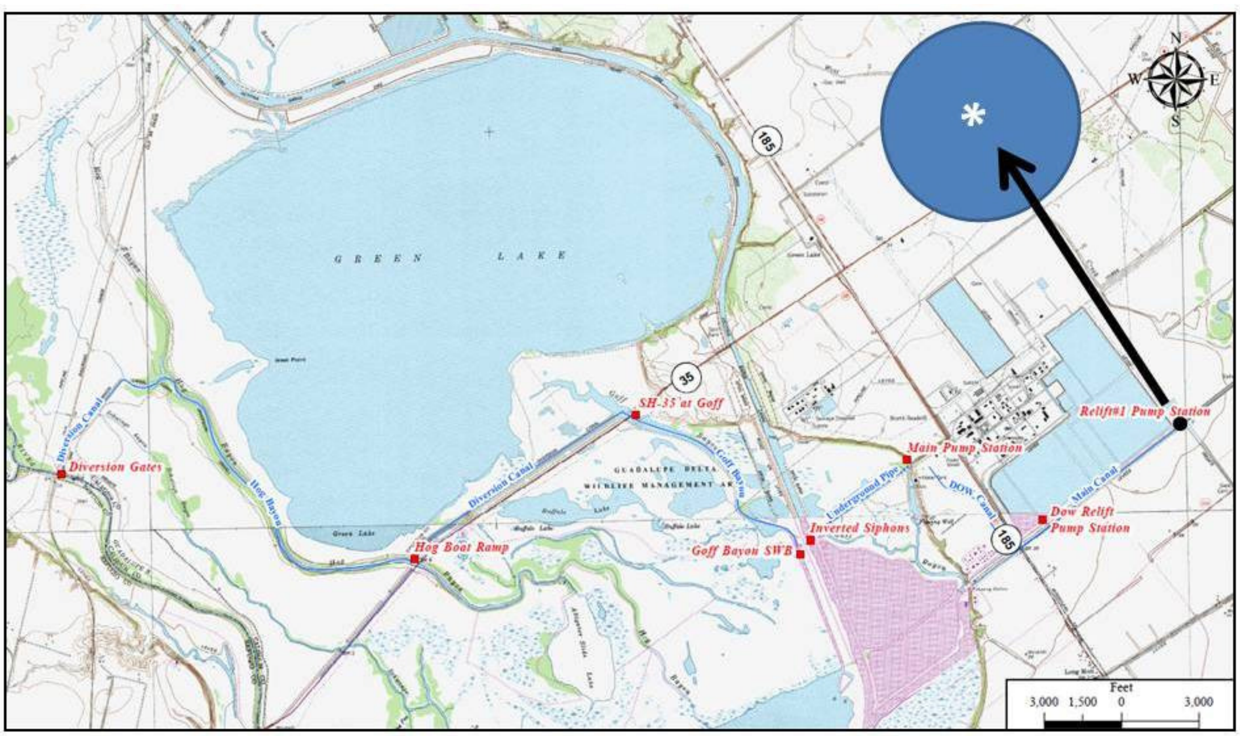
Water Quality Considerations:

The off-channel reservoir will aid in suspending river diversions to avoid poor water quality during flood events and facilitate maintenance of diversion facilities without stopping reservoir deliveries.

4C.14 GBRA New Appropriation (Lower Basin)

4C.14.1 Description of Water Management Strategy

The Guadalupe-Blanco River Authority (GBRA) is in the planning and permitting stages of a new appropriation for diversion of up to 189,484 acft/yr from the Guadalupe River in Calhoun County using existing gravity-flow diversion facilities located immediately upstream of GBRA's Saltwater Barrier and Diversion Dam at a rate of diversion not to exceed 500 cfs (within the existing 622 cfs maximum authorized diversion rate) and authorization to impound up to 200,000 acft in Calhoun County (Figure 4C.14-1). The diversion and storage will serve municipal and industrial water users in GBRA's ten-county statutory district and are the subject of Application No. 12482 for surface water rights pending before the Texas Commission on Environmental Quality (TCEQ). Implementation of this water management strategy will help to meet projected demands for current and future GBRA customers through the next 50 years and beyond.



*Location to be determined and size based on 25,000 acft at 25-foot depth

Figure 4C.14-1. Project Location for GBRA New Appropriation (Lower Basin)

4C.14.2 Water Availability

4C.14.2.1 Water Availability Modeling

The GBRA New Appropriation (Lower Basin) water management strategy (WMS) is evaluated using the Guadalupe-San Antonio Basin Water Availability Model (GSAWAM), as modified for regional water planning purposes. This water management strategy is subject to full application of environmental flow standards adopted pursuant to Section 11.1471 of the Texas Water Code when they become available. During the simulation period from 1934-1989, availability subject to an assumed maximum diversion rate of 253 cfs and place-holder environmental flow restrictions derived using Consensus Criteria for Environmental Flow Needs (CCEFN) (Table 4C.14-1 and Figure 4C.14-2) is calculated for diversions from the Guadalupe River. The GSAWAM is a monthly timestep model, however, the GSAWAM, as modified for regional water planning purposes, has a subroutine designed specifically to perform supplemental calculations that quantify water availability for a new water right subject to daily flow variations, senior water rights, instantaneous instream flow restrictions, and an instantaneous maximum diversion rate.

The GSAWAM is used to quantify water available for diversion under the new appropriation (Table 4C.14-2). Hydrologic simulations and calculations are performed subject to the General Assumptions for Applications of Hydrologic Models, as adopted by the SCTRWPG for the 2011 Regional Water Plan.

4C.14.2.2 Modeling Results

GSAWAM simulations were performed for off-channel reservoir sizes of 25,000 acft, 50,000 acft, 100,000 acft, 150,000 acft, and 200,000 acft under two environmental flow criteria scenarios—CCEFN and no environmental flow restrictions. With the outcome of the Environmental Flows process promulgated by Senate Bill 3 of the 80th Texas Legislature unknown, these two environmental flow scenarios are used to establish a range of potential firm yields for a range of potential reservoir sizes. Table 4C.14-3 and Figure 4C.14-3 show the results from the simulations at five off-channel reservoir sizes.

Table 4C.14-1.
Environmental Flow Restrictions for New Appropriation from the Guadalupe River in Calhoun County

Month	Natural Median Flow for Guadalupe River at Saltwater Barrier (cfs)	Natural Quartile Flow for Guadalupe River at Saltwater Barrier (cfs)	Natural 7Q2 Flow for Guadalupe River at Saltwater Barrier (cfs)	Maximum Harvest (MaxH) Guadalupe Estuary Inflow Recommendation Pro-rated to Saltwater Barrier (acft/mo)
JAN	1,477	899	742	96,714
FEB	1,670	999	742	108,020
MAR	1,483	927	742	45,591
APR	1,513	914	742	45,591
MAY	1,963	1,038	742	193,602
JUN	1,814	962	742	141,505
JUL	1,279	742*	742	77,067
AUG	1,022	742*	742	76,823
SEP	1,224	742*	742	45,591
OCT	1,361	746	742	45,591
NOV	1,365	861	742	64,212
DEC	1,356	837	742	57,576

*Natural 7Q2 exceeds natural quartile flow

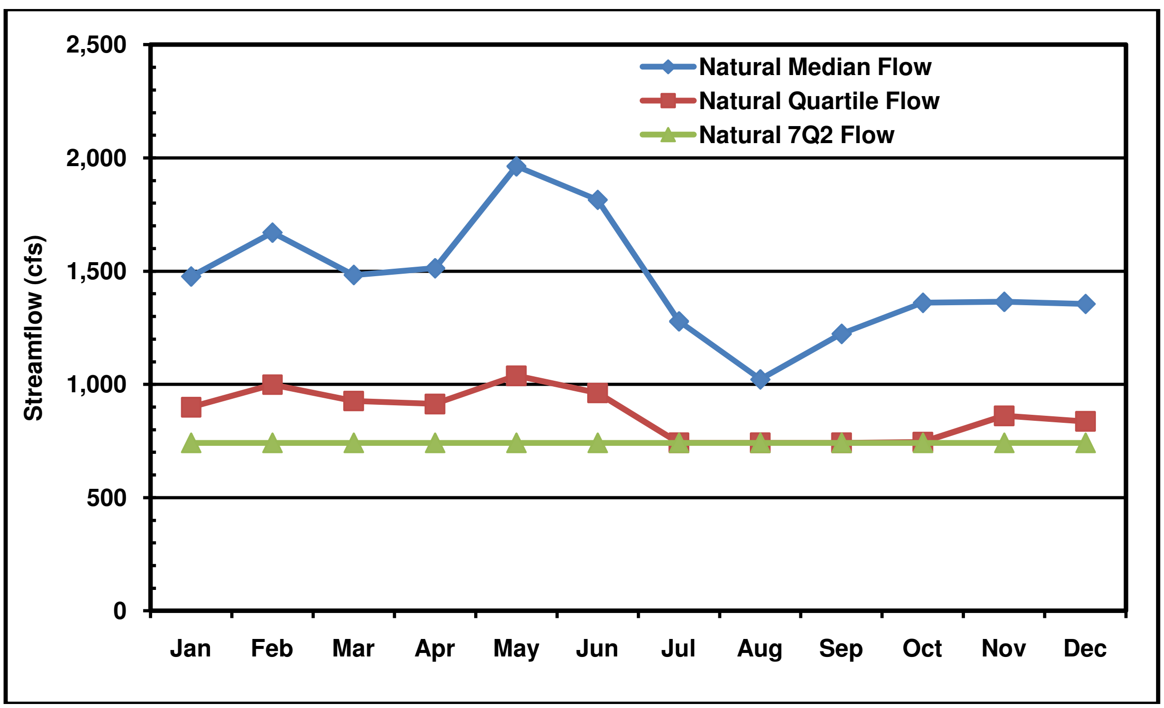


Figure 4C.14-2. Instream Flow Restrictions for Diversions from the Guadalupe River at the Saltwater Barrier

The firm yield is greatly influenced by the environmental flow criteria chosen. Under the application of CCEFN, diversions from the river are limited, and as such, there is a point at which the evaporative loss from the reservoir is large enough to cause the firm yield to decrease with increasing reservoir size. Under the application of CCEFN, the ideal reservoir size appears to be somewhere between 50,000 acft and 150,000 acft. Without environmental flow criteria, this is not the case and the firm yield continues to increase as the reservoir size increases throughout the range of sizes simulated. For a 100,000 acft off-channel reservoir, long-term average net evaporation loss is 7,629 acft/yr (67.5 percent of the firm yield) under CCEFN and is 7,647 acft/yr (17.1 percent of the firm yield) without environmental flow restrictions.

Table 4C.14-2.
Water Availability to GBRA New Appropriation (Lower Basin)

Year	Monthly Availability by Year (acft)												Total
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
1934	15,556	10,946	15,556	13,186	0	0	15,556	0	0	0	14,760	5,416	90,976
1935	742	6,018	3,273	8,036	15,124	15,054	13,027	710	14,789	12,895	9,683	15,206	114,557
1936	9,606	8,123	5,122	409	15,389	8,889	15,556	5,249	15,043	15,556	15,054	14,406	128,401
1937	1,685	12,023	15,425	6,862	0	14,119	0	0	0	1,779	0	15,067	66,961
1938	13,879	9,032	14,507	11,899	15,205	6,226	0	0	0	0	0	1,291	72,039
1939	77	0	0	0	0	563	2,902	0	16	0	0	0	3,557
1940	0	331	0	620	0	5,248	11,902	0	0	4,295	14,377	15,225	51,999
1941	13,288	13,738	15,556	15,054	15,556	15,054	15,556	2,834	5,433	13,712	4,813	13,381	143,973
1942	0	13,008	0	9,770	9,716	0	15,063	15,475	14,298	15,556	11,137	14,807	118,829
1943	5,018	7,859	14,597	0	4,221	5,423	2,715	0	59	0	728	2,142	42,762
1944	15,369	6,252	15,556	8,037	14,667	7,312	0	0	12,508	1,836	2,729	15,003	99,267
1945	13,698	14,050	15,556	15,054	10,194	6,074	0	15,556	0	5,718	0	1,132	97,032
1946	4,963	13,681	14,082	8,792	6,523	14,022	0	10,036	15,054	15,556	15,054	13,573	131,335
1947	15,539	4,516	8,135	13,102	14,834	2,984	0	408	0	0	0	0	59,518
1948	0	5,321	956	0	3,274	0	0	335	3,009	0	0	0	12,895
1949	0	555	3,578	10,603	8,793	3,007	4,671	0	0	11,052	134	3,007	45,401
1950	0	219	0	1,643	0	2,115	0	0	0	0	0	0	3,976
1951	0	0	0	0	6,860	7,482	0	0	8,399	0	0	0	22,740
1952	0	0	0	2,461	805	2,667	0	0	9,617	0	186	6,799	22,536
1953	1,476	335	0	267	3,640	0	0	4,169	5,898	4,014	0	502	20,302
1954	0	0	0	0	261	0	0	0	0	0	0	0	261
1955	0	502	0	0	1,418	627	0	0	672	0	0	0	3,219
1956	0	0	0	0	37	0	0	0	0	0	0	1,115	1,152
1957	0	99	10,825	10,381	15,183	14,265	0	0	4,014	14,769	15,054	12,582	97,172

Table 4C.14-2 (Concluded)

Year	Monthly Availability by Year (acft)												Total
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
1958	15,556	14,050	15,556	12,120	14,464	9,069	2,966	0	12,140	15,556	15,054	15,556	142,086
1959	7,810	14,050	6,218	14,384	11,189	5,928	696	3,084	0	14,367	5,457	9,384	92,566
1960	10,505	9,534	10,126	3,288	7,274	6,425	13,137	15,229	156	13,099	15,054	15,556	119,383
1961	15,556	14,050	15,556	12,534	1,266	11,807	15,556	0	11,258	2,541	12,435	0	112,558
1962	0	139	0	780	502	2,803	0	0	706	0	156	5,195	10,280
1963	0	929	0	0	0	0	0	0	0	0	0	0	929
1964	0	2,134	4,557	0	0	875	0	0	4,661	502	0	0	12,729
1965	4,118	13,218	1,364	1,723	12,746	13,815	0	0	0	10,250	8,798	15,512	81,543
1966	14,898	7,025	9,366	14,250	13,541	7,202	1,559	0	3,015	3,912	0	0	74,768
1967	0	0	0	0	418	0	0	814	13,240	15,556	13,766	14,972	58,766
1968	14,932	14,050	15,556	15,054	15,556	15,054	15,122	3,418	13,168	9,785	3,934	14,404	150,033
1969	12,545	11,344	14,949	15,014	15,330	8,702	0	0	230	12,050	9,266	10,561	109,991
1970	11,448	10,538	15,556	14,895	15,342	15,054	2,091	0	1,279	4,259	0	0	90,461
1971	0	0	0	0	0	0	0	10,803	15,054	15,556	15,054	15,556	72,022
1972	9,696	9,534	6,819	0	14,516	15,054	15,232	2,697	84	14,461	15,054	0	103,147
1973	5,993	4,771	11,076	14,731	7,025	14,243	15,556	15,556	15,054	15,556	15,054	15,556	150,170
1974	15,556	14,050	13,120	4,714	2,509	7,256	0	6,072	15,054	15,556	15,054	15,556	124,496
1975	15,556	14,050	15,556	15,054	15,556	15,054	15,556	15,556	12,155	5,160	10,947	7,566	157,765
1976	6,113	0	482	14,321	15,556	15,054	15,005	7,641	9,480	15,211	15,054	15,556	129,472
1977	15,556	14,050	15,556	15,054	15,556	15,054	12,862	209	4,051	2,957	13,389	443	124,738
1978	3,020	9,129	516	1,554	0	5,618	0	14,826	15,054	12,676	11,173	9,618	83,184
1979	15,556	14,050	15,556	15,054	15,556	15,054	15,556	14,952	15,054	0	0	73	136,461
1980	11,040	4,790	0	0	11,627	0	0	989	3,658	1,592	853	0	34,549
1981	1,720	0	9,234	7,431	5,018	15,054	15,556	15,556	15,054	15,556	15,054	12,941	128,173
1982	7,620	12,677	7,419	0	13,614	4,967	0	0	0	798	13,318	99	60,512
1983	0	5,479	10,291	695	1,717	6,775	10,454	0	2,435	5,919	66	0	43,831
1984	1,799	0	1,925	0	0	0	0	0	0	7,551	516	808	12,598
1985	9,967	5,215	14,799	15,054	10,014	14,626	13,294	0	242	11,074	14,693	15,556	124,532
1986	8,995	11,284	4,705	0	7,363	14,989	0	0	5,978	14,794	15,054	15,556	98,718
1987	15,556	14,050	15,556	13,389	14,110	15,054	15,556	15,556	14,912	14,757	14,293	13,511	176,299
1988	4,213	3,190	4,229	0	0	626	1,167	0	0	0	0	0	13,426
1989	97	0	0	444	3,925	786	0	0	0	0	0	0	5,251
MAX	15,556	14,050	15,556	15,054	15,556	15,054	15,556	15,556	15,054	15,556	15,054	15,556	176,299
AVG	6,541	6,678	7,292	6,388	7,553	7,199	5,248	3,531	5,571	6,925	6,647	6,968	76,541
MIN	0	0	0	0	0	0	0	0	0	0	0	0	261

Table 4C.14-3.
GBRA Lower Basin New Appropriation Firm Yield (acft/yr)

Reservoir Size (acft)	CCEFN			No Environmental Criteria		
	Firm Yield (acft/yr)	Long-Term Average Annual Diversion (acft/yr)	Maximum Annual Diversion (acft/yr)	Firm Yield (acft/yr)	Long-Term Average Annual Diversion (acft/yr	Maximum Annual Diversion (acft/yr)
25,000	5,300	7,103	30,582	24,100	26,038	44,692
50,000	9,000	12,524	59,450	35,000	38,761	82,850
100,000	11,300	18,596	97,365	44,600	52,021	130,080
150,000	11,900	23,169	97,365	53,200	64,346	133,673
200,000	11,400	26,716	137,997	61,800	76,683	172,811

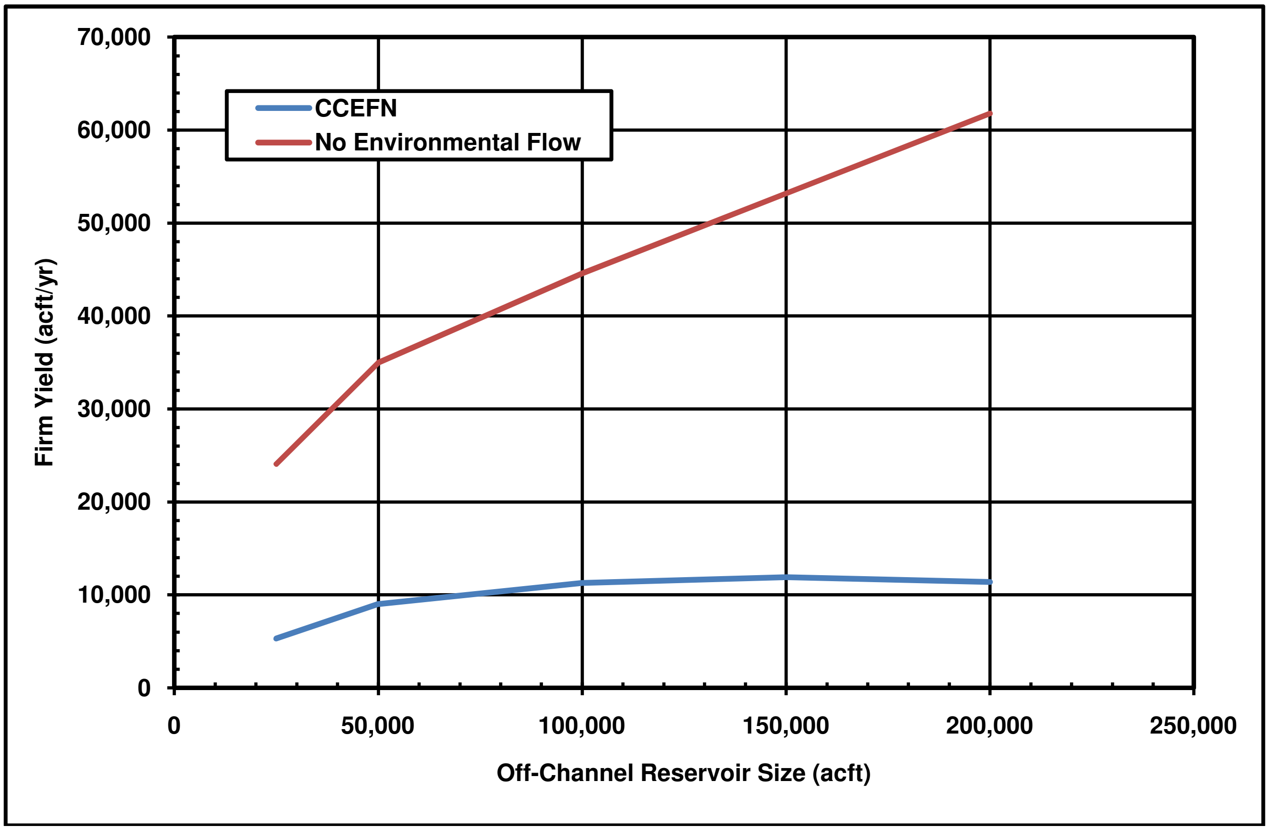


Figure 4C.14-3. GBRA Lower Basin New Appropriation Firm Yield vs. Off-Channel Reservoir Size

With any new project in the Guadalupe-San Antonio River Basin, there is always concern with the effects the project will have on freshwater inflows to the Guadalupe Estuary. Figures 4C.14-4 and 4C.14-5 illustrate simulated freshwater inflows to the Guadalupe Estuary with and without implementation of this water management strategy. The data labeled "With GBRA Lower Basin New Application" in Figures 4C.14-4 and 4C.14-5 are from Region L GSA WAM simulations including an 100,000 acft off-channel reservoir and annual diversion of the firm yield as reported in Table 4C.14-3.

GBRA is applying to the Texas Commission on Environmental Quality (TCEQ) for two new water rights to divert unappropriated flows of the Guadalupe River. One water right application (No. 12378) seeks to divert up to 75,000 acft/yr from the Guadalupe River in Gonzales County, in the Middle Guadalupe River Basin. The other application (No. 12482) seeks to divert up to 189,484 acft/yr from the Guadalupe River in Calhoun County, in the Lower Guadalupe River Basin. The lower basin application is in addition to water already permitted for diversion under existing rights held jointly by GBRA and Union Carbide Corporation (Dow Chemical Company).

The amount of water petitioned in both applications will have the potential to be available for diversion primarily in non-drought years for two reasons. First, the new water rights will have brand new priority dates, so the right to divert under those water rights will be junior (last in time) relative to all existing water rights. Second, diversions of this new water will be subject to environmental streamflow conditions to be imposed by the TCEQ for the protection of San Antonio Bay and estuary system. GBRA acknowledges the importance of ensuring that those rights are conditioned in order to ensure strong protection of instream flows and freshwater inflows. Accordingly, GBRA indicates its commitment that any permits issued pursuant to the applications, regardless of timing, will be made subject to the full application of environmental flow standards adopted pursuant to Section 11.1471 of the Texas Water Code that are applicable to affected portions of the Guadalupe River and to the San Antonio Bay estuary system.

4C.14.3 Environmental Issues

The GBRA New Appropriation (Lower Basin) water management strategy includes the diversion of water from the Guadalupe River via the Calhoun Canal Systems to an off-channel reservoir at a location yet to be determined in Calhoun County. The off-channel reservoir will facilitate water storage to be utilized by municipal and industrial operations. Additional facilities needed for this new water appropriation strategy will include upgrades to the existing Main Pump Station and the Calhoun Canal System, a new pump station and intake from the GBRA Main Canal, and a 96-inch diameter diversion pipeline estimated to be 10 miles in length.

The project area is located in the Gulf Coastal Plains of Texas Physiographic Province, specifically in the subprovince of the Coastal Prairies.1 This area is locally characterized as a nearly flat prairie composed of deltaic sands and muds which terminates at the Gulf of Mexico and includes topography changes of less than one foot per mile. Elevation levels in the Coastal Prairies range from 0 to 300 feet above mean sea level. Land uses found within the proposed on-site storage area include primarily farm, industrial, pasture and range areas.

The off-channel reservoir area is found within the Gulf Prairies and Marshes Vegetational Area.[2] Gulf Prairies have slow surface drainage and elevations that range from sea level to 250 feet. These areas include nearly level and virtually undissected plains. Originally the Gulf Prairies were composed of tallgrass prairie and post oak savannah. However tree species such as honey mesquite, and acacia, along with other trees and shrubs have increased in this area

[1] Bureau of Economic Geology. 1996. Physiographic map of Texas., The University of Texas at Austin, Austin, Texas.
[2] Gould, F. W.,1975. "The Grasses of Texas," Texas A&M University Press, College Station, Texas,.

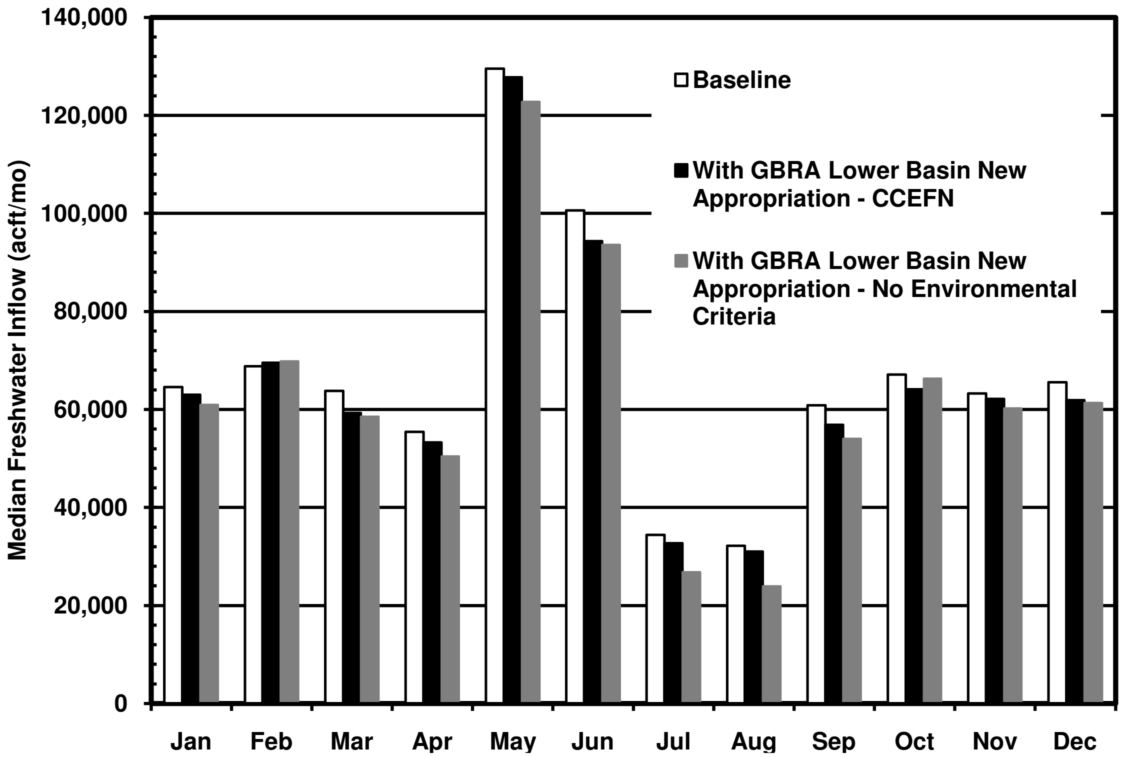


Figure 4C.14-4. Monthly Medians of Freshwater Inflows to the Guadalupe Estuary

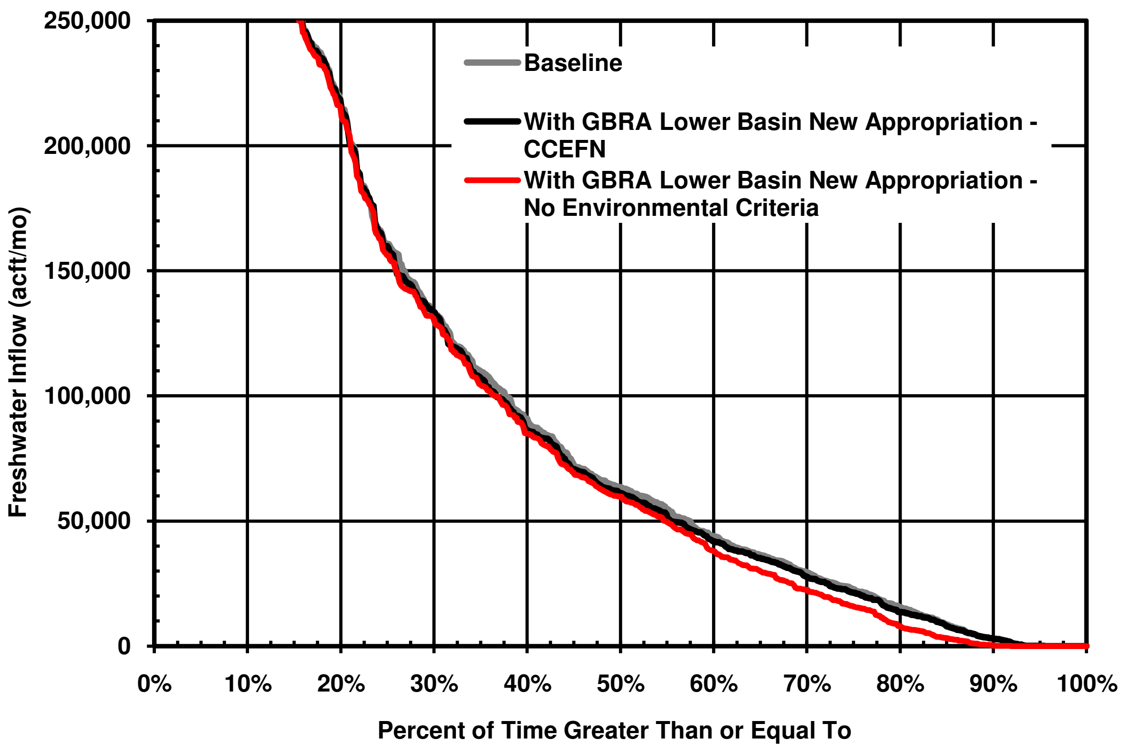


Figure 4C.14-5. Frequency of Freshwater Inflows to the Guadalupe Estuary

forming dense thickets in many places. Typical oak species found in this area include live oak (*Quercus virginiana*) and post oak (*Q. stellata*), in addition to huisache (*Acacia smallii*), black-brush (*A. rigidula*), and a dwarf shrub; bushy sea-ox-eye (*Borrichia frutescens*). Principal climax grasses of the Gulf Prairies include gulf cordgrass (*Spartina spartinae*), indiangrass (*Sorghastrum nutans*), and big bluestem (*Andropogon gerardii var. gerardii*). Prickly pear (*Opunita* spp.) are common within this area along with forbs including asters (*Aster* sp.), poppy mallows (*Callirhoe* sp.), bluebonnets (*Lupinus* sp.), and evening primroses (*Oenothera* spp.). Gulf Marshes range from sea level to a few feet in elevation, and include low, wet marshy coast areas commonly covered with saline water. These salty areas support numerous species of sedges (*Carex* and *Cyperus* sp.), bulrushes (*Scirpus* sp.), rushes (*Juncus* sp.), and grasses. Aquatic forbs found in these areas generally include pepperweeds (*Lepidium* sp.), smartweeds (*Polygonum* sp.), cattails (*Typha domingensis*) and spiderworts (*Tradescantia* sp.) among others. Upland game and waterfowl find these low marshy areas to be excellent natural wildlife habitat.

The federal Endangered Species Act of 1973, as amended, prohibits the "take" of any threatened or endangered species. The term "take" under the ESA means "to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or attempt to engage in any such conduct." The term "harm" was further defined to include "significant habitat modification or degradation where it actually kills or injures wildlife by significantly impairing essential behavioral patterns, including breeding, feeding or sheltering." Designation of critical habitat areas has been established for the public knowledge where the publishing of such information would not cause harm to the species. Additional federal protection is extended to migratory birds, and bald and golden eagles under the Migratory Bird Treaty Act (MBTA) as amended, and the Bald and Golden Eagle Protection Act. Protection is also afforded to Texas state-listed species. The Texas Parks and Wildlife Department (TPWD) enforces the state regulations.

The MBTA protects most bird species, including, but not limited to, cranes, ducks, geese, shorebirds, hawks, and songbirds. Migratory bird pathways, stopover habitats, wintering areas, and breeding areas may occur within and adjacent to the on-site storage area, and may be associated with wetlands, ponds, shorelines, riparian corridors, fallow fields and grasslands, and woodland and forested areas. On-site storage construction activities could disturb migratory bird habitats and/or species' activities.

Reasonable and prudent measures should be taken to avoid and minimize the potential effects of the proposed project activities on threatened and endangered species as well as bald eagles. Species' locations, activities, and habitat requirements should be considered based on U.S. Fish and Wildlife Service (USFWS) and TPWD recommendations.

In Calhoun County there may occur 32 state-listed endangered or threatened species and 17 federally-listed endangered or threatened wildlife species, according to the county lists of rare species published by the TPWD. A list of these species, their preferred habitat and potential occurrence in Calhoun County is provided in Table 4C.14-4.

Inclusion in Table 4C.14-4 does not imply that a species will occur within the project area, but only acknowledges the potential for its occurrence in Calhoun County. A more intensive field reconnaissance would be necessary to confirm and identify specific suitable habitat that may be present in the project area.

Four bird species federally or state listed as endangered are included in the project area. These include the Eskimo curlew (*Numenius borealis*), brown pelican (*Pelecanus occidentalis*), northern aplomado falcon (*Falco femoralis septentrionalis*), and whooping crane (*Grus americana*). The Eskimo curlew is a historic resident of the area, the northern aplomado falcon and the brown pelican are current residents. The brown pelican is listed as endangered by the state, but has recently been delisted by USFWS. The whooping crane is a seasonal migrant which could pass through the project area. The main whooping crane flock nests in Canada and migrates annually to their wintering grounds in and around the Aransas National Wildlife Refuge near Rockport on the Texas coast. Whooping cranes occasionally utilize wetlands as an incidental rest stop during this migration. Habitat elements which are attractive to several of these bird species may be present on or adjacent to the proposed off-channel reservoir site or pipeline route.

Avian species listed by the State of Texas as threatened include the peregrine falcon (*Falco peregrinus*), reddish egret (*Egretta rufescens*), sooty tern (*Sterna fuscata*), white-faced ibis (*Plegadis chihi*), white-tailed hawk (*Buteo albicaudatus*), wood stork (*Mycteria Americana*), piping plover (*Charadrius melodus*), and bald eagle (*Haliaeetus leucocephalus*). The peregrine falcon includes two subspecies which migrate across the state from more northern breeding areas in the U.S. and Canada to winter along the coast. The majority of nesting bald eagle pairs currently reported are found along major rivers and near reservoirs in Texas. Bald eagles are opportunistic predators, feeding primarily on fish captured in the shallow water of both lakes and streams or scavenged food sources. These birds may utilize tall trees near perennial water as

Table 4C.14-4. Endangered, Threatened, and Species of Concern for Calhoun County

Common Name	Scientific Name	Impact Value	Multiplier Based on Status	Adjusted Impact	Summary of Habitat Preference	Potential Occurrence in County	Federal Status	State Status
BIRDS								
Peregrine falcon	*Falco peregrinus anatum* (American)	0	2	0	Open county; cliffs	Nesting/Migrant	DL	T
	Falco peregrinus tundrius (Arctic)	0	1	0	Open county; cliffs	Nesting/Migrant	DL	
Bald eagle	*Haliaeetus leucoephalus*	1	2	2	Large bodies of water with nearby resting sites	Nesting/Migrant	DL	T
Brown pelican	*Pelecanus occidentalis*	1	3	3	Coastal inlands for nesting, shallow gulf and bays for foraging	Resident	DL	E
Eskimo curlew	*Numenius borealis*	0	3	0	Historic and non-breeding	Historic Resident	LE	E
Henslow's sparrow	*Ammodramus henslowii*	1	1	1	Wintering individuals found in weedy fields or cut-over areas.	Migrant		
Mountain plover	*Charadrius montanus*	1	1	1	Breeding, nesting on shortgrass prairie.	Resident		
Northern Aplomado Falcon	*Falco femoralis septentrionalis*	1	3	3	Found in open country, especially savanna and open woodland.	Resident	LE	E
Piping plover	*Charadrius melodus*	1	2	2	Beaches and flats of coastal Texas	Migrant	LT	T
Reddish egret	*Egretta rufescens*	1	2	2	Coastal inlands for nesting, coastal marshes for foraging	Resident		T
Snowy plover	*Charadrius alexandrinus*	1	1	1	Potential migrant, wintering along the coast	Migrant		
Sooty tern	*Sterna fuscata*	1	2	2	Catches small fish as it hovers or flies over water	Resident		T
Southeastern snowy plover	*Charadrius alexandrinus tenuirostris*	1	1	1	Wintering migrant along coast.	Migrant		
Western burrowing owl	*Athene cunicularia hypugaea*	1	1	1	Open grasslands, especially prairie.	Resident		
Western snowy plover	*Charadrius alexandrinus nivosus*	0	1	0	Uncommon breeder in Panhandle. Potential migrant.	Migrant		
White-faced ibis	*Plegadis chihi*	1	2	2	Prefers freshwater marshes	Resident		T
White-tailed hawk	*Buteo albicaudatus*	0	2	0	Coastal prairies, savannahs and marshes in Gulf Coastal Plain	Resident		T
Whooping crane	*Grus Americana*	1	3	3	Winters in coastal marshes	Migrant	LE	E

Table 4C.14-4 (Continued)

Common Name	Scientific Name	Impact Value	Multiplier Based on Status	Adjusted Impact	Summary of Habitat Preference	Potential Occurrence in County	Federal Status	State Status
Wood stork	*Mycteria Americana*	1	2	2	Forages in prairie ponds, ditches and shallow standing water; formerly nested in Texas	Migrant		T
MAMMALS								
Black bear	*Ursus americanus*	0	2	0	Possible as transient in bottomland hardwoods and inaccessible forested areas	Historic	T/SA;NL	T
Jaguarundi	*Herpailurus yaguarondi*	1	3	3	Thick brushlands near water.	Resident	LE	E
Louisiana black bear	*Ursus americanus luteolus*	0	2	0	Possible as transient in bottomland hardwoods and inaccessible forested areas	Historic	LT	T
Ocelot	*Leopardus pardalis*	1	3	3	Dense chaparral thickets; mesquite-thorn shrub and live oak stands.	Resident	LE	E
Plains spotted skunk	*Spilogale putorius interrupta*	1	1	1	Open fields, and prairies.	Resident		
Red wolf	*Canis rufus*	0	3	0	Extirpated	Historic	LE	E
West Indian manatee	*Trichechus manatus*	0	3	0	Gulf and bay system; opportunistic, aquatic herbivore	Aquatic Resident	LE	E
AMPHIBIANS								
Black-spotted newt	*Notophthalmus meridionalis*	1	2	2	Ponds and resacas in south Texas	Resident		T
Sheep frog	*Hypopachus variolosus*	1	2	2	Predominantly found in grassland and savannas; moist sites in arid areas	Resident		T
FISHES								
American eel	*Anguilla rostrata*	1	1	1	Coastal waterways to Gulf.	Resident		
Opossum pipefish	*Microphis brachyurus*	1	2	2	Brooding adults found in fresh or low salinity waters and young in more saline waters; Southern coastal areas	Aquatic Resident		T
Smalltooth sawfish	*Pristis pectinata*	1	3	3	Found in sheltered bays, on shallow banks and in estuaries or river mouths.	Aquatic Resident	LE	E
REPTILES								
Atlantic hawksbill sea turtle	*Eretmochelys imbricate*	0	3	0	Gulf and bay systems; warm shallow waters in rocky marine environments.	Aquatic Resident	LE	E
Green sea turtle	*Chelonia mydas*	0	2	0	Gulf and bay systems; shallow water seagrass beds	Aquatic Resident	LT	T

Table 4C.14-4 (Concluded)

Common Name	Scientific Name	Impact Value	Multiplier Based on Status	Adjusted Impact	Summary of Habitat Preference	Potential Occurrence in County	Federal Status	State Status
Gulf saltmarsh snake	*Nerodia clarkii*	1	1	1	Saline flats and river mouths	Resident		
Kemp's Ridley sea turtle	*Lepidochelys kempii*	0	3	0	Gulf and bay systems; shallow waters of the Gulf of Mexico	Aquatic Resident	LE	E
Leatherback sea turtle	*Dermochelys coriacea*	0	3	0	Gulf and bay systems; forages in Gulf of Mexico	Aquatic Resident	LE	E
Loggerhead sea turtle	*Caretta caretta*	0	2	0	Gulf and bay systems for juveniles, adults prefer open waters	Aquatic Resident	LT	T
Texas diamondback terrapin	*Malaclemys terrapin littoralis*	1	1	1	Coastal marshes and tidal flats.	Resident		
Texas horned lizard	*Phrynosoma cornutum*	1	2	2	Varied; sparsely vegetated uplands, grass, cactus, brush	Resident		T
Texas scarlet snake	*Cemophora coccinea lineri*	1	2	2	Mixed hardwood scrub on sandy soils	Resident		T
Texas tortoise	*Gopherus berlandieri*	1	2	2	Open bush with grass understory; open grass and bare ground avoided	Resident		T
Timber/Canebrake rattlesnake	*Crotalus horridus*	1	2	2	Floodplains, riparian zones with dense ground cover	Resident		T
PLANTS								
Three-flower broomweed	*Thurovia triflora*	1	1	1	Endemic, remnant grasslands and tidal flats	Resident		
MOLLUSKS								
Creeper (squawfoot)	*Strophitus undulates*	1	1	1	Freshwater mussel found in the Colorado, Guadalupe, San Antonio, Neches (historic), and Trinity (historic) River basins.	Resident		
Pistolgrip	*Tritogonia verrucosa*	1	1	1	Freshwater mussel found in east and central Texas in the Red through San Antonio River basins.	Resident		

Source: TPWD, Annotated County List of Rare Species, Calhoun County, Updated May 4, 2009.

DL = Delisted
PD = Proposed for Delisting
LE = Federally listed endangered
LT = Federally listed threatened
Blank = Not Federally or State Listed but considered a Species of Concern
E = State Endangered
T = State Threatened

roosting or nesting sites. Bald eagles occur as migrants within south Texas. The remaining bird species excluding the white-tailed hawk are generally found within marshy or wet areas foraging for food. Development of the off-channel storage site could provide additional habitat for species which prefer a wet environment.

Listed reptile species found within Calhoun County, such as the Texas tortoise, Texas scarlet snake, and the Texas horned lizard are dependent on shrubland or riparian habitats which should to be avoided wherever possible. Although suitable habitat for the state threatened Texas horned lizard may exist within the project area, no impact to this species is anticipated due to the abundance of similar habit near the project area and this species' ability to relocate to those areas if necessary. The Timber/Canebrake Rattlesnake, a threatened species, may be found in the riparian woody vegetation of the area. Destruction of these potential habitats can be minimized by selecting a corridor through previously disturbed areas, such as croplands. Selection of a pipeline right-of-way alongside existing habitat could also be beneficial to some wildlife species by providing edge habitat; however, the majority of these areas are small and fragmented. Care should be taken to ensure minimum impacts to these areas.

In addition to the Calhoun County list of rare species, the TPWD Texas Natural Diversity Database (TXNDD) map data was reviewed for known occurrences of listed species within or near the canal, pipeline or proposed on-site storage areas. This information indicated that there were several reported sightings of the state threatened bald eagle (*Haliaeetus leucoephalus*), within the surrounding area. Occurrences of three species of concern, the Texas diamondback terrapin (*Malaclemys terrapin littoralis*), Gulf saltmarsh snake (*Nerodia clarkia*), and threeflower broomweed (*Thurovia triflora*) are documented within 10 miles of the proposed project area. A rookery is located along Hog Bayou on the western side of Green Lake. No specific sightings of any endangered or threatened species were documented within the proposed diversion canal, pipeline or on-site storage site. The presence or absence of potential habitat within an area does not confirm the presence or absence of a listed species. No species specific surveys were conducted in the project area for this report.

After a review of the habitat requirements for each listed species, it is not anticipated that this project will have any permanent adverse effect on any federally listed threatened or endangered species, its habitat, or designated habitat, nor would it adversely affect any state listed species.

A review of the Texas Historical Commission Texas Historic Sites Atlas database indicated that there are no historical markers, National Register Properties, or cemeteries listed within the proposed on-site storage area or along the canal and pipeline routes.

4C.14.4 Engineering and Costing

Conceptual planning-level engineering and cost estimates are prepared for the GBRA New Appropriation (Lower Basin) WMS. Major facilities required to implement the river diversion option include:

- Main Pump Station and Canal Upgrades (from 355 cfs to 500 cfs);
- New Intake and Pump Station from Main Canal (~250 cfs);
- 10-mile, 96-inch diameter Diversion Pipeline;
- Off-Channel Storage between 25,000 acft and 200,000 acft; and
- Integration.

Total project costs for the GBRA New Appropriation (Lower Basin) WMS, assuming an 100,000 acft off-channel reservoir, are estimated at $246,849,000. Annual unit costs are estimated at $1,910/acft/yr (Table 4C.14-5). Annual costs are estimated based on debt service for a 20-year loan at 6 percent interest for the transmission system, debt service for a 40 year loan at 6 percent interest for the reservoir, and operation and maintenance costs, including power.

4C.14.5 Implementation Issues

Institutional arrangements may be needed to implement the project.

1. It will be necessary to obtain the following:
   a. TCEQ Diversion and Storage Permits (Application No. 12482, pending);
   b. USCE Sections 10 and 404 Dredge and Fill Permits for the reservoir and pipelines;
   c. GLO Sand and Gravel Removal permits;
   d. GLO Easement for use of state-owned land; and
   e. TPWD Sand, Gravel, and Marl permit.
2. Permitting may require these studies:
   a. Habitat mitigation plan;
   b. Environmental studies; and
   c. Cultural resource studies and mitigation.

3. Land will need to be acquired through either negotiations or condemnation.
4. Relocations for the off-channel storage facilities may include:
   a. County roads;
   b. Other utilities;
   c. Product transmission pipelines; and
   d. Power transmission lines.

Table 4C.14-5.
Cost Estimate Summary
GBRA New Appropriation (Lower Basin) – 100,000 acft of Storage Scenario
September 2008 Prices

Item	Estimated Costs for Facilities
Capital Costs	
Off-Channel Storage (Conservation Pool 100,000 acft, 4,061 acres)	$67,490,000
Intake and Pump Station (163.5 MGD)	$18,417,000
Transmission Pipeline (96 in dia., 10 miles)	$46,902,000
Integration	$13,385,000
Relocations & Other*	$13,827,000
Total Capital Cost	**$160,021,000**
Engineering, Legal Costs and Contingencies	$53,662,000
Environmental & Archaeology Studies and Mitigation	$11,626,000
Land Acquisition and Surveying (4,111 acres)	$12,045,000
Interest During Construction (1 years)	$9,495,000
Total Project Cost	**$246,849,000**
Annual Costs	
Debt Service (6 percent, 20 years)	$11,180,000
Reservoir Debt Service (6 percent, 40 years)	$7,884,000
Operation and Maintenance	
Intake, Pipeline, Pump Station	$1,063,000
Dam and Reservoir	$1,012,000
Pumping Energy Costs (4,950,978 kW-hr @ 0.09 $/kW-hr)	$446,000
Total Annual Cost	**$21,585,000**
Available Project Yield (acft/yr)	11,300
Annual Cost of Water ($ per acft)	$1,910
Annual Cost of Water ($ per 1,000 gallons)	$5.86

**Includes Canal and Main Pump Station Upgrades*

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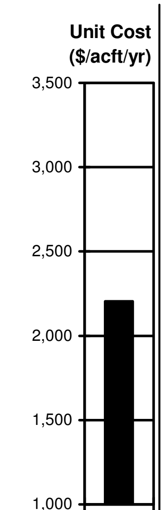
2011 South Central Texas Regional Water Plan
Water Management Strategy Summary Sheet



Name: **GBRA Mid-Basin Project (Surface Water)**

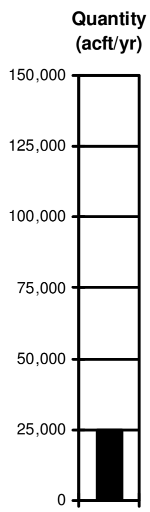
Description: Facilities include an intake and pump station on the Guadalupe River, a transmission pipeline from Gonzales to San Marcos through Luling, an off channel reservoir in Gonzales County (including piping between river intake and reservoir, intake and pump station at the reservoir); transmission booster pump stations; and water treatment plant expansions and enhancements at Luling and San Marcos.

***Decade Needed*:** 2010 - 2020

Cost, Quantity of Water, and Land Impacted

Unit Cost of Water:	**1,879 - 2,204**	**$/acft/yr**	**Treated Water Delivered**
Quantity of Water:	**25,000**	**acft/yr**	**Reliability = Firm**
Land Impacted:	**3919 - 5644**	**acres**	

Additional Considerations per Regional Water Planning Guidelines



Environmental Factors:

Conversion of existing habitats and land uses within the pipeline right-of-way and off-channel reservoir site.

Impacts on Water Resources:

Potential downstream effects due to modification of existing flow regime below the Gonzales diversion.

Impacts on Agricultural & Natural Resources:

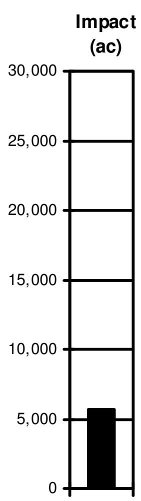
None anticipated.

Other Relevant Factors per SCTRWPG:

Project subject to senior water rights, full application of environmental flow standards adopted pursuant to Section 11.1471 of the Texas Water Code, and the TCEQ permitting process.

Comparison of Strategies to Meet Needs:

Options to meet needs are limited. No conflicts with other recommended water management strategies.



Interbasin Transfer Issues:

Not applicable.

Third-Party Impacts of Voluntary Transfers:

Not applicable.

Regional Efficiency:

Provides long-term water supplies throughout the GBRA statutory district.

Water Quality Considerations:

None of significant concern.

4C.15 GBRA Mid-Basin Project (Surface Water)

4C.15.1 Description of Water Management Strategy

The Guadalupe-Blanco River Authority (GBRA) is in the planning and permitting stages of a phased Mid-Basin Project to provide supplemental water supplies directly to customers in Hays and Caldwell Counties in the near-term and indirectly to customers in Comal, Guadalupe, and Kendall Counties by replacement or reduction of Canyon Reservoir supplies currently delivered to the San Marcos WTP in the long-term. GBRA is currently considering at least three formulations of the Mid-Basin Project using available surface water and/or groundwater supply sources to ensure unrestricted delivery of a firm yield of approximately 25,000 acft/yr. In all three formulations, 4,000 acft/yr will be delivered to the Luling Water Treatment Plant (WTP) and the remaining balance of approximately 21,000 acft/yr will be delivered to the San Marcos WTP. New supplies will be delivered uniformly throughout the year and customer peaking requirements will be met from other sources. This water management strategy focuses on the surface water only formulation which would divert run-of-river water from the Guadalupe River below Gonzales backed-up with stored water from an off-channel reservoir in Gonzales County. GBRA has submitted Application No. 12378 for the surface water rights associated with this water management strategy and this application has been declared administratively complete by the Texas Commission on Environmental Quality (TCEQ).

For this alternative, an intake on the Guadalupe River will divert water under a new appropriation into an off-channel reservoir in Gonzales County (Figure 4C.15-1), which is necessary to provide uniform delivery of 25,000 acft each year. The exact location, configuration, and capacity of the off-channel reservoir have yet to be determined. The main transmission pipeline follows US 183 from the surface water intake to the Luling WTP, where 4,000 acft/yr will be treated. From Luling, the pipeline follows SH 80 to the San Marcos WTP, where the remaining 21,000 acft/yr will be treated. The main transmission pipeline is assumed to be 36 inches in diameter for the main transmission pipeline between the off channel reservoir and the San Marcos WTP.

4C.15.2 Water Availability

The GBRA Mid-Basin (Surface Water) water management strategy (WMS) is evaluated under two scenarios: the Region L Scenario and the Permitting Scenario. For the Region L

Scenario, surface water availability is constrained by the Consensus Criteria for Environmental Flows Needs (CCEFN), includes a maximum diversion rate of 800 cfs, and includes treated effluent. For the Permitting Scenario, surface water availability is constrained by Modified Lyons Method (Lyons), includes a maximum diversion rate of 500 cfs, and does not include treated effluent. The two environmental flows criteria and the results from the two scenarios are discussed herein. It should be noted that the two environmental flow criteria presented herein are place-holders as GBRA has advised that this strategy will be subject to full application of environmental flow standards to be adopted pursuant to Section 11.1471 of the Texas Water Code.

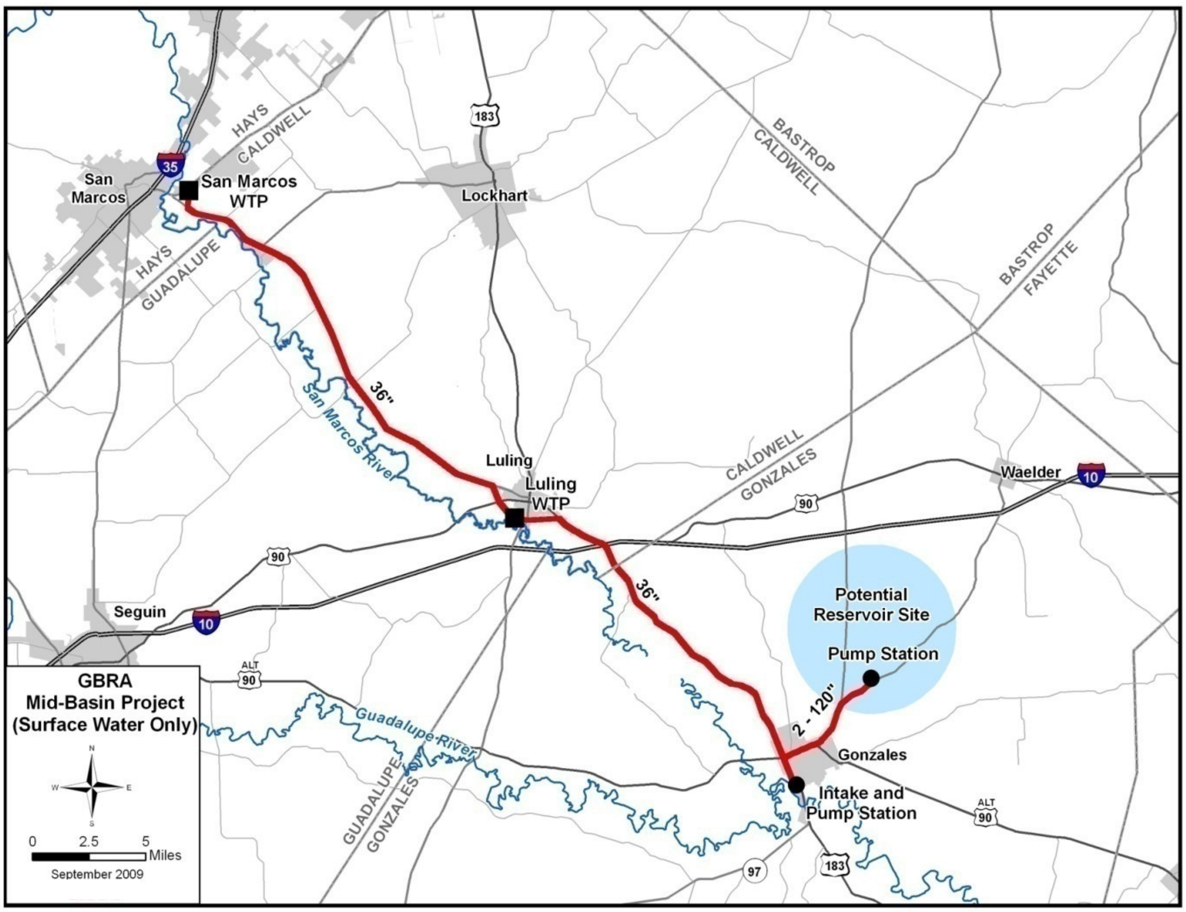


Figure 4C.15-1. Project Location for GBRA Mid-Basin Project (Surface Water)

4C.15.2.1 Environmental Flow Considerations

Any new surface water permit will include streamflow restrictions for environmental purposes. Comparison of potential environmental flow criteria for such a new water right authorizing run-of-river diversions from the Guadalupe River near Gonzales included the Modified Lyons Method and the Consensus Criteria for Environmental Flow Needs (CCEFN). Figure 4C.15-2 illustrates the monthly flow restrictions associated with the two criteria used for calculating water availability.

GBRA is applying to the Texas Commission on Environmental Quality (TCEQ) for two new water rights to divert unappropriated flows of the Guadalupe River. One water right application (No. 12378) seeks to divert up to 75,000 acft/yr from the Guadalupe River in Gonzales County, in the Middle Guadalupe River Basin. The other application (No. 12482) seeks to divert up to 189,484 acft/yr from the Guadalupe River in Calhoun County, in the Lower Guadalupe River Basin. The lower basin application is in addition to water already permitted for diversion under existing rights held jointly by GBRA and Union Carbide Corporation (Dow Chemical Company).

The amount of water petitioned in both applications will have the potential to be available for diversion primarily in non-drought years for two reasons. First, the new water rights will have brand new priority dates, so the right to divert under those water rights will be junior (last in time) relative to all existing water rights. Second, diversions of this new water will be subject to environmental streamflow conditions to be imposed by the TCEQ for the protection of San Antonio Bay and estuary system. GBRA acknowledges the importance of ensuring that those rights are conditioned in order to ensure strong protection of instream flows and freshwater inflows. Accordingly, GBRA indicates its commitment that any permits issued pursuant to the applications, regardless of timing, will be made subject to the full application of environmental flow standards adopted pursuant to Section 11.1471 of the Texas Water Code that are applicable to affected portions of the Guadalupe River and to the San Antonio Bay estuary system.

4C.15.2.2 Water Availability Modeling

The Guadalupe-San Antonio River Basin Water Availability Model (GSAWAM, as modified for regional water planning purposes) is used to quantify water available for diversion under the GBRA Mid-Basin (Surface Water) WMS. Hydrologic simulations and calculations are performed subject to the General Assumptions for Applications of Hydrologic Models, as adopted by the SCTRWPG for the 2011 Regional Water Plan.

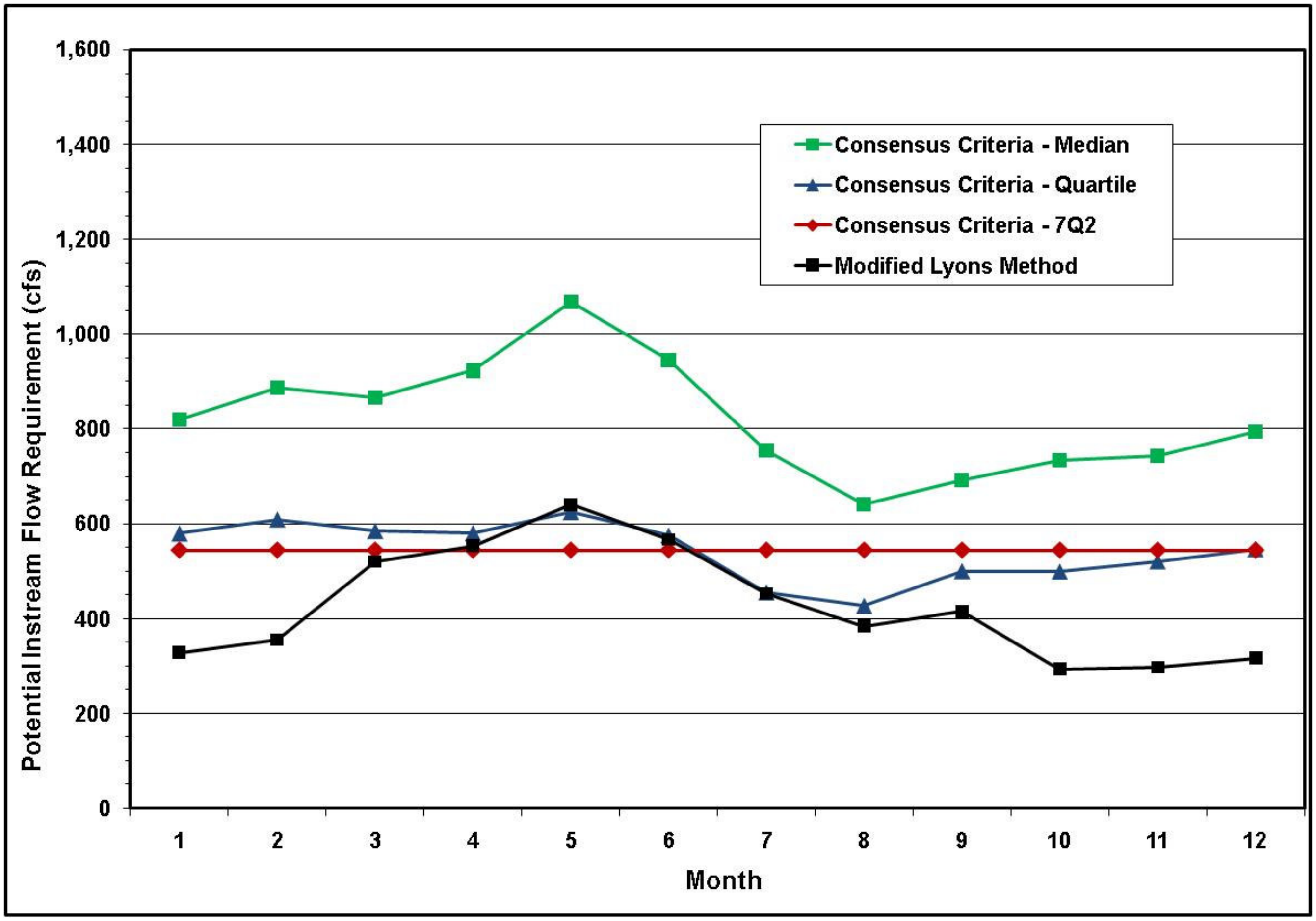


Figure 4C.15-2. Alternative Environmental Flow Criteria — Conceptual Assessment of a Diversion from the Guadalupe River @ Gonzales

Application of the GSAWAM, with a period of record from January 1934 to December 1989, demonstrates that the monthly equivalent of the 25,000 acft/yr firm yield is available from the Guadalupe River at Gonzales in about 62 percent of the months simulated under the Region L Scenario, limited by 800 cfs maximum diversion rate, and 71 percent of the months simulated under the Permitting Scenario, limited by 500 cfs maximum diversion rate. Monthly estimates of water available for the GBRA Mid-Basin (Surface Water) WMS are summarized in Table 4C.15-1 and 4C.15-2. Actual diversions from the Guadalupe River to the off-channel reservoir are further limited by amounts necessary to keep the reservoir full and meet the delivery amount of 25,000 acft/yr.

Table 4C.15-1.
Water Available to GBRA Mid-Basin Project (Surface Water) - Region L Scenario

Year	Monthly Availability by Year (acft)												Total
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
1934	12,753	11,992	25,987	27,259	6,362	1,226	3,424	456	42	0	4,802	11,918	106,221
1935	1,338	15,278	73	0	34,943	43,316	28,739	4,843	43,188	23,548	7,477	30,531	233,272
1936	12,634	9,552	11,722	0	25,983	20,091	49,191	15,333	16,599	49,191	33,837	27,792	271,924
1937	20,933	11,534	48,053	6,998	6,501	23,054	573	0	0	211	0	5,299	123,156
1938	35,518	26,916	9,316	47,573	49,040	9,760	0	0	0	0	0	0	178,123
1939	0	0	0	0	643	0	1,346	0	0	0	0	0	1,990
1940	0	0	109	2,993	0	1,587	40,921	0	0	1,546	22,110	30,669	99,935
1941	11,400	36,462	42,385	40,738	49,191	47,604	40,344	476	909	18,195	4,190	10,104	301,997
1942	4,173	2,640	0	23,408	18,019	3,203	16,089	563	33,210	38,466	33,740	18,993	192,504
1943	12,939	11,503	10,819	7,541	813	10,053	2,467	0	559	0	0	0	56,693
1944	8,666	14,799	42,166	16,351	23,396	35,990	3,408	0	17,573	4,995	11,499	29,662	208,504
1945	31,838	43,695	49,096	47,604	13,826	7,767	568	0	0	14,346	0	10,573	219,313
1946	11,277	14,681	29,779	14,109	22,993	22,063	0	3,533	33,982	49,094	39,730	36,782	278,023
1947	46,093	38,878	37,640	21,803	16,925	7,688	0	3,271	0	0	0	0	172,298
1948	0	0	0	0	4,450	0	0	0	0	0	0	0	4,450
1949	0	4,748	2,696	16,292	21,053	33	0	0	0	10,661	0	0	55,483
1950	0	1,138	0	4,904	1,296	6,846	0	0	0	0	0	0	14,185
1951	0	0	0	0	0	6,770	0	0	0	0	0	0	6,770
1952	0	0	0	0	4,416	3,403	0	0	3,174	0	4,243	9,354	24,590
1953	8,667	0	0	1,587	11,744	0	0	0	6,514	5,988	45	3,307	37,853
1954	0	0	0	0	1,587	0	0	0	0	0	0	0	1,587
1955	0	2,276	0	0	2,717	1,649	0	0	0	0	0	0	6,642
1956	0	0	0	0	0	0	0	0	0	0	0	250	250

Table 4C.15-1 (Concluded)

Year	Monthly Availability by Year (acft)												Total
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
1957	0	0	4,438	14,737	35,424	28,515	0	0	11,282	31,628	47,372	39,892	213,286
1958	45,459	44,243	49,159	36,337	25,876	19,548	12,520	0	19,387	30,310	41,348	19,725	343,913
1959	7,885	17,707	6,386	27,062	17,883	6,835	1,613	70	0	11,542	11,009	10,483	118,474
1960	19,462	17,698	8,999	6,790	20,598	7,481	23,680	18,210	2,883	30,148	47,604	48,724	252,278
1961	49,191	44,297	47,244	18,869	14,343	27,064	34,632	1,930	6,377	4,758	10,505	4,598	263,807
1962	1,185	238	0	659	127	2,542	0	0	3,144	2,285	41	2,011	12,232
1963	0	3,500	0	1,808	0	0	0	0	0	0	155	0	5,462
1964	0	322	2,402	0	0	149	0	0	6,209	144	1,995	0	11,221
1965	4,989	36,409	9,205	12,123	32,845	47,604	6,062	594	25	5,757	10,448	37,841	203,902
1966	17,419	23,471	26,367	23,562	22,869	5,775	0	5,345	7,354	7,970	0	0	140,133
1967	0	0	0	0	0	0	0	0	38,282	9,484	19,409	5,743	72,918
1968	35,342	44,430	43,198	46,297	47,088	45,936	18,751	828	3,238	1,177	6,442	13,443	306,169
1969	2,564	21,369	18,615	24,477	46,023	20,564	1,989	0	196	30,798	13,146	28,141	207,882
1970	22,595	29,546	49,181	29,942	35,581	39,529	8,450	1,007	253	6,962	266	0	223,311
1971	0	0	0	0	0	0	0	18,209	23,574	30,277	20,801	40,981	133,841
1972	15,504	6,737	14,172	0	41,727	34,660	9,434	15,417	59	2,062	5,863	10,219	155,854
1973	9,694	24,675	40,587	46,157	19,131	41,626	49,187	40,024	40,337	49,191	45,711	32,351	438,669
1974	40,676	22,023	14,048	11,790	21,173	13,944	885	22,986	47,268	22,780	47,604	49,028	314,205
1975	44,071	44,120	44,845	32,992	49,191	47,015	49,191	37,198	16,571	12,911	6,000	5,409	389,515
1976	4,126	1,654	1,297	38,730	49,191	38,989	45,511	26,907	23,103	37,691	47,604	49,191	363,993
1977	49,191	44,430	44,300	47,604	49,191	39,329	20,596	2,358	4,697	1,505	9,493	6,422	319,114
1978	3,118	1,831	1,136	239	0	4,185	0	41,197	37,164	11,257	28,739	15,942	144,807
1979	49,191	44,430	49,191	47,604	49,191	47,604	43,194	34,917	15,319	6,878	3,907	6,178	397,603
1980	3,930	11,446	7,634	0	22,696	283	0	0	6,643	15,574	7,651	9,176	85,034
1981	10,333	9,429	24,619	16,357	21,672	44,280	44,132	31,068	47,604	42,864	47,604	19,502	359,465
1982	10,124	3,227	13,356	9,069	38,270	16,372	0	0	0	0	328	0	90,746
1983	480	5,394	17,173	7,009	10,054	19,749	746	0	2,763	293	1,369	0	65,029
1984	0	120	0	0	0	0	0	0	0	601	781	1,404	2,905
1985	8,709	24,944	40,442	32,126	13,443	42,749	45,956	200	51	25,004	44,286	49,191	327,100
1986	35,019	33,617	9,385	11,840	25,225	44,542	3,781	0	31,623	41,178	44,772	49,191	330,173
1987	49,126	44,430	49,191	30,340	46,475	47,604	49,122	29,863	29,419	20,338	32,982	24,268	453,157
1988	11,573	4,905	10,927	8,581	9,637	7,059	21,453	5,677	2,069	0	0	0	81,882
1989	54	0	2,924	2,783	12,041	46	0	0	0	0	0	0	17,848
MAX	**49,191**	**44,430**	**49,191**	**47,604**	**49,191**	**47,604**	**49,191**	**41,197**	**47,604**	**49,191**	**47,604**	**49,191**	**453,157**
AVG	**13,736**	**15,299**	**17,147**	**15,447**	**19,515**	**17,744**	**12,106**	**6,473**	**10,404**	**12,672**	**13,695**	**14,362**	**168,602**
MIN	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**250**

Table 4C.15-2.
Water Available to GBRA Mid-Basin Project (Surface Water) - Permitting Scenario

Year	Monthly Availability by Year (acft)												Total
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
1934	30,694	27,769	30,744	29,753	5,161	560	6,969	7	3,102	6,604	18,716	30,744	190,821
1935	14,342	27,769	209	0	27,914	29,753	30,684	17,436	29,753	30,744	29,687	30,744	269,035
1936	30,744	26,765	17,452	0	24,966	26,395	30,744	28,018	10,909	30,744	29,753	30,744	287,234
1937	30,744	27,769	30,744	26,616	4,016	25,088	2,730	0	0	10,684	6,056	12,242	176,690
1938	30,744	27,769	28,595	29,753	30,744	9,438	1,172	395	353	5,653	5,673	5,465	175,754
1939	6,215	663	0	0	269	0	248	0	0	0	0	0	7,395
1940	1	1,989	795	2,647	0	992	30,744	0	0	1,272	29,489	26,621	94,550
1941	30,618	27,769	30,744	29,753	30,744	29,753	30,744	5,724	3,472	30,526	28,567	23,186	301,601
1942	18,646	13,774	0	22,317	19,924	2,949	24,062	2,439	27,809	30,744	29,753	30,744	223,161
1943	30,744	24,692	14,963	10,405	992	10,123	3,194	0	1,504	3,716	4,666	6,033	111,032
1944	21,600	25,888	30,744	28,746	18,854	29,753	9,200	0	26,232	19,212	23,802	30,290	264,320
1945	30,744	27,769	30,744	29,753	26,934	8,059	1,144	0	0	27,643	7,798	22,787	213,374
1946	27,533	27,769	30,716	21,031	21,241	26,066	481	2,819	29,753	30,744	29,753	30,744	278,649
1947	30,744	27,769	30,744	29,753	29,337	6,928	80	2,282	0	0	2,706	2,991	163,333
1948	2,465	4,829	0	0	4,076	0	0	0	0	0	0	0	11,370
1949	0	3,512	5,786	11,039	23,307	0	72	0	0	16,538	4,244	6,778	71,276
1950	1,096	6,217	0	3,464	1,779	4,496	0	0	0	0	0	0	17,052
1951	0	0	0	0	0	6,452	0	0	0	0	0	0	6,452
1952	0	0	0	0	3,573	3,502	0	0	1,984	1,426	5,035	21,956	37,475
1953	25,280	1,742	0	992	12,687	0	0	0	7,016	14,014	2,882	5,455	70,068
1954	0	0	0	0	639	0	0	0	0	0	0	0	639
1955	0	2,807	0	0	2,136	1,012	0	0	0	0	0	0	5,954
1956	0	0	0	0	0	0	0	0	0	0	0	992	992
1957	0	0	3,639	9,353	30,655	27,596	0	0	8,926	30,210	29,753	30,744	170,876
1958	30,744	27,769	30,744	29,753	26,304	26,630	22,855	0	20,167	30,744	29,753	30,744	306,206
1959	30,744	27,769	25,287	28,591	22,311	5,995	5,579	1,006	0	22,675	28,965	28,693	227,616
1960	30,744	27,769	23,386	4,800	25,451	7,543	30,197	20,863	9,829	27,566	29,753	30,744	268,644
1961	30,744	27,769	30,744	29,692	12,142	26,712	30,744	11,656	12,407	18,430	27,574	17,688	276,303
1962	13,810	8,122	5	1,348	23	2,396	0	0	4,521	7,952	5,706	12,117	55,999
1963	6,346	9,301	0	2,103	0	0	0	0	0	0	3,086	0	20,835
1964	0	3,847	4,132	0	0	0	0	0	4,945	1,439	10,015	1,158	25,535
1965	14,276	26,729	20,057	18,203	28,863	29,753	13,114	3,393	341	17,483	26,588	30,744	229,543
1966	30,744	27,769	30,744	29,753	30,744	6,091	264	16,911	21,665	22,463	7,067	6,328	230,543
1967	5,727	853	0	0	0	0	0	0	26,918	27,526	28,537	17,951	107,511
1968	30,744	27,769	30,744	29,753	30,744	29,753	30,607	9,870	10,492	15,284	17,511	28,749	292,019

Table 4C.15-2 (Concluded)

Year	Monthly Availability by Year (acft)												Total
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
1969	16,383	27,147	29,903	27,973	30,744	24,432	4,976	801	2,425	25,983	25,863	30,744	247,373
1970	30,744	27,769	30,744	29,753	30,707	29,753	16,336	8,884	3,748	20,434	13,072	11,577	253,521
1971	7,930	2,978	0	0	0	0	0	17,909	29,753	30,107	29,753	30,744	149,173
1972	30,744	27,769	17,312	0	27,934	29,753	26,505	25,970	5,489	16,831	28,972	27,503	264,781
1973	30,727	27,769	30,744	29,753	30,744	29,753	30,744	30,744	29,753	30,744	29,753	30,744	361,972
1974	30,744	27,769	29,630	21,139	29,616	21,257	2,141	29,833	29,753	30,744	29,753	30,744	313,121
1975	30,744	27,769	30,744	29,753	30,744	29,753	30,744	30,744	26,021	30,740	23,594	30,737	352,087
1976	18,717	13,728	2,117	28,378	30,744	29,753	30,744	30,744	27,707	30,744	29,753	30,744	303,873
1977	30,744	27,769	30,744	29,753	30,744	29,753	30,428	14,068	11,368	18,194	27,034	19,512	300,112
1978	17,708	14,808	2,712	195	0	3,003	0	29,185	29,753	30,579	29,753	30,744	188,439
1979	30,744	27,769	30,744	29,753	30,744	29,753	30,744	30,744	27,693	22,006	17,660	19,757	328,111
1980	29,881	24,635	10,574	0	20,590	228	0	0	14,448	29,987	23,224	27,641	181,208
1981	25,312	22,618	28,834	29,748	25,150	29,753	30,744	30,744	29,753	30,744	29,753	30,744	343,897
1982	30,744	27,769	16,296	9,589	25,998	23,140	777	0	0	4,689	9,949	8,552	157,503
1983	9,087	17,501	15,252	9,980	10,517	28,370	3,380	0	8,479	6,532	11,675	4,278	125,052
1984	5,541	4,490	0	0	0	0	0	0	0	4,383	3,631	8,201	26,244
1985	30,727	27,769	30,744	29,720	29,579	29,753	30,744	3,436	4,330	29,387	29,753	30,744	306,686
1986	30,744	27,769	27,296	12,360	24,665	29,753	11,561	133	26,984	30,744	29,753	30,744	282,506
1987	30,744	27,769	30,744	29,753	30,744	29,753	30,744	27,716	28,550	30,713	29,753	30,744	357,727
1988	30,744	27,769	21,387	9,102	7,424	11,389	23,635	17,464	7,631	2,332	419	4,352	163,647
1989	6,665	3,011	5,615	3,034	10,441	13	0	0	0	0	0	5	28,785
MAX	**30,744**	**27,769**	**30,744**	**29,753**	**30,744**	**29,753**	**30,744**	**30,744**	**29,753**	**30,744**	**29,753**	**30,744**	**361,972**
AVG	**19,530**	**18,119**	**16,154**	**14,627**	**17,042**	**14,695**	**11,439**	**8,070**	**10,817**	**16,762**	**17,067**	**18,281**	**182,601**
MIN	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**639**

The inclusion of an off-channel storage site proximate to the Gonzales diversion point of sufficient capacity to firm up run-of-river supplies is necessary to deliver a firm supply of 25,000 acft/yr without the commitment of any water from Canyon Reservoir. Water will be diverted into the off-channel reservoir during periods when run-of-river diversions are sufficient enough to meet the 25,000 acft/yr delivery amount and flows in the Guadalupe River are above the minimum instream requirements and other downstream commitments. Utilizing the GSA-WAM, off-channel reservoir sizes are determined for each of the simulation scenarios. In order to develop a firm yield of 25,000 acft/yr, the off-channel storage would need to be 188,800 acft and 105,500 acft for the Region L and Permitting Scenarios, respectively.

4C.15.3 Environmental Issues

Environmental issues for the proposed surface water only option for the GBRA Mid-Basin Project (Surface Water) in Gonzales and Caldwell counties are described below. Implementation of this pipeline and off-channel reservoir (OCR) would require field surveys by qualified professionals to document vegetation/habitat types, waters of the U.S. including wetlands and cultural resources that may be impacted. Where impacts to protected species habitat or significant cultural resources cannot be avoided, additional studies would be necessary to evaluate habitat use and/or value, or eligibility for inclusion in the National Register of Historic Places, respectively. Compensation would be required for unavoidable adverse impacts involving net losses of wetlands.

The proposed pipeline would cross several creeks and tributaries of the San Marcos and Guadalupe Rivers. The Texas Parks & Wildlife Department (TPWD) has identified a number of stream segments throughout the state as ecologically significant on the basis of biological function, hydrologic function, riparian conservation, exceptional aquatic life uses, and/or threatened or endangered species. Currently, 21 stream segments in Region L are considered ecologically significant by the TPWD.[1] None of the creeks crossed by the proposed pipeline are listed by the state as ecologically significant. However, the section of the Guadalupe River from U.S. 183 (near the Gonzales diversion point) upstream to Lake Gonzales Dam is listed as ecologically significant as it contains two of four known remaining populations of the golden orb, a rare, endemic mollusk. Coordination with the U.S. Army Corps of Engineers would be required for construction within waters of the U.S. Impacts from this proposed project resulting in a loss of less than 0.5 acres of waters of the U.S. could be covered under Nationwide Permit #12 for Utility Line Activities.

Cultural resources protection on public lands in Texas is afforded by the Antiquities Code of Texas (Title 9, Chapter 191, Texas Natural Resource Code of 1977), the National Historic Preservation Act (Pl96-515), and the Archeological and Historic Preservation Act (PL93-291). Based on the review of available GIS datasets, there are 17 cemeteries, 29 historical markers, four national register properties and one national register district located within a 0.5-mile buffer of the proposed pipeline route. Additionally, there are three cemeteries within the potential OCR

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[1] TPWD, "Ecologically Significant River and Stream Segments," http://www.tpwd.state.tx.us/landwater/water/environconcerns/water_quality/sigsegs/index.phtml accessed October 15, 2009.

site. A review of archaeological resources in the proposed project area should be conducted during the project planning phase. Considering that the owner or controller of the project will likely be a political subdivision of the State of Texas (i.e. river authority, municipality, county, etc.), they will be required to coordinate with the Texas Historical Commission regarding whether the project will affect waters of the United States or wetlands. The project sponsor will also be required to coordinate with the U.S. Army Corps of Engineers regarding impacts to cultural resources.

The GBRA Mid-Basin Project (Surface Water) involves the construction of approximately 45 miles of pipeline. Water would be diverted from the Guadalupe River below Gonzales and stored in an OCR for consistent delivery to the Luling WTP and San Marcos WTP in Caldwell County. The pipeline traverses through both the Oak Woods and Prairies and the Blackland Prairies ecoregions[2] and is within the Texan biotic province.[3] Vegetation within the project area is dominated by a mosaic of post oak woods, forest and grassland to the east and cropland along the western portion of the proposed pipeline[4]. The proposed pipeline would follow existing roadways.

The primary impacts that would result from construction of the proposed GBRA Mid-Basin Project (Surface Water) include conversion of existing habitats and land uses within the pipeline right-of-way to maintained areas and within the proposed off-channel storage area to open water. Furthermore, potential downstream effects due to modification of the existing flow regime would be anticipated. Indirect effects of reservoir construction may include land use changes in the area surrounding the reservoir and in mitigation areas that may be converted to alternate uses to compensate for losses of terrestrial habitat. Potential downstream impacts would include modification of the streamflow regime below the Gonzales diversion point, which may impact fish and wildlife species

The proposed pipeline from the Guadalupe River to the Luling and San Marcos WTPs, and the proposed OCR is approximately 45 miles long (Figure 4C.15-1). The water pipeline would require a construction corridor of about 100 feet and a maintenance corridor of about 30 feet. Construction of the pipeline would involve the disturbance of soils and vegetation on up

[2] TPWD, "Texas Partners in Flight; Ecological Region 7 – Edwards Plateau"http://www.tpwd.state.tx.us/huntwild/wild/birding/pif/assist/pif_regions/region_7.phtml accessed July 20, 2009.
[3] Blair, W.F., "The Biotic Provinces of Texas, "Tex. J. Sci. 2:93-117, 1950.
[4] McMahan, C. A., R. G. Frye and K. L. Brown, " The Vegetation Types of Texas -- Including Cropland," Texas Parks and Wildlife Department − PWD Bulletin 7000-120. 1984.

to approximately 550 acres, and the long-term impacts of maintaining the right-of-way free of woody vegetation would affect about 175 acres. The pipeline would pass through approximately 30 miles of crop and pastureland, approximately 10.0 miles forested land, approximately 6 miles of residential, commercial and industrial land uses.[5] Outside the maintained right-of-way, land use would not be anticipated to change due to pipeline construction. The size of the off-channel storage site would be between 3,678 and 5,403 acres. According to land use and land cover data[6], the primary land uses and land covers that would be converted to open water upon reservoir filling include mixed forest land, cropland and pasture.

The species listed by USFWS, and TPWD, as endangered or threatened with potential habitat in Gonzales and Caldwell counties are listed in Table 4C.15-3. The Texas Natural Diversity Database, maintained by TPWD, documents the occurrence of rare species within the state. There are no documented occurrences of any endangered species along or immediately adjacent to the proposed pipeline; however, there are documented occurrences of the threatened Cagle's map turtle along the Guadalupe River and immediately adjacent to the proposed Gonzales diversion point. Additionally, the western portion of the pipeline route and the San Marcos WTP site are within an area with documented occurrences of Hill Country wild-mercury, a rare plant and the rare Guadalupe bass has been documented along portions of the river immediately adjacent to the proposed diversion point. Endangered species including Texas wild-rice, San Marcos gambusia, fountain darter, and the Texas blind salamander, the threatened San Marcos salamander, and the rare Shinner's sunflower have all been documented within 2.5 miles of the proposed pipeline route.[7] Many of the species including Texas wild-rice, San Marcos gambusia, fountain darter, San Marcos salamander and the Texas blind salamander have a very limited distribution, several are endemic only to the headwaters of the San Marcos River. The project area may provide potential habitat to endangered or threatened species found in Gonzales or Caldwell counties. A survey of the project area may be required prior to pipeline and OCR construction to determine whether populations of or potential habitats used by listed species occur in the area to be affected. Coordination with TPWD and USFWS regarding threatened and

[5] USGS, 1990. "A Land Use and Land Cover Classification System for Use with Remote Sensor Data," Reston, VA 1990.

[6] [6] USGS, 1990. "A Land Use and Land Cover Classification System for Use with Remote Sensor Data," Reston, VA 1990.

[7] TPWD, 2009. Element of Occurrence Record – Texas Natural Diversity Database. Obtained from Texas Parks and Wildlife Department October 20, 2009.

endangered species with potential to occur in the project area should be initiated early in project planning.

Table 4C.15-3.
Endangered, Threatened, and Species of Concern for Caldwell and Gonzales Counties

Common Name	Scientific Name	Impact Value	Multiplier Based on Status	Adjusted Impact	Summary of Habitat Preference	Listing Entity		Potential Occurrence in County
						USFWS	TPWD	
BIRDS								
Bald eagle	*Haliaeetus leucoephalus*	*0*	*2*	*0*	Found primarily near rivers and large lakes.	DL	T	Possible Migrant
Black-capped Vireo	*Vireo atricapillus*	*1*	*3*	*3*	Oak-juniper woodlands,	LE	E	Resident
Henslow's Sparrow	*Ammodramus henslowii*	*1*	*1*	*1*	Found in weedy fields or cut-over areas			Resident
Interior least tern	*Sterna antillarum athalassos*	*0*	*3*	*0*	Nests along sand and gravel bars in braided streams	LE	E	Resident
Mountain Plover	*Charadrius montanus*	*1*	*1*	*1*	Non-breeding, shortgrass plains and fields			Nesting/Migrant
American peregrine falcon	*Falco peregrinus anatum*	*0*	*2*	*0*	Migrant and local breeder in West Texas.	DL	T	Possible Migrant
Artic peregrine falcon	*Falco peregrinus tundrius*	*0*	*1*	*0*	Migrant throughout the state.	DL		Possible Migrant
Western Burrowing Owl	*Athene cunicularia hypugaea*	*1*	*1*	*1*	Open grasslands, especially prairie, plains and savanna			Resident
Whooping Crane	*Grus americana*	*0*	*3*	*0*	Potential migrant	LE	E	Potential Migrant
Wood Stork	*Mycteria americana*	*1*	*2*	*2*	Forages in prairie ponds, ditches, and shallow standing water formerly nested in TX		T	Migrant
FISH								
Blue sucker	*Cycleptus elongates*	*1*	*2*	*2*	Major rivers in Texas.		T	Resident
Guadalupe Bass	*Micropterus treculi*	*1*	*1*	*1*	Endemic to perennial streams of the Edwards Plateau region.			Resident
Guadalupe Darter	*Percina sciera apristis*	*1*	*1*	*1*	Guadalupe River Basin. Usually found over gravel or gravel and sand raceways of larger streams and rivers.			Resident
MAMMALS								
Cave Myotis Bat	*Myotis velifer*	*0*	*1*	*0*	Roosts colonially in caves, rock crevices			Resident
Plains Spotted Skunk	*Spilogale putorius interrupta*	*1*	*1*	*1*	Prefers wooded, brushy areas.			Resident
Red Wolf	*Canis rufus*	*0*	*3*	*0*	Extirpated.	LE	E	Historic Resident
MOLLUSKS								
Creeper (squawfoot)	*Strophitus undulates*	*1*	*1*	*1*	Small to large streams			Resident

Table 4C.15-3 (Concluded)

Common Name	Scientific Name	Impact Value	Multiplier Based on Status	Adjusted Impact	Summary of Habitat Preference	Listing Entity USFWS	Listing Entity TPWD	Potential Occurrence in County
False spike mussel	*Quincuncina mitchelli*	1	2	2	Substrates of cobble and mud with water lilies present. Rio Grande, Brazos, Colorado and Guadalupe river basins.		T*	Resident
Golden orb	*Quadrula aurea*	1	2	2	Sand and gravel, Guadalupe, San Antonio, and Nueces River basins		T*	Resident
Palmetto pill snail	*Euchemostrema leai cheatumi*	0	1	0	Known only from Palmetto State Park.			Resident
Pistolgrip	*Tritogonia verrucosa*	1	1	1	Aquatic, stable substrate. Red through San Antonio river basins.			Resident
Rock pocketbook	*Arcidens confragosus*	1	1	1	Mud and sand, Red through Guadalupe River basins.			Resident
Texas fatmucket	*Lampsilis bracteata*	1	2	2	Streams and rivers on sand, mud and gravel, Colorado and Guadalupe River basins.		T*	Resident
Texas pimpleback	*Quadrula petrina*	1	2	2	Mud, gravel and sand substrates, Colorado and Guadalupe river basins		T*	Resident
PLANTS								
Elmendorf's onion	*Allium elmendorfii*	1	1	1	Endemic, in deep sands			Resident
Shinner's sunflower	*Helianthus occidentalis ssp.*	1	1	1	Found on prairies on the Coastal Plain.			Resident
Sandhill woolywhite	*Hymenopappus carrizoanus*	1	1	1	Found south of the Guadalupe River and the Balcones Escarpment. Prefers dense riparian corridors.			Resident
REPTILES								
Cagle's map turtle	*Graptemys caglei*	1	2	2	Endemic to Guadalupe River System. Found within 30 feet of waters' edge.		T	Resident
Spot-tailed earless lizard	*Holbrookia lacerata*	1	1	1	Moderately open prairie-brushland.			Resident
Texas Garter Snake	*Thamnophis sirtalis annectens*	1	1	1	Wet or moist microhabitats			Resident
Texas Horned Lizard	*Phrynosoma cornutum*	1	2	2	Varied, sparsely vegetated uplands.		T	Resident
Texas Tortoise	*Gopherus berlandieri*	1	2	2	Open brush w/ grass understory.		T	Resident
Timber/canebrake rattlesnake	*Crotalus horridus*	1	2	2	Floodplains, upland pine, deciduous woodlands, riparian zones.		T	Resident

TPWD, 2009. Annotated County List of Rare Species – Gonzales County. Revised May 4, 2009, and Caldwell County. Revised May 7, 2009.
USFWS, 2009. Endangered Species List for Texas. http://www.fws.gov/southwest/es/EndangeredSpecies/lists/ListSpecies.cfm accessed online October 26, 2009.

4C.15.4 Engineering and Costing

Conceptual planning-level engineering and cost estimates are prepared for the GBRA Mid-Basin (Surface Water) WMS for both the Region L and Permitting scenarios used to evaluate surface water available for diversion.

Major facilities required to implement the river diversion option include:

- Intake and pump station on the Guadalupe River;
- A main pipeline from Gonzales to San Marcos through Luling;
- An off-channel reservoir in Gonzales County, piping to and from the reservoir, and an intake and pump station at the off channel reservoir;
- Transmission booster pump stations; and
- Water treatment plant expansions and enhancements at Luling and San Marcos.

Total project cost for the GBRA Mid-Basin (Surface Water) WMS for the Region L Scenario is estimated at $546,941,000. Annual unit cost is estimated at $2,204/acft/yr (Table 4C.15-4). Annual costs are estimated based on debt service for a 20-year loan at 6 percent interest for the transmission system, debt service for a 40 year loan at 6 percent interest for the reservoir, and operation and maintenance costs, including power. The intake and pump station at the river are sized for diversion and transmission of 517 MGD (800 cfs). Two 120-inch diameter pipelines are assumed necessary to convey the instantaneous maximum diversion rate from the Guadalupe River to the off-channel reservoir.

Annual unit cost for the GBRA Mid-Basin (Surface Water) WMS for the Permitting Scenario is estimated at $1,879/acft/yr (Table 4C.15-5). Total project cost is estimated at $457,611,000. Annual costs, include debt service for a 20-year loan at 6 percent interest for the transmission system and debt service for a 40-year loan at 6 percent interest for the reservoir, and operation and maintenance costs, including power. The intake and pump station at the river are sized for diversion and transmission of 323 MGD (500 cfs). Two 96-inch diameter pipelines are assumed necessary to convey the instantaneous maximum diversion rate from the Guadalupe River to the off-channel reservoir.

Table 4C.15-4.
Cost Estimate Summary
GBRA Mid-Basin (Surface Water) – Region L Scenario
September 2008 Prices

Item	Estimated Costs for Facilities
Capital Costs	
Off-Channel Storage (Conservation Pool 188,800 acft, 5,403 acres)	$57,437,000
Guadalupe River Intake and Pump Station (517.04 MGD)	$40,772,000
Off-Channel Storage Intake and Pump Station (22 MGD)	$10,591,000
Transmission Pipeline (36 in dia., 44 miles)	$56,714,000
Transmission Pipelines (2-120 in dia., 14 miles)	$113,674,000
Transmission Pump Station(s)	$6,779,000
Luling Water Treatment Plant (3.6 MGD)	$5,788,000
San Marcos Water Treatment Plant (18.7 MGD)	$22,347,000
Integration	$31,797,000
Total Capital Cost	**$345,899,000**
Engineering, Legal Costs and Contingencies	$112,546,000
Environmental & Archaeology Studies and Mitigation	$25,836,000
Land Acquisition and Surveying (5644 acres)	$26,828,000
Interest During Construction (2 years)	$35,832,000
Total Project Cost	**$546,941,000**
Annual Costs	
Debt Service (6 percent, 20 years)	$36,221,000
Reservoir Debt Service (6 percent, 40 years)	$8,739,000
Operation and Maintenance	
Intake, Pipeline, Pump Station	$3,464,000
Dam and Reservoir	$862,000
Luling Water Treatment Plant (3.6 MGD)	$725,000
San Marcos Water Treatment Plant (18.7 MGD)	$2,587,000
Pumping Energy Costs (27,765,336 kW-hr @ 0.09 $/kW-hr)	$2,499,000
Total Annual Cost	**$55,097,000**
Available Project Yield (acft/yr)	25,000
Annual Cost of Water ($ per acft)	$2,204
Annual Cost of Water ($ per 1,000 gallons)	$6.76

Table 4C.15-5.
Cost Estimate Summary
GBRA Mid-Basin (Surface Water) – Permitting Scenario
September 2008 Prices

Item	*Estimated Costs for Facilities*
Capital Costs	
Off-Channel Storage (Conservation Pool 105,500 acft, 3,678 acres)	$49,744,000
Guadalupe River Intake and Pump Station (323.15 MGD)	$31,102,000
Off-Channel Storage Intake and Pump Station (22 MGD)	$10,591,000
Transmission Pipeline (36 in dia., 44 miles)	$56,714,000
Transmission Pipelines (2-96 in dia., 14 miles)	$79,348,000
Transmission Pump Station(s)	$6,779,000
Luling Water Treatment Plant (3.6 MGD)	$5,788,000
San Marcos Water Treatment Plant (18.7 MGD)	$22,347,000
Integration	$31,797,000
Total Capital Cost	**$294,210,000**
Engineering, Legal Costs and Contingencies	$96,171,000
Environmental & Archaeology Studies and Mitigation	$18,073,000
Land Acquisition and Surveying (3919 acres)	$18,979,000
Interest During Construction (2 years)	$30,178,000
Total Project Cost	**$457,611,000**
Annual Costs	
Debt Service (6 percent, 20 years)	$30,790,000
Reservoir Debt Service (6 percent, 40 years)	$6,942,000
Operation and Maintenance	
Intake, Pipeline, Pump Station	$2,879,000
Dam and Reservoir	$746,000
Luling Water Treatment Plant (3.6 MGD)	$725,000
San Marcos Water Treatment Plant (18.7 MGD)	$2,587,000
Pumping Energy Costs (2,573,2097 kW-hr @ 0.09 $/kW-hr)	$2,316,000
Total Annual Cost	**$46,985,000**
Available Project Yield (acft/yr)	25,000
Annual Cost of Water ($ per acft)	$1,879
Annual Cost of Water ($ per 1,000 gallons)	$5.77

4C.15.5 Implementation Issues

Institutional arrangements may be needed to implement the project.

1. It will be necessary to obtain the following:
   a. TCEQ Diversion and Storage Permits (Application No. 21378 is administratively complete);
   b. USCE Sections 10 and 404 Dredge and Fill Permits for the reservoir and pipelines;
   c. GLO Sand and Gravel Removal permits;
   d. GLO Easement for use of state-owned land; and
   e. TPWD Sand, Gravel, and Marl permit.
2. Permitting may require these studies:
   a. Habitat mitigation plan;
   b. Environmental studies; and
   c. Cultural resource studies and mitigation.
3. Land will need to be acquired through either negotiations or condemnation.
4. Relocations for the off-channel storage facilities may include:
   a. County roads;
   b. Other utilities;
   c. Product transmission pipelines; and
   d. Power transmission lines.

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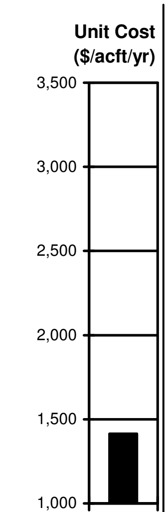
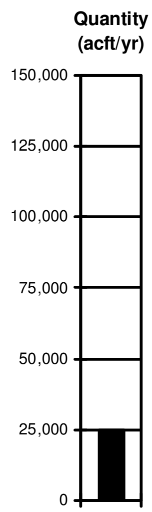
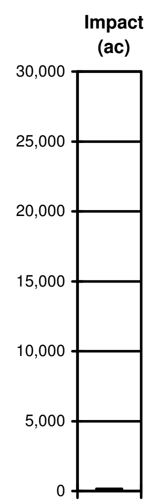
2011 South Central Texas Regional Water Plan
Water Management Strategy Summary Sheet







Name: GBRA Mid-Basin Project (Conjunctive Use)

Description: Facilities include an intake and pump station on the Guadalupe River, a transmission pipeline from Gonzales to San Marcos through Luling, a pump station and well field in Guadalupe County, a transmission pipeline from the well field to a pump station and to San Marcos through Luling; transmission booster pump stations; and water treatment plant expansions and enhancements at Luling and San Marcos.

***Decade Needed*:** 2010 - 2020

Cost, Quantity of Water, and Land Impacted

Unit Cost of Water:	**1,404 - 1,414**	**$/acft/yr**	**Treated Water Delivered**
Quantity of Water:	**25,000**	**acft/yr**	**Reliability = Firm**
Land Impacted:	**211**	**acres**	

Additional Considerations per Regional Water Planning Guidelines

Environmental Factors:

Cagle's map turtle has been documented in the Guadalupe River adjacent to the diversion point. Modification of existing habitats and land uses along pipeline and in the well field area

Impacts on Water Resources:

Potential downstream effects due to modification of existing flow regime below the Gonzales diversion.

Impacts on Agricultural & Natural Resources:

None anticipated.

Other Relevant Factors per SCTRWPG:

Part or all of the water needed by this Water Management Strategy (WMS) is anticipated to be supplied from locations within the jurisdiction of a groundwater conservation district (District) and may exceed the amount of available water identified in the District's approved management plan, or may for other reasons not be permitted by the District. The amount of water needed by this WMS that exceeds the available water in the District's management plan, or for other reasons is not permitted by the District, cannot be implemented as part of this WMS unless and until all necessary permits are received from the District. The amount of water needed by this WMS that exceeds the available water in the District's management plan, or for other reasons is not permitted by the District, introduces an added element of uncertainty to reliance upon this WMS and, therefore, additional management supplies may be needed for this WMS.

Permits required by GCUWCD include analyses of pumping impacts on groundwater levels, mitigation to existing well owners, Drought and Water Conservation Plans, and a needs assessment .

Project subject to senior water rights, full application of environmental flow standards adopted pursuant to Section 11.1471 of the Texas Water Code, and the TCEQ permitting process.

Comparison of Strategies to Meet Needs:

Options to meet needs are limited; this option has a moderate unit cost. Strategy may exceed the available groundwater in the GCUWCD's management plan.

Interbasin Transfer Issues:

Not applicable.

Third-Party Impacts of Voluntary Transfers:

None anticipated.

Regional Efficiency:

Provides long-term water supplies throughout the GBRA statutory district.

Water Quality Considerations:

None of significant concern.

4C.16 GBRA Mid-Basin Project (Conjunctive Use)

4C.16.1 Description of Water Management Strategy

The Guadalupe-Blanco River Authority (GBRA) is in the planning and permitting stages of a phased Mid-Basin Project to provide supplemental water supplies directly to customers in Hays and Caldwell Counties in the near-term and indirectly to customers in Comal, Guadalupe, and Kendall Counties by replacement or reduction of Canyon Reservoir supplies currently delivered to the San Marcos WTP in the long-term. GBRA is currently considering at least three formulations of the Mid-Basin Project using available surface water and/or groundwater supply sources to ensure unrestricted delivery of a firm yield of approximately 25,000 acft/yr. In all three formulations, plans are to deliver 4,000 acft/yr to the Luling Water Treatment Plant (WTP) and approximately 21,000 acft/yr to the San Marcos WTP. New supplies will be delivered uniformly throughout the year and customer peaking requirements will be met from other sources. This water management strategy focuses on the conjunctive use formulation which utilizes the Guadalupe River as the primary supply and groundwater in Gonzales County as a supplemental supply.

For this alternative, the primary source for the GBRA Mid-Basin Project will be surface water. An intake on the Guadalupe River will divert water under a new appropriation to provide uniform delivery of 25,000 acft each year. When surface water is not available, groundwater from the Carrizo Aquifer in west-central or northeast Gonzales County will be used to make-up the shortages (Figure 4C.16-1). The main transmission pipeline follows US 183 from the surface water intake to the Luling WTP, where 4,000 acft/yr will be treated. From Luling, the pipeline follows SH 80 to the San Marcos WTP, where the remaining 21,000 acft/yr will be treated. The assumed diameter of the main transmission pipeline between the Guadalupe River and the water treatment plants and between the well field and the main transmission pipeline is 36 inches. GBRA has submitted Application No. 12378 for the surface water rights associated with this water management strategy and this application has been declared administratively complete by the Texas Commission on Environmental Quality (TCEQ).

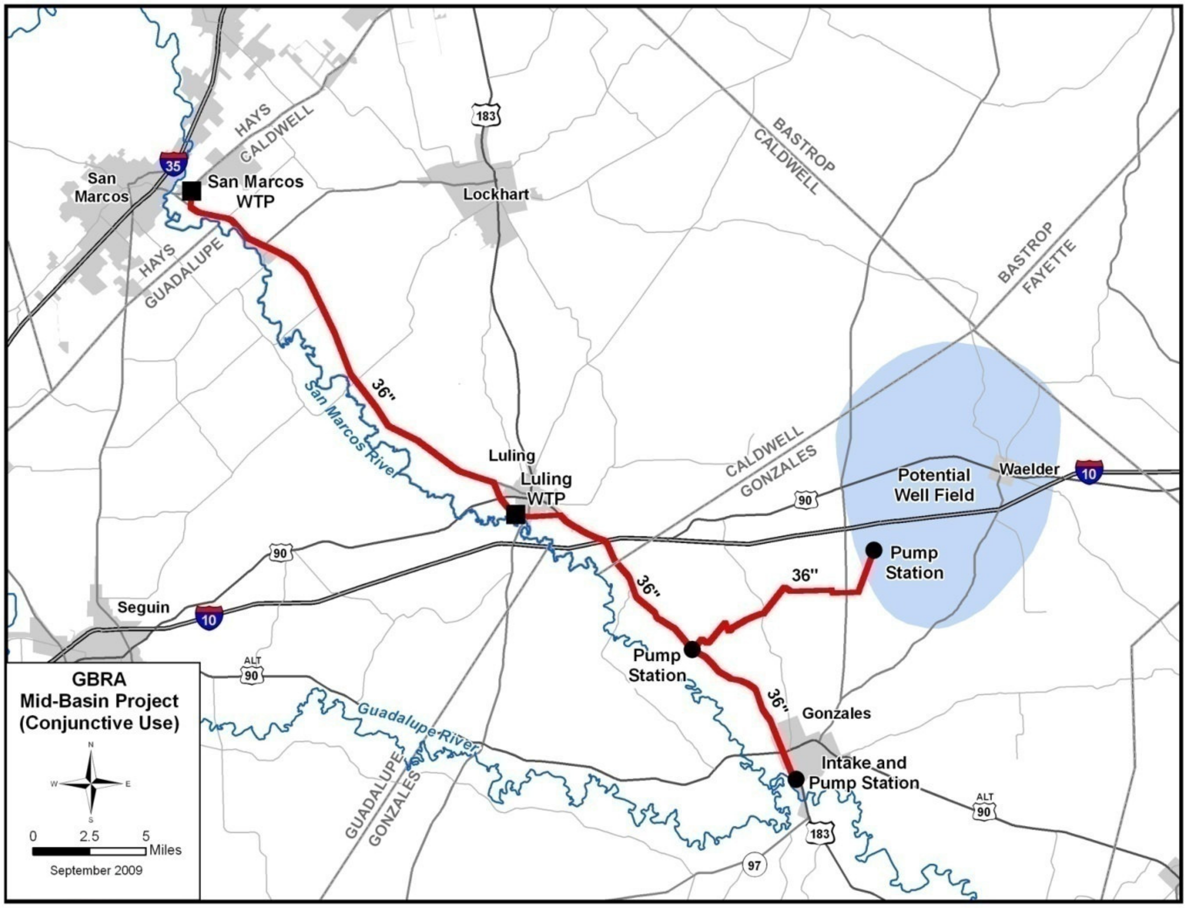


Figure 4C.16-1 Location of GBRA Mid-Basin Project (Conjunctive Use)

4C.16.2 Surface Water and Groundwater Availability

4C.16.2.1 Surface Water Availability

The surface water portion of the GBRA Mid-Basin (Conjunctive Use) water management strategy (WMS) is evaluated under two scenarios: the Region L Scenario and the Permitting Scenario. For the Region L Scenario, surface water availability is constrained by the Consensus Criteria for Environmental Flows Needs (CCEFN) and includes treated effluent. For the Permitting Scenario, surface water availability is constrained by Modified Lyons Method (Lyons) and does not include treated effluent. Both scenarios assume a maximum diversion rate of 35 cfs from the Guadalupe River. The two environmental flows criteria and the results from the two scenarios are discussed herein. It should be noted that the two environmental flow criteria presented herein are place-holders as GBRA has advised that this strategy will be subject to full application of environmental flow standards to be adopted pursuant to Section 11.1471 of the Texas Water Code.

4C.16.2.1.1 Environmental Flow Considerations

Any new surface water permit will include streamflow restrictions for environmental purposes. Comparison of potential environmental flow criteria for such a new water right authorizing run-of-river diversions from the Guadalupe River near Gonzales included the Modified Lyons Method and the Consensus Criteria for Environmental Flow Needs (CCEFN). Figure 4C.16-2 illustrates the monthly flow restrictions associated with the two criteria used for calculating water availability.

GBRA is applying to the Texas Commission on Environmental Quality (TCEQ) for two new water rights to divert unappropriated flows of the Guadalupe River. One water right application (No. 12378) seeks to divert up to 75,000 acft/yr from the Guadalupe River in Gonzales County, in the Middle Guadalupe River Basin. The other application (No. 12482) seeks to divert up to 189,484 acft/yr from the Guadalupe River in Calhoun County, in the Lower Guadalupe River Basin. The lower basin application is in addition to water already permitted for diversion under existing rights held jointly by GBRA and Union Carbide Corporation (Dow Chemical Company).

The amount of water petitioned in both applications will have the potential to be available for diversion primarily in non-drought years for two reasons. First, the new water rights will have brand new priority dates, so the right to divert under those water rights will be junior (last in time) relative to all existing water rights. Second, diversions of this new water will be subject to environmental streamflow conditions to be imposed by the TCEQ for the protection of San Antonio Bay and estuary system. GBRA acknowledges the importance of ensuring that those rights are conditioned in order to ensure strong protection of instream flows and freshwater inflows. Accordingly, GBRA indicates its commitment that any permits issued pursuant to the applications, regardless of timing, will be made subject to the full application of environmental flow standards adopted pursuant to Section 11.1471 of the Texas Water Code that are applicable to affected portions of the Guadalupe River and to the San Antonio Bay estuary system.

4C.16.2.1.2 *Surface Water Availability Modeling*

The Guadalupe-San Antonio River Basin Water Availability Model (GSAWAM, as modified for regional water planning purposes) is used to quantify water available for diversion under the GBRA Mid-Basin (Conjunctive Use) WMS. Hydrologic simulations and calculations are performed subject to the General Assumptions for Applications of Hydrologic Models, as adopted by the SCTRWPG for the 2011 Regional Water Plan.

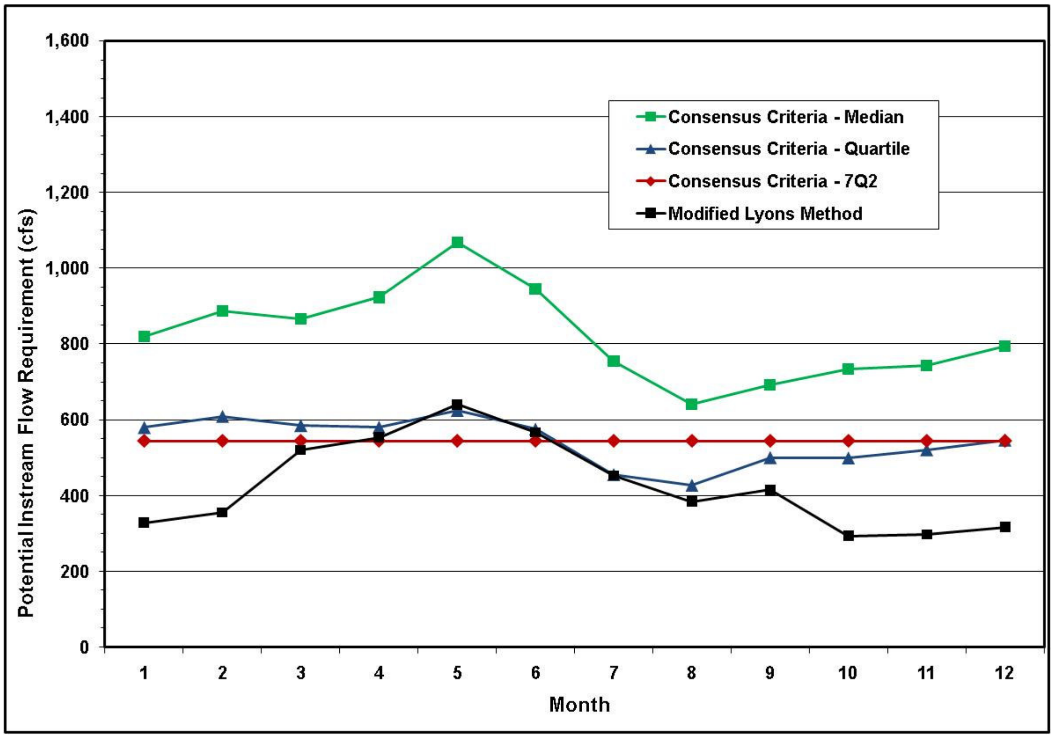


Figure 4C.16-2. Alternative Environmental Flow Criteria — Conceptual Assessment of a Diversion from the Guadalupe River @ Gonzales

Application of the GSAWAM, with a period of record from January 1934 to December 1989, demonstrates that the monthly equivalent of the 25,000 acft/yr firm yield is available from the Guadalupe River at Gonzales in about 62 percent of the months simulated under the Region L Scenario, limited by 35 cfs maximum diversion rate, and 71 percent of the months simulated under the Permitting Scenario, limited by 35 cfs maximum diversion rate. Monthly estimates of water available for the GBRA Mid-Basin (Conjunctive Use) WMS are summarized in Table 4C.16-1 and 4C.16-2. Actual diversions from the Guadalupe River to the off-channel reservoir are further limited by amounts necessary to keep the reservoir full and meet the delivery amount of 25,000 acft/yr.

Table 4C.16-1.
Water Available to GBRA Mid-Basin Project (Conjunctive Use) - Region L Scenario

Year	Monthly Availability by Year (acft)												Total
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
1934	32	0	0	0	95	996	1,801	1,881	2,040	2,152	96	0	9,091
1935	821	24	2,079	2,083	47	0	0	203	0	0	0	0	5,256
1936	0	311	58	2,083	51	39	0	0	1,180	0	0	0	3,722
1937	0	0	0	215	228	12	1,855	2,152	2,083	1,965	2,083	1,320	11,912
1938	0	0	0	0	0	0	2,152	2,152	2,083	2,152	2,083	2,152	12,773
1939	2,152	1,944	2,152	2,083	1,820	2,083	2,083	2,152	2,083	2,152	2,083	2,152	24,937
1940	2,152	1,944	2,043	1,805	2,152	2,013	0	2,152	2,083	2,083	33	214	18,673
1941	318	0	0	0	0	0	0	1,827	1,811	0	196	0	4,151
1942	0	336	2,152	0	60	995	22	2,001	0	0	0	0	5,565
1943	0	0	0	31	2,030	170	1,856	2,152	2,013	2,152	2,083	2,152	14,639
1944	549	65	0	0	0	0	858	2,152	0	391	66	64	4,145
1945	0	0	0	0	196	254	2,013	2,152	2,083	136	2,083	46	8,962
1946	167	247	0	87	0	9	2,152	1,944	0	0	0	0	4,605
1947	0	0	0	0	0	241	2,152	1,944	2,083	2,152	2,083	2,152	12,806
1948	2,152	1,944	2,152	2,083	1,530	2,083	2,152	2,152	2,083	2,152	2,083	2,152	24,716
1949	2,152	1,666	1,112	1,232	0	2,050	2,152	2,152	2,083	1,300	2,083	2,152	20,133
1950	2,152	1,527	2,152	1,612	1,898	1,538	2,152	2,152	2,083	2,152	2,083	2,152	23,651
1951	2,152	1,944	2,152	2,083	2,152	1,513	2,152	2,152	2,083	2,152	2,083	2,152	24,769
1952	2,152	1,944	2,152	2,083	1,805	1,605	2,152	2,152	1,944	2,152	1,736	425	22,301
1953	73	1,944	2,152	2,013	19	2,083	2,152	2,152	1,507	1,480	2,037	1,944	19,555
1954	2,152	1,944	2,152	2,083	2,083	2,083	2,152	2,152	2,083	2,152	2,083	2,152	25,269
1955	2,152	1,735	2,152	2,083	1,883	1,951	2,152	2,152	2,083	2,152	2,083	2,152	24,730
1956	2,152	1,944	2,152	2,083	2,152	2,083	2,152	2,152	2,083	2,152	2,083	2,083	25,269
1957	2,152	1,944	1,805	1,382	0	62	2,152	2,152	1,458	17	0	0	13,124
1958	0	0	0	0	21	49	90	2,152	447	0	0	0	2,758

Table 4C.16-1 (Concluded)

Year	Monthly Availability by Year (acft)												Total
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
1959	0	0	54	28	38	1,043	1,414	2,083	2,083	476	321	0	7,539
1960	0	0	203	1,666	68	1,058	0	833	885	0	0	0	4,712
1961	0	0	0	0	0	72	0	849	128	229	147	0	1,425
1962	968	1,763	2,152	1,859	2,057	1,781	2,152	2,152	1,666	1,805	2,042	1,553	21,950
1963	2,152	1,468	2,152	1,819	2,152	2,083	2,152	2,152	2,083	2,152	2,013	2,152	24,529
1964	2,152	1,665	1,712	2,083	2,152	2,013	2,152	2,152	1,527	2,019	1,874	2,152	23,653
1965	1,488	0	145	66	266	0	0	1,805	2,058	1,051	193	7	7,078
1966	0	0	0	0	0	2	2,152	124	264	206	2,083	2,152	6,983
1967	2,152	1,944	2,152	2,083	2,152	2,083	2,152	2,152	203	201	121	800	18,193
1968	0	0	0	0	0	0	0	1,426	170	1,436	585	117	3,733
1969	667	0	0	24	0	113	1,522	2,152	1,962	531	494	0	7,464
1970	0	0	0	0	0	0	243	1,649	1,906	48	1,824	2,152	7,822
1971	2,152	1,944	2,152	2,083	2,152	2,083	2,152	833	0	166	0	0	15,716
1972	0	0	0	2,083	0	0	0	0	2,024	609	50	0	4,766
1973	56	0	0	0	0	0	0	0	0	0	0	0	56
1974	0	0	0	159	5	0	1,666	0	0	0	0	0	1,830
1975	0	0	0	0	0	0	0	0	0	0	125	0	125
1976	0	561	1,064	0	0	0	0	0	39	0	0	0	1,664
1977	0	0	0	0	0	0	0	966	0	1,349	163	0	2,478
1978	37	755	1,242	1,858	2,152	1,559	2,152	8	0	0	0	0	9,762
1979	0	0	0	0	0	0	0	0	0	0	0	14	14
1980	970	0	0	2,083	0	1,984	2,152	2,152	451	0	125	519	10,436
1981	0	0	0	0	0	0	0	0	0	0	0	0	0
1982	0	22	0	0	0	279	2,152	2,152	2,083	2,152	1,943	2,152	12,934
1983	1,687	295	0	777	1,207	67	1,646	2,152	1,237	2,083	1,387	2,152	14,689
1984	2,152	1,824	2,152	2,083	2,152	2,083	2,152	2,152	2,083	1,911	1,678	1,203	23,624
1985	118	0	0	0	91	0	0	1,959	2,032	0	0	0	4,200
1986	0	0	240	0	0	0	685	2,152	106	0	0	0	3,183
1987	0	0	0	0	0	0	0	0	0	0	0	0	0
1988	0	0	379	0	23	312	0	567	1,187	2,152	2,083	2,152	8,855
1989	2,098	1,944	256	902	594	2,037	2,152	2,152	2,083	2,152	2,083	2,152	20,604
MAX	**2,152**	**1,944**	**2,152**	**2,083**	**2,152**	**2,083**	**2,152**	**2,152**	**2,083**	**2,152**	**2,083**	**2,152**	**25,269**
AVG	**794**	**671**	**798**	**871**	**669**	**796**	**1,239**	**1,523**	**1,209**	**999**	**939**	**876**	**11,384**
MIN	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**

Table 4C.16-2.
Water Available to GBRA Mid-Basin Project (Conjunctive Use) - Permitting Scenario

Year	Monthly Availability by Year (acft)												Total
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
1934	32	0	0	0	95	996	1,801	1,881	2,040	2,152	96	0	9,091
1935	821	24	2,079	2,083	47	0	0	203	0	0	0	0	5,256
1936	0	311	58	2,083	51	39	0	0	1,180	0	0	0	3,722
1937	0	0	0	215	228	12	1,855	2,152	2,083	1,965	2,083	1,320	11,912
1938	0	0	0	0	0	0	2,152	2,152	2,083	2,152	2,083	2,152	12,773
1939	2,152	1,944	2,152	2,083	1,820	2,083	2,083	2,152	2,083	2,152	2,083	2,152	24,937
1940	2,152	1,944	2,043	1,805	2,152	2,013	0	2,152	2,083	2,083	33	214	18,673
1941	318	0	0	0	0	0	0	1,827	1,811	0	196	0	4,151
1942	0	336	2,152	0	60	995	22	2,001	0	0	0	0	5,565
1943	0	0	0	31	2,030	170	1,856	2,152	2,013	2,152	2,083	2,152	14,639
1944	549	65	0	0	0	0	858	2,152	0	391	66	64	4,145
1945	0	0	0	0	196	254	2,013	2,152	2,083	136	2,083	46	8,962
1946	167	247	0	87	0	9	2,152	1,944	0	0	0	0	4,605
1947	0	0	0	0	0	241	2,152	1,944	2,083	2,152	2,083	2,152	12,806
1948	2,152	1,944	2,152	2,083	1,530	2,083	2,152	2,152	2,083	2,152	2,083	2,152	24,716
1949	2,152	1,666	1,112	1,232	0	2,050	2,152	2,152	2,083	1,300	2,083	2,152	20,133
1950	2,152	1,527	2,152	1,612	1,898	1,538	2,152	2,152	2,083	2,152	2,083	2,152	23,651
1951	2,152	1,944	2,152	2,083	2,152	1,513	2,152	2,152	2,083	2,152	2,083	2,152	24,769
1952	2,152	1,944	2,152	2,083	1,805	1,605	2,152	2,152	1,944	2,152	1,736	425	22,301
1953	73	1,944	2,152	2,013	19	2,083	2,152	2,152	1,507	1,480	2,037	1,944	19,555
1954	2,152	1,944	2,152	2,083	2,083	2,083	2,152	2,152	2,083	2,152	2,083	2,152	25,269
1955	2,152	1,735	2,152	2,083	1,883	1,951	2,152	2,152	2,083	2,152	2,083	2,152	24,730
1956	2,152	1,944	2,152	2,083	2,152	2,083	2,152	2,152	2,083	2,152	2,083	2,083	25,269
1957	2,152	1,944	1,805	1,382	0	62	2,152	2,152	1,458	17	0	0	13,124
1958	0	0	0	0	21	49	90	2,152	447	0	0	0	2,758
1959	0	0	54	28	38	1,043	1,414	2,083	2,083	476	321	0	7,539
1960	0	0	203	1,666	68	1,058	0	833	885	0	0	0	4,712
1961	0	0	0	0	0	72	0	849	128	229	147	0	1,425
1962	968	1,763	2,152	1,859	2,057	1,781	2,152	2,152	1,666	1,805	2,042	1,553	21,950
1963	2,152	1,468	2,152	1,819	2,152	2,083	2,152	2,152	2,083	2,152	2,013	2,152	24,529
1964	2,152	1,665	1,712	2,083	2,152	2,013	2,152	2,152	1,527	2,019	1,874	2,152	23,653
1965	1,488	0	145	66	266	0	0	1,805	2,058	1,051	193	7	7,078
1966	0	0	0	0	0	2	2,152	124	264	206	2,083	2,152	6,983
1967	2,152	1,944	2,152	2,083	2,152	2,083	2,152	2,152	203	201	121	800	18,193
1968	0	0	0	0	0	0	0	1,426	170	1,436	585	117	3,733

Table 4C.16-2 (Concluded)

Year	Monthly Availability by Year (acft)												Total
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
1969	667	0	0	24	0	113	1,522	2,152	1,962	531	494	0	7,464
1970	0	0	0	0	0	0	243	1,649	1,906	48	1,824	2,152	7,822
1971	2,152	1,944	2,152	2,083	2,152	2,083	2,152	833	0	166	0	0	15,716
1972	0	0	0	2,083	0	0	0	0	2,024	609	50	0	4,766
1973	56	0	0	0	0	0	0	0	0	0	0	0	56
1974	0	0	0	159	5	0	1,666	0	0	0	0	0	1,830
1975	0	0	0	0	0	0	0	0	0	0	125	0	125
1976	0	561	1,064	0	0	0	0	0	39	0	0	0	1,664
1977	0	0	0	0	0	0	0	966	0	1,349	163	0	2,478
1978	37	755	1,242	1,858	2,152	1,559	2,152	8	0	0	0	0	9,762
1979	0	0	0	0	0	0	0	0	0	0	0	14	14
1980	970	0	0	2,083	0	1,984	2,152	2,152	451	0	125	519	10,436
1981	0	0	0	0	0	0	0	0	0	0	0	0	0
1982	0	22	0	0	0	279	2,152	2,152	2,083	2,152	1,943	2,152	12,934
1983	1,687	295	0	777	1,207	67	1,646	2,152	1,237	2,083	1,387	2,152	14,689
1984	2,152	1,824	2,152	2,083	2,152	2,083	2,152	2,152	2,083	1,911	1,678	1,203	23,624
1985	118	0	0	0	91	0	0	1,959	2,032	0	0	0	4,200
1986	0	0	240	0	0	0	685	2,152	106	0	0	0	3,183
1987	0	0	0	0	0	0	0	0	0	0	0	0	0
1988	0	0	379	0	23	312	0	567	1,187	2,152	2,083	2,152	8,855
1989	2,098	1,944	256	902	594	2,037	2,152	2,152	2,083	2,152	2,083	2,152	20,604
MAX	**2,152**	**1,944**	**2,152**	**2,083**	**2,152**	**2,083**	**2,152**	**2,152**	**2,083**	**2,152**	**2,083**	**2,152**	**25,269**
AVG	**794**	**671**	**798**	**871**	**669**	**796**	**1,239**	**1,523**	**1,209**	**999**	**939**	**876**	**11,384**
MIN	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**

The inclusion of well field proximate to the Gonzales diversion point of sufficient capacity to firm up run-of-river supplies is necessary to deliver a firm supply of 25,000 acft/yr without the commitment of any water from Canyon Reservoir. In order to develop a firm yield of 25,000 acft/yr, groundwater would be used to make-up the differences between the Guadalupe River diversions and the firm yield. Utilizing the GSAWAM, water available from the Guadalupe River is calculated for each of the simulation scenarios, as is the make-up water needed from groundwater.

4C.16.2.2 Groundwater Availability

4C.16.2.2.1 Selection of Groundwater Model

Since 2001, several regional groundwater availability models (GAMs) have been developed for the Gonzales County area, including: Central Carrizo-Wilcox/Queen City-Sparta GAM (Central Carrizo GAM)[1], South Central Carrizo System (SCCS) Model[2], and Southern Carrizo-Wilcox/Queen City- Sparta GAM (Southern Carrizo GAM)[3]. Analyses of Carrizo and Wilcox supplies in Gonzales County for the 2006 South Central Texas Regional Water Plan (2006 Region L Plan)[4] were performed using the SCCS model and the Southern Carrizo GAM. The Southern Carrizo GAM provides suitable coverage for the western part of the county; however, as shown in Figure 4C.16-3, the model coverage ends just a few miles northeast of the county. The Southern Carrizo GAM includes fixed general head boundaries for the northeast edge of the model, which may inappropriately represent drawdown conditions for pumping near the model boundaries. The Central Carrizo GAM provides more complete coverage of Gonzales County and was selected for this analysis.

4C.16.2.2.2 Groundwater Demands

The groundwater model simulation period extends from 2010 to 2065. For planning purposes, the project is assumed to become operational in 2010. To coincide with the duration of the surface water model, the simulation is for a 56-year period. Annual groundwater demands during the simulation period are based on shortages of surface water supplies.

Once surface water availability was determined, groundwater was used to make up any surface water shortages and ensure a reliable 25,000 acft/yr water supply. Figure 4C.16-4 shows the annual groundwater pumping schedule using the Region L Scenario (black bars). The gray bars show the amounts of surface water supply available with a maximum instantaneous diversion of 770 cfs, which includes treated effluent. The least amount of surface water is available for diversion is during 1954 and 1956 hydrologic conditions (69 acft/yr). This means that 24,931 acft of groundwater supplies would be required during a reoccurrence of drought conditions equal in severity to that during these years. Long-term average groundwater

[1] Dutton, A.R., et al., Groundwater Availability Model for the Central Part of the Carrizo-Wilcox Aquifer in Texas, Texas Water Development Board, February 2003.
[2] HDR Engineering, Inc., South Central Carrizo System Groundwater Model, San Antonio Water System, November 2004.
[3] Deeds, N. et al., Groundwater Availability Model for the Southern Carrizo-Wilcox Aquifer, Texas Water Development Board, January 2003.
[4] South Central Texas Regional Water Planning Group, 2006 South Central Texas Regional Water Plan, Texas Water Development Board, San Antonio River Authority, HDR Engineering, Inc., January 2006.

production would average 11,712 acft/yr. No groundwater would be needed in 3 of the 56 years simulated, except as necessary to exercise the well pumps.

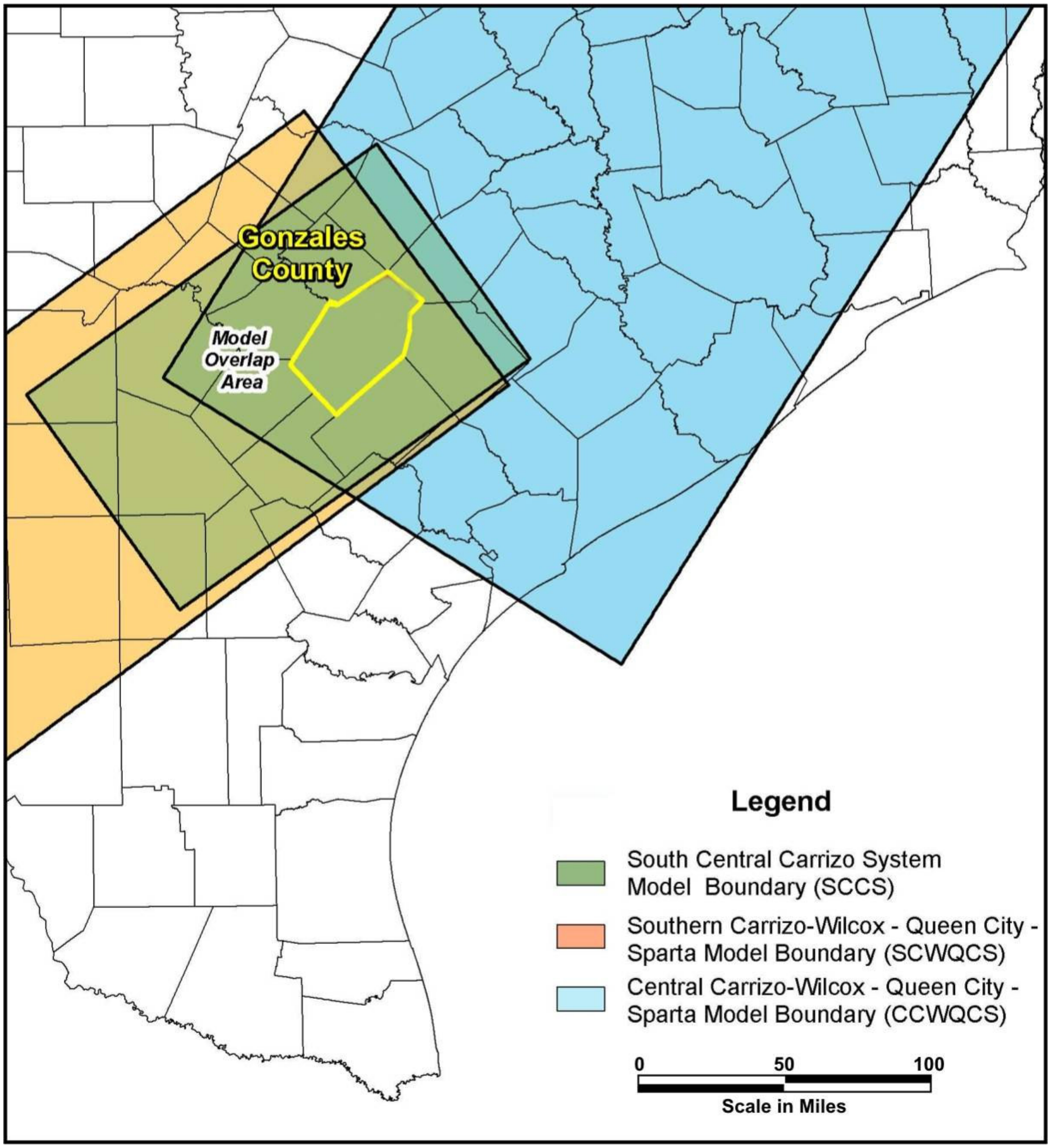


Figure 4C.16-3. Coverage of Regional Groundwater Models

Figure 4C.16-5 shows the annual groundwater pumping schedule using the Permitting Scenario (black bars). The gray bars show the amounts of surface water supply available with a maximum diversion of 500 cfs without return flows. For purposes of this analysis, the hydrologic conditions from 1934 to 1989 are assumed to be repeated from 2010 to 2065. The least amount of surface water is available for diversion is during 1954 and 1956 hydrologic conditions (69 acft/yr). This means that 24,931 acft of groundwater supplies would be required during a reoccurrence of drought conditions equal in severity to that during these years. Long-term average groundwater production, however, would average only 8,356 acft/yr. At least some groundwater would be needed during each of the years in the selected scenario.

The two instream flow restrictions result in different long-term average groundwater demands due to greater surface water availability afforded, in part, by drought relief provisions in the CCEFN that are absent in the Modified Lyons Method.

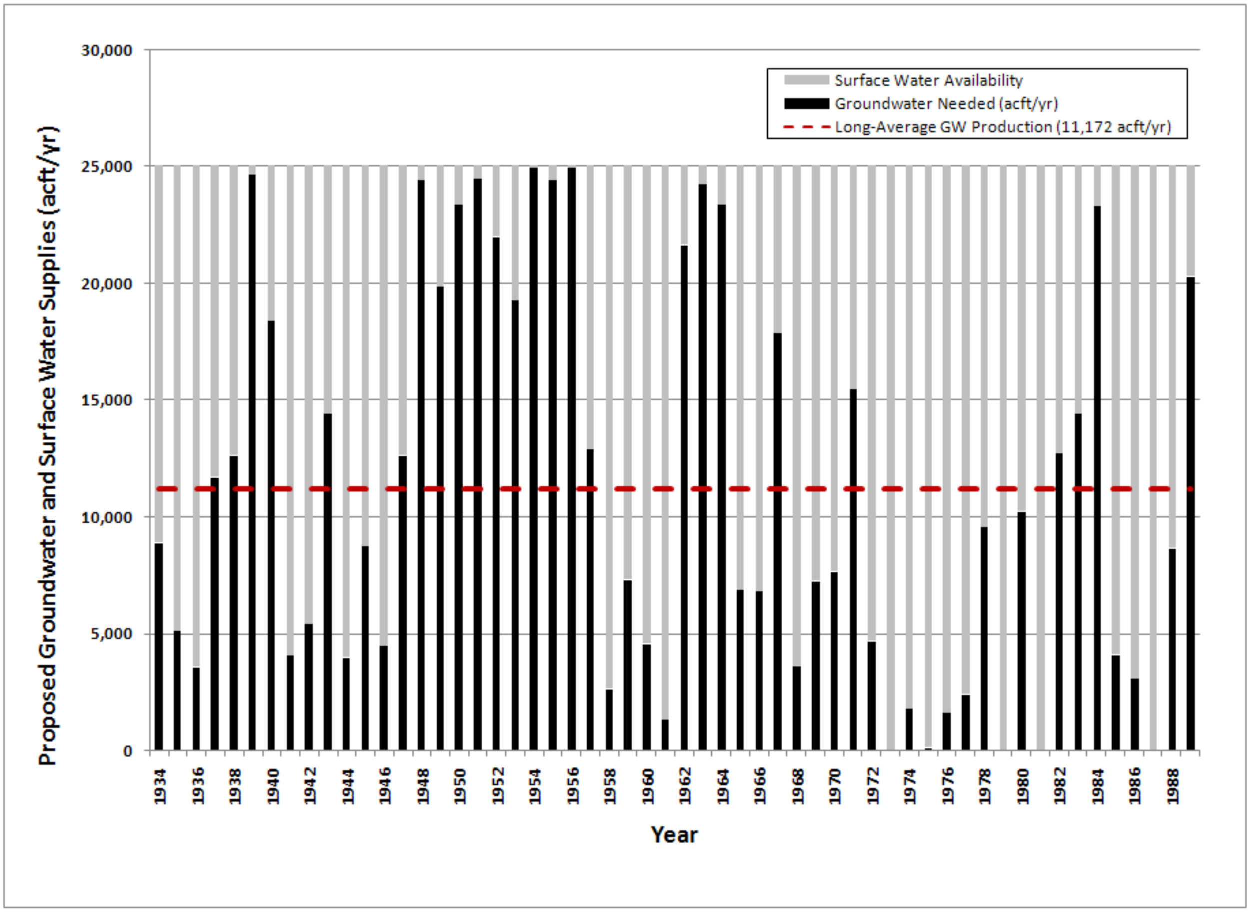


Figure 4C.16-4. Estimated Groundwater Supplies Required for a 25,000 acft/yr Supply Based Region L Scenario

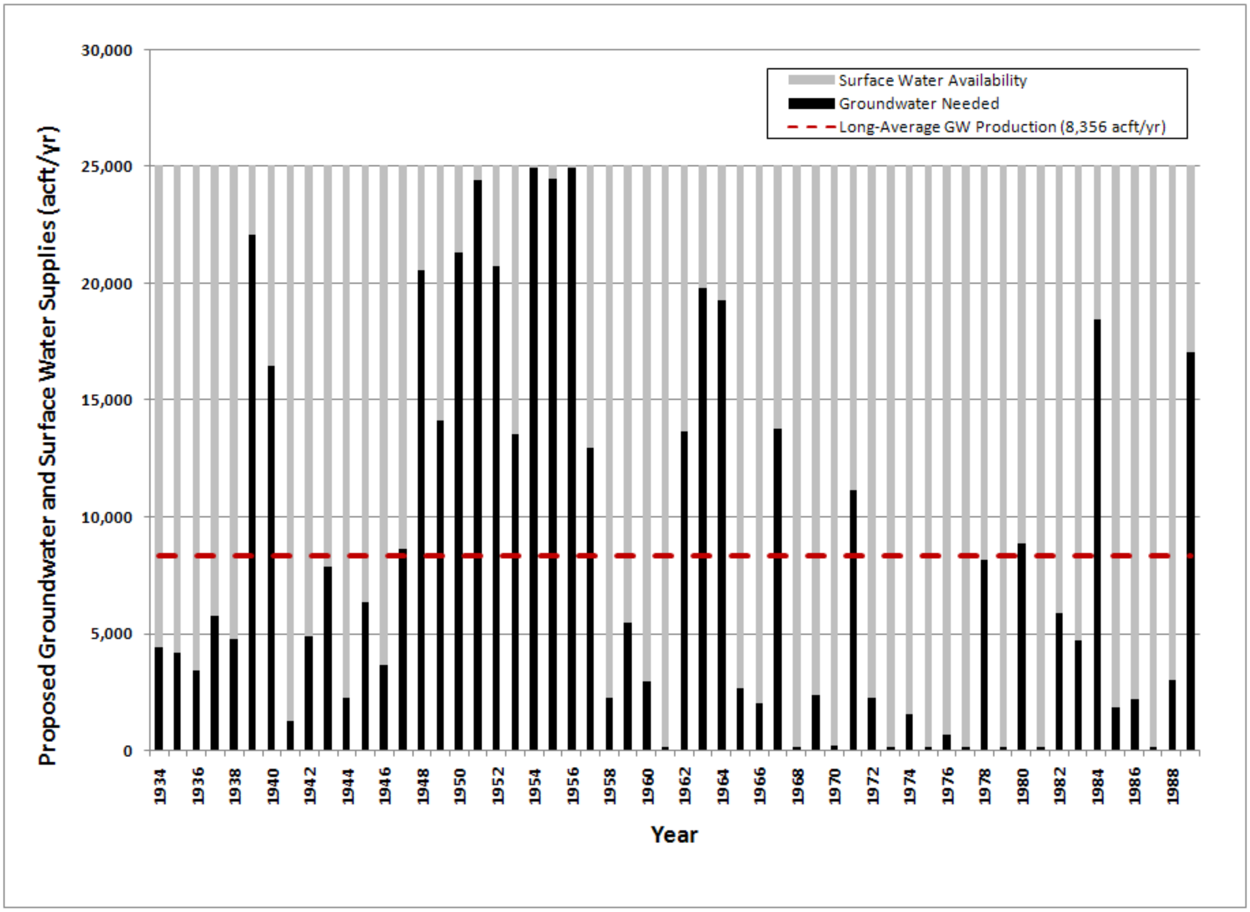


Figure 4C.16-5. Estimated Groundwater Supplies Required for a 25,000 acft/yr Supply Based on Permitting Scenario

4C.16.2.2.3 Proposed Well Field Layout

The well field consists of 16 Carrizo wells with pumping capacity of about 1,000 gallons per minute (gpm) per active well.[5] According to GCUWCD rules, 25,000 acres would need to be leased or purchased for the project (i.e., 1 acft per acre allowable production rate) and wells of this capacity would be subject to a setback of 6,000 feet from existing registered Carrizo wells. The proposed well locations were selected based on aquifer parameters including depth to water bearing zone, minimizing drawdown interference among wells, and spacing setbacks from existing Carrizo wells in the Gonzales County Underground Water Conservation District (GCUWCD) registered well database.

[7] The maximum Carrizo well production is 965 gpm per well for both the CCEFN and Modified Lyons instream flow restrictions.

4C.16.2.2.4 Well Field Pumping Simulations

Figures 4C.16-4 and 4C.16-5 show the groundwater pumping schedules for the two alternative instream flow restrictions based on the historical period from 1934 to 1989 (56 years). Assuming the 1934 to 1989 period would be repeated from 2010 to 2065, maximum groundwater demands occur in 2030 and 2032 for both instream flow restrictions. After 2032, groundwater pumping would be substantially less and groundwater levels would be expected to show recovery because the simulated drought of the 1950s has ended. To remove the effects of variable background pumping and to isolate the effects of pumping for the GBRA Mid-Basin Project (Conjunctive Use), baseline pumping was set equal to 2060 projected groundwater use (21,988 acft/yr in the Carrizo Aquifer) for the entire model simulation period (2010 to 2065) for both model scenarios. This is expected to have a minor effect because of minimal projected increases in background pumping in the Carrizo and Wilcox Aquifers from 2010 to 2060 for Gonzales County use. Model pumping in the remaining aquifers for Gonzales and surrounding counties was also set to 2060 levels, starting in 2010. The maximum simulated annual groundwater pumping from the Carrizo Aquifer in Gonzales County would be about 46,919 acft/yr for both pumping scenarios, which includes 21,988 for the background pumping and 24,931 acft/yr for the GBRA Mid-Basin Project (Conjunctive Use).

4C.16.2.2.5 Groundwater Model Results

The Central Carrizo GAM was used to simulate each scenario. Each simulation demonstrates the potential impacts of the GBRA Mid-Basin Project (Conjunctive Use) on groundwater levels associated with providing a firm yield supply of 25,000 acft/yr in conjunction with surface water from the Guadalupe River. Results of the groundwater analyses focus on 2032, when simulated pumping was the greatest, and 2065, which is at the end of the simulation period.

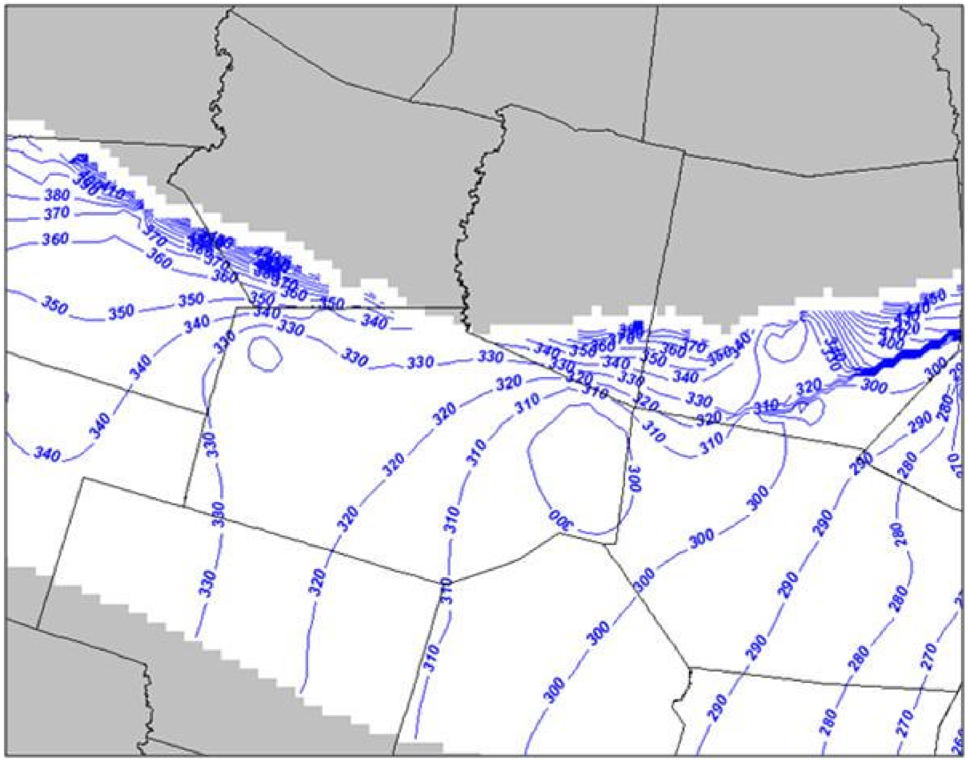
4C.16.2.2.5.1 Baseline + GBRA Mid-Basin Project (Conjunctive Use) using Region L Scenario

This scenario includes background pumping plus GBRA Mid-Basin Project (Conjunctive Use) pumping, which is presented in Figure 4C.16-4. The maximum GBRA Mid-Basin Project (Conjunctive Use) pumping for this scenario, 24,931 acft/yr, occurs in 2030 and 2032 which represent 1954 and 1956 conditions, respectively. Figure 4C.16-6 presents 2032 and 2065 Carrizo water levels for this scenario. 2032 represents the worst-case for groundwater impacts associated with GBRA Mid-Basin Project (Conjunctive Use) pumping conditions. Water levels observed around the GBRA Mid-Basin Project (Conjunctive Use) well field are approximately 300 ft-msl. For 2065, after several wet years based on historical hydrologic conditions and consequently less groundwater demands, the Carrizo Aquifer shows a water level recovery is also about 300 ft-msl within the well field. Figure 4C.16-7 presents the projected 2002-2032 and 2002-2065 drawdowns for this scenario. The maximum drawdown in the well field is 76 ft for 2032. It recovers by 4 ft from 2032 to 2065. Figure 4C.16-8 presents drawdowns attributed to GBRA Mid-Basin Project (Conjunctive Use) pumping from the well field in 2032 and 2065. This figure shows that the greatest drawdown attributed to the GBRA Mid-Basin Project (Conjunctive Use) is 58 ft for 2032. It recovers by 21 ft from 2032 to 2065.

4C.16.2.2.5.2 Baseline + GBRA Mid-Basin Project (Conjunctive Use) using Permitting Scenario

This scenario includes background pumping plus GBRA Mid-Basin Project (Conjunctive Use) pumping, which is presented in Figure 4C.16-5. The maximum GBRA Mid-Basin Project (Conjunctive Use) pumping for this scenario, 24,931 acft/yr, occurs in 2030 and 2032 which represent 1954 and 1956 conditions, respectively. Figure 4C.16-9 presents 2032 and 2065 Carrizo water levels for this scenario. 2032 represents the worst-case for groundwater impacts associated with GBRA Mid-Basin Project (Conjunctive Use) pumping conditions. Water levels observed around the GBRA Mid-Basin Project (Conjunctive Use) well field are approximately 300 ft-msl. For 2065, after several wet years based on historical hydrologic conditions and consequently less groundwater demands, the Carrizo Aquifer shows a water level recovery to about 310 ft-msl within the well field. Figure 4C.16-10 presents the projected 2002-2032 and 2002-2065 drawdowns for this scenario. The maximum drawdown in the well field is 75 ft in 2032. It recovers by 14 ft from 2032 to 2065. Figure 4C.16-11 presents drawdowns attributed to GBRA Mid-Basin Project (Conjunctive Use) pumping from the well field in 2032 and 2065. This figure shows that the greatest drawdown attributed to the GBRA Mid-Basin Project (Conjunctive Use) is 63 ft for 2032. It recovers by 15 ft from 2032 to 2065.

(a) 2032 Carrizo Water Level Elevation (ft-msl)



(b) 2065 Carrizo Water Level Elevation (ft-msl)

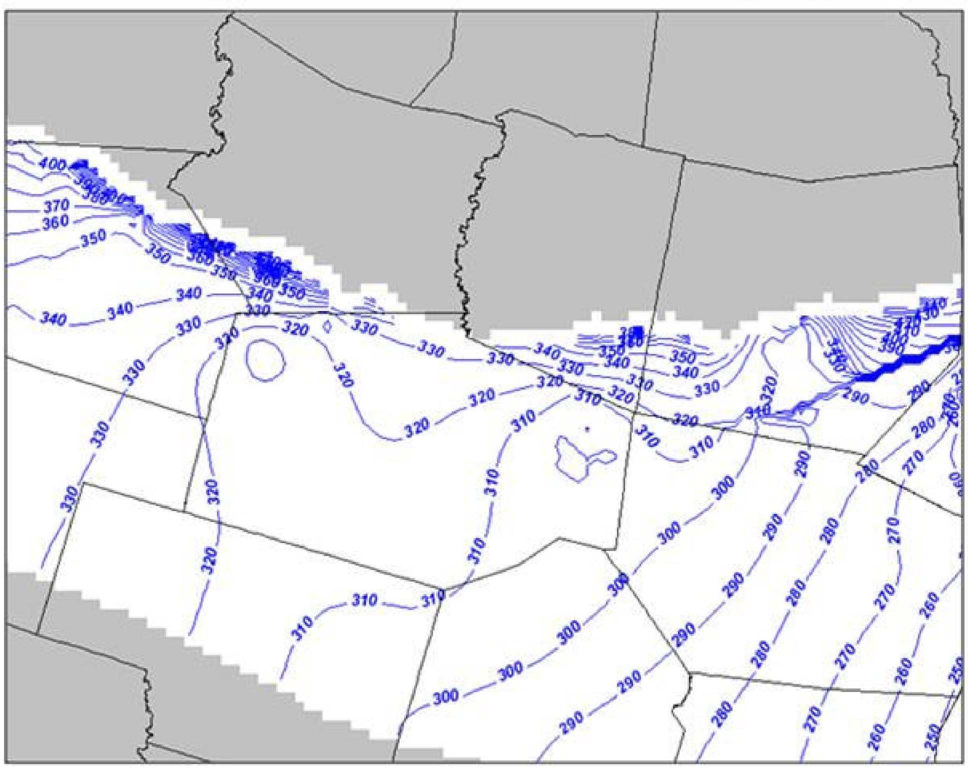


Figure 4C.16-6. Carrizo Water Level Elevations for the Baseline + GBRA Mid-Basin Project (Conjunctive Use) using Region L Scenario

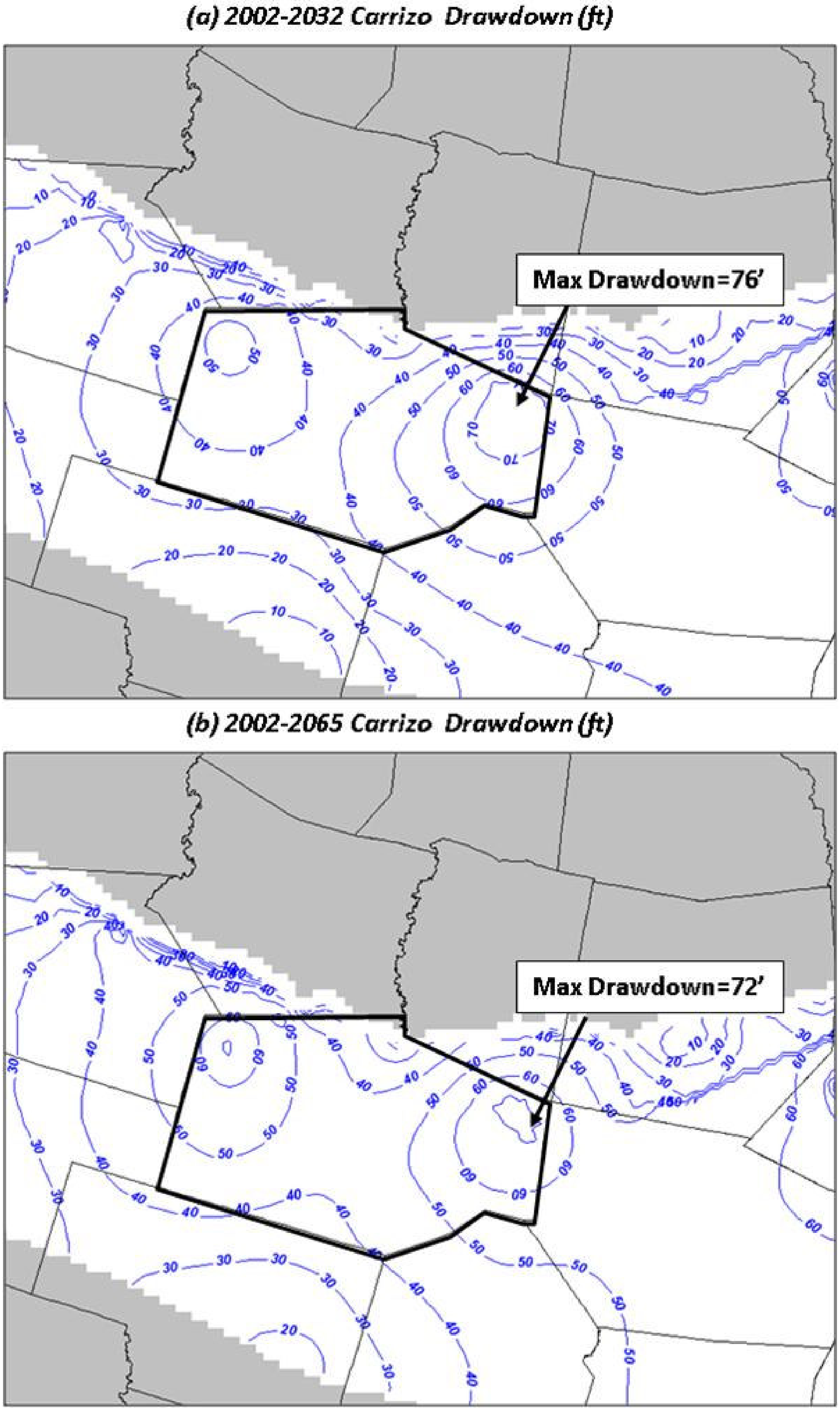


Figure* 4C.16-7. *Carrizo Drawdowns for the Baseline + GBRA Mid-Basin Project (Conjunctive Use) using Region L Scenario

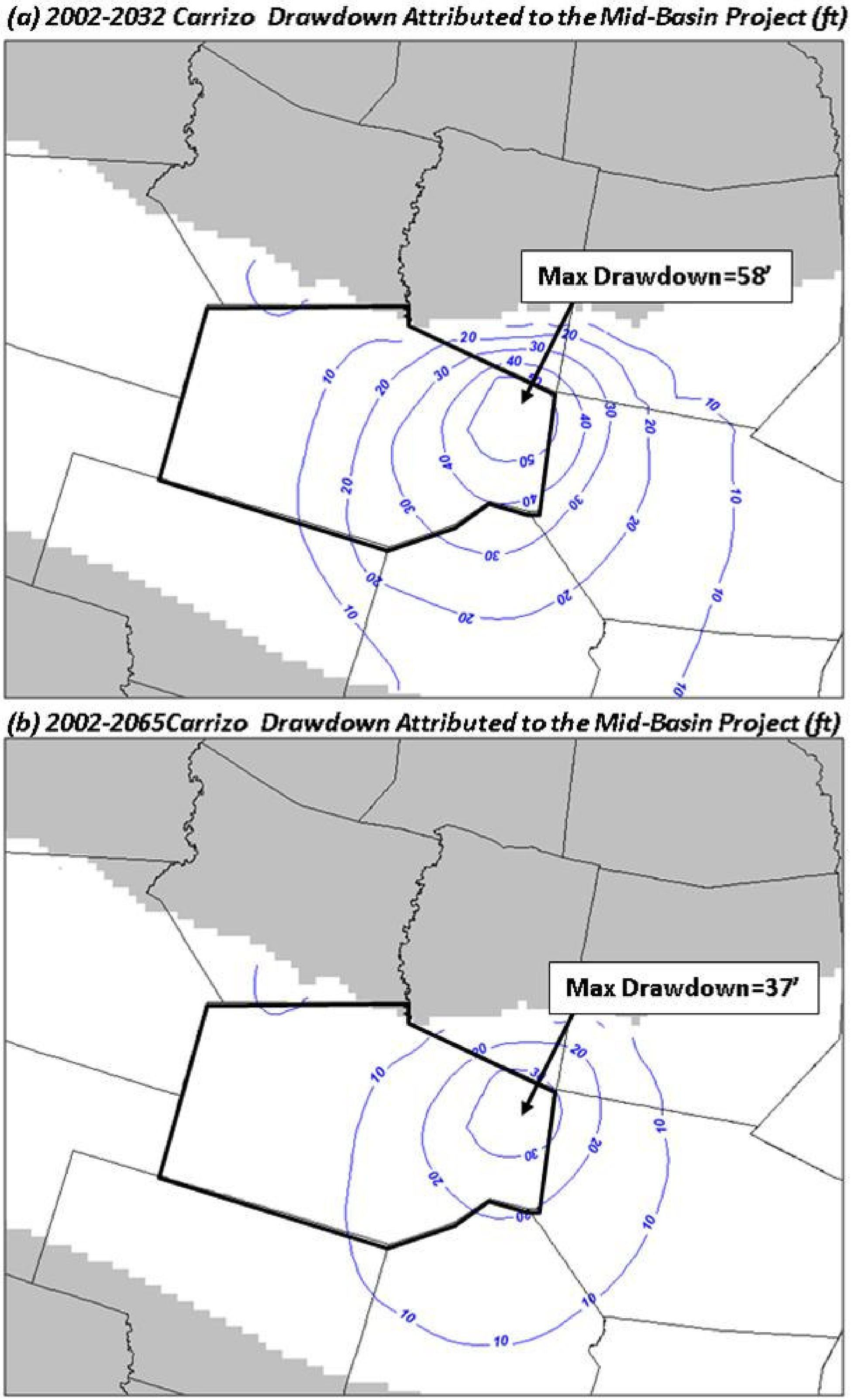
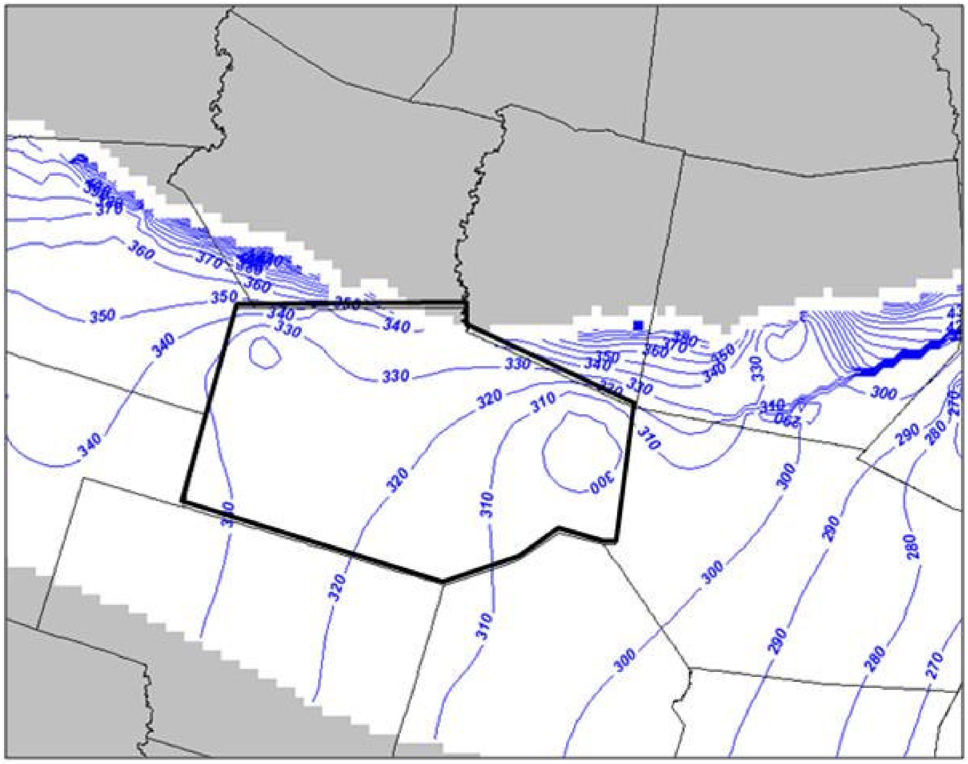


Figure 4C.16-8. Drawdowns Attributed to the GBRA Mid-Basin Project (Conjunctive Use) for the using Region L Scenario

(a) 2032 Carrizo Water Level Elevation (ft-msl)



(b) 2065 Carrizo Water Level Elevation (ft-msl)

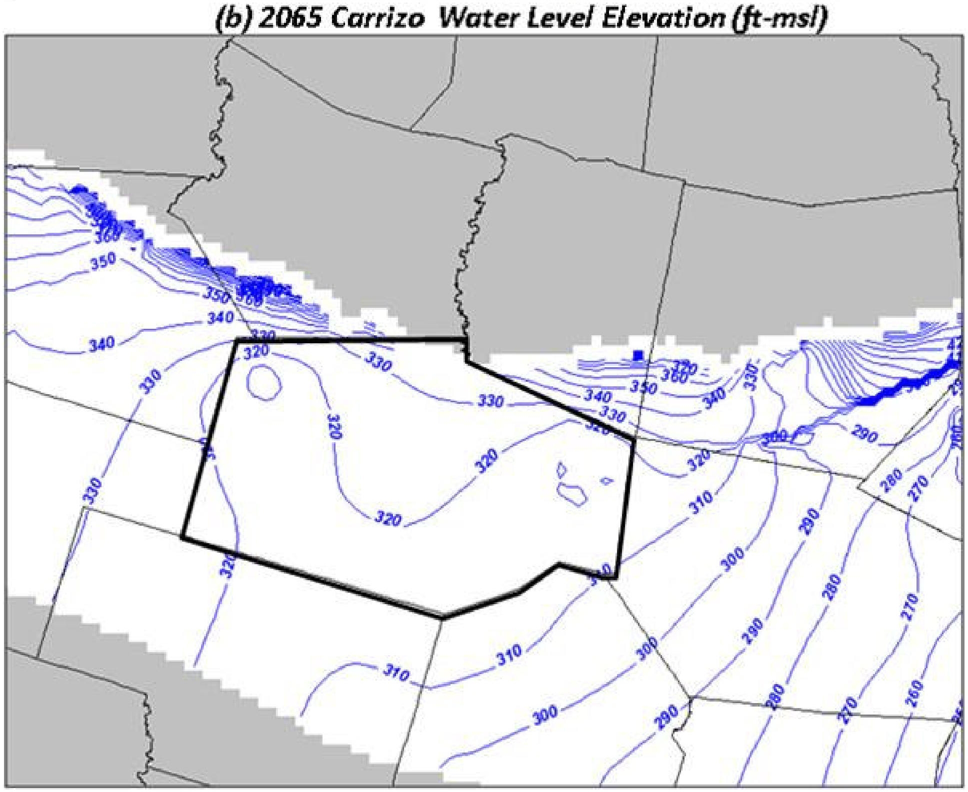


Figure 4C.16-9. Carrizo Water Level Elevations for the Baseline + GBRA Mid-Basin Project (Conjunctive Use) using the Permitting Scenario

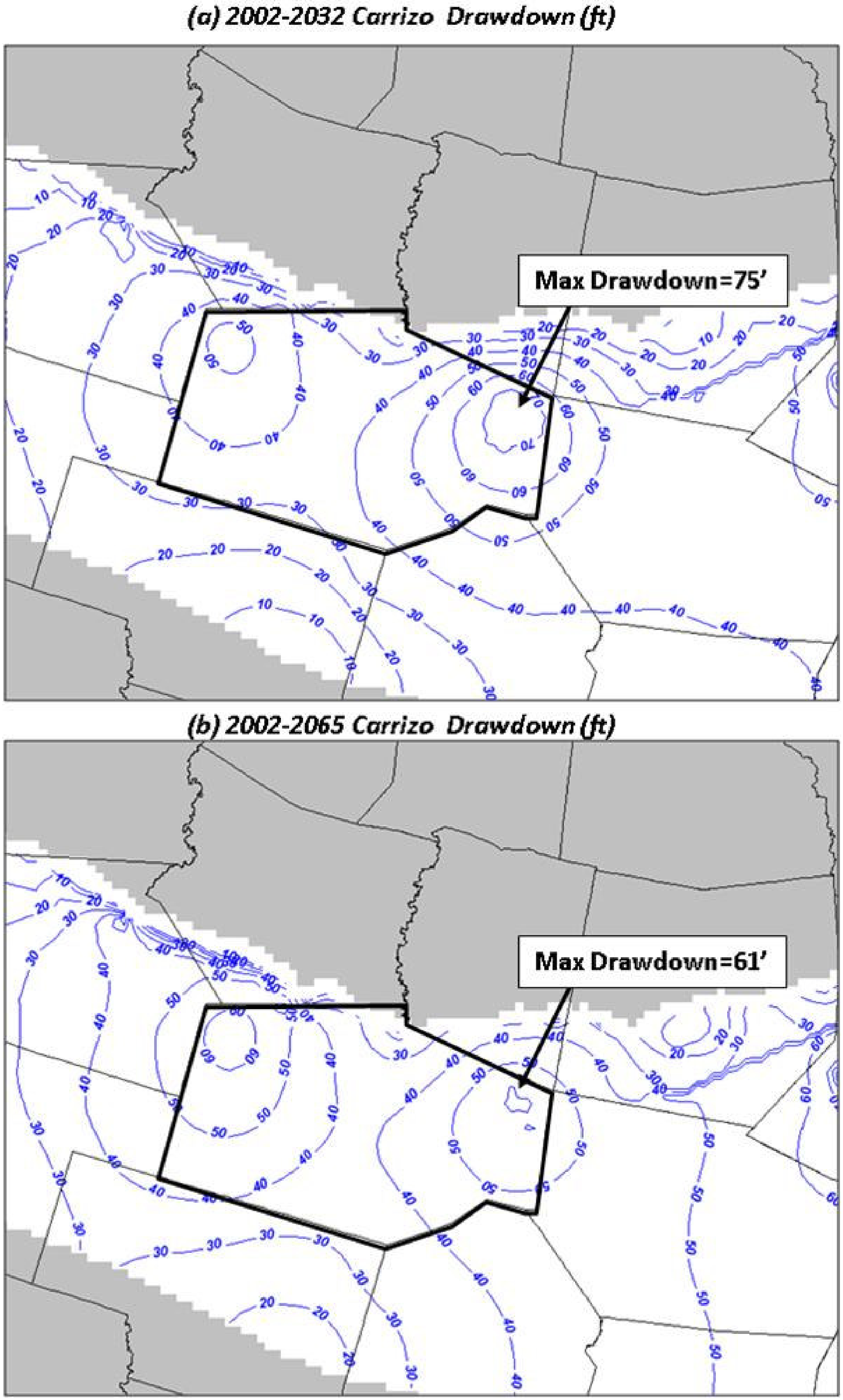
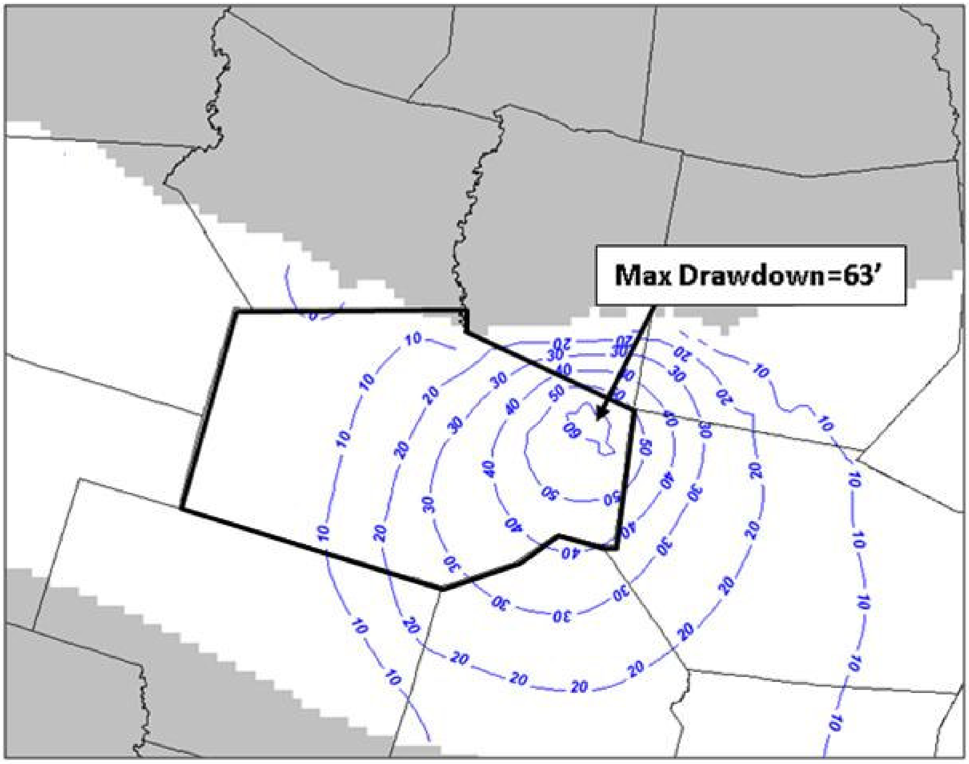


Figure 4C.16-10. Carrizo Drawdowns for the Baseline + GBRA Mid-Basin Project (Conjunctive Use) using Permitting Scenario

(a) 2002-2032 Carrizo Drawdown Attributed to the Mid-Basin Project (ft)



(b) 2002-2065 Carrizo Drawdown Attributed to the Mid-Basin Project (ft)

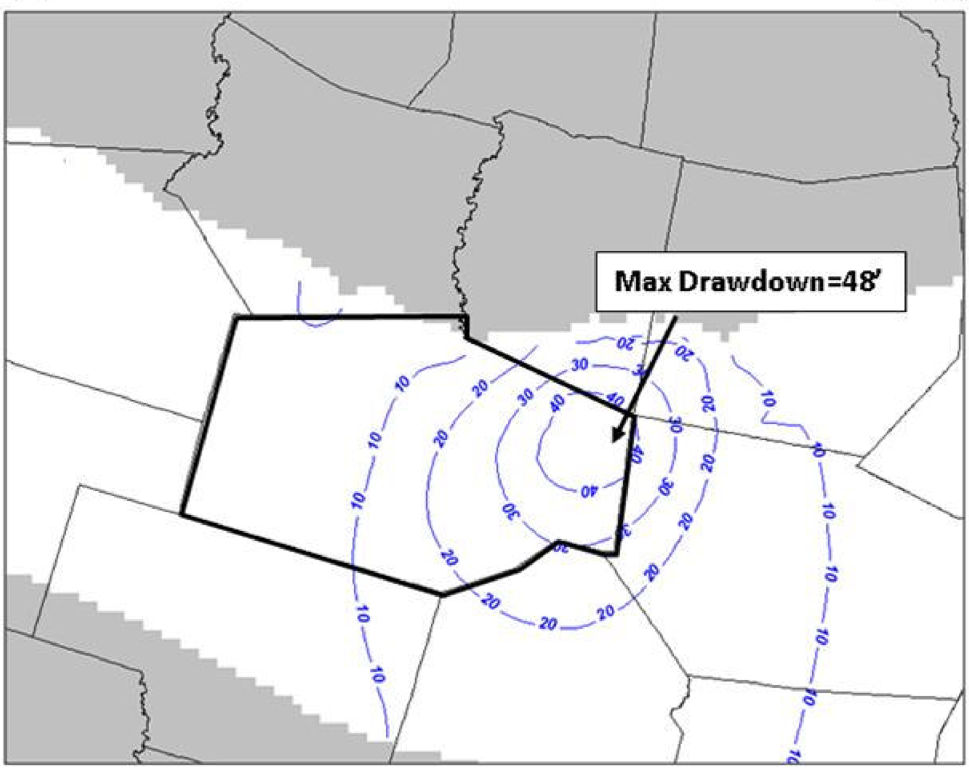


Figure 4C.16-11. Drawdowns Attributed to the GBRA Mid-Basin Project (Conjunctive Use) using Permitting Scenario

4C.16.3 Environmental Issues

Environmental issues for the proposed GBRA Mid-Basin Project (Conjunctive Use) in Gonzales and Caldwell counties are described below. Implementation of this option would require field surveys by qualified professionals to document vegetation/habitat types, waters of the U.S. including wetlands and cultural resources that may be impacted. Where impacts to protected species habitat or significant cultural resources cannot be avoided, additional studies would be necessary to evaluate habitat use and/or value, or eligibility for inclusion in the National Register of Historic Places, respectively. Compensation would be required for unavoidable adverse impacts involving net losses of wetlands.

The proposed pipeline would cross several creeks and tributaries of the San Marcos and Guadalupe Rivers. The Texas Parks & Wildlife Department (TPWD) has identified a number of stream segments throughout the state as ecologically significant on the basis of biological function, hydrologic function, riparian conservation, exceptional aquatic life uses, and/or threatened or endangered species. Currently, 21 stream segments in Region L are considered ecologically significant by the TPWD.[6] None of the creeks crossed by the proposed pipeline are listed by the state as ecologically significant. However, the section of the Guadalupe River from U.S. 183 (near the Gonzales diversion point) upstream to Lake Gonzales Dam is listed as ecologically significant as it contains two of four known remaining populations of the golden orb, a rare, endemic mollusk. Coordination with the U.S. Army Corps of Engineers would be required for construction within waters of the U.S. Impacts from this proposed project resulting in a loss of less than 0.5 acres of waters of the U.S. could be covered under Nationwide Permit #12 for Utility Line Activities.

Cultural resources protection on public lands in Texas is afforded by the Antiquities Code of Texas (Title 9, Chapter 191, Texas Natural Resource Code of 1977), the National Historic Preservation Act (Pl96-515), and the Archeological and Historic Preservation Act (PL93-291). Based on the review of available GIS datasets, there are 17 cemeteries, 29 historical markers, four national register properties and one national register district located within a 0.5-mile buffer of the proposed pipeline route. Additionally, there are three cemeteries within the potential OCR site. A review of archaeological resources in the proposed project area should be conducted during the project planning phase. Considering that the owner or controller of the project will

[6] TPWD, "Ecologically Significant River and Stream Segments," http://www.tpwd.state.tx.us/landwater/water/environconcerns/water_quality/sigsegs/index.phtml accessed October 15, 2009.

likely be a political subdivision of the State of Texas (i.e. river authority, municipality, county, etc.), they will be required to coordinate with the Texas Historical Commission regarding whether the project will affect waters of the United States or wetlands. The project sponsor will also be required to coordinate with the U.S. Army Corps of Engineers regarding impacts to cultural resources.

The GBRA Mid-Basin Project (Conjunctive Use) involves the construction of approximately 50 miles of pipeline. Water would be diverted from the Guadalupe River below Gonzales and delivered to the Luling and San Marcos WTPs. During periods when surface water is unavailable, groundwater from the Carrizo and/or Wilcox Aquifer in Gonzales County will be used to ensure consistent delivery to the Luling WTP and San Marcos WTP in Caldwell County. The pipeline traverses through both the Oak Woods and Prairies and the Blackland Prairies ecoregions[7] and is within the Texan biotic province.[8] Vegetation within the project area is dominated by a mosaic of post oak woods, forest and grassland to the east and cropland along the western portion of the proposed pipeline[9]. The proposed pipeline would follow existing roadways.

The primary impacts that would result from construction of the proposed conjunctive use option for the GBRA Mid-Basin Project (Conjunctive Use) include conversion of existing habitats and land uses within the pipeline right-of-way to maintained areas and potential downstream effects due to modification of the existing flow regime. Potential downstream impacts would include modification of the streamflow regime below the Gonzales diversion point, which may impact fish and wildlife species

The proposed pipeline from the Guadalupe River and the potential well field to the Luling and San Marcos WTPs is approximately 50 miles long (Figure 4C.16-1). The water pipeline would require a construction corridor of about 100 feet and a maintenance corridor of about 30 feet. Construction of the pipeline would involve the disturbance of soils and vegetation on up to approximately 620 acres, and the long-term impacts of maintaining the right-of-way free of woody vegetation would affect about 200 acres. The pipeline would pass through approximately 30 miles of crop and pastureland, approximately 12 miles forested land, approximately 8.0 miles

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[7] TPWD, "Texas Partners in Flight; Ecological Region 7 – Edwards Plateau"http://www.tpwd.state.tx.us/huntwild/wild/birding/pif/assist/pif_regions/region_7.phtml accessed July 20, 2009.
[8] Blair, W.F., "The Biotic Provinces of Texas, "Tex. J. Sci. 2:93-117, 1950.
[9] McMahan, C. A., R. G. Frye and K. L. Brown, " The Vegetation Types of Texas -- Including Cropland," Texas Parks and Wildlife Department − PWD Bulletin 7000-120. 1984.

of residential, commercial and industrial land uses.[10] Outside the maintained right-of-way, land use would not be anticipated to change due to pipeline construction.

The species listed by USFWS, and TPWD, as endangered or threatened with potential habitat in Gonzales and Caldwell counties are listed in Table 4C.16-3. The Texas Natural Diversity Database, maintained by TPWD, documents the occurrence of rare species within the state. There are no documented occurrences of any endangered species along or immediately adjacent to the proposed pipeline; however, there are documented occurrences of the threatened Cagle's map turtle along the Guadalupe River and immediately adjacent to the proposed Gonzales diversion point. Additionally, the western portion of the pipeline route and the San Marcos WTP site are within an area with documented occurrences of Hill Country wild-mercury, a rare plant and the rare Guadalupe bass has been documented along portions of the river immediately adjacent to the proposed diversion point. Endangered species including Texas wild-rice, San Marcos gambusia, fountain darter, and the Texas blind salamander, the threatened San Marcos salamander, and the rare Shinner's sunflower have all been documented within 2.5 miles of the proposed pipeline route[11]. Many of the species including Texas wild-rice, San Marcos gambusia, fountain darter, San Marcos salamander and the Texas blind salamander have a very limited distribution, several are endemic only to the headwaters of the San Marcos River. Shinner's sunflower is known to occur near the potential well field area. The project area may provide potential habitat to endangered or threatened species found in Gonzales or Caldwell counties. A survey of the project area may be required prior to pipeline and well construction to determine whether populations of or potential habitats used by listed species occur in the area to be affected. Coordination with TPWD and USFWS regarding threatened and endangered species with potential to occur in the project area should be initiated early in project planning.

[10] USGS, 1990. "A Land Use and Land Cover Classification System for Use with Remote Sensor Data," Reston, VA 1990.
[11] TPWD, 2009. Element of Occurrence Record – Texas Natural Diversity Database. Obtained from Texas Parks and Wildlife Department October 20, 2009.

Table 4C.16-3.
Threatened and Endangered Species
Caldwell and Gonzales Counties

Common Name	Scientific Name	Federal Status	State Status	Habitat
Birds				
American Peregrine Falcon	*Falco peregrinus anatum*	DL	T	Migrant; occupies wide range of habitats during fall migration. Occasional west Texas breeder.
Bald Eagle	*Haliaeetus leucocephalus*	DL	T	Found primarily near rivers and large lakes; nests in tall trees or on cliffs near water.
Interior Least Tern	*Sterna antillarum athalassos*	LE	E	Nests along sand and gravel bars within braided streams, rivers; also known to nest on man-made structures.
Peregrine Falcon	*Falco peregrinus*	DL	T	Migrant; winters along coast and farther south.
Whooping Crane	*Grus americana*	LE	E	Potential migrant; winters in coastal marshes of Aransas, Calhoun, and Refugio counties.
Wood Stork	*Mycteria americana*		T	Forages in prairie ponds, flooded pastures or fields, ditches and other shallow standing water. Formerly nested in Texas.
Fishes				
Blue sucker	*Cycleptus elongatus*		T	Larger portions of major rivers in Texas; usually in channels and flowing pools with a moderate current.
Mammals				
Red wolf	*Canis rufus*	LE	E	Extirpated.
Reptiles				
Cagle's map turtle	*Graptemys caglei*		T	Guadalupe River system; short stretches of shallow water with swift to moderate flow and gravel or cobble bottom connected by deeper pools with slower flow and silt or mud bottom.
Texas horned lizard	*Phrynosoma cornutum*		T	Open, arid and semi-arid regions with sparse vegetation.
Texas tortoise	*Gopherus berlandieri*		T	Open brush with a grass understory; open grass and bare ground are avoided. When inactive occupies shallow depressions at base of bush or cactus.
Timber/canebrake rattlesnake	*Crotalus horridus*		T	Swamps, floodplains, upland pine and deciduous woodlands, riparian zones and abandoned farmland. Prefers dense ground cover.

TPWD, 2009. Annotated County List of Rare Species – Gonzales County. Revised May 4, 2009.
TPWD, 2009. Annotated County List of Rare Species – Caldwell County. Revised May 7, 2009.
USFWS, 2009. Endangered Species List for Texas. http://www.fws.gov/southwest/es/EndangeredSpecies/lists/ListSpecies.cfm accessed online October 26, 2009.

4C.16.4 Engineering and Costing

Conceptual planning-level engineering and cost estimates are prepared for the GBRA Mid-Basin (Conjunctive Use) WMS and include groundwater lease fees at an estimated $100/acft/yr (combined minimum annual and production fees). The total annual cost includes the debt service for the project cost, the operation and maintenance costs, power costs, Gonzales County Underground Water Conservation District (GCUWCD) fees estimated at $10/acft/yr, and groundwater lease annual minimum and production fees at $50/acft/yr each. The total annual unit cost in dollars per acft is the total annual cost divided by the associated dependable, firm water supply of 25,000 acft/yr.

Total project costs for the GBRA Mid-Basin Project (Conjunctive Use) under the Region L Scenario are presented in Table 4C.16-4. Annual unit costs are $1,414/acft/yr. The annual costs are estimated based on debt service for a 20-year loan at 6 percent interest for the total project costs, and operation and maintenance costs, including power.

Total project costs for the GBRA Mid-Basin Project (Conjunctive Use) under the Permitting Scenario are the same as the Region L Scenario. Annual unit costs under the Permitting Scenario are estimated at $1,404/acft/yr (Table 4C.16-5), slightly lower than the Region L Scenario because of less groundwater pumping. Total project costs are estimated at $282,072,000. The annual costs are estimated based on debt service for a 20-year loan at 6 percent interest for the total project costs, and operation and maintenance costs, including power.

4C.16.5 Implementation Issues

4C.16.5.1 Surface Water Issues

Institutional arrangements may be needed to implement the project.

1. It will be necessary to obtain the following:
   a. TCEQ Diversion and Storage Permits (Application No. 21378 is administratively complete);
   b. USCE Sections 10 and 404 Dredge and Fill Permits for the reservoir and pipelines;
   c. GLO Sand and Gravel Removal permits;
   d. GLO Easement for use of state-owned land; and
   e. TPWD Sand, Gravel, and Marl permit.

**Table 4C.16-4.
Cost Estimate Summary
GBRA Mid-Basin Project (Conjunctive Use) – Region L Scenario
Sept 2008 Prices**

Item	Estimated Costs for Facilities
Capital Costs	
Intake and Pump Station (22 MGD)	$8,614,000
Transmission Pipeline (36 in dia., 51 miles)	$65,978,000
Transmission Pump Station(s)	$18,712,000
Well Fields	$37,574,000
Luling Water Treatment Plant (3.6 MGD)	$5,838,000
San Marcos Water Treatment Plant (18.7 MGD)	$22,615,000
Integration	$31,797,000
Total Capital Cost	**$191,128,000**
Engineering, Legal Costs and Contingencies	$63,596,000
Environmental & Archaeology Studies and Mitigation	$2,266,000
Land Acquisition and Surveying (211 acres)	$1,873,000
Interest During Construction (2 years)	$20,709,000
Groundwater Lease Signing Fee	$2,500,000
Total Project Cost	**$282,072,000**
Annual Costs	
Debt Service (6 percent, 20 years)	$24,374,000
Operation and Maintenance	
Intake, Pipeline, Pump Station	$2,000,000
Luling Water Treatment Plant (3.6 MGD)	$725,000
San Marcos Water Treatment Plant (18.7 MGD)	$2,587,000
Pumping Energy Costs (41,541,933 kW-hr @ 0.09 $/kW-hr)	$3,739,000
Groundwater Leases and Fees ($110/acft)	$1,920,000
Total Annual Cost	**$35,345,000**
Available Project Yield (acft/yr)	25,000
Annual Cost of Water ($ per acft)	$1,414
Annual Cost of Water ($ per 1,000 gallons)	$4.34

Table 4C.16-5.
Cost Estimate Summary
GBRA Mid-Basin Project (Conjunctive Use) Option – Permitting Scenario
Sept 2008 Prices

Item	Estimated Costs for Facilities
Capital Costs	
Intake and Pump Station (22 MGD)	$8,614,000
Transmission Pipeline (36 in dia., 51 miles)	$65,978,000
Transmission Pump Station(s)	$18,712,000
Well Fields	$37,574,000
Luling Water Treatment Plant (3.6 MGD)	$5,838,000
San Marcos Water Treatment Plant (18.7 MGD)	$22,615,000
Integration	$31,797,000
Total Capital Cost	**$191,128,000**
Engineering, Legal Costs and Contingencies	$63,596,000
Environmental & Archaeology Studies and Mitigation	$2,266,000
Land Acquisition and Surveying (211 acres)	$1,873,000
Interest During Construction (2 years)	$20,709,000
Groundwater Lease Signing Fee	$2,500,000
Total Project Cost	**$282,072,000**
Annual Costs	
Debt Service (6 percent, 20 years)	$24,374,000
Operation and Maintenance	
Intake, Pipeline, Pump Station	$2,000,000
Luling Water Treatment Plant (3.6 MGD)	$725,000
San Marcos Water Treatment Plant (18.7 MGD)	$2,587,000
Pumping Energy Costs (40,577,552 kW-hr @ 0.09 $/kW-hr)	$3,652,000
Groundwater Leases and Fees ($110/acft)	$1,751,000
Total Annual Cost	**$35,089,000**
Available Project Yield (acft/yr)	25,000
Annual Cost of Water ($ per acft)	$1,404
Annual Cost of Water ($ per 1,000 gallons)	$4.31

2. Permitting may require these studies:
   a. Habitat mitigation plan;
   b. Environmental studies; and
   c. Cultural resource studies and mitigation.

3. Land will need to be acquired through either negotiations or condemnation.

4. Relocations for the off-channel storage facilities may include:
   a. County roads;
   b. Other utilities;
   c. Product transmission pipelines; and
   d. Power transmission lines.

4C.16.5.2 Groundwater Issues

Part or all of the water needed by this Water Management Strategy (WMS) is anticipated to be supplied from locations within the jurisdiction of a groundwater conservation district (District) and may exceed the amount of available water identified in the District's approved management plan, or may for other reasons not be permitted by the District.

The amount of water needed by this WMS that exceeds the available water in the District's management plan, or for other reasons is not permitted by the District, cannot be implemented as part of this WMS unless and until all necessary permits are received from the District.

The amount of water needed by this WMS that exceeds the available water in the District's management plan, or for other reasons is not permitted by the District, introduces an added element of uncertainty to reliance upon this WMS and, therefore, additional management supplies may be needed for this WMS.

The development of groundwater in the Carrizo-Wilcox Aquifer in the South Texas Water Planning Region must address several issues. Major issues include:

- GCUWCD permits:
  - Analyses of pumping impacts on groundwater levels.
  - Mitigation of impacts on existing well owners.
  - Drought and Water Conservation Plans, and
  - Needs assessment.
- Impacts on:
  - Endangered and threatened species,
  - Water levels in the aquifer, including dewatering of the current artesian part of the aquifer

  - Baseflow in streams, and
  - Wetlands.
- Competition with others in the area for groundwater.
- Regulations by the GCUWCD, including periodic renewal of permits and potential pumping reductions.
- Obtain TCEQ permits.

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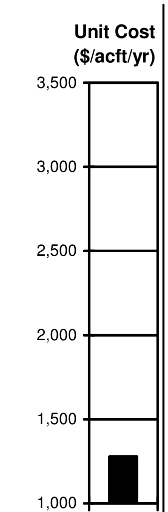
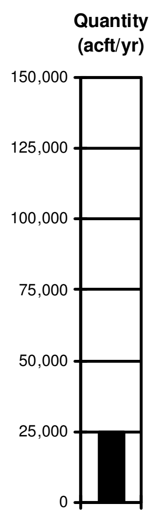
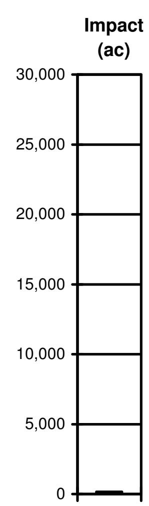
2011 South Central Texas Regional Water Plan
Water Management Strategy Summary Sheet







Name: **Regional Carrizo for Guadalupe Basin**

Description: The primary source for the Regional Carrizo for Guadalupe Basin Project will be groundwater from the Carrizo Aquifer in west-central or northeast Gonzales County. Facilities include a total of 17 Carrizo wells, a transmission pipeline from the well field to San Marcos through Luling, transmission booster pump stations; and water treatment plant expansions and enhancements at Luling and San Marcos.

***Decade Needed*:** 2010 - 2020

Cost, Quantity of Water, and Land Impacted

Unit Cost of Water:	**1,280**	**$/acft/yr**	**Treated Water Delivered**
Quantity of Water:	**25,000**	**acft/yr**	**Reliability = Firm**
Land Impacted:	**160**	**acres**	

Additional Considerations per Regional Water Planning Guidelines

Environmental Factors:

Conversion of existing habitats and land uses within the pipeline right-of-way and off-channel reservoir site.

Impacts on Water Resources:

Potential effects to water levels in the aquifer, baseflow in streams and wetlands.

Impacts on Agricultural & Natural Resources:

None anticipated.

Other Relevant Factors per SCTRWPG:

Part or all of the water needed by this Water Management Strategy (WMS) is anticipated to be supplied from locations within the jurisdiction of a groundwater conservation district (District) and may exceed the amount of available water identified in the District's approved management plan, or may for other reasons not be permitted by the District. The amount of water needed by this WMS that exceeds the available water in the District's management plan, or for other reasons is not permitted by the District, cannot be implemented as part of this WMS unless and until all necessary permits are received from the District. The amount of water needed by this WMS that exceeds the available water in the District's management plan, or for other reasons is not permitted by the District, introduces an added element of uncertainty to reliance upon this WMS and, therefore, additional management supplies may be needed for this WMS.

Permits required by GCUWCD include, an analyses of pumping impacts on groundwater levels, mitigation to existing well owners, Drought and Water Conservation Plans and a needs assessment.

Comparison of Strategies to Meet Needs:

Options to meet needs are limited; this option has a moderate unit cost. Strategy may exceed the available water in the District's management plan.

Interbasin Transfer Issues:

Not applicable.

Third-Party Impacts of Voluntary Transfers:

Not applicable.

Regional Efficiency:

Provides long-term water supplies throughout the GBRA statutory district.

Water Quality Considerations:

None of significant concern.

4C.17 Regional Carrizo for Guadalupe Basin

4C.17.1 Description of Water Management Strategy

The Guadalupe-Blanco River Authority (GBRA) is in the planning and permitting stages of a phased Mid-Basin Project to provide supplemental water supplies directly to customers in Hays and Caldwell Counties in the near-term and indirectly to customers in Comal, Guadalupe, and Kendall Counties by replacement or reduction of Canyon Reservoir supplies currently delivered to the San Marcos WTP in the long-term. GBRA is currently considering at least three formulations of the Mid-Basin Project using available surface water and/or groundwater supply sources to ensure unrestricted delivery of a firm yield of approximately 25,000 acft/yr. The Regional Carrizo for Guadalupe Basin is the groundwater formulation of the GBRA Mid-Basin Project. In all three formulations, 4,000 acft/yr will be delivered to the Luling Water Treatment Plant (WTP) and the remaining balance of approximately 21,000 acft/yr will be delivered to the San Marcos WTP. New supplies will be delivered uniformly throughout the year and customer peaking requirements will be met from other sources. This water management strategy focuses on the groundwater only option to supply the 25,000 acft/yr.

For this alternative, the primary source for the Regional Carrizo for Guadalupe Basin water management strategy will be groundwater from the Carrizo Aquifer in west-central or northeast Gonzales County (Figure 4C.17-1). The design concepts are to pump groundwater from a well field to the Luling WTP, divert 4,000 acft/yr to a water treatment plant at Luling, and boost the remaining water (21,000 acft/yr) to a water treatment plant at San Marcos. The transmission main pipeline route represents the shortest route between the well field and the Luling WTP. From Luling, the pipeline follows SH 80 to the San Marcos WTP. The main transmission pipeline is assumed to be 36 inches in diameter for all segments from the Luling WTP to the San Marcos WTP. Pump stations are used at the well-field to pump groundwater into the main pipeline and to boost the water to Luling. The well field includes 16-1,200 gpm (averaging 969 acft/yr) Carrizo wells and one standby well.

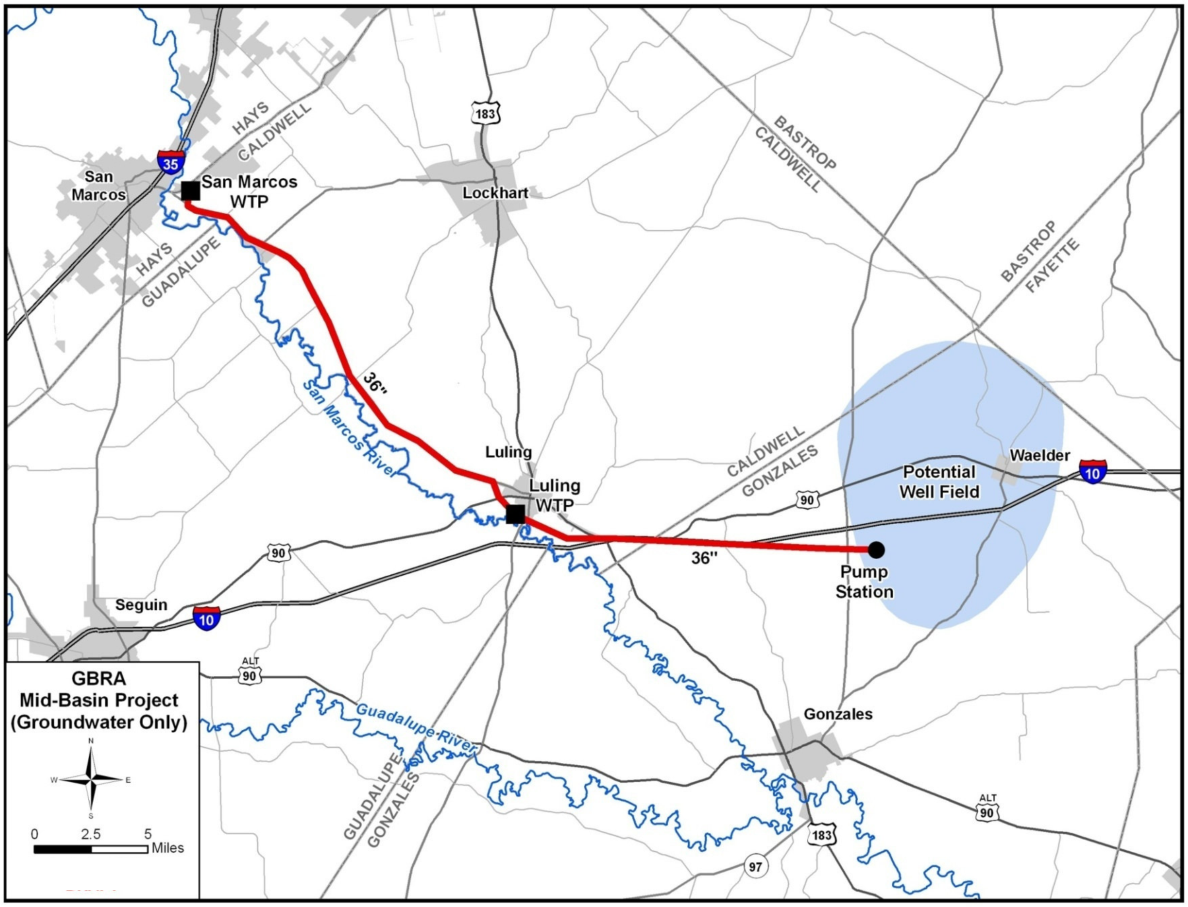


Figure 4C.17-1. Regional Carrizo for Guadalupe Basin

4C.17.2 *Groundwater*

4C.17.2.1 Selection of Groundwater Model

Since 2001, several regional groundwater availability models (GAMs) have been developed for the Gonzales County area, including: Central Carrizo-Wilcox/Queen City-Sparta GAM (Central Carrizo GAM)[1], South Central Carrizo System (SCCS) Model[2], and Southern Carrizo-Wilcox/Queen City- Sparta GAM (Southern Carrizo GAM)[3]. Analyses of Carrizo and Wilcox supplies in Gonzales County for the 2006 South Central Texas Regional Water Plan (2006 Region L Plan)[4] were performed using the SCCS model and the Southern Carrizo GAM. The Southern Carrizo GAM provides suitable coverage for the western part of the county; however, as shown in Figure 4C.17-2, the model coverage ends just a few miles northeast of the

[1] Dutton, A.R., et al., Groundwater Availability Model for the Central Part of the Carrizo-Wilcox Aquifer in Texas, Texas Water Development Board, February 2003.
[2] HDR Engineering, Inc., South Central Carrizo System Groundwater Model, San Antonio Water System, November 2004.
[3] Deeds, N. et al., Groundwater Availability Model for the Southern Carrizo-Wilcox Aquifer, Texas Water Development Board, January 2003.

county. The Southern Carrizo GAM includes fixed general head boundaries for the northeast edge of the model, which may inappropriately represent drawdown conditions for pumping near the model boundaries. The Central Carrizo GAM provides more complete coverage of Gonzales County and was selected for this analysis.

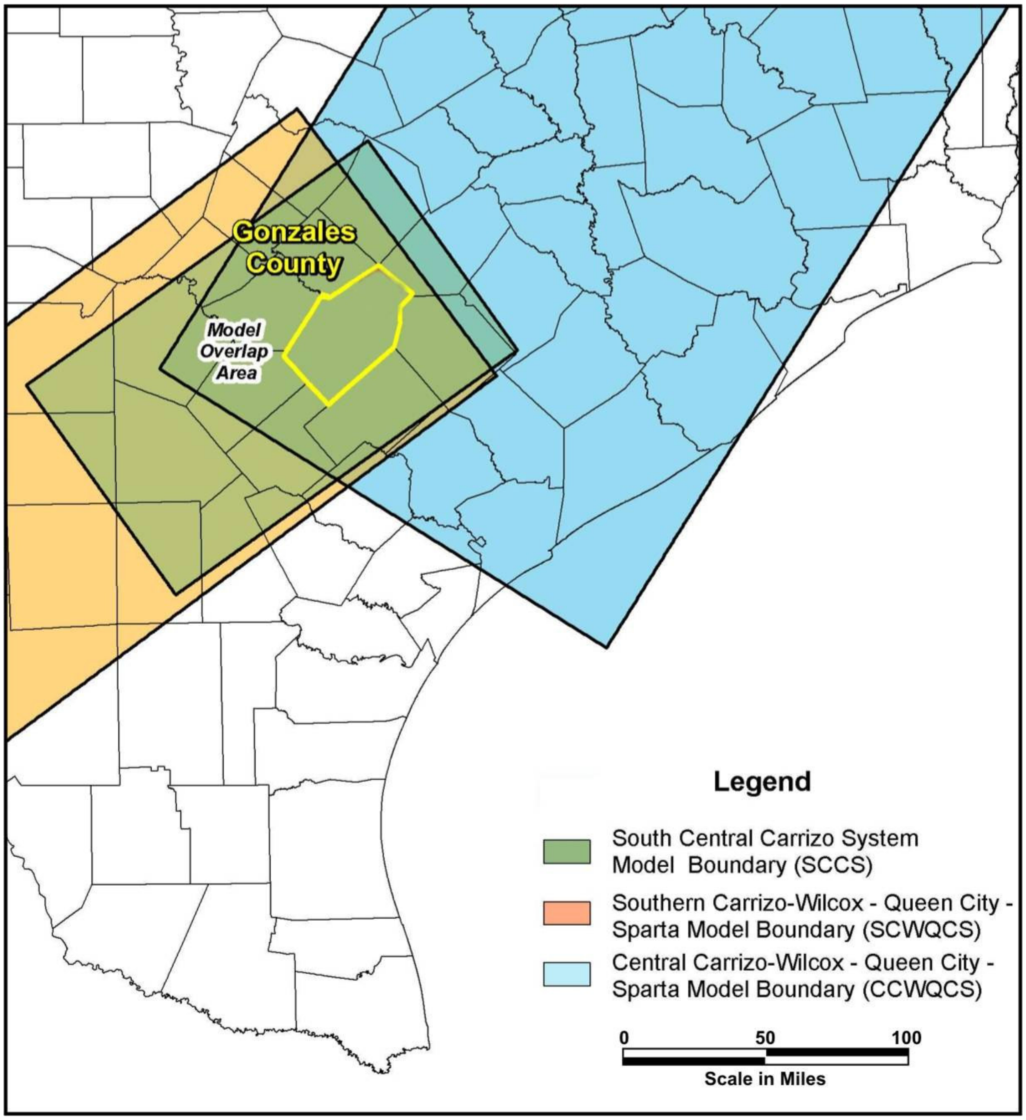


Figure 4C.17-2. Coverage of Regional Groundwater Models

[4] South Central Texas Regional Water Planning Group, 2006 South Central Texas Regional Water Plan, Texas Water Development Board, San Antonio River Authority, HDR Engineering, Inc., January 2006.

4C.17.2.2 Proposed Well Field Layout

For modeling purposes, the well field consists of 16 Carrizo wells with pumping capacity of about 1,000 gallons per minute (gpm) per active well. According to GCUWCD rules, 25,000 acres would need to be leased or purchased for the project (i.e., 1 acft per acre allowable production rate) and wells of this capacity would be subject to a setback of 6,000 feet from existing registered Carrizo wells. The proposed well locations were selected based on aquifer parameters including depth to water bearing zone, minimizing drawdown interference among wells, and spacing setbacks from existing Carrizo wells in the Gonzales County Underground Water Conservation District (GCUWCD) registered well database.

4C.17.2.3 Carrizo GAM Model Results

The Central Carrizo GAM baseline run did not include the potential GBRA well field in the simulation. The calculated 2002-2059 drawdown is presented in Figure 4C.17-4. The drawdown for baseline pumping over this period in the GBRA well field area is approximately 20 ft.

In the Central Carrizo GAM baseline + GBRA simulation, baseline pumping remains unchanged and the GBRA well field is simulated to begin production in 2010 and to pump 25,000 acre-feet per year from 16-1,200 gpm wells through 2059. Figure 4C.17-5 presents the projected total drawdown for the predictive simulation period. Figure 4C.17-6 presents the drawdown attributed to pumping from GBRA well field in 2059. The maximum drawdown attributed to GBRA is about 80 ft.

4C.17.3 Environmental Issues

Environmental issues for the proposed groundwater Regional Carrizo for Guadalupe Basin are described below. Implementation of this project would require field surveys by qualified professionals to document vegetation/habitat types, waters of the U.S. including wetlands and cultural resources that may be impacted. Where impacts to protected species habitat or significant cultural resources cannot be avoided, additional studies would be necessary to evaluate habitat use and/or value, or eligibility for inclusion in the National Register of Historic Places, respectively. Compensation would be required for unavoidable adverse impacts involving net losses of wetlands.

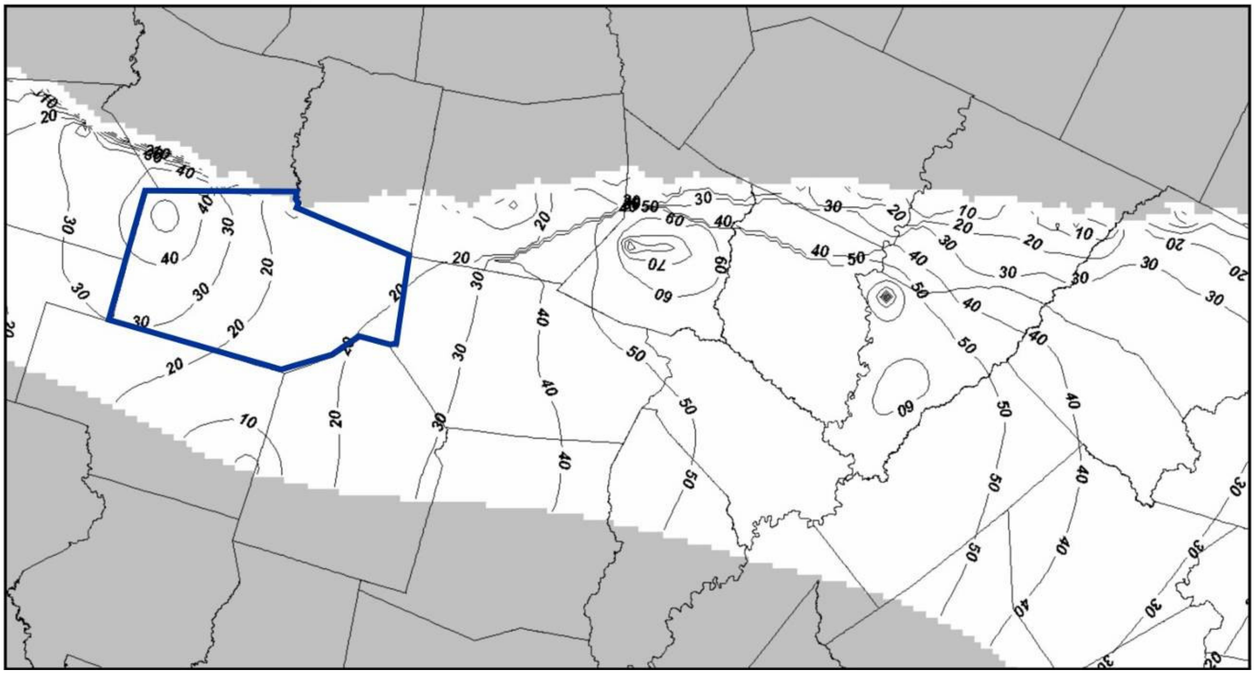


Figure* 4C.17-4. *Carrizo Water Level Elevations for the Baseline + GBRA Mid-Basin Project (Conjunctive Use) using Region L Scenario

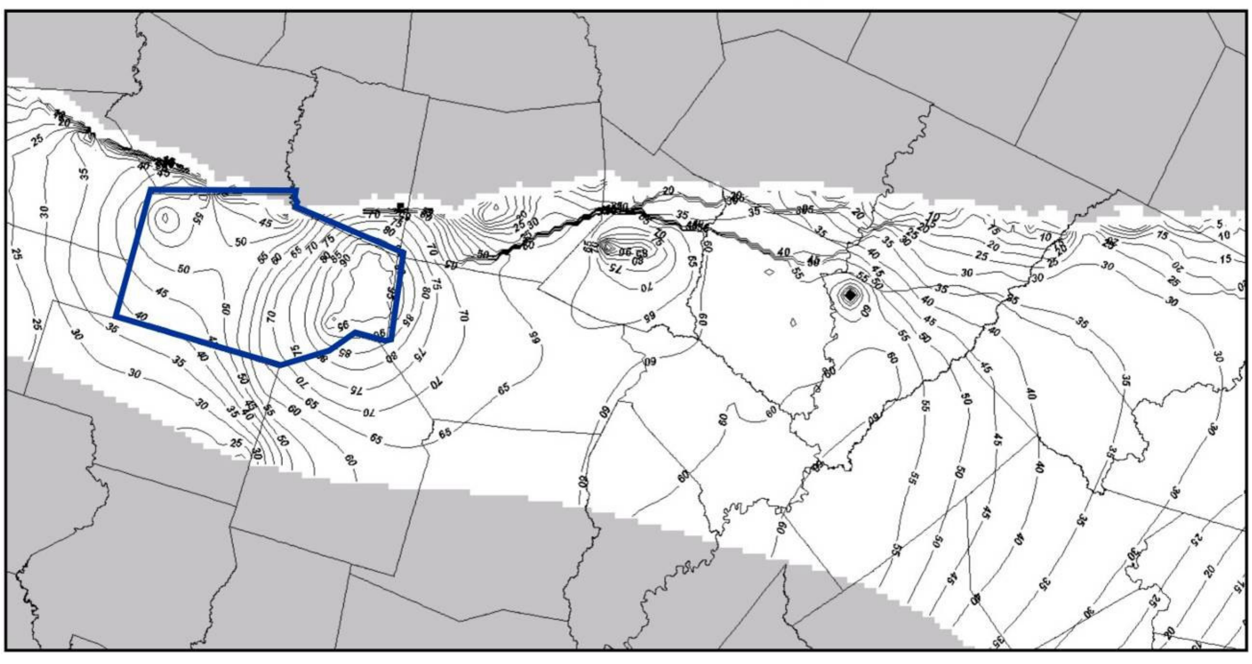


Figure* 4C.17-5. *Carrizo Drawdowns for the Baseline + GBRA Mid-Basin Project (Conjunctive Use) using Region L Scenario

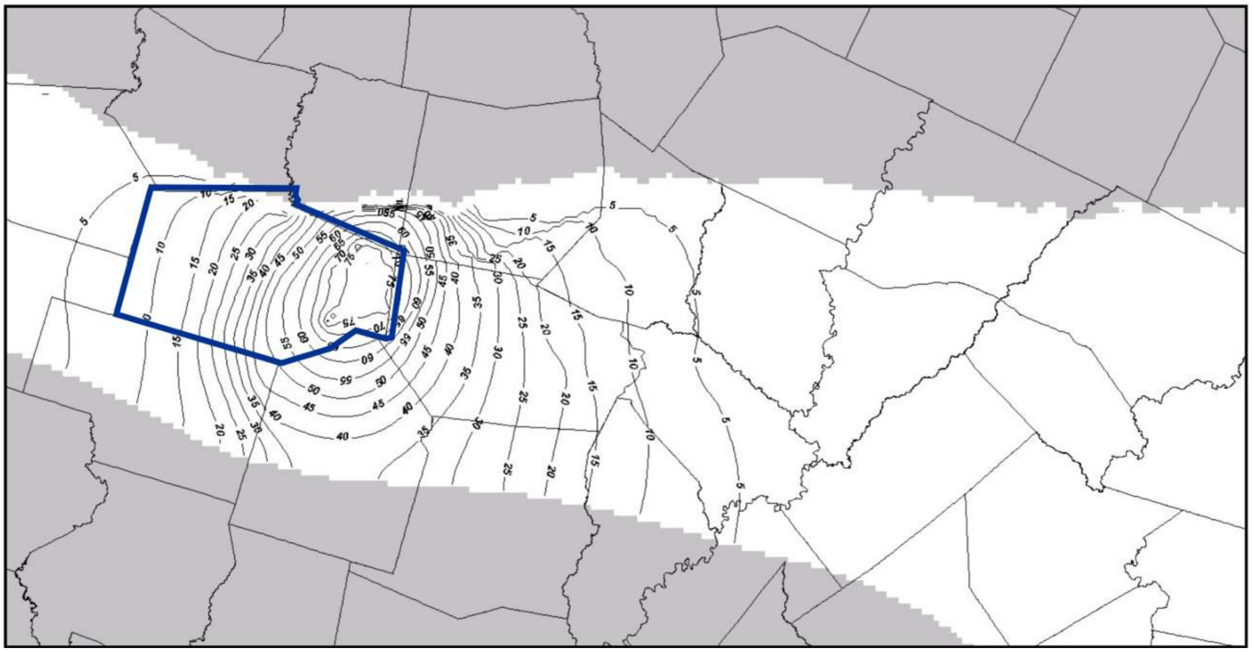


Figure 4C.17-5. Drawdowns Attributed to the GBRA Mid-Basin Project (Conjunctive Use) for the using Region L Scenario

The proposed pipeline would cross several creeks and tributaries of the San Marcos and Guadalupe Rivers. The Texas Parks & Wildlife Department (TPWD) has identified a number of stream segments throughout the state as ecologically significant on the basis of biological function, hydrologic function, riparian conservation, exceptional aquatic life uses, and/or threatened or endangered species. Currently, 21 stream segments in Region L have been designated as ecologically significant by the Regional Water Planning Group. None of the creeks crossed by the proposed pipeline are listed by the state as ecologically significant. Coordination with the U.S. Army Corps of Engineers would be required for construction within a waters of the U.S. Impacts from this proposed project resulting in a loss of less than 0.5 acres of waters of the U.S. could be covered under Nationwide Permit #12 for Utility Line Activities.

Cultural resources protection on public lands in Texas is afforded by the Antiquities Code of Texas (Title 9, Chapter 191, Texas Natural Resource Code of 1977), the National Historic Preservation Act (Pl96-515), and the Archeological and Historic Preservation Act (PL93-291). Based on the review of available GIS datasets, there are ten cemeteries, four historical markers and one national register property located within a 0.5-mile buffer of the proposed pipeline route. Additionally, there are five cemeteries and four historical markers within the potential well field area. A review of archaeological resources in the proposed project area should be conducted during the project planning phase. Considering that the owner or controller of the project will likely be a political subdivision of the State of Texas (i.e. river authority, municipality, county, etc.), they will be required to coordinate with the Texas Historical Commission regarding whether the project will affect waters of the United States or wetlands. The project sponsor will also be required to coordinate with the U.S. Army Corps of Engineers regarding impacts to cultural resources.

The Regional Carrizo for Guadalupe Basin water management strategy involves the construction of approximately 40 miles of pipeline from a well field in west-central or northeast Gonzales County to the Luling WTP in Caldwell County and San Marcos WTP in Hays County. The pipeline traverses through both the Oak Woods and Prairies and the Blackland Prairies ecoregions and is within the Texan biotic province. Vegetation within the project area is dominated by a mosaic of post oak woods, forest and grassland to the east and cropland along the western portion of the pipeline.

The proposed pipeline from the potential well field to the San Marcos WTP is approximately 40 miles long (Figure 4C.17-1). The water pipeline would require a construction corridor of about 100 feet and a maintenance corridor of about 30 feet. Construction would involve the disturbance of soils and vegetation on up to approximately 490 acres, and the long-term impacts of maintaining the right-of-way free of woody vegetation would affect about 150 acres. The pipeline would pass through approximately 30 miles of crop and pastureland, 2.0 miles of shrub and brush rangeland, approximately 4.0 miles of forested land, and less than 1.0 miles each of transportation, communications, and utility, residential, and industrial land uses. Outside the maintained right-of-way, land use would not be anticipated to change due to pipeline construction.

The species listed by USFWS, and TPWD, as endangered or threatened with potential habitat in Gonzales and Caldwell counties are listed in Table 4C.17-1. The Texas Natural Diversity Database, maintained by TPWD, documents the occurrence of rare species within the state. There are no documented occurrences of threatened or endangered species along or immediately adjacent to the proposed pipeline; however, the western portion of the pipeline route and the San Marcos WTP site are within an area with documented occurrences of Hill Country

Table 4C.17-1.
Threatened and Endangered SpeciesCaldwell and Gonzales Counties

Common Name	Scientific Name	Federal Status	State Status	Habitat
Birds				
American Peregrine Falcon	*Falco peregrinus anatum*	DL	T	Migrant; occupies wide range of habitats during fall migration. Occasional west Texas breeder.
Bald Eagle	*Haliaeetus leucocephalus*	DL	T	Found primarily near rivers and large lakes; nests in tall trees or on cliffs near water.
Interior Least Tern	*Sterna antillarum athalassos*	LE	E	Nests along sand and gravel bars within braided streams, rivers; also known to nest on man-made structures.
Peregrine Falcon	*Falco peregrinus*	DL	T	Migrant; winters along coast and farther south.
Whooping Crane	*Grus americana*	LE	E	Potential migrant; winters in coastal marshes of Aransas, Calhoun, and Refugio counties.
Wood Stork	*Mycteria americana*		T	Forages in prairie ponds, flooded pastures or fields, ditches and other shallow standing water. Formerly nested in Texas.
Fishes				
Blue sucker	*Cycleptus elongatus*		T	Larger portions of major rivers in Texas; usually in channels and flowing pools with a moderate current.
Mammals				
Red wolf	*Canis rufus*	LE	E	Extirpated.
Reptiles				
Cagle's map turtle	*Graptemys caglei*		T	Guadalupe River system; short stretches of shallow water with swift to moderate flow and gravel or cobble bottom connected by deeper pools with slower flow and silt or mud bottom.
Texas horned lizard	*Phrynosoma cornutum*		T	Open, arid and semi-arid regions with sparse vegetation.
Texas tortoise	*Gopherus berlandieri*		T	Open brush with a grass understory; open grass and bare ground are avoided. When inactive occupies shallow depressions at base of bush or cactus.
Timber/canebrake rattlesnake	*Crotalus horridus*		T	Swamps, floodplains, upland pine and deciduous woodlands, riparian zones and abandoned farmland. Prefers dense ground cover.

TPWD, 2009. Annotated County List of Rare Species – Gonzales County. Revised May 4, 2009.

TPWD, 2009. Annotated County List of Rare Species – Caldwell County. Revised May 7, 2009.

USFWS, 2009. Endangered Species List for Texas. http://www.fws.gov/southwest/es/EndangeredSpecies/lists/ListSpecies.cfm accessed online October 26, 2009.

wild-mercury, a rare plant. Endangered species including Texas wild-rice, San Marcos gambusia, fountain darter, and the Texas blind salamander, and the threatened Cagle's map turtle and San Marcos salamander, and the rare Guadalupe bass and Shinner's sunflower have all been documented within 2.5 miles of the proposed pipeline route . Many of the species including Texas wild-rice, San Marcos gambusia, fountain darter, San Marcos salamander and the Texas blind salamander have a very limited distribution, several are endemic only to the headwaters of the San Marcos River. The project area may provide potential habitat to endangered or threatened species found in Gonzales or Caldwell counties. A survey of the project area may be required prior to pipeline construction to determine whether populations of or potential habitats used by listed species occur in the area to be affected. Coordination with TPWD and USFWS regarding threatened and endangered species with potential to occur in the project area should be initiated early in project planning.

4C.17.4 Engineering and Costing

Conceptual planning-level engineering and cost estimates are prepared for the Regional Carrizo for Guadalupe Basin WMS and include groundwater lease fees at an estimated $100/acft/yr (combined minimum annual and production fees). The total annual cost includes the debt service for the project cost, the operation and maintenance costs, power costs, Gonzales County Underground Water Conservation District (GCUWCD) fees estimated at $10/acft/yr, and groundwater lease annual minimum and production fees at $50/acft/yr each. The total annual unit cost in dollars per acft is the total annual cost divided by the associated dependable, firm water supply of 25,000 acft/yr.

The costs are estimated for the annual costs, including debt service for a 20-year loan at 6 percent interest and operation and maintenance costs, including power. The total project costs for the Regional Carrizo for Guadalupe Basin is $239,245,000. The annual costs for this option under average conditions are $31,995,000 with a unit cost of $1,280/acft.

4C.17.5 Implementation Issues

Part or all of the water needed by this Water Management Strategy (WMS) is anticipated to be supplied from locations within the jurisdiction of a groundwater conservation district (District) and may exceed the amount of available water identified in the District's approved management plan, or may for other reasons not be permitted by the District.

The amount of water needed by this WMS that exceeds the available water in the District's management plan, or for other reasons is not permitted by the District, cannot be implemented as part of this WMS unless and until all necessary permits are received from the District.

The amount of water needed by this WMS that exceeds the available water in the District's management plan, or for other reasons is not permitted by the District, introduces an added element of uncertainty to reliance upon this WMS and, therefore, additional management supplies may be needed for this WMS.

- GCUWCD permits:
  - Analyses of pumping impacts on groundwater levels.
  - Mitigation of impacts on existing well owners.
  - Drought and Water Conservation Plans, and
  - Needs assessments.
- Impact on:
  - Endangered and threatened wildlife species,
  - Water levels in the aquifer, including dewatering of the current artesian part of the aquifer,
  - Baseflow in streams, and
  - Wetlands.
- Securing groundwater leases.
- Competition with others in the area for groundwater.
- Regulations by the GCUWCD, including periodic renewal of permits and potential pumping cutbacks.
- Obtaining TCEQ permits.

Table 4C.17-2.
Cost Estimate Summary
Regional Carrizo for Guadalupe Basin
Sept 2008 Prices

Item	Estimated Costs for Facilities
Capital Costs	
Transmission Pipeline (36 in dia., 38 miles)	$49,981,000
Transmission Pump Station(s)	$13,993,000
Well Fields	$37,574,000
Luling Water Treatment Plant (3.6 MGD)	$5,888,000
San Marcos Water Treatment Plant (18.7 MGD)	$22,607,000
Integration	$31,797,000
Total Capital Cost	**$161,840,000**
Engineering, Legal Costs and Contingencies	$54,145,000
Environmental & Archaeology Studies and Mitigation	$1,837,000
Land Acquisition and Surveying (160 acres)	$1,386,000
Interest During Construction (2 years)	$17,537,000
Groundwater Lease Signing Fee	$2,500,000
Total Project Cost	**$239,245,000**
Annual Costs	
Debt Service (6 percent, 20 years)	$20,640,000
Operation and Maintenance	
Intake, Pipeline, Pump Station	$1,520,000
Water Treatment Plant	$3,316,000
Pumping Energy Costs (41,875,309 kW-hr @ 0.09 $/kW-hr)	$3,769,000
Gonzales County Fees ($110/acft)	$2,750,000
Total Annual Cost	**$31,995,000**
Available Project Yield (acft/yr)	25,000
Annual Cost of Water ($ per acft)	$1,280
Annual Cost of Water ($ per 1,000 gallons)	$3.93

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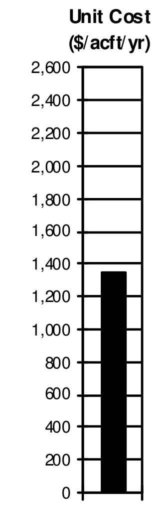
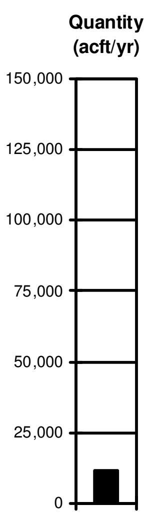
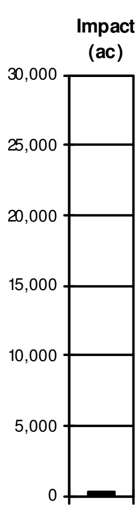
2011 South Central Texas Regional Water Plan
Water Management Strategy Summary Sheet







Name: Regional Carrizo for SAWS

Description: The SAWS Regional Carrizo Project involves:(1) pumping groundwater from a planned Buckhorn well field in southwestern Gonzales County, (2) conveying the raw groundwater to the SAWS Twin Oaks Water Treatment Plant (Twin Oaks WTP), in southern Bexar County, (3) treating the water at SAWS Twin Oaks WTP, and (4) pumping the water through SAWS' new and/or existing pipeline to their distribution system. The preliminary cost estimate does not include the delivering treated water to SAWS distribution system.

***Decade Needed*:** 2010 – 2020

Cost, Quantity of Water, and Land Impacted

Unit Cost of Water:	**$1,343**	**$/acft/yr**	**Treated Water Delivered**
Quantity of Water:	**11,687**	**acft/yr**	**Reliability = Firm**
Land Impacted:	**270**	**acres**	

Additional Considerations per Regional Water Planning Guidelines

Environmental Factors:

No protected species have been documented within the project area.

Impacts on Water Resources:

Groundwater levels will decline and could affect the baseflow of surrounding streams and wetlands.

Impacts on Agricultural & Natural Resources:

Minimal impacts anticipated.

Other Relevant Factors per SCTRWPG:

Part or all of the water needed by this Water Management Strategy (WMS) is anticipated to be supplied from locations within the jurisdiction of a groundwater conservation district (District) and may exceed the amount of available water identified in the District's approved management plan, or may for other reasons not be permitted by the District. The amount of water needed by this WMS that exceeds the available water in the District's management plan, or for other reasons is not permitted by the District, cannot be implemented as part of this WMS unless and until all necessary permits are received from the District. The amount of water needed by this WMS that exceeds the available water in the District's management plan, or for other reasons is not permitted by the District, introduces an added element of uncertainty to reliance upon this WMS and, therefore, additional management supplies may be needed for this WMS.

Comparison of Strategies to Meet Needs:

Cost estimates indicate that this strategy is moderate in cost.

Interbasin Transfer Issues:

None.

Third-Party Impacts of Voluntary Transfers:

None anticipated.

Regional Efficiency:

Provides long-term, reliable water supplies to SAWS, while adding a diversity of sources.

Water Quality Considerations:

Overall, the water quality of the Carrizo-Wilcox Aquifer is suitable for use as a water supply, except for elevated concentrations of iron and manganese in many areas.

4C.18 Regional Carrizo for SAWS

4C.18.1 Description of Water Management Strategy

The Carrizo-Wilcox Aquifer is one of four major aquifers in the South Central Texas Water Planning Region. In the Wintergarden area, which is generally considered to be west of the Atascosa-Frio county line, the aquifer has been extensively developed for many decades. In Atascosa County, the aquifer has had moderate development. In Bastrop, Caldwell, Gonzales, Guadalupe, and Wilson Counties, there has been limited development. Overall, the water quality of the Carrizo-Wilcox Aquifer is suitable for use as a water supply, except for elevated concentrations of iron and manganese in many areas.

Bexar County and other counties along the IH-35 corridor have near-term projected shortages in municipal supply. Several water purveyors in Region L, including SAWS, Schertz-Seguin Local Government Corporation (SSLGC), Canyon Regional Water Authority (CRWA), Hays Caldwell Public Utility Agency (Hays Caldwell), Aqua WSC, and Texas Water Alliance, are evaluating alternative regional projects to import groundwater from the Carrizo-Wilcox to their demand centers. The general location of the well fields associated with these projects is shown in Figure 4C.18-1.

This water management strategy is known as the SAWS Regional Carrizo Project and involves (1) pumping groundwater from a planned well field in Gonzales County, (2) conveying the raw groundwater pumped to the SAWS Twin Oaks Water Treatment Plant (Twin Oaks WTP), in southern Bexar County, (3) treating the water at SAWS Twin Oaks WTP, and (4) pumping the water through SAWS' new and/or existing pipeline to their distribution system. The general locations of the facilities are shown in Figure 4C.18-2.

SAWS is moving forward with a major revision to their previous Regional Carrizo Project, which limits groundwater development to a well field in southwestern Gonzales County. Currently (2009), SAWS is attempting to obtain well construction and production and water export permits from the Gonzales County Underground Water Conservation District (GCUWCD). GCUWCD rules and regulations affect the production and export of groundwater and implementation of any project.

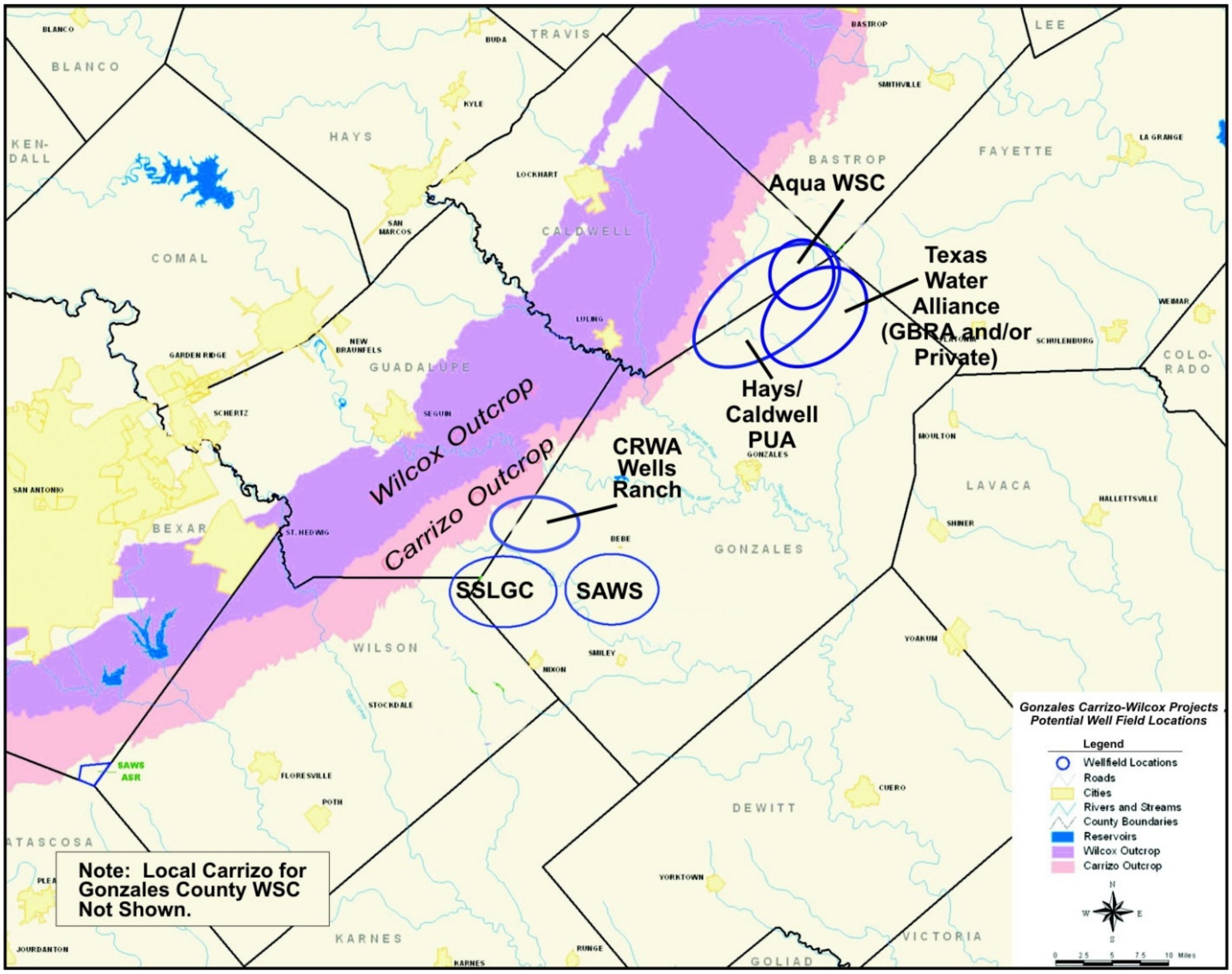


Figure 4C.18-1. General Location of Planned Well Fields for Carrizo Aquifer Projects

Under this water management strategy, SAWS is planning the development of a 11,687 acft/yr supply from the Carrizo-Wilcox Aquifer from the SAWS Buckhorn well field (Figure 4C.18-1) for municipal and industrial demands in San Antonio, the major municipal demand center of the South Central Texas Region. The evaluation included: (1) making revisions to a previous water management strategy, (2) assessing the potential environmental impacts, (3) estimating costs for project implementation, and (4) listing potential implementation issues.

The conceptual plan considers projected water demands for SAWS and the likelihood of obtaining groundwater production and export permits from groundwater districts. As illustrated in Figure 4C.18-2, groundwater production will come from wells in the SAWS Buckhorn well field. A raw water pipeline with two pump stations will convey groundwater across Gonzales and Wilson Counties to SAWS Twin Oaks WTP where the water will be cooled and excessive iron and manganese removed. Water treatment will require an expansion of the Twin Oaks WTP. A treated water pipeline will deliver the water from the WTP either through a new integration pipeline to the west side of San Antonio or an existing pipeline to the east side of San Antonio. Water from the Gonzales-Carrizo well fields will be delivered at a uniform rate of 10.5 MGD. Production is planned to begin in 2016.

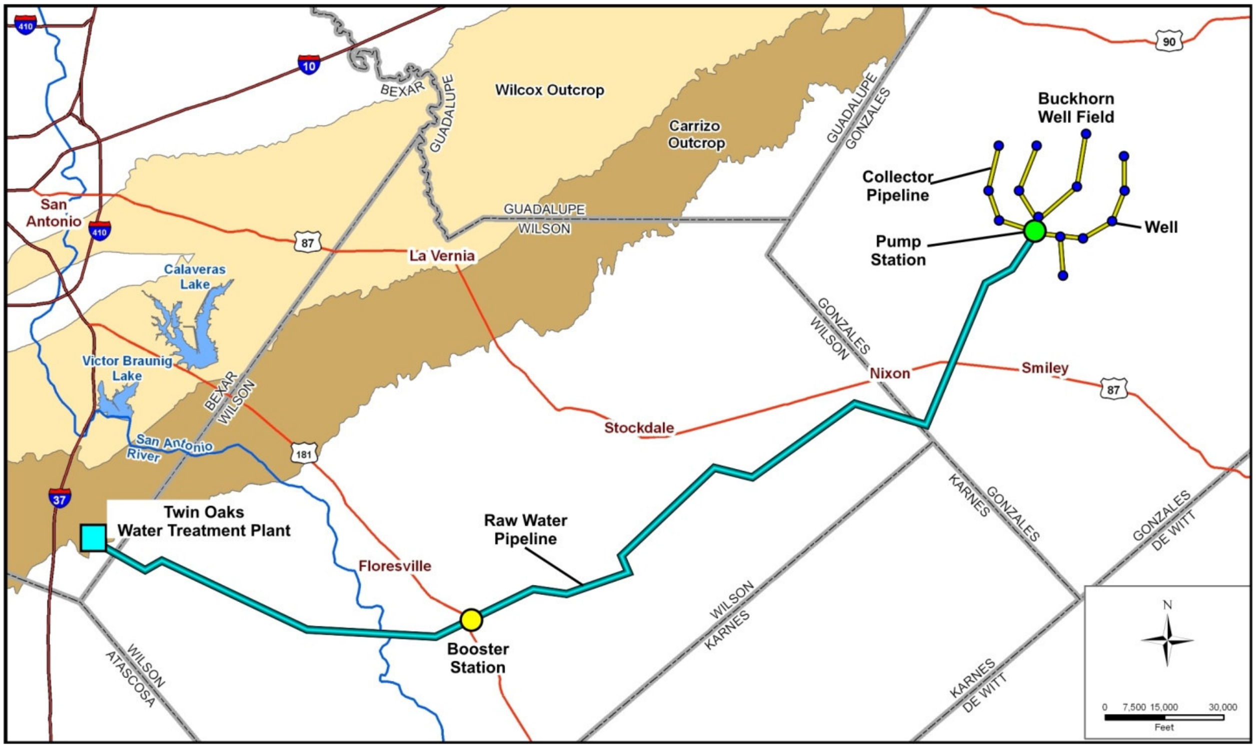


Figure 4C.18-2. Regional Carrizo for SAWS

4C.18.2 Groundwater Availability

The Carrizo Aquifer in the vicinity of the planned well field is several miles downdip of the Carrizo outcrop. Test drilling by SAWS and hydrogeologic maps of the aquifer in this area suggest that wells in the area would be capable of producing in excess of 2,000 gpm and would range in depth from 1,200 to 2,400 ft deep. Groundwater quality in the planned well field usually has a concentration of total dissolved solids of less than 300 mg/L. However, the water typically has elevated concentrations of iron and manganese that requires removal before being used by the public.

Regional Carrizo projects in this area of Gonzales County include the Shertz-Seguin Local Government Corporation Project Expansion and Canyon Regional Water Authority's

Wells Ranch Project. Groundwater production, well spacing, and export of groundwater are subject to rules of the GCUWCD.

A 2009 GCUWCD Water Management Plan does not include an estimate of groundwater availability in this part of the aquifer. Also, GMA-13 adopted a Desired Future Condition (DFC) on April 9, 2010 (after the deadline set by the SCTRWPG and after the IPP) which includes the GCUWCD. Thus, the amount of Managed Available Groundwater (MAG) has not been determined.

No assessment has been made to determine if the project complies with Gonzales Underground Water Conservation District's (GCUWCD) water management plan and rules other than well spacing. Before the project could become operational, permits for well construction, water production, and water export would have to be obtained from GCUWCD.

The effects of the groundwater pumping on groundwater levels and streamflow will be developed and presented in the cumulative effects section of the 2011 SCTRWP.

4C.18.3 Environmental Issues

The development of a well field in southwestern Gonzales County and the construction of a pipeline to deliver raw water to a terminus in Bexar County will potentially involve several regulatory approvals that have environmental and cultural resource components. As a subdivision of the State, SAWS' easements are considered public lands, and SAWS is charged with protecting the historic, cultural, and environmental resources of the State of Texas. The determination of locations of environmental and cultural resources (such as the potential presence of protected species, waters of the United States, adjacent wetlands and cultural resources) will assist SAWS in selecting facility locations and construction procedures that can minimize potential delays, and reduce mitigation liabilities. This report section discusses the potential impacts to environmental and cultural resources known to exist along the proposed pipeline route.

The project area includes land primarily in the South Texas Plains vegetational area, with the eastern end of the proposed pipeline and well field entering into the edges of the Blackland Prairies vegetational area.[1] The landforms of the project area are typically nearly level to gently rolling and are slightly-to-moderately dissected by streams which are tributaries of the San Antonio and Guadalupe Rivers. The original vegetation was a brushy chaparral-grassland with

[1] Gould, F.W., "The Grasses of Texas," Texas A&M University Press, College Station, Texas, 1975.

dense thickets of oaks and mesquites on the ridges and oak, pecan, and ash common along streams. Continued grazing and cessation of fires altered the vegetation to such a degree that the region south of San Antonio is now commonly called the Texas Brush Country.[2] Thorny brush is the predominant vegetation type in the region, including mesquite (*Prosopis pubescens*) acacia (*Acacia greggii*), prickly pear (*Opuntia spp.)* and mimosa, among others. Many of the vegetational elements common to the Brush Country are seen in the western half of the proposed pipeline. The vegetation of Wilson and Gonzales Counties is now primarily composed of rangeland and crops and post-oak woodlands. Common woody species include mesquite (*Prosopis glandulosa*), live oak (*Quercus virginiana*), post oak (*Quercus stellata*), acacia (*Acacia sp.*), brazil (*Zizyphus obovata*), spiny hackberry (*Celtis pallida*), whitebrush (*Aloysia gratissima*), lime pricklyash (*Zanthoxylum fagara*), Texas persimmon (*Diospyros texana*), shrubby blue sage (*Salvia ballotiflora*) and lotebush (*Zizyphus obtusifolia*). Grasses of the area commonly include little bluestem (*Schizachyrium scoparium*), indiangrass (*Sorghastrum nutans*) and switchgrass (*Panicum virgatum*). Pricklypear (*Opuntia sp.*) is common throughout most of the area.[3]

The eastern end of the proposed pipeline and well field are located in the Blackland Prairies vegetational area in Gonzales County. This rolling and well-dissected vegetational area was historically a luxuriant tallgrass prairie dominated by little bluestem, big bluestem (*Andropogon gerardii*), indiangrass, and dropseeds (*Sporobolus sp.*). During the turn of the 20th century, about 98 percent of the Blackland Prairie was cultivated for crops. Livestock production has increased dramatically since the 1950s and now only 50 percent of the area is used for cropland. Grazing pressure has increased grass species such as sideoats grama (*Bouteloua curtipendula*), hairy grama (*B. hirsuta*), Mead's sedge (*Carex meadii*), Texas wintergrass (*Stipa leucotricha*) and buffalograss (*Buchloe dactyloides*). Common woody species include mesquite, huisache (*Acacia smallii*), oak (*Quercus sp.*) and elm (*Ulmus sp.*). Oak, elm, cottonwood (*Populus sp.*) and native pecan (*Carya*) are common along drainages.

Vertebrate fauna typifying these regions include the opossum, raccoon, weasel, skunk, white-tailed deer and bobcat as well as a wide variety of amphibians, reptiles, and birds. The

[2] Inglis, J.M., "A History of Vegetation on the Rio Grande Plain," Project W-84-R-Texas, Bulletin No. 45, Texas Parks and Wildlife Department. Austin, Texas, 1964.
[3] Hatch, S.L., K.N. Gandhi, and L. E. Brown, "Checklist of the Vascular Plants of Texas," Texas Agricultural Experiment Station, Texas A & M University, College Station, 1990.

coyote and javelina are also common to the area, but are found mainly in brush/shrub areas while the red and gray fox are more common in woodlands.[4]

Plant and animal species listed by the USFWS and TPWD as endangered, threatened or rare in the project area are presented in Table 4C.18-1. All endangered, threatened and rare species identified on the TPWD Annotated County Lists of Rare Species for Bexar, Wilson and Gonzales Counties have been included in Table 4C.18-1. Inclusion in Table 4C.18-1 does not mean that a species will occur within the project area, but only acknowledges the potential for occurrence in the project area counties.

In addition to the county lists, the Natural Diversity Database (NDD) maintained by the TPWD was reviewed for known occurrences of listed species within or near the project area. The sandhill woolywhite and Elmendorf's onion, two rare plant species, have been documented within the project area, along the pipeline and near the Twin Oaks WTP. The sandhill woollywhite and Elmendorf's onion prefer areas of deep sand. These species of concern are considered to be rare, but are not protected by USFWS or TPWD.

Waters of the U.S. crossings along the pipeline corridor consist primarily of the riverine habitats of Cibilo and Sandies Creeks and the San Antonio River and their tributaries, as well as associated palustrine habitats that are generally composed of narrow bands of wetlands adjacent to these watercourses. Although the USFWS National Wetlands Inventory (NWI) maps identify both temporary and permanent palustrine wetlands adjacent to the pipeline corridors, and well fields, a ground survey wetland delineation will be required to determine which of these and other features would be affected and to what extent. The wetland delineation will document the locations of streambeds, stream widths, quality and type of water bodies, types of aquatic vegetation, presence of special aquatic resources (such as wetlands) and area of jurisdictional Waters of the U.S. likely to be disturbed during construction. Unclassified intermittent streams are typically unnamed upper headwater and pasture drainages while classified streambeds are typically larger, well-defined bodies of water such as the San Antonio River and Cibolo Creek. Perennial streams are of greatest concern, and therefore should be considered for a

[4] Jones, J.K. et al., "Annotated Checklist of Recent Land Mammals of Texas," Occasional Papers of the Museum OP-119, Texas Tech University, 1988.

Table 4C.18-1
Endangered, Threatened, or Species of Concern
Listed for Bexar, Wilson and Gonzales County

Common Name	Scientific Name	Impact Value	Multiplier Based on Status	Adjusted Impact	Summary of Habitat Preference	Listing Entity FWS	Listing Entity TPW	Potential Occurrence County
AMPHIBIANS								
Cascade Caverns salamander	*Eurycea latitans complex*	0	2	0	Endemic, subaquatic in Edwards Aquifer Area		T	Resident
Comal Blind Salamander	*Eurycea tridentifera*	0	2	0	Endemic; springs and waters of caves in Bexar County.		T	Resident
Texas Salamander	*Eurycea neotenes*	0	1	0	Endemic; springs, seeps, cave streams, Helotes and Leon Creek drainages in Bexar County			Resident
ARACHNIDS								
Braken Bat Cave Meshweaver	*Cicurina venii*	0	3	0	Karst features in western Bexar County	LE		Resident
Cokendolpher cave harvestman	*Texella cokendolpheri*	0	3	0	Karst features in north-central Bexar County	LE		Resident
Government Canyon Bat Cave Meshweaver	*Cicurina vespera*	0	3	0	Karst features in northwestern Bexar County	LE		Resident
Government Canyon Bat Cave Spider	*Neoleptoneta microps*	0	3	0	Karst features in northwestern Bexar County	LE		Resident
Madla Cave Meshweaver	*Cicurina madla*	0	3	0	Karst features in northern Bexar County	LE		Resident
Robber Baron Cave Meshweaver	*Cicurina baronia*	0	3	0	Karst features in north-central Bexar County	LE		Resident
BIRDS								
Bald eagle	*Haliaeetus leucoephalus*	0	2	0	Found primarily near rivers and large lakes.	DL	T	Possible Migrant
Black-capped Vireo	*Vireo atricapillus*	0	3	0	Oak-juniper woodlands,	LE	E	Resident
Golden-cheeked Warbler	*Dendroica chrysoparia*	0	3	0	Juniper-oak woodlands.	LE	E	Resident
Henslow's Sparrow	*Ammodramus henslowii*	1	1	1	Found in weedy fields or cut-over areas			Resident

Table 4C.18-1 (Continued)

Common Name	Scientific Name	Impact Value	Multiplier Based on Status	Adjusted Impact	Summary of Habitat Preference	Listing Entity		Potential Occurrence County
						FWS	TPW	
Interior least tern	*Sterna antillarum athalassos*	0	3	0	Nests along sand and gravel bars in braided streams	LE	E	Resident
Mountain Plover	*Charadrius montanus*	0	1	0	Non-breeding, shortgrass plains and fields			Nesting/ Migrant
Peregrine Falcon	*Falco peregrinus anatum (American)*	0	2	0	Resident and local breeder in West Texas. Migrant across the state.	DL	T	Possible Migrant
	Falco peregrinus tundrius (Arctic)	0	1	0	Migrant throughout the state.	DL		Possible Migrant
Western Burrowing Owl	*Athene cunicularia hypugaea*	1	1	1	Open grasslands, especially prairie, plains and savanna			Resident
White-faced Ibis	*Plegadis chihi*	0	2	0	Prefers freshwater marshes.		T	Resident
Whooping Crane	*Grus americana*	0	3	0	Potential migrant	LE	E	Potential Migrant
Wood Stork	*Mycteria americana*	0	2	0	Forages in prairie ponds, ditches, and shallow standing water formerly nested in TX		T	Migrant
Zone-tailed Hawk	*Buteo albonotatus*	1	2	2	Arid open country, often near watercourses		T	Resident
CRUSTACEANS								
A cave obligate crustacean	*Monodella texana*	1	1	1	Subaquatic, underground freshwater aquifers			Resident
FISHES								
Blue sucker	*Cycleptus elongates*	1	2	2	Major rivers in Texas.		T	Resident
Guadalupe Bass	*Micropterus treculi*	1	1	1	Endemic to perennial streams of the Edwards Plateau region.			Resident

Table 4C.18-1 (Continued)

Common Name	Scientific Name	Impact Value	Multiplier Based on Status	Adjusted Impact	Summary of Habitat Preference	Listing Entity		Potential Occurrence County
						FWS	TPW	
Guadalupe Darter	*Percina sciera apristis*	1	1	1	Guadalupe River Basin. Usually found over gravel or gravel and sand raceways of larger streams and rivers.			Resident
Toothless Blindcat	*Trogloglanis pattersoni*	1	2	2	Troglobitic, blind catfish endemic to the San Antonio Pool of the Edwards Aquifer		T	Resident
Widemouth Blindcat	*Satan eurystomus*	1	2	2	Troglobitic, blind catfish endemic to the San Antonio Pool of the Edwards Aquifer.		T	Resident
INSECTS								
A Ground Beetle	*Rhadine exilis*	0	3	0	Karst features in northern Bexar County	LE		Resident
A Ground Beetle	*Rhadine infernalis*	0	3	0	Karst features in northern and western Bexar County	LE		Resident
Helotes Mold Beetle	*Batrisodes venyivi*	0	3	0	Karst features in northwestern Bexar County	LE		Resident
Manfreda Giant-skipper	*Stallingsia maculosus*	1	1	1	Skipper larvae usually feed inside a leaf shelter.			Resident
Rawson's metalmark	*Calephelis rawsoni*	1	1	1	Moist areas in shaded limestone outcrops			Resident
MAMMALS								
Black Bear	*Ursus americanus*	0	2	0	Inhabits bottomland hardwoods	T/SA;NL	T	Historic Resident
Cave Myotis Bat	*Myotis velifer*	0	1	0	Roosts colonially in caves, rock crevices			Resident
Ghost-faced bat	*Mormoops megalophylla*	0	1	0	Roosts in caves, crevices and buildings			Resident

Table 4C.18-1 (Continued)

Common Name	Scientific Name	Impact Value	Multiplier Based on Status	Adjusted Impact	Summary of Habitat Preference	Listing Entity		Potential Occurrence County
						FWS	TPW	
Gray wolf	*Canis lupus*	0	3	0	Extirpated, forests, brushlands or grasslands	LE	E	Historic resident
Plains Spotted Skunk	*Spilogale putorius interrupta*	1	1	1	Prefers wooded, brushy areas.			Resident
Red Wolf	*Canis rufus*	0	3	0	Extirpated.	LE	E	Historic Resident
MOLLUSKS								
Creeper (squawfoot)	*Strophitus undulates*	1	1	1	Small to large streams			Resident
False spike mussel	*Quincuncina mitchelli*	1	1	1	Substrates of cobble and mud with water lilies present. Rio Grande, Brazos, Colorado and Guadalupe river basins.			Resident
Golden orb	*Quadrula aurea*	1	2	2	Sand and gravel, Guadalupe, San Antonio, and Nueces River basins		T	Resident
Mimic Cavesnail	*Phreatodrobia imitata*	1	1	1	Subaquatic; only known from two wells penetrating the Edwards Aquifer			Resident
Palmetto pill snail	*Euchemostrem a leai cheatumi*	0	1	0	Known only from Palmetto State Park.			Resident
Pistolgrip	*Tritogonia verrucosa*	1	1	1	Aquatic, stable substrate. Red through San Antonio river basins.			Resident
Rock pocketbook	*Arcidens confragosus*	1	1	1	Mud and sand, Red through Guadalupe River basins.			Resident
Texas fatmucket	*Lampsilis bracteata*	1	2	2	Streams and rivers on sand, mud and gravel, Colorado and Guadalupe River basins.		T	Resident
Texas pimpleback	*Quadrula petrina*	1	2	2	Mud, gravel and sand substrates, Colorado and Guadalupe river basins		T	Resident

Table 4C.18-1 (Continued)

Common Name	Scientific Name	Impact Value	Multiplier Based on Status	Adjusted Impact	Summary of Habitat Preference	Listing Entity		Potential Occurrence County
						FWS	TPW	
PLANTS								
Big red sage	*Salvia penstemonoides*	1	1	1	Endemic; moist to seasonally wet clay or silt soils in creek beds.			Resident
Bracted twistflower	*Streptanthus bracteatus*	1	1	1	Endemic: found in shallow, well-drained gravelly clays and clay loams over limestone.			Resident
Correll's false dragon-head	*Physostegia correllii*	1	1	1	Found in wet, silty clay loams on sides of streams and other wet areas.			Resident
Elmendorf's onion	*Allium elmendorfii*	2	1	2	Endemic, in deep sands			Resident
Hill Country wild-mercury	*Argythamnia aphoroides*	1	1	1	Endemic: found in grasslands associated with oak woodlands.			Resident
Park's jointweed	*Polygonella parksii*	2	1	2	Endemic; deep loose sands of Carrizo and similar Eocene formations.			Resident
Sandhill woolywhite	*Hymenopappus carrizoanus*	2	1	2	Found south of the Guadalupe River and the Balcones Escarpment. Prefers dense riparian corridors.			Resident
REPTILES								
Cagle's map turtle	*Graptemys caglei*	1	2	2	Endemic to Guadalupe River System. Found within 30 feet of waters' edge.		T	Resident
Indigo snake	*Drymarchon carais*	1	2	2	Found south of the Guadalupe river and Balcones Escarpment.		T	Resident
Spot-tailed earless lizard	*Holbrookia lacerata*	1	1	1	Moderately open prairie-brushland.			Resident

Table 4C.18-1 (Concluded)

Common Name	Scientific Name	Impact Value	Multiplier Based on Status	Adjusted Impact	Summary of Habitat Preference	Listing Entity		Potential Occurrence County
						FWS	TPW	
Texas Garter Snake	*Thamnophis sirtalis annectens*	1	1	1	Wet or moist microhabitats			Resident
Texas Horned Lizard	*Phrynosoma cornutum*	1	2	2	Varied, sparsely vegetated uplands.		T	Resident
Texas Tortoise	*Gopherus berlandieri*	1	2	2	Open brush w/ grass understory.		T	Resident
Timber/ Canebrake Rattlesnake	*Crotalus horridus*	1	2	2	Floodplains, upland pine, deciduous woodlands, riparian zones.		T	Resident

Source: TPWD, Annotated County List of Rare Species, Bexar County (Updated 10/6/2009),
TPWD, Annotated County List of Rare Species, Gonzales County (Updated 5/4/2009),
TPWD, Annotated County List of Rare Species, Wilson County (Updated 5/4/2009)

LE/L = Federally Listed Endangered/Threatened
DL, PDL = Federally Delisted/proposed for delisting
T/SA = Listed as Threatened by similarity of appearance
E, T = State listed Endangered/Threatened
C = Species of Concern
Blank = Not yet listed by TPWD or USFWS, but considered rare

boring/tunneling approach. All of the streams named above, Cibolo Creek, Sandies Creek and the San Antonio River, are perennial streams crossed by the pipeline route. A wetland delineation must be conducted on the pipeline easement, well pads, access roads and other areas to be disturbed during construction.

Most of the proposed well field areas and pipeline route have not been subjected to systematic archeological survey. Therefore, the available information on site occurrence is incomplete. An archeological survey of the project area should be undertaken to more accurately determine actual impacts to cultural resources. The issuance of a 404 permit for the project constitutes a federal action under 36 CFR 800. In this context, federal agencies must consider impacts to cultural resources within their jurisdiction that are either listed, or eligible for listing, on the National Register of Historic Places prior to permit approval. In addition, SAWS is considered a political subdivision of the State of Texas and derives its powers from the State Constitution, therefore SAWS must also comply with the Antiquities Code of Texas. The Antiquities Code considers all sites, whether known or unknown, on land owned or controlled by a political subdivision, as State Archeological Landmarks, which may not be altered, damaged, or destroyed without a state permit. The procedure for complying with these regulations involves consultation with the USCOE and the THC. It is likely that these agencies will require that the selected pipeline route and the improvements associated with the development of the well fields (e.g., access roads) all undergo an archeological survey to identify potential impacts to cultural resources. Once potential impacts are identified, these agencies may require that the affected sites be avoided or the impacts be mitigated by data recovery or other means.

A review of the Texas Historical Commission Texas Historic Sites Atlas database indicated that the Fairview Historical Marker, Oakley, Demmer and Clabber Town cemeteries are all within one mile of the proposed pipeline route and/or well field area. No National Register Properties were listed within one mile of the proposed pipeline route or well field area.

The project activities which entail regulatory liability result from temporary and permanent disturbance to soils, Waters of the U.S., wetlands, protected species and habitats and cultural resources during construction of well pads, access roads, pipelines and other facilities; permanent conversion of existing habitats or land uses to maintained pipeline rights-of-way; potential disturbance of minor acreages for water treatment facilities, storage stations and well facilities. Indirect effects of construction may include mitigation areas converted to alternate uses to compensate for losses of terrestrial and wetland habitat.

The possibility exists that water in the aquifer, affected by the additional wells, could decrease before stabilizing. The water level in the aquifer could affect the baseflow of surrounding streams and wetlands, thereby impacting wildlife habitat.

4C.18.4 Engineering and Costing

The preliminary engineering analyses have groundwater being developed for base load operations (uniform rate) of 10.5 MGD (11,687 acft/yr). The preliminary design is to construct a transmission pipeline at a capacity of 10.5 MGD. SAWS is planning to construct 14 water supply wells, which includes a contingency of about 6 wells. According to current GCUWCD rules, the project would require groundwater leases or land ownership of about 11,687 contiguous acres and well spacing of 6,000 feet for nominal 1,000 gpm wells.

Groundwater would be developed by constructing the Buckhorn well field and associated conveyance and storage facilities that extend from southern Bexar County to southwestern Gonzales County, as shown in Figure 4C.18-2. The raw water pipeline route traverses about 54 miles with a 33-inch diameter pipe from the Buckhorn Well Field to the Twin Oaks WTP. It requires two pump stations, one is near the well field and the other is near US Hwy 181. Water treatment will consist of iron and manganese removal and cooling. Constructing SAWS west side integration pipeline is beyond the scope of this strategy.

The major facilities required for this strategy include:

- Water Collection and Conveyance System:
  - Wells, and
  - Pipelines.
- Storage,
- Pipeline,
- Pump Stations, and
- Water Treatment Plant (Upgrade of Existing Plant).

The approximate locations of these facilities were shown in Figure 4C.18-2.

Cost estimates were developed using regional planning procedures. These costs are summarized in Table 4C.18-2. The estimated project cost is $136,550,000. The annual costs include debt service for a 20-year loan at 6 percent interest and operation and maintenance costs, including power. The costs also include a groundwater lease fee of $62.50/acft and a groundwater district export fee of $8.71/acft. The cost of water is estimated to be $1,343/acft/yr ($4.12 per 1,000 gallons) for treated water at the Twin Oaks WTP in South Bexar County.

4C.18.5 Implementation Issues

Implementation of the Regional Carrizo for SAWS water management strategy could involve conflicts with other water supply plans as they will be competing for limited groundwater supplies within the GCUWCD. Because the district's permitting process is independent of the regional planning process, potentially competing groundwater management strategies are not prioritized.

This project considers existing rules of the GCUWCD with regard to well yield, spacing, and acreage. An assessment has not been conducted of the maximum drawdown criteria, which will be performed in the cumulative effects section of the plan.

Table 4C.18-2.
Cost Estimate Summary
Regional Carrizo for SAWS
Sept 2008 Prices

Item	***Estimated Costs for Facilities***
Capital Costs	
Transmission Pipeline (33 inch dia, 54 miles long)	$58,506,000
Transmission Pump Stations (2), 10.45 MGD	$9,188,000
Well Fields (14 Wells, yielding 500 to 1,000 gpm)	$25,028,000
Water Treatment Plant (Cooling and Removal of Iron and Manganese)	$3,457,000
Total Capital Cost	**$96,179,000**
Engineering, Legal Costs and Contingencies	$30,737,000
Environmental & Archaeology Studies and Mitigation	$1,838,000
Land Acquisition and Surveying (270 acres)	$2,544,000
Interest During Construction (1 years)	$5,252,000
Total Project Cost	**$136,550,000**
Annual Costs	
Debt Service (6 percent, 20 years)	$11,905,000
Operation and Maintenance	
Pipeline, Pump Station, and Well Field	$1,051,000
Water Treatment Plant	$933,000
Pumping Energy Costs ($0.09/kWh)	$975,000
Groundwater Leases ($62.50/acft)	$730,000
Groundwater District Export Fees ($8.71/acft)	$102,000
Total Annual Cost	**$15,696,000**
Available Project Yield (acft/yr)	11,687
Annual Cost of Water ($ per acft)	$1,343
Annual Cost of Water ($ per 1,000 gallons)	$4.12

Part or all of the water needed by this Water Management Strategy (WMS) is anticipated to be supplied from locations within the jurisdiction of a groundwater conservation district (District) and may exceed the amount of available water identified in the District's approved management plan, or may for other reasons not be permitted by the District.

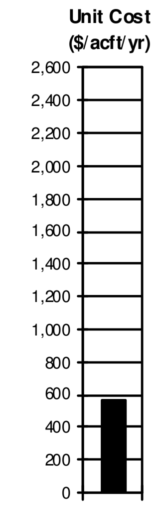
The amount of water needed by this WMS that exceeds the available water in the District's management plan, or for other reasons is not permitted by the District, cannot be implemented as part of this WMS unless and until all necessary permits are received from the District.

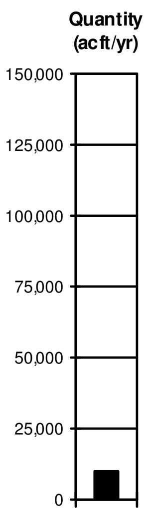
The amount of water needed by this WMS that exceeds the available water in the District's management plan, or for other reasons is not permitted by the District, introduces an added element of uncertainty to reliance upon this WMS and, therefore, additional management supplies may be needed for this WMS.

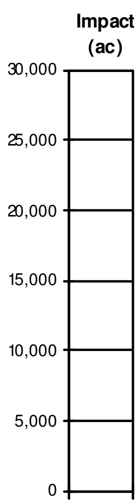
The development of groundwater in the Carrizo-Wilcox Aquifer in the South Texas Water Planning Region must address several issues. Major issues include:

- GCUWCD permits:
  - Analyses of pumping impacts on groundwater levels;
  - Mitigation of impacts on existing well owners;
  - Drought and Water Conservation Plans; and
  - Needs assessment.
- Impacts on:
  - Endangered and threatened species;
  - Water levels in the aquifer, including dewatering of the current artesian part of the aquifer;
  - Baseflow in streams; and
  - Wetlands.
- Competition with others in the area for groundwater;
- Regulations by the GCUWCD, including periodic renewal of permits and potential pumping reductions; and
- Obtain TCEQ permits.

2011 South Central Texas Regional Water Plan
Water Management Strategy Summary Sheet







Name: Regional Carrizo for SSLGC Project Expansion

Description: The Schertz-Seguin Water Supply Project, owned and operated by Schertz-Seguin Local Government Corp (SSLGC), currently holds permits to pump 12,910 acft/yr of groundwater from Gonzales County from the Carrizo Aquifer in southwestern Gonzales County and 3,226 acft/yr from the Carrizo Aquifer in southeastern Guadalupe County. The primary recipients of the water are the cities of Schertz and Seguin. SSLGC also provides some water to the cities of Selma and Universal City. The project presently consists of eight 1,000-gpm Carrizo wells in southwestern Gonzales County. Four wells are planned for construction in Guadalupe County and eight in Guadalupe County. When completed,this water supply project is planned to provide a total supply of 26,500 acft/yr, with 20,000 acft/yr and 6,500 acft/yr coming from Gonzales and Guadalupe Counties, respectively. This project expansion is for 10,364 acft/yr and involves the expansion of: (1) an existing well field in southwestern Gonzales County, (2) a permitted well field in Guadalupe County, and (3) current water treatment facilities.

Decade Needed: 2010 -2020

Cost, Quantity of Water, and Land Impacted

Unit Cost of Water:	**$568**	**$/acft/yr**	**Treated Water Delivered**
Quantity of Water:	**10,364**	**acft/yr**	**Reliability = Firm**
Land Impacted:	**<10**	**acres**	

Additional Considerations per Regional Water Planning Guidelines

Environmental Factors:

Within the well field areas, several species listed as threatened by the state may possibly have habitat which could be affected by the project. These include the Texas horned lizard, Texas tortoise, and timber/canebrake rattlesnake.

Impacts on Water Resources:

Groundwater levels will decline and could affect the baseflow of surrounding streams and wetlands.

Impacts on Agricultural & Natural Resources:

Minimal impacts anticipated.

Other Relevant Factors per SCTRWPG:

Part or all of the water needed by this Water Management Strategy (WMS) is anticipated to be supplied from locations within the jurisdiction of a groundwater conservation district (District) and may exceed the amount of available water identified in the District's approved management plan, or may for other reasons not be permitted by the District. The amount of water needed by this WMS that exceeds the available water in the District's management plan, or for other reasons is not permitted by the District, cannot be implemented as part of this WMS unless and until all necessary permits are received from the District. The amount of water needed by this WMS that exceeds the available water in the District's management plan, or for other reasons is not permitted by the District, introduces an added element of uncertainty to reliance upon this WMS and, therefore, additional management supplies may be needed for this WMS.

Comparison of Strategies to Meet Needs:

Cost estimates indicate that this strategy may be more economical than other potentially feasible WMS.

Interbasin Transfer Issues:

None.

Third-Party Impacts of Voluntary Transfers:

None anticipated.

Regional Efficiency:

Allows SSLGC the ability to fully utilize existing transmission facilities while providing a reliable, long-term water supply.

Water Quality Considerations:

Overall, the water quality of the Carrizo-Wilcox Aquifer is suitable for use as a water supply, except for elevated concentrations of iron and manganese in many areas.

4C.19 Regional Carrizo for SSLGC Project Expansion

4C.19.1 Description of Water Management Strategy

The Schertz-Seguin Water Supply Project, owned and operated by Schertz-Seguin Local Government Corp (SSLGC), currently holds permits to pump 12,910 acft/yr of groundwater from Gonzales County from the Carrizo Aquifer in western Gonzales County and 3,226 acft/yr from the Carrizo Aquifer in southeastern Guadalupe County. The primary recipients of the water are the cities of Schertz and Seguin. SSLGC also provides some water to the cities of Selma, Universal City, and Springs Hill Water Supply Corporation. The project presently consists of eight 1,000-gpm Carrizo wells in Western Gonzales County. Four wells are planned for construction in Guadalupe County. This water management strategy is planned to expand the existing Regional Carrizo for SSLGC Project by 10,364 acft/yr, to provide a total supply of 26,500 acft/yr, with 20,000 acft/yr and 6,500 acft/yr coming from Gonzales and Guadalupe Counties, respectively. Figure 4C.19-1 illustrates the existing Schertz-Seguin Water Supply Project system.

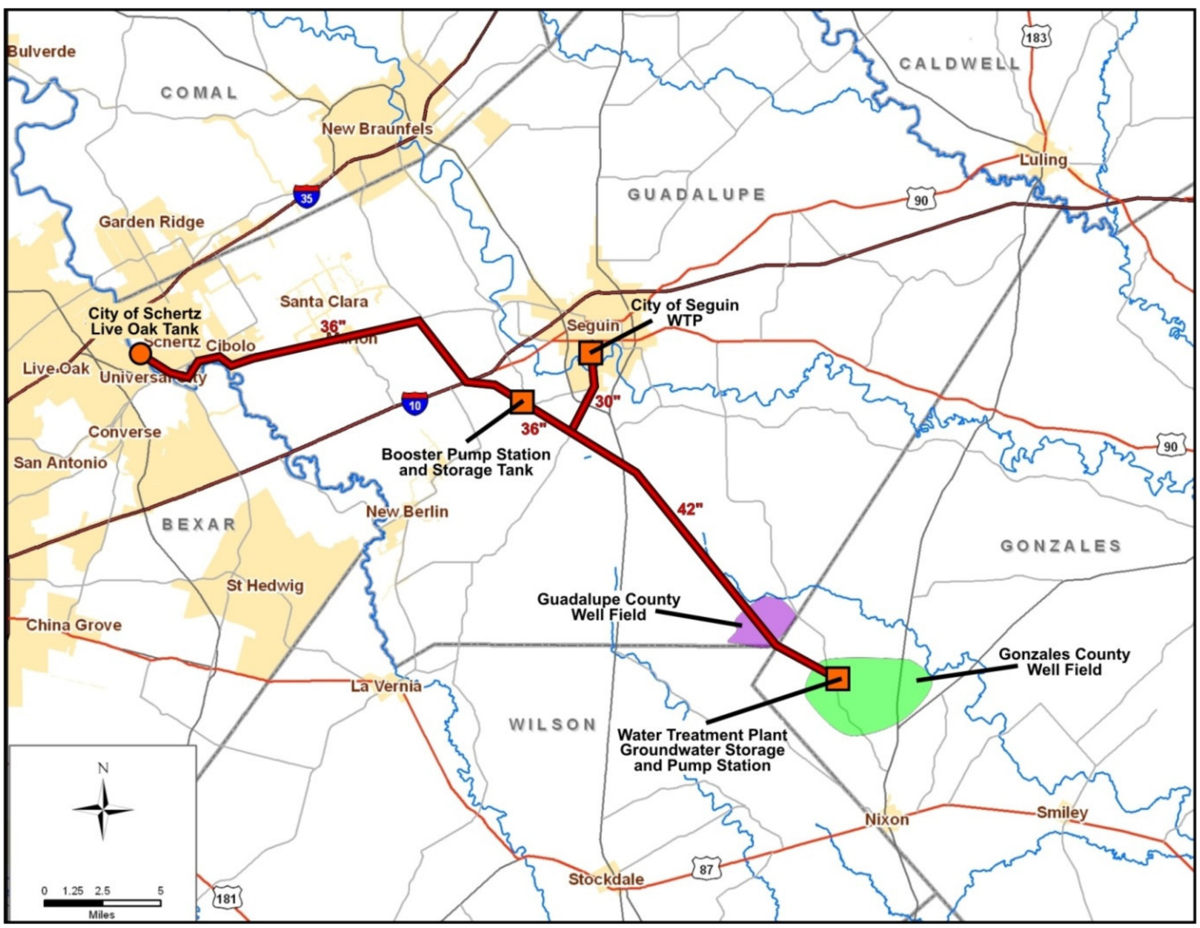


Figure 4C.19-1. Schertz-Seguin Water Supply Project

4C.19.2 Groundwater Availability

The Carrizo Aquifer in the vicinity of the planned well field expansion is a few miles downdip of the Carrizo outcrop. Well tests and hydrogeologic maps of the aquifer in this area suggest that wells in the area would be capable of producing in excess of 2,000 gpm and would range in depths up to 1,400 ft deep. Groundwater quality in the planned well field usually has a concentration of total dissolved solids of less than 300 mg/L. However, the water typically has elevated concentrations of iron and manganese that requires removal before being used by the public.

Regional Carrizo projects in this area of Gonzales County include Regional Carrizo for SAWS and Canyon Regional Water Authority's Wells Ranch Project. Groundwater production, well spacing, and export of groundwater are subject to rules of the GCUWCD. In Guadalupe County, Canyon Regional is also planning a new well field.

A Desired Future Condition (DFC) has not been established for GMA-13, which includes the Gonzales and Guadalupe Counties. Thus, the amount of Managed Available Groundwater (MAG) has not been determined.

No assessment has been made to determine if the project complies with Gonzales County Underground Water Conservation District's (GCUWCD) and Guadalupe County Groundwater Conservation District (GCGCD) water management plans and rules. Before the project could become operational, permits for well construction, water production, and water export would have to be obtained from the two districts.

The effects of the groundwater pumping on groundwater levels and streamflow will be developed and presented in the cumulative effects section of the 2011 SCTRWP.

4C.19.3 Environmental Issues

The Regional Carrizo for SSLGC Project Expansion involves the expansion of an existing well field in western Gonzales County and its current treatment facilities and the construction of a new well field and treatment plant in Guadalupe County. This report section discusses the potential impacts to environmental and cultural resources known to exist within the proposed well field areas.

The project area lies within the Post Oak Savannah vegetational area.[1] The vegetation of this portion of Guadalupe and Gonzales Counties is now primarily composed of rangeland, crops, and post-oak woodlands. Common woody species include post oak (*Quercus stellata*), blackjack oak (*Quercus marilandica*), and species of *Carya* (hickory). Grasses of the area commonly include little bluestem (*Schizachyrium scoparium*), indiangrass (*Sorghastrum nutans*) and switchgrass (*Panicum virgatum*). pricklypear (*Opuntia sp.*) is common throughout most of the area.[2]

Vertebrate fauna typifying these regions include the opossum, raccoon, weasel, skunk, white-tailed deer and bobcat as well as a wide variety of amphibians, reptiles and birds. The coyote and javelina are also common to the area, but are found mainly in brush/shrub areas while the red and gray fox are more common in woodlands.[3]

Plant and animal species listed by the USFWS and TPWD as endangered, threatened or species of concern in the project area are presented in Table 4C.19-1. Within the well field areas, several species listed as threatened by the state may possibly have habitat which could be affected by the project. These include the Texas horned lizard (*Phrynosoma cornutum)*, Texas tortoise (*Gopherus berlandieri)*, and timber/canebrake rattlesnake (*Crotalus horridus)*. The Texas horned lizard prefers a varied habitat which includes grass, cactus and brush, while the Texas tortoise inhabits primarily open brush areas with a grass understory. The timber/ canebrake rattlesnake is generally found within floodplains or riparian zones that contain dense ground cover such as the areas near Sandies Creek or its tributaries.

The Texas Parks and Wildlife Department Natural Diversity Database system files identify three plant species of concern documented within the vicinity of the well field areas. These include Elmendorf's onion (*Allium elmendorfii*), sandhill woolywhite (*Hymenopappus carrizoanus*), and Park's jointweed (*Polygonella parksii*), all species which are generally found in areas of deep sand. These species of concern are considered to be rare, but are not protected by USFWS or TPWD.

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[1] Gould, F.W., "The Grasses of Texas," Texas A&M University Press, College Station, Texas, 1975.
[2] Hatch, S.L., K.N. Gandhi, and L. E. Brown, "Checklist of the Vascular Plants of Texas," Texas Agricultural Experiment Station, Texas A & M University, College Station, 1990.
[3] Manning, Richard W., Clyde Jones and Franklin D. Yancy, II. 2008. Annotated checklist of recent land mammals of Texas, 2008. Natural Science Research Laboratory, Occasional Papers, Texas Tech University, Lubbock, Texas.

**Table 4C.19-1.
Endangered, Threatened, and Species of Concern for
Gonzales and Guadalupe Counties**

Common Name	Scientific Name	Impact Value	Multiplier Based on Status	Adjusted Impact	Summary of Habitat Preference	Listing Entity USFWS	Listing Entity TPWD	Potential Occurrence in County
BIRDS								
Bald eagle	*Haliaeetus leucoephalus*	0	2	0	Large bodies of water with nearby resting sites	DL	T	Nesting/Migrant
Henslow's sparrow	*Ammodramus henslowii*	1	1	1	Wintering individuals found in weedy fields			Migrant
Interior least tern	*Sterna antillarum athalassos*	0	3	0	Inland river sandbars for nesting and shallow water for foraging	LE	E	Nesting/Migrant
Mountain plover	*Charadrius montanus*	1	1	1	Breeding, nesting on shortgrass prairie.			Resident
American peregrine falcon	*Falco peregrinus anatum*	0	2	0	Migrant and local breeder in West Texas.	DL	T	Possible Migrant
Arctic peregrine falcon	*Falco peregrinus tundrius*	0	1	0	Migrant throughout the state.	DL		Possible Migrant
Western burrowing owl	*Athene cunicularia hypugaea*	1	1	1	Open grasslands, especially prairie.			Resident
Whooping crane	*Grus Americana*	0	3	0	Winters in coastal marshes	LE	E	Migrant
Wood stork	*Mycteria Americana*	0	2	0	Forages in prairie ponds, ditches and shallow standing water; formerly nested in Texas		T	Migrant
MAMMALS								
Cave myotis bat	*Myotis velifer*	0	1	0	Colonial and cave-dwelling, also roosting in rock crevices and other areas.			Resident
Plains spotted skunk	*Spilogale putorius interrupta*	1	1	1	Open fields, and prairies.			Resident
Red wolf	*Canis rufus*	0	3	0	Extirpated, formerly known throughout the eastern half of Texas.	LE	E	Historic
FISH								
Blue sucker	*Cycleptus elongates*	1	2	2	Found in larger portions of major rivers in Texas.		T	Resident
Guadalupe bass	*Micropterus treculii*	1	1	1	Endemic to perennial streams of the Edwards Plateau region.			Resident
Guadalupe darter	*Percina sciera apristis*	1	1	1	Guadalupe river basin, most common over gravel in large streams and rivers.			Resident
INSECTS								
A mayfly	*Campsurus decoloratus*	0	1	0	Adults found in shoreline vegetation.			Resident

Table 4C.19-1 (Continued)

Common Name	Scientific Name	Impact Value	Multiplier Based on Status	Adjusted Impact	Summary of Habitat Preference	Listing Entity		Potential Occurrence in County
						USFWS	TPWD	
MOLLUSKS								
Creeper	*Strophitus undulates*	1	1	1	Small to large streams.			Aquatic Resident
False spike mussel	*Quincuncina mitchelli*	1	2	2	Substrates of cobble and mud.		T	Aquatic Resident
Golden Orb	*Quadrula aurea*	1	2	2	Sand and gravel areas in river basins. Endemic to the Guadalupe-San Antonio and Nueces-Frio systems.		T	Aquatic Resident
Palmetto pill snail	*Euchemotrema leai cheatumi*	0	1	0	Terrestrial snail known from only one location, moist palmetto woodlands of Palmetto State Park.			Resident
Pistolgrip	*Tritogonia verrucosa*	1	1	1	Stable substrate in river basins.			Aquatic Resident
Rock pocketbook	*Arcidens confragosus*	1	1	1	Substrates of medium to large rivers.			Aquatic Resident
Texas fatmucket	*Lampsilis bracteata*	1	2	2	Found in streams and rivers on sand, mud, and gravel substrates within the Colorado and Guadalupe River basins. Intolerant of impoundment.		T	Aquatic Resident
Texas pimpleback	*Quadrula petrina*	1	2	2	An endemic species confined to the Colorado and Guadalupe drainages. Generally in areas with slow flow rates.		T	Aquatic Resident
REPTILES								
Cagle's map turtle	*Graptemys caglei*	1	2	2	Endemic to Guadalupe River System		T	Resident
Spot-tailed earless lizard	*Holbrookia lacerate*	1	1	1	Open prairie-brushland.			Resident
Texas garter snake	*Thamnophis sirtalis annectens*	1	1	1	Generally found in wet or moist microhabitats.			Resident
Texas horned lizard	*Phrynosoma cornutum*	2	2	4	Varied; sparsely vegetated uplands, grass, cactus, brush		T	Resident
Texas tortoise	*Gopherus berlandieri*	2	2	4	Open brush with grass understory; open grass and bare ground avoided		T	Resident
Timber/Canebrake rattlesnake	*Crotalus horridus*	2	2	4	Floodplains, riparian zones with dense ground cover		T	Resident
PLANTS								
Big red sage	*Salvia penstemonoides*	1	1	1	Endemic in moist to seasonally wet, steep limestone outcrops on seeps within canyons or along creek banks.			Resident

Table 4C.19-1 (Concluded)

Common Name	Scientific Name	Impact Value	Multiplier Based on Status	Adjusted Impact	Summary of Habitat Preference	Listing Entity		Potential Occurrence in County
						USFWS	TPWD	
Elmendorf's onion	*Allium elmendorfii*	2	1	2	Endemic to grassland openings in woodlands			Resident
Parks' jointweed	*Polygonella parksii*	2	1	2	Endemic, found primarily on deep, loose, whitish sand blowouts in Post Oak Savannahs.			Resident
Sandhill woollywhite	*Hymenopapus carrizoanus*	2	1	2	Endemic, found in disturbed or open areas in grasslands and post oak woodlands.			Resident

Source: TPWD, Annotated County List of Rare Species, Gonzales County, revised May 4, 2009 and Guadalupe County revised May 7, 2009.

DL = Delisted
PDL = Proposed for Delisting
LE = Federally listed endangered
LT = Federally listed threatened
Blank = Not Federal or State Listed but considered a Species of Concern
E = State Endangered
T = State Threatened

Concerns associated with the expansion of the existing well field and development of the new well field area involve water levels in the aquifer, baseflow of the surrounding streams and wetlands. The possibility exists that water levels in the aquifer, affected by the additional wells, could decrease before stabilizing, thus affecting habitat within the area. Waters of the U.S. crossings within the well field area consists of the riverine habitat of Sandies Creek, as well as associated palustrine habitats that are generally composed of narrow bands of wetlands adjacent to this watercourse. A ground survey wetland delineation will be required to determine whether wetlands would be impacted by the project and to what extent. The wetland delineation will document the locations of streambeds, stream widths, quality and type of water bodies, types of aquatic vegetation, presence of special aquatic resources (such as wetlands) and area of jurisdictional Waters of the U.S. likely to be disturbed during construction. Disturbance from construction is great concern for perennial streams such as Sandies Creek. A wetland delineation must also be conducted on the well pads, access roads and other areas to be disturbed during construction.

A review of the Texas Historical Commission Texas Historic Sites Atlas data base indicated that there are no historical markers, National Register Properties or cemeteries listed within the proposed well field areas.

Most of the proposed well field areas have not been subjected to systematic archeological survey. Therefore, the available information on site occurrence is incomplete. An archeological survey of the project area should be undertaken to more accurately determine actual impacts to cultural resources. Cultural resources protection on public lands in Texas is afforded by the Antiquities Code of Texas (Title 9, Chapter 191, Texas Natural Resource Code of 1977), the National Historic Preservation Act (Pl96-515), and the Archeological and Historic Preservation Act (PL93-291). Cultural resource occurrences within this project area are expected to be present due to the well fields' location near Sandies Creek. Coordination with the Texas Historical Commission will need to be initiated prior to project construction. If the project will affect waters of the United States or wetlands, the project sponsor will also be required to coordinate with the U.S. Army Corps of Engineers regarding any impacts to cultural resources.

4C.19.4 Engineering and Costing

Groundwater will be developed by constructing 4 new wells in Gonzales County and 8 new wells and treatment plant in Guadalupe County, installing a pipeline collection system, and expanding existing treatment facilities for chlorine disinfection and iron/manganese removal. The existing conveyance facilities are already sized to convey the water associated with this expansion.

The Regional Carrizo for SSLGC Project Expansion is planned to provide an additional 10,364 acft/yr above currently permitted 16,136 acft/yr. When completed, this water management strategy is to yield 26,500 acft/yr. The major facilities required for this strategy are:

- Wells,
- Well field collection pipeline(s), and
- Water treatment plant (upgrade existing plant).

The approximate locations of these facilities are displayed in Figure 4C.19-1.

Wells located in Gonzales County were assumed to be 1,200 feet deep, similar to the existing wells. They will have a peak capacity of approximately 1,500 gpm, but are rated at approximately 1,000 gpm. The Guadalupe County wells were assumed to be 800 feet deep since they are located updip of the existing wells and have a rated capacity of 500 gpm. Power costs for conveyance of the additional 10,364 acft/yr associated with the SSLGC expansion were estimated by calculating the horsepower needed to lift the water from the water treatment plant to City of Schertz-Live Oak Tank and overcome the pipe friction of an equivalent diameter pipeline. Existing pump station, storage tanks, or pipelines are assumed to have adequate capacity for the expansion. Costs were included for leasing property necessary to obtain groundwater permits, and for anticipated third party well mitigation activities to compensate for lowered pumping levels in existing wells.

Based on these assumptions, and on an assumed yield of 10,364 acft/yr, it is estimated that the project cost will be about $28,189,000, and the annual cost will be about $5,885,000 during the period when debt service is required. The water obtained through this water management strategy will have a unit cost of $538/acft/yr, or $1.74/1,000 gallons (Table 4C.19-2).

4C.19.5 Implementation Issues

Implementation of the Regional Carrizo to Bexar County water management strategy could involve conflicts with other water supply plans as they will be competing for limited groundwater supplies within Gonzales and Guadalupe Counties. Because the district's permitting process is independent of the regional planning process, potentially competing groundwater management strategies are not prioritized.

This project considers existing rules of the GCUWCD and the GCGCD with regard to well yield, spacing, and acreage. An assessment has not been conducted of the maximum drawdown criteria, which will be performed in the cumulative effects section of the plan.

Part or all of the water needed by this Water Management Strategy (WMS) is anticipated to be supplied from locations within the jurisdiction of a groundwater conservation district (District) and may exceed the amount of available water identified in the District's approved management plan, or may for other reasons not be permitted by the District.

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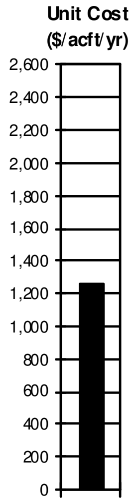
Table 4C.19-2.
Cost Estimate Summary
Regional Carrizo for SSLGC Project Expansion
Sept 2008 Prices

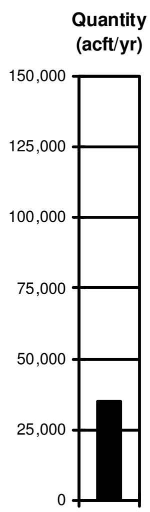
Item	Estimated Costs for Facilities
Capital Costs	
Well Fields (Guadalupe Co: 8 wells; and Gonzales Counties: 5 wells)	$13,237,000
Water Treatment Plant (11.6 MGD)	$3,607,000
Pump Stations and Pipelines	$0
Total Capital Cost	**$16,844,000**
Engineering, Legal Costs and Contingencies	$5,895,000
Environmental & Archaeology Studies and Mitigation	$225,000
Groundwater Lease Acquisition	$1,406,000
Mitigation Reserve for Possible Impacts to Local Wells	$2,734,000
Interest During Construction (1 years)	$1,085,000
Total Project Cost	**$28,189,000**
Annual Costs	
Debt Service (6 percent, 20 years)	$2,458,000
Operation and Maintenance	
Well field and Collector Pipelines	$132,000
Water Treatment Plant	$991,000
Pumping Energy Costs ($0.09 per kWh)	$1,416,000
Groundwater Lease Payments ($40/acft)	$804,000
District Export Fee ($8.15/acft)	$84,000
Total Annual Cost	**$5,885,000**
Available Project Yield (acft/yr)	10,364
Annual Cost of Water ($ per acft)	$568
Annual Cost of Water ($ per 1,000 gallons)	$1.74

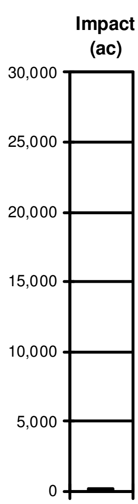
The development of groundwater in the Carrizo-Wilcox Aquifer in the South Texas Water Planning Region must address several issues. Major issues include:

- GCUWCD and GCGCD permits:
  - Analyses of pumping impacts on groundwater levels;
  - Mitigation of impacts on existing well owners; and
  - Drought and Water Conservation Plans.
- Needs assessment.
- Impacts on:
  - Endangered and threatened species;
  - Water levels in the aquifer, including dewatering of the current artesian part of the aquifer;
  - Baseflow in streams; and
  - Wetlands.
- Competition with others in the area for groundwater;
- Regulations by GCUWCD and GCGCD, including periodic renewal of permits and potential pumping reductions; and
- Obtain TCEQ permits.

2011 South Central Texas Regional Water Plan
Water Management Strategy Summary Sheet







Name: Hays/Caldwell PUA Project

Description: The Hays/Caldwell PUA Project involves: (1) pumping groundwater from planned well fields in Caldwell and Gonzales Counties, (2) treating the water near the well field, and (3) conveying the water to a delivery point about 5 miles northeast of San Marcos.

This project is planned in two phases. Phase I plans include a well field in Caldwell County, being operational in about 2018, and and producing an average of 12,000 acft/yr. Phase II plans have the well field located in Gonzales County, being operational in about 2032, and producing an average of 23,000 acft/yr. Raw groundwater would be pumped by the well pumps to a water treatment plant near the well field for removal of iron and manganese. Then, the water would be pumped to a delivery point near the Hays-Caldwell county line, about 5 miles northeast of San Marcos.

***Decade Needed*:** 2010 – 2040

Cost, Quantity of Water, and Land Impacted

Unit Cost of Water:	**$1,245**	**$/acft/yr**	**Treated Water Delivered**
Quantity of Water:	**35,000**	**acft/yr**	**Reliability = Firm**
Land Impacted:	**220**	**acres**	

Additional Considerations per Regional Water Planning Guidelines

Environmental Factors:

Cagle's map turtle has been documented within three miles of the water delivery point.

Impacts on Water Resources:

Groundwater levels will decline and could affect the baseflow of surrounding streams and wetlands.

Impacts on Agricultural & Natural Resources:

Minimal impacts anticipated.

Other Relevant Factors per SCTRWPG:

Part or all of the water needed by this Water Management Strategy (WMS) is anticipated to be supplied from locations within the jurisdiction of a groundwater conservation district (District) and may exceed the amount of available water identified in the District's approved management plan, or may for other reasons not be permitted by the District. The amount of water needed by this WMS that exceeds the available water in the District's management plan, or for other reasons is not permitted by the District, cannot be implemented as part of this WMS unless and until all necessary permits are received from the District. The amount of water needed by this WMS that exceeds the available water in the District's management plan, or for other reasons is not permitted by the District, introduces an added element of uncertainty to reliance upon this WMS and, therefore, additional management supplies may be needed for this WMS.

Comparison of Strategies to Meet Needs:

Cost estimates indicate that this strategy is moderate in cost.

Interbasin Transfer Issues:

None.

Third-Party Impacts of Voluntary Transfers:

None anticipated.

Regional Efficiency:

Regional partnership amongst four or more WUGs allows for economy of scale and use of shared facilities.

Water Quality Considerations:

Overall, the water quality of the Carrizo-Wilcox Aquifer is suitable for use as a water supply, except for elevated concentrations of iron and manganese in many areas. For this strategy, iron and manganese will be removed from raw groundwater at a water treatment facility.

4C.20 Hays/Caldwell PUA Project

4C.20.1 Description of Water Management Strategy

The Carrizo-Wilcox Aquifer is one of four major aquifers in the South Central Texas Water Planning Region. In the Wintergarden area, which is generally considered to be west of the Atascosa-Frio county line, the aquifer has been extensively developed for many decades. In Atascosa County, the aquifer has had moderate development. In Bastrop, Caldwell, Gonzales, Guadalupe, and Wilson Counties, there has been limited development. Overall, the water quality of the Carrizo-Wilcox Aquifer is suitable for use as a water supply, except for elevated concentrations of iron and manganese in many areas.

Along the IH-35 corridor in Region L, there are wide-spread, near-term projected shortages in municipal supplies. Several other water purveyors in Region L, including SAWS, Schertz-Seguin Local Government Corporation (SSLGC), Canyon Regional Water Authority (CRWA), Texas Water Alliance and Aqua WSC, are evaluating regional projects to import groundwater from the Carrizo-Wilcox to their demand centers. The general location of the well fields associated with these projects is shown in Figure 4C.20-1.

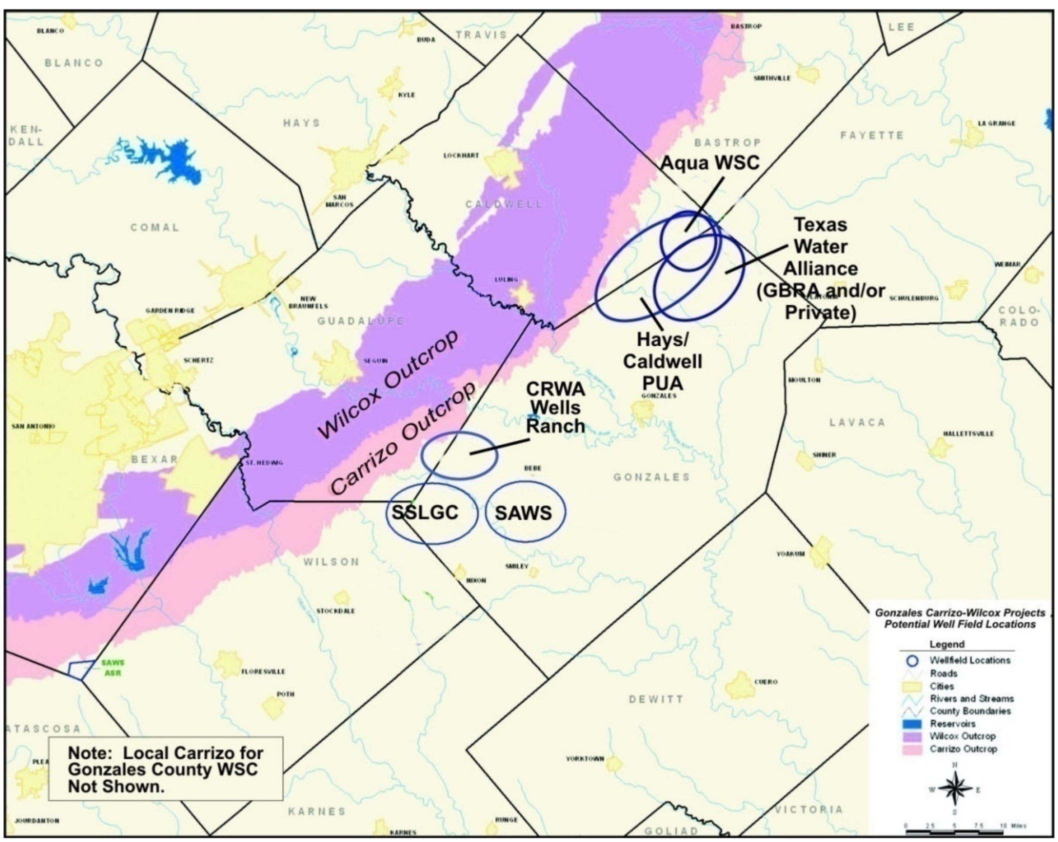


Figure 4C.20-1. General Location of Carrizo Aquifer Water Supply Projects

This water management strategy is known as the Hays/Caldwell PUA Project and involves: (1) pumping groundwater from planned well fields in Caldwell and Gonzales Counties, (2) treating the water near the well field, and (3) conveying the water to a delivery point about 5 miles northeast of San Marcos. The general locations of the facilities are shown in Figure 4C.20-2.

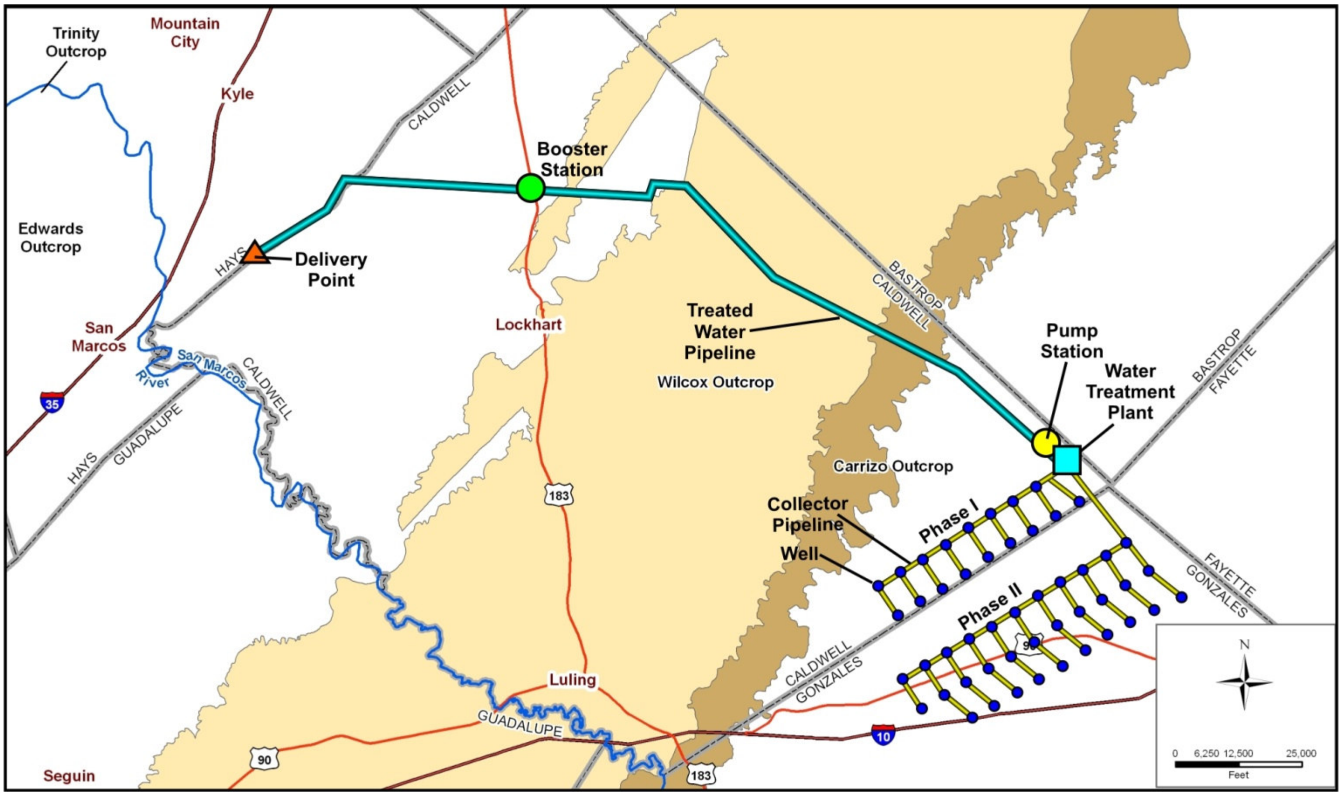


Figure 4C.20-2. Hays Caldwell PUA Project

The Hays/Caldwell PUA Project consists of two phases. Phase I plans for the well field to be located in Caldwell County, to begin producing in about 2018, to have a peaking capacity of 21.4 MGD, and to produce an average of 12,000 acft/yr. Phase II plans for the well field to be located in Gonzales County, to begin producing in about 2032, to have a peaking capacity of 41.1 MGD, and to produce an average of 23,000 acft/yr. These rates are designed to approximate a typical annual demand pattern where the peak demand is about twice the average annual demand. Raw groundwater is pumped by the well to a water treatment plant near the well field for removal of iron and manganese. Then, the water would be pumped to a delivery point near the Hays-Caldwell county line and about 5 miles northeast of San Marcos.

A feasibility report on this project (and alternatives) was prepared by Lockwood, Andrews, and Newnam (LAN) and Thornhill Group Inc., and submitted to Canyon Regional Water Authority (CRWA) in March 2005. The current participants in Hays/Caldwell PUA Project include:

- Canyon Regional Water Authority (CRWA),
- City of Kyle,
- City of San Marcos, and
- City of Buda.

The Hays Caldwell Public Utility Agency (HCPUA) has been formed to administer the project.

4C.20.2 Groundwater Availability

The Carrizo Aquifer in the vicinity of the planned well field is within a few miles of the Carrizo outcrop. A study of maps and reports of the aquifer in this area suggest that wells in the area would be capable of producing in excess of 1,000 gpm and would range in depth from about 500 to 2,000 ft deep. Other potential water supply projects in this part of the Carrizo Aquifer includes Caldwell and Gonzales County.

A 2009 Gonzales County Underground Water Conservation District (GCUWCD) Water Management Plan does not include an estimate of groundwater availability in this part of the aquifer. Also, in GMA-13 which includes the GCUWCD, a Desired Future Condition (DFC) has not been established. Thus, the amount of Managed Available Groundwater (MAG) has not been established.

No assessment has been made to determine if the drawdown in the Carrizo and other aquifers complies with GCUWCD water management plan and rules. Currently, the water management plan specifies a maximum allowable drawdown of 100 ft in the Carrizo and 50 ft in the Queen City. For a new Carrizo well, the GCUWCD draft rules require a spacing of 6,000 ft and 8,000 ft for a well with a pumping capacity of 501-1,500 gpm and greater than 1,500 gpm respectively from a registered or authorized Carrizo well. Before the project could become operational, permits for well construction, water production, and water exports would have to be obtained from GCUWCD. The effects of the groundwater pumping on groundwater levels and streamflow will be developed and presented in the cumulative effects section of the 2011 SCTRWP.

4C.20.3 Environmental Issues

The Hays/Caldwell PUA Project involves developing new well fields in Caldwell and Gonzales Counties, pumping water from planned well fields, treating water at a new water treatment plant and construction of an approximately 35 mile pipeline to transport water to a delivery point approximately five miles northeast of San Marcos. This report section discusses the potential impacts to environmental and cultural resources known to exist within the area of the proposed facilities as shown on Figure 4C.20-2.

The project area lies within the Blackland Prairie and Oak Woods and Prairies ecoregions.[1] The vegetation of this portion of Caldwell and Gonzales Counties is primarily composed of crops, post-oak woodlands and grasslands. Common woody species include post oak (*Quercus stellata*), blackjack oak (*Quercus marilandica*), eastern redcedar (*Juniperus virginiana*), mesquite (*Prosopis glandulosa*), black hickory (*Carya texana*), and cedar elm (*Ulmus crassifolia*). Grasses of the area commonly include little bluestem (*Schizachyrium scoparium*), silver bluestem (*Bothriochloa saccharoides*) and sand lovegrass (*Eragrostis trichodes*). Crops include a variety of cover or row crops. [2]

Vertebrate fauna typifying these regions include the opossum, raccoon, weasel, skunk, white-tailed deer and bobcat as well as a wide variety of amphibians, reptiles and birds. The coyote and javelina are also common to the area, but are found mainly in brush/shrub areas while the red and gray fox are more common in woodlands.[3]

Plant and animal species listed by the USFWS and TPWD as endangered, threatened or species of concern in the project area are presented in Table 4C.20-1. Within the potential well field areas and the proposed pipeline route, several rare or listed species may have habitat which could be affected by the project. These include the Texas Horned Lizard (*Phrynosoma cornutum)*, Texas Tortoise (*Gopherus berlandieri)*, Elmendorf's onion (*Allium elmendorfii)* and sandhill woollywhite (*Hymenopapus carrizoanus*). The Texas horned lizard prefers a varied habitat which includes grass, cactus and brush, while the Texas tortoise inhabits primarily open

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[1] TPWD, "The Natural Regions of Texas," Texas Parks and Wildlife Department GIS Lab, March 2006.
[2] McMahan, C.A., R.G. Frye, and K.L. Brown. An Illustrated Synopsis to Accompany the Map "The Vegetation Types of Texas." Texas Parks and Wildlife Department, 1984.
[3] Manning, Richard W., Clyde Jones and Franklin D. Yancy, II. 2008. Annotated checklist of recent land mammals of Texas, 2008. Natural Science Research Laboratory, Occasional Papers, Texas Tech University, Lubbock, Texas.

Table 4C.20-1. Federal- and State-Listed Threatened, Endangered, and Species of Concern Listed for Caldwell and Gonzales Counties

Common Name	Scientific Name	Impact Value	Multiplier Based on Status	Adjusted Impact	Summary of Habitat Preference	Potential Occurrence in County	Federal Status	State Status
BIRDS								
Bald eagle	*Haliaeetus leucoephalus*	0	2	0	Large bodies of water with nearby resting sites	Nesting/ Migrant	DL	T
Black-capped Vireo	*Vireo atricapillus*	0	3	0	Oak-juniper woodlands	Nesting/ Migrant	LE	E
Henslow's sparrow	*Ammodramus henslowii*	1	1	1	Wintering individuals found in weedy fields	Migrant		
Interior least tern	*Sterna antillarum athalassos*	0	3	0	Inland river sandbars for nesting and shallow water for foraging	Nesting/ Migrant	LE	E
Mountain plover	*Charadrius montanus*	1	1	1	Breeding, nesting on shortgrass prairie.	Resident		
Peregrine falcon	*Falco peregrinus anatum* (American)	0	2	0	Open county; cliffs	Nesting/ Migrant	DL	T
	Falco peregrinus tundrius (Artic)	0	1	0	Open county; cliffs	Nesting/ Migrant	DL	
Western burrowing owl	*Athene cunicularia hypugaea*	1	1	1	Open grasslands, especially prairie.	Resident		
Whooping crane	*Grus Americana*	0	3	0	Winters in coastal marshes	Migrant	LE	E
Wood stork	*Mycteria Americana*	0	2	0	Forages in prairie ponds, ditches and shallow standing water; formerly nested in Texas	Migrant		T
MAMMALS								
Cave myotis bat	*Myotis velifer*	1	1	1	Colonial and cave-dwelling, also roosting in rock crevices and other areas.	Resident		
Plains spotted skunk	*Spilogale putorius interrupta*	2	1	2	Open fields, and prairies.	Resident		

Table 4C.20-1 (Continued)

Common Name	Scientific Name	Impact Value	Multiplier Based on Status	Adjusted Impact	Summary of Habitat Preference	Potential Occurrence in County	Federal Status	State Status
Red wolf	*Canis rufus*	0	3	0	Extirpated, formerly known throughout the eastern half of Texas.	Historic	LE	E
FISH								
Blue sucker	*Cycleptus elongates*	1	2	2	Found in larger portions of major rivers in Texas.	Resident		T
Guadalupe bass	*Micropterus treculii*	1	1	1	Endemic to perennial streams of the Edwards Plateau region.	Resident		
Guadalupe darter	*Percina sciera apristis*	1	1	1	Guadalupe river basin, most common over gravel in large streams and rivers.	Resident		
MOLLUSKS								
Creeper	*Strophitus undulates*	1	1	1	Small to large streams.	Aquatic Resident		
False spike mussel	*Quincuncina mitchelli*	1	2	2	Substrates of cobble and mud.	Aquatic Resident		T
Golden Orb	*Quadrula aurea*	1	2	2	Sand and gravel areas in river basins. Endemic to the Guadalupe-San Antonio and Nueces-Frio systems.	Aquatic Resident		T
Palmetto pill snail	*Euchemotrema leai cheatumi*	0	1	0	Terrestrial snail known from only one location, moist palmetto woodlands of Palmetto State Park.	Resident		
Pistolgrip	*Tritogonia verrucosa*	1	1	1	Stable substrate in river basins.	Aquatic Resident		
Rock pocketbook	*Arcidens confragosus*	1	1	1	Substrates of medium to large rivers.	Aquatic Resident		
Texas fatmucket	*Lampsilis bracteata*	1	2	2	Found in streams and rivers on sand, mud, and gravel substrates within the Colorado and Guadalupe River basins. Intolerant of impoundment.	Aquatic Resident		T

Table 4C.20-1 (Concluded)

Common Name	Scientific Name	Impact Value	Multiplier Based on Status	Adjusted Impact	Summary of Habitat Preference	Potential Occurrence in County	Federal Status	State Status
Texas pimpleback	*Quadrula petrina*	1	2	2	An endemic species confined to the Colorado and Guadalupe drainages. Generally in areas with slow flow rates.	Aquatic Resident		T
REPTILES								
Cagle's map turtle	*Graptemys caglei*	1	2	2	Endemic to Guadalupe River System	Resident		T
Spot-tailed earless lizard	*Holbrookia lacerate*	1	1	1	Open prairie-brushland.	Resident		
Texas garter snake	*Thamnophis sirtalis annectens*	1	1	1	Generally found in wet or moist microhabitats.	Resident		
Texas horned lizard	*Phrynosoma cornutum*	2	2	4	Varied; sparsely vegetated uplands, grass, cactus, brush	Resident		T
Texas tortoise	*Gopherus berlandieri*	2	2	4	Open brush with grass understory; open grass and bare ground avoided	Resident		T
Timber/Canebrake rattlesnake	*Crotalus horridus*	1	2	2	Floodplains, riparian zones with dense ground cover	Resident		T
PLANTS								
Elmendorf's onion	*Allium elmendorfii*	1	1	1	Endemic to grassland openings in woodlands	Resident		
Sandhill woollywhite	*Hymenopapus carrizoanus*	2	1	2	Endemic, found in disturbed or open areas in grasslands and post oak woodlands.	Resident		
Shinner's sunflower	*Helianthus occidentalis* ssp.	2	1	2	Found on prairies on the Coastal Plain.	Resident		

Source: TPWD, Annotated County List of Rare Species, Gonzales County, revised May 4, 2009 and Caldwell County revised May 7, 2009.

DL Delisted
PDL Proposed for Delisting
LE Federally listed endangered
LT Federally listed threatened
Blank Not Federal or State Listed but considered a species of concern
E State Endangered
T State Threatened

brush areas with a grass understory. Elmendorf's onion and sandhill woollywhite are found in openings or grasslands areas within woodlands.

Several occurrences of rare, threatened or endangered species have been documented in the TPWD Natural Diversity Database system files within the vicinity of the proposed well fields and the water delivery pipeline. These include Cagle's map turtle, Guadalupe bass and hill country wild-mercury within three miles of the water delivery point. A colonial waterbird rookery is located along the proposed water pipeline and Shinner's sunflower and sandhill woolywhite have been documented near the proposed well field areas. With the exception of Cagle's map turtle, which is state threatened, the other species are considered to be rare, but are not protected by USFWS or TPWD.

Concerns associated with the development of the new well field areas involve water levels in the aquifer, and baseflow of the surrounding streams and wetlands. The possibility exists that water levels in the aquifer, affected by the wells, could decrease before stabilizing, thus affecting habitat within the area. Waters of the U.S. crossings within the proposed project area consists of Plum Creek which would be crossed by the proposed water transmission pipeline. Coordination with the U.S. Army Corps of Engineers regarding impacts to waters of the U.S. (including wetlands) should be initiated for impacts to Plum Creek. The project would likely be covered under Nationwide Permit 12 for utility lines provided the activity does not result in the loss of greater than ½ acre of waters of the U.S.

A review of GIS files maintained by the Texas Historical Commission indicated that there are four cemeteries and one historical marker along or immediately adjacent to the proposed water pipeline. No National Register Properties were identified along the pipeline or within the proposed well field area. No cemeteries, historical markers or National Register Properties appear to be within the proposed well field area.

Cultural resource occurrences may be present in the project area. An archeological survey of the project area should be undertaken to determine impacts to cultural resources. Cultural resources protection on public lands in Texas is afforded by the Antiquities Code of Texas (Title 9, Chapter 191, Texas Natural Resource Code of 1977), the National Historic Preservation Act (Pl96-515), and the Archeological and Historic Preservation Act (PL93-291). Coordination with the Texas Historical Commission will need to be initiated prior to project construction. If the project will affect waters of the United States or wetlands, the project sponsor will also be required to coordinate with the U.S. Army Corps of Engineers regarding any impacts to cultural resources.

4C.20.4 Engineering and Costing

According to an engineering consultant for Hays/Caldwell PUA, the project is planned to be developed in two phases. Phases I is to have a peak capacity of 21.4 MGD and an annual delivery of 12,000 acft/yr; and, Phase II is to have a peak capacity of 41.1 MGD and an annual delivery of 23,000 acft/yr. They are to come online in about 2018 and 2032, respectively. Together, the project is to produce about 35,000 acft/yr and have a peaking capacity of about 62.5 MGD. The project is designed for a normal demand operation where the maximum daily demand is about two times the annual average demand. The preliminary design is to construct a transmission pipeline at buildout capacity of 62.5 MGD during Phase I. Phase I requires 17 wells, and Phase II requires 32 wells, which includes a ten percent contingency. The water treatment plant built in Phase I will be expanded to accommodate the Phase II project. According to current GCUWCD rules, the project would require groundwater leases of about 35,000 acres and well spacing of 6,000 ft from existing registered and authorized Carrizo wells.

When completed, the project would consist of about 49 high capacity wells, 35.6 miles of 60-inch pipeline, 66 miles of 12- to 48-inch collector pipeline, one pump station, one booster station, and one water treatment plant for iron and manganese removal. The approximate locations of these planned facilities are shown in Figure 4C.20-2.

Cost estimates using regional planning procedures. Well depths are estimated to range from 750 ft in the southwestern part of the well field to 1,900 ft in the northeast part. Using GCUWCD rules as a guide, well yield will be 1,000 gpm, which requires a well spacing of 6,000 ft from project and existing wells. It should be noted that the preliminary, or conceptual, well field layout considered the spacing requirements among the project wells, but did not consider existing registered Carrizo wells. As shown in Figure 4C.20-2, the Phase I well field is in Caldwell County; and, Phase II well field is in Gonzales County. The water treatment plant and pump station is on the northwest side of the well fields. A booster station is planned in the vicinity of US Hwy 281. Other estimated project costs include groundwater leases of $120/acft and GCUWCD export fees of $8.71/acft. The costs are estimated for the annual costs, including debt service for a 20-year loan at 6 percent interest and operation and maintenance costs, including power.

Based on this preliminary design and assumptions, Phase I is estimated to have a unit cost of $1,810/acft, or $5.55 per 1,000 gallons (Table 4C.20-2). As noted earlier, this cost includes the cost of the pipeline capacity for Phase II. Phase II unit costs are estimated to be about $950/acft or $2.91 per 1,000 gallons (Table 4C.20-2). At buildout, the unit cost will be about $1,245/acft and $3.82 per 1,000 gallons (Table 4C.20-2).

As shown in Table 4C.20-3, the project costs were assigned to WUGs and WWPs based on the percent of the total project yield that they were expected to utilize.

4C.20.5 Implementation Issues

Implementation of the Regional Carrizo to Bexar County water management strategy could involve conflicts with other water supply plans as they will be competing for limited groundwater supplies within the GCUWCD. Because the district's permitting process is independent of the regional planning process, potentially competing groundwater management strategies are not prioritized.

This project considers existing rules of the GCUWCD with regard to well yield, spacing, and acreage. An assessment has not been conducted of the maximum drawdown criteria, which will be performed in the cumulative effects section of the plan.

Part or all of the water needed by this Water Management Strategy (WMS) is anticipated to be supplied from locations within the jurisdiction of a groundwater conservation district (District) and may exceed the amount of available water identified in the District's approved management plan, or may for other reasons not be permitted by the District.

The amount of water needed by this WMS that exceeds the available water in the District's management plan, or for other reasons is not permitted by the District, cannot be implemented as part of this WMS unless and until all necessary permits are received from the District.

The amount of water needed by this WMS that exceeds the available water in the District's management plan, or for other reasons is not permitted by the District, introduces an added element of uncertainty to reliance upon this WMS and, therefore, additional management supplies may be needed for this WMS.

Table 4C.20-2.
Cost Estimate Summary
Water Supply Project Option
2011 Region L Hays-Caldwell Project
September 2008 Prices

Item	Estimated Costs for Facilities		
	Phase I	Phase II	Total
Capital Costs			
Transmission Pipeline (60 in dia., 35.6 miles)	$88,846,000	$0	$88,846,000
Transmission Pump Stations	$10,500,000	$19,882,000	$30,382,000
Well Fields	$25,716,000	$62,122,000	$87,838,000
Water Treatment Plant (Iron and Manganse Removal, Total 62.5 MGD)	$5,183,000	$5,183,000	$10,366,000
Integration	$4,286,000	$8,214,000	$12,500,000
Total Capital Cost	**$134,531,000**	**$95,401,000**	**$229,932,000**
Engineering, Legal Costs and Contingencies	$42,643,000	$33,391,000	$76,034,000
Environmental & Archaeology Studies and Mitigation	$1,543,000	$1,242,000	$2,785,000
Land Acquisition and Surveying (220 acres)	$1,753,000	$357,000	$2,110,000
Interest During Construction (1 years)	$7,219,000	$5,216,000	$12,435,000
Total Project Cost	**$187,689,000**	**$135,607,000**	**$323,296,000**
Annual Costs			
Debt Service (6 percent, 20 years)	$16,364,000	$11,823,000	$28,187,000
Operation and Maintenance			
Intake, Pipeline, Pump Station	$1,427,000	$1,160,000	$2,587,000
Water Treatment Plant	$1,598,000	$2,807,000	$4,405,000
Pumping Energy Costs (43,141,000 kW-hr at $0.09 per kW-hr)	$786,000	$3,097,000	$3,883,000
Purchase of Water ($120.00 per acft)	$1,440,000	$2,760,000	$4,200,000
GW District Fees ($8.71 per acft)	$104,000	$200,000	$304,000
Total Annual Cost	**$21,719,000**	**$21,847,000**	**$43,566,000**
Available Project Yield (acft/yr)	12,000	23,000	35,000
Annual Cost of Water ($ per acft)	$1,810	$950	$1,245
Annual Cost of Water ($ per 1,000 gallons)	$5.55	$2.91	$3.82

Table 4C.20-3.
Project Cost Assigned to WUGs/WWPs
2011 Region L Hays-Caldwell Project

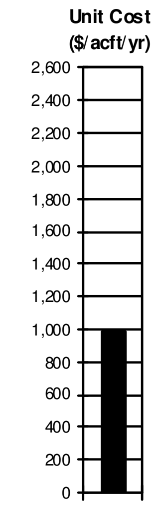
WUG/WWP	Year 2060 Supply from Project (acft/yr)	% of Total Supply	Project Costs Assigned to WUG/WWP
Canyon Regional Water Authority	10,260	29.3%	$ 94,758,058
Goforth WSC	1,639	4.7%	$ 15,139,490
City of Kyle	9,335	26.7%	$ 86,417,021
Mountain City	150	0.4%	$ 1,385,554
City of San Marcos	11,910	34.0%	$ 110,017,629
City of Buda	N/D	N/D	N/D

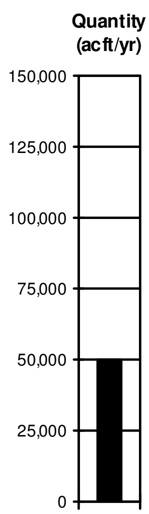
N/D - City of Buda is not located within Region L. The remaining project capacity could be used to meet a portion of Buda's need or other needs within Region L or Region K. The full project cost have not been assigned to WUGs and/or WWPs.

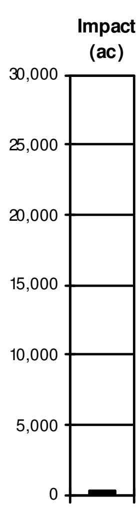
The development of groundwater in the Carrizo-Wilcox Aquifer in the South Texas Water Planning Region must address several issues. Major issues include:

- GCUWCD permits:
  - Analyses of pumping impacts on groundwater levels,
  - Mitigation of impacts on existing well owners,
  - Drought and Water Conservation Plans, and
  - Needs assessment.
- Impacts on:
  - Endangered and threatened species,
  - Water levels in the aquifer, including dewatering of the current artesian part of the aquifer
  - Baseflow in streams, and
  - Wetlands.
- Competition with others in the area for groundwater.
- Regulations by the GCUWCD, including periodic renewal of permits and potential pumping reductions.
- Obtain TCEQ permits.

2011 South Central Texas Regional Water Plan
Water Management Strategy Summary Sheet







Name: GBRA Simsboro Project

Description: The GBRA Simsboro Project consists of the development of a well field in Bastrop County and another one in Lee County. The wells would withdraw water from the Simsboro member of the Wilcox Group, which is part of the Carrizo-Wilcox Aquifer. This project would provide supplemental water supplies directly to customers in Hays and Caldwell Counties in the near-term and indirectly to customers in Comal, Guadalupe, and Kendall by replacement or reduction of Canyon Reservoir supplies currently delivered to the San Marcos WTP in the long-term.

Major project components include: Phase I 30,000 acft/yr well field in Bastrop County, Phase II 20,000 acft/yr well field in Lee County, ground storage and pump stations at the well fields, major transmission pipeline, water treatment near San Marcos, and integration into the current water supply system. This pipeline would be about 52 miles long and 60 inches in diameter.

***Decade Needed*:** 2010 – 2030

Cost, Quantity of Water, and Land Impacted

Unit Cost of Water:	**$982**	**$/acft/yr**	**Treated Water Delivered**
Quantity of Water:	**50,000**	**acft/yr**	**Reliability = Firm**
Land Impacted:	**200**	**acres**	

Additional Considerations per Regional Water Planning Guidelines

Environmental Factors:

The Houston toad is listed as endangered by TPWD and U.S. Fish and Wildlife Service. The Colorado River and Blanco River, crossed by the proposed pipeline route, have both been identified by Texas Parks and Wildlife Department (TPWD) as Ecologically Significant River and Stream Segments.

Impacts on Water Resources:

Groundwater levels will decline and could affect the baseflow of surrounding streams and wetlands, thereby impacting wildlife habitat.

Impacts on Agricultural & Natural Resources:

Minimal impacts anticipated.

Other Relevant Factors per SCTRWPG:

Part or all of the water needed by this Water Management Strategy (WMS) is anticipated to be supplied from locations within the jurisdiction of a groundwater conservation district (District) and may exceed the amount of available water identified in the District's approved management plan, or may for other reasons not be permitted by the District. The amount of water needed by this WMS that exceeds the available water in the District's management plan, or for other reasons is not permitted by the District, cannot be implemented as part of this WMS unless and until all necessary permits are received from the District. The amount of water needed by this WMS that exceeds the available water in the District's management plan, or for other reasons is not permitted by the District, introduces an added element of uncertainty to reliance upon this WMS and, therefore, additional management supplies may be needed for this WMS.

The well fields for this WMS are in the Lower Colorado (K) and Brazos G Water Planning Regions, which necessitates coordination with these regions.

Comparison of Strategies to Meet Needs:

Cost estimates indicate that this strategy may be more economical than other potentially feasible WMS.

Interbasin Transfer Issues:

None.

Third-Party Impacts of Voluntary Transfers:

None.

Regional Efficiency:

Location of delivery point allows for distribution to GBRA customers through existing facilities.

Water Quality Considerations:

The water quality of the Simsboro Aquifer is suitable for use as a water supply, except for elevated concentrations of iron and manganese in many areas. For this strategy, iron and manganese will be removed from raw groundwater at a water treatment facility.

4C.21 GBRA Simsboro Project

4C.21.1 Description of Water Management Strategy

The Guadalupe-Blanco River Authority (GBRA) is considering a Simsboro Project to provide supplemental water supplies directly to customers in Hays and Caldwell Counties in the near-term and indirectly to customers in Comal, Guadalupe, and Kendall Counties by replacement or reduction of Canyon Reservoir supplies currently delivered to the San Marcos WTP in the long-term. The GBRA Simsboro Project consists of the development of a well field in Bastrop County and another one in Lee County, transporting the water to a water treatment plant near San Marcos, treating the water, and integrating the water into existing water distribution systems. The wells would withdraw water from the Simsboro member of the Wilcox Group, which is part of the Carrizo-Wilcox Aquifer.

The GBRA Simsboro Project under consideration is expected to be implemented in two phases, with Phase I delivering 30,000 acft/yr of water from Bastrop County beginning in 2012; and, Phase II delivering 20,000 acft/yr of water from Lee County, possibly also starting in 2012. GBRA is considering a range of staging options that might not be completed until 2027. Preliminary plans are to have the system designed for a peaking factor of 1.25 times the annual average yield. Thus, the system capacity would be 33.5 MGD for Phase I and 55.8 MGD for Phase II.

The preliminary design concept is shown on Figure 4C.21-1. Major project components include: Phase I well field in Bastrop County, Phase II well field in Lee County, ground storage and pump stations at the well fields, major transmission pipeline, one booster station, water storage and water treatment near San Marcos, and integration into the current water supply systems. High capacity Simsboro wells in this area of the Carrizo-Wilcox Aquifer are expected to yield about 2,500 gallons per minute (gpm) and have a depth ranging from 1,300 to 2,100 ft. The delivery of raw water from the water supply wells and through the collector pipelines to the storage tanks at the terminal point of the well field would utilize well pumps. The main transmission pipeline emphasizes following existing electric transmission easements to avoid congested areas along Texas Hwy 21. This pipeline would be about 52 mile long and 60 inches in diameter. The booster station would be located near the town of Cedar Creek.

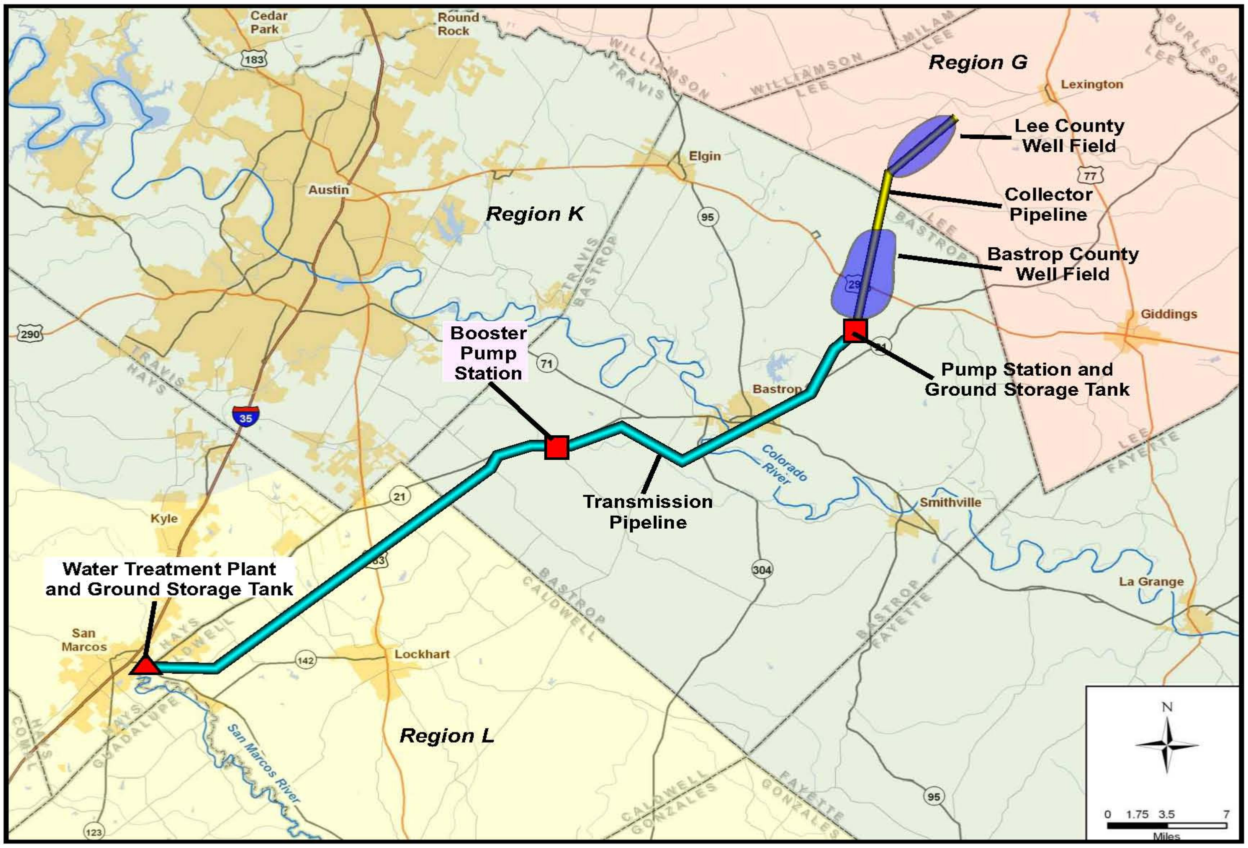


Figure 4C.21-1 Location of the GBRA Simsboro Project

4C.21.2 Groundwater Availability

The Carrizo-Wilcox Aquifer System in Central Texas is capable of producing large quantities of fresh water from the Simsboro and Carrizo Formations.[1,2] The aquifer is primarily used for domestic, livestock, public supplies, and some industrial purposes (mining and power plants). The largest municipal pumpage to date from the Simsboro is for public supply in the Bryan-College Station area, which began over 50 years ago and is associated with wells in Brazos County. Other significant pumping is in Milam and Robertson Counties for mining and steam electric purposes and is also from the Simsboro. In the vicinity of the planned well fields, most all of the water use is for rural domestic and livestock uses. Much of this water is like that pumped from the shallower Carrizo Aquifer, instead of the relatively deep Simsboro Aquifer.

[1] Thorkildsen, D. and Price, R. D., 1991, “Groundwater Resources of the Carrizo-Wilcox Aquifer in the Central Texas Region,” Texas Water Development Board (TWDB) Report 332.
[2] Kelley, V.A., and others, 2004, “Groundwater Availability Models for the Queen City and Sparta Aquifers”, prepared for Texas Water Development Board by Intera, Inc, The University of Texas Bureau of Economic Geology and R.J. Brandes Co.

Overall, the water quality of the Carrizo-Wilcox Aquifer is suitable for use as a water supply, except for elevated concentrations of iron and manganese in many areas.

The Simsboro Aquifer in the vicinity of the planned well field is 5-10 miles downdip of the outcrop and a short distance updip of the major Mexia-Talco Fault Zone. Overlying formations include the Calvert Bluff (a member of the Wilcox Group) and the Carrizo Sands.

Groundwater availability in the Bastrop and Lee Counties is pending adoption of the Desired Future Conditions (DFC) by representatives of GMA-12 and a determination of the Managed Available Groundwater (MAG) by the Texas Water Development Board.

4C.21.3 Environmental Issues

The GBRA Simsboro Project includes Simsboro well fields located in northeast Bastrop County and southwest Lee County, ground storage and a pump station at each well field, a booster station, the main transmission pipeline, and ground storage and a water treatment plant near San Marcos. The proposed pipeline route crosses the Colorado River near Bastrop, West Yegua, Cedar, and Plum Creeks, and the Blanco River near San Marcos. Both of the rivers have been identified by the Texas Parks and Wildlife Department as Ecologically Significant River and Stream Segments.

The proposed project is located in Lee, Bastrop, Caldwell, and Hays Counties, crossing the Texas Blackland Prairies and East Central Texas Plains ecoregions[3]. Eastern portions of the project lie within the Post Oak Savannah vegetational area of Texas, with the middle of the project located in the Blackland Prairie and the most western portion in the Edwards Plateau.[4] The entire project area is found within in the Texan biotic province.[5] Vegetation types within the project area include primarily crops, post oak (*Quercus stellata*) woods and forest, native and introduced grasses, and wetland areas located principally near stream and river crossings. Potential downstream impacts would include modification of the streamflow regime below the well field and a negligible reduction of groundwater flux into the Colorado River.

[3] Griffith, G.E., Bryce, S.A., Omernik, J.M., Comstock, J.A., Rogers, A.C., Harrison, B., Hatch, S.L., and Bezanson, D., 2004, Ecoregions of Texas (color poster with map, descriptive text, and photographs): Reston, Virginia, U.S. Geological Survey (map scale 1:2,500,000)..
[4] Gould, F.W., "The Grasses of Texas," Texas A&M University Press, Texas Agricultural Experiment Station, College Station, Texas, 1962.
[5] Blair, W.F., "The Biotic Provinces of Texas, "Tex. J. Sci. 2:93-117, 1950.

Table 4C.21-1 lists the 29 state listed endangered, threatened or proposed to be listed as threatened species, and the 13 federally listed endangered or threatened species that may occur in Bastrop, Hays, Guadalupe, Caldwell, or Lee Counties, according to the county lists of rare species published by Texas Parks and Wildlife Department (TPWD) online in the "Annotated County Lists of Rare Species." Inclusion in Table 4C.21-1 does not mean that a species will occur within the project area, but only acknowledges the potential for occurrence in the project area counties.

In addition to the county lists, data received from the Natural Diversity Database (NDD) was reviewed for known occurrences of listed species within or near the project area. This database documents occurrences of the Houston toad (*Bufo houstonensis*), Texas garter snake (*Thamnophis sirtalis annectens*), Timber/canebrake rattlesnake (*Crotalis horridus*), and Elliot's short-tailed shrew (*Blarina hylophaga*) within central Bastrop County and the project area. In addition, the Guadalupe bass (*Micropterus treculi*) has been documented in the Blanco River near the western terminus of the pipeline. All these species excluding the Houston Toad are considered species of concern with no regulatory status. The Houston toad is listed by both USFWS and TPWD as endangered.

The Houston toad is a terrestrial amphibian which is associated with the Post Oak Savannah vegetational area of Texas. This species prefers deep sandy soils greater than forty inches deep for burrowing. They require still or slow-flowing bodies of water that persist for at least a month for breeding purposes. Habitat loss and alteration are thought to be the main reason for this species decline. Existing regulations may require that habitat studies and surveys for protected species be conducted at the proposed well field sites, construction activity sites, and along pipeline routes. Monitoring saturated sands of the Carrizo for effects by pumping groundwater may be required to protect the Houston Toad habitat. When potential protected species habitat or other significant resources cannot be avoided, additional studies would be required to evaluate habitat use, permit requirements, and other mitigative measures.

The Timber Rattlesnake is generally found on floodplains, in upland pine and deciduous woodlands and within riparian zones. The Texas garter snake lives primarily in wet or moist habitats. Elliot's short-tailed shrew frequents sandy and grassy areas near pine trees. Although habitat for these species exists within the project area, the presence or absence of potential habitat does not confirm the presence or absence of any species. No species specific surveys were conducted in the project area for this report.

Table 4C.21-1.
Endangered, Threatened, and Species of Concern in Bastrop, Caldwell, Guadalupe, Hays, and Lee Counties

Common Name	Scientific Name	Impact Value	Multiplier Based on Status	Adjusted Impact	Summary of Habitat Preference	Listing Entity		Potential Occurrence in County
						USFWS	TPWD	
A cave obligate crustacean	*Monodella texana*	0	1	0	Subaquatic, underground freshwater aquifers			Resident
A mayfly	*Campsurus decoloratus*	0	1	0	Found in Texas and Mexico. Possibly in clay substrates.			Resident
American Peregrine Falcon	*Falco peregrinus anatum*	0	2	0	Resident and local breeder in West Texas. Migrant across the state.	DL	T	Possible Migrant
Arctic Peregrine Falcon	*Falco peregrinus tundrius*	0	2	0	Migrant, winters along the coast.	DL	T	Possible Migrant
Balcones Cave amphipod	*Stygobromus balconies*	0	1	0	Subaquatic, subterranean obligate amphipod.			Resident
Bald Eagle	*Haliaeetus leucocephalus*	0	2	0	Primarily found near large rivers and lakes; nests in tall trees or cliffs near water.	DL	T	Possible Migrant
Bandit cave spider	*Cicurina bandida*	0	1	0	Small, subterrestrial obligate.			Resident
Big red sage	*Salvia penstemonoides*	1	1	1	Endemic; moist to seasonally wet clay or silt soils in creek beds.			Resident
Black-capped Vireo	*Vireo atricapillus*	0	3	0	Oak-juniper woodlands,	LE	E	Resident
Blanco blind salamander	*Eurycea robusta*	0	2	0	Found in water filled caves within the Balcones aquifer.		T	Resident
Blanco River springs salamander	*Eurycea pterophila*	0	1	0	Springs and caves in the Blanco River drainage.			Resident
Blue Sucker	*Cycleptus elongates*	1	2	2	Found in major rivers in Texas.		T	Resident
Branched gay-feather	*Liatris cymosa*	1	1	1	Endemic in barren grassland openings in post oak woodlands.			Resident
Cagle's map turtle	*Graptemys caglei*	1	2	2	Endemic to Guadalupe River System. Found within 30 feet of waters' edge.		T	Resident

Table 4C.21-1 (Continued)

Common Name	Scientific Name	Impact Value	Multiplier Based on Status	Adjusted Impact	Summary of Habitat Preference	Listing Entity		Potential Occurrence in County
						USFWS	TPWD	
Canyon mock-orange	*Philadelphus ernestii*	1	1	1	Endemic, usually found growing on outcrops of limestone on mesic canyons.			Resident
Cave Myotis Bat	*Myotis velifer*	0	1	0	Roosts colonially in caves, rock crevices			Resident
Comal Springs dryopid beetle	*Stygoparnus comalensis*	0	3	0	Generally found clinging to objects in streams.	LE		Resident
Comal Springs riffle beetle	*Heterelmis comalensis*	0	3	0	Found in Comal and San Marcos Springs	LE		Resident
Creeper (squawfoot)	*Strophitus undulates*	1	1	1	Small to large streams			Resident
Edwards Aquifer diving beetle	*Haideoporus texanus*	0	1	0	Known from an artesian well in Hays County.			Resident
Elliot's short-tailed shrew	*Blarina hylophaga hylophaga*	2	1	2	Found in sandy areas in live oak mottes and grassy areas with Loblolly pine.			Resident
Elmendorf's onion	*Allium elmendorfii*	1	1	1	Endemic, in deep sands			Resident
Ezell's cave amphipod	*Stygobromus flagellatus*	0	1	0	Known only from artesian wells.			Resident
False spike mussel	*Quincuncina mitchelli*	1	2	2	Known only from central Texas and the Rio Grande drainage.		T	Resident
Flint's net-spinning caddisfly	*Cheumatopsyche flinti*	0	1	0	Known from springs.			Resident
Fountain darter	*Etheostoma fonticola*	0	3	0	Fish known only from the San Marcos and Comal Rivers.	LE	E	Resident
Golden orb	*Quadrula aurea*	0	2	0	Endemic to the Guadalupe-San Antonio and Nueces-Frio river systems.		T	Resident
Golden-cheeked Warbler	*Dendroica chrysoparia*	0	3	0	Juniper-oak woodlands.	LE	E	Resident
Guadalupe Bass	*Micropterus treculi*	1	1	1	Endemic to perennial streams of the Edwards Plateau region.			Resident

Table 4C.21-1 (Continued)

Common Name	Scientific Name	Impact Value	Multiplier Based on Status	Adjusted Impact	Summary of Habitat Preference	Listing Entity		Potential Occurrence in County
						USFWS	TPWD	
Guadalupe Darter	*Percina sciera apristis*	1	1	1	Guadalupe River Basin. Usually found over gravel or gravel and sand raceways of larger streams and rivers.			Resident
Henslow's Sparrow	*Ammodramus henslowii*	0	1	0	Wintering individuals found in weedy fields and cut-over areas.			Migrant
Hill Country wild-mercury	*Argythamnia aphoroides*	1	1	1	Endemic, found on shallow clays over limestone on rolling uplands.			Resident
Houston Toad	*Bufo houstonensis*	2	3	6	Endemic: found in sandy substrates in pools of water.	LE	E	Resident
Interior least tern	*Sterna antillarum athalassos*	0	3	0	Nests along sand and gravel bars in braided streams	LE	E	Migrant
Ironcolor shiner	*Notropis chalybaeus*	0	1	0	Found in Big Cypress Bayou and Sabine river basins.			Resident
Leonora's dancer damselfly	*Argia leonorae*	1	1	1	Known from small streams and seepages in south central and western Texas.			Resident
Mountain Plover	*Charadrius montanus*	0	1	0	Non-breeding, shortgrass plains and fields			Nesting/Migrant
Navasota ladies'-tresses	*Spiranthes parksii*	1	3	3	Endemic, found in openings in post oak woodlands in sandy loams along drainages or streams.	LE	*E*	Resident
Park's jointweed	*Polygonella parksii*	1	1	1	Endemic; deep loose sands of Carrizo and similar Eocene formations.			Resident
Peregrine Falcon	*Falco peregrinus*	0	2	0	Migrates across the state from northern breeding areas.	DL	T	Possible Migrant
Pistolgrip	*Tritogonia verrucosa*	1	1	1	Aquatic, stable substrate. Red through San Antonio river basins.			Resident
Plains Spotted Skunk	*Spilogale putorius interrupta*	1	1	1	Prefers wooded, brushy areas.			Resident
Rawson's metalmark	*Calephelis rawsoni*	1	1	1	Moist areas in shaded limestone outcrops			Resident

Table 4C.21-1 (Continued)

Common Name	Scientific Name	Impact Value	Multiplier Based on Status	Adjusted Impact	Summary of Habitat Preference	Listing Entity USFWS	Listing Entity TPWD	Potential Occurrence in County
Red Wolf	*Canis rufus*	0	3	0	Extirpated.	LE	E	Historic Resident
Rock pocketbook	*Arcidens confragosus*	1	1	1	Mud and sand, Red through Guadalupe River basins.			Resident
San Marcos gambusia	*Gambusia georgei*	0	3	0	Extinct, endemic known from the upper San Marcos River.	LE	E	Extinct Resident
San Marcos saddle-case	*Protoptila arca*	0	1	0	Known from an artesian well in Hays County. Locally very abundant.			Resident
San Marcos salamander	*Eurycea nana*	0	1	0	Found in the headwaters of the San Marcos River downstream to ca. ½ mile past IH35.			Resident
Sandhill woolywhite	*Hymenopappus carrizoanus*	1	1	1	Endemic; open areas in deep sands derived from Carrizo and similar Eocene formations.			Resident
Shinners's sunflower	*Helianthus occidentalis ssp.*	1	1	1	Found primarily in prairies on the Coastal Plain, with disjunct populations in the Pineywoods and South Texas Brush Country.			Resident
Smooth pimpleback	*Quadrula houstonensis*	1	2	2	Endemic restricted to the Colorado and Brazos River drainages.		T	Resident
Spot-tailed earless lizard	*Holbrookia lacerata*	1	1	1	Moderately open prairie-brushland.			Resident
Texas austrotinodes caddisfly	*Autrotinodes texensis*	1	1	1	Endemic to Karst springs and spring runs of the Edwards Plateau region.			Resident
Texas blind salamander	*Eurycea rathbuni*	0	3	0	Found in water filled caves along the San Marcos Spring Fault.	LE	E	Resident
Texas cave shrimp	*Palaemonetes antrorum*	0	1	0	Subterranean species found in sluggish streams and pools.			Resident
Texas fatmucket	*Lampsilis bracteata*	1	2	2	Historically occurring in the Colorado and Guadalupe river basins in Central Texas.		T	Resident
Texas fawnsfoot	*Truncilla macrodon*	1	2	2	Historically occurred in the Colorado and Brazos drainages of Central Texas.		T	Resident
Texas garter snake	*Thamnophis sirtalis annectens*	2	1	2	Wet or moist microhabitats			Resident
Texas horned lizard	*Phrynosoma cornutum*	2	2	4	Varied, sparsely vegetated uplands.		T	Resident

Table 4C.21-1 (Concluded)

Common Name	Scientific Name	Impact Value	Multiplier Based on Status	Adjusted Impact	Summary of Habitat Preference	Listing Entity		Potential Occurrence in County
						USFWS	TPWD	
Texas pimpleback	*Quadrula petrina*	1	2	2	Endemic species confined to the Colorado and Guadalupe drainages.		T	Resident
Texas Tortoise	*Gopherus berlandieri*	1	2	2	Open brush w/ grass understory.		T	Resident
Texas troglobitic water slater	*Lirceolus smithii*	0	1	0	Subaquatic, subterranean obligate found in aquifers.			Resident
Texas wild-rice	*Zizania texana*	0	3	0	Endemic, found in spring-fed river.	LE	E	Resident
Timber/Canebrake Rattlesnake	*Crotalus horridus*	2	2	4	Floodplains, upland pine, deciduous woodlands, riparian zones.		T	Resident
Warnock's coral-root	*Hexalectris warnockii*	1	1	1	Found in leaf litter and humus I oak-juniper woodlands.			Resident
Western Burrowing Owl	*Athene cunicularia hypugaea*	0	1	0	Open grasslands, especially prairie, plains and savanna			Resident
Whooping Crane	*Grus americana*	0	3	0	Potential migrant	LE	E	Potential Migrant
Wood Stork	*Mycteria americana*	0	2	0	Forages in prairie ponds, ditches, and shallow standing water formerly nested in TX.		T	Migrant
Zone-tailed Hawk	*Buteo albonotatus*	0	2	0	Arid open country, often near watercourses.		T	Resident

Source: TPWD, Annotated County List of Rare Species, Bastrop County 5/7/2009, Caldwell County 5/7/2009, Hays County 7/16/09, Guadalupe County 5/7/09, Lee County 5/4/09.

LE/LT=Federally Listed Endangered/Threatened
DL, PDL=Federally Delisted/Proposed for Delisting
T/SA=Listed as Threatened by Similarity of Appearance
E, T=State Listed Endangered/Threatened
Blank = Rare, but no regulatory listing status

Habitat studies and surveys for protected species and cultural resources may need to be conducted at the proposed well sites and along any pipeline routes. Potential wetland impacts are expected to primarily include pipeline stream and river crossings, which can be minimized by right-of-way selection and appropriate construction methods, including erosion controls and revegetation procedures. Compensation for net losses of wetlands would be required where impacts are unavoidable.

A review of the Texas Historical Commission Texas Historic Sites Atlas database indicated that there are a number of historical markers, National Register Properties, and cemeteries listed near the proposed pipeline route and well field areas. Avoidance of these areas should be possible by careful selection of the pipeline route and well field areas.

4C.21.4 Engineering and Costing

The GBRA Simsboro Project is planned to be developed in two phases. Phase I is to have a peak capacity of 33.5 MGD and an annual delivery of 30,000 acft/yr; and, Phase II is to have a peak capacity of 22.3 MGD and an annual delivery of 20,000 acft/yr. They are to come online in 2012 or later. Together, the project is to produce about 50,000 acft/yr and have a peak capacity of about 55.8 MGD. The project is designed for a peak capacity of 1.25 times the annual delivery rate. The preliminary design is to construct a transmission pipeline at buildout capacity of 55.8 MGD during Phase I. Phase I requires 11 wells, and Phase II requires 8 wells, which includes at least a ten percent contingency. The pump station, booster station, and water treatment will be designed during Phase I to accommodate expansion for Phase II. Groundwater royalties are expected to be paid to land owners for access to their groundwater rights.

At completion, the GBRA Simsboro Project would consist of about 11 high capacity Simsboro wells in Bastrop County (Phase I) and 8 in Lee County (Phase II), 52.5 miles of 60-inch pipeline, 13.2 miles of 14- to 54-inch diameter collector pipeline, one pump station, one booster station, one water treatment plant for iron and manganese removal near San Marcos, and associated ground storage tanks. Well depths are estimated to range from 1,300 ft in the Bastrop County well field to 2,100 ft in the Lee County well field. The well field layout spaces the wells at least 6,000 ft apart, or more. A booster station and ground storage are planned to be constructed near the town of Cedar Creek. The approximate locations of these facilities are shown in Figure 4C.21-1.

Cost estimates have been developed using standard regional planning procedures (Appendix A). Other than the operation of project facilities, annual costs includes groundwater royalties at $71.39/acft and Lost Pine Groundwater Conservation District (Lost Pines) production and export fees of $55.39/acft. Annual costs include debt service for a 20-year loan at 6 percent interest and operation and maintenance costs, including power.

Based on this preliminary conceptual design and technical assumptions, the Phase I project is estimated to have a unit cost of $1,215/acft, or $3.73 per 1,000 gallons (Table 4C.21-2). As noted earlier, this cost includes debt service and the cost of the pipeline capacity for Phase II. Phase II unit costs are estimated to be about $633/acft or $1.94 per 1,000 gallons. As shown in Table 4C.21-2, the unit cost for both phases will be about $982/acft and $3.01 per 1,000 gallons.

4C.21.5 Implementation Issues

The GBRA Simsboro Project could be reliant on the same groundwater sources as water management strategies that are under consideration in Brazos G and Lower Colorado River (Region K) Planning Regions. If the planned withdrawals associated with such water management strategies in Bastrop County and/or Lee County exceed regional planning estimates of groundwater available from the Simsboro Aquifer, then apparent over-allocation of a source would be noted by the TWDB. Region L believes that an apparent over-allocation of this nature does not constitute a conflict because the groundwater conservation district (Lost Pines) responsible for management of the resource in accordance with its rules and under state law will issue production permits only up to the amounts determined to be available, even if the production envisioned by one or more recommended water management strategies is substantially greater than the amounts determined to be available.

Table 4C.21-2.
Cost Estimate Summary
GBRA Simsboro Project
September 2008 Prices

Item	Estimated Costs for Facilities		
	Phase I	Phase II	Total
Capital Costs			
Pump Station and Ground Storage	$6,557,000	$3,878,000	$10,435,000
Transmission Pipeline (60-inch dia, 52.5 miles)	$136,855,000	$0	$136,855,000
Booster Pump Station and Ground Storage	$7,780,000	$4,079,000	$11,859,000
Well Fields: (Wells: 19, Yield: 2,500 gpm, Depth: 1,300-2,100 ft)	$31,959,000	$32,152,000	$64,111,000
Water Treatment (Disinfection and Iron and Manganese Removal)	$7,109,000	$3,642,000	$10,751,000
Total Capital Cost	**$190,260,000**	**$43,751,000**	**$234,011,000**
Engineering, Legal Costs and Contingencies	$62,092,000	$16,875,000	$78,967,000
Environmental & Archaeology Studies and Mitigation	$1,704,000	$424,000	$2,128,000
Land Acquisition and Surveying	$2,508,000	$16,000	$2,524,000
Interest During Construction (1 years)	$10,531,000	$2,621,000	$13,152,000
Total Project Cost	**$267,095,000**	**$63,687,000**	**$330,782,000**
Annual Costs			
Debt Service (6 percent, 20 years)	$23,870,000	$5,942,000	$29,812,000
Operation and Maintenance	$0	$0	$0
Pipeline, Pump Station, and Storage Tanks	$2,096,000	$557,000	$2,653,000
Water Treatment Plant	$2,340,000	$1,425,000	$3,765,000
Pumping Energy Costs ($0.09/kW-hr)	$4,339,000	$2,203,000	$6,542,000
Purchase of Water and Well Field Easements ($71.39/acft)	$2,141,000	$1,427,000	$3,568,000
Groundwater District Production and Export Fees ($55.39/acft)	$1,662,000	$1,108,000	$2,770,000
Total Annual Cost	**$36,448,000**	**$12,662,000**	**$49,110,000**
Available Project Yield (acft/yr)	30,000	20,000	50,000
Annual Cost of Water ($ per acft)	$1,215	$633	$982
Annual Cost of Water ($ per 1,000 gallons)	$3.73	$1.94	$3.01

An assessment has not been conducted to determine the maximum drawdown from this and other projects with a groundwater availability model. Because the DFC and the MAG have not been finalized, a comparison with these constraints cannot be made. In any case, the strategy cannot be implemented unless is groundwater production and export permits from Lost Pines are obtained. Because Lost Pines' permitting process is independent of the regional planning process, potentially competing regional water management strategies developed from the Simsboro Aquifer are not prioritized.

The development of the Simsboro Project must address several issues, including:

- Lost Pines permits:
  - Analyses of pumping impacts on groundwater levels;
  - Mitigation of impacts on existing well owners;
  - Drought and Water Conservation Plans; and
  - Needs assessments.
- Impact on:
  - Endangered and threatened wildlife species;
  - Water levels in the aquifer, including dewatering of the current artesian part of the aquifer;
  - Baseflow in streams; and
  - Wetlands.
- Securing groundwater royalties;
- Competition with others in the area for groundwater;
- Regulations by Lost Pines, including periodic renewal of permits and potential pumping cutbacks;
- Land will need to be acquired through either negotiations or condemnation; and
- Relocations for the pipeline and pump station facilities may include:
  a. County roads;
  b. Other utilities;
  c. Product transmission pipelines; and
  d. Power transmission lines.

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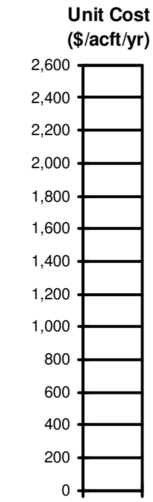
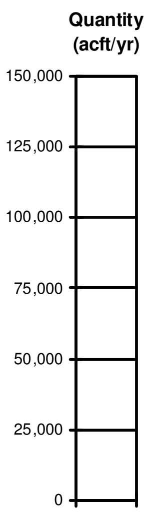
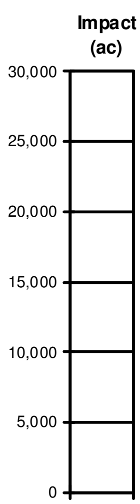
2011 South Central Texas Regional Water Plan
Water Management Strategy Summary Sheet







Name: Local Groundwater Supplies

Description: The Local Groundwater Supplies strategy is the continued utilization of local aquifers by municipal and Water Supply Corporations (WSC) water utilities to meet future shortages. These water utilities currently produce their supplies from the Carrizo-Wilcox, Trinity, Gulf Coast or Edwards (Barton Springs) Aquifers. A Local Groundwater Supply strategy was identified for 20 water utilities.

***Decade Needed*:** 2010 – 2060

Cost, Quantity of Water, and Land Impacted

Unit Cost of Water:	**Varies**		**Treated Water Delivered**
Quantity of Water:	**Varies**	**acft/yr**	**Reliability = Firm**
Land Impacted:	**Varies**	**acres**	

Additional Considerations per Regional Water Planning Guidelines

Environmental Factors:

No significant impacts on wildlife and cultural features are expected.

Impacts on Water Resources:

None.

Impacts on Agricultural & Natural Resources:

None.

Other Relevant Factors per SCTRWPG:

Part or all of the water needed by this Water Management Strategy (WMS) is anticipated to be supplied from locations within the jurisdiction of a groundwater conservation district (District) and may exceed the amount of available water identified in the District's approved management plan, or may for other reasons not be permitted by the District. The amount of water needed by this WMS that exceeds the available water in the District's management plan, or for other reasons is not permitted by the District, cannot be implemented as part of this WMS unless and until all necessary permits are received from the District. The amount of water needed by this WMS that exceeds the available water in the District's management plan, or for other reasons is not permitted by the District, introduces an added element of uncertainty to reliance upon this WMS and, therefore, additional management supplies may be needed for this WMS.

Comparison of Strategies to Meet Needs:

Cost estimates indicate that this strategy may be more economical than other potentially feasible WMS.

Interbasin Transfer:

None.

Issues:

None.

Third-Party Impacts of Voluntary Transfers:

None anticipated.

Regional Efficiency:

Locations of new wells are likely to be proximate to existing treatment and distribution facilities.

Water Quality Considerations:

None.

4C.22 Local Groundwater Supplies

Many water utilities for municipalities and Water Supply Corporations (WSC) in the South Central Texas Water Planning Region commonly use the Carrizo-Wilcox, Gulf Coast, or Trinity Aquifers for their supply. Where local groundwater supplies are available, these utilities have a strong preference for local groundwater because it is: (1) usually readily available at different locations within their distribution system, (2) relatively inexpensive, and (3) often requires minimal treatment.

The purposes of this study are to:

- Evaluate aquifers and existing well field(s) of each municipality and WSC as to their ability to meet projected water supply requirements through 2060 in consideration of groundwater supply estimates and reported well capacity.
- If additional supplies are needed, identify whether or not additional wells are the most likely water management strategy or whether an alternative strategy, such as purchase from a wholesale water provider, is recommended.
- If additional wells are needed, identify a reconnaissance level location for new well(s).
- If the water needs to be treated, estimate the cost of the facilities.

The evaluation of a Local Water Management strategy for individual municipal and WSC water utilities is at a reconnaissance level includes the following steps:

- Compile information prepared for the South Central Texas Regional Water Planning Group on current and TWDB's projected populations and water demands for each of the municipalities and WSCs.
- Estimate system capacity for each water system through 2060 by using TCEQ reported system information.
- Compile and summarize publicly available information for each water utility from TCEQ and TWDB.
- If the estimated groundwater supply after adjustments was greater than the estimated required capacity in 2060, the evaluation concludes that the existing water supply is adequate for the planning period.
- If the estimated supply after adjustments was less than the estimated required capacity in the year 2060, the evaluation concluded that an additional water supply is needed during the planning period.
- If new wells are the most feasible water management strategy, estimate when new wells are needed and the cost of adding the new wells to the water system.

The selected approach in developing plans for water utilities that show a projected shortage includes: (1) a reviewing demands and supplies, (2) estimating when shortages occur, (3) preparing reconnaissance level designs, and (4) estimating cost for new wells and associated improvements. It's assumed that the utilities that do not have a shortage will continue to utilize the local groundwater supply with their existing wells. For the water utilities with wells in the Carrizo-Wilcox Aquifer, the cumulative effects analysis will account for the existing and projected demands by all of the water utilities.

For water utilities entities with shortages, TCEQ water utility data sheets were studied to provide information on the number, depth, and reported capacity of existing wells. This information provided guidance for costing purposes. For the reconnaissance level design, a water demand peaking factor of 2.0 times the average annual water use was used. The pipeline requirements to connect the new wells to a main pipeline within the distribution system was assumed to be one-half mile per well. Other costs such as storage and pump stations are included in a system improvement cost of $200,000 per MGD of peak capacity. For the purposes of estimating well pumping power costs, a total dynamic head is estimated on a case by case basis. An assessment of likely treatment requirements and cost is based on typical water quality data and water treatment requirements in the vicinity of each utility.

All cost estimates were performed by using the 2011 Regional Water Planning criteria. These criteria include estimating the project cost as of September 2008 and amortizing the debt at a 6.0 percent interest rate over a 20-year period. Following the criteria, all wells costs were estimated as of September 2008, even if they are not scheduled to be needed until some time in the future.

4C.22.1 Carrizo-Wilcox Aquifer

The following entities utilize the Carrizo-Wilcox Aquifer and are expected to have a water shortage by 2060: Benton City WSC, McCoy WSC, City of Jourdanton, Atascosa County Steam Electric, Bexar Met, City of Lockhart, City of Luling, Aqua WSC, Polonia WSC, Crystal Clear WSC, Yancy WSC, City of Floresville, Oak Hills WSC, SS WSC, Sunko WSC. City of Karnes City, and Figure 4C.22-1 presents the location of the entities with projected needs to be met from Local Carrizo-Wilcox Aquifer wells. Table 4C.22-1 displays the projected needs and number of new wells, by decade, for each of these entities. Table 4C.22-1 also presents the capital cost, project cost (including land acquisition, environmental, permitting, and mitigation), annual cost, yield, and unit cost (in $/acft and $/1,000 gallons) for water

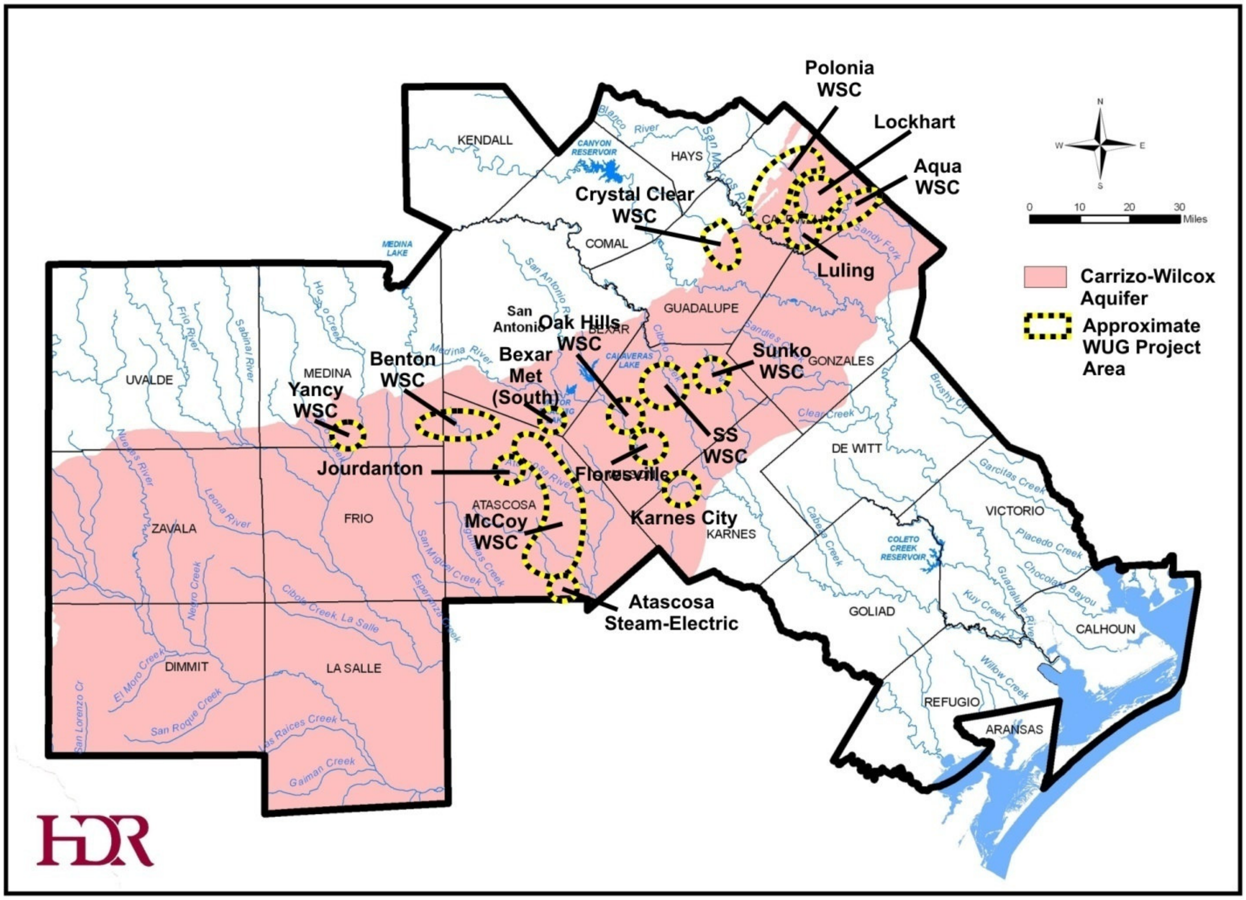


Figure 4C.22-1. Local Carrizo-Wilcox Aquifer Projects

obtained under this strategy. This strategy does not include utility expenses attributed to regional water level declines that may cause the system operators to lower pumps and to replace old wells. Water from the Carrizo-Wilcox Aquifer often has iron concentrations greater than 0.3 milligrams per liter, which exceeds guidelines for aesthetic effects. The costs of adding a water treatment plant to treat iron and manganese removal, as well as chlorination, were included in the cost estimates for these cities. Some of the well fields are located where the Carrizo Aquifer is very deep and produces relatively hot water, which may need to be cooled prior to integration.

Table 4C.22-1.
Local Groundwater Water Management Strategy: Summary of Schedule and Cost

User	County	Aquifer		Needs 2010	Needs 2020	Needs 2030	Needs 2040	Needs 2050	Needs 2060	Total Wells	Total Capital Cost	Total Project Cost	Total Annual Cost	Available Project Yield	Annual Unit Cost ($/acft)	Non-Debt Unit Cost	Annual Unit Cost ($/1,000 gal)
Benton City WSC	Atascosa	Carrizo	Projected Needs	0	0	199	454	696	885	2	$3,069,000	$4,372,000	$641,000	1,613	$397	$161	$1.22
			New Wells			1			1								
			Total Wells	0	0	1	1	1	2								
McCoy WSC	Atascosa	Carrizo	Projected Needs	0	12	208	436	650	812	2	$4,088,000	$5,803,000	$778,000	1,613	$482	$169	$1.48
			New Wells		1				1								
			Total Wells	0	1	1	1	1	2								
Atascosa Steam Electric	Atascosa	Carrizo	Projected Needs	263	0	0	0	604	942	2	$3,380,000	$4,808,000	$499,000	1,613	$309	$49	$0.95
			New Wells	1					1								
			Total Wells	1	1	1	1	1	2								
Jourdanton	Atascosa	Carrizo	Projected Needs	112	172	225	267	306	338	1	$1,719,000	$2,441,000	$349,000	403	$865	$338	$2.66
			New Wells	1													
			Total Wells	1	1	1	1	1	1								
Bexar Met (North)[2]	Bexar	Trinity	Projected Needs	2,000	2,000	2,000	2,000	2,000	2,000	10	$6,582,000	$9,662,000	$1,043,000	2,016	$517	$99	$1.59
			New Wells	10	0	0	0	0	0								
			Total Wells	10	10	10	10	10	10								
Bexar Met (South)[2]	Bexar	Carrizo	Projected Needs	4,000	6,000	8,000	8,000	12,000	16,000	20	$31,024,000	$44,372,000	$6,707,000	16,129	$416	$176	$1.28
			New Wells	5	3	2	0	5	5								
			Total Wells	5	8	10	10	15	20								
Lockhart	Caldwell	Carrizo	Projected Needs	0	321	856	1,407	1,952	2,512	7	$16,753,000	$24,246,000	$2,999,000	2,823	$1,062	$314	$3.26
			New Wells		1	2	1	1	2								
			Total Wells	0	1	3	4	5	7								
Luling	Caldwell	Carrizo	Projected Needs	0	122	211	296	398	506	2	$4,139,000	$5,906,000	$875,000	807	$1,085	$446	$3.33
			New Wells		1				1								
			Total Wells	0	1	1	1	1	2								
Aqua WSC	Caldwell	Carrizo	Projected Needs	49	121	178	240	300	362	1	$1,393,000	$1,984,000	$303,000	403	$751	$322	$2.31
			New Wells	1													
			Total Wells	1	1	1	1	1	1								
Polonia WSC	Caldwell	Wilcox	Projected Needs	0	0	0	0	66	265	2	$1,455,000	$2,087,000	$284,000	323	$880	$316	$2.70
			New Wells					1	1								
			Total Wells	0	0	0	0	1	2								
Crystal Clear WSC	Guadalupe	Wilcox	Projected Needs	0	0	509	1,138	1,926	2,716	14	$23,309,000	$33,754,000	$4,029,000	2,823	$1,427	$385	$4.38
			New Wells			3	3	4	4								
			Total Wells	0	0	3	6	10	14								

Table 4C.22-1 (Concluded)

User	County	Aquifer		Needs						Total Wells	Total Capital Cost	Total Project Cost	Total Annual Cost	Available Project Yield	Annual Unit Cost ($/acft)	Non-Debt Unit Cost	Annual Unit Cost ($/1,000 gal)
				2010	2020	2030	2040	2050	2060								
			Projected Needs	182	203	224	242	253	262								
Karnes City	Karnes	Carrizo	New Wells	1						1	$2,425,000	**$3,430,000**	$404,000	323	$1,252	$325	$3.84
			Total Wells	1	1	1	1	1	1								
			Projected Needs	0	0	0	37	86	118								
Kenedy	Karnes	Gulf Coast	New Wells				1			1	$1,546,000	$2,194,000	$294,000	**161**	$1,823	$637	$5.59
			Total Wells	0	0	0	1	1	1								
			Projected Needs	0	29	433	879	1,427	1,872								
Goforth SUD	Hays	Edwards (BSprs)	New Wells		1		1	1	1	4	$3,024,000	$4,321,000	$490,000	2,420	$203	$47	$0.62
			Total Wells	0	1	1	2	3	4								
			Projected Needs	0	1,049	1,433	1,603	1,921	2,386								
County Line WSC	Hays	Trinity	New Wells		7	2	1	2	3	15	$14,413,000	$20,562,000	$2,105,000	2,420	$870	$129	$2.67
			Total Wells	0	7	9	10	12	15								
			Projected Needs	214	395	562	710	851	985								
Yancey WSC	Medina	Carrizo	New Wells	1		1		1		3	$3,921,000	$5,813,000	$626,000	1,210	$517	$99	$1.59
			Total Wells	1	1	2	2	3	3								
			Projected Needs	0	0	0	0	159	433								
Floresville	Wilson	Carrizo	New Wells					1		1	$1,650,000	$2,344,000	$356,000	484	$736	$313	$2.26
			Total Wells	0	0	0	0	1	1								
			Projected Needs	0	0	0	0	0	298								
Oak Hills WSC	Wilson	Carrizo	New Wells						1	1	$1,207,000	$259,000	$260,000	323	$806	$736	$2.47
			Total Wells	0	0	0	0	0	1								
			Projected Needs	223	864	1,546	2,214	2,939	3,690								
SS WSC	Wilson	Carrizo	New Wells	1	1		1	1	1	5	$20,806,000	$29,537,000	$4,632,000	4,033	$1,149	$510	$3.53
			Total Wells	1	2	2	3	4	5								
			Projected Needs	0	0	0	0	0	70								
Sunko WSC	Wilson	Carrizo	New Wells						1	1	$965,000	$1,375,000	$161,000	161	$998	$255	$3.06
			Total Wells	0	0	0	0	0	1								

4C.22.2 Gulf Coast Aquifer

The City of Kenedy, in Karnes County, was the only municipal system identified with projected needs that are likely to be met through local development of the Gulf Coast Aquifer (Figure 4C.22-2). This entity is expected to need one new supply wells in the Gulf Coast Aquifer added to their system by the year 2060. Cost estimates are summarized in Table 4C.22-1.

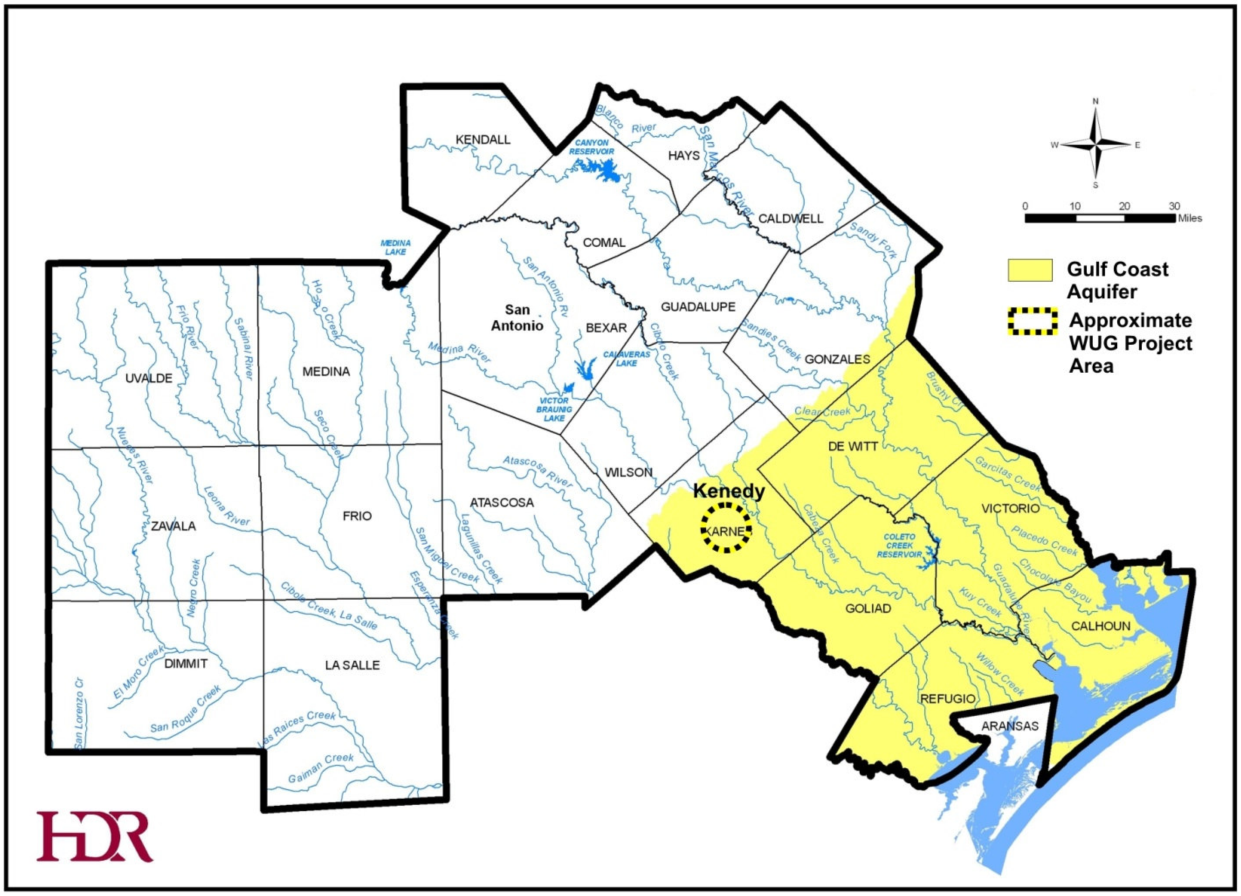


Figure 4C.22-2. Gulf Coast Aquifer Project

Groundwater from the Catahoula Formation in this part of the Gulf Coast Aquifer has TDS concentrations greater than 1,000 ppm. Current treatment is through a reverse osmosis membrane system. Costs for this advanced treatment were included in cost estimates.

4C.22.3 Trinity Aquifer

The County Line WSC and BMWD have indicated their intent to utilize local Trinity Aquifer supplies to meet projected needs through 2060 (Figure 4C.22-3). Plans for County Line

WSC are to develop Trinity wells to supply approximately 800 acft/year from Caldwell County. BMWD's present plans are to utilize the Trinity Aquifer within Bexar County to meet part of the projected needs in northern Bexar County. Cost estimates are provided in Table 4C.22-1.

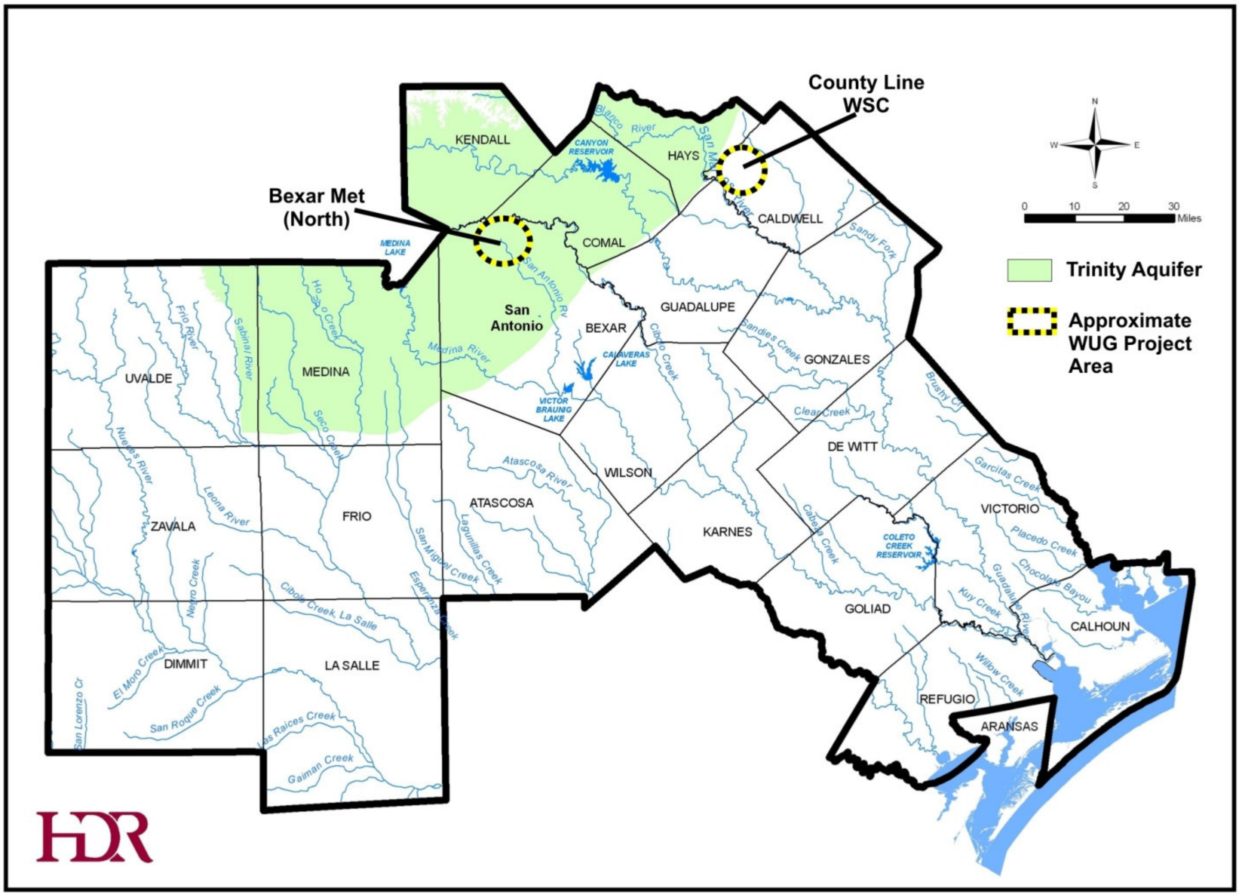


Figure 4C.22-3. Local Trinity Aquifer Projects

Water quality in the Trinity Aquifer is generally favorable for incorporation into a water supply system with only chlorination as treatment.

4C.22.4 Barton Springs Segment of Edwards Aquifer

The local water management strategy for Goforth WSC is to develop new groundwater supplies from the Barton Springs segment of the Edwards Aquifer through construction of new wells and/or acquisition of rights to pump from existing wells. The location of this WSC is shown in Figure 4C.22-4. Estimated costs are presented in Table 4C.22-1.

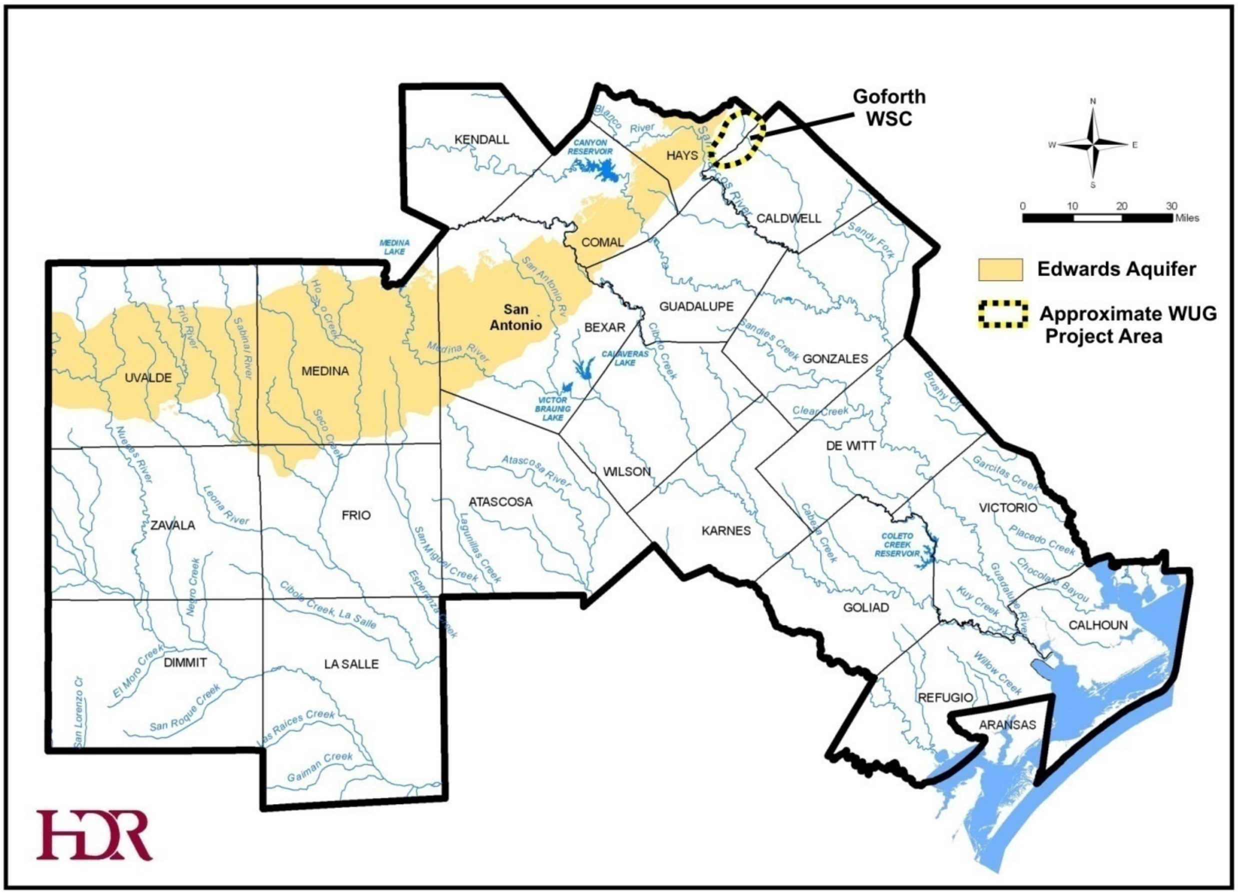


Figure 4C.22-4. Local Edwards Aquifer — Barton Springs Segment Project

4C.22.5 Drawdown

Predictive groundwater model simulations to estimate drawdown were only performed for the cumulative effects of all pumping for the Carrizo-Wilcox, including background and Water Management Strategies.

4C.22.6 Environmental Issues

In the local groundwater water management strategy, existing municipal and WSC well fields will be expanded for the new wells. .

Available water level data in the vicinity of the proposed well fields show some of the areas have declining trends. In most all these cases, the declines are expected to continue or to possibly increase. Areas with little or no groundwater level declines in the past may start to experience groundwater declines in the future due to increases in groundwater pumping. Nearby pumping for water supply, recharge from rainfall, and other factors can also affect groundwater levels.

The pumping of groundwater from the Carrizo-Wilcox Aquifer for a Local Groundwater Supply could have a very minor impact on springflow and temporary pools in small streams in the outcrop area, which may be habit for some plant and animal species.

4C.22.7 Engineering and Costing

A summary of projected needs and cost estimates for development of local groundwater supply in the three subject aquifers, subject to the assumptions previously discussed, is presented in Table 4C.22-1.

4C.22.8 Implementation Issues

Part or all of the water needed by this Water Management Strategy (WMS) is anticipated to be supplied from locations within the jurisdiction of a groundwater conservation district (District) and may exceed the amount of available water identified in the District's approved management plan, or may for other reasons not be permitted by the District.

The amount of water needed by this WMS that exceeds the available water in the District's management plan, or for other reasons is not permitted by the District, cannot be implemented as part of this WMS unless and until all necessary permits are received from the District.

The amount of water needed by this WMS that exceeds the available water in the District's management plan, or for other reasons is not permitted by the District, introduces an added element of uncertainty to reliance upon this WMS and, therefore, additional management supplies may be needed for this WMS.

The development of additional wells and well fields by water utilities may encounter the following issues:

- Impact on:
  - Endangered and threatened species,
  - Water levels in the aquifer,
  - Baseflow in streams, and
  - Wetlands.
- Competition with others for groundwater in the area.

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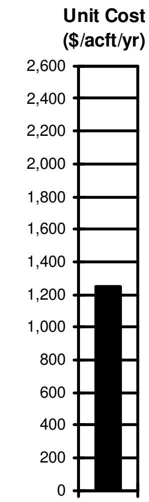
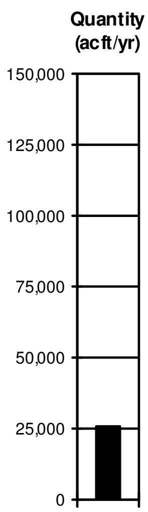
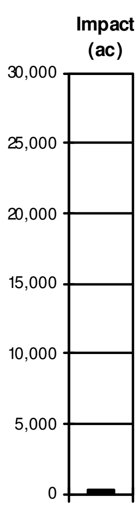
2011 South Central Texas Regional Water Plan
Water Management Strategy Summary Sheet







Name: Brackish Wilcox Groundwater for SAWS

Description: A strategy has been developed in three phases to produce a total of 26,000 acft/yr of potable water. The source of the water would be wells that are screened in the brackish part of the Wilcox Aquifer. The well field for Phase I is planned for southern Bexar County. The locations of the well fields for Phases II and III have not been determined. All three phases of this strategy include treatment of raw water at a desalination water treatment plant in the vicinity of the Twin Oaks WTP. Concentrate disposal will be deep well injection into a depleted oil and gas reservoir.

Phase I would require 12 wells designed to produce 12,000 acft/yr of potable water. With allowance for concentrate produced from the desalination process, about 13,500 acft/yr of raw water would have to be pumped from the Wilcox. Phases II and III are planned to produce 9,000 and 5,400 acft/yr of potable water, respectively.

***Decade Needed*:** 2010 – 2030 (Phased)

Cost, Quantity of Water, and Land Impacted

Unit Cost of Water:	**$1,245**	**$/acft/yr**	**Treated Water Delivered**
Quantity of Water:	**26,000**	**acft/yr**	**Reliability = Firm**
Land Impacted:	**200+**	**acres**	

Additional Considerations per Regional Water Planning Guidelines

Environmental Factors:

None.

Impacts on Water Resources:

The wells would be developed in the deep, confined section of the Wilcox, which is substantially removed from the outcrop area. There is concern about the possibility of interaction between the Wilcox and Carrizo layers of the Carrizo-Wilcox Aquifer. If the interaction is significant, pumping the Wilcox will cause some downward leakage of Carrizo water into the Wilcox, which will cause some lowering of water levels in the Carrizo.

Impacts on Agricultural & Natural Resources:

Minimal impacts anticipated.

Other Relevant Factors per SCTRWPG:

Part or all of the water needed by this Water Management Strategy (WMS) is anticipated to be supplied from locations within the jurisdiction of a groundwater conservation district (District) and may exceed the amount of available water identified in the District's approved management plan, or may for other reasons not be permitted by the District. The amount of water needed by this WMS that exceeds the available water in the District's management plan, or for other reasons is not permitted by the District, cannot be implemented as part of this WMS unless and until all necessary permits are received from the District. The amount of water needed by this WMS that exceeds the available water in the District's management plan, or for other reasons is not permitted by the District, introduces an added element of uncertainty to reliance upon this WMS and, therefore, additional management supplies may be needed for this WMS.

Comparison of Strategies to Meet Needs:

Cost estimates indicate that this strategy is moderate in cost.

Interbasin Transfer Issues:

None.

Third-Party Impacts of Voluntary Transfers:

None anticipated.

Regional Efficiency:

Locations of well fields are proximate to existing WTP and distribution facilities.

Water Quality Considerations:

Water from the Wilcox at this location is expected to have a total dissolved solids concentration of about 1,200-1,500 mg/L. Concentrate disposal would be to the Austin Chalk and/or the Edwards formations.

4C.23 Brackish Wilcox Groundwater for SAWS

In the Texas Water Development Board's February 2003 report[1], the availability of brackish water in the Carrizo-Wilcox Aquifer in Region L is shown to range from "moderate" to "high" while source water production costs range from "low" to "high." A study completed in July 2004[2] to evaluate the potential for a brackish groundwater source from the Wilcox Aquifer further defined the water quality and indicated that slightly brackish groundwater was available from the Wilcox Aquifer in Bexar County. A detailed study[3] was completed in October 2008 for San Antonio Water System (SAWS) on the hydrogeology, water quality, water treatment and facilities, disposal of concentrate, permitting, and procurement and financial considerations.

Based on the findings of these studies, a strategy has been developed in three phases to produce a total of 26,000 acft/yr of potable water. The source of the water would be wells that are screened in the brackish part of the Wilcox Aquifer. The well field for Phase I is planned for southern Bexar County. The locations of the well fields for Phases II and III have not been determined. The desalination water treatment plant would be located at SAWS' Twin Oaks WTP and pumped to the SAWS distribution system either through a new western integration pipeline and/or an existing eastern integration pipeline, or stored in the SAWS ASR well field.

4C.23.1 Description of Water Management Strategy

Brackish Wilcox Groundwater for SAWS is a water supply strategy based on the development of brackish groundwater in the Wilcox Aquifer in southern Bexar, southwestern Wilson, and northern Atascosa Counties (Figure 4C.23-1). The target locations of the well fields were selected primarily on the basis of favorable well yields and water quality, with consideration of property availability.

All three phases of this strategy include treatment of the raw water at a desalination water treatment plant in the vicinity of the Twin Oaks WTP. The product water would be pumped with water recovery from the ASR well field to SAWS distribution system through a planned west pipeline and/or the existing east pipeline Preliminary plans for to dispose of the concentrate in

[1] LBG-Guyton Associates, "Brackish Groundwater Manual for Texas Regional Water Planning Groups," prepared for the Texas Water Development Board, February 2003.
[2] HDR Engineering, Inc., "Water Quality Characteristics of the Wilcox Aquifer in the Vicinity of San Antonio, TX," prepared for San Antonio Water System, July 2004.
[3] R.W. Beck, "Brackish Groundwater Desalination Feasibility Assessment Report," prepared for SAWS, October 2008.

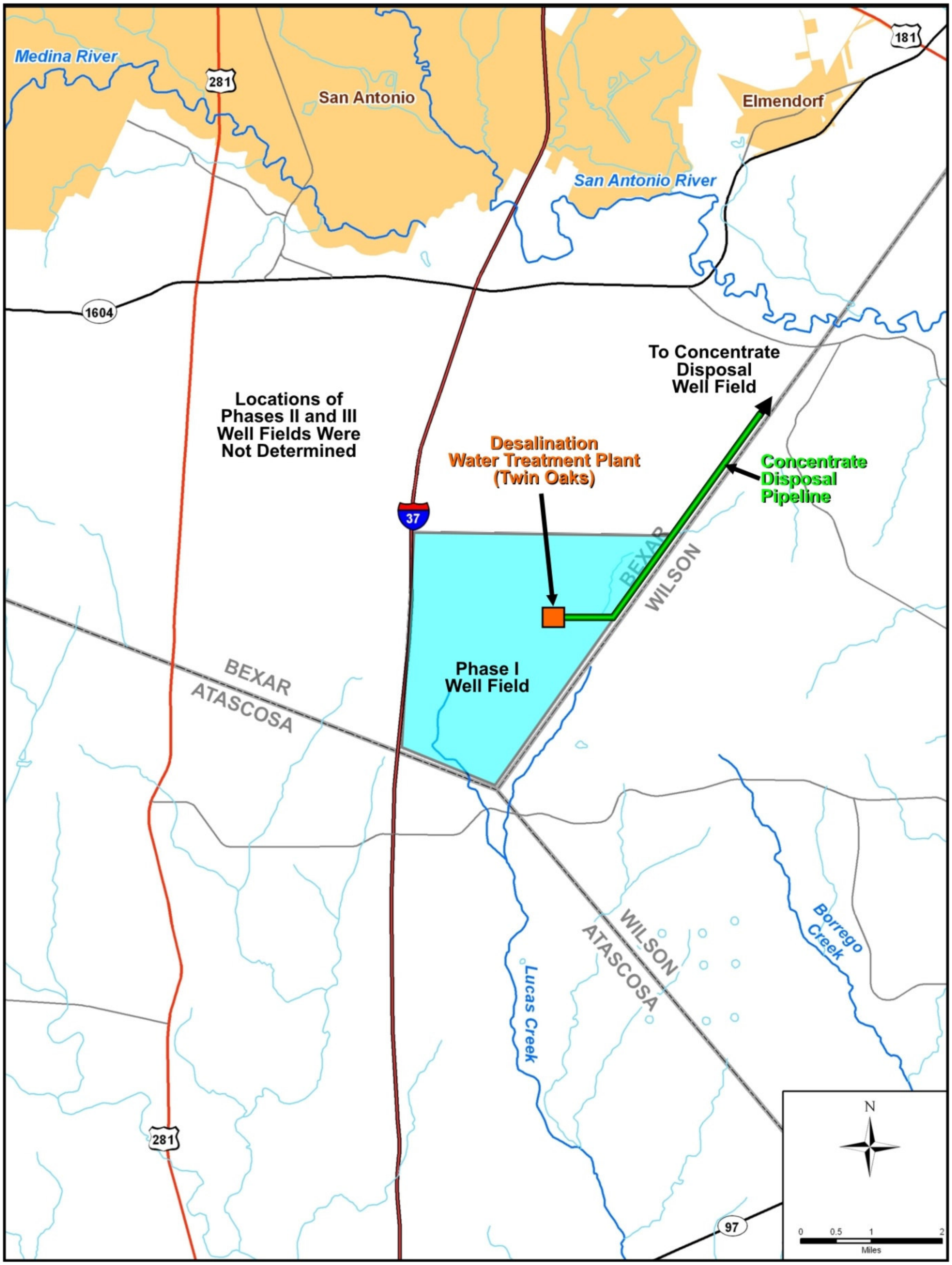


Figure 4C.23-1. Location of Brackish Wilcox Groundwater for SAWS – Phase I

the either the Austin Chalk or Edwards Formation in Wilson County by using deep injection wells. This strategy is designed to produce water at a uniform (base load) rate.

Phase I of this strategy is in southern Bexar County and is designed to produce 12,000 acft/yr of potable water. Twelve wells are required and plans are to locate the wells in or near SAWS ASR well field. These wells are expected to produce about 900 gpm, have a depth ranging from 2,000 to 2,500 ft. With allowance for concentrate produced from the desalination process, about 13,500 acft/yr of raw water would have to be pumped from the Wilcox. Water from the Wilcox at this location is expected to have a total dissolved solids concentration of about 1,200-1,500 mg/L.

Phases II and III are planned to produce 9,000 and 5,000 acft/yr of potable water, respectively. Phases II and III will require about 10,100 and 5,600 acft/yr of raw water, respectively. The locations these well fields have not been determined. For costing purposes, the well yield and water quality will be assumed to be approximately the same as Phase I. With these assumptions, Phase II will require nine wells and Phase III will require five wells.

4C.23.2 Available Yield

A study of water well data, geophysical logs from oil and gas exploratory test holes, and test drilling by R.W. Beck (2008) for SAWS characterized the Wilcox Aquifer as a major source of brackish water in southern Bexar, northern Atascosa, and eastern Wilson Counties. Test drilling and field studies in the area by SAWS have greatly improved and refined the previous characterizations of the Wilcox Aquifer with regard to potential well yields and water quality. According to the Beck report, analysis of geophysical log data indicates the thickness of sand layers to range from about 300 to 500 ft in the favorable areas for well field development. Aquifer testing at three sites indicates a well yield of 800 to 1,000 gpm for a drawdown of about 100 ft. Because of the dip of the Wilcox is toward the Gulf Coast, the top of the sands are shallower to the northwest and deeper to the southeast. The range in the concentration of total dissolved solids typically ranged from about 1,200 to 1,700 mg/L. A clear, discernable aquitard between the water-bearing sands in the Carrizo and Wilcox Aquifers was reported to be 200 to 300 ft thick in the study area. Results of groundwater modeling in the Beck 2008 report. indicates 2060 drawdown in the Wilcox would be about 250 ft from 15 wells pumping in three well fields for a total of 25 MGD. The modeling analysis also showed drawdown in the Carrizo to be less than 8 ft by 2060. Results from the Beck study suggest that well fields located in this area are suitable for a long-term supply of brackish groundwater. Please note that these simulations only approximately match the preliminary designs of this strategy. Thus, the drawdown for this strategy may be somewhat different.

The procedure for obtaining groundwater supplies for the project is dependent on securing groundwater rights from the land owners. In Bexar County, there is no groundwater district to regulate well spacing and production in the Wilcox Aquifer. If the well fields are located in either Atascosa or Wilson Counties, well, production, and transportation permits must be obtained from the Evergreen Underground Water Conservation District. According to the District rules, the spacing and production of the wells are dependent on results of a groundwater model, location of the well field, distance to other wells, and the amount of requested water.

Groundwater modeling was not performed to estimate the long-term drawdown from this strategy. However, groundwater modeling of all recommended water management strategies are presented in the cumulative effects section of this report (Section 7).

4C.23.3 Environmental Issues

Brackish Wilcox Groundwater for SAWS involves the development of a well field in the brackish portion of the Wilcox Aquifer in Atascosa, Bexar and Wilson Counties, a desalination plant at the Twin Oaks WTP, and a concentrate disposal pipeline; the finished water will then be pumped with ASR water through an existing (east) or planned (west) pipeline to SAWS distribution system.

The proposed project is located in the South Texas brush country ecoregion[4]. The project area is found within in the Tamaulipan biotic province and is on the edge of the Balconian biotic province.[5] Vegetation types within the project area include primarily crops, post oak (*Quercus stellata*) woods and forest, and grasslands. Potential downstream impacts would include modification of the streamflow regime below the well field and a negligible reduction of freshwater inflows.

Table 4C.23-1 lists the 23 state listed endangered and threatened species, and the 17 federally listed endangered or threatened wildlife and plant species that may occur in Atascosa,

[4] Griffith, G.E., Bryce, S.A., Omernik, J.M., Comstock, J.A., Rogers, A.C., Harrison, B., Hatch, S.L., and Bezanson, D., 2004, Ecoregions of Texas (color poster with map, descriptive text, and photographs): Reston, Virginia, U.S. Geological Survey (map scale 1:2,500,000)..
[5] Blair, W.F., "The Biotic Provinces of Texas, "Tex. J. Sci. 2:93-117, 1950.

Table 4C.23-1.
Important Species Having Habitat or Known to Occur in Atascosa, Bexar or Wilson Counties

Common Name	Scientific Name	Impact Value	Multiplier Based on Status	Adjusted Impact	Summary of Habitat Preference	Listing Entity FWS	Listing Entity TPW	Potential Occurrence in County
AMPHIBIANS								
Cascade Caverns salamander	*Eurycea latitans complex*	0	2	0	Endemic, subaquatic in Edwards Aquifer Area		T	Resident
Comal Blind Salamander	*Eurycea tridentifera*	0	2	0	Endemic; springs and waters of caves in Bexar County.		T	Resident
Texas Salamander	*Eurycea neotenes*	0	1	0	Endemic; springs, seeps, cave streams, Helotes and Leon Creek drainages in Bexar County			Resident
ARACHNIDS								
Braken Bat Cave Meshweaver	*Cicurina venii*	0	3	0	Karst features in western Bexar County	LE		Resident
Cokendolpher cave harvestman	*Texella cokendolpheri*	0	3	0	Karst features in north-central Bexar County	LE		Resident
Government Canyon Bat Cave Meshweaver	*Cicurina vespera*	0	3	0	Karst features in northwestern Bexar County	LE		Resident
Government Canyon Bat Cave Spider	*Neoleptoneta microps*	0	3	0	Karst features in northwestern Bexar County	LE		Resident
Madla Cave Meshweaver	*Cicurina madla*	0	3	0	Karst features in northern Bexar County	LE		Resident
Robber Baron Cave Meshweaver	*Cicurina baronia*	0	3	0	Karst features in north-central Bexar County	LE		Resident
BIRDS								
Black-capped Vireo	*Vireo atricapillus*	0	3	0	Oak-juniper woodlands,	LE	E	Resident
Golden-cheeked Warbler	*Dendroica chrysoparia*	0	3	0	Juniper-oak woodlands.	LE	E	Resident
Interior least tern	*Sterna antillarum athalassos*	0	3	0	Nests along sand and gravel bars in braided streams	LE	E	Resident

Table 4C.23-1 (Continued)

Common Name	Scientific Name	Impact Value	Multiplier Based on Status	Adjusted Impact	Summary of Habitat Preference	Listing Entity FWS	Listing Entity TPW	Potential Occurrence in County
Mountain Plover	*Charadrius montanus*	1	1	1	Non-breeding, shortgrass plains and fields			Nesting/Migrant
Peregrine Falcon	*Falco peregrinus anatum (American)*	0	2	0	Resident and local breeder in West Texas. Migrant across the state.	DL	T	Possible Migrant
	Falco peregrinus tundrius (Arctic)	0	1	0	Migrant throughout the state.	DL		Possible Migrant
Western Burrowing Owl	*Athene cunicularia hypugaea*	1	1	1	Open grasslands, especially prairie, plains and savanna			Resident
White-faced Ibis	*Plegadis chihi*	0	2	0	Prefers freshwater marshes.		T	Resident
Whooping Crane	*Grus americana*	0	3	0	Potential migrant	LE	E	Potential Migrant
Wood Stork	*Mycteria americana*	0	2	0	Forages in prairie ponds, ditches, and shallow standing water formerly nested in Texas		T	Migrant
White-faced Ibis	*Plegadis chihi*	0	2	0	Prefers freshwater marshes.		T	Resident
CRUSTACEANS								
A cave obligate crustacean	*Monodella texana*	1	1	1	Subaquatic, underground freshwater aquifers			Resident
Nueces crayfish	*Procambarus nueces*	0	1	0	Known only from one tributary to the Nueces River.			Resident
FISHES								
Guadalupe Bass	*Micropterus treculi*	1	1	1	Endemic to perennial streams of the Edwards Plateau region.			Resident
Toothless Blindcat	*Trogloglanis pattersoni*	0	2	0	Troglobitic, blind catfish endemic to the San Antonio Pool of the Edwards Aquifer		T	Resident

Table 4C.23-1 (Continued)

Common Name	Scientific Name	Impact Value	Multiplier Based on Status	Adjusted Impact	Summary of Habitat Preference	Listing Entity		Potential Occurrence in County
						FWS	TPW	
Widemouth Blindcat	*Satan eurystomus*	0	2	0	Troglobitic, blind catfish endemic to the San Antonio Pool of the Edwards Aquifer.		T	Resident
INSECTS								
A Ground Beetle	*Rhadine exilis*	0	3	0	Karst features in northern Bexar County	LE		Resident
A Ground Beetle	*Rhadine infernalis*	0	3	0	Karst features in northern and western Bexar County	LE		Resident
Helotes Mold Beetle	*Batrisodes venyivi*	0	3	0	Karst features in northwestern Bexar County	LE		Resident
Manfreda Giant-skipper	*Stallingsia maculosus*	1	1	1	Skipper larvae usually feed inside a leaf shelter.			Resident
Rawson's metalmark	*Calephelis rawsoni*	1	1	1	Moist areas in shaded limestone outcrops			Resident
MAMMALS								
Black Bear	*Ursus americanus*	0	2	0	Inhabits bottomland hardwoods	T/SA;NL	T	Historic Resident
Cave Myotis Bat	*Myotis velifer*	1	1	1	Roosts colonially in caves, rock crevices			Resident
Ghost-faced bat	*Mormoops megalophylla*	1	1	1	Roosts in caves, crevices and buildings			Resident
Gray wolf	*Canis lupus*	0	3	0	Extirpated, forests, brushlands or grasslands	LE	E	Historic resident
Ocelot	*Leopardus pardalis*	1	3	3	Found in dense chaparral thickets, and oak mottes.	LE	E	Resident
Plains Spotted Skunk	*Spilogale putorius interrupta*	1	1	1	Prefers wooded, brushy areas.			Resident
Red Wolf	*Canis rufus*	0	3	0	Extirpated.	LE	E	Historic Resident

Table 4C.23-1 (Continued)

Common Name	Scientific Name	Impact Value	Multiplier Based on Status	Adjusted Impact	Summary of Habitat Preference	Listing Entity		Potential Occurrence in County
						FWS	TPW	
MOLLUSKS								
Creeper (squawfoot)	*Strophitus undulates*	1	1	1	Small to large streams			Resident
False spike mussel	*Quincuncina mitchelli*	1	1	1	Substrates of cobble and mud with water lilies present. Rio Grande, Brazos, Colorado and Guadalupe river basins.			Resident
Golden orb	*Quadrula aurea*	1	2	2	Sand and gravel, Guadalupe, San Antonio, and Nueces River basins		T	Resident
Mimic Cavesnail	*Phreatodrobia imitata*	0	1	0	Subaquatic; only known from two wells penetrating the Edwards Aquifer			Resident
Pistolgrip	*Tritogonia verrucosa*	1	1	1	Aquatic, stable substrate. Red through San Antonio river basins.			Resident
Rock pocketbook	*Arcidens confragosus*	1	1	1	Mud and sand, Red through Guadalupe River basins.			Resident
Texas fatmucket	*Lampsilis bracteata*	1	2	2	Streams and rivers on sand, mud and gravel, Colorado and Guadalupe River basins.		T	Resident
Texas pimpleback	*Quadrula petrina*	1	2	2	Mud, gravel and sand substrates, Colorado and Guadalupe river basins		T	Resident
PLANTS								
Big red sage	*Salvia penstemonoides*	1	1	1	Endemic; moist to seasonally wet clay or silt soils in creek beds.			Resident

Table 4C.23-1 (Continued)

Common Name	Scientific Name	Impact Value	Multiplier Based on Status	Adjusted Impact	Summary of Habitat Preference	Listing Entity		Potential Occurrence in County
						FWS	TPW	
Bracted twistflower	*Streptanthus bracteatus*	1	1	1	Endemic: found in shallow, well-drained gravelly clays and clay loams over limestone.			Resident
Correll's false dragon-head	*Physostegia correllii*	1	1	1	Found in wet, silty clay loams on sides of streams and other wet areas.			Resident
Elmendorf's onion	*Allium elmendorfii*	2	1	2	Endemic, in deep sands			Resident
Park's jointweed	*Polygonella parksii*	1	1	1	Endemic; deep loose sands of Carrizo and similar Eocene formations.			Resident
Sandhill woolywhite	*Hymenopappus carrizoanus*	2	1	2	Endemic; open areas in deep sands derived from Carrizo and similar Eocene formations.			Resident
REPTILES								
Indigo snake	*Drymarchon carais*	1	2	2	Found south of the Guadalupe river and Balcones Escarpment.		T	Resident
Spot-tailed earless lizard	*Holbrookia lacerata*	1	1	1	Moderately open prairie-brushland.			Resident
Texas Garter Snake	*Thamnophis sirtalis annectens*	1	1	1	Wet or moist microhabitats			Resident
Texas Horned Lizard	*Phrynosoma cornutum*	2	2	4	Varied, sparsely vegetated uplands.		T	Resident
Texas Tortoise	*Gopherus berlandieri*	2	2	4	Open brush w/ grass understory.		T	Resident

Table 4C.23-1 (Concluded)

Common Name	Scientific Name	Impact Value	Multiplier Based on Status	Adjusted Impact	Summary of Habitat Preference	Listing Entity		Potential Occurrence in County
						FWS	TPW	
Timber/Canebrake Rattlesnake	*Crotalus horridus*	1	2	2	Floodplains, upland pine, deciduous woodlands, riparian zones.		T	Resident

Source: TPWD, Annotated County List of Rare Species, Atascosa County (Updated 5/7/2009).
TPWD, Annotated County List of Rare Species, Bexar County (Updated 10/6/2009).
TPWD, Annotated County List of Rare Species, Wilson County (Updated 5/4/2009).

LE/LT = Federally Listed Endangered/Threatened
DL, PDL = Federally Delisted/proposed for delisting
T/SA = Listed as Threatened by similarity of appearance
E, T = State listed Endangered/Threatened
C = Species of ConcernBlank = Not yet listed by TPWD or USFWS, but considered rare

Bexar, or Wilson Counties, according to county lists of rare species published by Texas Parks and Wildlife Department (TPWD) online in the "Annotated County Lists of Rare Species." Inclusion in Table 4C.23-1 does not mean that a species will occur within the project area, but only acknowledges the potential for occurrence in the project area counties. In addition to the county lists, the Natural Diversity Database (NDD) maintained by the TPWD was reviewed for known occurrences of listed species within or near the project area. No known occurrences of threatened or endangered species were documented near the project area; however, the sandhill woollywhite, a rare plant species has been documented near the well field area. The sandhill woollywhite prefers areas of deep sand.

After a review of the habitat requirements for each listed species, it is expected that this project will have no adverse effect on any federally listed threatened or endangered species, its habitat, or designated habitat, nor would it adversely affect any state endangered species. Although suitable habitat for the state threatened Texas horned lizard and Texas tortoise may exist within the project area, no impact to this species is anticipated due to the abundance of similar habitat near the project area and this species' ability to relocate to those areas if necessary. The presence or absence of potential habitat does not confirm the presence or absence of a listed species. No species specific surveys were conducted in the project area for this report.

Habitat studies and surveys for protected species and cultural resources may need to be conducted at the proposed well sites and along any pipeline routes. Potential wetland impacts are expected to primarily include pipeline stream crossings, which can be minimized by right-of-way selection and appropriate construction methods, including erosion controls and revegetation procedures. Compensation for net losses of wetlands would be required where impacts are unavoidable.

A review of the Texas Historical Commission Texas Historic Sites Atlas database indicated that there are no historical markers, or National Register Properties listed within one mile of the proposed pipeline route or well field area. However this database indicates that there are three recorded cemeteries within one mile of the proposed pipeline. These include the Shelley-Fleming and Oakley Cemeteries in Bexar County and St. Luke Cemetery in Wilson County.

Cultural resources protection on public lands in Texas is afforded by the Antiquities Code of Texas (Title 9, Chapter 191, Texas Natural Resource Code of 1977), the National Historic Preservation Act (Pl96-515), and the Archeological and Historic Preservation Act (PL93-291). No archaeological review was completed for this analysis. An archeological survey of the project area may need to be conducted to determine actual impacts to cultural resources.

The possibility exists that water in the aquifer, affected by the additional wells, could decrease before stabilizing. The water level in the aquifer could affect the baseflow of surrounding streams and wetlands, thereby impacting wildlife habitat.

4C.23.4 Engineering and Costing

Preliminary engineering and costing analyses have been performed for each of the three phases using 2011 Regional Water Planning methods. For Region L, HDR utilized the standard costing procedures and unit costs. Earlier, SAWS had performed preliminary engineering and costing analyses in their feasibility studies. The two analyses include all facilities required for water production, collection, transmission and treatment and concentrate disposal. The well field will require wells and a collector pipeline. Reverse Osmosis technology is planned for the desalination process. Disposal of the concentrate is planned by deep well injection into a depleted oil and gas field in eastern Bexar County. For the Phase I project in Bexar County, the pumps in the wells will be sized to deliver the raw water to the water treatment plant. For Phases II and III, it is assumed that a pump station near the new the well field is needed for delivery of the raw water to the Twin Oaks water treatment plant. The desalination water treatment plant will be located on the SAWS property and near the Twin Oaks WTP. Treated water will be either delivered to the ASR facility or to SAWS distribution system by a new west side integration pipeline or the existing east side pipeline. Phase I costs includes the cost for the concentrate disposal pipeline at full project capacity.

The preliminary design produces a treated water TDS concentration of about 420 mg/L. The required secondary Maximum Contaminant Level (MCL) for TDS is 1,000 mg/L. Pretreatment prior to the desalination process includes cartridge filtration; it does not include additional pretreatment to remove particulates such as iron or manganese. The preliminary design has 70% the raw water from the well field being sent to the desalination plant to remove dissolved solids. The desalination plant recovery rate is estimated to be 85% meaning that 85% of the water entering the desalination plant passes through as purified water and 15% of the water remains as concentrated brine that contains the constituents removed from the purified water. The desalinated water is blended back with 30 percent of the pretreated brackish water to produce a blended finished water with a TDS concentration of about 420 mg/L. The TDS concentration of the concentrate is estimated at about 9,300 mg/L.

Phase I will produce a uniform 10.7 MGD (12,000 acft/yr) of potable water from Bexar County. Facilities include a well field with 12 wells, including 2 backup wells. Allowing for losses to concentrate, the well will have an average production of about 12.0 MGD. This initial phase will require construction of a water treatment plant. It will also require the construction of the concentrate pump station and pipeline, concentrate storage at the disposal site, and three 500 gpm deep injection wells for disposal into the Austin Chalk or Edwards Formation in Wilson County. For regional planning purposes, the brackish water wells are assumed to be on SAWS property, so groundwater leases are not necessary.

Phase II will produce a uniform 8.0 MGD (9,000 acft/yr) of potable water. Facilities include: a well field with nine wells, which includes one backup well, for an average raw water production of 9.0 MGD, a raw water pump station at the well field, expansion of the water treatment plant, expansion of the concentrate pump stations, and two new concentrate injection wells. For planning purposes, groundwater leases and groundwater district export fees are assumed to be required.

Phase III will produce a uniform 4.5 MGD (5,000 acft/yr) of potable water from a third well field. Facilities include: a well field with five wells, which includes one backup well, average raw water production of 5.0 MGD, a raw water pump station at the well field, expansion of the water treatment plant, expansion of the concentrate pump stations, and one new concentrate injection well. Groundwater leases and district export fees are assumed to be required.

When complete, the Brackish Wilcox Groundwater for SAWS will produce about 23.2 MGD (26,000 acft/yr) of potable water and about 2.87 MGD (3,210 acft/yr) of concentrate. The blended finished water TDS concentration will be about 420 mg/L. The Region L cost estimates for all phases of the project are shown in Table 4C.23-2.

A cost estimate provided by SAWS for the Brackish Wilcox Groundwater for SAWS is shown in Table 4C.23-3. SAWS developed these cost estimates in January 2009. At that time, SAWS planned for Phases I, II, and III to yield 11,800, 8,800, and 5,400 acft/yr, respectively, which is slightly different than the rates used in the Region L analysis.

A comparison of the cost estimates developed with Region L procedures with the estimates provided by SAWS show the SAWS unit cost estimates are about 50 percent higher during Phase I and within 15 percent for Phases II and III. Major causes for the SAWS estimates being higher in Phase I are cost differences in brackish wells, land purchases, engineering, and contingency. SAWS also included facilities for disposal of backwash and residuals (sludge). The Region L cost estimate included considerations for water system improvements while the SAWS estimates did not include this item. Both cost estimates assume a desalination water treatment plant with an 85 percent recovery of potable water.

4C.23.5 Implementation Issues

Part or all of the water needed by this Water Management Strategy (WMS) is anticipated to be supplied from locations within the jurisdiction of a groundwater conservation district (District) and may exceed the amount of available water identified in the District's approved management plan, or may for other reasons not be permitted by the District.

The amount of water needed by this WMS that exceeds the available water in the District's management plan, or for other reasons is not permitted by the District, cannot be implemented as part of this WMS unless and until all necessary permits are received from the District.

Table 4C.23-2.
Cost Estimate Summary Using Region L Costing Procedures

Brackish Wilcox Groundwater for SAWS
September 2008 Prices

Item	Phase I	Phase II	Phase III	All Phases
Capital Costs				
Transmission Pipeline and Pump Station: Brackish Water	$0	$5,084,000	$5,489,000	$10,573,000
Transmission Pipeline and Pump Stations: Concentrate Disposal	$15,698,000	$0	$0	$15,698,000
Well Field: Brackish Water	$20,893,000	$23,396,000	$9,850,000	$54,139,000
Well Field: Concentrate Disposal	$8,420,000	$338,000	$2,309,000	$11,067,000
Water Treatment Plants (Pretreatment & Desalination)	$17,449,000	$10,406,000	$5,203,000	$33,058,000
Water System Improvements	$14,628,000	$10,971,000	$6,095,000	$31,694,000
Total Capital Cost	**$77,088,000**	**$50,195,000**	**$28,946,000**	**$156,229,000**
Engineering, Legal Costs and Contingencies	$26,545,000	$17,451,000	$9,998,000	$53,994,000
Environmental & Archaeology Studies and Mitigation	$1,094,000	$541,000	$430,000	$2,065,000
Land Acquisition and Surveying (145 acres)	$1,313,000	$676,000	$516,000	$2,505,000
Interest During Construction (3 years)	$12,725,000	$5,510,000	$3,192,000	$21,427,000
Total Project Cost	**$118,765,000**	**$74,373,000**	**$43,082,000**	**$236,220,000**
Annual Costs				
Debt Service (6 percent, 20 years)	$10,354,000	$6,484,000	$3,756,000	$20,594,000
Operation and Maintenance				
Intake, Pipeline, Pump Station	$633,000	$433,000	$276,000	$1,342,000
Water Treatment Plant	$3,357,000	$2,589,000	$1,511,000	$7,457,000
Pumping Energy Costs (9614845 kW-hr @ 0.09 $/kW-hr)	$865,000	$863,000	$631,000	$2,359,000
Purchase of Water	$0	$631,000	$351,000	$982,000
Groundwater District Fees	$0	$82,000	$46,000	$128,000
Total Annual Cost	**$15,209,000**	**$11,082,000**	**$6,571,000**	**$32,862,000**
Available Project Yield (acft/yr)	**12,000**	**9,000**	**5,400**	**26,400**
Annual Cost of Water ($ per acft)	**$1,267**	**$1,231**	**$1,217**	**$1,245**
Annual Cost of Water ($ per 1,000 gallons)	**$3.89**	**$3.78**	**$3.73**	**$3.82**

Table 4C.23-3.
Cost Estimate Summary Provided by SAWS
Brackish Wilcox Groundwater for SAWS
Fourth Quarter 2008 Prices

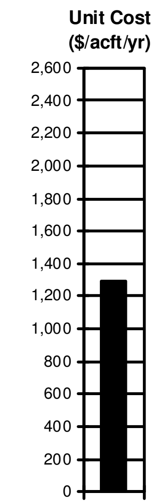
Item	Phase I	Phase II	Phase III	All Phases
Capital Costs				
Transmission Pipeline and Pump Station: Brackish Water	$591,000	$1,634,000	$1,832,000	$4,057,000
Transmission Pipeline and Pump Stations: Concentrate Disposal	$8,140,000	$0	$0	$8,140,000
Well Field: Brackish Water	$33,135,000	$34,055,000	$20,974,000	$88,164,000
Well Field: Concentrate Disposal	$9,387,000	$6,091,000	$0	$15,478,000
Water Treatment Plants (Pretreatment & Desalination)	$27,394,000	$4,122,000	$4,826,000	$36,342,000
Water System Improvements	$0	$0	$0	$0
Residuals	$7,731,000	$0	$0	$7,731,000
Backwash Disposal	$6,898,000	$0	$0	$6,898,000
Total Capital Cost	**$93,276,000**	**$45,902,000**	**$27,632,000**	**$166,810,000**
Engineering, Legal Costs and Contingencies	$62,721,000	$12,726,000	$7,529,000	$82,976,000
Environmental & Archaeology Studies and Mitigation	$500,000	$500,000	$500,000	$1,500,000
Land Acquisition and Surveying	$8,889,000	$23,000	$9,603,000	$18,515,000
Interest During Construction	$19,216,000	$6,873,000	$5,259,000	$31,348,000
Total Project Cost	**$184,602,000**	**$66,024,000**	**$50,523,000**	**$301,149,000**
Annual Costs				
Debt Service	$12,009,000	$4,295,000	$3,287,000	$19,591,000
Operation and Maintenance				
Intake, Pipeline, Pump Station	$7,514,000	$2,016,000	$1,381,000	$10,911,000
Water Treatment Plant	$426,000	$321,000	$199,000	$946,000
Pumping Energy Costs	$2,750,000	$2,392,000	$1,483,000	$6,625,000
Purchase of Water	$0	$542,000	$162,000	$704,000
Groundwater District Fees	$0	$106,000	$66,000	$172,000
Total Annual Cost	**$22,699,000**	**$9,672,000**	**$6,578,000**	**$38,949,000**
Available Project Yield (acft/yr)	**11,800**	**8,800**	**5,400**	**26,000**
Annual Cost of Water ($ per acft)	**$1,924**	**$1,099**	**$1,218**	**$1,498**
Annual Cost of Water ($ per 1,000 gallons)	**$5.90**	**$3.37**	**$3.74**	**$4.60**

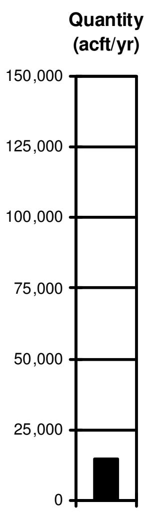
The amount of water needed by this WMS that exceeds the available water in the District's management plan, or for other reasons is not permitted by the District, introduces an added element of uncertainty to reliance upon this WMS and, therefore, additional management supplies may be needed for this WMS.

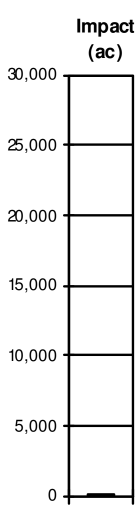
Implementation of the SAWS Local Wilcox Desalination Project includes the following issues:

- Potential adverse impacts on other aquifers (additional research regarding potential interaction between the Wilcox and Carrizo formations has been suggested);
- Verification that desalinated Wilcox Aquifer water is compatible with other water sources and will meet all water quality requirements in distribution system;
- Permitting Class 1 disposal wells for deep well injection of desalination concentrate;
- Experience in operating and maintaining a desalination water treatment plant;
- Brine Disposal Discharge Permits by TCEQ;
- Possibly having to secure permits from a groundwater district; and
- Securing water rights to the Wilcox Aquifer.

2011 South Central Texas Regional Water Plan
Water Management Strategy Summary Sheet







Name: Brackish Wilcox Groundwater for Regional Water Alliance

Description: The Brackish Wilcox Groundwater for Regional Water Alliance (RWA) strategy includes developing a brackish groundwater supply from the Wilcox Aquifer in Guadalupe and Wilson Counties for several RWA members who are in the vicinity of the project. It is designed to produce an average annual water supply of 14,700 acft/yr and have a daily peaking factor of 1.3. The well field is planned for northern Wilson County and southern Guadalupe County and near Highway 123. The water treatment plant and site of concentrate disposal is in the vicinity of the well field. The water will be integrated into an existing distribution system at the Liessner Booster Station.

***Decade Needed*:** 2020 – 2030

Cost, Quantity of Water, and Land Impacted

Unit Cost of Water:	**$1,293**	**$/acft/yr**	**Treated Water Delivered**
Quantity of Water:	**14,700**	**acft/yr**	**Reliability = Firm**
Land Impacted:	**128**	**acres**	

Additional Considerations per Regional Water Planning Guidelines

Environmental Factors:

None.

Impacts on Water Resources:

The wells would be developed in the deep, confined section of the Wilcox, which is substantially removed from the outcrop area. There is concern about the possibility of interaction between the Wilcox and Carrizo layers of the Carrizo-Wilcox Aquifer. If the interaction is significant, pumping the Wilcox will cause downward leakage of Carrizo water into the Wilcox and cause some lowering of water levels in the Carrizo.

Impacts on Agricultural & Natural Resources:

Minimal impacts anticipated.

Other Relevant Factors per SCTRWPG:

Part or all of the water needed by this Water Management Strategy (WMS) is anticipated to be supplied from locations within the jurisdiction of a groundwater conservation district (District) and may exceed the amount of available water identified in the District's approved management plan, or may for other reasons not be permitted by the District. The amount of water needed by this WMS that exceeds the available water in the District's management plan, or for other reasons is not permitted by the District, cannot be implemented as part of this WMS unless and until all necessary permits are received from the District. The amount of water needed by this WMS that exceeds the available water in the District's management plan, or for other reasons is not permitted by the District, introduces an added element of uncertainty to reliance upon this WMS and, therefore, additional management supplies may be needed for this WMS.

Comparison of Strategies to Meet Needs:

Cost estimates indicate that this strategy is moderate in cost.

Interbasin Transfer Issues:

None.

Third-Party Impacts of Voluntary Transfers:

None anticipated.

Regional Efficiency:

Regional partnership amongst four or more WUGs allows for economy of scale and use of shared facilities.

Water Quality Considerations:

The salinity (total dissolved solids) of the raw brackish Wilcox water is expected to range and 800 and 1,200 mg/L. Concentrate disposal would be to a deep and depleted or partially depleted oil and gas reservoir.

4C.24 Brackish Wilcox Groundwater for Regional Water Alliance

4C.24.1 Description of Water Management Strategy

This strategy includes developing a brackish groundwater supply from the Wilcox Aquifer in Guadalupe and Wilson Counties for members of the Regional Water Alliance (RWA) with service areas in Bexar, Guadalupe, and Wilson Counties. Utility members of the RWA who are potentially interested in this WMS include: Canyon Regional Water Authority, Bexar Met Water District, East Central Special Utility District, Green Valley Special Utility District, and SS Water Supply Corporation. It is designed to produce an average annual water supply of 13.1 MGD and a peak demand of 17.1 MGD. The well field is planned for northern Wilson County and southern Guadalupe County and near Hwy 123. The water treatment plant and site of concentrate disposal is in the vicinity of the well field. The water will be delivered to the Liessner Booster Station for distribution to participating water utilities. The location of the project is shown in Figure 4C.24-1.

This strategy builds on a preliminary assessment of potential brackish groundwater supplies from the Wilcox Aquifer in a target area that is generally a 10- to 20-mile-wide band that is south of Interstate 10 and between Loop 410 and Seguin[1]. The study and a summary of the findings are briefly discussed in the following section.

4C.24.2 Available Yield

HDR conducted a study[2] to identify the *favorable* and *most favorable* areas for a brackish water wells in the Wilcox Aquifer. More specifically, the study identified trends and patterns of well yields, total dissolved solids, chlorides, and sulfates with well depth in the target area. The study relied on TWDB well data and TCEQ oil and gas well logs.

An analysis of the TCEQ logs identified water-bearing sands and categorized the water quality characteristics into (1) saline, brackish, and fresh, (2) brackish and fresh, or (3) fresh. A summary of the occurrence of water-bearing sands and salinity with depth were delineated into five layers within the Wilcox. In the outcrop area, the layers were 200 ft thick. In the confined section, the data are divided into five evenly divided layers. The sand thicknesses for the three

[1] HDR Engineering, Inc, February 2008, Preliminary assessment of potential water supplies from the Wilcox Aquifer in parts of Bexar, Guadalupe, and Wilson Counties: Prepared for the Regional Water Alliance.
[2] Ibid.

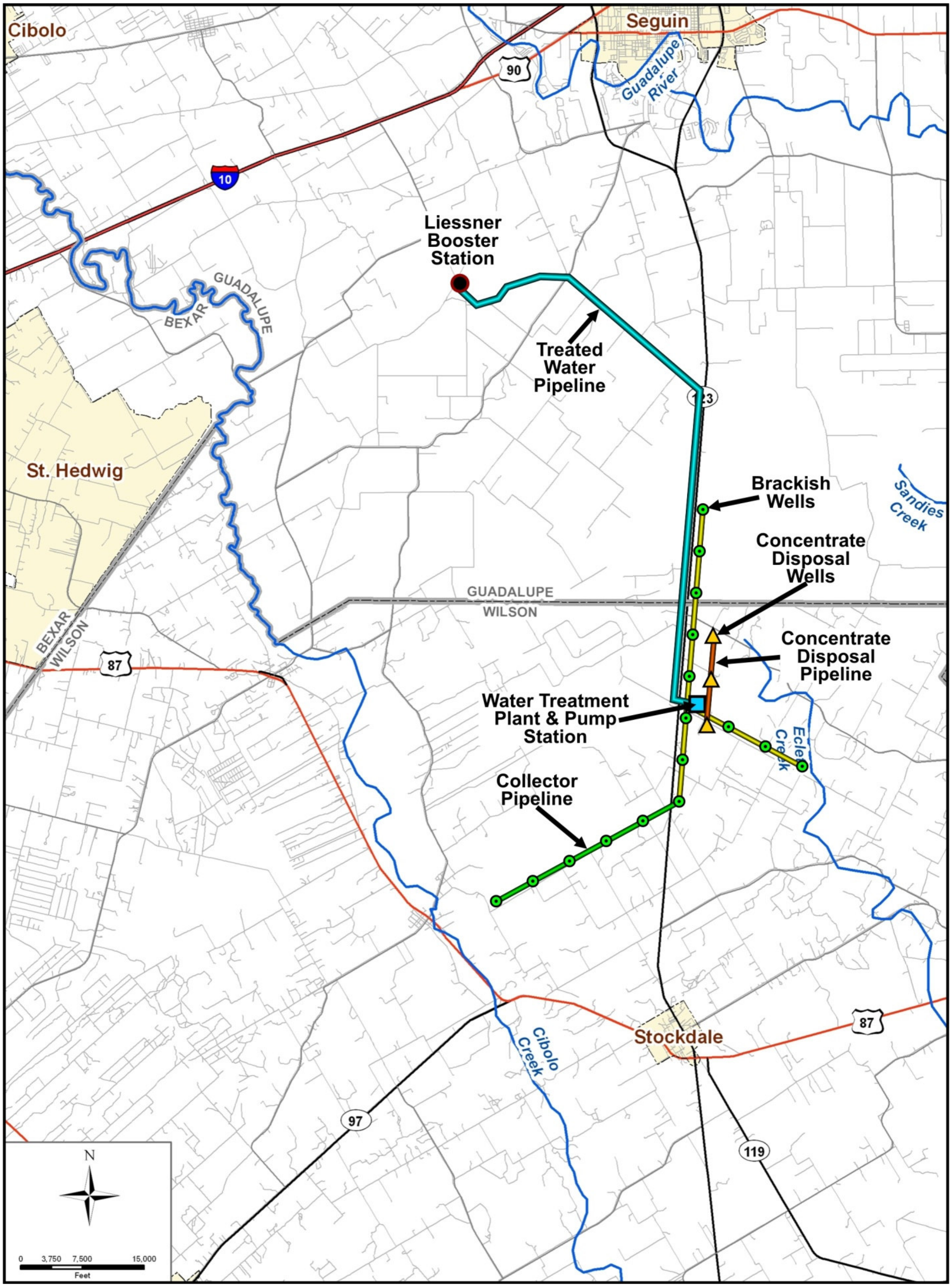


Figure 4C.24-1. Project Location for the Brackish Wilcox Groundwater for RWA

categories of water quality were summed by layer, total thickness, and middle three layers. Finally, all sand layers that were 40 ft or more thick were summed to identify the major water-bearing zones where there is a reasonably good opportunity to develop a high capacity well. In concept, the cumulative thickness of the water-bearing sands should: (1) be thicker in the confined section than the unconfined section, (2) increase with depth in the downdip direction for a limited distance, and (3) begin to thin at great depths where the Wilcox becomes more compact and saline.

An analysis of the TWDB data provided information on well depths, well yields, and several water quality parameters, including total dissolved solids, chlorides, and sulfates from existing Wilcox wells to identify any tendencies and patterns with location and well depth. These data points were largely restricted to the outcrop area of the Wilcox because, in the downdip direction, one can develop a well in the shallower Carrizo and generally get much better, higher quality water. The data suggest that well yields tend to increase with depth. The water quality data show great scatter for relatively shallow wells and more consistent values of the selected properties at moderate and deeper depths. Overall, the Wilcox consists of many strata with a wide range of water bearing and water quality properties, which is reflected in the TWDB data. For shallow, low capacity wells, common decisions of well owners and drillers are to tap the first water-bearing sand. With good luck, this first water-bearing sand was satisfactory and produced a good well with favorable water. Otherwise, the first water-bearing sand probably was relatively poor and resulted in marginal or poor water. For deeper, high capacity wells, the driller probably identified several water-bearing zones and selected the most favorable zone to develop the well. Thus, the data showing more favorable well yields and water quality conditions are believed to be representative of the potential wells where the owner and driller searched for and found a good water-bearing zone(s) rather than using aggressive well development procedures. In general, the chance of developing a good well appears to be better in areas where the potential well depth is greater than 200 ft.

Analyses and interpretations of the TCEQ oil and gas well logs provided information on the thicknesses of water-bearing sands and associated salinity. Graphics and maps were prepared to identify any tendencies and patterns of water-bearing sand thicknesses and salinity with depth. In contrast to the TWDB well data, the TCEQ oil and gas logs were concentrated in the confined section of the Wilcox instead of in the outcrop area. Because the selected logs only included those that fully penetrated the Wilcox, these data provides an opportunity to study the entire vertical section of the Wilcox, except for the upper section (generally about 100 ft) which was cased. In general, the study showed that the middle part of the Wilcox had more water-bearing sands of better quality than the upper and lower parts.

Considering the vertical distribution of the water-bearing sands and salinity, well designs are most likely to focus on the middle part of the aquifer where the water-bearing sands and favorable salinity tend to be more plentiful. A well in the middle part of the Wilcox provided considerable separation from the Carrizo, yet avoids great well depths.

The classification of potential target areas for well fields was divided into *most favorable* and *favorable* areas. The classification considers several factors, including: (1) concentration of existing wells in the Wilcox, (2) water quality, (3) potential well yields, (4) expected well depths, and (5) expected future water development by other entities. The concentration of wells in the Wilcox is assumed to generally follow TWDB's inventory of Wilcox wells. Basic water quality conditions are assumed to be represented by TWDB data and estimates of salinity are from interpretations of the TCEQ electric logs of oil and gas test holes.

As shown in Figure 4C.24-2, the *favorable* and *most favorable* areas are in a 5- to 8-mile-wide band with the northwest boundary about 1 to 2 miles southeast of the downdip limit of the Wilcox outcrop. This band extends from near the San Antonio River to about 3 miles northeast of the intersection of Texas Highway 123 and the Guadalupe-Wilson County line, which was the extent of the study area. The vicinity of the Guadalupe-Wilson County line and Hwy 123 is in the most favorable area.

Based on the TWDB well data and sand thicknesses, potential well yields in the favorable and most favorable areas are expected to be 500 to 800 and 700 to 1,000 gpm, respectively. The salinity (total dissolved solids) is expected to range between 1,000 and 1,500 mg/L in the favorable area and 800 and 1,200 mg/L for the most favorable area. The Wilcox wells are expected to be between 1,200 and 1,700 ft deep.

A determination of the estimated drawdown in the Wilcox and potential leakage from the overlying Carrizo is beyond the scope of this assessment. However, groundwater modeling of all recommended water management strategies are presented in the cumulative effects section of this report (Section 7).

4C.24.3 Environmental Issues

The primary environmental issues related to the development of the brackish groundwater from the Wilcox Aquifer in Guadalupe and Wilson Counties are the development of the well fields, brackish water treatment, integration into an existing pipeline system, and the deep well injection of brine concentrate. As stated earlier, raw water from the well field will be pumped through a collector pipeline to a desalination water treatment plant located near the

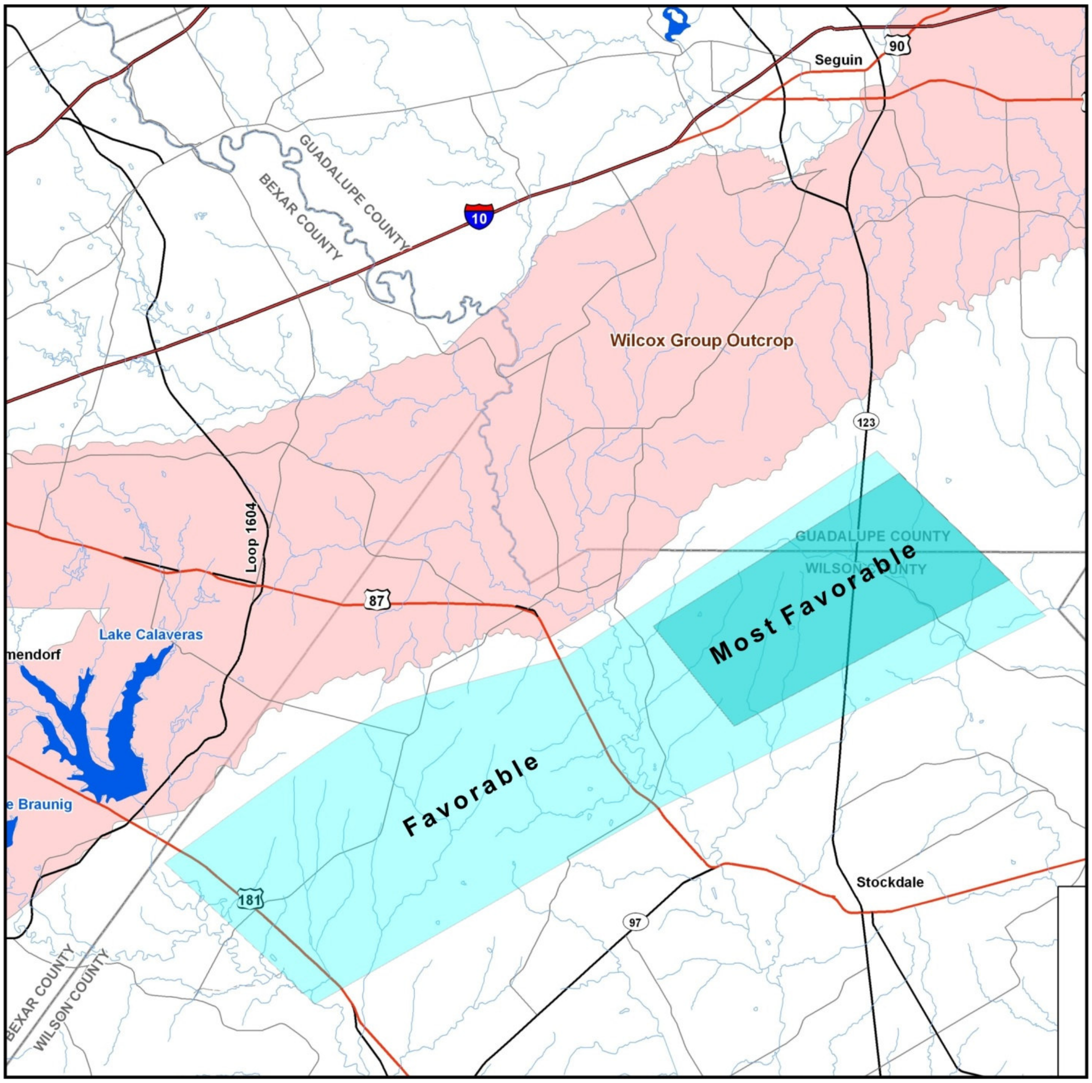


Figure 4C.24-2. Location of Favorable and Most Favorable Areas for Groundwater Development in Wilcox

intersection of TX Hwy 123 and FM 1681 which plans to use RO technology. The finished water will then be pumped through a treated water pipeline to the Wagner Booster Station which is part of the Mid-Cities distribution system.

Table 4C.24-1 lists the 21 state listed endangered and threatened species, and the 16 federally listed endangered or threatened wildlife and plant species that may occur in Bexar, Wilson, or Guadalupe Counties, according to county lists of rare species published by Texas Parks and Wildlife Department (TPWD) online in the "Annotated County Lists of Rare Species." Inclusion in Table 4C.24-1 does not mean that a species will occur within the project area, but only acknowledges the potential for occurrence in the project area counties. In addition to the county lists, the Natural Diversity Database (NDD) was reviewed for known occurrences of listed species within or near the project area. The only occurrences this database documents are several rare plant species including Parks Jointweed (*Polygonella parksii*), Big Red Sage (*Salvia penstemonoides*), and Elmendorf's Onion (*Allium elmendorfi*) near the project area.

After a review of the habitat requirements for each listed species, it is expected that this project will have no adverse effect on any federally listed threatened or endangered species, its habitat, or designated habitat, nor would it adversely affect any state endangered species. Although suitable habitat for the state threatened Texas horned lizard may exist within the project area, no impact to this species is anticipated due to the abundance of similar habit near the project area and this species' ability to relocate to those areas if necessary. The presence or absence of potential habitat does not confirm the presence or absence of a listed species. No species specific surveys were conducted in the project area for this report.

Habitat studies and surveys for protected species and cultural resources may need to be conducted at the proposed well sites and along any pipeline routes. Potential wetland impacts are expected to primarily include pipeline stream crossings, which can be minimized by right-of-way selection and appropriate construction methods, including erosion controls and revegetation procedures. Compensation for net losses of wetlands would be required where impacts are unavoidable.

A review of the Texas Historical Commission Texas Historic Sites Atlas database indicated that there are no historical markers, or National Register Properties listed within one mile of the proposed pipeline route. However this database indicates that there are three recorded cemeteries within one-half mile of the proposed pipeline. These include the Neyland Cemetery in Wilson County, and the Elm Creek and Boeker Cemeteries in Guadalupe County.

**Table 4C.24-1.
Endangered, Threatened, or Species of Concern in
Bexar, Guadalupe, and Wilson Counties**

Common Name	Scientific Name	Impact Value	Multiplier Based on Status	Adjusted Impact	Summary of Habitat Preference	Listing Entity		Potential Occurrence in County
						USFWS	TPWD	
A cave obligate crustacean	*Monodella texana*	0	1	0	Subaquatic, underground freshwater aquifers			Resident
A Ground Beetle	*Rhadine exilis*	0	3	0	Karst features in northern Bexar County	LE		Resident
A Ground Beetle	*Rhadine infernalis*	0	3	0	Karst features in northern and western Bexar County	LE		Resident
A mayfly	*Campsurus decoloratus*	0	1	0	Found in Texas and Mexico. Possibly in clay substrates.			Resident
American peregrine falcon	*Falco peregrinus anatum*	0	2	0	Migrant and local breeder in West Texas.	DL	T	Possible Migrant
Arctic peregrine falcon	*Falco peregrinus tundrius*	0	1	0	Migrant throughout the state.	DL		Possible Migrant
Big red sage	*Salvia penstemonoides*	1	1	1	Endemic; moist to seasonally wet clay or silt soils in creek beds.			Resident
Black Bear	*Ursus americanus*	0	2	0	Inhabits bottomland hardwoods	T/SA;NL	T	Historic Resident
Black-capped Vireo	*Vireo atricapillus*	0	3	0	Oak-juniper woodlands,	LE	E	Resident
Bracted twistflower	*Streptanthus bracteatus*	1	1	1	Endemic; shallow clay soils over limestone.			Resident
Braken Bat Cave Meshweaver	*Cicurina venii*	0	3	0	Karst features in western Bexar County	LE		Resident
Cagle's map turtle	*Graptemys caglei*	1	2	2	Endemic to Guadalupe River System. Found within 30 feet of waters' edge.		T	Resident
Cascade Caverns salamander	*Eurycea latitans complex*	0	2	0	Endemic, subaquatic in Edwards Aquifer Area		T	Resident
Cave Myotis Bat	*Myotis velifer*	0	1	0	Roosts colonially in caves, rock crevices			Resident
Cokendolpher cave harvestman	*Texella cokendolpheri*	0	3	0	Karst features in north-central Bexar County	LE		Resident
Comal Blind Salamander	*Eurycea tridentifera*	1	2	2	Endemic; springs and waters of caves in Bexar County.		T	Resident

Table 4C.24-1 (Continued)

Common Name	Scientific Name	Impact Value	Multiplier Based on Status	Adjusted Impact	Summary of Habitat Preference	Listing Entity		Potential Occurrence in County
						USFWS	TPWD	
Correll's false dragon-head	*Physostegia correllii*	1	1	1	Wet soils including roadside ditches and irrigation channels.			Resident
Creeper (squawfoot)	*Strophitus undulates*	1	1	1	Small to large streams			Resident
Elmendorf's onion	*Allium elmendorfii*	2	1	2	Endemic, in deep sands			Resident
False spike mussel	*Quincuncina mitchelli*	1	2	2	Substrates of cobble and mud with water lilies present. Rio Grande, Brazos, Colorado and Guadalupe river basins.		T	Resident
Golden orb	*Quadrula aurea*	1	2	2	Sand and gravel, Guadalupe, San Antonio, and Nueces River basins		T	Resident
Golden-cheeked Warbler	*Dendroica chrysoparia*	0	3	0	Juniper-oak woodlands.	LE	E	Resident
Ghost-faced bat	*Mormoops megalophylla*	0	1	0	Roosts in caves, crevices and buildings			Resident
Government Canyon Bat Cave Meshweaver	*Cicurina vespera*	0	3	0	Karst features in northwestern Bexar County	LE		Resident
Government Canyon Bat Cave Spider	*Neoleptoneta microps*	0	3	0	Karst features in northwestern Bexar County	LE		Resident
Gray wolf	*Canis lupus*	0	3	0	Extirpated, forests, brushlands or grasslands	LE	E	Historic resident
Guadalupe Bass	*Micropterus treculi*	1	1	1	Endemic to perennial streams of the Edwards Plateau region.			Resident
Guadalupe Darter	*Percina sciera apristis*	0	1	0	Guadalupe River Basin. Usually found over gravel or gravel and sand raceways of larger streams and rivers.			Resident
Helotes Mold Beetle	*Batrisodes venyivi*	0	3	0	Karst features in northwestern Bexar County	LE		Resident
Hill Country wild-mercury	*Argythamnia aphoroides*	1	1	1	Shallow clays over limestone			Resident
Indigo snake	*Drymarchon corais*	1	2	2	Dense riparian corridors		T	Resident
Interior least tern	*Sterna antillarum athalassos*	0	3	0	Nests along sand and gravel bars in braided streams	LE	E	Resident

Table 4C.24-1 (Continued)

Common Name	Scientific Name	Impact Value	Multiplier Based on Status	Adjusted Impact	Summary of Habitat Preference	Listing Entity		Potential Occurrence in County
						USFWS	TPWD	
Madla Cave Meshweaver	*Cicurina madla*	0	3	0	Karst features in northern Bexar County	LE		Resident
Manfreda Giant-skipper	*Stallingsia maculosus*	1	1	1	Skipper larvae usually feed inside a leaf shelter.			Resident
Mimic Cavesnail	*Phreatodrobia imitata*	1	1	1	Subaquatic; only known from two wells penetrating the Edwards Aquifer			Resident
Mountain Plover	*Charadrius montanus*	0	1	0	Non-breeding, shortgrass plains and fields			Nesting/Migrant
Park's jointweed	*Polygonella parksii*	2	1	2	Endemic; deep loose sands of Carrizo and similar Eocene formations.			Resident
Peregrine Falcon	*Falco peregrinus*	0	2	0	Migrates across the state from northern breeding areas.	DL	T	Possible Migrant
Pistolgrip	*Tritogonia verrucosa*	1	1	1	Aquatic, stable substrate. Red through San Antonio river basins.			Resident
Plains Spotted Skunk	*Spilogale putorius interrupta*	2	1	2	Prefers wooded, brushy areas.			Resident
Rawson's metalmark	*Calephelis rawsoni*	1	1	1	Moist areas in shaded limestone outcrops			Resident
Red Wolf	*Canis rufus*	0	3	0	Extirpated.	LE	E	Historic Resident
Robber Baron Cave Meshweaver	*Cicurina baronia*	0	3	0	Karst features in north-central Bexar County	LE		Resident
Rock pocketbook	*Arcidens confragosus*	1	1	1	Mud and sand, Red through Guadalupe River basins.			Resident
Sandhill woolywhite	*Hymenopappus carrizoanus*	2	1	2	Endemic; open areas in deep sands derived from Carrizo and similar Eocene formations.			Resident
Spot-tailed earless lizard	*Holbrookia lacerata*	1	1	1	Moderately open prairie-brushland.			Resident
Texas fatmucket	*Lampsilis bracteata*	1	1	1	Streams and rivers on sand, mud and gravel, Colorado and Guadalupe River basins.			Resident
Texas Garter Snake	*Thamnophis sirtalis annectens*	1	1	1	Wet or moist microhabitats			Resident

Table 4C.24-1 (Concluded)

Common Name	Scientific Name	Impact Value	Multiplier Based on Status	Adjusted Impact	Summary of Habitat Preference	Listing Entity		Potential Occurrence in County
						USFWS	TPWD	
Texas Horned Lizard	*Phrynosoma cornutum*	1	2	2	Varied, sparsely vegetated uplands.		T	Resident
Texas pimpleback	*Quadrula petrina*	1	1	1	Mud, gravel and sand substrates, Colorado and Guadalupe river basins			Resident
Texas Salamander	*Eurycea neotenes*	1	1	1	Endemic; springs, seeps, cave streams, Helotes and Leon Creek drainages in Bexar County			Resident
Texas Tortoise	*Gopherus berlandieri*	1	2	2	Open brush w/ grass understory.		T	Resident
Timber/Canebrake Rattlesnake	*Crotalus horridus*	1	2	2	Floodplains, upland pine, deciduous woodlands, riparian zones.		T	Resident
Toothless Blindcat	*Trogloglanis pattersoni*	0	2	0	Troglobitic, blind catfish endemic to the San Antonio Pool of the Edwards Aquifer		T	Resident
Western Burrowing Owl	*Athene cunicularia hypugaea*	1	1	1	Open grasslands, especially prairie, plains and savanna			Resident
White-faced Ibis	*Plegadis chihi*	0	2	0	Prefers freshwater marshes.		T	Resident
Whooping Crane	*Grus americana*	0	3	0	Potential migrant	LE	E	Potential Migrant
Widemouth Blindcat	*Satan eurystomus*	0	2	0	Troglobitic, blind catfish endemic to the San Antonio Pool of the Edwards Aquifer.		T	Resident
Wood Stork	*Mycteria americana*	0	2	0	Forages in prairie ponds, ditches, and shallow standing water formerly nested in TX		T	Migrant
Zone-tailed Hawk	*Buteo albonotatus*	0	2	0	Arid open country, often near watercourses		T	Resident

Source: TPWD, Annotated County List of Rare Species, Bexar County, Guadalupe County, and Wilson County. All lists updated April 1, 2009.

LE/LT = Federally Listed Endangered/Threatened
DL, PDL = Federally Delisted/Proposed for Delisting
T/SA = Listed as Threatened by Similarity of Appearance
E, T = State Listed Endangered/Threatened
Blank = Rare, but no regulatory listing status

4C.24.4 Engineering and Costing

The planned site of the well field is along the east side of TX Hwy 123 and straddles the Guadalupe-Wilson County line. The wells would be spaced about a mile apart. The desalination water treatment plant, disposal well for the concentrate, and booster station would be located near the intersection of TX Hwy 123 and FM 1681. A raw water collector pipeline from three pipeline spurs would deliver brackish Wilcox water from the wells to the water treatment plant. Water treatment will consist of pretreatment and desalination. A treated water pipeline would deliver water to the Liessner Booster Station. A concentrate water pipeline would deliver reject water to a ground storage tank. A small pump and a pipeline will transport the concentrate to disposal well field with three deep injection wells. The system is designed to provide an annual average 13.1 MGD and a peak demand of 17.1 MGD.

Based on the results from the earlier study and for planning purposes, a typical Wilcox well in this locale is expected to be about 1,500 ft deep, yield about 800 gpm, and produce water with a total dissolved solids (TDS) concentration of about 1,200 mg/L.

The engineering and costing analysis for Brackish Wilcox Groundwater for RWA project includes all facilities required for water production from the Wilcox Aquifer in Wilson County, including wells, collector pipeline, water treatment, treated water pipeline and pump stations, and disposal of concentrate. The well field consists of 21 brackish water supply wells, 20 miles of collector pipelines with diameters ranging from 12 to 24 inches. Water treatment will consist of pretreatment and desalination. Pretreatment will include filtration and possibly other processes to remove particulates such as iron or manganese and to condition the water for optimal desalination. Desalination treatment is expected to be by Reverse Osmosis (RO). The treated water facilities consists of a 14.6-mile transmission pipeline with a diameter of 30 inches, a pump station and booster station and a ground storage tank at each station, and integration into the Liessner Booster Station. Concentrate disposal wells, ground storage tank, pipelines and facilities are planned near the water treatment plant. The target disposal of the concentration will be deep well injection into depleted or partially depleted oil and gas producing reservoirs (Austin Chalk or Edwards Limestone).

The required secondary Maximum Contaminant Level (MCL) for TDS is 1,000 mg/L. The design of the water treatment facilities is to produce potable water with a TDS concentration of about 400-450 mg/L. The preliminary water treatment design includes: (1) Pretreatment of all raw water, (2) about 65 percent of this water will be sent to the desalination water treatment plant, and (3) the remaining 35 percent of this water will be blended with the desalinated water. The desalination plant recovery rate using conventional RO with raw water having a TDS of about 1,200 mg/Lis 80 percent, meaning that 80 percent of the water entering the desalination plant becomes purified water and 20 percent of the water remains as concentrated brine. The desalinated water and the treated brackish water are blended to produce treated water with a TDS of about 420 mg/L, which is reasonably consistent with water currently being used by the customers in the area. This process converts about 86 percent of the quantity of raw water produced from the well field into potable water. The remaining 14 percent is a concentrate and is discharged to a deep injection well.

Cost estimates were computed for capital costs, annual debt service, operation and maintenance, power, land, and environmental mitigation for seasonal and peak day demands. These costs are summarized in Table 4C.24-2. Treatment costs are for removal of iron, manganese, and desalination. The project costs, including capital, are estimated to be $127,753,000. As shown, the annual costs, including debt service, operation and maintenance, power, and groundwater leases, are estimated to be $19,014,000. This water management strategy produces potable water at an estimated cost of $1,293 per acft/yr ($3.97 per 1,000 gallons).

As shown in Table 4C.24-3, the project costs were assigned to WUGs and WWPs based on the percent of the total project yield that they were expected to utilize.

4C.24.5 Implementation Issues

Part or all of the water needed by this Water Management Strategy (WMS) is anticipated to be supplied from locations within the jurisdiction of a groundwater conservation district (District) and may exceed the amount of available water identified in the District's approved management plan, or may for other reasons not be permitted by the District.

The amount of water needed by this WMS that exceeds the available water in the District's management plan, or for other reasons is not permitted by the District, cannot be implemented as part of this WMS unless and until all necessary permits are received from the District.

The amount of water needed by this WMS that exceeds the available water in the District's management plan, or for other reasons is not permitted by the District, introduces an added element of uncertainty to reliance upon this WMS and, therefore, additional management supplies may be needed for this WMS.

Table 4.C.24-2. Cost Estimate Summary Brackish Wilcox Groundwater for Regional Water Alliance (13.1 MGD Project)

Sept 2008 Prices

Item	*Estimated Costs for Facilities*
Treated Water Pump Stations (17.1 MGD)	$4,988,000
Treated Water Transmission Facilities (Pipeline: 30 in dia., 14.7 mi long)	$12,663,000
Concentrate Pump Station and Storage (2.8 MGD)	$2,331,000
Well Fields and Collector Pipelines [Raw Water (21) and Conc. (6)]	$41,389,000
Water Treatment Plants (Pretreatment and Desalination)	$25,096,000
Total Capital Cost	**$86,467,000**
Engineering, Legal Costs and Contingencies	$29,631,000
Environmental & Archaeology Studies and Mitigation	$1,120,000
Land Acquisition (118 acres) and Surveying	$1,071,000
Interest During Construction (2 years)	$9,464,000
Total Project Cost	**$127,753,000**
Annual Costs	
Debt Service (6 percent, 20 years)	$11,138,000
Operation and Maintenance	
Pipelines and Pump Stations	$689,000
Water Treatment Plants	$5,077,000
Pumping Energy Costs (14,509,587 kW-hr @ 0.09 $/kW-hr)	$1,306,000
Evergreen UWCD and Guadalupe Co GCD Fees	$120,000
Purchase of Brackish Groundwater ($40/acft)	$684,000
Total Annual Cost	**$19,014,000**
Available Project Yield (acft/yr)	14,700
Annual Cost of Water ($ per acft)	$1,293
Annual Cost of Water ($ per 1,000 gallons)	$3.97

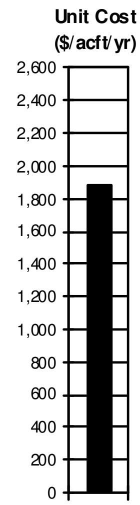
Table 4C.24-3.
Project Cost Assigned to WUGs/WWPs
Brackish Wilcox Groundwater for Regional Water Alliance (13.1 MGD Project)

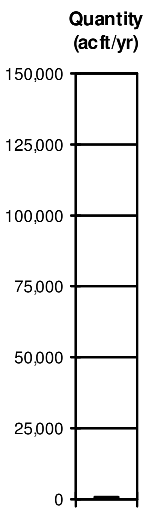
WUG/WWP	Year 2060 Supply from Project (acft/yr)	% of Total Supply	Project Costs Assigned to WUG/WWP
Canyon Regional Water Authority	11,200	76.2%	$97,347,786
Schertz-Seguin LGC	2,000	13.6%	$17,374,408
Springs Hill WSC	1,500	10.2%	$13,030,806

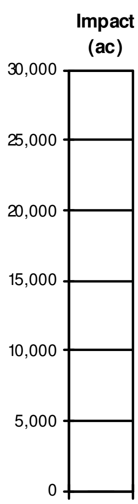
Implementation of the Brackish Wilcox Groundwater for RWA water management strategy includes the following issues:

- Verification of available groundwater quantity and well productivity;
- Verification of water quality for concentrations of dissolved constituents, such as TDS, chloride, sulfate, iron, manganese and hydrogen sulfide;
- Verification of minimal impacts to Carrizo;
- Verification of the potential for deep well injection of concentrate;
- Permitting Class I disposal well for deep well injection of desalination concentrate;
- Regulations by TCEQ;
- Regulations by the Evergreen Underground Water Conservation District and Guadalupe County Groundwater Conservation District;
- Verification that desalinated Wilcox Aquifer water is compatible with other water sources being used by customers and will meet all water quality requirements in the end user's distribution system; and
- Experience in operating and maintaining a desalination water treatment plant.

2011 South Central Texas Regional Water Plan
Water Management Strategy Summary Sheet







Name: Brackish Wilcox Groundwater for SS Water Supply Corporation

Description:

The strategy includes developing a brackish groundwater supply from the Wilcox Aquifer in Wilson County for the SS Water Supply Corporation (SSWSC). It is designed to produce an average annual water supply of 1.0 million gallons per day (MGD) and a peak demand of 2.0 MGD. The project's facilities are planned to be located in the vicinity of SSWSC's Sutherland Springs Road Plant, which is located about 3 miles west-northwest of the town of Sutherland Springs. The facilities include Wilcox Aquifer wells to provide a brackish groundwater supply, water treatment plant for pretreatment and desalination, delivery of treated water to the existing distribution system, and concentrate disposal to deep injection wells.

This strategy is related to a preliminary assessment of potential brackish groundwater supplies from the Wilcox Aquifer in a target area that is generally a 10- to 20-mile-wide band that is south of Interstate 10 and between Loop 410 and Seguin.

***Decade Needed*:** 2030 – 2040

Cost, Quantity of Water, and Land Impacted

Unit Cost of Water:	**$1,883**	**$/acft/yr**	**Treated Water Delivered**
Quantity of Water:	**1,120**	**acft/yr**	**Reliability = Firm**
Land Impacted:	**31**	**acres**	

Additional Considerations per Regional Water Planning Guidelines

Environmental Factors:

None.

Impacts on Water Resources:

The wells would be developed in the deep,confined section of the Wilcox, which is substantially removed from the outcrop area. There is concern about the possibility of interaction between the Wilcox and Carrizo layers of the Carrizo-Wilcox Aquifer. If the interaction is significant, pumping the Wilcox is likely to cause downward leakage of Carrizo water into the Wilcox and cause some long-term lowering of water levels in the Carrizo

Impacts on Agricultural & Natural Resources:

Minimal impacts anticipated.

Other Relevant Factors per SCTRWPG:

Part or all of the water needed by this Water Management Strategy (WMS) is anticipated to be supplied from locations within the jurisdiction of a groundwater conservation district (District) and may exceed the amount of available water identified in the District's approved management plan, or may for other reasons not be permitted by the District. The amount of water needed by this WMS that exceeds the available water in the District's management plan, or for other reasons is not permitted by the District, cannot be implemented as part of this WMS unless and until all necessary permits are received from the District. The amount of water needed by this WMS that exceeds the available water in the District's management plan, or for other reasons is not permitted by the District, introduces an added element of uncertainty to reliance upon this WMS and, therefore, additional management supplies may be needed for this WMS.

Comparison of Strategies to Meet Needs:

Cost estimates indicate that this strategy is moderate to high in cost.

Interbasin Transfer Issues:

None.

Third-Party Impacts of Voluntary Transfers:

None anticipated.

Regional Efficiency:

Location of well field is proximate to existing WTP and distribution facilities.

Water Quality Considerations:

The salinity (total dissolved solids) is expected to range between 1,000 and 1,500 mg/L .Concentrate disposal would be to a deep and depleted or partially depleted oil and gas reservoir.

4C.25 Brackish Wilcox Groundwater for SS Water Supply Corporation

4C.25.1 Description of Water Management Strategy

The Brackish Wilcox Groundwater for SS Water Supply Corporation (SSWSC) water management strategy includes developing a brackish groundwater supply from the Wilcox Aquifer in Wilson County for the SSWSC. It is designed to produce an average annual water supply of 1.0 MGD and a peak demand of 2.0 MGD. The project's facilities are planned to be located in the vicinity of SSWSC's Sutherland Springs Road Plant, which is located about 3 miles west-northwest of the town of Sutherland Springs. The facilities include Wilcox Aquifer wells to provide a brackish groundwater supply, water treatment plant for pretreatment and desalination, delivery of treated water to the existing distribution system, and concentrate disposal to deep injection wells. The location of the project is shown in Figure 4C.25-1.

This strategy builds on a preliminary assessment of potential brackish groundwater supplies from the Wilcox Aquifer in a target area that is generally a 10- to 20-mile-wide band that is south of Interstate 10 and between Loop 410 and Seguin[1]. The study and a summary of the findings are briefly discussed in the following section.

4C.25.2 Available Yield

HDR conducted a study[2] to identify the *favorable* and *most favorable* areas for a brackish water wells in the Wilcox Aquifer. More specifically, the study identified trends and patterns of well yields, total dissolved solids, chlorides, and sulfates with well depth in the target area. The study relied on TWDB well data and TCEQ oil and gas well logs.

An analysis of the TCEQ logs identified water-bearing sands and categorized the water quality characteristics into (1) saline, brackish, and fresh, (2) brackish and fresh, or (3) fresh. A summary of the occurrence of water-bearing sands and salinity with depth were delineated into five layers within the Wilcox. In the outcrop area, the layers were 200 ft thick. In the confined section, the data are divided into five evenly divided layers. The sand thicknesses for the three categories of water quality were summed by layer, total thickness, and middle three layers. Finally, all sand layers that were 40 ft or more thick were summed to identify the major water-

[1] HDR Engineering, Inc, February 2008, Preliminary assessment of potential water supplies from the Wilcox Aquifer in parts of Bexar, Guadalupe, and Wilson Counties: Prepared for San Antonio River Authority.
[2] Ibid.

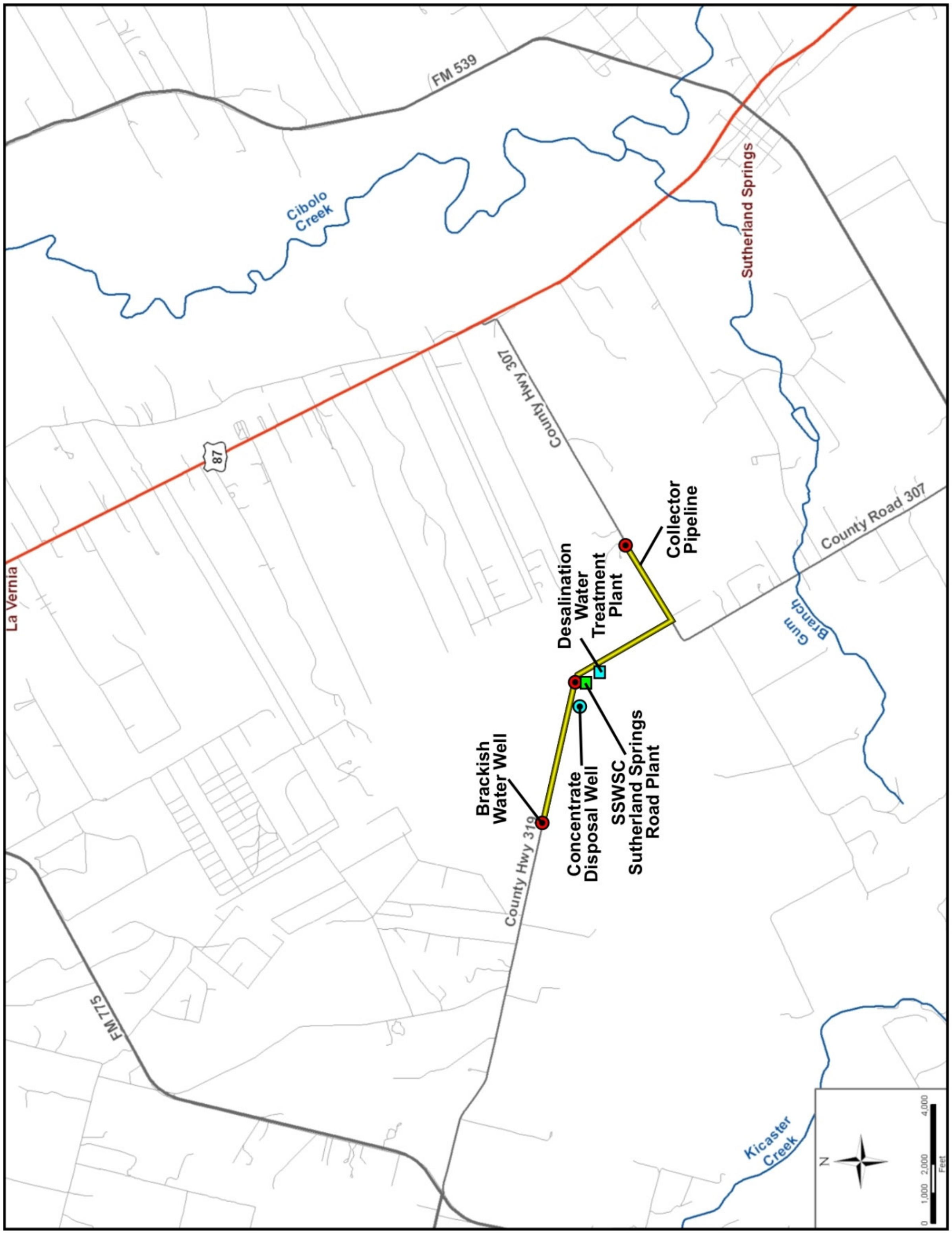


Figure 4C.25-1. Project Location

bearing zones where there is a reasonably good opportunity to develop a high capacity well. In concept, the cumulative thickness of the water-bearing sands should: (1) be thicker in the confined section than the unconfined section, (2) increase with depth in the downdip direction for a limited distance, and (3) begin to thin at great depths where the Wilcox becomes more compact and saline.

An analysis of the TWDB data provided information on well depths, well yields, and several water quality parameters, including total dissolved solids, chlorides, and sulfates from existing Wilcox wells to identify any tendencies and patterns with location and well depth. These data points were largely restricted to the outcrop area of the Wilcox because, in the downdip direction, one can develop a well in the shallower Carrizo and generally get much better, higher quality water. The data suggest that well yields tend to increase with depth. The water quality data show great scatter for relatively shallow wells and more consistent values of the selected properties at moderate and deeper depths. Overall, the Wilcox consists of many strata with a wide range of water bearing and water quality properties, which is reflected in the TWDB data. For shallow, low capacity wells, common decisions of well owners and drillers are to tap the first water-bearing sand. With good luck, this first water-bearing sand was satisfactory and produced a good well with favorable water. Otherwise, the first water-bearing sand probably was relatively poor and resulted in marginal or poor water. For deeper, high capacity wells, the driller probably identified several water-bearing zones and selected the most favorable zone to develop the well. Thus, the data showing more favorable well yields and water quality conditions are believed to be representative of the potential wells where the owner and driller searched for and found a good water-bearing zone(s) rather than using aggressive well development procedures. In general, the chance of developing a good well appears to be better in areas where the potential well depth is greater than 200 ft.

Considering the vertical distribution of the water-bearing sands and salinity, well designs are most likely to focus on the middle part of the aquifer where the water-bearing sands and favorable salinity tend to be more plentiful. A well in the middle part of the Wilcox provided considerable separation from the Carrizo, yet avoids great well depths.

The classification of potential target areas for well fields was divided into *most favorable* and *favorable* areas. The classification considers several factors, including: (1) concentration of existing wells in the Wilcox, (2) water quality, (3) potential well yields, (4) expected well depths, and (5) expected future water development by other entities. The concentration of wells in the

Wilcox is assumed to generally follow TWDB's inventory of Wilcox wells. Basic water quality conditions are assumed to be represented by TWDB data and estimates of salinity are from interpretations of the TCEQ electric logs of oil and gas test holes.

The classification of potential target areas for well fields was divided into *most favorable* and *favorable* areas. The classification considers several factors, including: (1) concentration of existing wells in the Wilcox, (2) water quality, (3) potential well yields, (4) expected well depths, and (5) expected future water development by others. The concentration of wells in the Wilcox is assumed to generally follow TWDB's inventory of Wilcox wells. Basic water quality conditions are assumed to be represented by TWDB data and estimates of salinity are from interpretations of the TCEQ electric logs of oil and gas test holes.

As shown in Figure 4C.25-2, the *favorable* and *most favorable* areas are in a 5- to 8-mile-wide band with the northwest boundary about 1 to 2 miles southeast of the downdip limit of the Wilcox outcrop. This band extends from near the San Antonio River to about 3 miles northeast of the intersection of Texas Highway 123 and the Guadalupe-Wilson County line, which was the extent of the study area. The vicinity of the Guadalupe-Wilson County line and Hwy 123 is in the most favorable area.

Based on the TWDB well data and sand thicknesses, potential well yields in the favorable and most favorable areas are expected to be 500 to 800 and 700 to 1,000 gpm, respectively. The salinity (total dissolved solids) is expected to range between 1,000 and 1,500 mg/L in the favorable area and 800 and 1,200 mg/L for the most favorable area. The Wilcox wells are expected to be between 1,200 and 1,700 ft deep. As shown in Figure 4C.25-2, the planned location of the Wilcox wells is in the favorable, but near the most favorable areas. At this location, analyses of nearby oil and gas logs suggest: (1) a well depth of about 1,100 ft, (2) 350-375 ft of sands in the middle Wilcox that contain either fresh or brackish water, and (3) well yields of about 750 gpm.

A determination of the estimated drawdown in the Wilcox and potential leakage from the overlying Carrizo is beyond the scope of this assessment. However, groundwater modeling of all recommended water management strategies is presented in the cumulative effects section of this report (Section 7).

4C.25.3 Environmental Issues

The primary environmental issues related to the development of brackish groundwater from the Wilcox Aquifer in Guadalupe and Wilson Counties are the development of the well fields including pipeline systems, brackish water treatment, and integration into the existing pipeline system, and the deep well injection of brine concentrate. Raw water produced by the well field will be piped through a raw water collector pipeline to a desalination facility located adjacent to the existing Southerland Springs Water Supply Corp water treatment plant. After treatment, the finished water will then be pumped through an existing water pipeline to be distributed to participating water utilities. Disposal of the brine concentrate will be by injection into a deep well located near the brackish water well field.

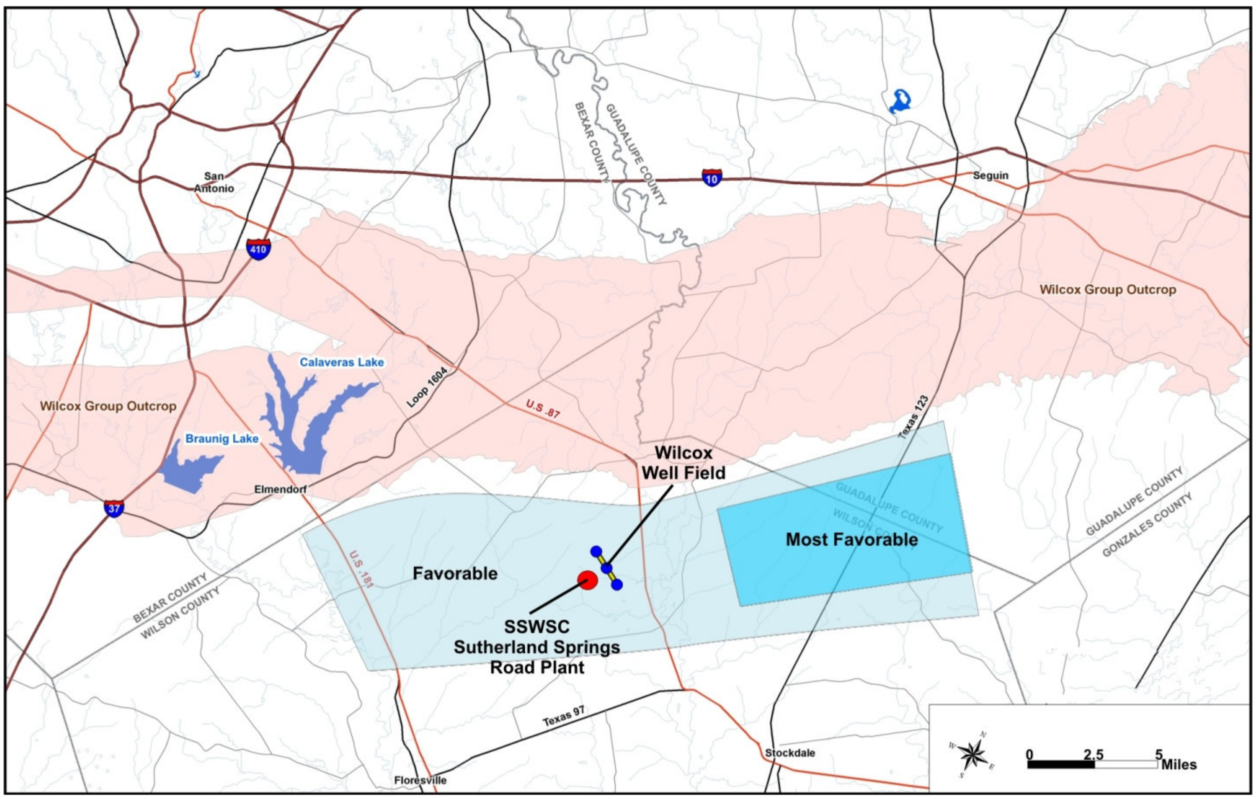


Figure 4C.25-2. Selected Locations for Groundwater Development in Wilcox and Location of Proposed Well Field

Table 4C.25-1 lists the 21 state listed endangered and threatened species, and the 16 federally listed endangered or threatened wildlife and plant species that may occur in Bexar, Wilson, or Guadalupe Counties, according to county lists of rare species published by Texas Parks and Wildlife Department (TPWD) online. Inclusion in Table 4C.25-1 does not mean that a species will occur within the project area, but only acknowledges the potential for occurrence in the three project area counties. In addition to the county lists, the TPWD Natural Diversity Database (NDD) was reviewed for known occurrences of any federal or state listed species found within or near the project area. This database documented no endangered or threatened species, however three rare plant species: Parks Jointweed (Polygonella parksii), Big Red Sage (Salvia penstemonoides), and Elmendorf's Onion (Allium elmendorfi) were listed within five miles of the project area.

Table 4C.25-1.
Endangered, Threatened, and Species of Concern in Bexar, Guadalupe, and Wilson Counties

Common Name	Scientific Name	Impact Value	Multiplier Based on Status	Adjusted Impact	Summary of Habitat Preference	Listing Entity		Potential Occurrence in County
						USFWS	TPWD	
A cave obligate crustacean	*Monodella texana*	0	1	0	Subaquatic, underground freshwater aquifers			Resident
A Ground Beetle	*Rhadine exilis*	0	3	0	Karst features in northern Bexar County	LE		Resident
A Ground Beetle	*Rhadine infernalis*	0	3	0	Karst features in northern and western Bexar County	LE		Resident
A mayfly	*Campsurus decoloratus*	0	1	0	Found in Texas and Mexico. Possibly in clay substrates.			Resident
American Peregrine Falcon	*Falco peregrinus anatum*	0	2	0	Resident and local breeder in West Texas. Migrant across the state.	DL	T	Possible Migrant
Arctic peregrine falcon	*Falco peregrinus tundrius*	0	1	0	Migrant throughout the state.	DL		Possible Migrant
Big red sage	*Salvia penstemonoides*	2	1	2	Endemic; moist to seasonally wet clay or silt soils in creek beds.			Resident
Black Bear	*Ursus americanus*	0	2	0	Inhabits bottomland hardwoods	T/SA;NL	T	Historic Resident
Black-capped Vireo	*Vireo atricapillus*	0	3	0	Oak-juniper woodlands,	LE	E	Resident
Bracted twistflower	*Streptanthus bracteatus*	1	1	1	Endemic; shallow clay soils over limestone.			Resident
Braken Bat Cave Meshweaver	*Cicurina venii*	0	3	0	Karst features in western Bexar County	LE		Resident
Cagle's map turtle	*Graptemys caglei*	1	2	2	Endemic to Guadalupe River System. Found within 30 feet of waters' edge.		T	Resident
Cascade Caverns salamander	*Eurycea latitans complex*	1	2	2	Endemic, subaquatic in Edwards Aquifer Area		T	Resident

Table 4C.25-1 (Continued)

Common Name	Scientific Name	Impact Value	Multiplier Based on Status	Adjusted Impact	Summary of Habitat Preference	Listing Entity		Potential Occurrence in County
						USFWS	TPWD	
Cave Myotis Bat	*Myotis velifer*	0	1	0	Roosts colonially in caves, rock crevices			Resident
Cokendolpher cave harvestman	*Texella cokendolpheri*	0	3	0	Karst features in north-central Bexar County	LE		Resident
Comal Blind Salamander	*Eurycea tridentifera*	0	2	0	Endemic; springs and waters of caves in Bexar County.		T	Resident
Correll's false dragon-head	*Physostegia correllii*	1	1	1	Wet soils including roadside ditches and irrigation channels.			Resident
Creeper (squawfoot)	*Strophitus undulates*	1	1	1	Small to large streams			Resident
Elmendorf's onion	*Allium elmendorfii*	2	1	2	Endemic, in deep sands			Resident
False spike mussel	*Quincuncina mitchelli*	1	2	2	Substrates of cobble and mud with water lilies present. Rio Grande, Brazos, Colorado and Guadalupe river basins.		T	Resident
Golden orb	*Quadrula aurea*	1	2	2	Sand and gravel, Guadalupe, San Antonio, and Nueces River basins		T	Resident
Golden-cheeked Warbler	*Dendroica chrysoparia*	0	3	0	Juniper-oak woodlands.	LE	E	Resident
Ghost-faced bat	*Mormoops megalophylla*	0	1	0	Roosts in caves, crevices and buildings			Resident
Government Canyon Bat Cave Meshweaver	*Cicurina vespera*	0	3	0	Karst features in northwestern Bexar County	LE		Resident
Government Canyon Bat Cave Spider	*Neoleptoneta microps*	0	3	0	Karst features in northwestern Bexar County	LE		Resident
Gray wolf	*Canis lupus*	0	3	0	Extirpated, forests, brushlands or grasslands	LE	E	Historic resident
Guadalupe Bass	*Micropterus treculi*	1	1	1	Endemic to perennial streams of the Edwards Plateau region.			Resident
Guadalupe Darter	*Percina sciera apristis*	1	1	1	Guadalupe River Basin. Usually found over gravel or gravel and sand raceways of larger streams and rivers.			Resident
Helotes Mold Beetle	*Batrisodes venyivi*	0	3	0	Karst features in northwestern Bexar County	LE		Resident
Hill Country wild-mercury	*Argythamnia aphoroides*	1	1	1	Shallow clays over limestone			Resident

Table 4C.25-1 (Continued)

Common Name	Scientific Name	Impact Value	Multiplier Based on Status	Adjusted Impact	Summary of Habitat Preference	Listing Entity: USFWS	Listing Entity: TPWD	Potential Occurrence in County
Indigo snake	*Drymarchon corais*	1	2	2	Dense riparian corridors		T	Resident
Interior least tern	*Sterna antillarum athalassos*	0	3	0	Nests along sand and gravel bars in braided streams	LE	E	Resident
Madla Cave Meshweaver	*Cicurina madla*	0	3	0	Karst features in northern Bexar County	LE		Resident
Manfreda Giant-skipper	*Stallingsia maculosus*	1	1	1	Skipper larvae usually feed inside a leaf shelter.			Resident
Mimic Cavesnail	*Phreatodrobia imitata*	0	1	0	Subaquatic; only known from two wells penetrating the Edwards Aquifer			Resident
Mountain Plover	*Charadrius montanus*	0	1	0	Non-breeding, shortgrass plains and fields			Nesting/Migrant
Park's jointweed	*Polygonella parksii*	2	1	2	Endemic; deep loose sands of Carrizo and similar Eocene formations.			Resident
Peregrine Falcon	*Falco peregrinus*	0	2	0	Migrates across the state from northern breeding areas.	DL	T	Possible Migrant
Pistolgrip	*Tritogonia verrucosa*	1	1	1	Aquatic, stable substrate. Red through San Antonio river basins.			Resident
Plains Spotted Skunk	*Spilogale putorius interrupta*	2	1	2	Prefers wooded, brushy areas.			Resident
Rawson's metalmark	*Calephelis rawsoni*	1	1	1	Moist areas in shaded limestone outcrops			Resident
Red Wolf	*Canis rufus*	0	3	0	Extirpated.	LE	E	Historic Resident
Robber Baron Cave Meshweaver	*Cicurina baronia*	0	3	0	Karst features in north-central Bexar County	LE		Resident
Rock pocketbook	*Arcidens confragosus*	1	1	1	Mud and sand, Red through Guadalupe River basins.			Resident
Sandhill woolywhite	*Hymenopappus carrizoanus*	2	1	2	Endemic; open areas in deep sands derived from Carrizo and similar Eocene formations.			Resident
Spot-tailed earless lizard	*Holbrookia lacerata*	1	1	1	Moderately open prairie-brushland.			Resident
Texas fatmucket	*Lampsilis bracteata*	1	2	2	Streams and rivers on sand, mud and gravel, Colorado and Guadalupe River basins.		T	Resident

Table 4C.25-1 (Concluded)

Common Name	Scientific Name	Impact Value	Multiplier Based on Status	Adjusted Impact	Summary of Habitat Preference	Listing Entity		Potential Occurrence in County
						USFWS	TPWD	
Texas Garter Snake	*Thamnophis sirtalis annectens*	1	1	1	Wet or moist microhabitats			Resident
Texas Horned Lizard	*Phrynosoma cornutum*	1	2	2	Varied, sparsely vegetated uplands.		T	Resident
Texas pimpleback	*Quadrula petrina*	1	2	2	Mud, gravel and sand substrates, Colorado and Guadalupe river basins		T	Resident
Texas Salamander	*Eurycea neotenes*	0	1	0	Endemic; springs, seeps, cave streams, Helotes and Leon Creek drainages in Bexar County			Resident
Texas Tortoise	*Gopherus berlandieri*	1	2	2	Open brush w/ grass understory.		T	Resident
Timber/Canebrake Rattlesnake	*Crotalus horridus*	1	2	2	Floodplains, upland pine, deciduous woodlands, riparian zones.		T	Resident
Toothless Blindcat	*Trogloglanis pattersoni*	0	2	0	Troglobitic, blind catfish endemic to the San Antonio Pool of the Edwards Aquifer		T	Resident
Western Burrowing Owl	*Athene cunicularia hypugaea*	1	1	1	Open grasslands, especially prairie, plains and savanna			Resident
White-faced Ibis	*Plegadis chihi*	0	2	0	Prefers freshwater marshes.		T	Resident
Whooping Crane	*Grus americana*	0	3	0	Potential migrant	LE	E	Potential Migrant
Widemouth Blindcat	*Satan eurystomus*	0	2	0	Troglobitic, blind catfish endemic to the San Antonio Pool of the Edwards Aquifer.		T	Resident
Wood Stork	*Mycteria americana*	0	2	0	Forages in prairie ponds, ditches, and shallow standing water formerly nested in TX		T	Migrant
Zone-tailed Hawk	*Buteo albonotatus*	0	2	0	Arid open country, often near watercourses		T	Resident

Source: TPWD, Annotated County List of Rare Species, Bexar County, Guadalupe County, and Wilson County. All lists updated April 1, 2009.

LE/LT = Federally Listed Endangered/Threatened
DL, PDL = Federally Delisted/Proposed for Delisting
T/SA = Listed as Threatened by Similarity of Appearance
E, T = State Listed Endangered/Threatened
Blank = Rare, but no regulatory listing status

After a review of the habitat requirements for each listed species, it is expected that this project will have no adverse effect on any federally listed threatened or endangered species, its habitat, or designated habitat, nor would it adversely affect any state endangered species. Although suitable habitat for the state threatened Texas horned lizard may exist within the project area, no impact to this species is anticipated due to the small area utilized by the wells and new desalinization water plant, and the abundance of similar habit near the project area. The presence or absence of potential habitat does not confirm the presence or absence of a listed species. No species specific surveys were conducted in the project area for this report.

Habitat studies and surveys for protected species and cultural resources may need to be conducted at the proposed well sites, desalination facility, and along any pipeline routes. Potential wetland impacts are expected to include one pipeline stream crossing, which can be minimized by right-of-way selection and appropriate construction methods, including erosion controls and revegetation procedures. Compensation for net losses of wetlands would be required where impacts are unavoidable.

A review of the Texas Historical Commission Texas Historic Sites Atlas database indicated that there are no historical markers, or National Register Properties listed within one mile of the proposed brine wells, water treatment plant or concentrate disposal well.

4C.25.4 Engineering and Costing

The planned site of the facilities is in the vicinity of SSWSC's Sutherland Springs Road Plant. The brackish well field will consist of three wells and be along CR 319 and would be spaced about a mile apart. The desalination water treatment plant would be located at SSWSC's existing water plant. The disposal well for the concentrate would be nearby. A raw water collector pipeline would deliver brackish Wilcox water from the wells to the water treatment plant. Water treatment will consist of pretreatment and desalination. A treated water pipeline and booster pump station would deliver water to the Sutherland Springs Road Plant. A concentrate water pipeline would deliver reject water to a ground storage tank. A small pump and a pipeline will transport the concentrate to a new, deep injection well. The system is designed to provide an annual average 1.0 MGD and a peak demand of 2.0 MGD.

Based on the results from the earlier study and for planning purposes, a typical Wilcox well in this locale is expected to be about 1,100 ft deep, yield about 750 gpm, and produce water with a total dissolved solids (TDS) concentration of about 1,200 mg/L.

The engineering and costing analysis for Brackish Wilcox Groundwater for SSWSC project includes all facilities required for water production from the Wilcox Aquifer, including wells, collector pipeline, water treatment, treated water pipeline and pump stations, and disposal of concentrate to deep injection wells. The well field consists of three brackish water supply wells, two miles of collector pipelines with a diameter of 12 inches. Water treatment will consist of pretreatment and desalination. Pretreatment will include filtration and possibly other processes to remove particulates such as iron or manganese and to condition the water for optimal desalination. Desalination treatment is expected to be by Reverse Osmosis (RO). The treated water facilities consist of a short transmission pipeline with a diameter of 12 inches, a pump station and integration into the existing distribution system. A concentrate disposal well, ground storage tank, pipelines and facilities are planned near the Sutherland Springs Road Plant. The target disposal of the concentration will be deep well injection into depleted or partially depleted oil and gas producing reservoirs (Austin Chalk or Edwards Limestone).

The required secondary Maximum Contaminant Level (MCL) for TDS is 1,000 mg/L. The design of the water treatment facilities is to produce potable water with a TDS concentration of about 400-500 mg/L. The preliminary water treatment design includes: (1) Pretreatment of all raw water, (2) about 60 percent of this water will be sent to the desalination water treatment plant, and (3) the remaining 40 percent will be blended with the desalinated water. The desalination plant recovery rate using conventional RO with raw water having a TDS of about 1,200 mg/L is estimated to be 85 percent, meaning that 85 percent of the water entering the desalination plant becomes purified water and 15 percent of the water remains as concentrated brine. The desalinated water and the treated brackish water are blended to produce a treated water with a TDS of about 480 mg/L. This process converts about 90 percent of the quantity of raw water produced from the well field into potable water. The remaining 10 percent is a concentrate and is discharged to a deep injection well.

Cost estimates were computed for capital costs, annual debt service, operation and maintenance, power, land, and environmental mitigation for seasonal and peak day demands. These costs are summarized in Table 4C.25-2. Treatment costs are for removal of iron, manganese, and desalination. The project costs, including capital, are estimated to be $14,357,000. As shown, the annual costs, including debt service, operation and maintenance, power, and groundwater leases, are estimated to be $2,109,000. This option produces potable water at an estimated cost of $1,883/acft/yr ($5.78 per 1,000 gallons).

Table 4.C.25-2.
Cost Estimate Summary
Brackish Wilcox Groundwater for SSWSC

Sept 2008 Prices

Item	***Estimated Costs for Facilities***
Capital Costs	
Treated Water Transmission (12 in, 500 ft)	$300,000
Brackish Water Well Field (3-800 gpm, 1,100 ft deep water wells)	$2,433,000
Brackish Well Field Collector Pipelines (12 in, 2 mi)	$560,000
Concentrate Disposal Well Field (1-400 gpm, 4,500 ft deep injection well)	$1,860,000
Concentrate Disposal Transmission (12 in, 500 ft)	$130,000
Water Treatment Plants (Pretreatment & Desalination)	$4,770,000
Total Capital Cost	**$10,053,000**
Engineering, Legal Costs and Contingencies	$3,517,000
Environmental & Archaeology Studies and Mitigation	$103,000
Land Acquisition and Surveying (31 acres)	$131,000
Interest During Construction (1 years)	$553,000
Total Project Cost	**$14,357,000**
Annual Costs	
Debt Service (6 percent, 20 years)	$1,252,000
Operation and Maintenance	
Wells, Pipeline, Pump Stations	$55,000
Water Treatment Plant	$704,000
Pumping Energy Costs	$35,000
Purchase of Water (1,343 ??acft/yr @ $40/acft)	$54,000
Groundwater District Fees (1,120 acft/yr @$8.15/acft)	$9,000
Total Annual Cost	**$2,109,000**
Available Project Yield (acft/yr)	1,120
Annual Cost of Water ($ per acft)	$1,883
Annual Cost of Water ($ per 1,000 gallons)	$5.78

4C.25.5 Implementation Issues

Part or all of the water needed by this Water Management Strategy (WMS) is anticipated to be supplied from locations within the jurisdiction of a groundwater conservation district (District) and may exceed the amount of available water identified in the District's approved management plan, or may for other reasons not be permitted by the District.

The amount of water needed by this WMS that exceeds the available water in the District's management plan, or for other reasons is not permitted by the District, cannot be implemented as part of this WMS unless and until all necessary permits are received from the District.

The amount of water needed by this WMS that exceeds the available water in the District's management plan, or for other reasons is not permitted by the District, introduces an added element of uncertainty to reliance upon this WMS and, therefore, additional management supplies may be needed for this WMS.

Implementation of the Wilcox Aquifer Brackish groundwater strategy includes the following issues:

- Verification of available groundwater quantity and well productivity;
- Verification of water quality for concentrations of dissolved constituents, such as TDS, chloride, sulfate, iron, manganese and hydrogen sulfide;
- Verification of minimal impacts to Carrizo;
- Verification of the potential for deep well injection of concentrate;
- Permitting Class I disposal well for deep well injection of desalination concentrate;
- Regulations by TCEQ;
- Regulations by the Evergreen Underground Water Conservation District;
- Verification that desalinated Wilcox Aquifer water is compatible with other water sources being used by customers and will meet all water quality requirements in the end user's distribution system; and
- Experience in operating and maintaining a desalination water treatment plant.

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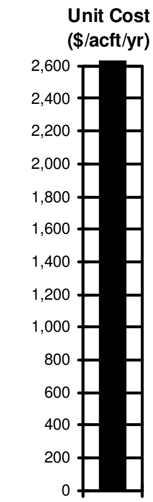
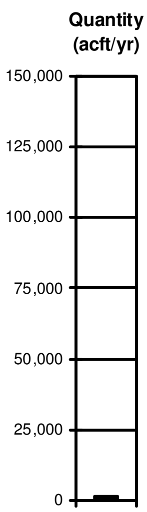
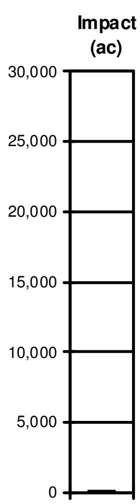
2011 South Central Texas Regional Water Plan
Water Management Strategy Summary Sheet







Name: Calhoun County Brackish Groundwater Project

Description: The Calhoun County Brackish Groundwater strategy has been developed to provide an average of 1,344 acf/yr of treated water with a peaking factor of 2.5 to potential new residential and commercial developments in the vicinity of Seadrift. The source of the water would be brackish wells that are in the Gulf Coast Aquifer. Plans are to locate the well field as far as possible from bays and other saltwater bodies. The desalination water treatment plant would be in the vicinity of Seadrift. Concentrate disposal is planned to San Antonio Bay.

***Decade Needed*:** 2020 – 2030

Cost, Quantity of Water, and Land Impacted

Unit Cost of Water:	**$2,678**	**$/acft/yr**	**Treated Water Delivered**
Quantity of Water:	**1,344**	**acft/yr**	**Reliability = Firm**
Land Impacted:	**92**	**acres**	

Additional Considerations per Regional Water Planning Guidelines

Environmental Factors:

The primary environmental issue related to the project is the operation of a concentrate pipeline from the desalination water treatment plant to San Antonio Bay and its discharge into the waters of San Antonio Bay. Concentrate from desalination will be discharged to San Antonio Bay at a concentration that is no more than sea water.

Wintering population of endangered Whooping Cranes at Aransas National Wildlife Refuge located adjacent to Lower San Antonio Bay. A review of the Texas Historical Commission Sites Atlas database indicated that the Sea View Cemetery and the Sea View Cemetery Historical Marker are within one mile of the proposed concentrate pipeline. No National Register Properties were identified in the nearby area. No archaeological survey has been completed for the project area.

Impacts on Water Resources:

None.

Impacts on Agricultural & Natural Resources:

Temporary impacts during construction.

Other Relevant Factors per SCTRWPG:

None.

Comparison of Strategies to Meet Needs:

No conflicts with other recommended water management strategies.

Interbasin Transfer Issues:

None.

Third-Party Impacts of Voluntary Transfers:

Not applicable.

Regional Efficiency:

Project meets needs in area with limited alternatives of new supply.

Water Quality Considerations:

Water from the Gulf Coast Aquifer at this location is expected to have a total dissolved solids (TDS) concentration of about 2,500 mg/L.

Concentrate disposal would be to San Antonio Bay and have a TDS concentration of about 10,000 mg/L.

4C.26 Calhoun County Brackish Groundwater Project

4C.26.1 Description

The Calhoun County Brackish Groundwater Project is a strategy to accommodate projected future demands from potential coastal residential developments in the vicinity of Seadrift and between Seadrift and Port O'Connor (Figure 4C.26-1). This strategy does not include expansion of the City of Seadrift and the Port O'Connor Municipal Utility District water supplies. The project is planned for an average daily demand of 1.2 MGD (1,344 acft/yr) and a peak day demand of 3.0 MGD. The selected peak demand factor is 2.5, which is greater than a typical peak demand factor of 2.0, because of high influx of seasonal residents and visitors in the summer.

The strategy includes the construction of new wells, transmission of raw well water to the water treatment plant, water treatment plant for pretreatment and desalination, storage, transmission to the residential developments, and disposal of concentrate. The goal of the water supply is to produce a potable water supply with a total dissolved solids (TDS) concentration of about 300 mg/L. After water treatment, blended potable water from desalination and pretreatment will be delivered to the potential new developments toward Port O'Conner and Victoria. The water treatment facility is planned near the City of Seadrift, primarily to accommodate the disposal of the concentrate to San Antonio Bay and to be near the projected demand center. The well field is planned to be northeast of the water treatment plant.

4C.26.2 Available Yield and Water Quality

The estimated supply of groundwater from the Gulf Coast Aquifer in Calhoun County in each decade of this planning period is 2,940 acft/yr, of which 2,594 acft/yr was allocated in year 2060. Some of these supplies and demands are in other parts of Calhoun County. Also, the supplies do not distinguish between freshwater and brackish water. Although there are no specific estimates of the availability of brackish groundwater supplies, they are believed to be considerably greater than the freshwater supplies and sufficiently large to accommodate this water supply strategy.

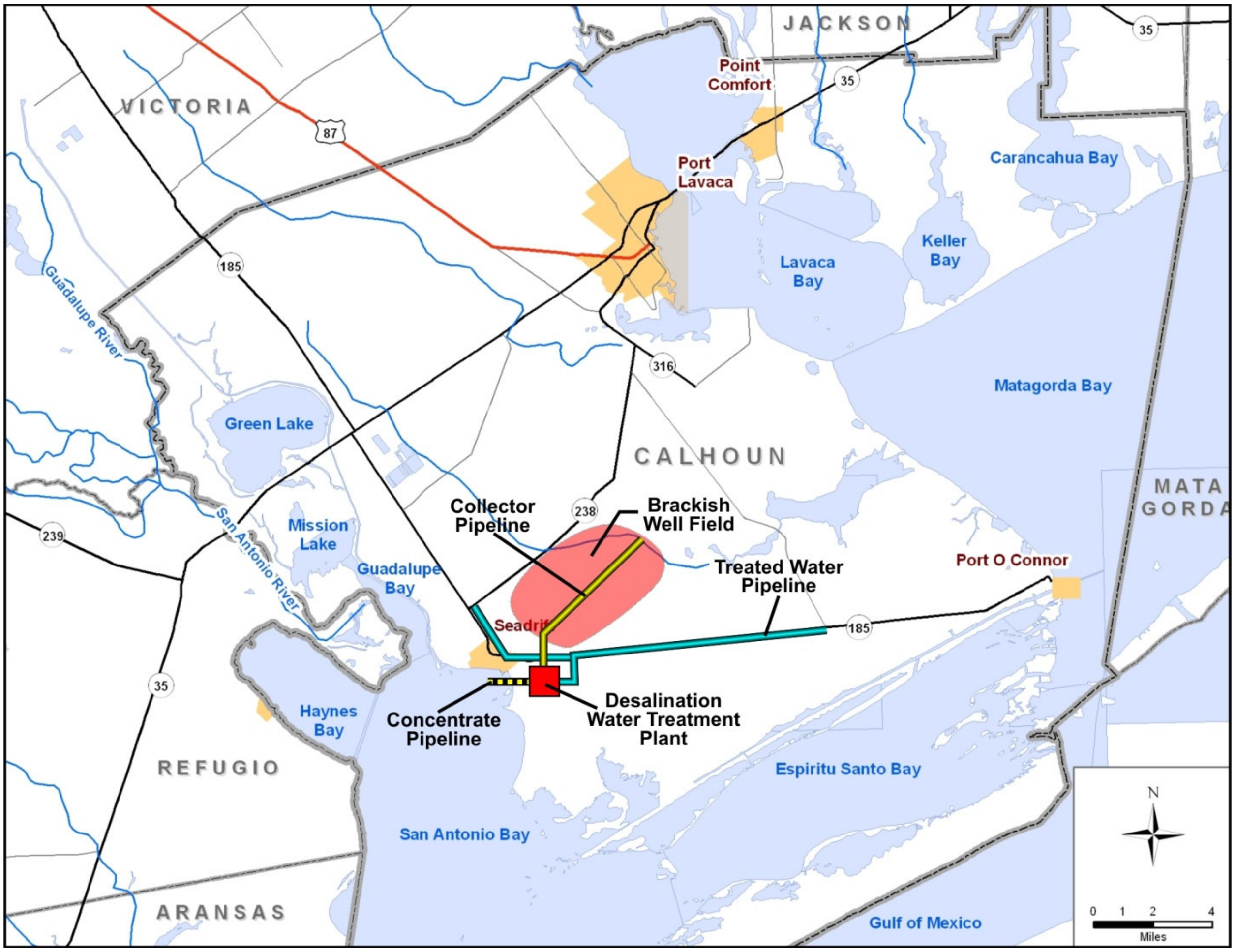


Figure 4C.26-1. Calhoun County Brackish Groundwater Project

A compilation of well data from the TWDB database shows high capacity wells in the vicinity of Seadrift to have depths between 250 and 350 ft and potential well yields between 600 to 1,000 gpm. The data show the concentrations of chlorides (Cl) and total dissolved solids (TDS) to commonly be in the 800 to 2,000 mg/L and 1,500 to 4,000 mg/L ranges, respectively. A review of water quality data for arsenic, iron, and manganese shows some wells producing water that exceeds EPA's Maximum Contamination Level (MCL) or Texas secondary drinking water standards. A study of electric geophysical logs from oil and gas exploratory test holes in the vicinity of Seadrift show little, if any, fresh groundwater (TDS less than 1,000 mg/L). The base of the brackish groundwater appears to be about 400 ft below land surface. Below this depth, the groundwater appears to be saline.

4C.26.3 Environmental Issues

This strategy includes all facilities for the Calhoun County Brackish Groundwater Project: brackish well field, collection and transmission of the raw water to the Seadrift water treatment plant, desalination, other treatment, and disposal of concentrate to San Antonio Bay. These features are all located in the Gulf Coast Prairies and Marshes ecoregion[1].

The primary environmental issue related to the project is the operation of a concentrate pipeline from the desalination water treatment plant to San Antonio Bay and its discharge into the waters of San Antonio Bay. Concentrate from desalination will be discharged to San Antonio Bay at a concentration that is no more than sea water. The discharge of desalination concentrate into the bay may require multiple outfall locations or installation of a diffuser system to avoid high localized concentrations.

Potential environmental effects resulting from the construction of a brackish groundwater desalination plant in the vicinity of San Antonio Bay will be sensitive to the siting of the plant and its concentrate discharge pipeline location. Construction will temporarily disrupt shoreline and benthic habitats in the immediate vicinity, including wetlands and other sensitive areas. Discharge sites may be selected to avoid oyster reefs and areas where organisms tend to concentrate. These include rock outcrops, man-made structures, the vicinities of tidal passes and the surf zone. It can be assumed that the permitting process will require a demonstration that the design of the discharge structure will be adequate to rapidly disperse the brine plume to ambient salinities within a relatively small mixing zone.

Table 4C.26-1 lists the 31 state listed endangered and threatened species, and the 16 federally listed endangered or threatened wildlife and plant species that may occur in Calhoun County, according to county lists of rare species published by Texas Parks and Wildlife Department (TPWD) online in the "Annotated County Lists of Rare Species." Inclusion in Table 4C.26-1 does not mean that a species will occur within the project area, but only acknowledges the potential for occurrence in the project area county. In addition to the county list, the Natural Diversity Database (NDD) map data was reviewed for known occurrences of listed species within or near the project area. This database documents occurrences of one species, threeflower

[1] TPWD, 2009. Natural Regions of Texas.

Table 4C.26-1
Endangered, Threatened, or Species of Concern Listed for Calhoun County

Common Name	Scientific Name	Summary of Habitat Preference	Listing Entity		Potential Occurrence in County
			USFWS	TPWD	
AMPHIBIANS					
Black-spotted newt	*Notophthalmus meridionalis*	Usually found in wet or sometimes wet areas in the Gulf Coastal Plain south of the San Antonio River.		T	Resident
Sheep frog	*Hypopachus variolosus*	Found in grassland and savanna; moist sites in arid areas.		T	Resident
BIRDS					
Bald eagle	*Haliaeetus leucoephalus*	Found primarily near rivers and large lakes.	DL	T	Possible Migrant
Brown pelican	*Pelecanus occidentalis*	Largely coastal and near shore areas.	DL	E	Resident
Eskimo curlew	*Numenius borealis*	Historic, nonbreeding.	LE	E	Historic Resident
Henslow's Sparrow	*Ammodramus henslowii*	Found in weedy fields or cut-over areas			Resident
Mountain Plover	*Charadrius montanus*	Non-breeding, shortgrass plains and fields			Nesting/Migrant
Northern Aplomado Falcon	*Falco femoralis septentrionalis*	Found in open country, especially savanna and open woodland.	LE	E	Resident
Peregrine Falcon	*Falco peregrinus anatum* (American)	Resident and local breeder in West Texas. Migrant across the state.	DL	T	Possible Migrant
	Falco peregrinus tundrius (Arctic)	Migrant throughout the state.	DL		Possible Migrant
Piping plover	*Charadrius melodus*	Wintering migrant along the Texas Gulf Coast.	LT	T	Migrant
Reddish Egret	*Egretta rufescens*	Resident of Texas Gulf coast.		T	Resident
Snowy Plover	*Charadrius alexandrines*	Potential migrant, winters along coast			Migrant
Sooty Tern	*Sterna fuscata*	Usually flies or hovers over water.		T	Resident
Southeastern Snowy Plover	*Charadrius alexandrines tenuirostris*	Wintering migrant along the Texas Gulf Coast.			Migrant
Western Burrowing Owl	*Athene cunicularia hypugaea*	Open grasslands, especially prairie, plains and savanna			Resident
White-faced Ibis	*Plegadis chihi*	Prefers freshwater marshes.		T	Resident
White-tailed Hawk	*Buteo albicaudatus*	Found near the coast on prairies.		T	Resident
Whooping Crane	*Grus americana*	Potential migrant	LE	E	Potential Migrant

Table 4C.26-1 (Continued)

Common Name	Scientific Name	Summary of Habitat Preference	Listing Entity USFWS	Listing Entity TPWD	Potential Occurrence in County
Wood Stork	*Mycteria americana*	Forages in prairie ponds, ditches, and shallow standing water formerly nested in TX		T	Migrant
FISHES					
American eel	*Anguilla rostrata*	Coastal waterways below reservoirs to gulf.			Resident
Opossum pipefish	*Microphis brachyurus*	Adults found in fresh or low salinity waters.		T	Resident
Smalltooth sawfish	*Pristis pectinata*	Found in bays, estuaries or river mouths.	LE	E	Resident
MAMMALS					
Black Bear	*Ursus americanus*	Inhabits bottomland hardwoods	T/SA;NL	T	Historic Resident
Jaguarundi	*Herpailurus yaguarondi*	Found in thick brushlands near water.	LE	E	Resident
Louisiana black bear	*Ursus americanus luteolus*	Possible transient.	LT	T	Transient
Ocelot	*Leopardus pardalis*	Found in dense chaparral thrickets; mesquite-thorn scrub and live oak motts.	LE	E	Resident
Plains Spotted Skunk	*Spilogale putorius interrupta*	Prefers wooded, brushy areas.			Resident
Red Wolf	*Canis rufus*	Extirpated.	LE	E	Historic Resident
West Indian manatee	*Trichechus manatus*	Gulf and bay systems.	LE	E	Resident
MOLLUSKS					
Creeper (squawfoot)	*Strophitus undulates*	Small to large streams			Resident
Pistolgrip	*Tritogonia verrucosa*	Aquatic, stable substrate. Red through San Antonio river basins.			Resident
PLANTS					
Threeflower broomweed	*Thurovia triflora*	Endemic: near coast.			Resident
REPTILES					
Atlantic hawksbill sea turtle	*Eretmochelys imbricate*	Found in Gulf and bay systems.	LE	E	Resident
Green sea turtle	*Chelonia mydas*	Gulf and bay systems.	LT	T	Resident
Gulf Saltmarsh snake	*Nerodia clarkii*	Found on saline flats.			Resident
Kemp's Ridley sea turtle	*Lepidochelys kempii*	Found in gulf and bay systems.	LE	E	Resident
Leatherback sea turtle	*Dermochelys coriacea*	Gulf and bay systems.	LE	E	Resident
Loggerhead sea turtle	*Caretta caretta*	Gulf and bay systems for juveniles, ocean for adults.	LT	T	Resident

Table 4C.26-1 (Concluded)

Common Name	Scientific Name	Summary of Habitat Preference	Listing Entity		Potential Occurrence in County
			USFWS	TPWD	
Texas diamondback terrapin	*Malaclemys terrapin littoralis*	Found in coastal marshes and tidal flats.			Resident
Texas Horned Lizard	*Phrynosoma cornutum*	Varied, sparsely vegetated uplands.		T	Resident
Texas scarlet snake	*Cemophora coccinea lineri*	Mixed hardwood scrub on sandy soils.		T	Resident
Texas Tortoise	*Gopherus berlandieri*	Open brush w/ grass understory.		T	Resident
Timber/ Canebrake Rattlesnake	*Crotalus horridus*	Floodplains, upland pine, deciduous woodlands, riparian zones.		T	Resident

LE/LT -- Federally Listed Endangered/Threatened
DL, PDL -- Federally Delisted/proposed for delisting
T/SA -- Listed as Threatened by similarity of appearance
E, T -- State listed Endangered/Threatened
T* -- in the process of being listed as Threatened by State
C -- Species of Concern
Blank -- Not yet listed by TPWD or USFWS, but considered rare
Source: TPWD, Annotated County List of Rare Species, Calhoun County (Updated 12/18/2009),

broomweed (*Thurovia triflora*), a rare plant endemic to tidal flats. Additionally, the database documented the occurrence of a colonial waterbird rookery near the terminus of the concentrate pipeline.

Many migratory birds are dependent on the quality of estuarine environments in order to complete their foraging and nesting requirements during migration. One of the most well known of these migratory birds is the Whooping Crane (*Grus Americana)*, which is listed as endangered by both United States Fish and Wildlife Service (USFWS) and TPWD. A growing population of whooping cranes winter in and near the Aransas National Wildlife Refuge located adjacent to the Mesquite Bay and the southern and western portions of San Antonio Bay. Three other migratory birds known to the San Antonio Bay area are listed as threatened by TPWD: the reddish egret (*Egretta rufescens*), wood stork (*Mycteria Americana*), and piping plover (*Charadrius melodus*). The piping plover is also listed as threatened by USFWS.

Several species listed as threatened by the state may possibly be affected. These include the Texas horned lizard (*Phrynosoma cornutum)*, Texas scarlet snake (*Cemophora coccinea* lineri), Texas tortoise (*Gopherus berlandieri)*, and timber/canebrake rattlesnake (*Crotalus horridus)*. Many of these reptile species are dependent on shrubland or riparian habitat. The opossum pipefish (*Microphis brachyurus*), also a state threatened species, requires fresh or low salinity waters for brooding and could be affected by salinity changes.

The presence or absence of potential habitat does not confirm the presence or absence of a listed species. Surveys for protected species should be conducted within the proposed construction corridors where preliminary evidence indicates their existence. No species specific surveys were conducted in the project area for this report.

Cultural resources protection on public lands in Texas is afforded by the Antiquities Code of Texas (Title 9, Chapter 191, Texas Natural Resource Code of 1977), the National Historic Preservation Act (Pl96-515), and the Archeological and Historic Preservation Act (PL93-291). A review of the Texas Historical Commission Sites Atlas database indicated that the Sea View Cemetery and the Sea View Cemetery Historical Marker are within one mile of the proposed concentrate pipeline. No National Register Properties were identified in the nearby area. No archaeological survey has been completed for the project area. An archaeological survey of the project area should be undertaken to accurately determine actual impacts to cultural resources.

4C.26.4 Engineering and Costing

The Calhoun County Brackish Groundwater Project is designed to provide an average daily supply of 1.2 MGD and to meet a peak daily demand of 3.0 MGD. During a peak day of operation, the desalination water treatment plant will produce about 0.88 MGD of concentrate with a TDS concentration of about 10,000 mg/L. This concentration is the same as the approximate median TDS concentration of about 10,000 mg/L of water in San Antonio Bay.

A major consideration in selecting the location and design of a new well field is minimizing the potential for future intrusion of saline water. In general, saline water intrusion into a well in a hydrogeologic setting like southern Calhoun County can occur as upward migration from an underlying water-bearing strata or lateral migration. Saline water intrusion into a well field is most likely to occur if the wells are very near a body of sea water, clustered in a small area, and pumped at high capacities. To minimize the chance of saline water intrusion over the planning period, the proposed wells will be located at least 2 miles inland from the nearest coast line; wells will be spaced about 1-mile apart; and, enough wells will be included for pumping rates to be at set at moderate levels, which is considered to be about 700 gpm. The wells would produce a raw water with a total dissolved concentration of about 2,500 mg/L.

In the proposed well field, the Cl and TDS concentrations may be four times greater than Texas Primary and/or Secondary Drinking Water Standards for Cl and TDS, which are 300 and 1,000 mg/L, respectively. The preliminary water treatment design has: (1) all the water undergoing pretreatment and removal of iron and manganese, (2) about 88 percent of the pretreated well water will be sent to the desalination plant to remove inorganic and organic water quality constituents, and (3) the remaining 12 percent will be blended with the desalinated water. Based on a conventional reverse osmosis (RO) desalination process, the desalination plant recovery rate is estimated to be 75 percent, meaning that 75 percent of the water entering the desalination plant passes through as purified water and 25 percent of the water remains as concentrated brine. The desalinated water is blended back with the raw brackish water to produce the finished water. This process converts about 77 percent of the quantity of raw water produced from the well field into potable water. The remaining 23 percent is a concentrate and is discharged to San Antonio Bay. The blended finished water is expected to have a Cl and TDS concentrations of about 120 and 300 mg/L, respectively.

Based on the loss of raw water to concentrate in the desalination process, the well field capacity will need to be about 3.9 MGD. For this feasibility level design and with a 20 percent contingency, 5 wells with a capacity of about 700 gpm are needed for the project. The length of the pipeline collecting the raw water from the well field will need to be about 5 miles long. The pipeline diameters vary from 8 to 20 inches. Well pumps will be sized to deliver the raw water directly to the water treatment plant. The integration pipeline to the developments will be about 15 miles long and have a diameter 12-14 inches. The pipeline for discharging the concentrate to San Antonio Bay is estimated to be about 1 mile long and have a diameter of 8 inches. Its preliminary designed has a diffuser to prevent localized concentrations of the concentrate in the bay. The location of the facilities is shown in Figure 4C.26-1.

Cost estimates for the Calhoun County Brackish Groundwater Project is shown in Table 4C.26-2. The average annual demand for is 1.2 MGD (1,344 acft/yr). Peak daily capacity will be 3.0 MGD. As shown in Table 4C.26-2, project cost is $24,887,000. The annual cost is $3,599,000, including a debt service of $2,170,000 for 20 years. During the period when a debt payment is required, the unit cost is $2,678/acft/yr ($8.22/1,000 gallons).

Table 4C.26-2.
Cost Estimate Summary for Calhoun County Brackish Groundwater Project
(Sept 2008 Prices)

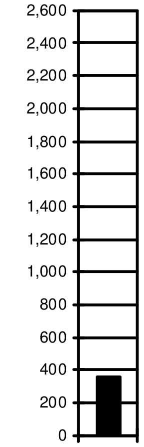
Item	Estimated Costs for Facilities
Capital Costs	
Transmission Pipelines (Treated Water and Concentrate Disposal)	$4,725,000
Transmission Pump Stations (Treated Water and Concentrate Disposal)	$1,421,000
Well Field (five 700 gpm wells) and Collection Pipelines (5-miles)	$3,758,000
Water Treatment Plant (Pre-treatment and Brackish Desalination)	$7,012,000
Diffuser for Concentrate Disposal in Bay	$40,000
Total Capital Cost	**$16,956,000**
Engineering, Legal Costs and Contingencies	$5,698,000
Environmental & Archaeology Studies and Mitigation	$533,000
Land Acquisition and Surveying (92 acres)	$742,000
Interest During Construction (1 years)	$958,000
Total Project Cost	**$24,887,000**
Annual Costs	
Debt Service (6 percent, 20 years)	$2,170,000
Operation and Maintenance	
Wells, Pipelines, Storage Tanks and Pump Stations	$117,000
Water Treatment Plants	$1,154,000
Pumping Energy Costs (993,435 kW-hr @ 0.09 $/kW-hr)	$89,000
Purchase of Groundwater ($40/acft)	$69,000
Total Annual Cost	**$3,599,000**
Available Project Yield (acft/yr)	1,344
Annual Cost of Water ($ per acft)	$2,678
Annual Cost of Water ($ per 1,000 gallons)	$8.22

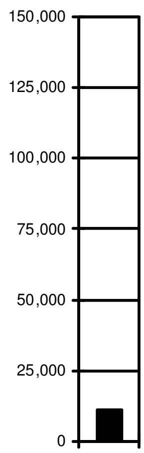
4C.26.5 Implementation Issues

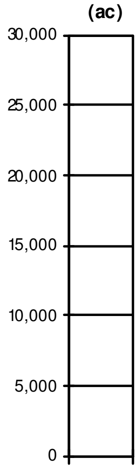
Implementation of the Southern Calhoun County Groundwater Desalination Project strategy includes the following issues:

- Verification of the Gulf Coast Aquifer water quality for concentrations of the dissolved constituents such as TDS, chloride, sulfate, iron, and manganese;
- Permitting desalination concentrate discharge to San Antonio Bay;
- Brine Disposal Discharge Permits by TCEQ; and
- Purchase or lease of property for well field and coordination with landowners.

2011 South Central Texas Regional Water Plan
Water Management Strategy Summary Sheet







Name: CRWA Wells Ranch Project

Description: The CRWA Wells Ranch Project is a two phased project that will supply 5,200 acft/yr in Phase I and 5,800 acft/yr in Phase II. The infrastructure for Phase I, including portions of the transmission facilities, have been constructed. Phase I is awaiting production permits. Phase II will include the completion of the transmission facilities, expansion of the existing well field, and a water treatment plant expansion. Cost estimates for this project assume that Phase I is complete.

***Decade Needed*:** 2010 -2020

Cost, Quantity of Water, and Land Impacted

Unit Cost of Water:	**$725**	**$/acft/yr**	**Treated Water Delivered**
Quantity of Water:	**11,000**	**acft/yr**	**Reliability = Firm**
Land Impacted:	**~11**	**acres**	

Additional Considerations per Regional Water Planning Guidelines

Environmental Factors:

Within the well field areas, several species listed as threatened by the state may possibly have habitat which could be affected by the project. These include the Cagle's Map Turtle, Texas horned lizard, Texas tortoise, and timber/canebrake rattlesnake.

Impacts on Water Resources:

Groundwater levels will decline and could affect the baseflow of surrounding streams and wetlands.

Impacts on Agricultural & Natural Resources:

Minimal impacts anticipated.

Other Relevant Factors per SCTRWPG:

Part or all of the water needed by this Water Management Strategy (WMS) is anticipated to be supplied from locations within the jurisdiction of a groundwater conservation district (District) and may exceed the amount of available water identified in the District's approved management plan, or may for other reasons not be permitted by the District. The amount of water needed by this WMS that exceeds the available water in the District's management plan, or for other reasons is not permitted by the District, cannot be implemented as part of this WMS unless and until all necessary permits are received from the District. The amount of water needed by this WMS that exceeds the available water in the District's management plan, or for other reasons is not permitted by the District, introduces an added element of uncertainty to reliance upon this WMS and, therefore, additional management supplies may be needed for this WMS.

Comparison of Strategies to Meet Needs:

Cost estimates indicate that this strategy may be more economical than other potentially feasible WMS.

Interbasin Transfer Issues:

None.

Third-Party Impacts of Voluntary Transfers:

None anticipated.

Regional Efficiency:

Allows CRWA the ability to fully utilize existing transmission facilities while providing a reliable, long-term water supply.

Water Quality Considerations:

Overall, the water quality of the Carrizo-Wilcox Aquifer is suitable for use as a water supply, except for elevated concentrations of iron and manganese in many areas.

4C.27 CRWA Wells Ranch Project

4C.27.1 Description of Water Management Strategy

The Carrizo-Wilcox Aquifer is one of four major aquifers in the South Central Texas Water Planning Region. In the Wintergarden area, which is generally considered to be west of the Atascosa-Frio county line, the aquifer has been extensively developed for many decades. In Atascosa County, the aquifer has had moderate development. In Bastrop, Caldwell, Gonzales, Guadalupe, and Wilson Counties, there has been limited development. Overall, the water quality of the Carrizo-Wilcox Aquifer is suitable for use as a water supply, except for elevated concentrations of iron and manganese in many areas.

Bexar County and other counties along the IH-35 corridor have near-term projected shortages in municipal supply. Several water purveyors in Region L, including SAWS, Schertz-Seguin Local Government Corporation (SSLGC), Canyon Regional Water Authority (CRWA), Hays Caldwell Public Utility Agency (Hays Caldwell), Aqua WSC, and Texas Water Alliance, are evaluating alternative regional projects to import groundwater from the Carrizo-Wilcox to their demand centers. The general location of the well fields associated with these projects is shown in Figure 4C.27-1.

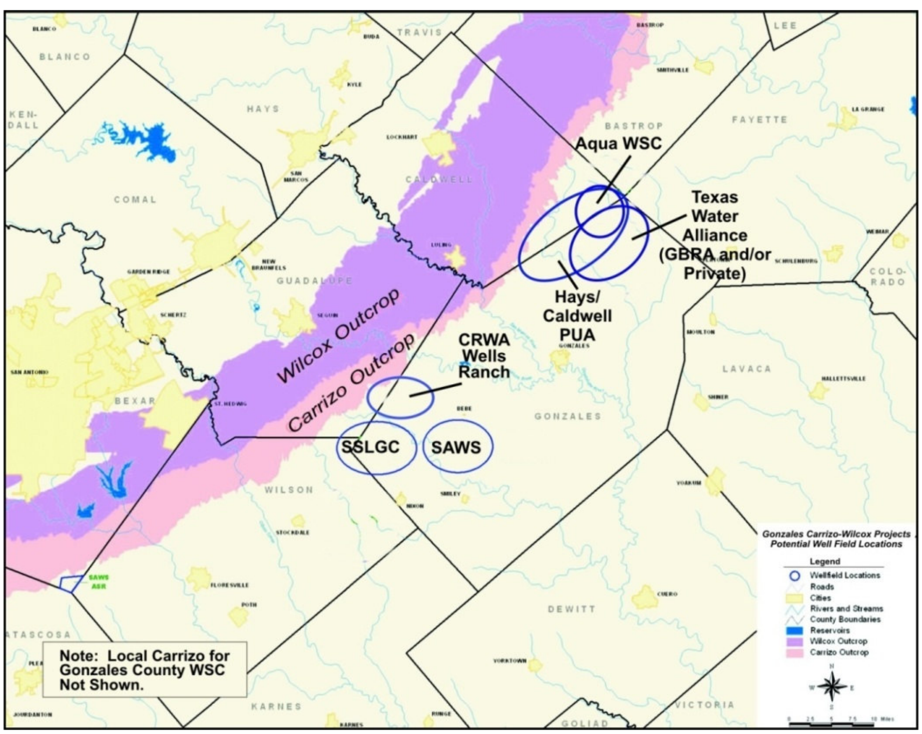


Figure 4C.27-1. General Location of Planned Well Fields for Carrizo Aquifer Projects

Canyon Regional Water Authority (CRWA) is in the planning, permitting, and construction stages of a well field at Wells Ranch, straddling the border of Guadalupe and Gonzales Counties. The project has two phases. Phase I will supply 5,200 acft/yr of water to CRWA customers and Phase II is envisioned to supply an additional 5,800 acft/yr in the future. To date, CRWA has: (1) conducted test drilling and well performance testing, (2) obtained drilling and production permits for wells from the Gonzales County Underground Water Conservation District (GCUWCD) and Guadalupe County Groundwater Conservation District (GCGCD), and (3) built conveyance infrastructure suitable for transmitting the full 11,000 acft/yr of supply to their distribution system. As such, this water management strategy focuses on the Phase II portion of the project. Figure 4C.27-2 shows the location of this water management strategy.

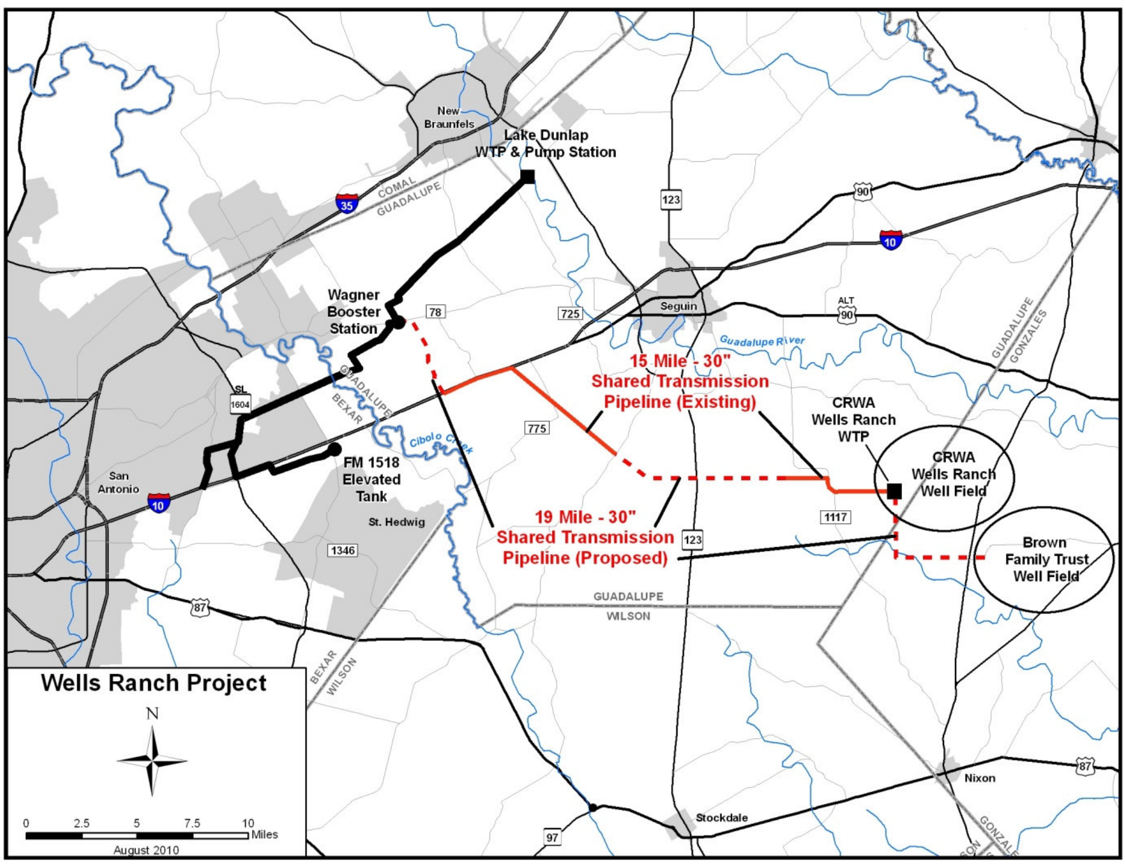


Figure 4C.27-2. Wells Ranch Project Location Map

An earlier version of this project appeared in the 2006 South Central Texas Regional Water Plan (SCTRWP) as a water management strategy identified as "Wells Ranch Project" and was a joint project between CRWA and Bexar Metropolitan Water District (BMWD). The strategy identified an estimated supply of 9,000 acft/yr in the 2006 plan. During the intervening 5 years, the CRWA has acquired the Wells Ranch project from BMWD.

4C.27.2 Water Availability

The Carrizo Aquifer in the vicinity of the planned well field is just downdip of the Carrizo outcrop. Hydrogeologic maps of the aquifer in this area suggest that wells in the area would be capable of producing in excess of 2,000 gpm and would range in depth from 500 to 1,200 ft deep. Most of the wells are planned to be screened in the Carrizo, however, some of the wells in Guadalupe County are to be screened in the Wilcox. Groundwater quality in the planned well field usually has a concentration of total dissolved solids of less than 300 mg/L. However, the water typically has elevated concentrations of iron and manganese that requires removal before being used by the public.

Regional Carrizo projects in this area of Gonzales County include the Shertz-Seguin Local Government Corporation Project Expansion and the Regional Carrizo for San Antonio Water System project. Groundwater production, well spacing, and export of groundwater are subject to rules of the GCUWCD. Regional Carrizo projects in this area of Guadalupe County include the Shertz-Seguin Local Government Corporation Project Expansion.

A 2009 GCUWCD Water Management Plan does not include an estimate of groundwater availability in this part of the aquifer. Also, a Desired Future Condition (DFC) has not been established for GMA-13, which includes the GCUWCD and GCGCD. Thus, the amount of Managed Available Groundwater (MAG) has not been determined.

No assessment has been made to determine if the project complies with the GCUWCD and GCWCD water management plan and rules other than well spacing. Before the Phase II project could become operational, permits for well construction, water production, and water export would have to be obtained from GCUWCD and GCGCD.

The effects of the groundwater pumping on groundwater levels and streamflow will be developed and presented in the cumulative effects section of the 2011 SCTRWP.

4C.27.3 Environmental Issues

The proposed CRWA Wells Ranch Project facilities includes a well field in Gonzales and Guadalupe counties, a collection system, water treatment plant, transmission pump station, and 30 mile transmission pipeline. The pipeline route would originate at the Wells Ranch well field in eastern Guadalupe County, and travel in a northwest direction until it intersects with IH10, then west along IH10 and finally north, terminating at the Wagner Booster Station on FM 78.

The proposed pipeline route would traverse two of Omernik's[1] ecoregions: the East Central Texas Plains, and the westernmost reaches of the Texas Blackland Prairie. The project area would lie in the Texas Blackland Prairies and East Central Texas ecoregions.[2] The dominant vegetation of the Texas Blackland Prairies is mesquite, post oak, bluestems, switchgrass and blackjack oak supported by clay soils mixed with sandy loams. The Post Oak Savannah vegetational area is characterized by gently rolling to hilly terrain with an understory that is typically tall grass and an overstory that is primarily post oak *(Quercus stellata)* and blackjack oak *(Q. marilandica).* The proposed pipeline corridor is a mosaic of the Post Oak Savannah and the Blackland Prairie ecoregions and could potentially include a wide variety of species. The land use for the area included in the pipeline route is composed of three major vegetation types. The northern section of the route above IH10 is located in an area usually utilized for crop production. The center portion of the route is situated in a post oak wood and grassland mosaic, and the lower one third of the route traverses a post oak wood or forest.

Although the pipeline route parallels the Guadalupe River along a portion of its course, it does not cross any water sources listed by Texas Parks and Wildlife as Ecologically Significant River and Stream Segments.

Table 4C.27-1 lists rare and protected species that may have habitat in the project area. The TPWD Species Diversity Database maps several species and essential habitat in the vicinity of the pipeline route. Protected species appear to be primarily those dependent on shrubland or riparian habitat.

Threatened species possibly found within the project area include Cagle's Map Turtle (*Graptemys caglei*), Texas horned lizard (*Phrynosoma cornutum)*, *Texas* tortoise (*Gopherus berlandieri)*, and the timber/canebrake rattlesnake (*Crotalus horridus)*. The Cagle's map turtle is found only in the waters of the Guadalupe River Basin, the timber/canebrake rattlesnake can be found in woodlands consisting of oak and other hardwoods. The Texas tortoise prefers open brush with grass understory and usually occupies shallow depressions at the base of a bush or cactus, a similar habitat to the Texas horned lizard which occupies sparsely vegetated uplands.

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[1] Omernik, J. M, "Ecoregions of the conterminous United States," Annals of the Association of American Geographers, 77: 118-125, 1987.
[2] Gould, F.W., "The Grasses of Texas," Texas A&M University Press, College Station, Texas, 1975.

Table 4C.27-1.
Endangered, Threatened or Species of Concern in Guadalupe and Gonzales Counties

Common Name	Scientific Name	Impact Value	Multiplier Based on Status	Adjusted Impact	Summary of Habitat Preference	Listing Entity		Potential Occurrence in County
						USFWS[1]	TPWD[1]	
A mayfly	*Campsurus decoloratus*	0	1	0	Found in Texas and Mexico. Possibly in clay substrates.			Resident
American Peregrine Falcon	*Falco peregrinus anatum*	0	3	0	Open country; cliffs	DL	T	Nesting/Migrant
Arctic Peregrine Falcon	*Falco peregrinus tundrius*	0	2	0	Open country; cliffs	DL		Nesting/Migrant
Bald eagle	*Haliaeetus leucoephalus*	0	2	0	Found primarily near rivers and large lakes.	DL	T	Possible Migrant
Big Red Sage	*Salvia penstemonoides*	1	1	1	Endemic; Creekbeds and seepage slopes of limestone canyons			Resident
Blue Sucker	*Cycleptus elongates*	1	2	2	Found in major rivers in Texas.		T	Resident
Cagle's Map Turtle	*Graptemys caglei*	1	2	2	Waters of the Guadalupe River Basin	C1	T	Resident
Cave Myotis Bat	*Myotis velifer*	0	1	0	Colonial & cave dwelling; hibernates in limestone caves of Edwards Plateau			Resident
Creeper (squawfoot)	*Strophitus undulates*	0	1	0	Small to large streams			Resident
Elmendorf's Onion	*Allium elmendorfii*	1	1	1	Endemic; deep sands derived from Queen City and similar Eocene formations			Resident
False spike mussel	*Quincuncina mitchelli*	0	1	0	Substrates of cobble and mud with water lilies present. Rio Grande, Brazos, Colorado and Guadalupe river basins.			Resident
Golden orb	*Quadrula aurea*	0	2	0	Sand and gravel, Guadalupe, San Antonio, and Nueces River basins		T	Resident
Guadalupe Bass	*Micropterus treculi*	1	1	1	Streams of eastern Edwards Plateau			Resident
Guadalupe Darter	*Percina sciera apristis*	1	1	1	Raceways of medium streams and rivers.			
Henslow's Sparrow	*Ammodramus henslowii*	0	1	0	Wintering individuals found in weedy fields and cut-over areas.			Migrant
Interior Least Tern	*Sterna antillarum athalassos*	0	3	0	Inland river sandbars for nesting and shallow water for foraging	LE	E	Nesting/Migrant
Mountain Plover	*Charadrius montanus*	1	1	1	Shortgrass plains and fields, sandy deserts, plowed fields			Nesting/Migrant
Northern Aplomado Falcon	*Falco femoralis septentrionalis*	0	3	0	Found in open country, especially savanna and open woodland.	LE	E	Resident
Palmetto Pill snail	Euchemotrema leai cheatumi	0	1	0	Terrestrial snail with only one known population, from moist palmetto woodlands of Palmetto State Park.			Resident
Parks' Jointweed	*Polygonella parksii*	2	1	2	South Texas Plains; subherbaceous annual in deep loose sands, spring-summer			Resident

Table 4C.27-1 (Concluded)

Common Name	Scientific Name	Impact Value	Multiplier Based on Status	Adjusted Impact	Summary of Habitat Preference	Listing Entity USFWS[1]	Listing Entity TPWD[1]	Potential Occurrence in County
Pistolgrip	*Tritogonia verrucosa*	0	1	0	Aquatic, stable substrate. Red through San Antonio river basins.			Resident
Plains Spotted Skunk	*Spilogale putorius interrupta*	0	1	0	Catholic; Wooded, brushy areas and tallgrass prairies			Resident
Red Wolf	*Canis rufus*	0	3	0	Extirpated.	LE	E	Historic Resident
Rock pocketbook	*Arcidens confragosus*	0	1	0	Mud and sand, Red through Guadalupe River basins.			Resident
Sandhill Woolywhite	*Hymenopappus carrizoanus*	2	1	2	Endemic; Open areas in deep sands derived from Carrizo and similar Eocene formations			Resident
Spot-tailed earless lizard	*Holbrookia lacerata*	1	1	1	Moderately open prairie-brushland.			Resident
Texas fatmucket	*Lampsilis bracteata*	0	1	0	Streams and rivers on sand, mud and gravel, Colorado and Guadalupe River basins.			Resident
Texas Garter Snake	*Thamnophis sirtalis annectens*	1	1	1	Varied, especially wet areas; bottomlands and pastures			Resident
Texas Horned Lizard	*Phrynosoma cornutum*	2	2	4	Varied, sparsely vegetated uplands		T	Resident
Texas pimpleback	*Quadrula petrina*	0	2	0	Mud, gravel and sand substrates, Colorado and Guadalupe river basins			
Texas Tortoise	*Gopherus berlandieri*	2	2	4	Open brush with grass understory; open grass and bare ground avoided; occupies shallow depressions at base of bush or cactus, underground burrows, under objects; active March-Nov		T	Resident
Timber/Canebrake Rattlesnake	*Crotalus horridus*	1	2	2	Bottomland hardwoods		T	Resident
Western Burrowing Owl	*Athene cunicularia hypugaea*	1	1	1	Open grasslands, especially prairie, plains and savanna			Resident
Western Burrowing Owl	*Athene cunicularia hypugaea*	1	1	1	Open grasslands, especially prairie, plains and savanna			Resident
Whooping Crane	*Grus americana*	0	3	0	Potential migrant	LE	E	Migrant
Wood Stork	*Buteo americana*	0	2	0	Prairie ponds, flooded pastures or fields; shallow standing water		T	Nesting/Migrant

[1] Source: TPWD, Annotated County List of Rare Species, Guadalupe and Gonzales Counties, January 2010.
* LE/LT=Federally Listed Endangered/Threatened E/SA, T/SA=Federally Listed Endangered/Threatened by Similarity of Appearance
C1=Federal Candidate for Listing DL, PDL=Federally Delisted/Proposed for Delisting NL=not Federally Listed E, T =State Listed Endangered/Threatened
PE, PT=Federally Proposed Endangered/ Threatened Blank = Rare, but no regulatory listing status

In addition to these species, the proposed pipeline passes in the vicinity of several mapped species of concern: Mountain Plover *(Charadrius montanus)*, Parks jointweed (*Polygonella parksii*), and Sandhill woollywhite (*Hymenopappus carrizoanus*). Additional species of concern which may be affected by the pipeline include the Guadalupe Bass *(Micropterus treculi)*, Elmendorf's Onion (*Allium elmendorfii*), Texas Garter Snake (*Thamnophis sirtalis annectens)* and big red sage *(Salvia penstemonoides)*.

4C.27.4 Cultural Resources

Field surveys conducted at the appropriate phase of development should be employed to minimize the impacts of construction and operation on sensitive resources. Specific project features, such as well field, pipelines, and off-channel reservoirs generally have sufficient design flexibility to avoid most impacts or significantly mitigate potential impacts to geographically limited environmental and cultural resource sites. Cultural resources protection on public lands in Texas is afforded by the Antiquities Code of Texas (Title 9, Chapter 191, Texas Natural Resource Code of 1977), the National Historic Preservation Act (P196-515), and the Archeological and Historic Preservation Act (PL93-291). Based on the review of available records housed at the Texas Archeological Research Laboratory in Austin, six cultural resource sites occur within a 1-mile corridor of the proposed project area. Taking into consideration that the owner or controller of the project will likely be a political subdivision of the State of Texas (i.e., river authority, municipality, county, etc.), they will be required to coordinate with the Texas Historical Commission prior to project construction. If the project will affect waters of the United States or wetlands, the project sponsor will also be required to coordinate with the U.S. Army Corps of Engineers regarding impacts to cultural resources.

Table 4C.27-2.
Previously Recorded Cultural Resource Sites
Within the Proposed Project Area

Archeological Sites within the Proposed Project Area of the Wagner Booster Station Project	41GU3	41GU29
	41GU19	41GU35
	41GU28	41GU36

4C.27.5 Engineering and Costing

The preliminary engineering analyses have groundwater being developed for base load operations (uniform rate), including both Phase I and Phase II. All facilities for Phase I are assumed to be completed with the exception of three transmission pipeline segments. As such, the cost estimate included is for the completion of the transmission pipeline and the Phase II expansion. The completed water pipeline route will traverse about 34 miles with a 30-inch diameter pipe from the Wells Ranch and Brown Family Trust well fields to the Wagner Booster Station. Water treatment consists of iron and manganese removal.

The major facilities required for this strategy (Phase II) include:

- Completion of three segments of 30 in transmission pipeline
  - Brown Family Trust Well Field to CRWA Wells Ranch Water Treatment Plant (7 miles)
  - Blue Stem Road to FM 467 (8 miles)
  - I-10 at Santa Clara to Wagner Booster Station Ground Storage Tank (4 miles)
- 9 – 500 GPM Wells,
- Well Collection Pipelines, and
- Water Treatment Plant Expansion.

Cost estimates were developed using regional planning procedures. These costs are summarized in Table 4C.27-3. The estimated project cost is $34,910,000. The annual costs include debt service for a 20-year loan at 6 percent interest and operation and maintenance costs, including power. The costs also include a groundwater lease fee of $62.50/acft and a groundwater district export fee of $8.71/acft. The cost of water is estimated to be $725/acft/yr ($2.22 per 1,000 gallons) for treated water.

4C.18.6 Implementation Issues

Implementation of the CRWA Wells Ranch water management strategy could involve conflicts with other water supply plans as they will be competing for limited groundwater supplies within the GCUWCD. Because the district's permitting process is independent of the regional planning process, potentially competing groundwater management strategies are not prioritized.

This project considers existing rules of the GCUWCD with regard to well yield, spacing, and acreage. An assessment has not been conducted of the maximum drawdown criteria, which will be performed in the cumulative effects section of the plan.

Table 4C.27-3.
Cost Estimate Summary
CRWA Wells Ranch Project – Phase II Expansion
Sept 2008 Prices

Item	Estimated Costs for Facilities
Capital Costs	
Transmission Pipeline Completion (30 in dia., 21.4 miles)	$15,780,000
Well Field Expansion	$7,227,000
Water Treatment Plant Expansion (5.2 MGD)	$1,467,000
Total Capital Cost	**$24,474,000**
Engineering, Legal Costs and Contingencies	$7,777,000
Environmental & Archaeology Studies and Mitigation	$621,000
Land Acquisition and Surveying (11 acres)	$695,000
Interest During Construction (1 years)	$1,343,000
Total Project Cost	**$34,910,000**
Annual Costs	
Debt Service (6 percent, 20 years)	$3,044,000
Operation and Maintenance	
Intake, Pipeline, Pump Station	$230,000
Water Treatment Plant	$422,000
Pumping Energy Costs (1,056,191 kW-hr @ 0.09 $/kW-hr)	$95,000
Purchase of Water (5,800 acft/yr @ 71.27 $/acft)	$413,000
Total Annual Cost	**$4,204,000**
Available Project Yield (acft/yr)	5,800
Annual Cost of Water ($ per acft)	$725
Annual Cost of Water ($ per 1,000 gallons)	$2.22

Part or all of the water needed by this Water Management Strategy (WMS) is anticipated to be supplied from locations within the jurisdiction of a groundwater conservation district (District) and may exceed the amount of available water identified in the District's approved management plan, or may for other reasons not be permitted by the District.

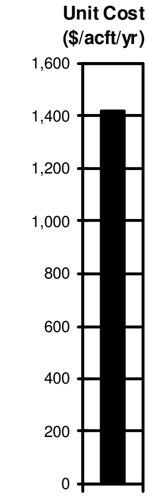
The amount of water needed by this WMS that exceeds the available water in the District's management plan, or for other reasons is not permitted by the District, cannot be implemented as part of this WMS unless and until all necessary permits are received from the District.

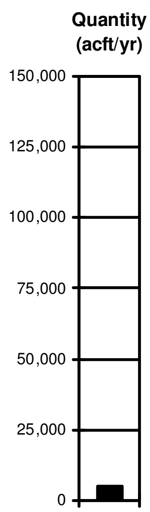
The amount of water needed by this WMS that exceeds the available water in the District's management plan, or for other reasons is not permitted by the District, introduces an added element of uncertainty to reliance upon this WMS and, therefore, additional management supplies may be needed for this WMS.

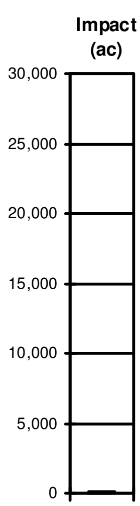
The development of groundwater in the Carrizo-Wilcox Aquifer in the South Texas Water Planning Region must address several issues. Major issues include:

- GCUWCD permits:
  - Analyses of pumping impacts on groundwater levels;
  - Mitigation of impacts on existing well owners;
  - Drought and Water Conservation Plans; and
  - Needs assessment.
- GCGCD permits:
  - Analyses of pumping impacts on groundwater levels;
  - Mitigation of impacts on existing well owners;
  - Drought and Water Conservation Plans; and
  - Needs assessment.
- Impacts on:
  - Endangered and threatened species;
  - Water levels in the aquifer, including dewatering of the current artesian part of the aquifer;
  - Baseflow in streams; and
  - Wetlands.
- Competition with others in the area for groundwater;
- Regulations by the GCUWCD, including periodic renewal of permits and potential pumping reductions; and
- Obtain TCEQ permits.

2011 South Central Texas Regional Water Plan
Water Management Strategy Summary Sheet







Name:* *CRWA Siesta Project

Description: Water management strategy includes an amendment to CRWA's existing Siesta water right on Cibolo Creek (changing the authorized diversions from 42 acft/yr to 5,042 acft/yr), acquisition and consolidation of other existing water rights on Cibolo Creek, and purchase of reuse make-up water from SARA and or CCMA WWTPs. Should treated effluent from wastewater treatment facilities not be available, the project could include brackish groundwater as an alternate back-up source. Facilities include an intake & pump station at the Siesta Cattle Company site, water treatment plant, and a 23-mile 20-inch pipeline to the existing FM 1518 elevated tank. Strategy has been sized for delivery on a peak month basis for municipal supply.

***Decade Needed*:** 2000 – 2010

Cost, Quantity of Water, and Land Impacted

Unit Cost of Water:	**$1,421**	**$/acft/yr**	**Treated Water Delivered**
Quantity of Water:	**5,042**	**acft/yr**	**Reliability = Firm**
Land Impacted:	**92**	**acres**	

Additional Considerations per Regional Water Planning Guidelines

Environmental Factors:

Threatened species include the Texas Horned Lizard and the Texas Tortoise.

Impacts on Water Resources:

Some reductions in streamflows in Cibolo Creek associated with greater utilization of existing water rights and the CRWA Amendment.

Impacts on Agricultural & Natural Resources:

Minimal, if any.

Other Relevant Factors per SCTRWPG:

Encourages beneficial use of available rights. The use of effluent from SARA and/or CCMA WWTPs, as make-up water, is subject to necessary permitting and contractual agreements.

Comparison of Strategies to Meet Needs:

Limited conflicts with other recommended water management strategies including the GBRA New Appropriation (Lower Basin) WMS.

Interbasin Transfer Issues:

None anticipated.

Third-Party Impacts of Voluntary Transfers:

None anticipated.

Regional Efficiency:

Utilizes reuse water or brackish groundwater as a make-up source, in lieu of storage or fresh groundwater.

Water Quality Considerations:

Use of treated effluent as a make-up supply source may require added treatment.

4C.28 CRWA Siesta Project

4C.28.1 Description of Water Management Strategy

The Canyon Regional Water Authority (CRWA) Siesta Project is based on diversions from Cibolo Creek in Wilson County under existing and amended water rights along with treated effluent from wastewater treatment facilities operated by San Antonio River Authority (SARA) and/or Cibolo Creek Municipal Authority (CCMA) as raw water sources for treatment and integration as a new municipal water supply for CRWA members. Should treated effluent from wastewater treatment facilities not be available, the project could include brackish groundwater as an alternate back-up source. The CRWA Siesta Project involves the acquisition/lease of additional water rights and the amendment of a surface water right presently held by CRWA in order to increase authorized diversions from Cibolo Creek by CRWA from 42 acft/yr to 5,042 acft/yr. The firm yield of the CRWA Siesta Project at the Siesta Cattle Company site is to be available to the CRWA members of LaVernia, SS Water Supply Corporation, East Central Water Supply Corporation, Bexar Metropolitan Water District, and to others via the existing CRWA Mid-Cities Pipeline (Figure 4C.28-1).

4C.28.2 Water Availability

As of July 2005, CRWA had acquired two water rights on Cibolo Creek – Certificate of Adjudication (CA) #19-1155 for 42 acft/yr (formerly held by the Siesta Cattle Company) and CA #19-1151 for 86 acft/yr (formerly held by Raymond D Hegwer et ux). CRWA has entered into agreements to lease water from two water rights holders on Cibolo Creek – CA #19-1152 for 35 acft/yr and CA #19-1157 for 117 acft/yr. In addition, CRWA is in negotiations to acquire/lease up to 455 acft/yr of additional water rights to be included in the CRWA Siesta Project. CRWA will be seeking to amend these water rights so that a common diversion point can be utilized at the Siesta Cattle Company site and to increase total authorized diversions at that point to 5,042 acft/yr.

The Guadalupe-San Antonio River Basin Water Availability Model (GSAWAM, as modified for regional water planning purposes) was used to quantify water available for diversion under the existing water rights CRWA has either already acquired/leased or is seeking to acquire/lease. Hydrologic simulations and calculations were performed subject to the General

Assumptions for Applications of Hydrologic Models adopted by the South Central Texas Regional Water Planning Group and listed in Appendix B of Volume II.

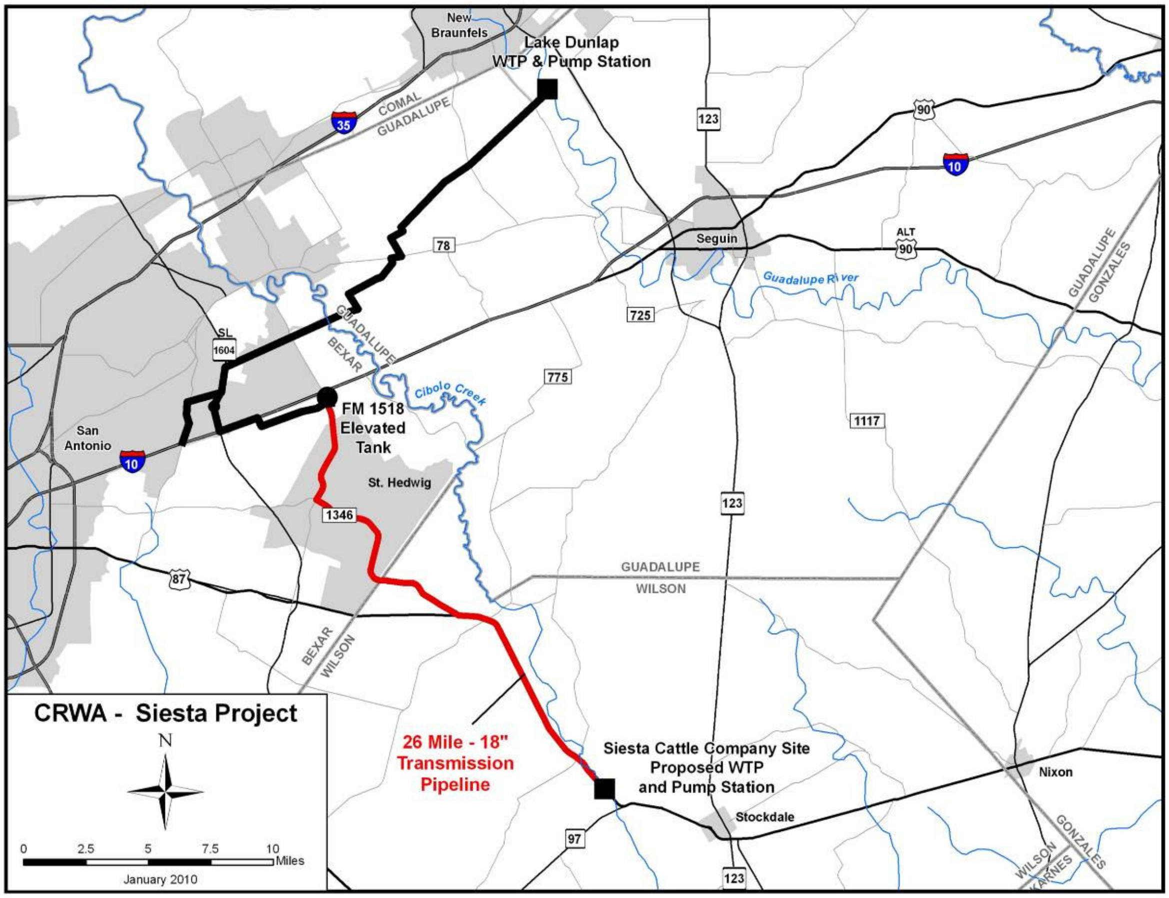


Figure 4C.28-1. CRWA Siesta Project

The GSAWAM was also used to quantify the water available under a proposed amendment to the Siesta water right (CA #19-1155) thereby increasing authorized diversion by 4,307 acft/yr. The proposed amendment to CA #19-1155 was modeled as a new appropriation subject to environmental flow restrictions consistent with Consensus Criteria for Environmental Flow Needs (CCEFN). Table 4C.28-1 includes the streamflow statistics used in the application of CCEFN.

Water diverted for the CRWA Siesta Project under the various water rights acquisitions, leases, and amendments is shown in Figure 4C.28-2. In addition, Figure 4C.28-2 shows the make-up water necessary from SARA and/or CCMA wastewater treatment plants on Martinez Creek to obtain a firm yield of 5,042 acft/yr. The long-term average (1934-1989) diversion from Cibolo Creek under the various water rights is 2,706 acft/yr, while the drought average (1947-

1956) diversion is 1,493 acft/yr. The corresponding long-term and drought average make-up water requirements are 2,336 acft/yr and 3,549 acft/yr, respectively.

Table 4C.28-1.
Daily Naturalized Streamflow Statistics for Cibolo Creek at Falls City

Month	Median Flows - Zone 1 Pass-Through Requirement (cfs)	25th Percentile Flows - Zone 2 Pass-Through Requirement (cfs)
January	26.9	19.2
February	27.1	19.4
March	26.9	19.1
April	26.0	17.0
May	30.0	15.9
June	29.2	13.4
July	20.0	11.0*
August	16.0	11.0*
September	19.0	11.0*
October	22.1	13.0
November	26.0	15.2
December	26.2	16.7
Zone 3 Pass-Through Requirement (cfs)		11.0
** Zone 3 Pass-Through Requirement exceeds 25th Percentile Flow.*		

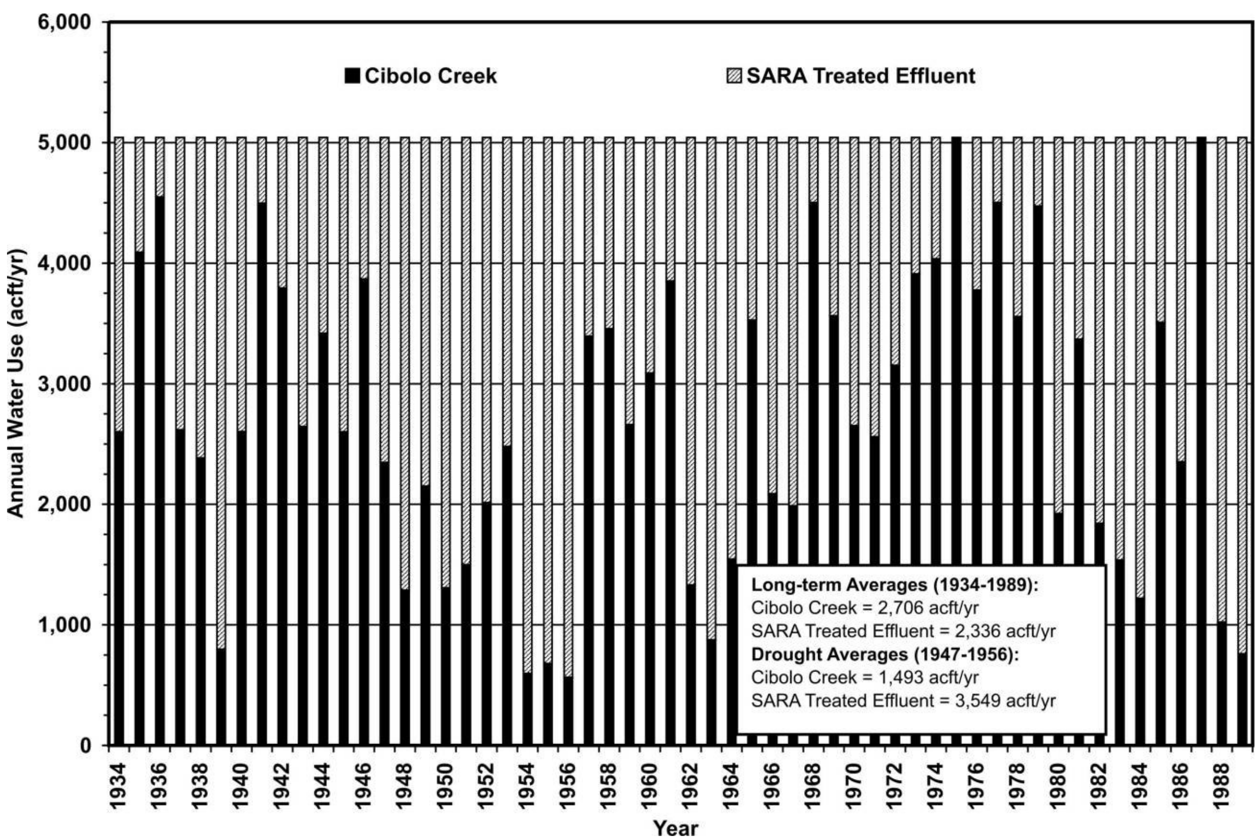


Figure 4C.28-2. CRWA Siesta Project – Water Supply Sources

Figure 4C.28-3 shows the monthly median streamflows and overall streamflow frequency for Cibolo Creek at Falls City with and without the CRWA Siesta Project. Percent changes in monthly median streamflow range from a high of an 11% decrease in October to essentially no change in the months of July and August. Streamflow statistics and surface water diversion presented herein are based on current levels of treated effluent.

4C.28.3 Environmental Issues

The CRWA Siesta Project facilities include an intake and pump station, water treatment plant and a 23 mile pipeline to the existing FM 1518 elevated tank. The project area includes land primarily in the South Texas Plains vegetational area, with the northwestern end of the proposed pipeline entering into the edges of the Blackland Prairies vegetational area.[1] The vegetation of these areas of Bexar and Wilson County is now primarily composed of rangeland, crops and post-oak woodlands. Landforms of the project area are typically nearly level to gently rolling and are slightly-to-moderately dissected by streams which are tributaries of the San Antonio and Guadalupe Rivers.

The original vegetation of the South Texas Plains was a brushy chaparral-grassland with dense thickets of oaks and mesquites on the ridges, and oak, pecan and ash common along streams. Continued grazing and cessation of fires altered the vegetation to such a degree that the region south of San Antonio is now commonly called the South Texas Brush Country.[2] Thorny brush is the predominant vegetation type in this region, including mesquite (*Prosopis pubescens*) acacia (*Acacia greggii*), prickly pear (*Opuntia spp.)* and mimosa, among others. Grasses characteristic of these sandy loam soils are seacoast bluestem (*Schizachyrium scoparium* var. *littoralis)*, tanglehead (*Heteropogon contortus)*, and species of bluestem (*Bothriochloa)*, *Paspalum*, windmill grass (*Chloris)* and lovegrass (*Eragrostis)*. Many of these vegetational elements of the South Texas Brush Country are seen in the southern half of the proposed pipeline route.

The northern portion of the proposed pipeline route passes through the Blackland Prairie vegetational area, which is characterized by prairie grass and forbs. Most of this area is now cultivated in crops, however there are still small pockets of meadowland present which is composed of climax tall grass vegetation. The dominant grass in this area is little bluestem,

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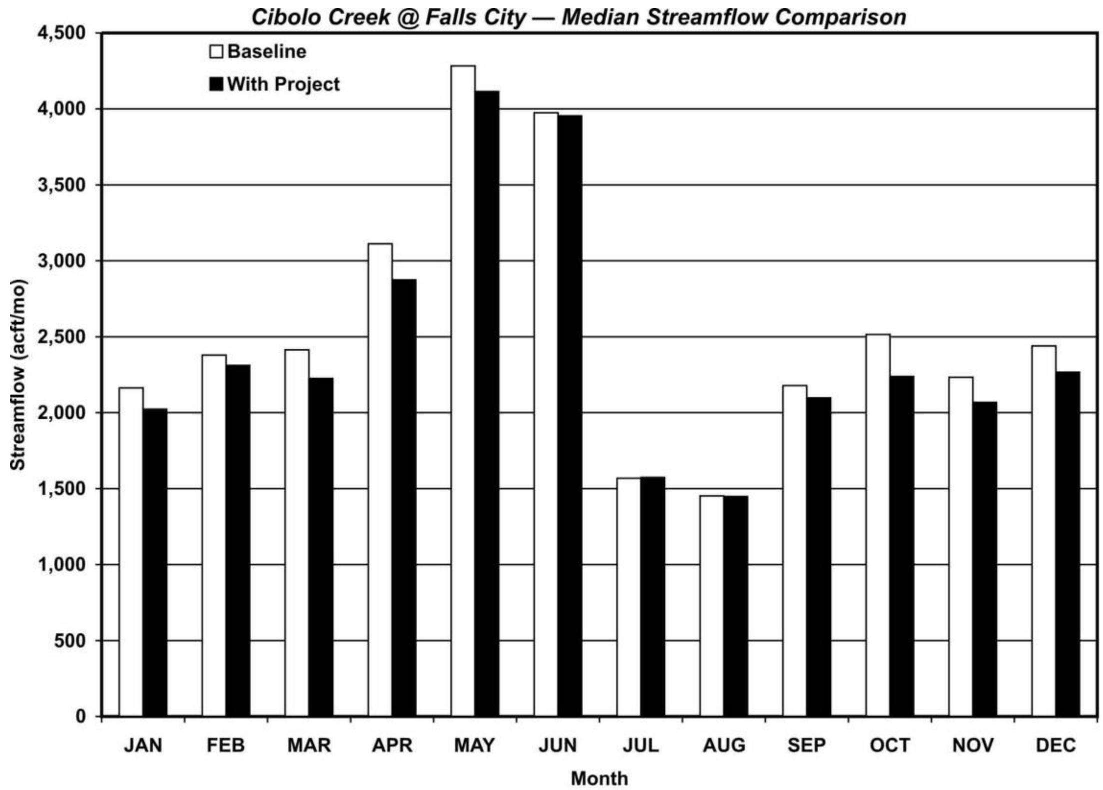
[1] Gould, F.W., "The Grasses of Texas," Texas A&M University Press, College Station, Texas, 1975.

2 Inglis, J.M., "A History of Vegetation on the Rio Grande Plain," Project W-84-R-Texas, Bulletin No. 45, Texas Parks and Wildlife Department. Austin, Texas, 1964.



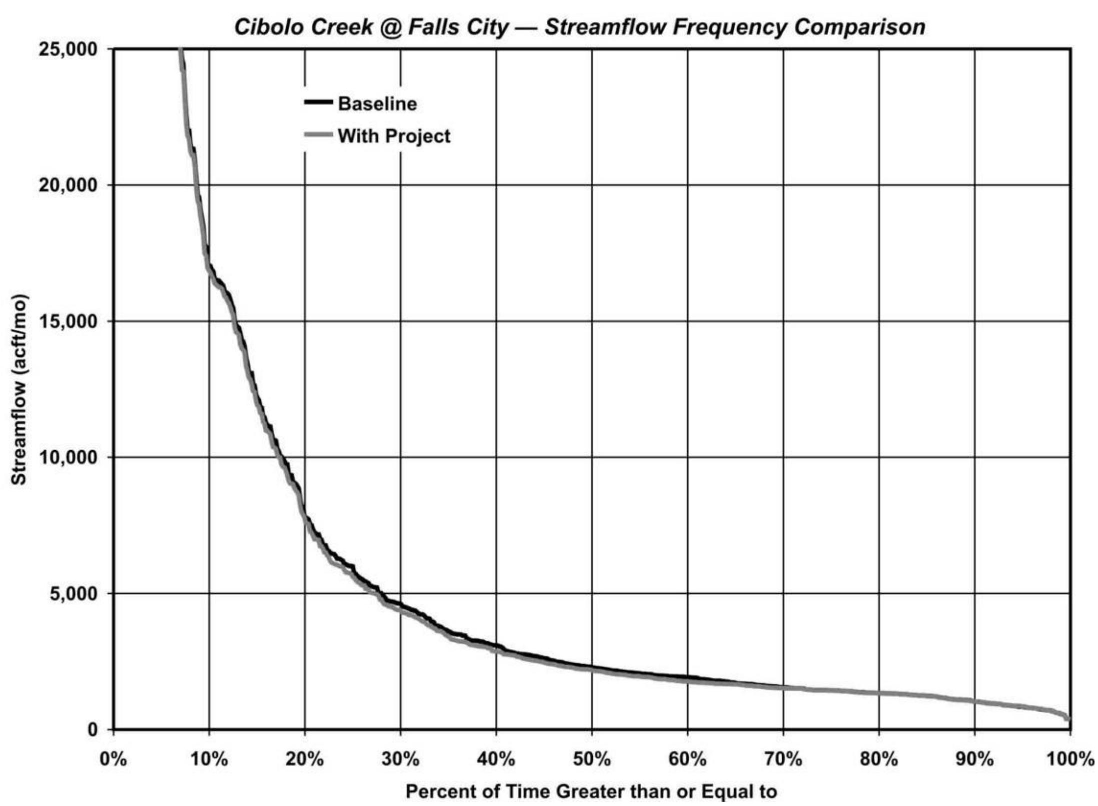


Figure 4C.28-3. Streamflow Changes Associated with CRWA Siesta Project

(*Schizachyrium scoparium* var. *frequens*), with other important grasses including big bluestem (*Andropogon gerardii)*, indiangrass (*Sorghastgrum nutans)*, switchgrass (*Panicum virgatum)*, and sideoats grama (*Bouteloua curtipendula)*. During the turn of the 20th century, about 98 percent of the Blackland Prairie was cultivated for crops. Livestock production has increased dramatically since that time, and now only about 50 percent of the area is used for cropland. Common woody plant species in this area include mesquite, huisache (*Acacia smallii*), oak (*Quercus sp.*) and elm (*Ulmus sp.*). Oak, elm, cottonwood (*Populus sp.*) and native pecan (*Carya*) are common along drainages.

Vertebrate fauna typifying these regions include the opossum, raccoon, weasel, skunk, white-tailed deer and bobcat as well as a wide variety of amphibians, reptiles and birds. The coyote and javelina are also common to the area, but are found mainly in brush/shrub areas while the red and gray fox are more common in woodlands.[3]

Plant and animal species listed by the USFWS and TPWD as endangered, threatened or rare in the project area are presented in Table 4C.28-1. The ranges of the endangered golden-cheeked warbler (*Dendroica chrysoparia*) and black-capped vireo (*Vireo atricapillus*) only extend into northern and western Bexar County and not Wilson County. Consequently, the presence of these species or their typical nesting habitat, in the vicinity of the proposed pipeline is unlikely.

Several species listed as threatened by the state may occur in the vicinity of the pipeline right of way. These include the indigo snake (*Drymarchon corais erebennus)*, Texas horned lizard (*Phrynosoma cornutum*), and Texas tortoise (*Gopherus berlandieri).*

The only endangered, threatened species, or species of special concern identified as occurring on or in the vicinity of the proposed pipeline route by the TPWD Natural Diversity Database files include Elmendorf's onion (*Allium elmendorfii*), big red sage *(Salvia penstemonoides),* and Parks jointweed (*Polygonella parksii)*. Both Elmendorf's onion and Parks' jointweed are found in deep sands. The big red sage usually grows along creek beds and seepage slopes of limestone canyons. These species of concern are considered to be rare, but are not protected by USFWS or TPWD.

[3] Jones, J.K. et al., "Annotated Checklist of Recent Land Mammals of Texas," Occasional Papers of the Museum OP-119, Texas Tech University, 1988.

Table 4C.28-1
Endangered, Threatened, and Species of Concern in Bexar and Wilson Counties

Common Name	Scientific Name	Impact Value	Multiplier Based on Status	Adjusted Impact	Summary of Habitat Preference	Listing Entity		Potential Occurrence in County
						USFWS[1]	TPWD[1]	
A cave obligate crustacean	*Monodella texana*	0	0	0	Subaquatic, found in underground freshwater aquifers			Resident
American Peregrine Falcon	*Falco peregrinus anatum*	0	3	0	Open country; cliffs	DL	T	Nesting/Migrant
Arctic Peregrine Falcon	*Falco peregrinus tundrius*	0	2	0	Open country; cliffs	DL		Nesting/Migrant
Big Red Sage	*Salvia penstemonoides*	2	1	2	Endemic; Creekbeds and seepage slopes of limestone canyons			Resident
Black Bear	*Usus americanus*	0	2	0	Mountains, broken country, woods, brushlands, forests	T/SA; NL	T	Resident
Black-capped Vireo	*Vireo atricapillus*	2	3	3	Semi-open broad-leaved shrublands	LE	E	Nesting/Migrant
Bracted Twistflower	*Streptanthus bracteatus*	1	1	1	Endemic; Shallow clay soils over limestone; rocky slopes			Resident
Braken Bat Cave Meshweaver	*Cicurina venii*	0	3	0	Small eyeless spider, in Karst features in western Bexar County.	LE		Resident
Cascade Cavern salamander	*Eurycea latitans complex*	0	2	0	Endemic, subaquatic in Edwards Aquifer area.		T	Resident
Cave Myotis Bat	*Myotis velifer*	0	1	0	Colonial & cave dwelling; hibernates in limestone caves of Edwards Plateau			Resident
Cokendolpher Cave Harvestman	*Texella cokendolpheri*	0	3	0	Small eyeless harvestman, karst features in north-central Bexar county.	LE		Resident
Comal Blind Salamander	*Eurycea tridentifera*	0	2	0	Endemic; Semi-troglobitic; Springs and waters of caves		T	Resident
Correll's False Dragon-Head	*Physostegia correllii*	1	1	1	Wet soils			Resident
Creeper mussel	*Strophitus undulates*	0	1	0	Found in small to large streams.			Resident
Edwards Plateau Spring Salamander	*Eurycea sp. 7*	0	1	0	Troglobitic; Edwards Plateau			Resident
Elmendorf's Onion	*Allium elmendorfii*	2	1	2	Endemic; deep sands derived from Queen City and similar Eocene formations			Resident
False spike mussel	Quincuncina mitchelli	0	2	0	Found in larger river basins.		T	Resident
Ghost-faced bat	*Mormoops megalophylla*	0	1	0	Roosts in caves, crevices and buildings			Resident
Golden orb	*Quadrula aurea*	0	2	0	Sand and gravel, Guadalupe, San Antonio, and Nueces River basins		T	Resident

Table 4C.28-1 (Continued)

Common Name	Scientific Name	Impact Value	Multiplier Based on Status	Adjusted Impact	Summary of Habitat Preference	Listing Entity		Potential Occurrence in County
						USFWS[1]	TPWD[1]	
Golden-Cheeked Warbler	Dendroica chrysoparia	1	3	3	Woodlands with oaks and old juniper	LE	E	Nesting/Migrant
Government Canyon Bat Cave Meshweaver	*Cicurina vespera*	0	3	0	Small, eyeless spider, karst features in northwestern Bexar County.	LE		Resident
Government Canyon Bat Cave Spider	*Neoleptoneta microps*	0	3	0	Small, eyeless or essentially eyeless spider; karst features in N and NW Bexar Co.	LE		Resident
Gray Wolf	*Canis Lupus*	0	3	0	Extirpated.	LE	E	Exitinct
Ground Beetle #1	*Rhadine exilis*	0	3	0	Eyeless beetle, karst features in northern Bexar County.	LE		Resident
Ground Beetle #2	Rhadine infernalis	0	3	0	Small eyeless ground beetle; karst features in northern and western Bexar County.	LE		Resident
Guadalupe Bass	*Micropterus treculi*	0	1	0	Streams of eastern Edwards Plateau			Resident
Helotes Mold Beetle	*Bastrisodes venyivi*	0	3	0	Small, essentially eyeless mold beetle; karst features in N and NW Bexar Co.	LE		Resident
Hill Country wild-mercury	*Argythamnia aphoroides*	1	1	1	Endemic: found in grasslands associated with oak woodlands.			Resident
Indigo Snake	*Drymarchon corais erebennus*	1	2	2	Grass prairies and sand hills; usually thornbush woodland and mesquite savannah of coastal plain		T	Resident
Interior least tern	*Sterna antillarum athalassos*	0	3	3	Nests along sand and gravel bars in braided streams			
Manfreda Giant-Skipper	*Stallingsia maculosus*	1	1	1	Larvae feed inside leaf shelter and pupae found in cocoon made of leaves fastened by silk			Resident
Madla's Cave Meshweaver	*Cicurina madla*	0	3	0	Small, eyeless or essentially eyeless spider; karst features in N and NW Bexar Co.	LE		Resident
Mimic Cavesnail	*Phreatodrobia imitata*	0	1	0	Subaquatic; wells in Edwards Aquifer			Resident
Mountain Plover	*Charadrius montanus*	0	1	0	Shortgrass plains and fields, sandy deserts, plowed fields			Nesting/Migrant
Parks' Jointweed	*Polygonella parksii*	2	1	2	South Texas Plains; subherbaceous annual in deep loose sands, spring-summer			Resident
Pistolgrip	*Tritogonia verrucosa*	0	1	0	Aquatic, stable substrate. Red through San Antonio river basins.			Resident
Plains Spotted Skunk	*Spilogale putorius interrupta*	0	1	0	Catholic; Wooded, brushy areas and tallgrass prairies			Resident
Rawson's metalmark	*Calephelis rawsoni*	1	1	1	Moist areas in shaded limestone outcrops			Resident

Table 4C.28-1 (Concluded)

Common Name	Scientific Name	Impact Value	Multiplier Based on Status	Adjusted Impact	Summary of Habitat Preference	Listing Entity		Potential Occurrence in County
						USFWS[1]	TPWD[1]	
Red Wolf	*Canis rufus*	0	3	0	Extirpated.	LE	E	Historic Resident
Robber Baron Cave Meshweaver	*Cicurina baronia*	0	3	0	Small, eyeless or essentially eyeless spider; karst features in N and NW Bexar Co.	LE		Resident
Rock pocketbook	*Arcidens confragosus*	0	1	0	Mud and sand, Red through Guadalupe River basins.			Resident
Sandhill Woolywhite	*Hymenopappus carrizoanus*	1	1	1	Endemic; Open areas in deep sands derived from Carrizo and similar Eocene formations			Resident
Spot-tailed Earless Lizard	*Holbrookia lacerata*	1	1	1	Oak-juniper woodlands and mesquite-prickly pear			Resident
Texas fatmucket	*Lampsilis bracteata*	0	2	0	Streams and rivers on sand, mud and gravel, Colorado and Guadalupe River basins.		T*	Resident
Texas Garter Snake	*Thamnophis sirtalis annectens*	1	1	1	Varied, especially wet areas; bottomlands and pastures			Resident
Texas Horned Lizard	*Phrynosoma cornutum*	1	2	2	Varied, sparsely vegetated uplands		T	Resident
Texas pimpleback	*Quadrula petrina*	0	2	0	Mud, gravel and sand substrates, Colorado and Guadalupe river basins		T	Resident
Texas Salamander	*Eurycea neotenes*	0	1	0	Endemic, from springs, seeps and caves.			Resident
Texas Tortoise	*Gopherus berlandieri*	2	2	4	Open brush with grass understory; open grass and bare ground avoided; occupies shallow depressions at base of bush or cactus, underground burrows, under objects; active March-Nov		T	Resident
Timber/Canebrake rattlesnake	*Crotalus horridus*	1	2	2	Floodplains, upland pine, deciduous woodlands, riparian zones.		T	Resident
Toothless Blindcat	*Trogloglanis pattersoni*	0	2	0	Troglobitic, blind catfish endemic to the San Antonio Pool of the Edwards Aquifer		T	Resident
Western Burrowing Owl	*Athene cunicularia hypugaea*	0	1	0	Open grasslands, especially prairie, plains and savanna			Resident
Whooping Crane	*Grus americana*	0	3	0	Potential migrant	LE	E	Migrant
White-faced Ibis	*Plegadis chihi*	0	2	0	Prefers freshwater marshes.		T	
Widemouth Blindcat	*Satan eurystomus*	0	1	0	Troglobitic, blind catfish endemic to the San Antonio Pool of the Edwards Aquifer.		T	Resident
Wood Stork	*Buteo americana*	0	2	0	Prairie ponds, flooded pastures or fields; shallow standing water		T	Nesting/Migrant
Zone-tailed Hawk	*Buteo albonotatus*	0	2	0	Arid, open country including deciduous or pine-oak woodland.		T	Nesting/Migrant

[1] Source: TPWD, Annotated County List of Rare Species, Bexar and Wilson Counties, January 2010.
LE/LT=Federally Listed Endangered/Threatened E/SA, T/SA=Federally Listed Endangered/Threatened by Similarity of Appearanc e
C1=Federal Candidate for Listing DL, PDL=Federally Delisted/Proposed for Delisting NL=not Federally Listed E, T=State Listed Endangered/Threatened
PE, PT=Federally Proposed Endangered/ Threatened Blank = Rare, but no regulatory listing status

Field surveys conducted at the appropriate phase of development should be employed to minimize the impacts of construction and operation on sensitive resources. Specific project features, such as well field, pipelines, and off-channel reservoirs generally have sufficient design flexibility to avoid most impacts or significantly mitigate potential impacts to geographically limited environmental and cultural resource sites.

Cultural resources protection on public lands in Texas is afforded by the Antiquities Code of Texas (Title 9, Chapter 191, Texas Natural Resource Code of 1977), the National Historic Preservation Act (P196-515), and the Archeological and Historic Preservation Act (PL93-291). Based on the review of available records housed at the Texas Archeological Research Laboratory in Austin, seventeen cultural resource sites occur within a one-mile corridor of the proposed project area. Taking into consideration that the owner or controller of the project will likely be a political subdivision of the State of Texas (i.e., river authority, municipality, county, etc.), they will be required to coordinate with the Texas Historical Commission prior to project construction. If the project will affect waters of the United States or wetlands, the project sponsor will also be required to coordinate with the U.S. Army Corps of Engineers regarding impacts to cultural resources.

4C.28.4 Engineering and Costing

Facilities for the CRWA Siesta Project include a raw water intake and pump station and a water treatment plant at the Siesta Cattle Company site as well as a 23-mile 20-inch treated water transmission pipeline to the existing FM 1518 elevated tank, part of the existing CRWA Mid-Cities Pipeline. Facilities have been sized to meet peak month demands. For costing purpose only, it is assumed that the entire 5,042 acft/yr would be delivered to the FM 1518 elevated tank. Cost estimates were developed in accordance with the methodology for regional planning studies (Appendix A).

As suggested by CRWA, water rights acquisition costs are based on a one-time cost of $500/acft and lease costs are based on an annual cost of $55/acft/yr. Table 4C.28-4 contains the cost estimate for the CRWA Siesta Project. The capital cost for the facilities of the CRWA Siesta Project, including $292,000 for the acquisition of 583 acft/yr in water rights, is $37,444,000. With the inclusion of other project costs (contingencies, environmental, land acquisition, etc), the total project cost is $53,481,000. The annual cost for the CRWA Siesta

Project, including amortization and O&M, is $7,167,000, yielding a unit cost of water of $1,421/acft/yr or $4.36/1,000-gallons.

Table 4C.28-4.
Cost Estimate Summary
CRWA Siesta Project
September 2008 Prices

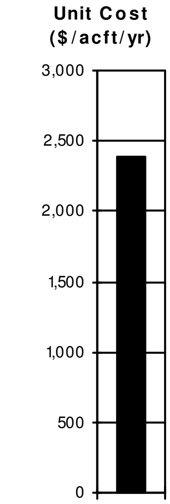
Item	*Estimated Costs for Facilities (September 2008)*
Capital Costs	
Intake and Pump Station (7.0 MGD)	$6,371,000
Transmission Pipeline (20 in dia., 23 miles)	$11,677,000
Transmission Pump Station	$4,395,000
Water Treatment Plant (7.0 MGD)	$14,709,000
Acquisition of Water Rights (583 acft/yr)	$292,000
Total Capital Cost	**$37,444,000**
Engineering, Legal Costs and Contingencies	$12,521,000
Environmental & Archaeology Studies and Mitigation	$613,000
Land Acquisition and Surveying (92 acres)	$846,000
Interest During Construction (1 years)	$2,057,000
Total Project Cost	**$53,481,000**
Annual Costs	
Debt Service (6 percent, 20 years)	$4,663,000
Operation and Maintenance	
Intake, Pipeline, Pump Station	$381,000
Water Treatment Plant	$1,157,000
Pumping Energy Costs (5,945,192 kW-hr @ 0.09 $/kW-hr)	$543,000
Water Rights Leases (152 acft/yr)	$8,000
Purchase of Treated Effluent (5,644[1] acft/yr @ 75 $/acft)	$423,000
Total Annual Cost	**$7,167,000**
Available Project Yield (acft/yr)	5,042
Annual Cost of Water ($ per acft)	$1,421
Annual Cost of Water ($ per 1,000 gallons)	$4.36

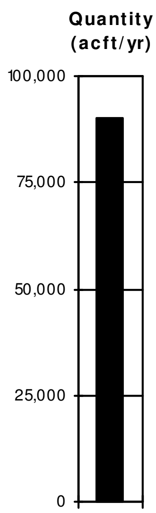
4C.28.5 Implementation Issues

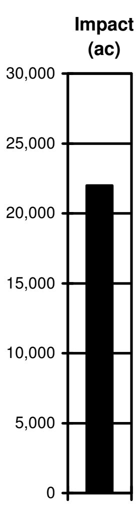
Potential issues or challenges associated with implementation of the CRWA Siesta Project could include:

- Purchase or lease agreements with water rights holders on Cibolo Creek.
- Permit amendments for each of the water rights to be purchased or leased in order to allow diversion from a common point at the Siesta Cattle Company site.
- Permit amendment for the Siesta water right (CA #19-1155) to authorize increased diversions.
- Agreement between CRWA and SARA and/or CCMA for the purchase and use of treated effluent from the SARA wastewater treatment plants on Martinez Creek.
- SARA and/or CCMA to obtain an authorization for the bed and banks transfer of treated effluent from the discharge points along Martinez Creek to the Siesta Cattle Company site.

2011 South Central Texas Regional Water Plan
Water Management Strategy Summary Sheet







Name: **LCRA-SAWS Water Project (LSWP)**

Description: This management strategy is based on a Definitive Agreement between SAWS and LCRA, signed in 2002, for the purchase of up to 90,000 acft/yr of surface water from the Lower Colorado River Basin. Facilities include: 2 intakes and pump stations on the Colorado River, an off-channel storage facility of 212,000 acft, a 66-inch 140-mile transmission pipeline to a new WTP, 3 booster stations, and system improvements for integration of the additional supply. Facility locations are subject to change.

***Decade Needed*:** 2020 – 2030

Cost, Quantity of Water, and Land Impacted

Unit Cost of Water:	**$2,394**	**$/acft/yr**	**Treated Water Delivered**
Quantity of Water:	**90,000**	**acft/yr**	**Reliability = Firm**
Land Impacted:	**22,000**	**acres**	**Reservoir, transmission, water treatment plant.**

Additional Considerations per Regional Water Planning Guidelines

Environmental Factors:

Potential concerns with endangered species, habitat, cultural resources, and TPWD Ecologically Unique Stream Segments. Endangered species include the Attwater's Prairie Chicken, Whooping Crane, Jaguarundi, and Ocelot. Pipeline could come in close proximity to a Bald Eagle rookery in Jackson County.

Impacts on Water Resources:

Reductions in freshwater inflows to Matagorda Bay associated with greater utilization of existing water rights and new appropriation. Potential effects of these reductions are being studied by LCRA & SAWS. Significant additional Gulf Coast Aquifer groundwater production for agricultural use and associated reductions in local and regional groundwater levels.

Impacts on Agricultural & Natural Resources:

Threatened and endangered species habitat destruction could be avoided by selecting a corridor through previously disturbed areas, such as croplands. There are potential increases in reliable water supply for irrigation and improved irrigation efficiency in Region K. The off-channel reservoir will inundate approximately 21,200 acres in Wharton County.

Other Relevant Factors per SCTRWPG:

Encourages beneficial use of available rights. Protects instream flows and recreational opportunities through lower basin diversion. Equitable cost sharing for development of water supplies in Region K and Region L. Diversion points along the Colorado River from Colorado County to Bay City in Matagorda County are still under consideration at this time.

Comparison of Strategies to Meet Needs:

High unit cost. No conflicts with other recommended water management strategies.

Interbasin Transfer Issues:

An amendment to the existing LCRA permits for the interbasin transfer of this water would be required. Environmental flow constraints limiting diversions under the existing water rights may be added during the amendment process thereby reducing the dependable supply and increasing the unit cost of water.

Third-Party Impacts of Voluntary Transfers:

Potential benefits to Lower Colorado River Basin irrigation interests in Region K.

Regional Efficiency:

Potential for shared water treatment and balancing storage facilities in Bexar County.

Water Quality Considerations:

None of significant concern.

4C.29 LCRA-SAWS Water Project

4C.29.1 Description of Water Management Strategy

The Lower Colorado River Authority – San Antonio Water System (LCRA-SAWS) Water Project (LSWP) involves the conservation and development of approximately 330,000 acft/yr in the Lower Colorado River Basin Counties of Matagorda, Wharton, and Colorado. Of that 330,000 acft/yr, LCRA has made up to 90,000 acft/yr available to the San Antonio Water System (SAWS), for an 80-year period. In 2002, SAWS signed a Definitive Agreement with LCRA for the purchase and use of this water. The LSWP involves the potential future diversion of water from the Colorado River, development of off-channel storage, and conveyance through a transmission pipeline to a new water treatment plant (WTP) site and SAWS terminal storage in western Guadalupe County. Water would then be treated and integrated into municipal supply systems in and around the City of San Antonio.

The configuration of the LSWP water management strategy is still being studied. Diversion points along the Colorado River from Colorado County to Bay City in Matagorda County are under consideration at this time. The Colorado River diversion location and conceptual pipeline route for the Bay City diversion is shown in Figure 4C.29-1. Figure 4C.29-2 shows the approximate off-channel storage facility location for the LSWP.

4C.29.2 Available Yield

Sources of water for the LSWP include presently under-utilized surface water rights, stored water from the Highland Lakes System, and new surface water appropriations. In order to meet local irrigation needs, various water conservation measures and periodic utilization of groundwater from the Gulf Coast Aquifer will be necessary. The Gulf Coast Aquifer groundwater will be used conjunctively with LCRA surface water rights to meet the needs of in-district farmers and will not be exported as part of the LSWP. While no final determination has been made to-date, one potential scenario for utilization of potential sources (provided by R.J. Brandes Company on behalf of LCRA and SAWS) is shown in Figure 4C.29-3 which summarizes simulated diversions from the Colorado River (in Wharton County) into off-channel

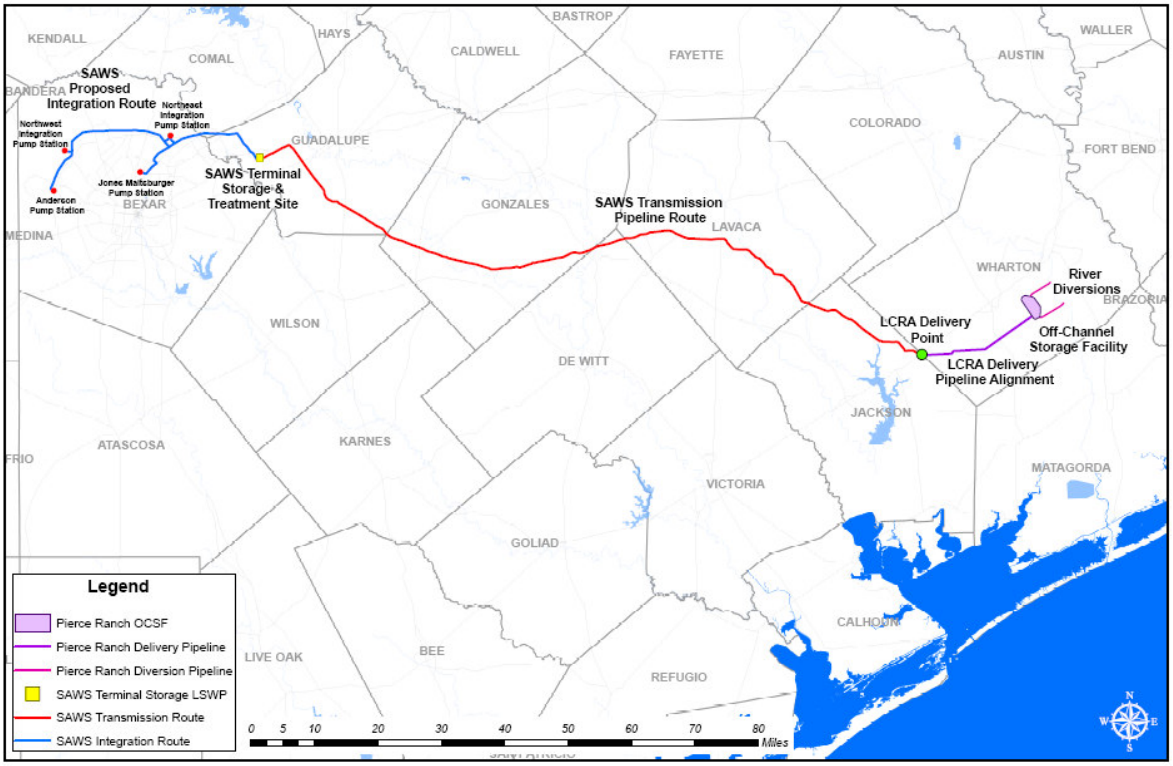


Figure 4C.29-1. LCRA-SAWS Water Project – Bay City to Bexar County (Facility Locations Subject to Change)

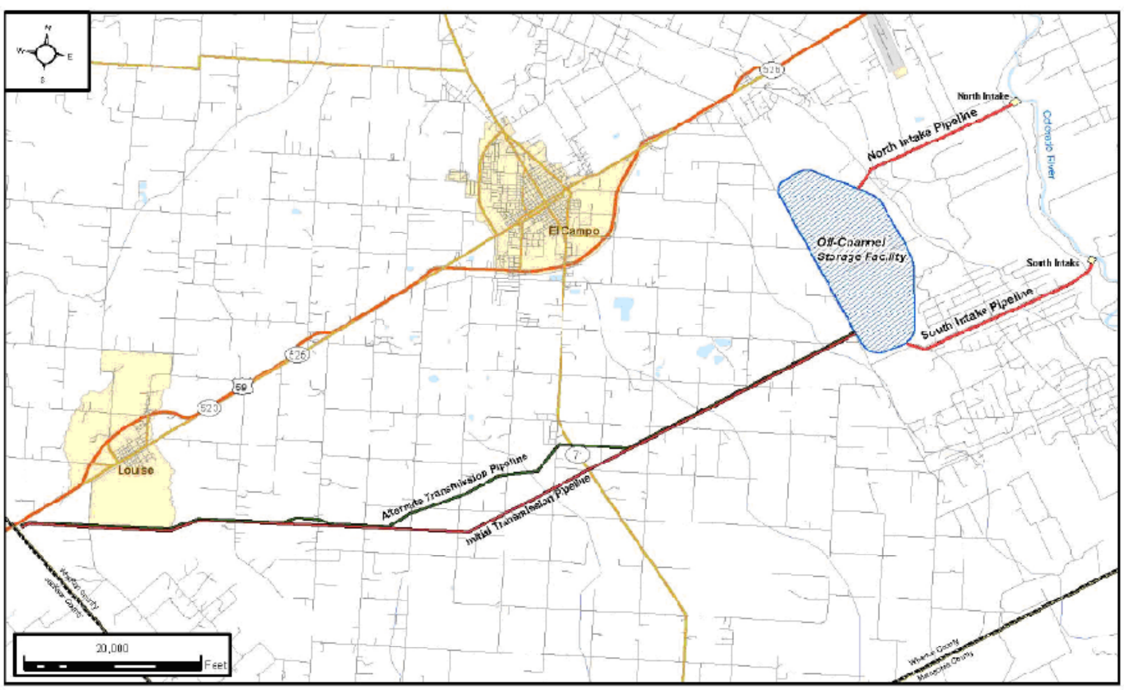


Figure 4C.29-2. LCRA-SAWS Water Project – Off-Channel Storage Facility Location

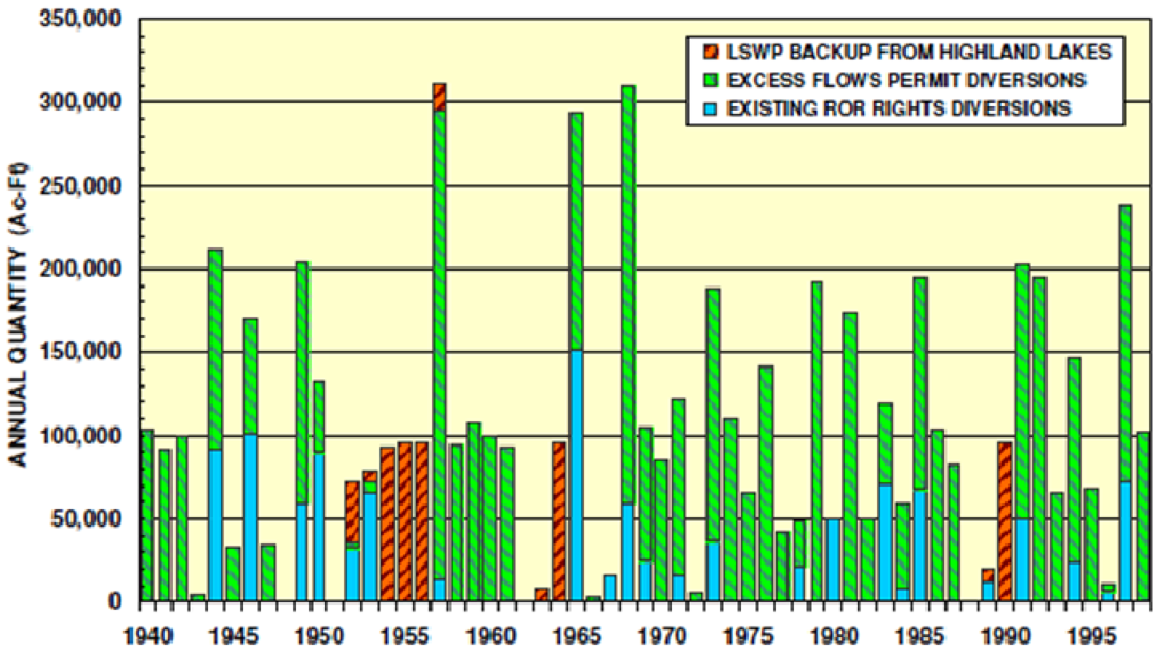


Figure 4C.29-3. LCRA-SAWS Water Project – Potential Water Supply Sources

storage. Figure 4C.29-4 illustrates the total storage in Lakes Travis and Buchanan of the LCRA Highland Lakes System with and without the project. With the LSWP, the minimum storage in the system increases from about 0 acft to about 300,000 acft. Monthly long-term and drought average freshwater inflows for Matagorda Bay with and without implementation of the LSWP are illustrated in Figures 4C.29-5 and 4C.29-6, respectively. The largest long-term average decrease is 7,237 acft/month in April. The largest long-term average increase is 8,808 acft/month in May. Figure 4C.29-7 shows simulated annual inflows to Matagorda Bay for each year of the 1940-1998 simulation period. It is important to note that figures showing sources of water, lake levels, and streamflow changes have been provided by LCRA, SAWS, and their consultant(s). For more information on modeling assumptions, baseline conditions, and system operation, please contact LCRA or SAWS.

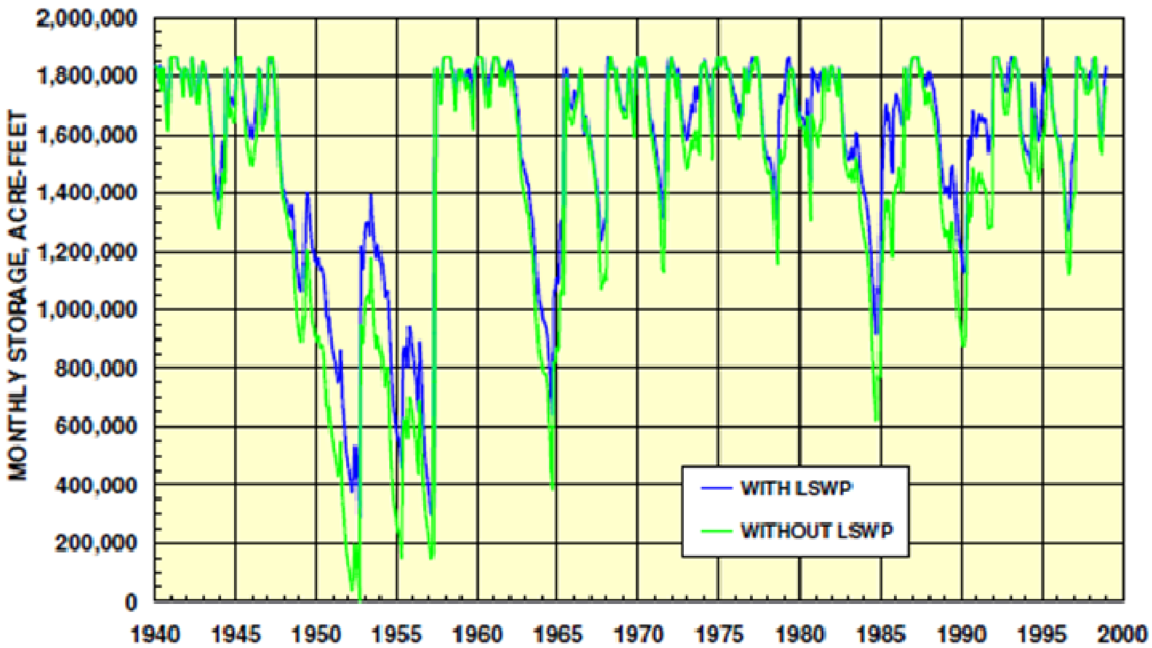


Figure 4C.29-4. LCRA-SAWS Water Project – Simulated Monthly Storage of LCRA System

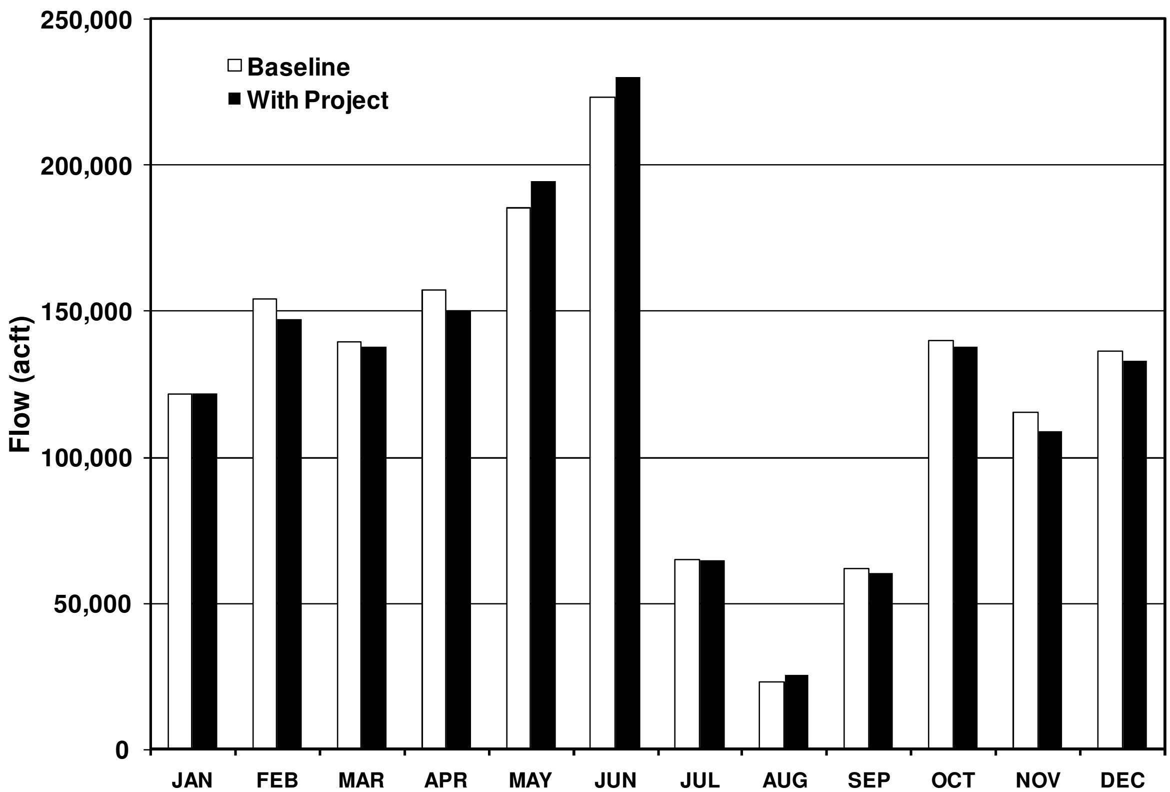


Figure 4C.29-5. LCRA-SAWS Water Project – Simulated Monthly Long-Term Average Inflows to Matagorda Bay

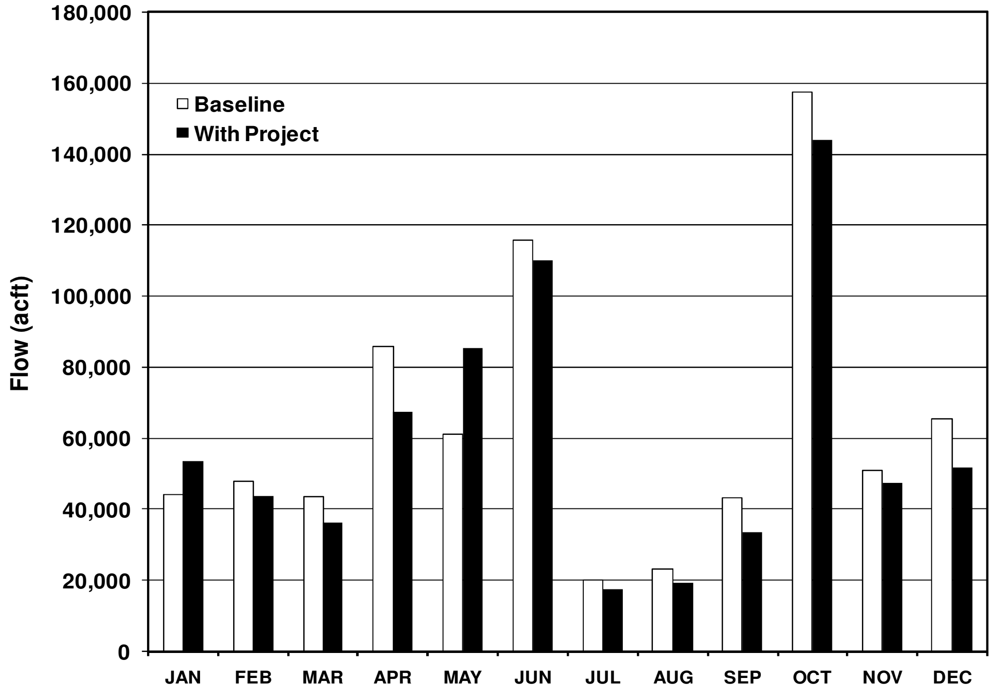


Figure 4C.29-6. LCRA-SAWS Water Project – Simulated Monthly Drought Average Inflows to Matagorda Bay

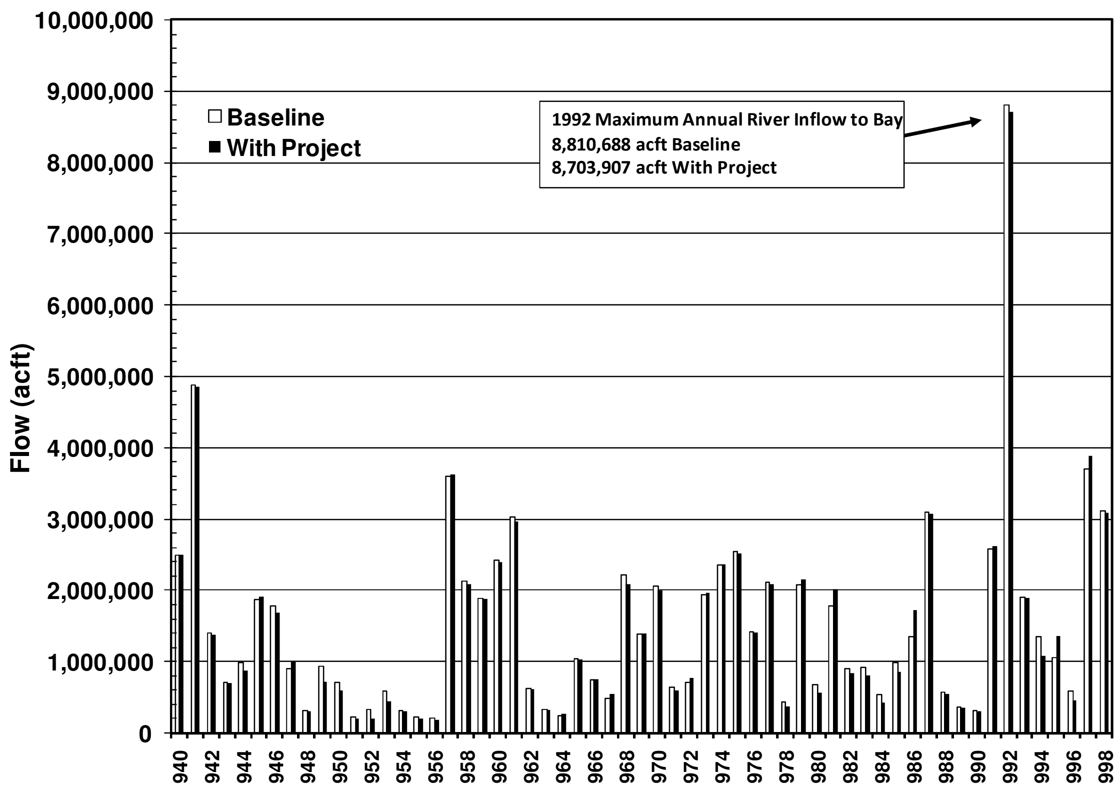


Figure 4C.29-7. LCRA-SAWS Water Project – Simulated Annual Inflows to Matagorda Bay

4C.29.3 Environmental Issues

This strategy is based on an agreement between SAWS and LCRA which involves the purchase of up to 90,000 acft/yr of surface water from the Lower Colorado River Basin for an 80-year period. Facilities in this plan include the development of 2 - 144-inch diversion pipelines (each approximately five miles long), a 212,000 acft off-channel storage reservoir to be located in Wharton County, a 140-mile 66-inch transmission pipeline running from near Bay City to Guadalupe County, transmission booster stations, terminal storage, a new water treatment plant in Guadalupe County, and integration into Bexar County.

Construction of the off-channel reservoir and pipeline would include the clearing and removal of some areas of woody vegetation. The proposed pipeline route would traverse three ecoregions: the Western Gulf Coastal Plain, the East Central Texas Plains, and the westernmost reaches of the Texas Blackland Prairies.[1] These areas include the Tamaulipan and Texan biotic provinces.[2] The pipeline corridor crosses three different types of vegetational areas; the Gulf Prairies and Marshes, Post Oak Savannah, and Blackland Prairie.[3] The climax vegetation of these vegetational areas is considered to be post oak or live oak savannah and grassland, but much of the area presently consists of rangeland, small farms, and brushland, with woodlands tending to occur as remnant riparian strips.[4] In addition, the Colorado River in Wharton County where the diversion pipeline originates, and West Mustang Creek in Lavaca County, crossed by the transmission pipeline to Bexar County, are listed by TPWD as Ecologically Significant River and Stream Segments.

Table 4C.29-1 lists 40 state listed endangered and threatened wildlife and plant species, 23 federally listed endangered or threatened wildlife and plant species, and state and federal species of concern that may occur in Bexar, De Witt, Gonzales, Guadalupe, Lavaca, Wharton and Jackson Counties. Information for this table originates from the county lists of rare species provided by the Texas Parks and Wildlife Department (TPWD) online in the "Annotated County Lists of Rare Species."

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[1] Griffith, G.E., Bryce, S.A., Omernik, J.M., Comstock, J.A., Rogers, A.C., Harrison, B., Hatch, S.L., and Bezanson, D., 2004, Ecoregions of Texas (color poster with map, descriptive text, and photographs): Reston, Virginia, U.S. Geological Survey (map scale 1:2,3000,000).
[2] Blair, W. Frank, "The Biotic Provinces of Texas," Texas Journal of Science 2(1):93-117, 1950.
[3] Gould, F. W., "The Grasses of Texas," Texas A&M University Press, College Station, Texas, 1975.
[4] Ibid.

Table 4C.29-1.
Endangered, Threatened, and Species of Concern for Bexar, DeWitt, Gonzales, Guadalupe, Lavaca, Wharton and Jackson Counties

Common Name	Scientific Name	Impact Value	Multiplier Based on Status	Adjusted Impact	Summary of Habitat Preference	Listing Entity		Potential Occurrence in County
						USFWS	TPWD	
A cave obligate crustacean	*Monodella texana*	*0*	*1*	*0*	Subaquatic, underground freshwater aquifers			Resident
A crayfish	*Cambarellus texanus*	*1*	*1*	*1*	Found in shallow water, benthic.			Resident
A Ground Beetle	*Rhadine exilis*	*0*	*3*	*0*	Karst features in northern Bexar County	LE		Resident
A Ground Beetle	*Rhadine infernalis*	*0*	*3*	*0*	Karst features in northern and western Bexar County	LE		Resident
A mayfly	*Campsurus decoloratus*	*1*	*1*	*1*	Found in Texas and Mexico. Possibly in clay substrates.			Resident
American eel	*Anguilla rostrata*	*1*	*1*	*1*	Coastal waterways below reservoirs to gulf.			Resident
American Peregrine Falcon	*Falco peregrinus anatum*	*0*	*2*	*0*	Resident and local breeder in West Texas. Migrant across the state.	DL	T	Possible Migrant
Arctic Peregrine Falcon	*Falco peregrinus tundrius*	*0*	*1*	*0*	Migrant throughout the state.	DL		Possible Migrant
Attwater's Greater Prairie Chicken	*Tympanuchus cupido attwateri*	*0*	*3*	*0*	Endemic, within historic range.	LE	E	Historic
Bald eagle	*Haliaeetus leucoephalus*	*0*	*2*	*0*	Found primarily near rivers and large lakes.	DL	T	Possible Migrant
Big red sage	*Salvia penstemonoides*	*1*	*1*	*1*	Endemic; moist to seasonally wet clay or silt soils in creek beds.			Resident
Black Bear	*Ursus americanus*	*0*	*2*	*0*	Inhabits bottomland hardwoods	T/SA;NL	T	Historic Resident
Black-capped Vireo	*Vireo atricapillus*	*0*	*3*	*0*	Oak-juniper woodlands,	LE	E	Resident
Blue sucker	*Cycleptus elongates*	*2*	*2*	*4*	Major rivers in Texas.		T	Resident
Braken Bat Cave Meshweaver	*Cicurina venii*	*0*	*3*	*0*	Karst features in western Bexar County	LE		Resident

Table 4C.29-1 (Continued)

Common Name	Scientific Name	Impact Value	Multiplier Based on Status	Adjusted Impact	Summary of Habitat Preference	Listing Entity		Potential Occurrence in County
						USFWS	TPWD	
Brown pelican	*Pelecanus occidentalis*	*1*	*3*	*3*	*Largely coastal and near shore areas.*	DL	E	Resident
Cagle's map turtle	*Graptemys caglei*	*1*	*2*	*2*	Endemic to Guadalupe River System. Found within 30 feet of waters' edge.		T	Resident
Cascade Caverns salamander	*Eurycea latitans complex*	*0*	*2*	*0*	Endemic, subaquatic in Edwards Aquifer Area		T	Resident
Cave Myotis Bat	*Myotis velifer*	*0*	*1*	*0*	Roosts colonially in caves, rock crevices			Resident
Cokendolpher cave harvestman	*Texella cokendolpheri*	*0*	*3*	*0*	Karst features in north-central Bexar County	LE		Resident
Comal Blind Salamander	*Eurycea tridentifera*	*0*	*2*	*0*	Endemic; springs and waters of caves in Bexar County.		T	Resident
Creeper (squawfoot)	*Strophitus undulates*	*1*	*1*	*1*	Small to large streams			Resident
Elmendorf's onion	*Allium elmendorfii*	*2*	*1*	*2*	Endemic, in deep sands			Resident
False spike mussel	*Quincuncina mitchelli*	*1*	*2*	*2*	Substrates of cobble and mud with water lilies present. Rio Grande, Brazos, Colorado and Guadalupe river basins.		T	Resident
Golden orb	*Quadrula aurea*	*1*	*2*	*2*	Sand and gravel, Guadalupe, San Antonio, and Nueces River basins		T	Resident
Golden-cheeked Warbler	*Dendroica chrysoparia*	*0*	*3*	*0*	Juniper-oak woodlands.	LE	E	Resident
Ghost-faced bat	*Mormoops megalophylla*	*0*	*1*	*0*	Roosts in caves, crevices and buildings			Resident
Government Canyon Bat Cave Meshweaver	*Cicurina vespera*	*0*	*3*	*0*	Karst features in northwestern Bexar County	LE		Resident
Government Canyon Bat Cave Spider	*Neoleptoneta microps*	*0*	*3*	*0*	Karst features in northwestern Bexar County	LE		Resident

Table 4C.29-1 (Continued)

Common Name	Scientific Name	Impact Value	Multiplier Based on Status	Adjusted Impact	Summary of Habitat Preference	Listing Entity		Potential Occurrence in County
						USFWS	TPWD	
Gray wolf	*Canis lupus*	*0*	*3*	*0*	Extirpated, forests, brushlands or grasslands	LE	E	Historic resident
Green sea turtle	*Chelonia mydas*	*0*	*2*	*0*	Gulf and bay systems.	LT	T	Resident
Guadalupe Bass	*Micropterus treculi*	*1*	*1*	*1*	Endemic to perennial streams of the Edwards Plateau region.			Resident
Guadalupe Darter	*Percina sciera apristis*	*0*	*1*	*0*	Guadalupe River Basin. Usually found over gravel or gravel and sand raceways of larger streams and rivers.			Resident
Gulf Saltmarsh Snake	*Nerodia clarkia*	*1*	*1*	*1*	Found on saline flats.			Resident
Helotes Mold Beetle	*Batrisodes venyivi*	*0*	*3*	*0*	Karst features in northwestern Bexar County	LE		Resident
Henslow's Sparrow	*Ammodramus henslowii*	*1*	*1*	*1*	Found in weedy fields or cut-over areas			Resident
Houston toad	*Bufo houstonensis*	*1*	*3*	*3*	Endemic in sandy substrate with water in pools.	LE	E	Resident
Interior least tern	*Sterna antillarum athalassos*	*1*	*3*	*3*	Nests along sand and gravel bars in braided streams	LE	E	Resident
Kemp's Ridley sea turtle	*Lepidochelys kempii*	*0*	*3*	*0*	Found in gulf and bay systems.	LE	E	Resident
Leonora's dancer damselfly	*Argia leonorae*	*1*	*1*	*1*	Found near small streams and seepages.			Resident
Loggerhead sea turtle	*Caretta caretta*	*0*	*2*	*0*	Gulf and bay systems for juveniles, ocean for adults.	LT	T	Resident
Louisiana black bear	*Ursus americanus luteolus*	*0*	*2*	*0*	Possible transient.	LT	T	Transident
Madla Cave Meshweaver	*Cicurina madla*	*0*	*3*	*0*	Karst features in northern Bexar County	LE		Resident
Manfreda Giant-skipper	*Stallingsia maculosus*	*1*	*1*	*1*	Skipper larvae usually feed inside a leaf shelter.			Resident

Table 4C.29-1 (Continued)

Common Name	Scientific Name	Impact Value	Multiplier Based on Status	Adjusted Impact	Summary of Habitat Preference	Listing Entity		Potential Occurrence in County
						USFWS	TPWD	
Mimic Cavesnail	*Phreatodrobia imitata*	*0*	*1*	*0*	Subaquatic; only known from two wells penetrating the Edwards Aquifer			Resident
Mountain Plover	*Charadrius montanus*	*1*	*1*	*1*	Non-breeding, shortgrass plains and fields			Nesting/Migrant
Palmetto pill snail	*Euchemostrema leai cheatumi*	*0*	*1*	*0*	Known only from Palmetto State Park.			Resident
Park's jointweed	*Polygonella parksii*	*2*	*1*	*2*	Endemic; deep loose sands of Carrizo and similar Eocene formations.			Resident
Peregrine Falcon	*Falco peregrinus*	*0*	*2*	*0*	Migrates across the state from northern breeding areas.	DL	T	Possible Migrant
Pistolgrip	*Tritogonia verrucosa*	*1*	*1*	*1*	Aquatic, stable substrate. Red through San Antonio river basins.			Resident
Plains Spotted Skunk	*Spilogale putorius interrupta*	*1*	*1*	*1*	Prefers wooded, brushy areas.			Resident
Rawson's metalmark	*Calephelis rawsoni*	*1*	*1*	*1*	Moist areas in shaded limestone outcrops			Resident
Red Wolf	*Canis rufus*	*0*	*3*	*0*	Extirpated.	LE	E	Historic Resident
Reddish Egret	*Egretta rufescens*	*0*	*2*	*0*	Resident of Texas Gulf coast.		T	Resident
Robber Baron Cave Meshweaver	*Cicurina baronia*	*0*	*3*	*0*	Karst features in north-central Bexar County	LE		Resident
Rock pocketbook	*Arcidens confragosus*	*1*	*1*	*1*	Mud and sand, Red through Guadalupe River basins.			Resident
Sandhill woolywhite	*Hymenopappus carrizoanus*	*2*	*1*	*2*	Endemic; open areas in deep sands derived from Carrizo and similar Eocene formations.			Resident
Sharpnose shiner	*Notropis oxyrhynchus*	*1*	*1*	*1*	Endemic to Brazos River drainage.	C		Resident

Table 4C.29-1 (Continued)

Common Name	Scientific Name	Impact Value	Multiplier Based on Status	Adjusted Impact	Summary of Habitat Preference	Listing Entity USFWS	Listing Entity TPWD	Potential Occurrence in County
Shinner's sunflower	*Helianthus occidentalis ssp. Plantagineus*	2	1	2	Found on prairies on the Coastal Plain			Resident
Smalltooth sawfish	*Pristis pectinata*	1	3	3	Found in bays, estuaries or river mouths.	LE	E	Resident
Smooth pimpleback	*Quadrula houstonensis*	1	2	2	Found in small to moderate streams and rivers as well as moderate size reservoirs.		T	Resident
Snowy Plover	*Charadrius alexandrines*	0	1	0	Potential migrant, winters along coast			Migrant
Sooty Tern	*Sterna fuscata*	0	2	0	Usually flies or hovers over water.		T	Resident
Southeastern Snowy Plover	*Charadrius alexandrines tenuirostris*	0	1	0	Wintering migrant along the Texas Gulf Coast.			Migrant
Spot-tailed earless lizard	*Holbrookia lacerata*	1	1	1	Moderately open prairie-brushland.			Resident
Texas diamondback terrapin	*Malaclemys terrapin littoralis*	1	1	1	Found in coastal marshes and tidal flats.			Resident
Texas fatmucket	*Lampsilis bracteata*	1	2	2	Streams and rivers on sand, mud and gravel, Colorado and Guadalupe River basins.		T	Resident
Texas fawnsfoot	*Truncilla macrodon*	1	2	2	Possibly found in rivers and larger streams.		T	Resident
Texas Garter Snake	*Thamnophis sirtalis annectens*	1	1	1	Wet or moist microhabitats			Resident
Texas Horned Lizard	*Phrynosoma cornutum*	1	2	2	Varied, sparsely vegetated uplands.		T	Resident
Texas pimpleback	*Quadrula petrina*	1	1	1	Mud, gravel and sand substrates, Colorado and Guadalupe river basins		T	Resident
Texas Salamander	*Eurycea neotenes*	0	1	0	Endemic; springs, seeps, cave streams, Helotes and Leon Creek drainages in Bexar County			Resident

Table 4C.29-1 (Continued)

Common Name	Scientific Name	Impact Value	Multiplier Based on Status	Adjusted Impact	Summary of Habitat Preference	Listing Entity		Potential Occurrence in County
						USFWS	TPWD	
Texas scarlet snake	*Cemophora coccinea lineri*	1	1	1	Mixed hardwood scrub on sandy soils.		T	Resident
Texas Tortoise	*Gopherus berlandieri*	1	2	2	Open brush w/ grass understory.		T	Resident
Threeflower broomweed	*Thurovia triflora*	1	1	1	Endemic: near coast.			Resident
Timber/Canebrake Rattlesnake	*Crotalus horridus*	1	2	2	Floodplains, upland pine, deciduous woodlands, riparian zones.		T	Resident
Toothless Blindcat	*Trogloglanis pattersoni*	0	2	0	Troglobitic, blind catfish endemic to the San Antonio Pool of the Edwards Aquifer		T	Resident
Welder machaeranthera	*Psilactis heterocarpa*	1	1	1	Texas endemic found on grasslands.			Resident
West Indian manatee	*Trichechus manatus*	0	3	0	Gulf and bay systems.	LE	E	Resident
Western Burrowing Owl	*Athene cunicularia hypugaea*	1	1	1	Open grasslands, especially prairie, plains and savanna			Resident
White-faced Ibis	*Plegadis chihi*	0	2	0	Prefers freshwater marshes.		T	Resident
White-tailed Hawk	*Buteo albicaudatus*	0	2	0	Found near the coast on prairies.		T	Resident
Whooping Crane	*Grus americana*	0	3	0	Potential migrant	LE	E	Potential Migrant
Widemouth Blindcat	*Satan eurystomus*	0	2	0	Troglobitic, blind catfish endemic to the San Antonio Pool of the Edwards Aquifer.		T	Resident
Wood Stork	*Mycteria americana*	1	2	2	Forages in prairie ponds, ditches, and shallow standing water formerly nested in TX		T	Migrant

Table 4C.29-1 (Concluded)

Common Name	Scientific Name	Impact Value	Multiplier Based on Status	Adjusted Impact	Summary of Habitat Preference	Listing Entity		Potential Occurrence in County
						USFWS	TPWD	
Zone-tailed Hawk	*Buteo albonotatus*	0	2	0	Arid open country, often near watercourses		T	Resident

LE/LT=Federally Listed Endangered/Threatened
DL, PDL=Federally Delisted/Proposed for Delisting
T/SA=Listed as Threatened by Similarity of Appearance
E, T=State Listed Endangered/Threatened
NL=Not Listed
Blank = Rare, but no regulatory listing status
C = Species of Concern
Source: TPWD, Annotated County List of Rare Species, Bexar County (4/1/09), Guadalupe County (4/1/09), De Witt County (5/4/09), Gonzales County (5/4/09), Lavaca County (5/4/09), Wharton County (10/28/09), and Jackson County (5/4/09).

Inclusion in Table 4C.29-1 does not mean that a species will occur within the project area, but only acknowledges the potential for occurrence in the project area counties. In addition to the county lists, the TPWD Natural Diversity Database (NDD) was reviewed for known occurrences of listed species within or near the project area.[5]

Listed species may have habitat requirements or preferences that suggest they could be present within the project area. The presence or absence of potential habitat does not confirm the presence or absence of a listed species. No species specific surveys were conducted in the project area for this report. Surveys for protected species should be conducted within the proposed construction corridors where preliminary evidence indicates their existence. Areas included in Bexar County associated with the development of additional pump stations and improvements to the existing water treatment facilities will have to be carefully sited due to the presence of numerous potential karst and other listed species identified within the area.

The Migratory Bird Treaty Act protects most bird species, including, but not limited to, cranes, ducks, geese, shorebirds, hawks, and songbirds. Migratory bird pathways, stopover habitats, wintering areas, and breeding areas may occur within and adjacent to the project area, and may be associated with wetlands, ponds, shorelines, riparian corridors, fallow fields and grasslands, and woodland and forested areas. Although construction of the proposed off-channel reservoir could remove some habitats utilized by certain migratory bird species, it would create more habitats for others.

[5] TPWD Natural Diversity Database Information received December 8, 2009.

Five bird species federally and state listed as endangered are included in the project area counties. These include the Attwater's greater prairie chicken (*Tympanuchus cupido attwateri*), black-capped vireo (*Vireo atricapillus*), golden-cheeked warbler (*Dendroica chrysoparia*), interior least tern (*Sterna antillarum athalassos*), and whooping crane (*Grus americana*). Attwater's greater prairie chicken is a historic resident of the area, and the other four bird species are all seasonal migrants which could pass through the project area. The black-capped vireo only nests in dense underbrush in semi-open woodlands having distinct upper and lower stories. The golden-cheeked warbler utilizes juniper-oak woodlands found on canyon slopes. The interior least tern typically nests on bare or sparsely vegetated areas associated with streams or lakes, such as sand and gravel bars, beaches, islands, and salt flats. The main whooping crane flock nests in Canada and migrates annually to their wintering grounds in and around the Aransas National Wildlife Refuge near Rockport on the Texas coast. Whooping cranes occasionally utilize wetlands as an incidental rest stop during this migration. Habitat elements particularly attractive to the black-capped vireo, golden-cheeked warbler, interior least tern, and whooping crane do not appear to be present on or adjacent to the proposed off-channel reservoir site or pipeline route, although migrants are possible. The brown pelican (*Pelecanus occidentalis*) is listed as endangered by the state, but has recently been delisted by USFWS.

Avian species listed by the State of Texas as threatened include the peregrine falcon (*Falco peregrinus*), reddish egret (*Egretta rufescens*), sooty tern (*Sterna fuscata*), white-faced ibis (*Plegadis chihi*), white-tailed hawk (*Buteo albicaudatus*), wood stork (*Mycteria Americana*), zone-tailed hawk (*Buteo albonotatus*), and bald eagle (*Haliaeetus leucocephalus*). The peregrine falcon includes two subspecies which migrate across the state from more northern breeding areas in the U.S. and Canada to winter along the coast. The majority of nesting bald eagle pairs, currently reported, is found along major rivers and near reservoirs in Texas. Bald eagles are opportunistic predators, feeding primarily on fish captured in the shallow water of both lakes and streams or scavenged food sources. These birds may utilize tall trees near perennial water as roosting or nesting sites. Bald eagles occur as migrants and are documented by the NDD within the project area.

There is a NDD documented occurrence of the state and federally listed endangered Houston toad (*Bufo houstonensis*) within four miles of the pipeline corridor. The Houston toad is a terrestrial amphibian which species prefers deep sandy soils greater than forty inches deep for burrowing. They require still or slow-flowing bodies of water that persist for at least a month for breeding purposes. Habitat loss and alteration are thought to be the main reason for this species decline.

Many of the listed species found within the pipeline route, such as the Texas Tortoise and the Texas Horned Lizard are dependent on shrubland or riparian habitats which should be avoided wherever possible. Although suitable habitat for the state threatened Texas horned lizard may exist within the project area, no impact to this species is anticipated due to the abundance of similar habit near the project area and this species' ability to relocate to those areas if necessary. The Texas Garter Snake may be present in wetland habitat, and the Timber/Canebrake Rattlesnake, a threatened species, may be found in the riparian woody vegetation of the area. Destruction of these potential habitats can be minimized by selecting a corridor through previously disturbed areas, such as croplands. Selection of a pipeline right-of-way alongside existing habitat could also be beneficial to some wildlife species by providing edge habitat; however, the majority of these areas are small and fragmented. Care should be taken to ensure minimum impacts to these areas.

Big red sage (*Salvia penstemonoides*), Elmendorf's onion (*Allium elmendorfii*), Parks' jointweed (*Polygonella parksii*), Shinner's sunflower (*Helianthus occidentalis* ssp. *Plantagineus*), and sandhill woolywhite (*Hymenopappus carrizoanus*) are all rare plants listed by the NDD as occurring within one mile of the project corridor. Although Big Red Sage grows in creek beds and seepage slopes of limestone canyons, the other four plant species are usually found in grassland habitats.

After a review of the habitat requirements for each listed species, it is not anticipated that this project will have any permanent adverse effect on any federally listed threatened or endangered species, its habitat, or designated habitat, nor would it adversely affect any state endangered species.

Habitat studies and surveys for protected species and cultural resources may need to be conducted at the proposed off channel site, within the expansion of the water facilities in Bexar County, and along the pipeline routes. Specific project features, such as pipelines, and off-channel reservoirs generally have sufficient design flexibility to avoid most impacts or significantly mitigate potential impacts to geographically limited environmental and cultural resource sites. Field surveys conducted at the appropriate phase of development should be employed to minimize the impacts of construction and operation on sensitive resources.

Potential wetland impacts are expected to primarily include pipeline stream crossings, which can be minimized by right-of-way selection and appropriate construction methods, including erosion controls and revegetation procedures. Compensation for net losses of wetlands would be required where impacts are unavoidable.

A review of the Texas Historical Commission Texas Historic Sites Atlas database indicated that there are eight historical markers within one mile of the proposed pipeline route. There are no National Register Properties listed within one mile of the proposed pipeline route, however this database indicates that there are at least 13 small family cemeteries recorded within one mile of the proposed pipeline. Avoidance of these areas should be possible through appropriate siting of the transmission pipeline.

Matagorda Bay is an estuarine environment dependent on freshwater inflows from the Colorado River. Changes in streamflow in the Colorado River below a Bay City diversion were reported during the Project Viability Assessment for the LCRA-SAWS Water Project in November 2004. It was concluded that diversion of previously existing surface water from the Lower Colorado River Basin would not significantly alter the existing freshwater inflow regime of Matagorda Bay, or the existing dissolved oxygen levels in the Colorado River. The results of the environmental studies (water quality, river habitat, and bay health) have not revealed any serious limiting factors for this project. It is expected that the ongoing studies will identify the methods necessary for designing and operating this project to meet environmental needs as determined by legislative requirements, agency guidance, and/or permit conditions.

4C.29.4 Engineering and Costing

As part of their agreement, SAWS and LCRA have prepared a Project Viability Assessment (PVA) that is to be updated annually. The PVA includes five elements: water availability, water quality, impacts to Matagorda Bay, meeting the needs of local agricultural interests, and project cost. In order to be consistent with the PVA study and the Region L costing procedures (Appendix A), cost estimates for the LSWP have been developed using the Region L costing procedures, using facilities information from the PVA. Adjustments have been added to these costs to account for integration and associated project costs. The major facilities that would need to be constructed to divert, store, and deliver water from the Colorado River near Bay City to the new WTP facility in south Bexar County and associated costs are summarized in Table 4C.29-2.

Table 4C.29-2.
Cost Estimate Summary for
LCRA-SAWS Water Project – Bay City to Bexar County
(September 2008 Prices)

Item	***Region L Estimated Costs (September 2008Prices)***
Capital Costs	
Off-Channel Storage Facility (212,000 acft)	$128,600,000
Primary Intake and Transmission Pump Stations 84 MGD)[1]	$70,975,000
Intake Pipeline (4.6 miles of 2 – 144 inch pipes - 84 MGD[1])	$92,294,000
Transmission Pipeline (66-in dia., 140 miles)	$386,471,000
Booster Stations	$42,150,000
Terminal Storage (12,000 acft)[2]	$27,654,000
Water Treatment Plant (84 MGD)[1]	$102,695,000
Well Field (10-mile Piping, 36 Wells, 2000 GPM)	$32,450,000
Agriculture Conservation	$232,400,000
Total Capital Cost	**$1,235,538,000**
Engineering, Legal Costs and Contingencies (E, A, L, F, B, & C) [3]	$407,073,000
Environmental & Archaeology Studies and Mitigation	$63,587,000
Land Acquisition and Surveying	$67,625,000
Interest During Construction (3 years)	$212,860,000
Total Project Cost	**$1,986,684,000**
Annual Costs	
Debt Service (6 percent, 20 years)	$140,914,000
Reservoir Debt Service (6 percent, 40 years)	$24,618,000
Operation and Maintenance	$22,144,000
Well Pumping Energy Costs	$891,000
Pumping Energy Costs	$25,122,000
Purchase of Water (90,000 acft/yr @ $20/acft)	$1,800,000
Total Annual Cost	**$215,489,000**
Available Project Yield (acft/yr)	90,000
Annual Cost of Water ($ per acft)	$2,394
Annual Cost of Water ($ per 1,000 gallons)	$7.35

[1]Regional Planning costs procedure plans for a 5% downtime; the PVA estimates do not account for downtime.
[2]Cost estimate not provided in PVA – Region L cost used with CCI adjustments, where appropriate.
[3]E, A, L, F, B, & C = Engineering, Administration, Legal, Financing, Bonding, & Contingencies
[4]LSWP Study Period Costs in the PVA
[5]O&M for diversion works, wells, & off-channel reservoirs covered by Purchase of Water Cost.
[6]Reservoir O&M for Terminal Storage only. O&M for off-channel reservoirs covered by Purchase of Water Cost.

The diversion facilities for the off-channel storage facility would allow average flows to pass the transmission intake, while withdrawing excess flows for storage. When water is unavailable in the river for delivery, the off-channel storage facility would release water back into the river to be diverted at the downstream transmission intake. Additional information regarding operations of facilities may be found in the PVA.

The 140-mile, 66-inch pipeline, would deliver water from the river at a uniform rate of 84 MGD (90,000 acft/yr with 5 percent downtime for maintenance) to the new WTP facility, as shown in Figure 4C.29-1. The capital cost for this strategy is $1,235,538,000. With contingencies, land acquisition, interest during construction, engineering, legal costs, and other studies, the total project cost would be $1,986,684,000. Financing the non-reservoir portion of the project over 20 years at a 6 percent annual interest rate results in an annual cost of $140,914,000. Estimated cost for the off-channel reservoirs, financed at 6 percent for 40 years, is $24,618,000 annually. The annual costs, including debt repayment, interest, pumping energy, raw water purchases, and operation and maintenance total $215,489,000. For an annual supply of 90,000 acft, the resulting annual cost of water of is $2,394 per acft/yr, or $7.35 per 1,000 gallons.

4C.29.5 Implementation Issues

Institutional arrangements are needed to implement projects, potentially including financing on a regional basis.

4C.29.5.1 Requirements for Purchase and Amendments to Existing Water Rights

1. Obtain TCEQ approval for amendments to the existing water rights to reflect:
   a. New type of water use.
   b. New diversion point.
   c. Interbasin transfer.
2. Water sales contracts must be approved by the TCEQ.

4C.29.5.2 Off-Channel Reservoir

1. Necessary permits for the off-channel storage reservoir could include:
   a. TCEQ Storage permit.
   b. USCE Sections 10 and 404 dredge and fill permits for the reservoir and pipelines.
   c. GLO Sand and Gravel Removal review.
   d. GLO Easement for use of state-owned land.

   e. Coastal Coordination Council review.
   f. TPWD Sand, Gravel, and Marl permit.
2. Permitting may require these studies:
   a. Assessment of changes in instream flow and freshwater inflows to bays and estuaries.
   b. Habitat mitigation plan.
   c. Environmental studies.
   d. Cultural resource studies.
3. Land must be acquired through either negotiations or condemnation.
4. Relocations for the reservoirs could include:
   a. County roads.
   b. Utilities.

4C.29.5.3 Groundwater Well Field

1. Competition for groundwater in the area with others.
2. Potential regulations by local groundwater district(s).
3. Insufficient technical data and information on the hydrogeology and environment to make a comprehensive determination on the effects of pumping the Gulf Coast Aquifer for an extended period of time.

4C.29.5.4 Requirements Specific to the Transmission Pipeline

1. Necessary permits:
   a. USCE Sections 10 and 404 dredge and fill permits for stream crossings.
   b. GLO Sand and Gravel Removal permits.
   c. TPWD Sand, Gravel and Marl permit for river crossings.
2. Right-of-way and easement acquisition.
3. Crossings:
   a. Highways and railroads.
   b. Creeks and rivers.
   c. Other utilities.

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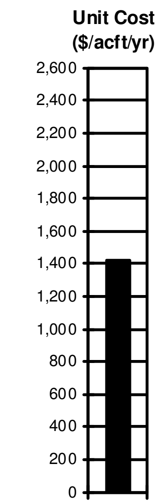
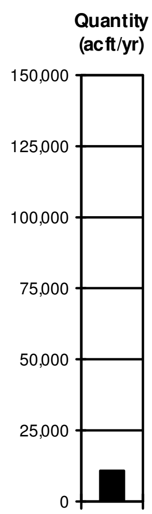
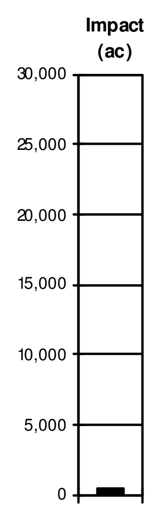
2011 South Central Texas Regional Water Plan
Water Management Strategy Summary Sheet







Name: Medina Lake Firm-Up – Aquifer Storage and Recovery System (Scenario 1)

Description: Water management strategies of the 2011 South Central Texas Regional Water Plan are sized and scheduled to meet seasonal and daily variations of demand, but, without storage, some current and proposed supplies may not be fully reliable during extended droughts. This strategy involves the implementation of a large-scale aquifer storage and recovery (ASR) system under the Medina Lake System water rights and contracts. An ASR system for the Carrizo aquifer was studied to meet the goals of the water management strategy. Facilities include intake and pump station at the Medina River, 33" transmission pipeline, ASR wells and a water treatment plant.

***Decade Needed*:** 2010

Cost, Quantity of Water, and Land Impacted

Unit Cost of Water:	**$2,195**	**$/acft/yr**	**Treated Water Delivered**
Quantity of Water:	**6,943**	**acft/yr**	**Reliability = Firm**
Land Impacted:	**86**	**acres**	

Additional Considerations per Regional Water Planning Guidelines

Environmental Factors:

Potential environmental issues associated with implementation of this option include consideration and mitigation of affected aquatic and terrestrial habitats, cultural resources, and threatened and endangered species, in accordance with applicable state and federal requirements.

Impacts on Water Resources:

Only flood water from the Medina River would be diverted for this strategy so downstream impacts to water resources would not be anticipated.

Impacts on Agricultural & Natural Resources:

Conversion of existing land uses and habitats to open water.

Other Relevant Factors per SCTRWPG:

Encourages beneficial use of available rights. Protects instream flows and recreational opportunities through lower basin diversion.

Comparison of Strategies to Meet Needs:

No conflicts with other recommended water management strategies.

Interbasin Transfer Issues:

Since this specific strategy is intended to serve water user groups within the GBRA district, no inter-basin transfer issues are anticipated.

Third-Party Impacts of Voluntary Transfers:

None anticipated.

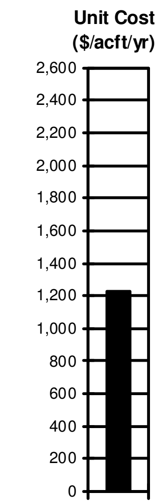
Regional Efficiency:

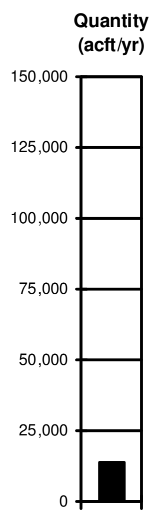
None.

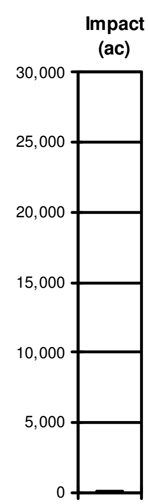
Water Quality Considerations:

None anticipated.

2011 South Central Texas Regional Water Plan
Water Management Strategy Summary Sheet







Name: Medina Lake Firm-Up – Aquifer Storage and Recovery System (Scenario 2)

Description: Water management strategies of the 2011 South Central Texas Regional Water Plan are sized and scheduled to meet seasonal and daily variations of demand, but, without storage, some current and proposed supplies may not be fully reliable during extended droughts. This strategy involves the implementation of a large-scale Aquifer Storage and Recovery (ASR) system under the Medina Lake System water rights and contracts. An ASR system for the Carrizo aquifer was studied to meet the goals of the water management strategy. Facilities include intake and pump station at the Medina River, 33" transmission pipeline, ASR wells and a water treatment plant.

***Decade Needed*:** 2010

Cost, Quantity of Water, and Land Impacted

Unit Cost of Water:	**$1,696**	**$/acft/yr**	**Treated Water Delivered**
Quantity of Water:	**9,933**	**acft/yr**	**Reliability = Firm**
Land Impacted:	**89**	**acres**	

Additional Considerations per Regional Water Planning Guidelines

Environmental Factors:

Potential environmental issues associated with implementation of this option include consideration and mitigation of affected aquatic and terrestrial habitats, cultural resources, and threatened and endangered species, in accordance with applicable state and federal requirements.

Impacts on Water Resources:

Only flood water from the Medina River would be diverted for this strategy so downstream impacts to water resources would not be anticipated.

Impacts on Agricultural & Natural Resources:

Conversion of existing land uses and habitats to open water.

Other Relevant Factors per SCTRWPG:

Encourages beneficial use of available rights. Protects instream flows and recreational opportunities through lower basin diversion.

Comparison of Strategies to Meet Needs:

No conflicts with other recommended water management strategies.

Interbasin Transfer Issues:

Since this specific strategy is intended to serve water user groups within the GBRA district, no inter-basin transfer issues are anticipated.

Third-Party Impacts of Voluntary Transfers:

None anticipated.

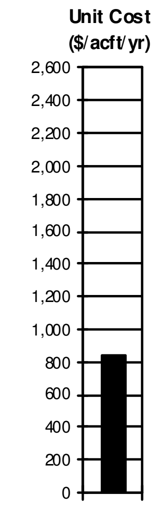
Regional Efficiency:

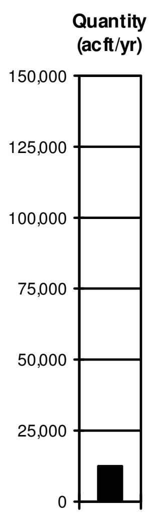
None.

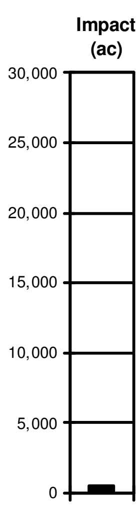
Water Quality Considerations:

None anticipated.

2011 South Central Texas Regional Water Plan
Water Management Strategy Summary Sheet







Name: Medina Lake Firm-Up – Off-channel Reservoir Site 3

Description: Water management strategies of the 2011 South Central Texas Regional Water Plan are sized and scheduled to meet seasonal and daily variations of demand, but, without storage, some current and proposed supplies may not be fully reliable during extended droughts. This strategy for off-channel reservoir Site 3 involves the construction of approximately 5.0 miles of pipeline to capture flood water from the Medina River, and dam construction and inundation of approximately 450 acres between Medio Creek and Potranca Creek, tributaries of the Medina River. This off-channel reservoir would be implemented under the Medina Lake System water rights and contracts.

***Decade Needed*:** 2010

Cost, Quantity of Water, and Land Impacted

Unit Cost of Water:	**$1,197**	**$/acft/yr**	**Treated Water Delivered**
Quantity of Water:	**9,078**	**acft/yr**	**Reliability = Firm**
Land Impacted:	**472**	**acres**	

Additional Considerations per
Regional Water Planning Guidelines

Environmental Factors:

The toothless blindcat, a state threatened fish, has been documented in two artesian wells, Verstraeten Well and Mitchell Well, which are on or immediately adjacent to the proposed water diversion pipeline route for this OCR.

Impacts on Water Resources:

Only flood water from the Medina River would be diverted for this strategy so downstream impacts to water resources would not be anticipated.

Impacts on Agricultural & Natural Resources:

Conversion of existing land uses and habitats to open water.

Other Relevant Factors per SCTRWPG:

None anticipated.

Comparison of Strategies to Meet Needs:

No conflicts with other recommended water management strategies.

Interbasin Transfer Issues:

Since this specific strategy is intended to serve water user groups within the GBRA district, no inter-basin transfer issues are anticipated.

Third-Party Impacts of Voluntary Transfers:

None anticipated.

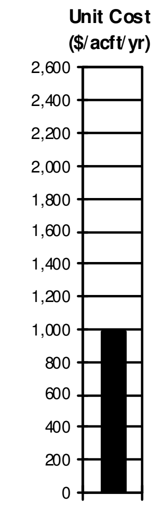
Regional Efficiency:

None.

Water Quality Considerations:

The off-channel reservoir will aid in suspending river diversions to avoid poor water quality during flood events and facilitate maintenance of diversion facilities without stopping reservoir deliveries.

2011 South Central Texas Regional Water Plan
Water Management Strategy Summary Sheet



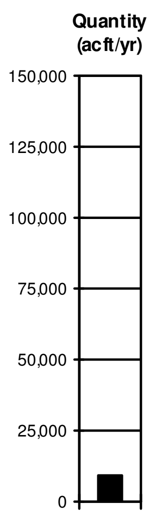
Name: Medina Lake Firm-Up – Off-channel Reservoir Site 4A

Description: Water management strategies of the 2011 South Central Texas Regional Water Plan are sized and scheduled to meet seasonal and daily variations of demand, but, without storage, some current and proposed supplies may not be fully reliable during extended droughts. The strategy for off-channel reservoir Site 4A involves the construction of approximately 8.4 miles of pipeline to capture flood water from the Medina River, and dam construction and inundation of approximately 726 acres along an approximately 2.5-mile reach of Portranca Creek, a tributary of the Medina River. This off-channel reservoir would be implemented under the Medina Lake System water rights and contracts.

***Decade Needed*:** 2010

Cost, Quantity of Water, and Land Impacted

Unit Cost of Water:	**$1,688**	**$/acft/yr**	**Treated Water Delivered**
Quantity of Water:	**5,378**	**acft/yr**	**Reliability = Firm**
Land Impacted:	**761**	**acres**	



Additional Considerations per Regional Water Planning Guidelines

Environmental Factors:

The toothless blindcat, a state threatened fish, has been documented in two artesian wells, Verstraeten Well and Mitchell Well, which are on or immediately adjacent to the proposed water diversion pipeline route for this OCR. The Bracken Bat Cave meshweaver (*Cicurina venii*) a federally-endangered arachnid has been documented within 1.5-miles northwest of Site 4A

Impacts on Water Resources:

Only flood water from the Medina River would be diverted for this strategy so downstream impacts to water resources would not be anticipated.

Impacts on Agricultural & Natural Resources:

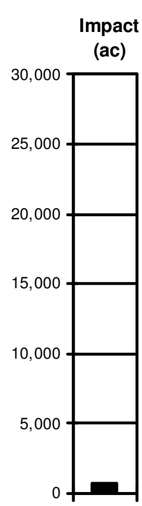
Conversion of existing land uses and habitats to open water.

Other Relevant Factors per SCTRWPG:

None anticipated

Comparison of Strategies to Meet Needs:

No conflicts with other recommended water management strategies.



Interbasin Transfer Issues:

Since this specific strategy is intended to serve water user groups within the GBRA district, no inter-basin transfer issues are anticipated.

Third-Party Impacts of Voluntary Transfers:

None anticipated.

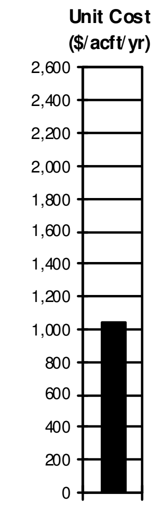
Regional Efficiency:

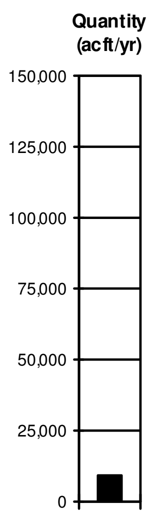
None.

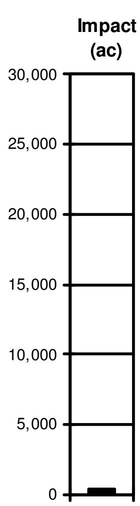
Water Quality Considerations:

The off-channel reservoir will aid in suspending river diversions to avoid poor water quality during flood events and facilitate maintenance of diversion facilities without stopping reservoir deliveries.

2011 South Central Texas Regional Water Plan
Water Management Strategy Summary Sheet







Name: Medina Lake Firm-Up – Off-channel Reservoir Site 6

Description: Water management strategies of the 2011 South Central Texas Regional Water Plan are sized and scheduled to meet seasonal and daily variations of demand, but, without storage, some current and proposed supplies may not be fully reliable during extended droughts. The strategy for off-channel reservoir Site 6 involves the construction of approximately 12 miles of pipeline to divert flood water from the Medina River, and dam construction and inundation of approximately 380 acres along an approximately 2.25-mile reach of Lucas Creek, a tributary of the Medina River. This off-channel reservoir would be implemented under the Medina Lake System water rights and contracts.

***Decade Needed*:** 2010

Cost, Quantity of Water, and Land Impacted

Unit Cost of Water:	**$1,768**	**$/acft/yr**	**Treated Water Delivered**
Quantity of Water:	**5,403**	**acft/yr**	**Reliability = Firm**
Land Impacted:	**415**	**acres**	

Additional Considerations per Regional Water Planning Guidelines

Environmental Factors:

The toothless blindcat, a state threatened fish, has been documented in two artesian wells, Verstraeten Well and Mitchell Well, which are on or immediately adjacent to the proposed water diversion pipeline route for this OCR. The Bracken Bat Cave meshweaver (*Cicurina venii*) a federally-endangered arachnid has been documented within 2.0-miles northeast of Site 6.

Impacts on Water Resources:

Only flood water from the Medina River would be diverted for this strategy so downstream impacts to water resources would not be anticipated.

Impacts on Agricultural & Natural Resources:

Conversion of existing land uses and habitats to open water.

Other Relevant Factors per SCTRWPG:

None anticipated.

Comparison of Strategies to Meet Needs:

No conflicts with other recommended water management strategies.

Interbasin Transfer Issues:

Since this specific strategy is intended to serve water user groups within the GBRA district, no inter-basin transfer issues are anticipated.

Third-Party Impacts of Voluntary Transfers:

None anticipated.

Regional Efficiency:

None.

Water Quality Considerations:

The off-channel reservoir will aid in suspending river diversions to avoid poor water quality during flood events and facilitate maintenance of diversion facilities without stopping reservoir deliveries.

4C.30 Medina Lake Firm-Up

4C.30.1 Description of Water Management Strategy

The Medina Lake Firm-Up water management strategy involves implementing Aquifer Storage and Recovery (ASR) and/or off-channel reservoir (OCR) storage to firm-up Bexar Metropolitan Water District's (BMWD) existing water rights and contracts with Bexar-Medina-Atascosa Counties Water Improvement District No. 1 (BMA) for Medina Lake stored water. In addition, it is envisioned that BMWD and Benton City Water Supply Corporation (WSC), along with others, could potentially jointly develop the ASR project option.

One option presented in this water management strategy, a 15-well ASR system, is considered a recommended water management strategy to meet needs in the 2011 SCTRWP. In addition, the off-channel reservoir Site 3 option, is listed as an alternate water management strategy in the 2011 SCTRWP.

4C.30.1.1 Off-Channel Reservoir Screening Criteria and Site Selection

Screening criteria to be used to determine adequate off-channel reservoir sites were identified based on critical issues to be considered in meeting the goals of the strategy. Seven criteria were used in the screening process. Eight sites for surface storage were identified on tributaries of the Medina River downstream of Medina Lake. For the planning level purposes, these sites are meant to be illustrative only of potential sites and do not exclude other sites that may be identified upon further study. A list of the preliminary screening criteria includes the following:

- Amount of development in reservoir footprint and surrounding area;
- Distance from Bexar Metropolitan Water District (BMWD) water treatment plant (WTP);
- Natural topography;
- Site efficiency (i.e. Average Depth: Reservoir volume/reservoir area);
- Stream classification (perennial versus intermittent) based on USGS topographic maps;
- Environmental/cultural issues; and
- Water availability/accessibility and related infrastructure needs.

The reservoir site efficiency criterion provides a relative measure of reservoir site efficiency with respect to inflow, topography, and evaporation losses. Preference is given to reservoir sites for which available inflow is efficiently stored and evaporation losses are minimized, thereby maximizing firm yield.

Based on the screening criteria, three OCR sites shown in Figure 4C.30-1 were chosen for firm yield analyses. The OCR sites are identified by the initial numbering system of sites identified and include Sites 3, 4a, and 6. The sites are all northwest of the BMWD WTP and between the outcrops of the Edwards and Carrizo aquifers.

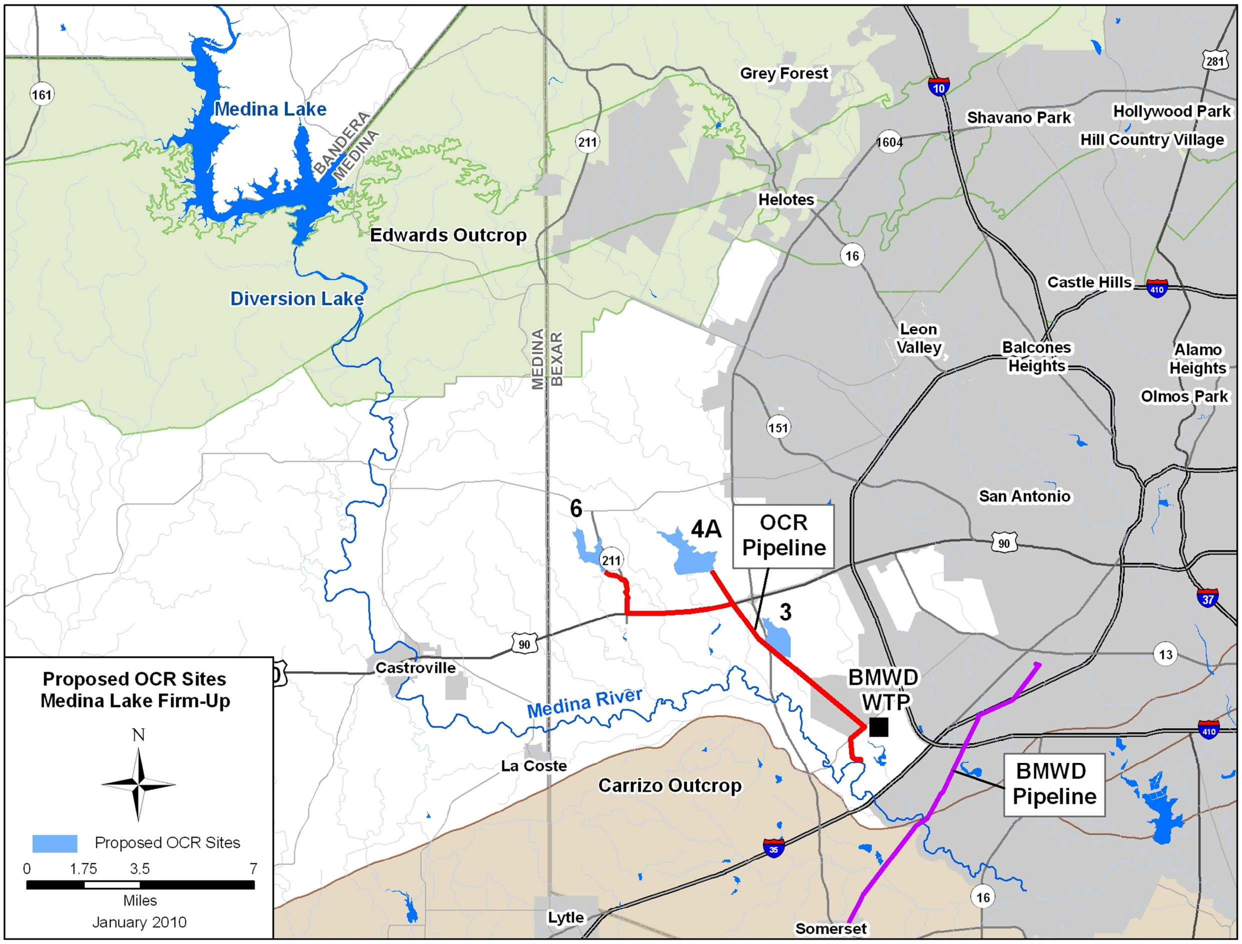


Figure 4C.30 1. Potential Off-Channel Reservoir Sites

Off-channel reservoir characteristics are shown in Table 4C.30-1. Site 3 has a storage capacity of 33,462 acft at a conservation pool elevation of 760 ft-msl and would use a 33-in, 5-mile pipeline to transport water diverted from the Medina River downstream of Medina Lake at the BMWD diversion point used to transmit water to the BMWD Water Treatment Plant. Site 4A has a storage capacity of 15,035 acft at a conservation pool elevation of 780 ft-msl and would utilize a 33-in, 8-mile pipeline to transport water diverted from the Medina River downstream of

Medina Lake at the BMWD diversion point. Site 6 has a storage capacity of 11,491 acft at a conservation pool elevation of 880 ft-msl and would utilize a 33-in, 12-mile pipeline to transport water diverted from the Medina River downstream of Medina Lake at the BMWD diversion point.

Table 4C.30-1.
Off-channel Reservoir Characteristics

	Off-channel Reservoir Site		
	Site 3	***Site 4A***	***Site 6***
Reservoir Capacity (acft)	33,462	15,035	11,491
Surface Area (acres)	451	726	380
Average Depth (ft)	74.2	20.7	30.3
Transmission Pipeline Diameter (inches)	33	33	33
Transmission Pipeline Length (miles)	5	8	12

4C.30.1.2 Identification of Aquifer Storage and Recovery Sites

Aquifer Storage and Recovery (ASR), or underground storage of water, could be used to meet the needs of the growing population west of San Antonio, including areas served by BMWD, Benton City WSC, and others. ASR could be used to store surface water available under Medina Lake System contracts and BMWD water rights. Potential ASR sites downdip of the Carrizo Aquifer outcrop were identified based on the geology of the area, water quality of the Carrizo in this area, and proximity to BMWD infrastructure. The area identified for potential ASR implementation shown in Figure 4C.30-2 was chosen based on an analysis of existing well yields and depth to the Carrizo Aquifer in the immediate area and is not meant to exclude other areas that may be identified as potential ASR sites in future studies.

The identified area follows the boundary of Carrizo Aquifer outcrop and includes an area to the south toward Jourdanton between the Frio/Atascosa county line to the west and Pleasanton to the east. The pipeline from the Medina River to the ASR well field site follows an existing BMWD pipeline route.

Water quality of the Carrizo Aquifer was considered when determining potential sites for an ASR well field. Local deposits of iron to the west excluded areas in Medina and Frio

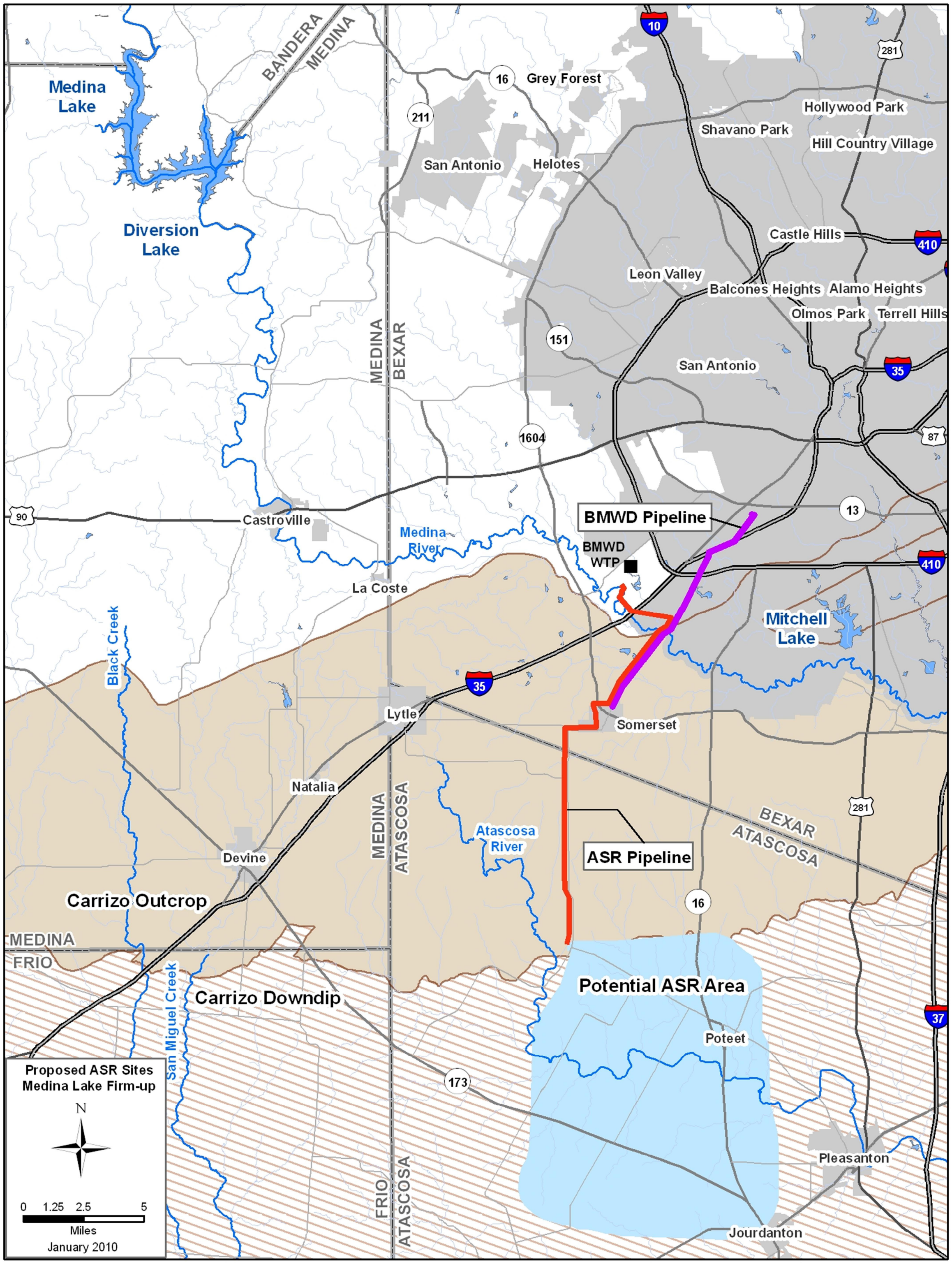
Counties. Iron can precipitate, filling pore spaces within the aquifer and making recovery of injected water difficult to impossible.

San Antonio Water System's (SAWS) existing ASR well field provides an analog for designing a future system. The SAWS ASR well field was constructed just downdip of the Carrizo Aquifer outcrop. In this location, wells can be drilled to a less-expensive, shallower depth than if they were further away from the outcrop. Locating an ASR well field further from the aquifer outcrop in a downdip direction will cause well depths to increase, which increases the cost of an ASR system.

The basic assumptions made to determine the size and characteristics of the components of the ASR site are listed in Table 4C.30-2. For the ASR well field, two scenarios are presented. The first includes an aquifer storage capacity of 15,000 acft for the ASR site and an injection rate of 800 gpm for ten wells. The second scenario includes an aquifer storage capacity of 30,000 acft for the ASR site and an injection rate of 800 gpm for fifteen wells. Any water injected into an ASR well field is treated to drinking water standards prior to injection into the aquifer. Facilities for both scenarios would include an intake(s) and pump station(s) at the Medina River, transmission pipeline to the ASR wells, treatment plant, and ASR wells.

Table 4C.30-2.
Engineering Assumptions and Characteristics for ASR Scenarios

Parameter	*Assumption*	*Description*
Injection Rate	800 gpm	Pumps used to meet demand are turned on automatically for injection when water is available.
Monthly Demand Pattern	Municipal	Municipal demand pattern from GSA Model
Transmission Pipeline Diameter (inches)	33	-
Transmission Pipeline Length (miles)	26	-
Scenario 1		
Aquifer Storage Capacity	15,000 acft	-
Number of ASR wells	10	Injection and Recovery
Scenario 2		
Aquifer Storage Capacity	30,000 acft	-
Number of ASR wells	15	Injection and Recovery



W:\007755\000000000093053_2011_Region_L_Plan\06.00_Project_Engineering_and_Design\Act 017 - Task 4.II.B.2 - Medina Lake Firm-Up\GIS\map_docs\arcmap\Potential_ASR_Area_010610.mxd

Figure 4C.30-2. Proposed Aquifer Storage and Recovery area.

4C.30.2 Water Availability

BMWD existing run-of-river water rights on the Medina River total 7,250 acft/yr. Based on the 2011 SCTRWP surface water supply analysis and associated hydrologic assumptions, the firm supply of these water rights is 3,797 acft/yr. BMWD also has a contract with BMA for 19,974 acft/yr, which is released from the Medina Lake System. However, since Medina Lake has no firm yield, the supply is not considered firm. The Medina Lake Firm-Up water management strategy is envisioned to enhance the amount of firm supply by utilizing storage (either OCR or ASR facilities). Therefore, the Medina Lake Firm-Up water management strategy is evaluated based on its ability to enhance the firm supply to BMWD.

4C.30.2.1 Off-Channel Reservoir Water Availability

The Guadalupe-San Antonio River Basin Water Availability Model (GSAWAM, as modified for regional water planning purposes) is used to quantify water available for diversion at the reservoir sites. Hydrologic simulations and calculations are performed subject to the General Assumptions for Applications of Hydrologic Models, as adopted by the SCTRWPG for the 2011 Regional Water Plan.

Diversions to the OCR sites were taken from the Medina River downstream of Medina Lake at the BMWD diversion point used to transmit water to the BMWD Water Treatment Plant. Diversions were taken under existing BMWD water rights and contract releases from Medina Lake, when available. Application of the GSAWAM, with a period of record from January 1934 to December 1989, demonstrates that the enhanced firm yield, above the firm yield of the existing BWMD water rights, are an additional 9,078 acft/yr for Site 3, 5,378 acft/yr for Site 4A, and 5,403 acft/yr for Site 6.

4C.30.2.2 Aquifer Storage and Recovery Water Availability

The amount of water available for injection into an ASR system was estimated using monthly GSAWAM results from 1934 to 1989. The firm yield supply of each scenario was estimated using an iterative spreadsheet-based model. The model incorporates a municipal demand pattern and first meets demands before any remaining available water is injected into the subsurface. The firm yield is estimated based on the storage in the aquifer reaching nearly 0 acft after meeting municipal demand. The enhanced firm supply of ASR Scenario 1, which includes 15,000 acft of aquifer storage and ten ASR wells is 6,943 acft/yr. The enhanced firm supply of

ASR Scenario 2, which includes 30,000 acft of aquifer storage and ten ASR wells is 9,933 acft/yr.

4C.30.3 Environmental Issues

Three proposed OCR sites, Site 3, Site 4A, and Site 6, have been identified for the Medina Lake Firm-Up as described in the subsections below. Implementation of any of these reservoir alternatives would require field surveys by qualified professionals to document vegetation/habitat types, waters of the U.S. including wetlands, and cultural resources that may be impacted by the proposed reservoir. Where impacts to protected species habitat or significant cultural resources cannot be avoided, additional studies would be necessary to evaluate habitat use and/or value, or eligibility for inclusion in the National Register of Historic Places, respectively. Compensation would be required for unavoidable adverse impacts involving net losses of wetlands.

The Texas Parks & Wildlife Department (TPWD) has identified a number of stream segments throughout the state as ecologically significant on the basis of biological function, hydrologic function, riparian conservation, exceptional aquatic life uses, and/or threatened or endangered species. Currently, 21 stream segments in Region L have been designated as ecologically significant by the Regional Water Planning Group. Subject to this criterion, reservoir sites that do not conflict with identified ecologically significant stream segments are scored more favorably. Applications of this criterion account for differences between inundation of and indirect impacts to stream segments. None of the creeks potentially affected by the proposed Medina Lake Firm-up OCR Site 3, Site 4A, or Site 6 are included on the list of ecologically significant streams.

Cultural resources protection on public lands in Texas is afforded by the Antiquities Code of Texas (Title 9, Chapter 191, Texas Natural Resource Code of 1977), the National Historic Preservation Act (Pl96-515), and the Archeological and Historic Preservation Act (PL93-291). Based on the review of available GIS datasets, no documented cemeteries, historic markers, or historic places are within the proposed project area for any of the three alternative sites; one unnamed cemetery is located approximately 0.25 miles northeast of Site 4A. Cultural resource occurrences within this project area are expected to be present due to the reservoirs locations on creeks. Coordination with the Texas Historical Commission will need to be initiated prior to project construction. If the project will affect waters of the United States or wetlands, the project sponsor will also be required to coordinate with the U.S. Army Corps of Engineers regarding any impacts to cultural resources.

4C.30.3.1 Site 3

Site 3 involves the construction of approximately 5.0 miles of pipeline to capture flood water from the Medina River, and dam construction and inundation of approximately 450 acres between Medio Creek and Potranca Creek, tributaries of the Medina River. The proposed reservoir site is located in western Bexar County within the South Texas Brushlands ecoregion,[1] and in the Balconian biotic province.[2] Vegetation within the project area is primarily mesquite-live oak-bluewood parks and cropland[3].

Six soils types underlie the proposed OCR Site 3 area. Houston Black series soils, specifically Houston Black clay with 1 to 3 percent slopes and Houston Black gravelly clay soils with 1 to 3 percent slopes, 3 to 5 percent slopes and 5 to 8 percent slopes, are the most abundant soils in the project area. The Houston Black series consist of clayey soils that are deep, dark gray to black, and calcareous; gravelly clay soils differ from clay soils in that more pebbles are present on the soil surface. These soils occur primarily on uplands. Houston Black soils have slow to rapid surface drainage and have a good water capacity. Houston-Sumter clays with 5 to 10 percent slopes, severely eroded occupy long narrow areas. The Houston soils in this association occur as strongly sloping areas that have been damaged by water erosion. Sumter gravelly clay is very shallow and occurs as strongly sloping to steep, narrow ridges. These soils are best suited to native grass because of the erosion hazard, steep slopes and shallow soils. The final soil type present in the OCR area is Trinity and Frio soils, frequently flooded with 0 to 1 percent slopes. These soils occur as narrow, long and irregularly shaped areas on floodplains of small streams. Most of these soils are used as pasture but some may be cultivated. These soil are deep, slowly permeable, have slow surface and internal drainage, and a high water capacity. Along with some of the soils mentioned above, gullied land, Houston Black clay, terrace with 0 to 1 percent slopes, and Lewisville silty clay with 0 to 1 percent slopes occur only in the proposed pipeline area.

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[1] TPWD, "Texas Partners in Flight; Ecological Region 7 – Edwards Plateau"http://www.tpwd.state.tx.us/huntwild/wild/birding/pif/assist/pif_regions/region_7.phtml accessed July 20, 2009.

[2] Blair, W.F., "The Biotic Provinces of Texas, "Tex. J. Sci. 2:93-117, 1950.

[3] McMahan, C. A., R. G. Frye and K. L. Brown, "The Vegetation Types of Texas -- Including Cropland," Texas Parks and Wildlife Department − PWD Bulletin 7000-120. 1984.

The primary impacts that would result from construction and operation of the proposed OCR at Site 3 include conversion of existing habitats and land uses within the conservation pool to open water. Site 3 would permanently inundate 450 acres below 1,320 ft-msl. Approximately 10 acres of commercial and services land, 85 acres of shrub and brush rangeland, and 360 acres of cropland and pasture would be converted to open water upon reservoir filling. The pipeline would pass through approximately 3.0 miles of crop and pastureland, 1.0 miles of shrub and brush rangeland, and less than 0.5 miles each of mixed rangeland, herbaceous rangeland, and urban or built-up land; land use would not change due to pipeline construction. Based on available information, no communities or other special resources are located within the reservoir area. Indirect effects of reservoir construction may include land use changes in the area surrounding the reservoir and in mitigation areas that may be converted to alternate uses to compensate for losses of terrestrial habitat.

Only flood water from the Medina River would be diverted for the OCR at Site 3. As such, this alternative would not alter the streamflow regime on the Medina River and potential downstream impacts would not be likely.

In addition to long-term impacts within the conservation pool, minor changes to existing resources situated between the conservation pool elevation and flood pool elevation could be anticipated due to occasional temporary inundation during flood events.

Plant and animal species listed by USFWS, and TPWD, as endangered or threatened with potential habitat in Bexar County are listed in Table 4C.30-3. The toothless blindcat (Trogloglanis pattersoni) is a state-listed threatened fish. The toothless blindcat has been documented in two artesian wells, Verstraeten Well and Mitchell Well, which are on or immediately adjacent to the proposed water diversion pipeline route for this OCR. Coordination with TPWD and USFWS regarding this state-listed species and other threatened and endangered species with potential to occur in the project area should be initiated early in project planning. The area may provide potential habitat to other endangered or threatened species found in Bexar County. A survey of the project area may be required prior to dam and pipeline construction to determine whether populations of or potential habitats used by listed species occur in the area to be affected.

Table 4C.30-3.
Endangered, Threatened and Species of Concern
Listed in Bexar County

Common Name	Scientific Name	Summary of Habitat Preference	Listing Entity		Potential Occurrence in County
			USFWS	TPWD	
AMPHIBIANS					
Cascade Caverns salamander	*Eurycea latitans complex*	Endemic, subaquatic in Edwards Aquifer Area	—	T	Resident
Comal Blind Salamander	*Eurycea tridentifera*	Endemic; springs and waters of caves in Bexar County.	—	T	Resident
Texas Salamander	*Eurycea neotenes*	Endemic; springs, seeps, cave streams, Helotes and Leon Creek drainages in Bexar County	—	—	Resident
ARACHNIDS					
Braken Bat Cave meshweaver	*Cicurina venii*	Karst features in western Bexar County	LE	—	Resident
Cokendolpher cave harvestman	*Texella cokendolpheri*	Karst features in north-central Bexar County	LE	—	Resident
Government Canyon Bat Cave meshweaver	*Cicurina vespera*	Karst features in northwestern Bexar County	LE	—	Resident
Government Canyon Bat Cave spider	*Neoleptoneta microps*	Karst features in northwestern Bexar County	LE	—	Resident
Robber Baron Cave meshweaver	*Cicurina baronia*	Karst features in north-central Bexar County	LE	—	Resident
BIRDS					
Black-capped Vireo	*Vireo atricapillus*	Oak-juniper woodlands,	LE	E	Resident
Golden-cheeked Warbler	*Dendroica chrysoparia*	Juniper-oak woodlands.	LE	E	Resident
Interior least tern	*Sterna antillarum athalassos*	Nests along sand and gravel bars in braided streams	LE	E	Resident
Mountain Plover	*Charadrius montanus*	Non-breeding, shortgrass plains and fields	—	—	Nesting/Migrant
Peregrine Falcon	*Falco peregrinus anatum* (American)	Open county; cliffs	T	DL	Nesting/Migrant
	Falco peregrinus tundrius (Arctic)	Open county; cliffs	—	DL	Nesting/Migrant
Western Burrowing Owl	*Athene cunicularia hypugaea*	Open grasslands, especially prairie, plains and savanna	—	—	Resident
White-faced Ibis	*Plegadis chihi*	Prefers freshwater marshes.	—	T	Resident

Table 4C.30-3 (Continued)

Common Name	Scientific Name	Summary of Habitat Preference	Listing Entity USFWS	Listing Entity TPWD	Potential Occurrence in County
Whooping Crane	*Grus americana*	Potential migrant	LE	E	Potential Migrant
Wood Stork	*Mycteria americana*	Forages in prairie ponds, ditches, and shallow standing water formerly nested in TX	—	T	Migrant
Zone-tailed Hawk	*Buteo albonotatus*	Arid open country, often near watercourses	—	T	Resident
CRUSTACEANS					
A cave obligate crustacean	*Monodella texana*	Subaquatic, underground freshwater aquifers	—	—	Resident
FISHES					
Guadalupe Bass	*Micropterus treculi*	Endemic to perennial streams of the Edwards Plateau region.	—	—	Resident
Toothless Blindcat	*Trogloglanis pattersoni*	Troglobitic, blind catfish endemic to the San Antonio Pool of the Edwards Aquifer	—	T	Resident
Widemouth Blindcat	*Satan eurystomus*	Troglobitic, blind catfish endemic to the San Antonio Pool of the Edwards Aquifer.	—	T	Resident
INSECTS					
A Ground Beetle	*Rhadine exilis*	Karst features in northern Bexar County	LE	—	Resident
A Ground Beetle	*Rhadine infernalis*	Karst features in northern and western Bexar County	LE	—	Resident
Helotes Mold Beetle	*Batrisodes venyivi*	Karst features in northwestern Bexar County.	LE	—	Resident
Manfreda Giant-skipper	*Stallingsia maculosus*	Skipper larvae usually feed inside a leaf shelter.	—	—	Resident
Rawson's metalmark	*Calephelis rawsoni*	Moist areas in shaded limestone outcrops	—	—	Resident
MAMMALS					
Black Bear	*Ursus americanus*	Inhabits bottomland hardwoods	T/SA;NL	T	Historic Resident
Cave Myotis Bat	*Myotis velifer*	Roosts colonially in caves, rock crevices	—	—	Resident

Table 4C.30-3 (Continued)

Common Name	Scientific Name	Summary of Habitat Preference	Listing Entity		Potential Occurrence in County
			USFWS	TPWD	
Ghost-faced bat	*Mormoops megalophylla*	Roosts in caves, crevices and buildings	—	—	Resident
Gray wolf	*Canis lupus*	Extirpated, forests, brushlands or grasslands	LE	E	Historic resident
Plains Spotted Skunk	*Spilogale putorius interrupta*	Prefers wooded, brushy areas.	—	—	Resident
Red Wolf	*Canis rufus*	Extirpated.	LE	E	Historic Resident
MOLLUSKS					
Creeper (squawfoot)	*Strophitus undulates*	Small to large streams	—	—	Resident
False spike mussel	*Quincuncina mitchelli*	Substrates of cobble and mud with water lilies present. Rio Grande, Brazos, Colorado and Guadalupe river basins.	—	—	Resident
Golden orb	*Quadrula aurea*	Sand and gravel, Guadalupe, San Antonio, and Nueces River basins	—	T*	Resident
Mimic Cavesnail	*Phreatodrobia imitata*	Subaquatic; only known from two wells penetrating the Edwards Aquifer	—	—	Resident
Pistolgrip	*Tritogonia verrucosa*	Aquatic, stable substrate. Red through San Antonio river basins.	—	—	Resident
Rock pocketbook	*Arcidens confragosus*	Mud and sand, Red through Guadalupe River basins.	—	—	Resident
Texas fatmucket	*Lampsilis bracteata*	Streams and rivers on sand, mud and gravel, Colorado and Guadalupe River basins.	—	T*	Resident
Texas pimpleback	*Quadrula petrina*	Mud, gravel and sand substrates, Colorado and Guadalupe river basins	—	T*	Resident
PLANTS					
Big red sage	*Salvia penstemonoides*	Endemic; moist to seasonally wet clay or silt soils in creek beds.	—	—	Resident
Bracted twistflower	*Streptanthus bracteatus*	Endemic, found in shallow, well-drained gravelly clays over limestone.	—	—	Resident

Table 4C.30-3 (Concluded)

Common Name	Scientific Name	Summary of Habitat Preference	Listing Entity		Potential Occurrence in County
			USFWS	TPWD	
Correll's false dragon-head	*Physostegia correllii*	Found in wet, silty clay loams on sides of streams and other drainages.	—	—	Resident
Elmendorf's onion	*Allium elmendorfii*	Endemic, in deep sands	—	—	Resident
Hill Country wild-mercury	*Argythamnia aphoroides*	Endemic, found primarily in bluestem-grama grasslands associated with oak woodlands.	—	—	Resident
Park's jointweed	*Polygonella parksii*	Endemic; deep loose sands of Carrizo and similar Eocene formations.	—	—	Resident
Sandhill woolywhite	*Hymenopappus carrizoanus*	Endemic; open areas in deep sands derived from Carrizo and similar Eocene formations.	—	—	Resident
REPTILES					
Indigo snake	*Drymarchon corais*	Found south of the Guadalupe River and Balcones Escarpment, primarily in riparian corridors.	—	T	Resident
Spot-tailed earless lizard	*Holbrookia lacerata*	Moderately open prairie-brushland.	—	—	Resident
Texas garter snake	*Thamnophis sirtalis annectens*	Wet or moist microhabitats	—	—	Resident
Texas horned lizard	*Phrynosoma cornutum*	Varied, sparsely vegetated uplands.	—	T	Resident
Texas tortoise	*Gopherus berlandieri*	Open brush w/ grass understory.	—	T	Resident
Timber/canebrake rattlesnake	*Crotalus horridus*	Floodplains, upland pine, deciduous woodlands, riparian zones.	—	T	Resident

LE/LT=Federally Listed Endangered/Threatened

DL, PDL=Federally Delisted/Proposed for Delisting

T/SA=Listed as Threatened by Similarity of Appearance

E, T=State Listed Endangered/Threatened T*= in process of being listed as threatened by State

-- = Species of concern, but no regulatory listing status

Source: TPWD, Annotated County List of Rare Species, Bexar County, updated 10/6/09)

4C.30.3.2 Site 4A

Site 4A involves the construction of approximately 8.4 miles of pipeline to capture flood water from the Medina River, and dam construction and inundation of approximately 710 acres along an approximately 2.5-mile reach of Portranca Creek, a tributary of the Medina River. The proposed reservoir site is located in western Bexar County within the South Texas Brushlands ecoregion, and in the Balconian biotic province. Vegetation within the project area is classified as Mesquite – Live Oak – Bluewood Parks and cropland.

Two main soil series occur within the proposed OCR Site 4A; Lewisville and Houston Black series. Lewisville soils are moderately deep, nearly level alluvial soils. These soils have slow or medium surface drainage and slow to moderate permeability, and high natural fertility. Lewisville silty clay with 1 to 3 percent slopes occurs within the proposed Site 4A boundaries. Houston Black series consists of clayey soils that are deep and calcareous. These soils occur on uplands and are nearly level to strongly sloping. Houston Black soils have slow to rapid surface drainage and high natural fertility. Water erosion is a hazard; generally theses soils are cultivated. Houston Black clay with 1 to 3 percent slopes and 3 to 5 percent slopes, Houston Black gravelly clay, 3 to 5 percent slopes and 5 to 8 percent slopes occur in the project area. Additionally, Brackett Series, Houston Series, Tarrant Series, Trinity Series and Venus Series soils along with hilly and gravelly land occur in the OCR Site 4A project area. Brackett Series soils are very shallow and shallow soils that developed over soft limestone interbedded with hard limestone. Brackett soils are well drained and generally suited to pasture or range. Brackett soils, 5 to 12 percent slopes, Brackett-Austin complex, 1 to 5 percent slopes, and Brackett clay loam, 1 to 5 percent slopes occur in the project area. Houston Series soils consists of upland soils that are deep, gently sloping to strongly sloping, have a slow to rapid surface drainage and are typically cultivated. Houston clay, 3 to 5 percent slopes, eroded occur in the project area. Tarrant Series soils are stony, very shallow, and gently undulating to steep. Tarrant Series soils have rapid surface drainage and good internal drainage; water erosion is a hazard. These soils are best suited to pasture or range. Specifically, Tarrant association, gently undulating soils are present. The Trinity Series consists of deep, nearly level alluvial soils. Trinity soils have slow surface drainage and slow internal drainage. Permeability is slow and occasional flooding is a hazard; Trinity and Frio soils, frequently flooded are present. The Venus Series consists of nearly level and gently sloping soils that are deep and limy. Venus soils are well drained with moderate permeability. Most of the acreage is cultivated. Within OCR Site 4A, areas of Venus clay loam, 1 to 3 percent slopes occur. Along with some of the soils mentioned above, gullied land, Houston Black clay, terrace with 0 to 1 percent slopes, and Lewisville silty clay with 0 to 1 percent slopes occur only in the proposed pipeline area.

The primary impacts that would result from construction and operation of the proposed OCR at this site include conversion of existing habitats and land uses within the conservation pool to open water. Site 4A would permanently inundate 710 acres below 1,100 ft-msl. According to land use and land cover data, approximately 330 acres of cropland and pasture, 325 acres of shrub and brush rangeland, 37 acres of evergreen forest land, 18 acres of agricultural land, and one acre of mixed rangeland would be converted to open water upon reservoir filling. The pipeline would pass through approximately 4.5 miles of crop and pastureland, 3.0 miles of shrub and brush rangeland, and less than 0.5 miles each of mixed rangeland, herbaceous rangeland, and urban or built-up land; land use would not change due to pipeline construction. Based on available information, no communities or other special resources are located within the reservoir area. Indirect effects of reservoir construction may include land use changes in the area surrounding the reservoir and in mitigation areas that may be converted to alternate uses to compensate for losses of terrestrial habitat.

Only flood water from the Medina River would be diverted for the OCR at Site 4A. As such, this alternative would not alter the streamflow regime on the Medina River and potential downstream impacts would not be likely.

In addition to long-term impacts within the conservation pool, minor changes to existing resources situated between the conservation pool elevation and flood pool elevation could be anticipated due to occasional temporary inundation during flood events.

Plant and animal species listed by USFWS, and TPWD, as endangered or threatened in Bexar County are previously listed in Table 4C.30-3. The toothless blindcat (*Trogloglanis pattersoni*) is a state-listed threatened fish. The toothless blindcat has been documented in two artesian wells, Verstraeten Well and Mitchell Well, which are on or immediately adjacent to the proposed water diversion pipeline. Coordination with TPWD and USFWS regarding this state-listed species and other threatened and endangered species with potential to occur in the project area should be initiated early in project planning. The Bracken Bat Cave meshweaver (*Cicurina venii*) a federally-endangered arachnid has been documented within 1.5-miles northwest of Site 4A. The study area may provide potential habitat to other endangered or threatened species found in Bexar County. Protected species may use habitats in the area during migration. A survey of the project area may be required prior to dam and pipeline construction to determine whether populations of or potential habitats used by listed species occur in the area to be affected.

4C.30.3.3 Site 6

Site 6 involves the construction of approximately 12 miles of pipeline to divert flood water from the Medina River, and dam construction and inundation of approximately 380 acres along an approximately 2.25-mile reach of Lucas Creek, a tributary of the Medina River. The proposed reservoir site is located in western Bexar County within the South Texas Brushlands ecoregion,[4] and in the Balconian biotic province.[5] Vegetation within the project area is classified as Mesquite – Live Oak – Bluewood Parks and cropland.

Soils underlying the proposed OCR Site 6 area are composed of seven soil types. Brackett soils, 5 to 12 percent slopes, Brackett clay loam, 1 to 5 percent slopes and Brackett-Austin complex, 1 to 5 percent slopes all belong to the Brackett Series. Brackett Series soils are very shallow and shallow soils that developed over soft limestone interbedded with hard limestone. Brackett soils are well drained and generally suited to pasture or range. Lewisville silty clay with 1 to 3 percent slopes occurs within the proposed Site 6 boundaries. Lewisville soils are moderately deep, nearly level alluvial soils. These soils have slow or medium surface drainage and slow to moderate permeability, and high natural fertility. Tarrant association, gently undulating (1 to 5 percent slopes) and Tarrant association, rolling (5 to 15 percent slopes) occur within the OCR Site 6 footprint. Tarrant Series soils have rapid surface drainage and good internal drainage; water erosion is a hazard. These soils are best suited to pasture or range. The final soil type found within OCR Site 6 is Trinity and Frio soils, frequently flooded. The Trinity Series consists of deep, nearly level alluvial soils. Trinity soils have slow surface drainage and slow internal drainage. Permeability is slow and occasional flooding is a hazard. Along with some of the soils mentioned above, gullied land, Houston Black clay, terrace with 0 to 1 percent slopes, and Lewisville silty clay with 0 to 1 percent slopes occur only in the proposed pipeline area.

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[4] TPWD, "Texas Partners in Flight; Ecological Region 7 – Edwards Plateau"http://www.tpwd.state.tx.us/huntwild/wild/birding/pif/assist/pif_regions/region_7.phtml accessed July 20, 2009.
[5] Blair, W.F., "The Biotic Provinces of Texas, "Tex. J. Sci. 2:93-117, 1950.

The primary impacts that would result from construction and operation of the proposed OCR at this site include conversion of existing habitats and land uses within the conservation pool to open water. Site 6 would permanently inundate 380 acres below 1,100 ft-msl. According to land use and land cover data[6], approximately 295 acres of evergreen forest land and approximately 85 acres of shrub and brush rangeland would be converted to open water upon reservoir filling. The pipeline would pass through approximately 7.25 miles of crop and pastureland, 3.5 miles of shrub and brush rangeland, and less than 0.5 miles each of mixed rangeland, herbaceous rangeland, evergreen forest land, and urban or built-up land; land use would not change due to pipeline construction. Based on available information, no communities or other special resources are located within the reservoir area. Indirect effects of reservoir construction may include land use changes in the area surrounding the reservoir and in mitigation areas that may be converted to alternate uses to compensate for losses of terrestrial habitat.

Only flood water from the Medina River would be diverted for the OCR at Site 6. As such, this alternative would not alter the streamflow regime on the Medina River and potential downstream impacts would not be likely.

In addition to long-term impacts within the conservation pool, minor changes to existing resources situated between the conservation pool elevation and flood pool elevation could be anticipated due to occasional temporary inundation during flood events.

Plant and animal species listed by USFWS, and TPWD, as endangered or threatened in Bexar County are previously listed in Table 4C.30-3. The toothless blindcat (*Trogloglanis pattersoni*) is a state-listed threatened fish. The toothless blindcat has been documented in two artesian wells, Verstraeten Well and Mitchell Well, which are on or immediately adjacent to the proposed water diversion pipeline. Coordination with TPWD and USFWS regarding this state-listed species and other threatened and endangered species with potential to occur in the project area should be initiated early in project planning. The Bracken Bat Cave meshweaver (*Cicurina venii*) a federally-endangered arachnid has been documented within 2.0-miles northeast of Site 6. The study area may provide potential habitat to other endangered or threatened species found in Bexar County. Protected species may use habitats in the area during migration. A survey of the project area may be required prior to dam and pipeline construction to determine whether populations of or potential habitats used by listed species occur in the area to be affected.

[6] USGS, 1990. “A Land Use and Land Cover Classification System for Use with Remote Sensor Data,” Reston, VA 1990.

4C.30.3.4 ASR

Potential environmental issues associated with implementation of the ASR water management strategy include consideration and mitigation of affected aquatic and terrestrial habitats, cultural resources, and threatened and endangered species, in accordance with applicable state and federal requirements. Implementation of any of this alternative would require field surveys by qualified professionals to document vegetation/habitat types, waters of the U.S. including wetlands, and cultural resources that may be impacted by the ASR system. Where impacts to protected species habitat or significant cultural resources cannot be avoided, additional studies would be necessary to evaluate habitat use and/or value, or eligibility for inclusion in the National Register of Historic Places, respectively. Compensation would be required for unavoidable adverse impacts involving net losses of wetlands.

Unappropriated flows from the Medina River would be diverted into a pipeline for storage within the Carrizo Aquifer. Neither the Medina River nor the Atascosa River (in the vicinity of the pipeline terminus) has been identified by the TPWD as ecologically significant. Construction of the proposed diversion pipeline would begin at the Medina River in Bexar County within the Blackland Prairies ecoregion and would terminate in Atascosa County near the Poteet within the South Texas Brush Country ecoregion[7] within the Tamaulipan biotic province of Texas.[8] Vegetation within the project area is primarily cropland with a band of post oak woods, forest and grassland mosaic[9].

Based on a review of available GIS datasets from the Texas Historical Commission, several cemeteries and at least four historical markers are located within one mile of the proposed pipeline route. Coordination with the Texas Historical Commission will need to be initiated prior to project construction. No review of archaeological resources has been completed. It is likely that a study of the pipeline route would need to be completed to determine impacts to archaeological resources. If the project will affect waters of the United States or wetlands, the project sponsor will also be required to coordinate with the U.S. Army Corps of Engineers regarding any impacts to cultural resources.

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[7] TPWD, "Texas Partners in Flight; Ecological Region 7 – Edwards Plateau"http://www.tpwd.state.tx.us/huntwild/wild/birding/pif/assist/pif_regions/region_7.phtml accessed July 20, 2009.
[8] Blair, W.F., "The Biotic Provinces of Texas, "Tex. J. Sci. 2:93-117, 1950.
[9] McMahan, C. A., R. G. Frye and K. L. Brown, "The Vegetation Types of Texas -- Including Cropland," Texas Parks and Wildlife Department − PWD Bulletin 7000-120. 1984.

The primary impacts that would result from construction and operation of the proposed ASR include the diversion of unappropriated flows from the Medina River and conversion of existing habitats along the pipeline route and within the well field area to maintained right-of-way. Land use in the surrounding area would not be anticipated to change due to this project.

Unappropriated flows from the Medina River would be diverted for the ASR option. As such, this alternative would not be expected to alter the streamflow regime on the Medina River and potential downstream impacts would not be likely.

Plant and animal species listed by USFWS, and TPWD, as endangered or threatened with potential habitat in Bexar and Atascosa counties are listed in Table 4C.30-4. The toothless blindcat, a state-listed threatened fish, has been documented in two artesian wells, Verstraeten Well and Mitchell Well, which are both within 0.5 miles of the proposed water diversion pipeline route, north of the Medina River. Additionally, two plant species, sandhill woollywhite (state threatened) and Parks' jointweed (species of concern) have been documented near the proposed pipeline route. Coordination with TPWD and USFWS regarding this state-listed species and other threatened and endangered species with potential to occur in the project area should be initiated early in project planning. The area may provide potential habitat to other endangered or threatened species found in Bexar or Atascosa counties. A survey of the project area to determine habitat within the project area should be completed.

Table 4C.30-4.
Endangered, Threatened and Species of Concern in Bexar and Atascosa County

Common Name	Scientific Name	Impact Value	Multiplier Based on Status	Adjusted Impact	Summary of Habitat Preference	Listing Entity		Potential Occurrence in County
						USFWS	TPWD	
AMPHIBIANS								
Cascade Caverns salamander	*Eurycea latitans complex*	*0*	*2*	*0*	Endemic, subaquatic in Edwards Aquifer Area		T	Resident
Comal Blind Salamander	*Eurycea tridentifera*	*1*	*2*	*2*	Endemic; springs and waters of caves in Bexar County.		T	Resident
Texas Salamander	*Eurycea neotenes*	*0*	*1*	*0*	Endemic; springs, seeps, cave streams, Helotes and Leon Creek drainages in Bexar County			Resident
ARACHNIDS								
Braken Bat Cave Meshweaver	*Cicurina venii*	*1*	*3*	*3*	Karst features in western Bexar County	LE		Resident
Cokendolpher cave harvestman	*Texella cokendolpheri*	*0*	*3*	*0*	Karst features in north-central Bexar County	LE		Resident
Government Canyon Bat Cave Meshweaver	*Cicurina vespera*	*0*	*3*	*0*	Karst features in northwestern Bexar County	LE		Resident
Government Canyon Bat Cave Spider	*Neoleptoneta microps*	*0*	*3*	*0*	Karst features in northwestern Bexar County	LE		Resident
Madla Cave Meshweaver	*Cicurina madla*	*0*	*3*	*0*	Karst features in northern Bexar County	LE		Resident
Robber Baron Cave Meshweaver	*Cicurina baronia*	*0*	*3*	*0*	Karst features in north-central Bexar County	LE		Resident
BIRDS								
Black-capped Vireo	*Vireo atricapillus*	*1*	*3*	*3*	Oak-juniper woodlands,	LE	E	Resident
Golden-cheeked Warbler	*Dendroica chrysoparia*	*1*	*3*	*3*	Juniper-oak woodlands.	LE	E	Resident
Interior least tern	*Sterna antillarum athalassos*	*0*	*3*	*0*	Nests along sand and gravel bars in braided streams	LE	E	Resident
Mountain Plover	*Charadrius montanus*	*1*	*1*	*0*	Non-breeding, shortgrass plains and fields			Nesting/Migrant

Table 4C.30-4 (Continued)

Common Name	Scientific Name	Impact Value	Multiplier Based on Status	Adjusted Impact	Summary of Habitat Preference	Listing Entity		Potential Occurrence in County
						USFWS	TPWD	
American Peregrine Falcon	*Falco peregrinus anatum*	*0*	*2*	*0*	Resident and local breeder in West Texas. Migrant across the state.	DL	T	Possible Migrant
Arctic peregrine falcon	*Falco peregrinus tundrius*	*0*	*1*	*0*	Migrant throughout the state.	DL		Possible Migrant
Western Burrowing Owl	*Athene cunicularia hypugaea*	*1*	*1*	*1*	Open grasslands, especially prairie, plains and savanna			Resident
White-faced Ibis	*Plegadis chihi*	*0*	*2*	*0*	Prefers freshwater marshes.		T	Resident
Whooping Crane	*Grus americana*	*0*	*3*	*0*	Potential migrant	LE	E	Potential Migrant
Wood Stork	*Mycteria americana*	*0*	*2*	*0*	Forages in prairie ponds, ditches, and shallow standing water formerly nested in TX		T	Migrant
Zone-tailed Hawk	*Buteo albonotatus*	*0*	*2*	*0*	Arid open country, often near watercourses		T	Resident
CRUSTACEANS								
A cave obligate crustacean	*Monodella texana*	*1*	*1*	*1*	Subaquatic, underground freshwater aquifers			Resident
Nueces crayfish	*Procambarus nueces*	0	1	0	Known only from one tributary to the Nueces River.			Resident
FISH								
Guadalupe Bass	*Micropterus treculi*	*0*	*1*	*1*	Endemic to perennial streams of the Edwards Plateau region.			Resident
Toothless Blindcat	*Trogloglanis pattersoni*	*2*	*2*	*4*	Troglobitic, blind catfish endemic to the San Antonio Pool of the Edwards Aquifer		T	Resident
Widemouth Blindcat	*Satan eurystomus*	*2*	*2*	*4*	Troglobitic, blind catfish endemic to the San Antonio Pool of the Edwards Aquifer.		T	Resident
INSECTS								
A Ground Beetle	*Rhadine exilis*	*0*	*3*	*0*	Karst features in northern Bexar County	LE		Resident

Table 4C.30-4 (Continued)

Common Name	Scientific Name	Impact Value	Multiplier Based on Status	Adjusted Impact	Summary of Habitat Preference	Listing Entity		Potential Occurrence in County
						USFWS	TPWD	
A Ground Beetle	*Rhadine infernalis*	*0*	*3*	*0*	Karst features in northern and western Bexar County	LE		Resident
Helotes Mold Beetle	*Batrisodes venyivi*	*0*	*3*	*0*	Karst features in northwestern Bexar County	LE		Resident
Manfreda Giant-skipper	*Stallingsia maculosus*	*1*	*1*	*1*	Skipper larvae usually feed inside a leaf shelter.			Resident
Rawson's metalmark	*Calephelis rawsoni*	*1*	*1*	*1*	Moist areas in shaded limestone outcrops			Resident
MAMMALS								
Black Bear	*Ursus americanus*	*0*	*1*	*0*	Inhabits bottomland hardwoods	T/SA;NL	T	Historic Resident
Cave Myotis Bat	*Myotis velifer*	*0*	*2*	*0*	Roosts colonially in caves, rock crevices			Resident
Ghost-faced bat	*Mormoops megalophylla*	*0*	*1*	*0*	Roosts in caves, crevices and buildings			Resident
Gray wolf	*Canis lupus*	*0*	*3*	*0*	Extirpated, forests, brushlands or grasslands	LE	E	Historic resident
Ocelot	*Leopardus pardalis*	0	3	0	Found in dense chaparral thickets, and oak mottes.	LE	E	Resident
Plains Spotted Skunk	*Spilogale putorius interrupta*	*1*	*1*	*1*	Prefers wooded, brushy areas.			Resident
Red Wolf	*Canis rufus*	*0*	*3*	*0*	Extirpated.	LE	E	Historic Resident
MOLLUSKS								
Creeper (squawfoot)	*Strophitus undulates*	*1*	*1*	*1*	Small to large streams			Resident
False spike mussel	*Quincuncina mitchelli*	*1*	*2*	*2*	Substrates of cobble and mud with water lilies present. Rio Grande, Brazos, Colorado and Guadalupe river basins.		T	Resident
Golden orb	*Quadrula aurea*	*1*	*2*	*2*	Sand and gravel, Guadalupe, San Antonio, and Nueces River basins		T	Resident

Table 4C.30-4 (Continued)

Common Name	Scientific Name	Impact Value	Multiplier Based on Status	Adjusted Impact	Summary of Habitat Preference	Listing Entity		Potential Occurrence in County
						USFWS	TPWD	
Mimic Cavesnail	*Phreatodrobia imitata*	0	1	0	Subaquatic; only known from two wells penetrating the Edwards Aquifer			Resident
Pistolgrip	*Tritogonia verrucosa*	1	1	1	Aquatic, stable substrate. Red through San Antonio river basins.			Resident
Rock pocketbook	*Arcidens confragosus*	1	1	1	Mud and sand, Red through Guadalupe River basins.			Resident
Texas fatmucket	*Lampsilis bracteata*	1	2	2	Streams and rivers on sand, mud and gravel, Colorado and Guadalupe River basins.		T	Resident
Texas pimpleback	*Quadrula petrina*	1	2	2	Mud, gravel and sand substrates, Colorado and Guadalupe river basins		T	Resident
PLANTS								
Big red sage	*Salvia penstemonoides*	1	1	1	Endemic; moist to seasonally wet clay or silt soils in creek beds.			Resident
Bracted twistflower	*Streptanthus bracteatus*	1	1	1	Endemic: found in shallow, well-drained gravelly clays and clay loams over limestone.			Resident
Correll's false dragon-head	*Physostegia correllii*	1	1	1	Found in wet, silty clay loams on sides of streams and other wet areas.			Resident
Elmendorf's onion	*Allium elmendorfii*	1	1	1	Endemic, in deep sands			Resident
Hill Country wild-mercury	*Argythamnia aphoroides*	1	1	1	Endemic: found in grasslands associated with oak woodlands.			Resident
Park's jointweed	*Polygonella parksii*	2	1	2	Endemic; deep loose sands of Carrizo and similar Eocene formations.			Resident

Table 4C.30-4 (Concluded)

Common Name	Scientific Name	Impact Value	Multiplier Based on Status	Adjusted Impact	Summary of Habitat Preference	Listing Entity		Potential Occurrence in County
						USFWS	TPWD	
Sandhill woolywhite	Hymenopappus carrizoanus	2	2	4	Found south of the Guadalupe River and the Balcones Escarpment. Prefers dense riparian corridors.		T	Resident
REPTILES								
Indigo snake	*Drymarchon carais*	1	2	2	Found south of the Guadalupe river and Balcones Escarpment.		T	Resident
Spot-tailed earless lizard	*Holbrookia lacerata*	1	1	1	Moderately open prairie-brushland.			Resident
Texas Garter Snake	*Thamnophis sirtalis annectens*	1	1	1	Wet or moist microhabitats			Resident
Texas Horned Lizard	*Phrynosoma cornutum*	1	2	2	Varied, sparsely vegetated uplands.		T	Resident
Texas Tortoise	*Gopherus berlandieri*	1	2	2	Open brush w/ grass understory.		T	Resident
Timber/Canebrake Rattlesnake	*Crotalus horridus*	1	2	2	Floodplains, upland pine, deciduous woodlands, riparian zones.		T	Resident

LE/LT=Federally Listed Endangered/Threatened
DL, PDL=Federally Delisted/Proposed for Delisting
T/SA=Listed as Threatened by Similarity of Appearance
E, T=State Listed Endangered/Threatened
Blank= Species of concern, but no regulatory listing status
Source: TPWD, Annotated County List of Rare Species, Bexar County, updated 10/6/09
TPWD, Annotated County List of Rare Species, Atascosa County, updated 05/07/09

4C.30.4 Engineering and Costing

The cost estimates for the different options of this water management strategy are shown in Table 4C.30-5. Included in the costs for the off-channel reservoirs and ASR scenarios are raw water intakes and pump stations, two-way transmission pipelines, and integration. The ASR scenarios also include the cost of a water treatment plant, ASR injection/recovery wells, and a transmission pump station. The OCR option also includes cost of the reservoir and dam. Depending upon the location(s) and type(s) of use for water supplies associated with an

Table 4C.30-5.
Cost Estimate Summary for
Medina Lake Firm-Up
(September 2008 Prices)

	OCR Site 3[1]	OCR Site 4A	OCR Site 6	ASR Scenario 1	ASR Scenario 2[2]
Capital Costs					
Off-Channel Storage	$49,093,000	$31,258,000	$27,027,000	$0	$0
Intake and Pump Station at Medina River Diversion Site	$3,374,000	$3,139,000	$3,125,000	$7,249,000	$7,249,000
Intake and Pump Station at Off-Channel Storage Site or ASR	$8,631,000	$10,162,000	$11,579,000	$3,430,000	$4,326,000
Two-Way Transmission Pipeline	$5,173,000	$8,894,000	$13,467,000	$18,504,000	$18,504,000
Transmission Pump Station(s)	$0	$0	$0	$3,982,000	$5,014,000
Well Fields	$0	$0	$0	$12,189,000	$18,619,000
Water Treatment Plant	$0	$0	$0	$33,958,000	$33,958,000
Integration	$16,064,000	$11,454,000	$11,454,000	$13,410,000	$17,181,000
Total Capital Cost	**$82,335,000**	**$64,907,000**	**$66,652,000**	**$92,722,000**	**$104,851,000**
Engineering, Legal Costs and Contingencies	$28,558,000	$22,272,000	$22,655,000	$30,327,000	$34,258,000
Environmental & Archaeology Studies and Mitigation	$1,717,000	$1,799,000	$1,895,000	$775,000	$910,000
Land Acquisition and Surveying	$1,786,000	$1,901,000	$2,036,000	$747,000	$759,000
Interest During Construction (2 years)	$7,355,000	$5,451,000	$5,317,000	$4,846,000	$5,459,000
Total Project Cost	**$121,751,000**	**$96,330,000**	**$98,555,000**	**$129,417,000**	**$146,237,000**
Annual Costs					
Debt Service (6 percent, 20 years)	$4,076,000	$4,127,000	$4,859,000	$10,984,000	$12,372,000
Reservoir Debt Service (6 percent, 40 years)	$4,985,000	$3,256,000	$2,846,000	$0	$0
Operation and Maintenance					
Intake, Pipeline, Pump Station	$512,000	$536,000	$617,000	$715,000	$841,000
Dam and Reservoir	$736,000	$469,000	$405,000	$0	$0
Water Treatment Plant	$0	$0	$0	$3,007,000	$3,007,000
Pumping Energy Costs	$560,000	$691,000	$826,000	$535,000	$626,000
Total Annual Cost	**$10,869,000**	**$9,079,000**	**$9,553,000**	**$15,241,000**	**$16,846,000**
Available Project Yield[3] (acft/yr)	9,078	5,378	5,403	6,943	9,933
Annual Cost of Water[3] ($ per acft)	$1,197	$1,688	$1,768	$2,195	$1,696
Annual Cost of Water[3] ($ per 1,000 gallons)	$3.67	$5.18	$5.43	$6.74	$5.20

[1] Alternative SCTRWP recommended water management strategy
[2] SCTRWP recommended water management strategy
[3] Accounting for 3,797 acft/yr run-of-river supply currently available to BMWD.

off-channel reservoir or ASR, additional facilities and costs could include additional pipelines to customers. Inundated land and mitigation land acquisition and operation and maintenance costs were developed in accordance with the standard cost estimating procedures summarized in Appendix A. Costs include land purchased within the spillway design flood pools for the off-channel reservoirs.

The costs presented in Table 4C.30-5 are based on the incremental firm yield increase of Medina Lake associated with each option. Currently the run-of-river supply available to BMWD is 3,797 acft/yr. The annual costs, including debt service and operation and maintenance, range from $9,079,000 for OCR Site 4A to $16,846,000 for ASR Scenario 2. For annual firm yields ranging from 5,378 acft to 9,933 acft, the resulting unit cost of treated water ranges from $1,197 to $2,195 per acft (Table 4C.30-5).

4C.30.5 Implementation Issues

An institutional arrangement may be needed to implement this project including financing on a regional basis.

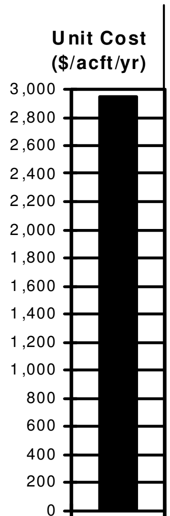
1. It will be necessary to obtain these permits:
   a. TCEQ Water Right and Storage permits.
   b. TCEQ Interbasin Transfer approval depending upon location(s) of use.
   c. USACE Sections 10 and 404 dredge and fill permits for the reservoir and pipelines.
   d. GLO Sand and Gravel Removal permits.
   e. GLO Easement for use of state-owned land.
   f. Coastal Coordination Council review.
   g. TPWD Sand, Gravel, and Marl permit.

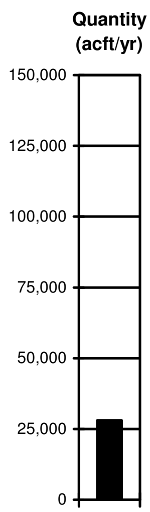
2. Permitting, at a minimum, will require these studies:
   a. Assessment of instream flow and bay and estuary inflow changes.
   b. Habitat mitigation plan.
   c. Environmental studies.
   d. Cultural resources.

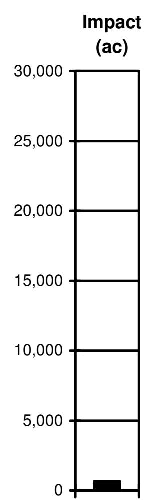
3. Land will need to be acquired through either negotiations or condemnation.

4. Relocations for the reservoir may include:
   a. County roads.
   b. Utilities.
   c. Structures of historical significance.
   d. Cemeteries.

2011 South Central Texas Regional Water Plan
Water Management Strategy Summary Sheet







Name: Seawater Desalination – 25 MGD

Description: This strategy includes desalting seawater from San Antonio Bay and conveying water to the major municipal demand center of the South Central Region. Facilities include a raw water intake and water treatment plant near Seadrift, brine transmission and off-shore disposal system, 42-inch treated water transmission pipeline and associated pump stations for delivery of water a distance of approximately 126 miles to south Bexar County, and distribution system improvements for integration of the additional supply.

***Decade Needed*:** 2050 – 2060

Cost, Quantity of Water, and Land Impacted

Unit Cost of Water:	**2,948**	**$/acft/yr**	**Treated Water Distributed**
Quantity of Water:	**28,004**	**acft/yr**	**Reliability = Firm**
Land Impacted:	**673**	**acres**	

Additional Considerations per Regional Water Planning Guidelines

Environmental Factors:

Wintering population of endangered Whooping Cranes at the Aransas National Wildlife Refuge located across San Antonio Bay from the proposed intake site near Seadrift. Potential effects of diversions on bay salinity and estuarine habitat and species. Pipeline could traverse Attwater Prairie Chicken habitat.

Impacts on Water Resources:

Potential benefit to instream flows in the San Antonio River due to increased discharge of treated effluent.

Impacts on Agricultural & Natural Resources:

Temporary impacts due to construction of pipeline.

Other Relevant Factors per SCTRWPG:

Confirmation of technology and values used in developing costs prior to implementation. Perceived to have fewer associated environmental effects than typical fresh surface water supplies.

If fresh groundwater from the lower Guadalupe Basin is added to this strategy, then the plan must be amended in order for the modified strategy to be recommended for implementation

Comparison of Strategies to Meet Needs:

High unit cost, but potential for large drought-proof water supply. Unit cost is approximately 50 percent treatment and 50 percent conveyance. No conflicts with other recommended water management strategies.

Interbasin Transfer Issues:

Not applicable.

Third-Party Impacts of Voluntary Transfers:

Not applicable.

Regional Efficiency:

Additional surface water supply without reductions in instream flows or freshwater inflows to the Guadalupe Estuary. Shared pipeline alignment with other recommended water management strategies.

Water Quality Considerations:

Integration of desalinated water with different corrosion chemistry may require conditioning of water to meet distribution system stability requirements. Operational treatment costs may be substantially reduced at source water salinities less than the assumed 25 ppt.

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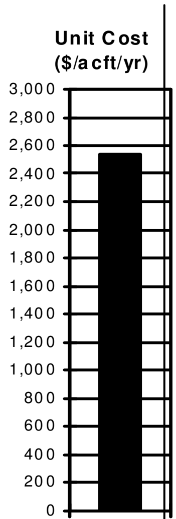
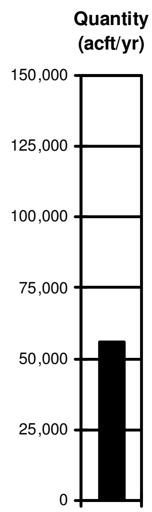
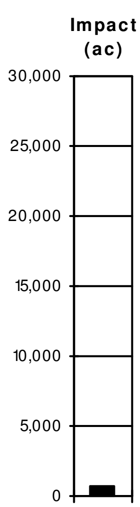
Water Management Strategy Summary Sheet







Name: Seawater Desalination – 50 MGD

Description: This strategy includes desalting seawater from San Antonio Bay and conveying water to the major municipal demand center of the South Central Region. Facilities include a raw water intake and water treatment plant near Seadrift, brine transmission and off-shore disposal system, 60-inch treated water transmission pipeline and associated pump stations for delivery of water a distance of approximately 126 miles to south Bexar County, and distribution system improvements for integration of the additional supply.

***Decade Needed*:** 2050 – 2060

Cost, Quantity of Water, and Land Impacted

Unit Cost of Water:	**2,541**	**$/acft/yr**	**Treated Water Distributed**
Quantity of Water:	**56,008**	**acft/yr**	**Reliability = Firm**
Land Impacted:	**692**	**acres**	

Additional Considerations per Regional Water Planning Guidelines

Environmental Factors:

Wintering population of endangered Whooping Cranes at the Aransas National Wildlife Refuge located across San Antonio Bay from the proposed intake site near Seadrift. Potential effects of diversions on bay salinity and estuarine habitat and species. Pipeline could traverse Attwater Prairie Chicken habitat.

Impacts on Water Resources:

Potential benefit to instream flows in the San Antonio River due to increased discharge of treated effluent.

Impacts on Agricultural & Natural Resources:

Temporary impacts due to construction of pipeline.

Other Relevant Factors per SCTRWPG:

Confirmation of technology and values used in developing costs prior to implementation. Perceived to have fewer associated environmental effects than typical fresh surface water supplies.

If fresh groundwater from the lower Guadalupe Basin is added to this strategy, then the plan must be amended in order for the modified strategy to be recommended for implementation

Comparison of Strategies to Meet Needs:

High unit cost, but potential for large drought-proof water supply. Unit cost is approximately 50 percent treatment and 50 percent conveyance. No conflicts with other recommended water management strategies.

Interbasin Transfer Issues:

Not applicable.

Third-Party Impacts of Voluntary Transfers:

Not applicable.

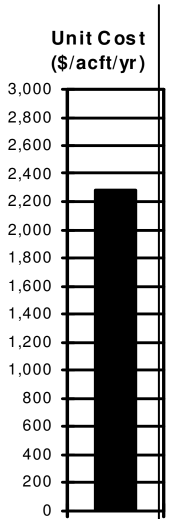
Regional Efficiency:

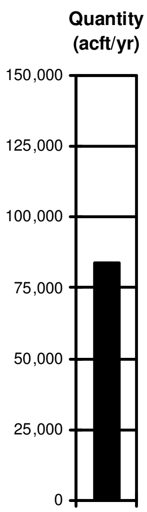
Additional surface water supply without reductions in instream flows or freshwater inflows to the Guadalupe Estuary. Shared pipeline alignment with other recommended water management strategies.

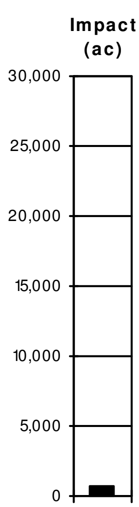
Water Quality Considerations:

Integration of desalinated water with different corrosion chemistry may require conditioning of water to meet distribution system stability requirements. Operational treatment costs may be substantially reduced at source water salinities less than the assumed 25 ppt.

2011 South Central Texas Regional Water Plan
Water Management Strategy Summary Sheet







Name: Seawater Desalination – 75 MGD

Description: This strategy includes desalting seawater from San Antonio Bay and conveying water to the major municipal demand center of the South Central Region. Facilities include a raw water intake and water treatment plant near Seadrift, brine transmission and off-shore disposal system, 66-inch treated water transmission pipeline and associated pump stations for delivery of water a distance of approximately 126 miles to south Bexar County, and distribution system improvements for integration of the additional supply.

***Decade Needed*:** 2050 – 2060

Cost, Quantity of Water, and Land Impacted

Unit Cost of Water:	**2,284**	**$/acft/yr**	**Treated Water Distributed**
Quantity of Water:	**84,012**	**acft/yr**	**Reliability = Firm**
Land Impacted:	**700**	**acres**	

Additional Considerations per Regional Water Planning Guidelines

Environmental Factors:

Wintering population of endangered Whooping Cranes at the Aransas National Wildlife Refuge located across San Antonio Bay from the proposed intake site near Seadrift. Potential effects of diversions on bay salinity and estuarine habitat and species. Pipeline could traverse Attwater Prairie Chicken habitat.

Impacts on Water Resources:

Potential benefit to instream flows in the San Antonio River due to increased discharge of treated effluent.

Impacts on Agricultural & Natural Resources:

Temporary impacts due to construction of pipeline.

Other Relevant Factors per SCTRWPG:

Confirmation of technology and values used in developing costs prior to implementation. Perceived to have fewer associated environmental effects than typical fresh surface water supplies.

If fresh groundwater from the lower Guadalupe Basin is added to this strategy, then the plan must be amended in order for the modified strategy to be recommended for implementation

Comparison of Strategies to Meet Needs:

High unit cost, but potential for large drought-proof water supply. Unit cost is approximately 50 percent treatment and 50 percent conveyance. No conflicts with other recommended water management strategies.

Interbasin Transfer Issues:

Not applicable.

Third-Party Impacts of Voluntary Transfers:

Not applicable.

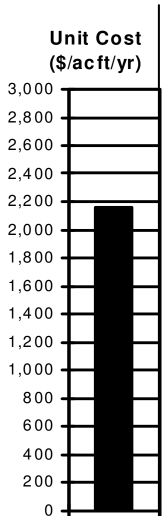
Regional Efficiency:

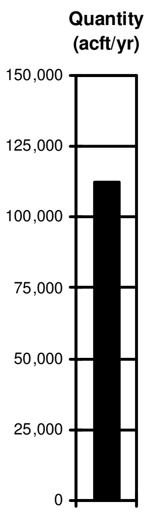
Additional surface water supply without reductions in instream flows or freshwater inflows to the Guadalupe Estuary. Shared pipeline alignment with other recommended water management strategies.

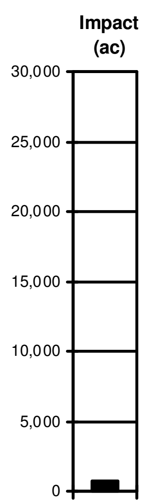
Water Quality Considerations:

Integration of desalinated water with different corrosion chemistry may require conditioning of water to meet distribution system stability requirements. Operational treatment costs may be substantially reduced at source water salinities less than the assumed 25 ppt.

2011 South Central Texas Regional Water Plan
Water Management Strategy Summary Sheet







Name: Seawater Desalination – **100 MGD**

Description: This strategy includes desalting seawater from San Antonio Bay and conveying water to the major municipal demand center of the South Central Region. Facilities include a raw water intake and water treatment plant near Seadrift, brine transmission and off-shore disposal system, 78-inch treated water transmission pipeline and associated pump stations for delivery of water a distance of approximately 126 miles to south Bexar County, and distribution system improvements for integration of the additional supply.

***Decade Needed*:** 2050 – 2060

Cost, Quantity of Water, and Land Impacted

Unit Cost of Water:	**2,158**	**$/acft/yr**	**Treated Water Distributed**
Quantity of Water:	**112,016**	**acft/yr**	**Reliability = Firm**
Land Impacted:	**705**	**acres**	

Additional Considerations per Regional Water Planning Guidelines

Environmental Factors:

Wintering population of endangered Whooping Cranes at the Aransas National Wildlife Refuge located across San Antonio Bay from the proposed intake site near Seadrift. Potential effects of diversions on bay salinity and estuarine habitat and species. Pipeline could traverse Attwater Prairie Chicken habitat.

Impacts on Water Resources:

Potential benefit to instream flows in the San Antonio River due to increased discharge of treated effluent.

Impacts on Agricultural & Natural Resources:

Temporary impacts due to construction of pipeline.

Other Relevant Factors per SCTRWPG:

Confirmation of technology and values used in developing costs prior to implementation. Perceived to have fewer associated environmental effects than typical fresh surface water supplies.

If fresh groundwater from the lower Guadalupe Basin is added to this strategy, then the plan must be amended in order for the modified strategy to be recommended for implementation

Comparison of Strategies to Meet Needs:

High unit cost, but potential for large drought-proof water supply. Unit cost is approximately 50 percent treatment and 50 percent conveyance. No conflicts with other recommended water management strategies.

Interbasin Transfer Issues:

Not applicable.

Third-Party Impacts of Voluntary Transfers:

Not applicable.

Regional Efficiency:

Additional surface water supply without reductions in instream flows or freshwater inflows to the Guadalupe Estuary. Shared pipeline alignment with other recommended water management strategies.

Water Quality Considerations:

Integration of desalinated water with different corrosion chemistry may require conditioning of water to meet distribution system stability requirements. Operational treatment costs may be substantially reduced at source water salinities less than the assumed 25 ppt.

4C.31 Seawater Desalination

4C.31.1 Description of Water Management Strategy

Desalting seawater from the Gulf of Mexico in the vicinity of San Antonio Bay is a potential source of freshwater supplies for municipal and industrial use. This section presents desalination information for a range of quantities so that a range of costs can be considered. The strategy will be a large-scale desalt plant with finished water capacity ranging from 25 to 100 MGD (28,004 to 112,016 acft/yr) drawing saline water from San Antonio Bay with a conveyance system for delivery of treated water to the major municipal water demand center of the South Central Texas Region.

The desalination treatment plant is located adjacent to San Antonio Bay near the City of Seadrift and the treated water delivery location is south Bexar County as shown in Figure 4C.31-1. The desalination process produces a concentrate that is conveyed out to the open Gulf of Mexico for diffusion in deep water. The treatment plant location and concentrate pipeline are shown in Figure 4C.31-2.

4C.31.1.1 General Desalination Background

The commercially available processes that are currently used to desalt seawater and brackish groundwater to produce potable water are:

- Distillation (thermal) Processes; and
- Membrane (non-thermal) Processes.

The following sections describe each of these processes and discuss a number of issues that should be considered before selecting a process for desalination of seawater.

4C.31.1.2 Distillation (Thermal) Processes

Distillation processes produce purified water by vaporizing a portion of the saline feedstock to form steam. Since the salts dissolved in the feedstock are nonvolatile, they remain unvaporized and the steam formed is captured as a pure condensate. Distillation processes are normally very energy-intensive, quite expensive, and are generally used for large-scale desalination of seawater. Heat is usually supplied by steam produced by boilers or from a turbine power cycle used for electric power generation. Distillation plants are commonly co-sited with power plants.

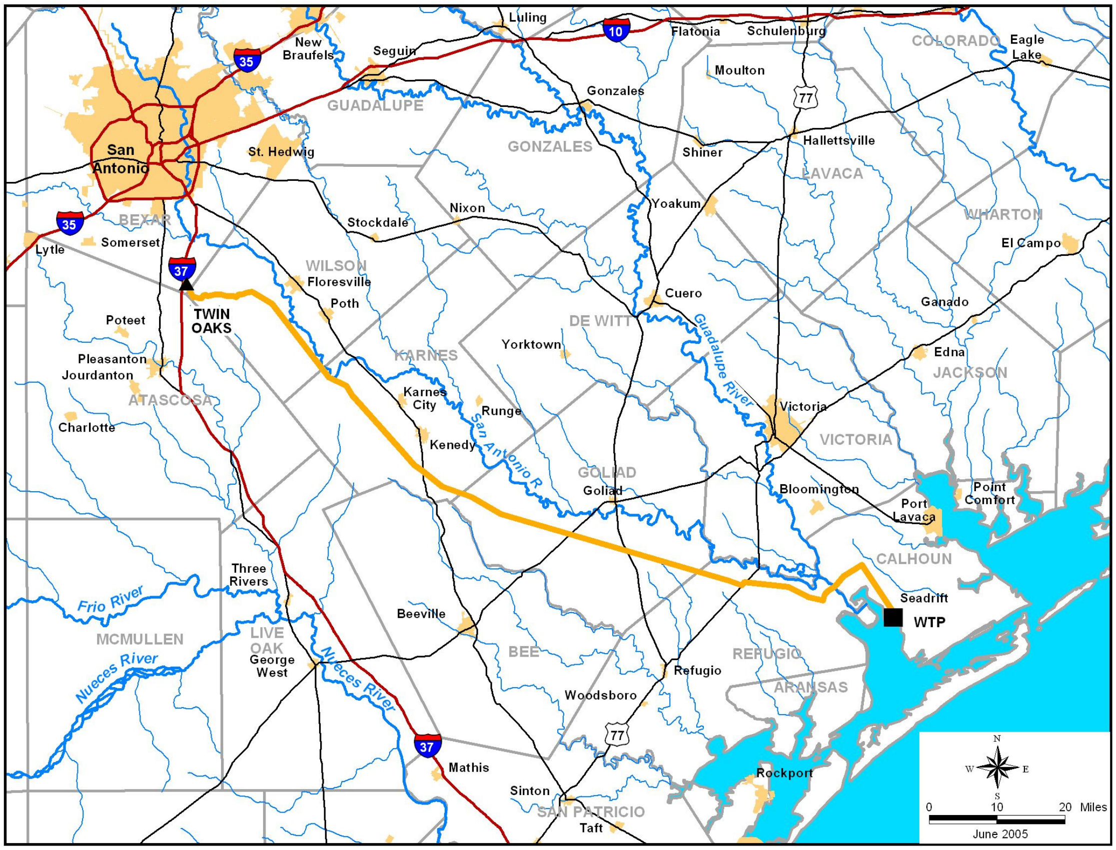


Figure 4C.31-1. Seawater Desalination Location Map

In general, for a specific plant capacity, the equipment in distillation plants tends to be much larger than membrane desalination equipment. However, distillation plants do not have the stringent feedwater quality requirements of membrane plants. Due to the relatively high temperatures required to evaporate water, distillation plants have high-energy requirements, making energy a large factor in the overall water cost. The high operating temperatures can result in scaling (precipitation of minerals from the feedwater), which reduces the efficiency of the evaporator processes, because once an evaporator system is constructed, the size of the exchange area and the operating profile are fixed, leaving energy transfer as a function of only the heat transfer coefficient. Therefore, any scale that forms on heat exchanger surfaces reduces heat transfer coefficients. Under normal circumstances, scale can be controlled by chemical inhibitors, which inhibit but do not eliminate scale, and by operating at temperatures of less than 200°F.

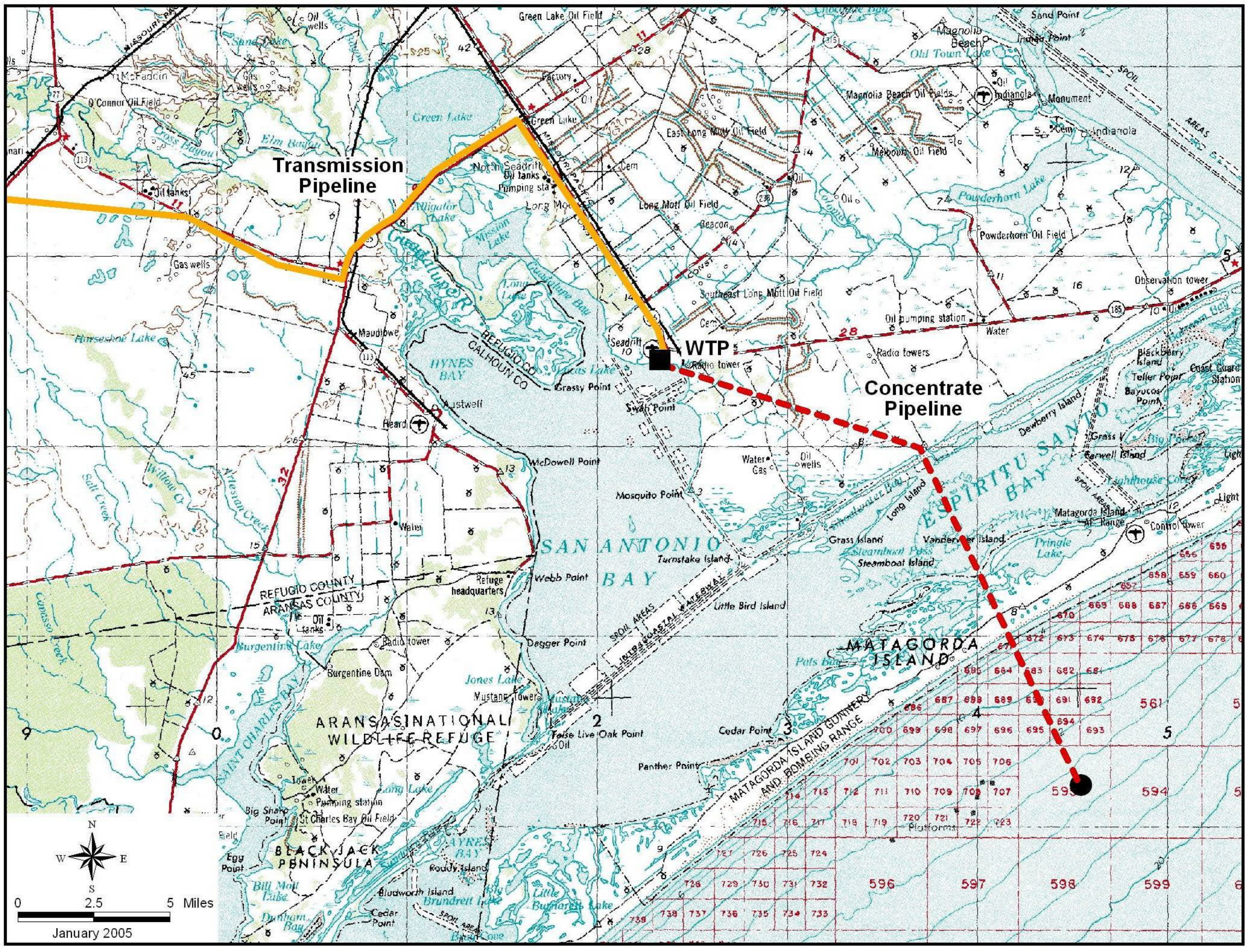


Figure 4C.31-2. Treatment Plant and Concentrate Pipeline Location

Distillation product water recoveries normally range from 15 to 45 percent, depending on the process. The product water from these processes is nearly mineral free, with very low total dissolved solids (TDS) of less than 25 mg/L. However, this product water is extremely aggressive and is too corrosive to meet the Safe Drinking Water Act (SDWA) corrosivity standards without post-treatment. Product water can be stabilized by chemical treatment or by blending with other potable water.

The three main distillation processes in use today are Multistage Flash Evaporation (MSF), Multiple Effect Distillation (MED), and Vapor Compression (VC). All three of these processes utilize an evaporator vessel that vaporizes and condenses the feedstock. The three processes differ in the design of the heat exchangers in the vessels and in the method of heat introduction into the process. Since there are no distillation processes in Texas that can be shown as comparable installations, distillation will not be further considered herein. However, there are membrane desalination operations in Texas, so the following discussion and analyses are based upon information from the use of membrane technology for desalination.

4C.31.1.3 Membrane (Non-thermal) Processes

The two types of membrane processes use either pressure, as in reverse osmosis, or electrical charge, as in electrodialysis reversal, to reduce the mineral content of water. Both processes use semi-permeable membranes that allow selected ions to pass through while other ions are blocked. Electrodialysis reversal (EDR) uses direct electrical current applied across a vessel to attract the dissolved salt ions to their opposite electrical charges. EDR can desalinate brackish water with TDS up to several thousand mg/L, but energy requirements make it economically uncompetitive for seawater, which typically contains approximately 35,000 mg/L TDS. As a result, only reverse osmosis (RO) is used for seawater desalination.

RO utilizes a semi-permeable membrane that limits the passage of salts from the saltwater side to the freshwater side of the membrane. Electric motor driven pumps or steam turbines (in dual-purpose installations) provide the 800 to 1,200 psi pressure to overcome the osmotic pressure and drive the freshwater through the membrane, leaving a waste stream of brine/concentrate. The basic components of an RO plant include pre-treatment, high-pressure pumps, membrane assemblies, and post-treatment. Pretreatment is essential because feedwater must pass through very narrow membrane passages during the process and suspended materials, biological growth, and some minerals can foul the membrane. As a result, virtually all suspended solids must be removed and the feedwater must be pre-treated so precipitation of minerals or growth of microorganisms does not occur on the membranes. This is normally accomplished by various levels of filtration and the addition of various chemical additives and inhibitors. Post-treatment of product water is usually required prior to distribution to reduce its corrosivity and to improve its aesthetic qualities. Specific treatment is dependent on product water composition.

A "single pass/stage" seawater RO plant will produce water with a TDS of 150 to 500 mg/L, most of which is sodium and chloride. The product water will be corrosive, but this may be acceptable, if a source of blending water is available. If not, and if post-treatment is required, the various post-treatment additives may cause the product water to exceed the desired TDS levels.

Recovery rates up to 50 percent are common for seawater RO facilities. The recovery rate is dependent on raw water quality and specifically the concentration of dissolved constituents. Higher recovery rates can be obtained for water in a bay or other location that is blended with some freshwater resulting in lower TDS. RO plants, which comprise about 59 percent of the world's desalting capacity, range from a few gallons per day to 130 MGD. The largest RO seawater plant in the United States is the 25-MGD plant in Tampa Bay, Florida. There are several recently completed RO seawater plants mainly in the Middle East with capacities around 85 MGD. The current domestic and worldwide trend is for the adoption of RO when a single purpose seawater desalting plant is to be constructed. RO membranes have been improved significantly over the past two decades (i.e., the membranes have been improved with respect to efficiency, longer life, and lower prices).

Table 4C.31-1. Municipal Use Desalt Plants in Texas (>25,000 gpd and as of 2008)

Location	Source	Total Capacity (MGD)	Desalt Capacity (MGD)	Membrane Type[1]
Abilene, City of	Surface Water	8	8	RO
Bardwell, City of	Groundwater	0.12	0.12	RO
Bayside, City of	Groundwater	0.15	0.15	RO
Brownsville, City of	Groundwater	7.5	7.5	RO
Burleson County MUD 1	Groundwater	0.43	0.43	RO
Country View Estates	Groundwater	0.18	0.18	RO
Dell City, City of	Groundwater	0.11	0.11	EDR
Electra, City of	Groundwater	2.23	2.23	RO
El Paso, City of	Groundwater	27.5	27.5	RO
Ft. Stockton, City of	Groundwater	7.0	6.0	RO
Granbury, City of	Surface Water	0.35	0.35	EDR
Haciendas del Norte (El Paso)	Groundwater	0.23	0.11	RO
Horizon Regional MUD (El Paso)	Groundwater	4	2.2	RO
Kenedy, City of	Groundwater	2.86	0.72	RO
Lake Granbury	Surface Water	10	6	RO
Los Ybanez, City of	Groundwater	0.11	0.11	RO
Oak Trail Shores	Lake Water	1.85	0.79	EDR
Primera, City of	Groundwater	2.5	2	RO
Robinson, City of	Surface Water	2.38	1.8	RO
Seadrift, City of	Groundwater	0.61	0.52	RO
Sherman, City of	Surface Water	10.0	7.5	EDR
Sportsman's World	Surface Water	0.17	0.17	RO
Southmost RWA	Groundwater	7.5	6.75	RO
Windermere Water System	Groundwater	2.88	1	RO

[1] RO = Reverse Osmosis EDR = Electrodialysis Reversal

4C.31.1.4 Examples of Relevant Existing Desalt Projects

Tampa, Florida: The water utility, Tampa Bay Water, has selected a 30-year design, build, operate, and own (DBOO) proposal to construct a nominal 25 MGD seawater desalt plant. The plant will use RO as the desalt process. The proposal included total capitalization and operations costs for producing high quality drinking water (chlorides less than 100 mg/L). The total cost to Tampa Bay Water in the original proposal was to be $2.08 per 1,000 gallons ($678 per acft) on a 30-year average, with first year cost being $1.71 per 1,000 gallons ($557 per acft). However, subsequent issues with the original design including significant problems in obtaining adequate pretreatment have increased the projected total cost to Tampa Bay Water to $3.18 per 1,000 gallons ($1,036 per acft) on a 30-year average. The results of Tampa Bay's competition has attracted international interest in the current cost profile of desalting seawater for drinking water supply, since these costs are only about one-half the levels experienced in previous desalination projects.

Tampa Bay Water selected the winning proposal from four DBOO proposals submitted, which ranged from $2.08 to $2.53 per 1,000 gallons. The factors listed below may be all or partially responsible for these seemingly low costs:

1. Salinity at the Tampa Bay sites ranges from 25,000 to 30,000 mg/L, lower than the more common 35,000 mg/L for seawater. RO cost is sensitive to salinity.
2. The power cost, which is interruptible, is below $0.04 per kilowatt-hour (kWh).
3. Construction cost savings through using existing power plant canals for intake and concentrate discharge.
4. Economy of scale at 25 MGD.
5. Amortizing over 30 years.
6. Use of tax-exempt bonds for financing.

The Tampa costs compare with other large-scale desalination projects that have completed construction and become operational in the last several years. A seawater reverse osmosis plant with a capacity of 86 MGD became operational in Ashkelon, Israel in 2005 with the total cost of water estimated in 2008 to be $2.95 per 1,000 gallons[1].

Large-Scale Demonstration Seawater Desalination in Texas: The Texas Water Development Board (TWDB) funded several studies to evaluate the feasibility of large-scale desalination in Texas. As part of this initiative, the City of Corpus Christi, Freeport, and the

[1] Global Water Intelligence, Water Desalination Report, Vol. 44, Num 33, September 15, 2008

Lower Rio Grande Valley-Brownsville were selected as potential locations for large-scale seawater desalination and feasibility studies were conducted for each of these locations. The draft feasibility reports were submitted to TWDB in August 2004 and indicated that the demonstration seawater desalination projects for the three locations are technically feasible. However, all three draft reports indicate that the estimated total costs for capital and O&M of the proposed projects will exceed the cost of alternative sources of drinking water at these locations[2].

Subsequent to the initial study, the Brownsville Public Utilities Board (BPUB) conducted an 18-month reverse osmosis desalination demonstration study at the Brownsville Ship Channel with the final report completed in October 2008[3]. The study evaluated several pretreatment and reverse osmosis desalination alternatives and presented a cost estimate for implementing a 25 MGD seawater desalination project at Brownsville. Table 4C.31-2 shows a summary of the capital cost estimate. At the time of the pilot study report BPUB decided that full scale project was not recommended for immediate implementation because there would not be adequate regional water demand and the cost of a 25 MGD seawater desalination project was greater than the cost of other water supply strategies. The study recommended that a 2.5-MGD seawater demonstration project be constructed instead with provisions made in the initial design to expand the facility to 25 MGD by 2050.

Table 4C.31-2.
Cost Summary for TWDB Texas Seawater Demonstration Project in Brownsville (Feasibility Estimate from 2004 Compared to Pilot Study Estimate from 2008)[2]

Project Component	Feasibility Estimate (2004)	Pilot Study Estimate (2008)
Capital Costs		
Desalination Plant	$90,167,000	$126,612,000
Concentrate Disposal System	$30,583,000	$21,217,000
Finished Water Transmission System	$9,232,000	$12,180,000
Project Implementation Costs	$21,406,000	$22,400,000
Total Capital Cost	**$151,388,000**	**$182,409,000**

[2] Texas Water Development Board, "The Future of Desalination in Texas Volume I, Biennial Report on Seawater Desalination", December 2004.
[3] NRS, "Final Pilot Study Repot Texas Seawater Demonstration Project", October 2008.

4C.31.2 Available Yield

Seawater from San Antonio Bay and the Gulf of Mexico is an unlimited quantity within the context of a supply for the South Central Texas Region. For the purpose of developing this strategy in which seawater from the bay is desalted to develop a significant drinking water supply for the major urban area in the region, it is assumed that the availability of water is unlimited and that its cost is zero prior to extraction from the source.

4C.31.3 Environmental Issues

4C.31.3.1 Seawater Desalination

The proposed location of the desalination facilities is near Seadrift on San Antonio Bay, which is part of the estuary of the San Antonio and Guadalupe Rivers (Figure 4C.31-2). This location would take advantage of the lower energy requirement of the desalination process at the lower salinity levels of the upper estuary, although the variable salinity can adversely affect operations. Estuaries, which serve as critical habitat and spawning grounds for many marine species and migratory birds, are marine environments maintained in a brackish state by the inflow of freshwater from rivers and streams. The high productivity characteristic of estuaries arises from the abundance of terrigenous nutrient input, shallow water, and the ability of a few marine species to exploit environments continually stressed by low, variable salinities, temperature extremes, and, on occasion, low dissolved oxygen concentrations.

The potential environmental effects resulting from the construction of a desalination plant in the vicinity of San Antonio Bay will be sensitive to the siting of the plant and its intake and locations. Construction of either will temporarily disrupt shoreline and benthic habitats in the immediate vicinity, including wetlands and other sensitive areas and operation of the intake will result in some impingement and entrainment of aquatic organisms. Impingement takes place when organisms are trapped against intake screens by the force of the water passing into the intake structure. Entrainment occurs when organisms are drawn through the water intake structure into the pump and transport system. Organisms that become impinged or entrained are normally relatively small organisms, including early life stages of fish and shellfish. Impingement can result in descaling or other physical damage, and starvation, exhaustion or asphyxiation when the organism cannot escape the intake structure. Entrained organisms are subject to mechanical, thermal, or toxic stress (e.g., biocides or low dissolved oxygen concentrations) as they pass through the system. In the case of either impingement or entrainment, a substantial proportion of the affected individuals will be killed or subjected to significant harm. Minimization of impingement and entrainment by appropriate site selection and through the use of appropriate screening technology must be considered during system design as part of the overall effort to avoid or minimize potential impacts to the estuarine environment.

Since the concentrate discharge point is planned to be located about 13 miles offshore, impacts of this feature on the estuary would be limited to the impacts of pipeline construction on bay bottom habitats. Of particular concern will be potential impacts to *Spartina* marshes and seagrass beds. Discharge structure sites should be selected to avoid areas where organisms tend to concentrate. These include rock outcrops, man-made structures, the vicinities of tidal passes and the surf zone. It can be assumed that the permit process will at sometime require a (modeling) demonstration showing that the design of the discharge structure will be adequate to rapidly disperse the concentrate plume to ambient salinities within a relatively small mixing zone.

A desalination facility using 50 MGD of feedwater would process about 154 acft of bay water per day, or up to 4,800 acft/month. This is a small amount (2.5 percent) compared to historical San Antonio Bay (Guadalupe Estuary) average inflows (195,000 acft/month). Four percent of median inflows (119,000 acft/month), and 1.3 percent of bay volume (360,000 acft). Only during low flow periods would the water withdrawal for desalination be substantial relative to inflows. For example, the 4,800 acft/month would be about 12 percent of monthly inflows during months so dry that they occur only 10 percent of the time, and is roughly equivalent to the lowest monthly inflow recorded for the estuary. Bay volumes, inflows, and tidal exchanges with the Gulf of Mexico are so large relative to this alternative that substantial impacts to overall salinity gradients, or to the delivery of nutrients and sediment are not realistic.

Many migratory birds are dependent on the quality of estuarine environments in order to complete the foraging and nesting of their migration. One of the most well known of the migratory birds is the Whooping Crane (*Grus Americana)*, which is listed as endangered by both USFWS and TPWD. A growing population of whooping cranes winter in and near the Aransas National Wildlife Refuge located adjacent to Mesquite Bay and the southern and western portions of San Antonio Bay. This wintering population has grown from a low of only 16 birds in 1941 to a high of 216 birds in 2004. Detailed research studies by Texas A&M University are underway at this time to identify and better understand factors affecting whooping crane population. Two other migratory birds known to the San Antonio Bay area are listed as threatened by TPWD: the Reddish Egret (*Egretta rufescens*), and the Piping Plover (*Charadrius melodus*). The Piping Plover is also listed as threatened by USFWS.

The water transmission pipeline between San Antonio Bay and Bexar County would be approximately 126 miles long. A construction right-of-way of approximately 140-feet wide would affect a total area of approximately 2,138 acres. The construction of the pipeline would include the clearing and removal of woody vegetation. A 40-foot wide right-of-way corridor, free of woody vegetation and maintained for the life of the project, would total 611 acres. The proposed pipeline route would traverse three of Omernik's[4] ecoregions: the Western Gulf Coastal Plain, the East Central Texas Plains, and the westernmost reaches of the Texas Blackland Prairie. In addition, the Guadalupe River is listed by TPWD as an Ecologically Significant River and Stream Segment. Surveys for protected species should be conducted within the proposed construction corridors where preliminary evidence indicates their existence. Many of these species, such as the Texas tortoise, the Texas horned lizard, and the indigo snake, are dependent on shrubland or riparian habitat. The timber/canebrake rattlesnake, a state threatened species, may be found in the riparian woody vegetation of the area.

Destruction of potential habitat can be avoided by selecting a corridor through previously disturbed areas, such as croplands. Selection of a pipeline right-of-way alongside the existing habitat could also be beneficial to some wildlife by providing edge habitat; however, the majority of these areas are small and fragmented, so care should be taken to ensure minimum impacts.

The TPWD Natural Diversity Database reports the occurrence of endangered, threatened, or rare species near the potential pipeline right-of-way. One endangered species known to exist near the pipeline corridor is the Attwater's greater prairie chicken in Goliad and Refugio Counties. The Attwater's greater prairie chicken prefers the coastal prairies grassland in areas with 0 to 24 inches vegetation height. Big red sage (*Salvia penstemonoides*), coastal gay feather (*Liatris bracteata*), plains gumweed (*Grindelia oolepsis*), Elmendorf's Onion (*Allium elmendorfii*), Parks' Jointweed (*Polygonella parksii*), Threeflower Broomweed (*Thurovia triflora*) and Welder Machaeranthera (*Psilactis heterocarpa*) are all rare plants found in this corridor. In addition, the Texas diamondback terrapin (*Malaclemys terrapin littoralis*), a species of concern, has been documented within 1 mile of the proposed project route. Plant and animal

[4] Omernik, J.M., "Ecoregions of the Conterminous United States," Annals of the Association of American Geographers, 77:118-125, 1987.

species in the project area listed by the USFWS, and TPWD as endangered or threatened are presented in Table 4C.31-3. All species listed have habitat requirements or preferences that suggest they could be present within the project area.

Cultural resources protection on public lands in Texas is afforded by the Antiquities Code of Texas (Title 9, Chapter 191, Texas Natural Resource Code of 1977), the National Historic Preservation Act (Pl96-515), and the Archeological and Historic Preservation Act (PL93-291). Based on the review of available records housed at the Texas Archeological Research Laboratory in Austin, six cultural resource sites appear to occur within the proposed project area. Table 4C.31-4 lists archeological sites within a one-mile corridor of the Seawater Desalination project area. Considering that the owner or controller of the project will likely be a political subdivision of the State of Texas (i.e. river authority, municipality, county, etc.), they will be required to coordinate with the Texas Historical Commission if the project will affect waters of the United States or wetlands, the project sponsor will also be required to coordinate with the U.S. Army Corps of Engineers regarding impacts to cultural resources.

4C.31.4 Engineering and Costing

4C.31.4.1 Seawater Desalination at San Antonio Bay

This water management strategy provides for a major desalination water treatment plant on the Texas coast and the infrastructure for transferring potable water from the coast to the major municipal demand center of the South Central Texas Region. The entire strategy consists of the intake, water treatment plant, storage tanks, pumping stations and a 126-mile pipeline. The water treatment plant component includes pretreatment necessary to ensure normal life and efficiency of the reverse osmosis membranes and post-treatment for disinfection and distribution system corrosion scale stability. This water management strategy is presented in terms of four firm capacities that demonstrate the potential economy of scale over a range from 25 MGD to 100 MGD.

Desalination treatment cost estimates are based on recent similar desalination treatment plant construction experience and feasibility studies. This approach takes advantage of the development of membrane technology and the resulting reduction in capital and operating costs in comparison to previously available technology. During the past 15 years, the price and

Table 4C.31-3.
Endangered, Threatened, and Species of Concern in Calhoun, Goliad, Karnes, Refugio and Wilson Counties

Common Name	Scientific Name	Impact Value	Multiplier Based on Status	Adjusted Impact	Summary of Habitat Preference	Listing Entity		Potential Occurrence in County
						USFWS[1]	TPWD[1]	
American Eel	*Anguilla rostrata*	1	1	1	Moist aquatic habitats.			Resident
American Peregrine Falcon	*Falco peregrinus anatum*	0	3	0	Open country; cliffs	DL	E	Nesting/ Migrant
Arctic Peregrine Falcon	*Falco peregrinus tundrius*	0	2	0	Open country; cliffs	DL	T	Nesting/Migrant
Atlantic Hawksbill Sea turtle	*Eretmochelys imbricata*	1	3	3	Gulf and bay system.	LE	E	Migrant
Attwater's Greater Prairie-Chicken	*Tympanuchus cupido attwateri*	2	3	6	Coastal Prairies of Gulf Coastal Plain	LE	E	Nesting
Bald Eagle	*Haliaeetus leucocephalus*	2	2	4	Large Bodies of water with nearby resting sites	LT-PDL	T	Nesting/Migrant
Big Red Sage	*Salvia penstemonoides*	2	1	2	Moist Creek and stream bed edges; historic; introduced in native plant nursery trade			Resident
Black Bear	*Usus americanus*	0	2	0	Mountains, broken country, woods, brushlands, forests	T/SA; NL	T	Resident
Black Lace Cactus	*Echinocereus reichenbachii var. albertii*	1	3	3	Grasslands, thorn shrublands, mesquite woodlands on sandy, somewhat saline soils on coastal prairie	LE	E	Resident
Black-Spotted Newt	*Notophthalmus meridionalis*	1	2	2	Ponds and resacas in south Texas		T	Resident
Brown Pelican	*Pelecanus occidentalis*	0	3	0	Coastal inlands for nesting, shallow gulf and bays for foraging	LE	E	Nesting/Migrant
Cave Myotis Bat	*Myotis velifer*	0	1	0	Roosts colonially in caves.			Resident
Coastal Gay Feather	*Liatris bracteata*	2	1	2	Black clay soils of midgrass grasslands on coastal prairie remnants.			Resident
Elmendorf's Onion	*Allium elmendorfii*	1	1	1	Endemic; deep sands derived from Queen City and similar Eocene formations			Resident
Eskimo Curlew	*Numenius borealis*	1	3	3	Grasslands, pastures.	LE	E	Nonbreeding Resident

Table 4C.31-3 (Continued)

Common Name	Scientific Name	Impact Value	Multiplier Based on Status	Adjusted Impact	Summary of Habitat Preference	Listing Entity USFWS[1]	Listing Entity TPWD[1]	Potential Occurrence in County
False spike mussel	*Quincuncina mitchelli*	0	1	0	Substrates of cobble and mud with water lilies present. Rio Grande, Brazos, Colorado and Guadalupe river basins.			Resident
Golden orb	*Quadrula aurea*	0	2	0	Sand and gravel, Guadalupe, San Antonio, and Nueces River basins		T	Resident
Green Sea Turtle	*Chelonia mydat*	1	2	2	Gulf and bay system.	LT	T	Migrant
Gulf Saltmarsh Snake	*Nerodia clarkii*	0	1	0	Brackish to saline coastal waters			Resident
Henslow's Sparrow	*Ammodramus henslowii*	1	1	1	Weedy fields, cut over areas; bare ground for running and walking			Nesting/Migrant
Indigo Snake	*Drymarchon corais erebennus*	1	2	2	Grass prairies and sand hills; usually thornbush woodland and mesquite savannah of coastal plain		T	Resident
Interior Least Tern	*Sterna antillarum athalassos*	1	3	3	Inland river sandbars for nesting and shallow water for foraging	LE	E	Nesting/Migrant
Jaguarundi	*Felis yagouaroundi*	0	3	0	South Texas thick brushlands, favors areas near water	LE	E	Resident
Kemp's Ridley Sea Turtle	*Lepidochelys kempii*	1	3	3	Gulf and bay system.	LE	E	Migrant
Keeled Earless Lizard	*Holbrookia propinqua*	1	1	1	Coastal dunes, Barrier islands and sandy areas			Resident
Leatherback Sea Turtle	*Dermochelys coriacea*	1	3	3	Gulf and bay system.	LE	E	Migrant
Loggerhead Sea Turtle	*Caretta caretta*	1	2	2	Gulf and bay system.	LT	T	Migrant
Louisiana Black Bear	*Ursus americanus luteolus*	0	2	0	Within historical range.	LT	T	
Manfreda Giant-skipper	*Stallingsia maculosus*	1	1	1	Fast erratic flight, larvae feed inside a leaf shelter, pupate in cocoon made of leaves & silk			Resident
Mountain Plover	*Charadrius montanus*	1	1	1	Non-breeding-shortgrass plains and fields, plowed fields and sandy deserts			Nesting/Migrant

Table 4C.31-3 (Continued)

Common Name	Scientific Name	Impact Value	Multiplier Based on Status	Adjusted Impact	Summary of Habitat Preference	Listing Entity USFWS[1]	Listing Entity TPWD[1]	Potential Occurrence in County
Northern Aplomado Falcon	*Falco femoralis septentrionalis*	0	3	0	Found in open country, especially savanna and open woodland.	LE	E	Resident
Ocelot	*Felis pardalis*	1	3	3	Dense chaparral thickets; mesquite-thorn scrub and live oak mottes	LE	E	Resident
Opossum Pipefish	*Microphis brachyurus*	1	2	2	Brooding adults found in fresh or low salinity waters.		T	Resident
Parks' Jointweed	*Polygonella parksii*	2	1	2	South Texas Plains; subherbaceous annual in deep loose sands, spring-summer			Resident
Piping Plover	*Charadrius melodus*	0	2	0	Beaches and flats of Coastal Texas	LT	T	Migrant
Pistolgrip	*Tritogonia verrucosa*	0	1	0	Aquatic, stable substrate. Red through San Antonio river basins.			Resident
Plains Gumweed	*Grindelia oolepsis*	1	1	1	Early successional patches in coastal prairie on heavy clay soils, sometimes in disturbed habitats in urban areas			Resident
Plains Spotted Skunk	*Spilogale putorius interrupta*	1	1	1	Prefers wooded, brushy areas and tallgrass prairie, fields, prairies, croplands, fence rows, forest edges			Resident
Red Wolf	*Canis rufus*	0	3	0	Extirpated.	LE	E	
Reddish Egret	*Egretta rufescens*	0	2	0	Coastal inlands for nesting, coastal marshes for foraging		T	Migrant
Rock pocketbook	*Arcidens confragosus*	0	1	0	Mud and sand, Red through Guadalupe River basins.			Resident
Runyon's Water Willow	*Justicia runyonii*	1	1	1	Openings in subtropical woodlands.			Resident
Sheep Frog	*Hypopachus variolosus*	1	2	2	Deep sandy soils of Southeast Texas		T	Resident
Shinner's sunflower	*Helianthus occidentalis ssp. Plantagineus*	1	1	0	Found on prairies on the Coastal Plain			Resident
Smalltooth sawfish	*Pristis pectinata*	1	3	3	Found in bays, estuaries or river mouths.	LE	E	Resident
Snowy Plover	*Charadrius alexandrinus*	0	1	0	Wintering Migrant on mud flats.			Migrant
Sooty Tern	*Sterna fuscata*	1	2	2	Catches small fish.			Resident

Table 4C.31-3 (Continued)

Common Name	Scientific Name	Impact Value	Multiplier Based on Status	Adjusted Impact	Summary of Habitat Preference	Listing Entity USFWS[1]	Listing Entity TPWD[1]	Potential Occurrence in County
Southeastern Snowy Plover	*Charadrius alexandrines tenuirostris*	0	1	0	Wintering migrant along the Texas Gulf Coast.			Migrant
Spot-Tailed Earless Lizard	*Holbrookia lacerata*	1	1	1	central & southern Texas; oak-juniper woodlands and mesquite-prickly pear			Resident
Texas Asaphomyian Tabanid Fly	*Asaphomyia texanus*	1	1	1	Found near slow-moving water, eggs laid on objects near water; larvae are aquatic, adults prefer shady areas; feed on nectar and pollen			Resident
Texas Diamondback Terrapin	*Malaclemys terrapin littoralis*	0	1	0	Bays, coastal marshes of the upper two-thirds of Texas Coast			Resident
Texas Horned Lizard	*Phrynosoma cornutum*	1	2	2	Varied, sparsely vegetated uplands, grass, cactus, brush		T	Resident
Texas pimpleback	*Quadrula petrina*	0	2	0	Mud, gravel and sand substrates, Colorado and Guadalupe river basins		T	Resident
Texas scarlet snake	*Cemophora coccinea lineri*	1	2	2	Mixed hardwood scrub on sandy soils.		T	Resident
Texas Tortoise	*Gopherus berlandieri*	1	2	2	Open brush w/ grass understory; open grass/bare ground avoided; occupies shallow depressions at base of bush or cactus, underground burrows, under objects; active March through November		T	Resident
Tharp's rhododon	*Rhododon angulatus*	0	1	0	Deep, sandy soils in dunes.			Resident
Threeflower broomweed	*Thurovia triflora*	1	1	1	Endemic, black clay soils.			Resident
Timber /Canebrake Rattlesnake	*Crotalus horridus*	1	2	2	Floodplains, upland pine, deciduous woodlands, riparian zones, abandoned farms, dense ground cover		T	Resident
Welder Machaeranthera	*Psilactis heterocarpa*	2	1	2	Coastal prairie; Shrub-infested grasslands and open mesquite-huisache woodlands			Resident
West Indian manatee	*Trichechus manatus*	0	3	0	Gulf and bay systems.	LE	E	Resident
Western Burrowing Owl	*Athene cunicularia hypugaea*	1	1	1	Open grasslands, especially prairie, plains and savanna			Resident

Table 4C.31-3 (Concluded)

Common Name	Scientific Name	Impact Value	Multiplier Based on Status	Adjusted Impact	Summary of Habitat Preference	Listing Entity		Potential Occurrence in County
						USFWS[1]	TPWD[1]	
White-faced Ibis	*Plegadis chihi*	0	2	0	Prefers freshwater marshes.		T	Resident
White-nosed coati	*Nasua narica*	1	2	2	Found in woodlands, riparian corridors and canyons. Mostly transients from Mexico.		T	Resident
White-tailed Hawk	*Buteo albicaudatus*	1	2	2	Coastal prairies, savannahs and marshes in Gulf coastal plain		T	Nesting/Migrant
Whooping Crane	*Grus americana*	0	3	0	Potential migrant	LE	E	Migrant
Wood Stork	*Mycteria americana*	0	2	0	Forages in prairie ponds, ditches, and shallow standing water formerly nested in TX		T	Migrant

[1] Source: TPWD, Annotated County List of Rare Species, Wilson, Karnes, Goliad, Refugio and Calhoun Counties, January 2010.

LE/LT=Federally Listed Endangered/Threatened E/SA, T/SA=Federally Listed Endangered/Threatened by Similarity of Appearance

C1=Federal Candidate for Listing DL, PDL=Federally Delisted/Proposed for Delisting NL=not Federally Listed

E, T=State Listed Endangered/Threatened

PE, PT=Federally Proposed Endangered/ Threatened Blank = Rare, but no regulatory listing status

Table 4C.31-4.
Previously Recorded Sites within 1-mile Corridor of the Proposed Seawater Desalination Project Area

Sites	41CL1
	41CL10
	41CL13
	41CL70
	41CL73
	41WN66

operating costs of membranes have declined due to improvements in materials and manufacturing. This contrasts with recent experience with conventional water treatment technology (i.e., costs for conventional water treatment technologies have not been influenced greatly by equipment innovations).

The basic assumptions made to determine the size and characteristics of the components of this seawater desalination strategy are listed in Table 4C.31-5. A 126-mile pipeline route from the desalination plant adjacent to San Antonio Bay near Seadrift to south Bexar County was assumed. The pumping capacities are equal to the nominal plant capacities, except for the raw water intake, which includes the full raw water quantity that is separated into desalinated finished water and concentrate in the plant. A conveyance line to carry the concentrate offshore is also included in the costs. A concentrate pump station is not included because it is assumed

Table 4C.31-5.
Engineering Assumptions for Seawater Desalination

Parameter	*Assumption*	*Description*
Raw water TDS	25,000 mg/L	Intake located near Seadrift
Finished water chlorides	100 mg/L	
Treatment capacities	25, 50, 75, 100 MGD	
Concentrate Pipeline Length	23 miles total (10 miles on land, 13 miles submerged)	Diffused in open Gulf
RO Recovery Rate	60 percent	
Power cost	$0.09 per kWh	Assume interruptible power
Pipeline diameter	42”, 60”, 66”, 78”	
Booster storage	5 percent of flow	More than 1 hour storage to avoid in-line pumps
Number of booster stations	2	

that the residual pressure from the desalination process is utilized to convey the concentrate offshore.

The treatment and delivery components and respective sizes and capacities are summarized in Table 4C.31-6. The concentrate capacities for each nominal plant capacity are based on a recovery rate of 60 percent. This means that of the 100 percent of flow taken from San Antonio Bay at the plant intake, 60 percent is desalted and 40 percent is returned to the Gulf as concentrate via a route approximately 23 miles long from the plant location through the barrier island. A recovery rate of 60 percent is assumed because the TDS of raw water from the bay is significantly less than pure seawater that is generally around 35,000 mg/l of TDS.

The estimated costs to desalt seawater range from $1,379 per acft for the 25 MGD size plant to $1,177 per acft for the 100 MGD size plant (Table 4C.31-7). The treatment costs include the water treatment plant (pretreatment, RO desalination, and post-treatment), raw water intake, and concentrate discharge to the open Gulf. The pretreatment portion of the plant is essentially a full conventional surface water plant to remove solids from the raw water prior to the RO desalination process. There is some economy of scale in the treatment process with larger processes in the pretreatment and RO desalination components. Also, there are greater economies of scale for components such as the intake and concentrate pump stations and pipelines.

Table 4C.31-6.
Capacities for Seawater Desalination Plant

Item/Facility	*Nominal Water Treatment Plant Capacity*			
	25 MGD	*50 MGD*	*75 MGD*	*100 MGD*
Intake Pump Station (MGD)	42	83	125	167
Intake Pipeline Diameter (inches)	48	72	84	102
Desalination Water Treatment Plants				
Plant Intake (seawater) (MGD)	42	83	125	167
Desalted Product Water (drinking water) (MGD)	25	50	75	100
Concentrate Discharge (MGD)	17	33	50	67
Concentrate Discharge Pipeline Diameter (inches)	30	42	54	66
Desalted Product Water (MGD)	25	50	75	100
Pump Station at Plant and Each Booster Station (gpm)	17,361	34,722	52,083	69,444
Finished Water Pipeline Diameter (inches)	42	60	66	78
Storage at Booster Pump Stations (MG, each)	1.25	2.5	3.75	5.0

There are some economies of scale with increasing capacity to convey the treated water to the municipal demand center. Over the range from 25 MGD to 100 MGD the conveyance unit costs decrease from about $1,569 per acft for the 25 MGD size project to $981 per acft for the 100 MGD size project (Table 4C.31-7). The estimated total desalination treatment and conveyance cost from San Antonio Bay to the major municipal demand center of the South Central Texas Region decreases from $2,948 per acft ($9.04 per 1,000 gallons) for the 25 MGD size project to $2,158 per acft ($6.62 per 1,000 gallons) for the 100 MGD size project (Table 4C.31-7).

For a conservative cost estimating purposes the salinity of the raw water drawn from San Antonio Bay near Seadrift was assumed to consistently be 25,000 mg/L of total dissolved solids, which is on the upper end of historically observed salinity in this area of the bay. One study of salinity during the period 1968 to 1987 reported mean salinity of 5,640 mg/L in San Antonio Bay near Seadrift[5]. To provide firm yield of desalinated bay water, the desalination facilities should

[5] Longley, W.L., ed. "Freshwater inflows to Texas bays and estuaries: ecological relationships and methods for determination of needs", TWDB and TPWD, 1994.

be constructed for the maximum anticipated salinity of 25,000 mg/L. Therefore, the capital costs would not decrease with lower mean salinity. However, if the mean salinity of the raw water delivered to the desalination plant is much less than the maximum, then the operations and maintenance costs may be significantly less than the costs shown in Table 4C.31-7. The primary cost savings for desalinating lower salinity water is the decrease in electrical power required due to an increase in the RO recovery rate and a decrease in the required pumping pressure to pass the desalinated water through the RO membranes. The decrease in cost to desalinate bay water with mean salinity of 5,640 mg/L versus the costs shown in Table 4C.31-7 would be approximately $226 per acft ($0.69 per 1,000 gallons).

4C.31.5 Implementation Issues

4C.31.5.1 Seawater Desalination

Implementation of this water management strategy requires overcoming several financial, environmental, and technological impediments. The capital cost is likely to be a somewhat serious limitation. The cost estimate shows that while the treatment cost, based on recent Tampa experience and other feasibility studies for a planned 25 MGD desalination facility may be competitive, transferring water from the coast makes the total cost quite high in relation to other water management strategies.

There are several environmental issues that must be considered. The first is the location of the intake in San Antonio Bay. It will be an advantage to take slightly lower salinity water, similar to Tampa, rather than Gulf water. However, to accomplish this means that dilution with freshwater from the San Antonio and Guadalupe Rivers is necessary. Studies will need to be performed to ensure that the removal of the somewhat diluted bay water causes no harmful effects on plant and animal life in San Antonio Bay. Another issue with the desalt plant is the disposal of the concentrate created from the desalination process. Disposal would have to occur at a location and in a manner that also did not disrupt plant or animal life in the Bay or in the Gulf. A further complication is the permitting of a 126-mile pipeline across rivers, highways, and private rural and urban property.

Technological issues include: (1) confirming that desalination as proposed with membranes is the appropriate technology; (2) confirming that blending desalted seawater with

Table 4C.31-7. Cost Estimate Summary for Desalination of Seawater (Fourth Quarter 2008 Prices)

Item	*Estimated Costs 25 MGD*	*Estimated Costs 50 MGD*	*Estimated Costs 75 MGD*	*Estimated Costs 100 MGD*
Capital Costs				
Water Treatment Plant (Pretreatment and Desal)	$100,486,000	$180,639,000	$257,808,000	$334,912,000
Concentrate Disposal	$45,007,000	$72,890,000	$94,617,000	$116,302,000
Transmission Pump Stations	$28,244,000	$37,720,000	$51,385,000	$56,871,000
Transmission Pipeline	$202,862,000	$327,468,000	$383,125,000	$478,817,000
Integration	$33,175,000	$66,350,000	$86,825,000	$107,300,000
Total Capital Cost	**$409,774,000**	**$685,067,000**	**$873,760,000**	**$1,094,202,000**
Engineering, Legal Costs and Contingencies	$131,255,000	$220,095,000	$282,345,000	$353,706,000
Environmental & Archaeology Studies and Mitigation	$9,333,000	$11,224,000	$13,333,000	$15,324,000
Land Acquisition and Surveying (673 acres)	$6,485,000	$6,676,000	$6,768,000	$6,816,000
Interest During Construction (2.5 years)	$55,685,000	$92,307,000	$117,621,000	$147,005,000
Total Project Cost	**$612,532,000**	**$1,015,369,000**	**$1,293,827,000**	**$1,617,053,000**
Annual Costs				
Debt Service (6 percent, 20 years)	$53,403,000	$88,524,000	$112,802,000	$140,982,000
Operation and Maintenance				
Pipeline, Pump Stations, Tank, Integration	$3,558,000	$5,665,000	$6,990,000	$8,513,000
Water Treatment Plant Except Energy	$10,320,000	$20,348,000	$29,220,000	$38,213,000
WTP Energy Costs (@ 0.09 $/kW-hr)	$9,488,000	$18,440,000	$26,925,000	$35,330,000
Transmission Pumping Energy Costs (@ 0.09 $/kW-hr)	$5,780,000	$9,333,000	$15,920,000	$18,702,000
Total Annual Cost	**$82,549,000**	**$142,310,000**	**$191,857,000**	**$241,740,000**
Available Project Yield (acft/yr)	28,004	56,008	84,012	112,016
Annual Cost of Water ($ per acft)	$2,948	$2,541	$2,284	$2,158
Annual Cost of Water ($ per 1,000 gallons)	$9.04	$7.80	$7.01	$6.62
Treatment Only	-	-	-	-
Total Annual Cost	$38,609,014	$98,370,769	$147,918,274	$197,799,563
Available Project Yield (acft/yr)	28,004	56,008	84,012	112,016
Annual Cost of Water ($ per acft)	$1,379	$1,276	$1,210	$1,177
Annual Cost of Water ($ per 1,000 gallons)	$4.23	$3.92	$3.71	$3.61
	-	-	-	-
Conveyance Only	-	-	-	-
Total Annual Cost	$43,939,674	$70,833,930	$90,208,243	$109,899,948
Available Project Yield (acft/yr)	28,004	56,008	84,012	112,016
Annual Cost of Water ($ per acft)	$1,569	$1,265	$1,074	$981
Annual Cost of Water ($ per 1,000 gallons)	$4.81	$3.88	$3.29	$3.01

the other water sources in the municipal demand distribution system can be successfully accomplished; and (3) obtaining an adequate source of electric power to drive the desalination process using membranes.

Substantial verification of technology would need to be accomplished prior to building this project. Blending differing treated waters is critical for the wellbeing of the customers and the distribution system. The characteristics of the desalted water are likely to be dramatically different from other drinking water in the major municipal demand center of the South Central Texas Region. Considerable investigation would be needed to determine if additional conditioning of the desalinated seawater would be required to make the new water source compatible with existing distribution systems. Conditioning of the desalinated seawater may include addition of alkalinity and hardness to bring the corrosion chemistry closer to existing water sources.

Finally, in spite of recent improvements in membrane technology, desalting seawater will require large amounts of electric power. Normally, this need is met by locating desalination plants near power plants. Future costs of electric power, however, are highly uncertain and represent a very significant component of annual operating costs for this strategy.

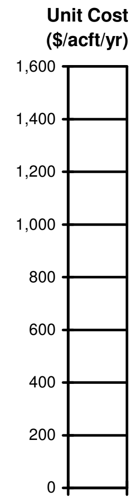
Requirements Specific to Water Rights

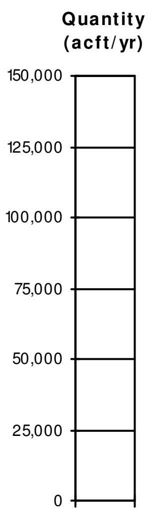
1. It will be necessary to obtain these permits:
   a. TCEQ Water Right permit.
   c. GLO Sand and Gravel Removal permits.
   d. GLO Easement for use of state-owned land.
   e. Coastal Coordination Council review.
   f. TPWD Sand, Gravel, and Marl permit.
2. Permitting, at a minimum, will require these studies:
   a. Assessment of changes in instream flows and freshwater inflows to bays and estuaries.
   b. Habitat mitigation plan.
   c. Environmental studies.
   d. Cultural resources.
3. Other Considerations:
   a. Water compatibility testing, including biological and chemical characteristics will need to be performed.

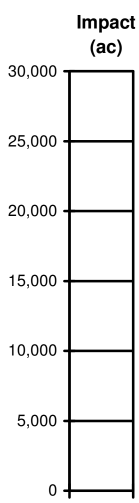
Requirements Specific to Pipelines

1. Necessary permits:
   a. USACE Sections 10 and 404 dredge and fill permits for stream crossings.
   b. GLO Sand and Gravel Removal permits.
   c. TPWD Sand, Gravel, and Marl permit for river crossings.
2. Right-of-way and easement acquisition.
3. Crossings:
   a. Highways and railroads
   b. Creeks and rivers
   c. Other utilities

2011 South Central Texas Regional Water Plan
Water Management Strategy Summary Sheet







Name: Surface Water Rights

Description: The Surface Water Rights water management strategy is included to explicitly recognize that use of water supplies made available under existing water rights by lease or purchase agreements between willing buyers and willing sellers is an activity consistent with the 2011 South Central Texas Regional Water Plan. The additions of diversion points or types and places of use for existing surface water rights are also activities consistent with the 2011 Regional Water Plan, if necessary authorizations are obtained pursuant to Texas Commission on Environmental Quality (TCEQ) rules and applicable law.

***Decade Needed*:** 2010 – 2060

Cost, Quantity of Water, and Land Impacted

Unit Cost of Water:	**Variable**	**$/acft/yr**	**Raw or Treated Water**
Quantity of Water:	**Variable**	**acft/yr**	**Reliability = Firm**
Land Impacted:	**Variable**	**acres**	

Additional Considerations per Regional Water Planning Guidelines

Environmental Factors:

Limited compared to other strategies because the source of water is existing water rights having prior authorizations for consumptive use. Must consider effects associated with new diversion, storage, transmission, treatment, and/or integration facilities in accordance with applicable state & federal requirements.

Impacts on Water Resources:

"No Injury" rule ensures protection of senior water rights. Potential reductions in instream flows or freshwater inflows to bays & estuaries associated with greater utilization of existing water rights.

Impacts on Agricultural & Natural Resources:

Minimal, if any.

Other Relevant Factors per SCTRWPG:

Encourages beneficial use of available rights. Downstream transfers can protect instream flows and recreational opportunities between the original and amended diversion points.

Comparison of Strategies to Meet Needs:

Low to high unit cost depending on location, reliability, and negotiations between willing buyers and sellers. No conflicts with other recommended water management strategies because existing water rights must be honored in assessment of water availability.

Interbasin Transfer Issues:

Interbasin transfer of water made available under existing surface water rights may involve additional regulatory requirements to amend place of use and may introduce changes in relative priority and inflow passage for environmental flow needs.

Third-Party Impacts of Voluntary Transfers:

None anticipated.

Regional Efficiency:

Maximizes beneficial use of existing permitted resources.

Water Quality Considerations:

None of significant concern.

4C.32 Surface Water Rights

4C.32.1 Description of Water Management Strategy

The Surface Water Rights water management strategy is included to explicitly recognize that use of water supplies made available under existing water rights by lease or purchase agreements between willing buyers and willing sellers is an activity consistent with the 2011 South Central Texas Regional Water Plan. The additions of diversion points or types and places of use for existing surface water rights are also activities consistent with the 2011 Regional Water Plan, if necessary authorizations are obtained pursuant to Texas Commission on Environmental Quality (TCEQ) rules and applicable law. It is important to note that this water management strategy is intended to address existing water rights (within currently authorized annual and instantaneous maximum diversion rates) and not applications for new surface water appropriations. Furthermore, this strategy focuses on maximizing beneficial use of existing run-of-river water rights as opposed to the development of new major reservoirs. As described in Section 3.2.1, existing firm supplies from major reservoirs are either committed to current steam-electric power generation uses (Coleto Creek Reservoir and Braunig and Calaveras Lakes) or are the subject of another water management strategy (Canyon Reservoir).

Key applicable water law regarding amendment of existing water rights to facilitate lease/purchase agreements is found in Section 11.122 of the Texas Water Code which requires water rights holders to obtain authorization from TCEQ to *"change the place of use, purpose of use, point of diversion, rate of diversion, acreage to be irrigated, or otherwise alter a water right."* Section 11.122 further provides that *"an amendment, except an amendment to a water right that increases the amount of water authorized to be diverted or the authorized rate of diversion, shall be authorized if the requested change will not cause adverse impact on other water right holders or the environment on the stream of greater magnitude than under circumstances in which the permit, certified filing, or certificate of adjudication that is sought to be amended was fully exercised according to its terms and conditions as they existed before the requested amendment."* This section is identified in the TCEQ rules as the "No Injury" Rule. Pursuant to the "No Injury" Rule, restrictions may be placed upon a right for which amendment is being sought in order to protect senior water rights. An example of such restrictions is subordination of an amended right to water rights situated between the existing and amended diversion locations.

4C.32.2 Available Yield

Available yield of run-of-river surface water rights, whether before or after lease/purchase under the Surface Water Rights water management strategy, is determined using the applicable water availability model (WAM). The Guadalupe – San Antonio River Basin WAM[1] and the Nueces River Basin WAM[2] are the primary tools applicable for consideration of water rights in the South Central Texas Regional Water Planning Area (Region L). These WAMs perform the complex calculations accounting for relative seniority, authorized annual diversion, type(s) of use, maximum diversion rate, instream flow requirements, physical location, and authorized storage associated with a particular water right, in the context of historical hydrology, as necessary to quantify firm diversion or available yield subject to drought of record conditions. Information regarding current surface water rights in Region L is summarized in Appendix B of Volume I.

The following subsections summarize examples of water rights acquisitions and/or planned activities relevant to the Surface Water Rights water management strategy by wholesale water providers and water user groups within Region L. The SCTRWPG intends for these examples to be illustrative of activities consistent with the Surface Water Rights water management strategy and explicitly does not intend to limit recommended activities to those listed herein. With respect to the development of new municipal and industrial water supplies through the Surface Water Rights water management strategy, the SCTRWPG concurs with the TCEQ and the Texas Water Development Board (TWDB) in stressing that such additional supplies should be reliable subject to drought of record conditions. Hence, to the extent that run-of-river water rights intended to be used for new municipal and industrial supplies are not reliable under drought conditions, additional facilities (e.g., off-channel storage) and/or additional sources of supply (e.g., groundwater) must be specified and the overall water management strategy evaluated in accordance with TWDB regional water planning guidelines to ensure consistency with the Regional Water Plan.

[1] HDR Engineering, Inc., "Water Availability in the Guadalupe – San Antonio River Basin," Texas Natural Resource Conservation Commission, December 1999.
[2] HDR Engineering, Inc., "Water Availability in the Nueces River Basin," Texas Natural Resource Conservation Commission, October 1999.

4C.32.2.1 San Antonio Water System (SAWS)

The San Antonio Water System (SAWS) has acquired five surface water rights having a combined total authorized annual diversion of 9,376 acft/yr from the San Antonio River and its tributaries the Medina River and Leon Creek (Table 4C.32-1). These water rights could be used at existing locations or consolidated at downstream location(s) for municipal, industrial, and/or steam-electric uses. At the appropriate time, SAWS may seek authorizations from TCEQ for changes in point(s) of diversion and purpose(s) and place(s) of use for these water rights. Examples of potential uses of these water rights include:

- Diversion from the Medina or San Antonio River in Bexar County for treatment and use by SAWS municipal and industrial customers. Storage authorizations associated with two of the water rights increase reliability under drought conditions.
- Diversion from the San Antonio River near Elmendorf to augment water supplies for steam-electric power generation by the City Public Service Board of San Antonio at their facilities located on Braunig and Calaveras Lakes.
- Diversion from the small reservoir formed by the Guadalupe River Saltwater Barrier and Diversion Dam located immediately downstream of the confluence of the San Antonio and Guadalupe Rivers as an additional source of supply for the Lower Guadalupe Water Supply Project (LGWSP). Pursuant to a May 10, 2001 Water Supply and Delivery Agreement, SAWS is presently a partner in the development of the LGWSP which could provide municipal and industrial water supplies for Bexar County and others.

Future acquisitions of existing water rights, as well as the above and/or other similar uses of existing surface water rights, in accordance with the Surface Water Rights water management strategy, are consistent with the 2011 South Central Texas Regional Water Plan.

Table 4C.32-1.
Example Water Rights Acquisitions by SAWS

Water Right Number	*Priority Date*	*Authorized Storage (acft)*	*Authorized Annual Diversion (acft)*	*Authorized Use*	*Maximum Diversion Rate (cfs)*	*Watercourse*
CA# 19-2156	3/24/1926	0	294	Irr	7.80	Medina River
CA# 19-2159	3/24/1926	0	60	Irr	2.23	San Antonio River
CA# 19-3867	6/22/1981	0	22	Irr	8.00	Medina River
P# 19-5469	5/11/1981	400	1,500	Irr, Ind	30.00	Leon Creek
P# 19-5517	1/30/1995	1,000	7,500	Irr, Ind	50.00	Leon Creek
Total	---	1,400	9,376	---	98.03	---

4C.32.2.2 Bexar Metropolitan Water District (BMWD)

Bexar Metropolitan Water District (BMWD) has acquired four surface water rights having a combined total authorized annual diversion of 7,881 acft/yr from the San Antonio River and its tributaries (Table 4C.32-2). These water rights may be used at existing locations or consolidated at downstream location(s) for municipal uses. At the appropriate time, BMWD may seek authorizations from TCEQ for changes in point(s) of diversion and purpose(s) and place(s) of use for these water rights. One example of potential use of these water rights is diversion from the Medina or San Antonio River in Bexar County for treatment and use by BMWD municipal customers. Storage authorizations associated with three of the water rights increase reliability under drought conditions. Future acquisitions of existing water rights, as well as the above and/or other similar uses of existing surface water rights, in accordance with the Surface Water Rights water management strategy, are consistent with the 2011 South Central Texas Regional Water Plan.

Table 4C.32-2.
Example Water Rights Acquisitions by BMWD

Water Right Number	Priority Date	Authorized Storage (acft)	Authorized Annual Diversion (acft)	Authorized Use	Maximum Diversion Rate (cfs)	Watercourse
CA# 19-1959	6/26/1914	0	150	Mun	2.22	San Antonio River
CA# 19-1966	8/9/1911	34	481	Mun	2.67	San Antonio River
P# 19-4768	Various	595	5,000	Mun	19.16	Medio Creek & Medina River
P# 19-5549	3/15/1996	148	2,250	Mun	22.30	Polecat & Potranco Creeks
Total	---	777	7,881	---	46.35	---

4C.32.2.3 Guadalupe-Blanco River Authority (GBRA)

Guadalupe-Blanco River Authority (GBRA) is considering the acquisition of existing surface water rights with the intent of augmenting future dependable water supplies in order to meet projected needs. Examples of potential uses of existing water rights provided include:

- Senior water rights acquisition with relocation of diversion point; and
- Purchase or lease surplus water under existing water right(s).

At the appropriate time, GBRA may seek authorizations from TCEQ for changes in point(s) of diversion and purpose(s) and place(s) of use for any acquired water rights. Future acquisitions of existing water rights, as well as the above and/or other similar uses of existing surface water rights, in accordance with the Surface Water Rights water management strategy, are consistent with the 2011 South Central Texas Regional Water Plan.

4C.32.2.4 Canyon Regional Water Authority (CRWA)

Canyon Regional Water Authority (CRWA) has acquired or leased several surface water rights including Certificate of Adjudication No. (CA#) 18-3834 for diversion of 90 acft/yr (18.52 acft/yr for municipal use and 71.48 acft/yr for irrigation use) from the Guadalupe River at Lake Dunlap, CA#18-3889 for diversion of 24 acft/yr from the San Marcos River, and CA# 19-1155 for diversion of 42 acft/yr from Cibolo Creek. CA# 18-3834 is presently being used by CRWA for municipal supply and is the basic water right for which an amendment seeking additional authorized diversions may be filed with TCEQ. CA# 19-1155 is the basic water right for which an amendment seeking additional authorized diversions may be filed with TCEQ as a part of the CRWA Siesta Project (Section 4C.28). The CRWA Siesta Project is expected to include acquisitions of additional existing water rights, conversion of purpose of use from irrigation to municipal, and consolidation of diversion points to one location on Cibolo Creek.

In addition, CRWA jointly owns water right CA# 18-3887 on San Marcos River, which totals 772 acft/yr. Future acquisitions of existing water rights, as well as the above and/or other similar uses of existing surface water rights, in accordance with the Surface Water Rights water management strategy, are consistent with the 2011 South Central Texas Regional Water Plan. New appropriations or water rights amendments seeking additional diversions as parts of the CRWA Dunlap and Siesta Projects are separate matters.

4C.32.2.5 San Antonio River Authority (SARA)

The San Antonio River Authority (SARA) has acquired five surface water rights having a combined total authorized annual diversion of 801 acft/yr from the San Antonio River and its tributaries (Table 4C.32-3). These water rights could be used at existing locations or consolidated at downstream location(s) for municipal or industrial uses. At the appropriate time, SARA may seek authorizations from TCEQ for changes in point(s) of diversion and purpose(s) and place(s) of use for acquired water rights. Future acquisitions of existing water rights, as well as the above and/or other similar uses of existing surface water rights, in accordance with the Surface Water Rights water management strategy, are consistent with the 2011 South Central Texas Regional Water Plan.

Table 4C.32-3.
Example Water Rights Acquisitions by SARA

Water Right Number	Priority Date	Authorized Storage (acft)	Authorized Annual Diversion (acft)	Authorized Use	Watercourse
CA# 19-2164	5/10/1926	0	23	Irr	San Antonio River
CA# 19-2164	8/31/1989	0	59	Irr	San Antonio River
CA# 19-2198	4/25/1950	0	333	Irr	San Antonio River
P# 19-4134	6/21/1981	0	200	Irr	Medina River
P# 19-4497	10/1/1984	0	186	Irr	Martinez Creeks
Total	---	0	801	---	---

4C.32.2.6 City of San Marcos

The City of San Marcos is considering the acquisition of existing surface water rights with the intent of augmenting future dependable water supplies in order to meet projected needs. Examples of potential uses of existing water rights provided by San Marcos include:

- Senior water rights acquisition with relocation of diversion point;
- Junior water rights acquisition and new appropriation with off-channel storage; and
- Purchase or lease surplus water under existing water right(s).

At the appropriate time, San Marcos may seek authorizations from TCEQ for changes in point(s) of diversion and purpose(s) and place(s) of use for any acquired water rights. Future acquisitions of existing water rights, as well as the above and/or other similar uses of existing surface water rights, in accordance with the Surface Water Rights water management strategy, are consistent with the 2011 South Central Texas Regional Water Plan.

4C.32.2.7 City of Victoria

The City of Victoria has acquired several water rights in the last few years and owns a total of seven water rights having a combined total authorized annual diversion of 27,006 acft/yr from the Guadalupe River (Table 4C.32-4). Victoria is presently involved in amending some of these water rights at TCEQ to include municipal supply as an authorized purpose of use for the full water right and to change the point of diversion to coincide with Victoria's existing surface water diversion works. Victoria continues to consider other opportunities for purchase or lease of additional surface water rights. Future acquisitions of existing water rights, as well as the above and/or other similar uses of existing surface water rights, in accordance with the Surface Water Rights water management strategy, are consistent with the 2011 South Central Texas Regional Water Plan.

Table 4C.32-4.
Example Water Rights Acquisitions by City of Victoria

Water Right Number	Priority Date	Authorized Storage (acft)	Authorized Annual Diversion (acft)	Authorized Use	Watercourse
CA# 18-3844	8/16/1918	0	608	Irr.	Guadalupe River
P# 18-3895	7/10/1978	0	4,676	Ind.	Guadalupe River
CA# 18-3860	8/15/1951	155	260	Mun.	Guadalupe River
CA# 18-3862	12/12/1951	0	262	Irr.	Guadalupe River
P# 18-5466	5/28/1993	1,000	20,000	Mun.	Guadalupe River
CA# 18-3858	6/27/1951	0	1,000	Irr.	Guadalupe River
P# 18-4441	4/2/1984	0	200		Guadalupe River
Total	---	1,155	27,006	---	---

4C.32.3 Environmental Issues

Potential environmental issues associated with implementation of the Surface Water Rights water management strategy are somewhat limited compared to other strategies because the source of water is existing water rights having prior authorizations for consumptive use. If an amendment to an existing water right is necessary to implement the strategy, Section 11.122 of the Texas Water Code indicates that only adverse impacts on the environment on the stream of greater magnitude than under circumstances in which the right sought to be amended was fully exercised prior to the amendment need be addressed. Environmental effects associated with new diversion, storage, transmission, treatment, and/or integration facilities necessary to use water available under existing rights must be addressed in accordance with applicable state and federal requirements.

4C.32.4 Engineering and Costing

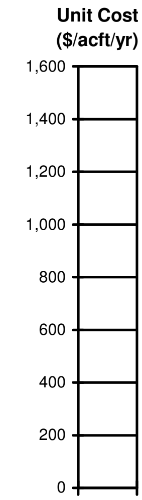
Estimated costs for purchase or lease of existing surface water rights are highly variable depending upon location, reliability, and negotiations between willing buyers and sellers. Future acquisitions of specific water rights are not addressed herein.

4C.32.5 Implementation Issues

Potentially significant implementation issues associated with the Surface Water Rights water management strategy include the following:

- Quantification and consideration of any potential effects on other water rights, streamflows, and freshwater inflows to bays and estuaries to the extent required by TCEQ rules and applicable state and federal law.
- Changes in the point of diversion may necessitate subordination of an amended right to water rights situated between the existing and amended diversion locations.
- Interbasin transfer of water made available under existing surface water rights may involve additional regulatory requirements to amend place of use and may introduce changes in relative priority and inflow passage for environmental flow needs.
- Run-of-river water rights often require storage and/or groundwater to firm up supply for municipal water use.

2011 South Central Texas Regional Water Plan
Water Management Strategy Summary Sheet



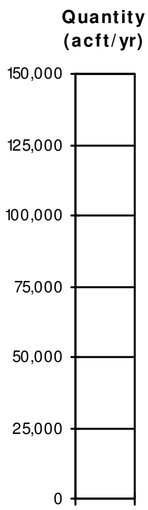
Name: Balancing Storage

Description: The Balancing Storage water management strategy is included to explicitly recognize that storage is needed at several locations within the region in order to firm up supplies from run-of-river diversions or interruptible groundwater sources and to ensure that supplies delivered through long distance conveyance facilities are available during drought and of sufficient quantity to meet daily and seasonal demands. The addition of Balancing Storage on the surface or in an aquifer is an activity consistent with the 2011 Regional Water Plan, if necessary authorizations are obtained pursuant to Texas Commission on Environmental Quality (TCEQ) or groundwater conservation district rules and applicable law.

***Decade Needed*:** 2010 – 2060

Cost, Quantity of Water, and Land Impacted

Unit Cost of Water:	**Variable**	**$/acft/yr**	**Raw or Treated Water**
Quantity of Water:	**Variable**	**acft/yr**	**Reliability = Firm**
Land Impacted:	**Variable**	**acres**	



Additional Considerations per Regional Water Planning Guidelines

Environmental Factors:

Must consider effects associated with construction of new facilities, including aquatic and terrestrial habitats, threatened and endangered species, and cultural resources in accordance with applicable state & federal requirements.

Impacts on Water Resources:

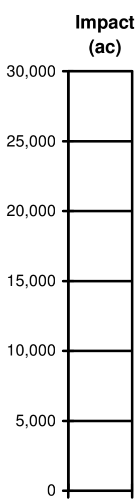
Would be designed to take advantage of high flow conditions, and therefore would have minimal to no effects.

Impacts on Agricultural & Natural Resources:

Minimal, if any.

Other Relevant Factors per SCTRWPG:

Improves efficiencies and reliability of other water management strategies.



Comparison of Strategies to Meet Needs:

Unit cost highly variable depending on location relative to water sources, proximate construction materials, land use, and/or aquifer characteristics.

Interbasin Transfer Issues:

None anticipated.

Third-Party Impacts of Voluntary Transfers:

None anticipated.

Regional Efficiency:

Increases efficiency and reliability of other strategies.

Water Quality Considerations:

Depends upon source water, but likely not of significant concern.

4C.33 Balancing Storage

4C.33.1 Description of Water Management Strategy

Water management strategies of the 2011 South Central Texas Regional Water Plan are sized and scheduled to meet seasonal and daily variations of demand, but, without storage, some current and proposed supplies may not be fully reliable during extended droughts. Several recommended strategies involve long distance pipelines of more than 125 miles in length that will be supplied from a combination of run-of-river diversions and groundwater. Thus, the need for surface reservoirs, large scale Aquifer Storage and Recovery (ASR) systems, or multipurpose reservoirs that are adequate in size to store surplus flows of surface water during periods of high streamflows, including flood flows, to be available during extended periods of drought. The Balancing Storage water management strategy involves implementing such ASR and/or surface storage facilities.

The San Antonio Water System (SAWS) has implemented a large scale ASR program, and is expanding its size for the purpose of storing and recovering surplus Edwards Aquifer water to meet seasonal peak demands, and the Cities of Victoria and San Marcos have indicated to the SCTRWPG a need for such storage as a part of their water plans to meet their respective water needs. SAWS may consider further expansions of its ASR program for multi-year storage to develop additional supply.

If the water management concern is a supply for emergencies or drought, water could be stored in the Carrizo or Gulf Coast Aquifers for several years before it is recovered. Water treatment capacity necessary to meet peak day demands may be available at non-peak times (fall, winter, and spring) to treat water for aquifer storage and subsequent recovery. Thus, a Balancing Storage component that is integrated into the water production and water treatment system has the potential to reduce costs and increase reliability and efficiency of the water management strategies necessary to meet projected need.

Cases for which balancing storage is needed include, off-channel storage for run-of-river diversions from the San Marcos River by San Marcos, gravel pit systems for Victoria to firm up run-of-river diversions from the Guadalupe River, and terminal or seasonal balancing storage for the Lower Colorado River Authority/San Antonio Water System Water Project. Terminal storage helps meet seasonal and daily peaks, allows for economical uniform long distance delivery, and provides short-term supply in the event of transmission system outages. The

Surface Water Rights water management strategy (4C.32) has been included in the regional plan to explicitly recognize that use of water supplies made available under existing water rights by lease or purchase agreements between willing buyers and willing sellers is an activity consistent with the 2011 South Central Texas Regional Water Plan. The addition of balancing storage is also an activity consistent with the 2011 Regional Water Plan, if necessary authorizations are obtained pursuant to Texas Commission on Environmental Quality (TCEQ) rules and applicable law.

4C.33.2 Available Yield

Available yield associated with balancing storage is typically determined using the applicable surface water availability model (WAM) to simulate operations of the respective water management strategies. The Guadalupe – San Antonio River Basin WAM,[1] the Nueces River Basin WAM,[2] and the Edwards Aquifer Groundwater Availability Model (GAM) are the primary tools applicable for consideration of surface and groundwater flows in the South Central Texas Regional Water Planning Area (Region L).

4C.33.3 Environmental Issues

Potential environmental issues associated with implementation of the Balancing Storage water management strategy include consideration and mitigation of affected aquatic and terrestrial habitats, cultural resources, and threatened and endangered species, in accordance with applicable state and federal requirements.

4C.33.4 Engineering and Costing

Estimated costs for development of balancing storage are highly variable depending upon location relative to water source(s), proximate construction materials, present land use, and/or aquifer characteristics.

[1] HDR Engineering, Inc., "Water Availability in the Guadalupe – San Antonio River Basin," Texas Natural Resource Conservation Commission, December 1999.
[2] HDR Engineering, Inc., "Water Availability in the Nueces River Basin," Texas Natural Resource Conservation Commission, October 1999.

4C.33.5 Implementation Issues

Potentially significant implementation issues associated with the Balancing Storage water management strategy include the following:

- Quantification and consideration of any potential effects on water rights, streamflows, and freshwater inflows to bays and estuaries to the extent required by TCEQ rules and applicable state and federal law.
- Run-of-river water rights often require surface storage and/or groundwater to firm up supply for municipal water use and a determination as to the most economically feasible of these is necessary.
- Acquisition of State, Federal, and Local permits.
- Environmental studies.
- Relocations of affected roads, railroads, utilities, and cultural resources.

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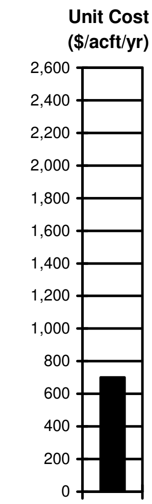
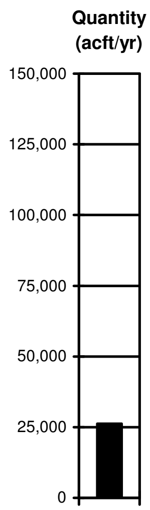
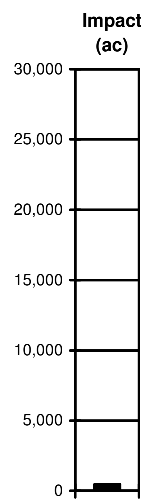
2011 South Central Texas Regional Water Plan
Water Management Strategy Summary Sheet







Name: Lavaca River Off-Channel Reservoir

Description: The Lavaca River Off-Channel Reservoir (OCR) consists of a 75,000 ac-ft OCR located approximately 10 miles west of Lake Texana. High flows from the Lavaca River would be diverted to the Lavaca River OCR via a 1.4-mile, 66-in diameter transmission pipeline. A 7.5-mile, 44-in diameter pipeline would transfer raw water stored in the Lavaca River OCR to Lake Texana. Other facilities needed for project implementation include an intake and pump station at the Lavaca River diversion point and intake and pump station at the Lavaca River OCR site for water transmission to Lake Texana. The project would be capable of providing a yield of 26,242 ac-ft/yr for contribution to Lake Texana storage.

***Decade Needed*:** 2010 – 2020

Cost, Quantity of Water, and Land Impacted

Unit Cost of Water:	**$701**	**$/acft/yr**	**Raw Water Delivered**
Quantity of Water:	**26,242**	**acft/yr**	**Reliability = Firm**
Land Impacted:	**454**	**acres**	

Additional Considerations per Regional Water Planning Guidelines

Environmental Factors:

No federal or state protected species are known to be present within the Lavaca River OCR area.

Impacts on Water Resources:

None anticipated.

Impacts on Agricultural & Natural Resources:

Purchase of reservoir land will result in reduced agricultural uses.

Other Relevant Factors per SCTRWPG:

Implementation of project will make the construction of Palmetto Bend – Stage II Reservoir less feasible.

Comparison of Strategies to Meet Needs:

No apparent negative impacts on other water resources.

Interbasin Transfer Issues:

Interbasin transfers may be necessary to meet needs in Calhoun County. Additionally, any water delivered to Corpus Christi in Region N will be an Interbasin transfer.

Third-Party Impacts of Voluntary Transfers:

None anticipated.

Regional Efficiency:

Provides regional opportunities.

Water Quality Considerations:

The off-channel reservoir will aid in suspending river diversions to avoid poor water quality during flood events and facilitate maintenance of diversion facilities without stopping reservoir deliveries.

4C.34 Lavaca River Off-Channel Reservoir[1]

4C.34.1 Description of Water Management Strategy

The Lavaca River Off-Channel Reservoir is currently being considered by the Lavaca-Navidad River Authority as a potentially recommended water management strategy in Region P, that could meet needs in Region L. The project involves building a large off-channel reservoir (OCR) approximately 10 miles west of Lake Texana. The proposed Lavaca River OCR would be constructed in a manner to allow LNRA to divert high flows from the Lavaca River to the reservoir, and then pump water at a constant rate to end users. This creates a mechanism to firm-up what is an otherwise interruptible water source in order to serve area needs. The pump station and pipeline sizing will also be discussed further in the following text.

4C.34.1.1 Proposed Off-Channel Reservoir

The proposed location for the Lavaca River OCR is approximately 10 miles to the west of Lake Texana. Four alternative reservoir sizes were assessed as part of this study, including a 25,000 acft, 50,000 acft, 75,000 acft, and 100,000 acft storage reservoir. The location and orientation of the proposed Lavaca River OCR can be seen in Figure 4C.34-1. The Lavaca River OCR will be generally square in shape, have side slopes of 4:1, and will include provisions for hurricane protection as discussed below.

4C.34.1.1.1 Reservoir Wave Run-Up Protection

The freeboard for the Lavaca River OCR was determined based upon the wave action from potential hurricanes. Categories 4 and 5 were reviewed, with these categories referring to maximum wind speeds of 145 and 179 mph, respectively. Because of the location and final configuration of the OCR, this situation would require freeboard levels of 10 feet for a category 4 hurricane and 12 feet for a category 5 hurricane. For the estimate of probably cost, a category 4 hurricane was assumed.

[1] Portions of the text for this report was provided by the Lavaca-Navidad River Authority (LNRA) in "Lavaca River Diversion and Off-Channel Reservoir", provided on January 21, 2010. The analysis and cost estimates herein, are based solely on the information provided by LNRA.

4C.34.1.2 Proposed River Intake and Pump Station

The river intake pumping station, which will be located approximately 50 feet off of the east bank of the Lavaca River, will be required to pump a maximum of 309 cfs of water to the

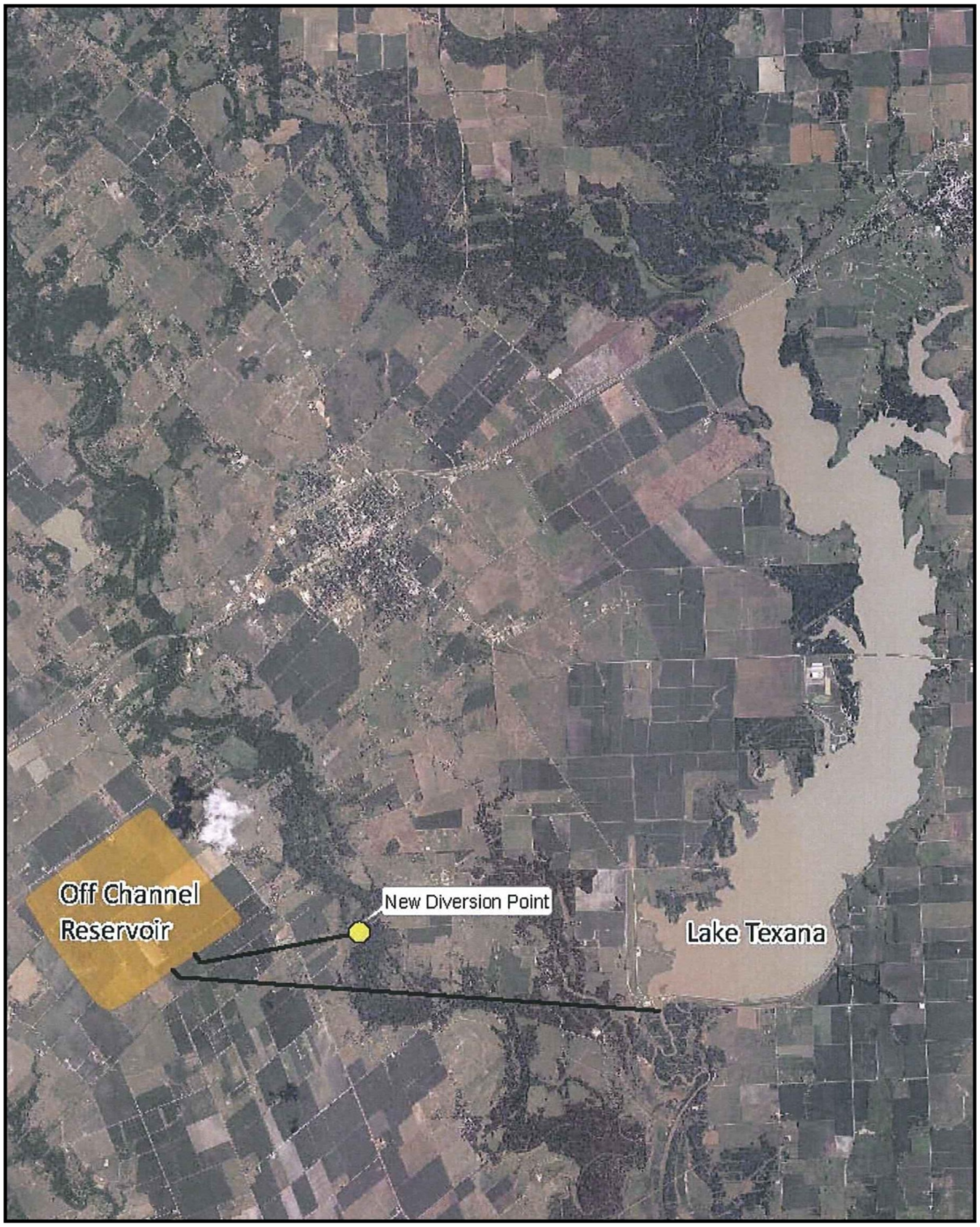


Figure 4C.34-1. Map of Proposed Lavaca River Off-Channel Reservoir

reservoir. This flowrate was determined while choosing the reservoir size, which is discussed further in Section 4C.34.2. Using this maximum flowrate, the optimal pipe size will be 66" in diameter. This was chosen because it is the largest diameter pipe that can be practically used while also reducing the yearly electricity costs to LNRA. The design of the pumping station for this intake will include a 50 ft wide by 85 ft long building that will house the pumps and electrical equipment.

4C.34.1.3 Proposed Raw Water Delivery System

The raw water delivery system will transport the water from the Lavaca River OCR using a pumping station located on the reservoir, and pump the raw water approximately 7 miles to the East Delivery System Pump Station. This water will be pumped at a rate of 6,200 gpm, which equates to 10,000 acft/yr. The pipeline transporting the water will be 42" in diameter.

This pipeline will be made of poly-coated steel and bar-wrapped concrete cylinder piping. The pipeline will also be required to cross back under the Lavaca River in order to connect to the existing delivery system located on Lake Texana. The pumping station will be housed in a building approximately 30 ft wide by 60 ft long, and will house the pumps and the electrical equipment.

4C.34.2 Available Yield

Firm yields were determined for the proposed off-channel reservoir by running the Lavaca River Basin Water Availability Model (WAM) with modifications to account for the proposed Lavaca River OCR. The firm yield estimates are based on the premises and assumptions reflected in the model. In addition to the four storage scenarios previously discussed (i.e., 25,000 acft, 50,000 acft, 75,000 acft, and 100,000 acft), five pump station diversion rates were modeled (i.e., 50 mgd, 100 mgd, 200 mgd, 500 mgd, and no limit) for a total of 20 simulations. The results of the analyses are presented in Table 4C.34-1.

The maximum theoretical firm yield considering instream flow requirements occurs when the pumping rate is not limited by the capacity of the pump. This situation is represented by the "no limit" simulations. Table 4C.34-1 shows that for a reservoir with a capacity of 25,000 acft, a pump capable of diverting 200 mgd is needed to maximize the firm yield. In other words, a pump with a larger capacity is unnecessary in this case. For a reservoir with a capacity of 50,000 acft, a pump capable of diverting 200 mgd is needed to maximize the firm yield. A pump capable of diverting just over 200 mgd is also necessary to maximize the firm yield of a reservoir with a capacity of 75,000 acft. For a reservoir with a capacity of 100,000 acft, a pump capable of diverting 500 mgd is needed to maximize the firm yield.

Table 4C.34-1.
Lavaca River Off-Channel Reservoir Firm Yields

Storage (acft)	Pumping Rate (mgd)	Firm Yield (acft/yr)
25,000	0	0
	50	9,818
	100	13,050
	200	14,308
	500	14,308
	No limit	14,308
50,000	0	0
	50	11,222
	100	17,235
	200	20,510
	500	20,510
	No limit	20,510
75,000	0	0
	50	11,572
	100	18,154
	200	26,242
	500	26,483
	No limit	26,483
100,000	0	0
	50	11,076
	100	17,838
	200	26,632
	500	32,459
	No limit	32,459

Table 4C.34-1 shows that as reservoir capacity increases by increments of 25,000 acft, maximum firm yield increased by around 6,000 acft/yr. The firm yield for a reservoir with a storage capacity of 100,000 acft and a pumping rate of 100 mgd is smaller than a reservoir of 75,000 acft with the same pumping rate. This is more likely due to greater evaporation rates from the reservoir with 100,000 acft of storage. Based on the results of the yield study, the optimum yield for the Lavaca Off-Channel Reservoir is approximately 26,242 acft when coupled with an off-channel reservoir of 75,000 acft and a 309 cfs diversion rate from the Lavaca River. This size reservoir is estimated to take up approximately 3,000 acres of land. While the 75,000 acft reservoir is the most optimal in terms of cost per acft of water, a different size may be chosen based upon the final decision of how much water is ultimately needed.

4C.34.3.1 Potential Water Use

The development of the Lavaca River OCR will result in approximately 26,242 acft/yr of water. There is an industrial need of approximately 10,000 acft/yr for an existing industrial customer of LNRA and projected needs of about 500 acft/yr for Point Comfort in Calhoun County, leaving 15,742 acft/yr of water supply for contract and/or project participation by other interested parties. It is currently expected that this excess water will be used for municipal and agricultural uses to meet future needs in Region P (Jackson County) or Region N.

4C.34.3 Environmental Issues[2]

The Lavaca Off-Channel Reservoir project involves the building of an approximately 3,000 acre OCR about ten miles west of Lake Texana in Jackson County. The purpose of this reservoir is to store excess river water available during high flow events via an intake and pipeline from the Lavaca River. The stored water would then be transferred via a pipeline to Lake Texana to serve area needs and stabilize an otherwise interruptible water source. Facilities in this plan include the development a new pump station and diversion pipeline from the Lavaca River to the Lavaca River OCR, a pump station associated with the Lavaca River OCR, a roughly 7 mile 48-inch diameter raw water pipeline from the OCR to Lake Texana, and an approximately 3,000 acre off-channel storage reservoir.

The proposed Lavaca River OCR and associated pipeline routes are situated within the Western Gulf Coastal Plain Ecoregion, in an area designated as the Northern Humid Gulf Costal Prairies.[3] Deltaic sands, silts, and clays underlie much of this area, which occurs on a gently sloping coastal plain. The original vegetation within this region included primarily grasslands with a few clusters of oaks (*Quercus* spp.) or maritime woodlands. Historically dominant grassland species include little bluestem (*Schizachyrium scoparium*), yellow Indiangrass (*Sorghastrum nutans*), brownseed paspalum (*Paspalum plicatulum*), gulf muhly (*Muhlenbergia capillaris*), and switchgrass (*Panicum virgatum*). The majority of this region is now utilized as

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[2] Environmental Issues was conducted by HDR Engineering to be consistent with RWPG guidelines.
[3] Griffith, G.E., Bryce, S.A., Omernik, J.M., Comstock, J.A., Rogers, A.C., Harrison, B., Hatch, S.L., and Bezanson, D., 2004, Ecoregions of Texas (color poster with map, descriptive text, and photographs): Reston, Virginia, U.S. Geological Survey (map scale 1:2,3000,000).

cropland, rangeland, pasture, or urban land, with woodlands occurring only as remnant riparian strips.[4] Construction of the off-channel reservoir is planned within an area normally used for agriculture; however the pipeline and pump station construction may include the clearing and removal of some areas of riparian vegetation along the Lavaca River and areas southwest of Lake Texana.

The project also lies within an area known as the Texan Biotic Province.[5] Mammals typical of this province include the Virginia opossum (*Didelphis virginiana*), fox squirrel (*Sciurus niger*), fulvous harvest mouse (*Reithrodontomys fulvescens*), and swamp rabbit (*Sylvilagus aquaticus*). Typical anuran species within this area include the Gulf Coast toad (*Bufo valliceps*), green treefrog (*Hyla cinerea*), bullfrog (*Rana catesbeiana),* and eastern narrowmouth toad (*Microhylla carolinensis*).

In addition, the Lavaca River locations where the new diversion pipeline to the Lavaca River OCR originates, and the area crossed by the raw water pipeline running from the Lavaca River OCR to Lake Texana, are listed by Texas Parks and Wildlife Department (TPWD) as occurring within an Ecologically Significant Stream Segment.

Table 4C.34-2 lists 18 state listed endangered and threatened wildlife and plant species, five federally listed endangered or threatened wildlife and plant species, and state and federal species of concern that may occur in Jackson County. Information found within this table originates from the county lists of rare species provided by the Texas Parks and TPWD online in the "Annotated County Lists of Rare Species."

Inclusion in Table 4C.34-2 does not mean that a species will occur within the project area, but only acknowledges the potential of its occurrence in Jackson County. In addition to the county lists, the TPWD Natural Diversity Database (NDD) was reviewed for known occurrences of listed species within or near the project area.

Listed species may have habitat requirements or preferences that suggest they could be present within the project area. The presence or absence of potential habitat does not confirm the presence or absence of a listed species. No species specific surveys were conducted in the project area for this report. Surveys for protected species should be conducted within the proposed construction corridors where preliminary evidence indicates their existence.

[4] Gould, F. W., "The Grasses of Texas," Texas A&M University Press, College Station, Texas, 1975.
[5] Blair, W. Frank, "The Biotic Provinces of Texas," Texas Journal of Science 2(1):93-117, 1950.

The Migratory Bird Treaty Act protects most bird species, including, but not limited to, cranes, ducks, geese, shorebirds, hawks, and songbirds. Migratory bird pathways, stopover habitats, wintering areas, and breeding areas may occur within and adjacent to the project area, and may be associated with wetlands, ponds, shorelines, riparian corridors, fallow fields and grasslands areas. Although construction of the proposed off-channel reservoir could remove some habitats utilized by certain migratory bird species, it would create additional habitats for others.

Table 4C.34-2.
Endangered, Threatened, and Species of Concern for Jackson County

Common Name	Scientific Name	Summary of Habitat Preference	Listing Entity		Potential Occurrence in County
			USFWS	TPWD	
American eel	*Anguilla rostrata*	Coastal waterways below reservoirs to gulf.			Resident
American Peregrine Falcon	*Falco peregrinus anatum*	Resident and local breeder in West Texas. Migrant across the state.	DL	T	Possible Migrant
Arctic Peregrine Falcon	*Falco peregrinus tundrius*	Migrant throughout the state.	DL		Possible Migrant
Bald eagle	*Haliaeetus leucoephalus*	Found primarily near rivers and large lakes.	DL	T	Possible Migrant
Brown pelican	*Pelecanus occidentalis*	*Largely coastal and near shore areas.*	DL	E	Resident
Green sea turtle	*Chelonia mydas*	Gulf and bay systems.	LT	T	Resident
Gulf saltmarsh snake	*Nerodia clarkia*	Found on saline flats.			Resident
Henslow's Sparrow	*Ammodramus henslowii*	Found in weedy fields or cut-over areas			Resident
Interior least tern	*Sterna antillarum athalassos*	Nests along sand and gravel bars in braided streams	LE	E	Resident
Kemp's Ridley sea turtle	*Lepidochelys kempii*	Found in gulf and bay systems.	LE	E	Resident
Loggerhead sea turtle	*Caretta caretta*	Gulf and bay systems for juveniles, ocean for adults.	LT	T	Resident
Mountain Plover	*Charadrius montanus*	Non-breeding, shortgrass plains and fields			Nesting/ Migrant
Reddish Egret	*Egretta rufescens*	Resident of Texas Gulf coast.		T	Resident
Rock pocketbook	*Arcidens confragosus*	Mud and sand, Red through Guadalupe River basins.			Resident
Shinner's sunflower	*Helianthus occidentalis ssp. Plantagineus*	Found on prairies on the Coastal Plain			Resident
Snowy Plover	*Charadrius alexandrines*	Potential migrant, winters along coast			Migrant
Sooty Tern	*Sterna fuscata*	Usually flies or hovers over water.		T	Resident
Southeastern Snowy Plover	*Charadrius alexandrines tenuirostris*	Wintering migrant along the Texas Gulf Coast.			Migrant
Texas diamondback terrapin	*Malaclemys terrapin littoralis*	Found in coastal marshes and tidal flats.			Resident
Texas fatmucket	*Lampsilis bracteata*	Streams and rivers on sand, mud and gravel, Colorado and Guadalupe River basins.		T	Resident
Texas Horned Lizard	*Phrynosoma cornutum*	Varied, sparsely vegetated uplands.		T	Resident

Table 4C.34-2 (Concluded)

Common Name	Scientific Name	Summary of Habitat Preference	Listing Entity		Potential Occurrence in County
			USFWS	TPWD	
Texas scarlet snake	*Cemophora coccinea lineri*	Mixed hardwood scrub on sandy soils.		T	Resident
Texas tortoise	*Gopherus berlandieri*	Open brush w/ grass understory.		T	Resident
Threeflower broomweed	*Thurovia triflora*	Endemic: near coast.			Resident
Timber/Canebrake rattlesnake	*Crotalus horridus*	Floodplains, upland pine, deciduous woodlands, riparian zones.		T	Resident
Welder machaeranthera	*Psilactis heterocarpa*	Texas endemic found on grasslands.			Resident
Western Burrowing Owl	*Athene cunicularia hypugaea*	Open grasslands, especially prairie, plains and savanna			Resident
White-faced Ibis	*Plegadis chihi*	Prefers freshwater marshes.		T	Resident
White-tailed hawk	*Buteo albicaudatus*	Found near the coast on prairies, cordgrass flats, and scrub-live oak.		T	Resident
Whooping Crane	*Grus americana*	Potential migrant	LE	E	Potential Migrant
Wood Stork	*Mycteria americana*	Forages in prairie ponds, ditches, and shallow standing water formerly nested in TX		T	Migrant

LE/LT=Federally Listed Endangered/Threatened
DL, PDL=Federally Delisted/Proposed for Delisting
E, T=State Listed Endangered/Threatened
Blank = Considered rare, but no regulatory listing status
Source: TPWD, Annotated County List of Rare Species, Jackson County (1/15/2010).

Three bird species federally or state listed as endangered are included in the project area county. These include the brown pelican (*Pelecanus occidentalis*), interior least tern (*Sterna antillarum athalassos*), and whooping crane (*Grus americana*). The brown pelican, a consistent coastal resident, is listed as endangered by the State, but has recently been delisted by the United States Fish and Wildlife Service. The interior least tern and whooping crane are seasonal migrants which could pass through the project area. The interior least tern typically nests on bare or sparsely vegetated areas associated with streams or lakes, such as sand and gravel bars, beaches, islands, and salt flats. The main whooping crane flock nests in Canada and migrates annually to their wintering grounds in and around the Aransas National Wildlife Refuge near Rockport on the Texas coast. Whooping cranes occasionally utilize wetlands as an incidental rest stop during this migration.

Avian species listed by the State of Texas as threatened include the peregrine falcon (*Falco peregrinus*), bald eagle (*Haliaeetus leucocephalus*), reddish egret (*Egretta rufescens*), sooty tern (*Sterna fuscata*), white-faced ibis (*Plegadis chihi*), white-tailed hawk (*Buteo albicaudatus*), and wood stork (*Mycteria Americana*). Resident bird species include the reddish egret, sooty tern and white-faced ibis. The peregrine falcon, bald eagle, snowy plover, southeastern snowy plover, and wood stork are migratory species expected to occur infrequently within the project area. The peregrine falcon includes two subspecies which migrate across the state from more northern breeding areas in the U.S. and Canada to winter along the coast. The majority of nesting bald eagle pairs currently reported are found along major rivers and near reservoirs in Texas. Bald eagles are opportunistic predators, feeding primarily on fish captured in the shallow water of both lakes and streams or scavenged food sources. These birds may utilize tall trees near perennial water as roosting or nesting sites. Bald eagles are documented by the NDD in areas above and below Lake Texana.

Many of the listed species found within the project area, such as the Texas Tortoise (*Gopherus berlandieri*), Texas scarlet snake (*Cemophora coccinea lineri*), timber/canebrake rattlesnake (*Crotalus horridus*), and the Texas Horned Lizard (*Phrynosoma cornutum*), are dependent on shrubland or riparian habitats which should be avoided wherever possible. The NDD indicates that the Texas diamondback terrapin (*Malaclemys terrapin littoralis)* has been documented near the mouth of the Lavaca-Navidad River where it empties into the Gulf of Mexico. This reptilian species of concern prefers a habitat which consists of coastal marshes and tidal flats.

Destruction of potential habitats has been minimized by the selection of an OCR project area which lies within previously disturbed areas of cropland. Care should be taken to ensure minimum impacts from construction to the existing riparian and wetland areas located along the Lavaca River and below Lake Texana. It is not anticipated that this project will have any permanent adverse effect on any state or federally listed threatened or endangered species, its habitat, or designated habitat.

Habitat studies and surveys for protected species and cultural resources may need to be conducted at the proposed off channel site, and along the pipeline routes. Specific project features, such as pipelines, and off-channel reservoirs generally have sufficient design flexibility to avoid most impacts or significantly mitigate potential impacts to geographically limited environmental and cultural resource sites. Field surveys conducted at the appropriate phase of development should be employed to minimize the impacts of construction and operation on sensitive resources.

Potential wetland impacts are expected to primarily include the raw water pipeline river crossing and wetland areas found south of Lake Texana. These impacts can be minimized by right-of-way selection and appropriate construction methods, including erosion controls and revegetation procedures. Compensation for net losses of wetlands would be required where impacts are unavoidable.

A review of the Texas Historical Commission Texas Historic Sites Atlas database indicated that there are two historical markers within one mile of the proposed pipeline route. There are no National Register Properties listed within one mile of the proposed pipeline route, however this database indicates that there are two small cemeteries recorded within one mile of the proposed pipeline. Avoidance of these areas should be possible through appropriate siting of the project pipelines.

4C.34.4 Engineering and Costing[6]

The major facilities included in this project are:

- A river intake and pump station;
- An off-channel storage reservoir ;
- A transmission pipeline from the river intake to the OCR and;
- An intake, pump station, and transmission pipeline from the OCR to Lake Texana.

A study completed by LNRA provided costs of the Lavaca River Off-Channel Reservoir project in November 2009 dollars. The costs were then prorated to reflect September 2008 Prices. The estimated capital cost for building the facilities identified above is $154,187,000 as shown in Table 4C.34-3. The off-channel storage reservoir is estimated to cost $124,059,000. After land acquisition costs and cost for engineering, legal, environmental mitigation, and interest during construction, the total project cost is estimated at $224,183,000.

The debt service at 6 percent over 20 years for non-reservoir facilities and at 6 percent for 40 years for the off-channel reservoir, and the annual operations and maintenance costs, including energy, result in a total annual cost of $18,387,000. Dividing by 26,242 acft/yr equates to an annual raw water cost of $701 per acft. Assuming treatment costs of $326 per acft, the treated water cost is $1,027 per acft. The values presented in Table 4C.34-8 are slightly different than what was provided in the study completed by LNRA. This is primarily due to differences in assumptions used for contingency costs and other non-capital costs.

[6] Cost estimate provided by LNRA and revised by HDR Engineering to be consistent with RWPG guidelines.

Table 4C.34-3.
Cost Estimate Summary for
Lavaca River Off-Channel Reservoir
(September 2008 Prices)

Item	*To Lake Texana*
Capital Costs	
Off-Channel Storage	$124,059,000
River Intake and Pump Station	9,470,000
River Intake Transmission Pipeline to OCR	2,760,000
OCR Intake and Pump Station	5,494,000
OCR Transmission Pipeline to Lake Texana	12,404,000
Total Capital Cost	**$154,187,000**
Engineering, Legal Costs, and Contingencies	$52,729,000
Environmental & Archaeological Studies and Mitigation	1,023,000
Land Acquisition and Surveying	1,117,000
OCR Interest During Construction (2 years)	13,528,000
Non-OCR Interest During Construction (1 year)	1,599,000
Total Project Cost	**$224,183,000**
Annual Costs	
Non-OCR Debt Service (6 percent for 20 years)	$3,623,000
OCR Debt Service (6 percent for 40 years)	12,138,000
Operation and Maintenance	
Intake, Pipeline, Pump Station	510,000
Dam and OCR	1,861,000
River Intake Pumping Energy Costs (1,077,307 kW-hr @ 0.09 per kWh)	97,000
OCR Intake Pumping Energy Costs (1,752,876 kW-hr @ 0.09 per kWh)	158,000
Total Annual Cost	**$18,387,000**
Available Project Yield (acft/yr)	**26,242**
Annual Cost of Water ($ per acft) Raw Water Delivered	**$701**
Annual Cost of Water ($ per 1,000 gallons) Raw Water Delivered	**$2.15**

4C.34.5 Implementation Issues

4C.34.5.1 Local Issues and Concerns

The development of the Lavaca River OCR would result in an increased water supply of approximately 26,242 acft for the area. However, 10,000 acft of this supply is being developed for an industrial entity located in Calhoun County, with the remaining 16,242 acft available for contract by other interested parties. While Jackson County has a relatively large demand for agricultural water, demand in Jackson County for municipal and/or industrial water supply is low. In addition, the Lavaca River OCR would result in a unit cost of water far in excess of what agricultural interests could afford. Therefore, it is very likely that the water supply created by the construction of the Lavaca River OCR would benefit other regions outside of Jackson County. The construction of the Lavaca River OCR is expected to inundate approximately 3,000 acres of land at 75,000 acft of storage capacity, therefore impacting landowners in Jackson County.

4C.34.5.2 Water Rights Permit Modifications

Under Certificates of Adjudication No. 16-2095, 16-2095A, 16-2095B, 16-2095C, and 16-2095D, LNRA is authorized to impound and divert water in the Lavaca and Navidad River basins for municipal, industrial, and recreational uses. These permits allow the use of water from two separate reservoirs, one on the Navidad River (existing Palmetto Bend Dam/Lake Texana) and one on the Lavaca River (proposed Palmetto Bend Stage II).

LNRA is authorized to impound up to 170,300 acft of water in Lake Texana on the Navidad River and an additional 93,340 acft in the proposed Palmetto Bend Stage II reservoir on the Lavaca River. LNRA is authorized to divert and use up to 79,000 acft from Lake Texana for municipal and industrial uses and an additional 36,000 acft (not including bay and estuary maintenance flows) from Palmetto Bend Stage II reservoir for municipal and industrial uses. Diversions are currently limited by location to two points on Lake Texana (East and West Delivery System Pump Stations) and by rate to up to 330 cfs total from Lake Texana. The impoundment and diversions of water each have a priority date of May 15, 1972.

In addition to the permit limitations specified above, the impoundment and diversion of water from Lake Texana is further subject to a bay and estuary release schedule. Inflows into Lake Texana are subject to release from Lake Texana as a function of both reservoir capacity and season. The existing permits further specify that prior to commencement of construction of Palmetto Bend Stage II reservoir, or any diversion of water from Stage II reservoir, upon the joint recommendation of LNRA, TWDB, and Texas Parks and Wildlife Department (TPWD), LNRA shall submit an application to the TCEQ to establish a schedule for the release of freshwater inflows from Stage II reservoir. In establishing the Stage II release schedule, the TCEQ may consider the modification to the Lake Texana release schedule. LNRA shall retain the right to withdraw its application at any time prior to any final decision by the TCEQ and upon withdrawal, the Lake Texana release schedule shall remain unchanged.

The existing water rights permits for Lake Texana and Stage II reservoirs would need to be modified to incorporate changes associated with the proposed Lavaca River Off-Channel Reservoir project. These modifications may include an additional diversion point on the Lavaca River, the impoundment of water in an off-channel reservoir as opposed to the currently permitted on-channel Stage II reservoir, likely changes in the amounts and distribution currently permitted for industrial and municipal uses, potential addition of agricultural use, and a proposed bay and estuary (i.e., pass through) schedule for the proposed Lavaca River Off-Channel Reservoir project.

It should be noted that these changes in conditions to the existing permit would likely require a major permit modification and require public notification. In addition, it should also be noted that any of these permit modifications, and specifically the required bay and estuary release schedule, could potentially reduce the project yield from the existing Lake Texana and/or the proposed Lavaca River Off-Channel Reservoir project.

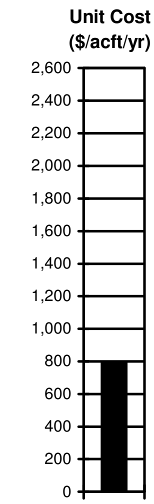
4C.34.5.3 Impact of the Lavaca River Off-Channel Reservoir Project to the Yield of Palmetto Bend Stage II Reservoir

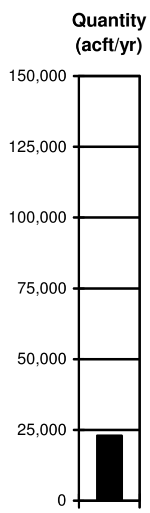
Table 4C.34-4 provides the impact and reduction in projected firm yield of the Palmetto Bend - Stage II Reservoir as a result of implementing the proposed Lavaca River Off-Channel Reservoir project. Based on the results of this analysis and depending on the storage capacity and diversion rate for the Lavaca River Off-Channel Reservoir project, the firm yield of Palmetto Bend - Stage II is reduced from between 38% and 78% of its original amount. The optimum configuration specified as a result of this study for the Lavaca River Off-Channel Reservoir project of 75,000 acft and a 200 mgd diversion rate, results in a reduction in the firm yield of Palmetto Bend Stage II of 42%.

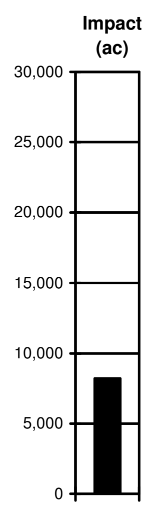
This reduction in yield of Palmetto Bend - Stage II due to implementation of the proposed Lavaca River Off-Channel Reservoir project will likely result in any future consideration of Palmetto Bend - Stage II not being feasible. The reduction in yield for Stage II would further increase the unit cost of the project and likely make it no longer economically viable compared to other alternatives. Therefore, it is likely that the implementation of the proposed Lavaca River Off-Channel Reservoir would negate the future construction of Stage II. Based on this, the assessment of Palmetto Bend - Stage II and the proposed Lavaca River Off-Channel Reservoir should probably be evaluated as an either/or condition, with the potential for implementing both projects very remote.

Table 4C.34-4.
Firm Yields for Off-Channel Reservoir and Palmetto Bend Stage II Reservoir for Different Storages and Pumping Rates

Storage (acft)	Pumping Rate (mgd)	Lavaca River OCR Firm Yield (acft/yr)	Palmetto Bend - Stage II Firm Yield (acft/yr)	Palmetto Bend - Stage II Yield (% Reduction due to OCR)
25,000	0	0	18,529	0
	50	9,818	11,566	38
	100	13,050	10,664	42
	200	14,308	10,664	42
	500	14,308	10,664	42
	No limit	14,308	10,664	42
50,000	0	0	18,529	0
	50	11,222	10,995	41
	100	17,235	10,664	42
	200	20,510	10,664	42
	500	20,510	9,608	48
	No limit	20,510	9,608	48
75,000	0	0	18,529	0
	50	11,572	10,995	41
	100	18,154	10,664	42
	200	26,242	10,664	42
	500	26,483	7,698	58
	No limit	26,483	7,698	58
100,000	0	0	18,529	0
	50	11,076	10,995	41
	100	17,838	10,664	42
	200	26,632	10,664	42
	500	32,459	3,936	79
	No limit	32,459	4,166	78







Name: Palmetto Bend – Stage II Reservoir Project

Description: The Palmetto Bend – Stage II Reservoir Project consists of a 57,676 acft impoundment on located approximately 1.4 miles upstream of Lake Texana on the Lavaca River. The reservoir will encompass 4,679 acres and provide a yield of 22,964 ac-ft/yr of raw water for transmission through the Mary Rhodes Pipeline.

***Decade Needed*:** 2010 – 2020

Cost, Quantity of Water, and Land Impacted

Unit Cost of Water:	**$795**	**$/acft/yr**	**Raw Water Delivered**
Quantity of Water:	**22,964**	**acft/yr**	**Reliability = Firm**
Land Impacted:	**8,224**	**acres**	

Additional Considerations per
Regional Water Planning Guidelines

Environmental Factors:

No federal or state protected species are known to be present within the reservoir area.

Impacts on Water Resources:

None anticipated.

Impacts on Agricultural & Natural Resources:

Purchase of reservoir land will result in reduced agricultural uses.

Other Relevant Factors per SCTRWPG:

Alternative project to meet needs in Eastern Calhoun County.

Comparison of Strategies to Meet Needs:

No apparent negative impacts on other water resources.

Interbasin Transfer Issues:

Interbasin transfers may be necessary to meet needs in Calhoun County. Additionally, any water delivered to Corpus Christi in Region N will be an Interbasin transfer.

Third-Party Impacts of Voluntary Transfers:

None anticipated.

Regional Efficiency:

Provides regional opportunities**.**

Water Quality Considerations:

The reservoir will aid in suspending flood flows to avoid poor water quality during flood events and facilitate maintenance of diversion facilities without stopping reservoir deliveries.

4C.35.1 Palmetto Bend – Stage II

4C.35.1 Description of Water Management Strategy

The Texas Water Development Board (TWDB) and the Lavaca-Navidad River Authority (LNRA) hold a Certificate of Adjudication, #16-2095B, for the completion of Palmetto Bend – Stage II Dam and Reservoir (Stage II of Lake Texana) on the Lavaca River. Stage I, now known as Lake Texana, was completed in 1981 and is located on the Navidad River. Stage I is operated by LNRA primarily for water supply purposes and has a firm yield of 79,000 acft/yr. In 1998, the Mary Rhodes Memorial Pipeline (MRP) was completed to deliver an initial 41,840 acft/yr from Lake Texana to the City of Corpus Christi.

The LNRA has expressed a renewed interest in the potential development of Palmetto Bend – Stage II. In the 2006 Coastal Bend Regional Water Plan, water supply from the development of Palmetto Bend – Stage II was evaluated as part of an interregional water supply by both the Coastal Bend Regional Water Planning Group (Region N) and the South Central Texas Regional Water Planning Group (Region L). Palmetto Bend – Stage II could be developed by LNRA to meet needs in Calhoun County (Point Comfort and Calhoun County Industrial).

Originally, the U.S. Bureau of Reclamation proposed that Palmetto Bend – Stage II would be located on the Lavaca River and share a common pool with Stage I (Lake Texana). However, previous studies have shown that Palmetto Bend – Stage II could be constructed more economically if operated separately from Lake Texana and located further upstream at an alternative site on the Lavaca River.[1] As proposed, at the original site, the Certificate of Adjudication states:

> *"Upon completion of the Stage 2 dam and reservoir on the Lavaca River, owner Texas Water Development Board is authorized to use an additional amount of 18,122 acft/yr, for a total of 48,122 acft/yr, of which up to 7,150 acft/yr shall be for municipal purposes, up to 22,850 acft/yr shall be for industrial purposes, and at least 18,122 acft/yr shall be for the maintenance of the Lavaca-Matagorda Bay and Estuary System. The entire Stage 2 appropriation remains subject to release of water for the maintenance of the bay and estuary system until a*

[1] HDR Engineering, Inc., "Regional Water Planning Study Cost Update for Palmetto Bend Stage 2 and Yield Enhancement Alternative for Lake Texana and Palmetto Bend Stage 2," Lavaca-Navidad River Authority, et al., May 1991.

release schedule is developed pursuant to the provisions of Section 4.B of this certificate of adjudication."[2]

For the purposes of this water management strategy, Palmetto Bend – Stage II is assumed to be constructed at the alternative site located approximately 1.4 miles upstream of the original site. Since this site results in a different yield than stated in the certificate, the conditions in the certificate will need to be revised to account for the change in yield of Palmetto Bend – Stage II. The revisions to the certificate should also reflect the impacts that joint operations of Lake Texana and Palmetto Bend – Stage II could have on the releases necessary to maintain the bay and estuary system downstream of the projects. In 1997, a study[3] was conducted by the LCRA to estimate target and critical freshwater inflow needs for the Matagorda Bay System from the Colorado River. Target inflow is defined based on criteria established for salinity and nutrient inflow, in addition to necessary long-term inflow to produce 98% of maximum population for nine key estuarine species. Critical freshwater inflow is the minimum inflow, based on salinity levels, necessary to provide for fish habitat during drought conditions. Recent studies of Matagorda Bay and Lavaca-Colorado Estuary[4] indicate that releases to the bay and estuary (from 1941-1987), on average, exceed target inflow by over 50% with an average inflow of 3,080,301 acft as compared to a target inflow of 2,000,100 acft.[5] These inflows, which include releases from Lake Texana, exceed mitigation requirements and may enhance the productivity of certain species in the bay and estuary. These results indicate that releases from Palmetto Bend – Stage II for maintaining the bay and estuaries may be less restrictive than those called for in the Environmental Water Needs Criteria of the Consensus Planning Process.[6] However, in addition to the bay and estuary requirements, releases from Palmetto Bend – Stage II might be required for the 3.5-mile reach of the Lavaca River downstream of the dam site to the confluence with the Navidad River.[7] Therefore, it is assumed that releases from Palmetto Bend – Stage II will be in accordance with the Consensus Criteria for maintenance of the river reach just below the dam.

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[2] Texas Natural Resource Conservation Commission Certificate of Adjudication No. 16-2095B, 1994.
[3] LCRA, "Freshwater Inflow Needs of the Matagorda Bay System," December 1997.
[4] TWDB, "Texas Bay and Estuary Program- Matagorda Bay and Lavaca-Colorado Estuary", 1998.
[5] The monthly average inflow exceeds target monthly inflow for all months, except April which is slightly less than target levels.
[6] Texas Water Development Board (TWDB), "Environmental Water Needs Criteria of the Consensus Planning Process," January 1996.
[7] Personal communications with Gary Powell, TWDB, July 1999.

The Freshwater Inflow Needs for the Matagorda Bay System is currently undergoing a revision which should be considered in future water planning efforts.

TWDB conducted a study to evaluate and select the most promising reservoir sites in Texas to satisfy future water supply needs. The TWDB Reservoir Site Protection Study[8] recommended Palmetto Bend – Stage II as one of the top-ranked sites in Texas for protection or acquisition. During the 2007 Texas legislative session, Palmetto Bend – Stage II was designated as one of 19 unique reservoir sites in the State of Texas. Figure 4C.35-1 shows the location of Palmetto Bend – Stage II. This report has been updated based on the TWDB Reservoir Site Protection Study.

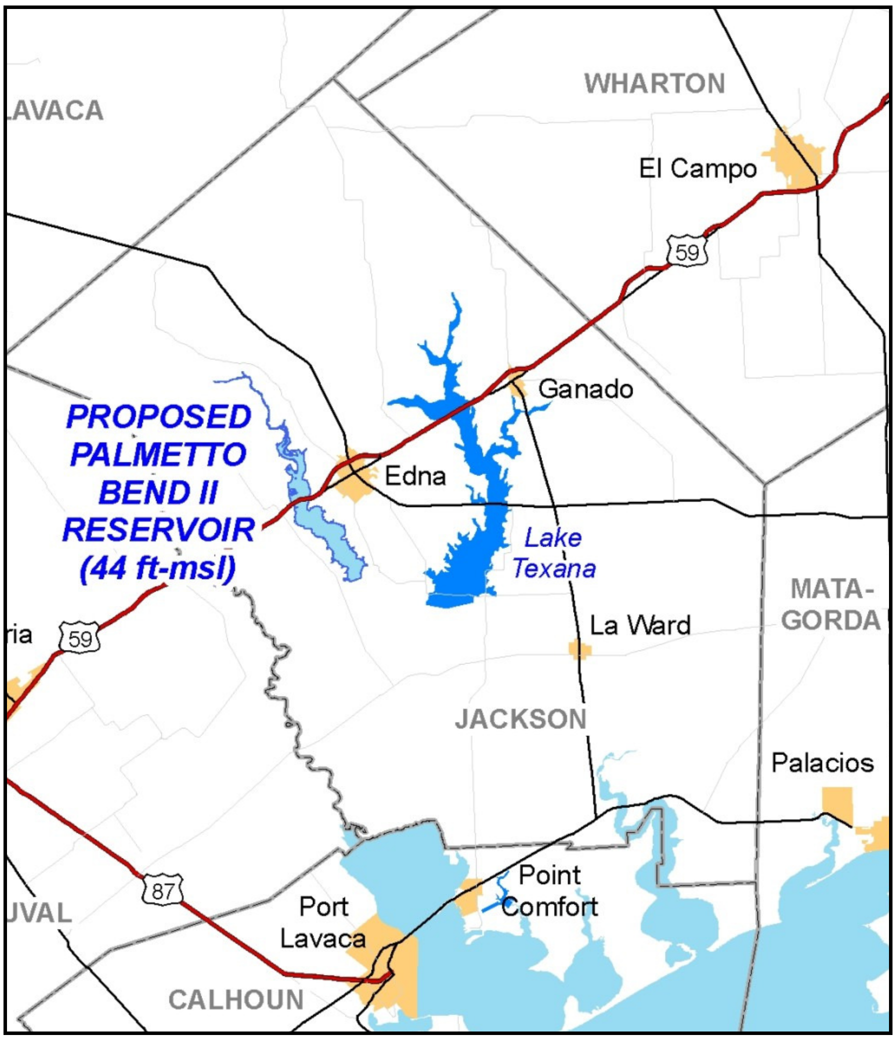


Figure 4C.35-1. Palmetto Bend – Stage II

[8] Texas Water Development Board, HDR Engineering, R.J. Brandes Company, et al "Reservoir Site Protection Study", TWDB Report 370, July 2008.

4C.35.2 Available Yield

The elevation-area-capacity relationship for Palmetto Bend – Stage II is shown in Table 4C.35-1 and was developed from 10-foot contour digital hypsography data from the Texas Natural Resources Information System.[9] These data are derived from the 1:24,000-scale (7.5-minute) quadrangle maps developed by the U.S. Geological Survey. At the conservation pool elevation of 44 feet, Palmetto Bend – Stage II will inundate 4,564 acres and have a capacity of 52,046 acft.

Table 4C.35-1.
Palmetto Bend – Stage II
Elevation, Area and Capacity Relationship

Elevation (ft-msl)	Area (acres)	Capacity (acft)
4	0	0
5	16	5
10	49	161
15	92	507
20	159	1,127
25	609	2,927
30	1,649	8,360
35	2,725	19,182
40	3,688	35,152
44*	4,564	52,046
45	4,783	56,269
50	5,868	82,851

*Top of conservation pool
Source: TWDB Reservoir Site Protection Study, 2008.

The monthly median flows (Zone 1) and 25th percentile flows (Zone 2) used to define the Consensus Criteria release requirements were computed from the monthly naturalized flows from the Lavaca-Navidad River Basin Model distributed to a daily time step. The Zone 3 requirement (7Q2) was taken from TCEQ's published water quality standards.[10] Table 4C.35-2 shows the daily release (inflow passage) requirements from Palmetto Bend – Stage II.

The firm yield of Palmetto Bend – Stage II was estimated by using the TCEQ Lavaca River Basin water availability model (BOR, 2001; February 24, 2003 version) data sets and the

[9] Ibid.
[10] Texas Administrative Code, Chapter 307, Texas Surface Water Quality Standards.

Water Rights Analysis Package. The water availability model simulates a repeat of the natural streamflows over the 57-year period of 1940 through 1996, accounting for the appropriated water rights of the Lavaca River Basin with respect to location, priority date, diversion amount and pattern, storage, and special conditions, including instream flow requirements. Palmetto Bend – Stage II is simulated with the priority date as provided by the TCEQ in Certificate of Adjudication No. 16-2095B. The TWDB study evaluated four potential conservation storage capacities associated with 50, 44, 40, and 35 foot conservation pool elevations. Current planning envisions a conservation elevation of 44 feet for Palmetto Bend – Stage II, thereby yielding a water supply of 22,964 acft/yr.

Palmetto Bend – Stage II was evaluated by the Coastal Bend Regional Water Planning Group in the 2006 Regional Water Plan. The reported firm yield of Palmetto Bend – Stage II was reported as 28,000 acft/yr at a conservation elevation of 44 feet. The firm yield estimate in this plan differs from the 2006 Regional Water Plan because the previous estimate used SIMDLY (a daily reservoir simulation model) rather than the Water Rights Analysis Package. In addition, the refined elevation-area-capacity relationship in this plan has reduced the conservation capacity at an elevation of 44 feet from 57,676 to 52,046 acft.

Table 4C.35-2. Consensus Criteria Release Requirements (cfs) for Palmetto Bend – Stage II

Month	Consensus Criteria Zone		
	1	2	3
	>80% Capacity Median	<80% to >50% Capacity 25^{th} Percentile	<50% Capacity 7Q2
January	63.0	26.1	21.6
February	92.8	39.0	21.6
March	76.9	37.6	21.6
April	78.9	36.8	21.6
May	92.2	35.4	21.6
June	85.6	36.7	21.6
July	47.5	22.7	21.6
August	37.3	21.6	21.6
September	41.2	21.6	21.6
October	39.2	21.6	21.6
November	48.3	21.6	21.6
December	55.1	24.3	21.6
Note: Consensus Criteria published in 2001 Coastal Bend Regional Water Plan.			

4C.35.3 Environmental Issues

Environmental issues associated with the construction of Palmetto Bend – Stage II can be categorized as follows:

- Effects of the construction and operation of the reservoir;
- Effects on the Lavaca River downstream from the dam; and
- Effects on Lavaca Bay.

The proposed dam would create a 4,564-acre conservation pool area at 44 ft-msl, inundating about 22 miles of the Lavaca River channel. Landcover for the reservoir site is dominated by grassland (42 percent), with broad-leaf evergreen forest (34 percent) and upland deciduous forest (11 percent) concentrated along the Lavaca River. Although no federal or state protected species are known to be present within the reservoir area, important species may be present in the surrounding areas and are listed in Table 4C.35-3. Suitable habitat for protected species may be present at the reservoir site. Several species of migratory birds, marine turtles, and mammals considered by the USFWS and National Marine Fisheries Service to be endangered or threatened are believed to utilize the Lavaca Estuary.

Palmetto Bend – Stage II will inundate a portion of the TCEQ classified stream segment 1601 on the Lavaca River. Texas Parks and Wildlife Department listed the segment of the Lavaca River immediately downstream of the reservoir as ecologically significant. Palmetto Bend – Stage II could have the following effects to Texas Parks and Wildlife Department criteria:

- Biological function — Extensive freshwater wetland habitat displays significant overall habitat value.
- Threatened or endangered species/ unique communities to the diamond back terrapin species of concern.

The importance of the flow reductions to the bay and estuary system is a complex function of bay physiography (estuarine volume, area/depth ratio, substrate composition, constrictions or compartmentalization), regional climate, and the flushing energy provided by tidal action, the effects of multiple freshwater inflows, and the estuarine population examined. The operating regime for Palmetto Bend – Stage II meets the Consensus Criteria for both streamflow and estuary requirements, based on the results of "Freshwater Inflow Needs of the

Table 4C.35-3. Important Species* Having Habitat or Known to Occur in Counties Potentially Affected by Option Palmetto Bend – Stage II Reservoir

Common Name	Scientific Name	Summary of Habitat Preference	Listing Agency			Potential Occurrence in County
			USFWS[1]	TPWD[1]	TOES[2,3,4]	
American Peregrine Falcon	*Falco peregrinus anatum*	Open country; cliffs	E	E	E	Nesting/Migrant
Arctic Peregrine Falcon	*Falco peregrinus tundrius*	Open country; cliffs	T/SA	T	T	Nesting/Migrant
Atlantic Hawksbill Sea Turtle	*Eretmochelys imbricata*	Coastal waters	E	E	E	Resident
Attwater's Prairie-Chicken	*Tympanuchus cupido attwateri*	Gulf coastal prairies	E	E	E	Resident
Bald Eagle	*Haliaeetus leucocephalus*	Large bodies of water with nearby resting sites	T	T	E	Nesting/Migrant
Black Bear	*Ursus americanus*	Mountains, broken country, woods, brushlands, forests	T/SA	T	T	Resident
Black-spotted Newt	*Notophthalmus meridionalis*	Wet or temporally wet arroyos, canals, ditches, shallow depressions; aestivates underground during dry periods	E	T		Resident
Brown Pelican	*Pelecanus Occidentalis*	Coastal islands; shallow Gulf and bays	E	E	E	Resident
Coastal Gay-feather	*Liatris bracteata*	Black clay soils of midgrass grasslands on coastal prairie remnants			WL	Resident
Eskimo Curlew	*Numenius borealis*	Coastal prairies	E	E	E	Migrant
Green Sea Turtle	*Chelonia mydas*	Gulf Coast	T	T	T	Resident
Guadalupe Bass	*Micropterus treculi*	Streams of eastern Edwards Plateau			WL	Resident
Gulf Saltmarsh Snake	*Nerodia clarkii*	Coastal waters		T	NL	Resident
Henslow's Sparrow	*Ammodramus henslowii*	Weedy fields or cut over areas; bare ground for running and walking			NL	Nesting/Migrant
Interior Least Tern	*Sterna antillarum athalassos*	Inland river sandbars for nesting and shallow waters for foraging	E	E	E	Nesting/Migrant
Jaguarundi	*Felis yagouaroundi*	South Texas thick brushlands, favors areas near water	E	E	E	Resident
Keeled Earless Lizard	*Holbrookia propinqua*	Coastal dunes, Barrier islands and sandy areas			NL	Resident
Kemp's Ridley Sea Turtle	*Lepidochelys kempii*	Coastal waters; bays	E	E	E	Resident
Leatherback Sea Turtle	*Dermochelys coriacea*	Coastal and offshore waters	E	E	E	Resident
Loggerhead Sea Turtle	*Caretta caretta*	Coastal waters; bays	T	T	T	Resident
Mulenbrock's Umbrella Sedge	*Cyperus grayioides*	Prairie grasslands, moist meadows	C2	NL	NL	Resident
Ocelot	*Felis pardalis*	Dense chaparral thickets; mesquite-thorn scrubland and live oak mottes; avoids open areas; primarily extreme south Texas	E	E	E	Resident
Peregrine Falcon	*Falco peregrinus*	Open country, cliffs, occasionally cities[5]	E/SA	NL	NL	Nesting/Migrant
Piping Plover	*Charadrius melodus*	Beaches, flats	T	T	T	Resident
Red Wolf (extirpated)	*Canis rufus*	Woods, prairies, river bottom forests	E	E	E	Resident
Reddish Egret	*Egretta rufescens*	Coastal islands for nesting; shallow areas for foraging		T	NL	Nesting/Migrant
Scarlet Snake	*Cemophora coccinea*	Sandy soils	NL	T	WL	Resident
Smooth Green Snake	*Liochlorophis vernalis*	Coastal grasslands		T	NL	Resident
Snowy Plover	*Charadrius alexandrus*	Beaches, flats, streamsides	NL		NL	Winter resident
Sooty Tern	*Sterna fuscata*	Coastal islands for nesting; deep Gulf for foraging	NL	T	WL	Resident
Texas Asaphomyian Tabanid Fly	*Asaphomyia texanus*	Near slow moving water, wait in shady areas for host			WL	Resident
Texas Diamondback Terrapin	*Malaclemys terrapin litoralis*	Bays and coastal marshes		T	T	Resident

Table 4C.35-3 (Concluded)

Common Name	Scientific Name	Summary of Habitat Preference	Listing Agency USFWS[1]	TPWD[1]	TOES[2,3,4]	Potential Occurrence in County
Texas Garter Snake	*Thamnophis sirtalis annectens*	Varied, especially wet areas; bottomlands and pastures			NL	Resident
Texas Horned Lizard	*Phrynosoma cornutum*	Varied, sparsely vegetated uplands		T	T	Resident
Texas Tortoise	*Gopherus berlandieri*	Open brush with grass understory; open grass and bare ground avoided; occupies shallow depressions at base of bush or cactus, underground burrows, under objects; active March to November		T	T	Resident
Threeflower Broomweed	*Thurovia triflora*	Black clay soils of remnant coastal prairie grasslands			WL	Resident
Timber/Canebrake Rattlesnake	*Crotalus horridus*	Bottomland hardwoods		T	T	Resident
Welder Machaeranthera	*Psilactis heterocarpa*	Mesquite-huisache woodlands, shrub-invaded grasslands in clay and silt soils			WL	Resident
West Indian Manatee	*Trichechus manatus*	Warm, vegetated coastal waters	E	E	E	
White-faced Ibis	*Plegadis chihi*	Varied, prefers freshwater marshes, sloughs and irrigated rice fields; Nests in low trees		T	T	Nesting/Migrant
White-tailed Hawk	*Buteo albicaudatus*	Prairies, mesquite and oak savannahs, scrub-live oak, cordgrass flats		T	T	Nesting/Migrant
Whooping Crane	*Grus americana*	Potential migrant	E	E	E	Migrant
Wood Stork	*Buteo americana*	Prairie ponds, flooded pastures or fields; shallow standing water		T	T	Nesting/Migrant

[1] Texas Parks and Wildlife Department. Unpublished 1999. September 1999, Data and map files of the Natural Heritage Program, Resource Protection Division, Austin, Texas.
[2] Texas Organization for Endangered Species (TOES). 1995. Endangered, threatened, and watch list of Texas vertebrates. TOES Publication 10. Austin, Texas. 22 pp.
[3] TOES. 1993. Endangered, threatened, and watch list of Texas plants. TOES Publication 9. Austin, Texas. 32 pp.
[4] TOES. 1988. Invertebrates of Special Concern. TOES Publication 7. Austin, Texas. 17 pp.
[5] Peterson, R.T. 1990. A Field Guide to Western Birds. Houghton Mifflin Company, Boston. pg. 86.

* E = Endangered T = Threatened C1 = Candidate Category, Substantial Information C2 = Candidate Category
C3 = No Longer a Candidate for Protection PE/PT = Proposed Endangered or Threatened
WL = Potentially endangered or threatened Blank = Rare, but no regulatory listing status NL = Not listed

Matagorda Bay System."[11] The changes in streamflow in the Lavaca River and the inflows into Lavaca Bay resulting from Palmetto Bend – Stage II operation are shown in Figure 4C.35-2. Both plots display the reduction in flows downstream of Palmetto Bend – Stage II when operating in accordance with Consensus Criteria and simulating the TWDB seasonal demands. The top charts show the monthly median flows in the Lavaca River and Lavaca Bay downstream of Palmetto Bend – Stage II with and without the project, while the bottom plot shows the reduction in combined Lavaca-Navidad River flows into Lavaca Bay, with Lake Texana in full operation, and with or without Palmetto Bend – Stage II.[12] It is important to note that the

[11] LCRA, Op. Cit., December 1997.
[12] R.J. Brandes Company, "Analysis of Lavaca Bay Salinity Impacts of a Proposed Release Program from Lake Texana," Texas Parks and Wildlife Department, Austin, TX, November 1990.

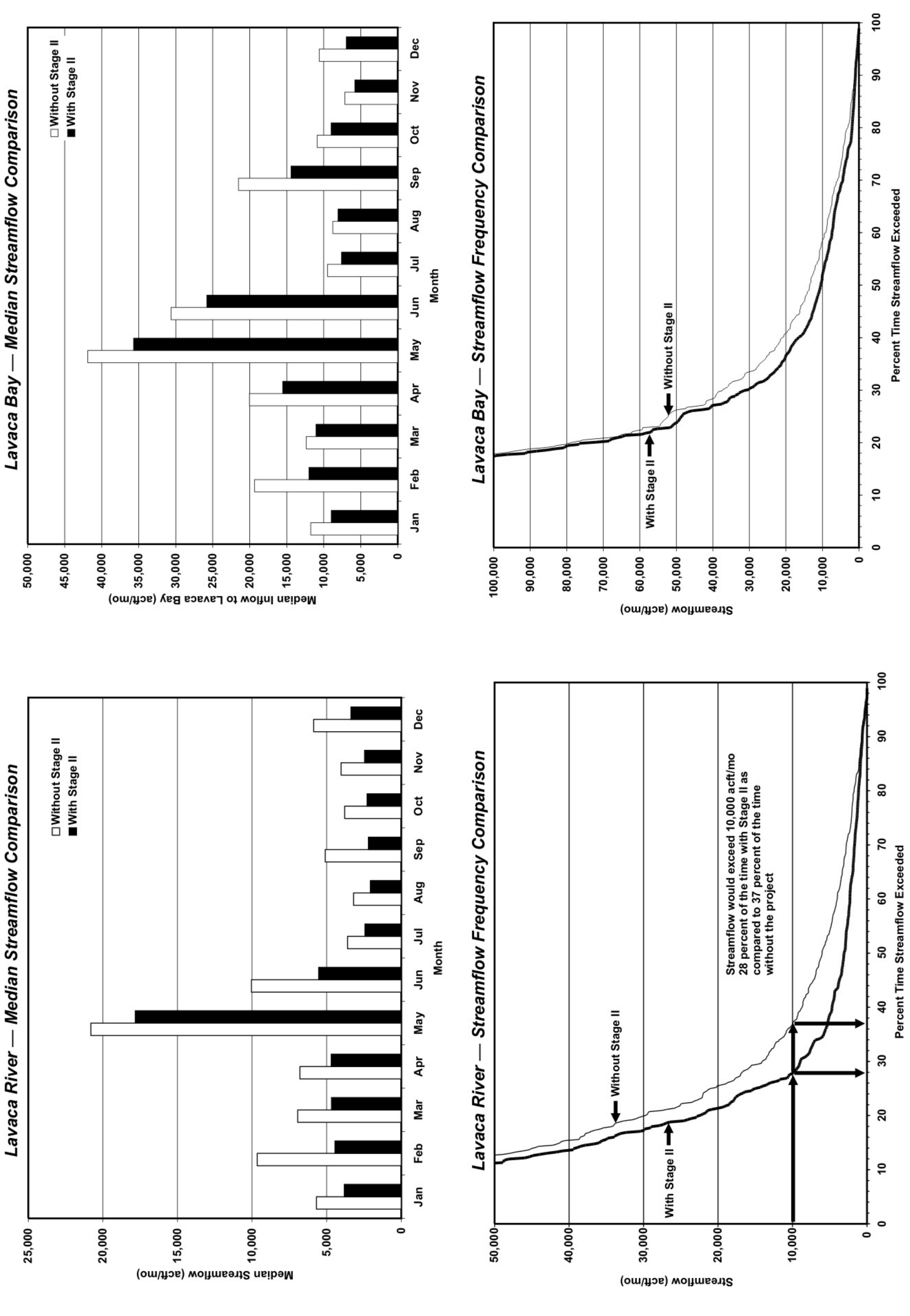


Figure 4C.35-2. Palmetto Bend — Stage II Streamflow Comparisons

Figure 4C.35-2 is consistent with how the reservoir was modeled in the 2006 Regional Water Plan. Although a different model was used to determine an updated yield for this plan, the downstream flows should be similar.

Freshwater inflows play an important role in determining the distribution and abundance of estuarine populations. Most importantly, inflows interact with the tidal regime to produce a range of salinity gradients that generally exhibit more or less predictable seasonal patterns. Freshwater inflows may also be important in transporting sediments that play a role in maintaining tidal marsh elevations against subsidence and erosion, and nutrients that may support high levels of planktonic production and respiration.

The Lavaca River is tidally influenced at the proposed dam site; consequently, its biota is variable depending on its recent history of tidal stages and stream discharge, but is typically dominated by a brackish or salt-tolerant fauna. Following completion of the dam for Palmetto Bend – Stage II, a continuous release requirement might prevent the development of adverse salinity and dissolved oxygen conditions below the dam that now accompany episodes of very low flow. Streamflows will tend to be more uniform over time than would be the case without the project, with most of the reduction occurring at flows above the median, while storage is taking place.

The characteristically large runoff events typical of this region have produced sufficient spills and releases from Lake Texana to maintain the Navidad River channel below the dam, and Palmetto Bend – Stage II is expected to operate similarly. Migration will be blocked in the Lavaca River as it is in the Navidad River by Stage I, but strongly migratory species do not have any particular community importance in the present river-estuary system, and none are known that would be eradicated by construction of Palmetto Bend – Stage II.

The slight decrease in estuarine inflows associated with implementation of Palmetto Bend – Stage II (Figure 4C.35-2) would have no net adverse effect on Lavaca Bay or the larger Matagorda Estuarine System. Inflows from the Lavaca-Navidad and Colorado Rivers, together with inflows from Tres Palacios and Garcitas Creeks and numerous, small local drainages are more than sufficient to maintain historic productivity levels with Palmetto Bend – Stage II in place.[13]

[13] LCRA, Op. Cit., December 1997.

In addition to the Palmetto Bend – Stage II Reservoir, this option includes diversion of Palmetto Bend – Stage II water by pipeline to Lake Texana. The reservoir and pipeline route are in the gulf Prairies vegetational area, the Western Gulf Coastal Plan ecoregion, and the Texan biotic province. Post oak savannah and tall grass prairies dominated by oaks, mesquites (*Prosopis glandulosa*), acacias and prickly pears (*Opuntia spp.*) characterize the Gulf Prairies vegetational area. This vegetation is supported by acidic clays and clay loams interspersed by sandy loams.

Plant and animal species listed by TPWD, USFWS, and TOES that may be within the vicinity of the pipeline route or the reservoir are listed in Table 4C.35-3. The Texas Natural Heritage Program (NHP) maps two plants, the Threeflower Broomweed (*Thurovia triflora*) and Welder Machaeranthera (*Psilactis heterocarpa*), in the vicinity of the pipeline route. The Threeflower Broomweed is found in black clay soils of remnant coastal prairie grasslands, while the Welder Machaeranthera thrives in shrub-invaded grasslands in clay and silt soils. This proposed route is located near two rookeries, a wildlife management area, and an area where endangered Attwater's Greater Prairie Chickens have been sighted.

The pipeline route passes through or in the vicinity of Bald Eagle (in 1999, downgraded from endangered to threatened status) habitat. The NHP has mapped Bald Eagle habitat, which extends south from Lake Texana along the Lavaca and Navidad Rivers, and could be affected by the construction of Palmetto Bend – Stage II Reservoir or the proposed pipeline to Lake Texana. Bald Eagles usually inhabit areas around large bodies of water with nearby resting sites.

Other protected species that were not mapped in the project area but that could have habitat in the vicinity of the reservoir or proposed pipeline, includes the Black Bear, Jaguarundi, Ocelot, and the Texas Tortoise. The animals depend on brushland and mesquite scrubland habitats in the coastal prairies. The Texas Tortoise occupies shallow depressions at the base of bushes and cacti and underground burrows. Another reptile, the Timber/Canebrake Rattlesnake is usually found in bottomland habitats that support hardwoods.

The White-tailed Hawk (*Buteo albicaudatus*), Interior Least Tern (S*terna antillarum athalassos*), and Eskimo Curlew (*Numensis borealis*) also inhabit the coastal prairies. The White-tailed Hawk can be found in open prairies and mesquite/oak savannah, while the Interior Least Tern inhabits barren to sparsely vegetated sandbars along river, lake, and reservoir shorelines. The Eskimo Curlew has historically migrated through the coastal prairies in March and April.

Implementation of this option is expected to require field surveys for protected species, vegetation, habitats, and cultural resources during right-of-way selection to avoid or minimize impacts. When potential protected species habitat or other significant resources cannot be avoided, additional studies would have to be conducted to evaluate habitat use or eligibility for inclusion in the National Register for Historic Places, respectively. Wetland impacts, primarily pipeline stream crossings, can be minimized by right-of-way selection and appropriate construction methods, including erosion controls and vegetation procedures. Compensation for net losses of wetlands would be required where impacts are unavoidable.

4C.35.4 Engineering and Costing

Costs associated with constructing Palmetto Bend – Stage II Dam and Reservoir at the site 1.4 miles upstream of the original site are shown in Table 4C.35-4. An intake and pump station at Palmetto Bend – Stage II, a 4.5-mile transmission line, and an outlet structure would be necessary to transfer water from Palmetto Bend – Stage II to Lake Texana. The total project cost with the reservoir is $232,828,000. The annual debt service with the transmission facilities financed over 20 years at 6 percent interest and the reservoir costs financed at 6 percent over 40 years comes to $15,832,000. The annual costs for operations and maintenance and power are estimated at $2,415,000. The total annual cost of constructing Palmetto Bend – Stage II is $18,247,000. Dividing annual cost by the firm yield of 22,964 equates to an annual cost of $795 per acft or $2.44 per 1,000 gallons (Table 4C.35-4).

4C.35.5 Implementation Issues

Implementation of Palmetto Bend – Stage II Reservoir could directly affect the feasibility of other water supply options under consideration by the Coastal Bend Region. Since the alternative site of Palmetto Bend – Stage II involves a different yield than that stated in Certificate of Adjudication #16-2095B, the certificate would need to be amended to reflect the yield at the proposed site and release requirements necessary for the bay and estuary system. An interbasin transfer permit from TCEQ will also be required to deliver of Palmetto Bend – Stage II water to Region L.

Table 4C.35-4.
Cost Estimate Summary for
Palmetto Bend – Stage II Dam and Reservoir to Lake Texana
(September 2008 Prices)

Item	To Lake Texana
Capital Costs	
Dam and Reservoir (Conservation Pool: 57,676 acft; 4,679 acres; 44 ft-msl)	$71,354,000
Dam and Reservoir Conflicts	47,505,000
Intake and Pump Station (33 MGD; 858 HP)	3,630,000
Outlet Structure	197,000
Transmission Pipeline (54-inch 4.5-mile)	6,125,000
Improvements to Lake Texana System	2,315,000
Total Capital Cost	**$131,126,000**
Engineering, Legal Costs, and Contingencies	$45,588,000
Environmental & Archaeological Studies and Mitigation	14,725,000
Land Acquisition and Surveying (8,224 acres)	15,082,000
Interest During Construction (4 years)	26,307,000
Total Project Cost	**$232,828,000**
Annual Costs	
Debt Service for Transmission Facilities (6 percent for 20 years)	$1,504,000
Reservoir Debt Service (6 percent for 40 years)	14,328,000
Operation and Maintenance	
Intake, Pipeline, Pump Station	152,000
Dam and Reservoir	1,783,000
Pumping Energy Costs (5,330,000 kWh @ $0.09 per kWh)	480,000
Total Annual Cost	**$18,247,000**
Available Project Yield (acft/yr)	**22,964**
Annual Cost of Water ($ per acft) Raw Water Delivered	**$795**
Annual Cost of Water ($ per 1,000 gallons) Raw Water Delivered	**$2.44**

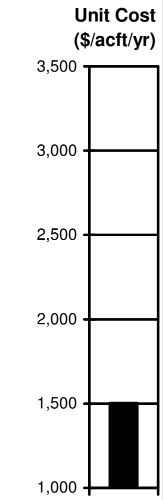
4C.35.6 Requirements Specific to Reservoirs

1. It will be necessary to obtain these permits:
   a. TCEQ Water Right and Storage permits, including interbasin transfer authorization.
   b. U.S. Army Corps of Engineers Sections 10 and 404 dredge and fill permits for the reservoir and pipelines.
   c. General Land Office Sand and Gravel Removal permits.
   d. General Land Office Easement for use of state-owned land.
   e. Coastal Coordination Council review.
   f. Texas Parks and Wildlife Department Sand, Gravel, and Marl permit.
2. Permitting, at a minimum, will require these studies:
   a. Assessment of effects on bays and estuaries.
   b. Habitat mitigation plan.
   c. Environmental studies.
   d. Cultural resource studies.
3. Land will need to be acquired through either negotiations or condemnation.
4. Relocations for the reservoir may include:
   a. Highways and railroads.
   b. Petroleum pipelines.
   c. Other utilities.
   d. Structures of historical significance.
   e. Cemeteries.

4C.35.7 Requirements Specific to Pipelines

1. Necessary permits:
   a. U.S. Army Corps of Engineers Sections 10 and 404 dredge and fill permits for stream crossings.
   b. General Land Office Sand and Gravel Removal permits.
   c. Texas Parks and Wildlife Department Sand, Gravel and Marl permit for river crossings.
2. Right-of-way and easement acquisition.
3. Crossings:
   a. Highways and railroads.
   b. Creeks and rivers.
   c. Other utilities.

2011 South Central Texas Regional Water Plan
Water Management Strategy Summary Sheet



Name: **TWA Regional Carrizo**

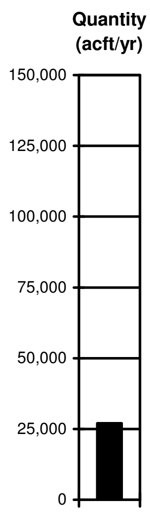
Description: The primary source for the TWA Regional Carrizo Project will be groundwater from the Carrizo Aquifer in Northeastern Gonzales County. Facilities include a total of 17 Carrizo wells, a transmission pipeline from the well field to the Gonzales County WSC, Spring Hill WSC, and Bulverde (SJWTX) delivery points, two transmission booster pump stations; and water treatment plant at the well field site.

***Decade Needed*:** 2010 - 2020

Cost, Quantity of Water, and Land Impacted

Unit Cost of Water:	**1,523**	**$/acft/yr**	**Treated Water Delivered**
Quantity of Water:	**27,000**	**acft/yr**	**Reliability = Firm**
Land Impacted:	**367**	**acres**	

Additional Considerations per
Regional Water Planning Guidelines



Environmental Factors:

Conversion of existing habitats and land uses within the pipeline right-of-way and off-channel reservoir site.

Impacts on Water Resources:

Potential effects to water levels in the aquifer, baseflow in streams and wetlands.

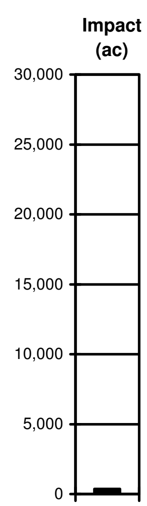
Impacts on Agricultural & Natural Resources:

None anticipated.

Other Relevant Factors per SCTRWPG:

Part or all of the water needed by this Water Management Strategy (WMS) is anticipated to be supplied from locations within the jurisdiction of a groundwater conservation district (District) and may exceed the amount of available water identified in the District's approved management plan, or may for other reasons not be permitted by the District. The amount of water needed by this WMS that exceeds the available water in the District's management plan, or for other reasons is not permitted by the District, cannot be implemented as part of this WMS unless and until all necessary permits are received from the District. The amount of water needed by this WMS that exceeds the available water in the District's management plan, or for other reasons is not permitted by the District, introduces an added element of uncertainty to reliance upon this WMS and, therefore, additional management supplies may be needed for this WMS.

Permits required by GCUWCD include, an analyses of pumping impacts on groundwater levels, mitigation to existing well owners, Drought and Water Conservation Plans and a needs assessment.



Comparison of Strategies to Meet Needs:

Options to meet needs are limited; this option has a moderate unit cost. Strategy may exceed the available water in the District's management plan.

Interbasin Transfer Issues:

Not applicable.

Third-Party Impacts of Voluntary Transfers:

Not applicable.

Regional Efficiency:

Provides long-term water supplies throughout the GBRA statutory district.

Water Quality Considerations:

None of significant concern.

4C.36 TWA Regional Carrizo

4C.36.1 Description of Water Management Strategy

The Texas Water Alliance (TWA) is currently securing groundwater leases in Northeastern Gonzales County to deliver up to 27,000 acft/yr of Carrizo Aquifer groundwater to entities in Gonzales, Guadalupe, and Comal Counties (Figure 4C.36-1). The TWA Regional Carrizo project would pump 27,000 acft/yr of treated groundwater from a well field to Gonzales County Water Supply Corporation (WSC) (500 acft/yr), Spring Hills WSC 3,000 acft/yr), and Canyon Lake Water Service Company (12,000 acft/yr). The remaining 11,500 acft/yr is available to meet needs of other Water User Groups within proximity of the pipeline route. The 85-mile transmission pipeline route illustrated in Figure 4C.36-1 represents the most advantageous route between the well field and the Gonzales County WSC, Spring Hill WSC, and Canyon Lake Water Service Company delivery points. The well field includes 17-1,200 gpm (averaging 985 acft/yr) Carrizo wells and two standby well.

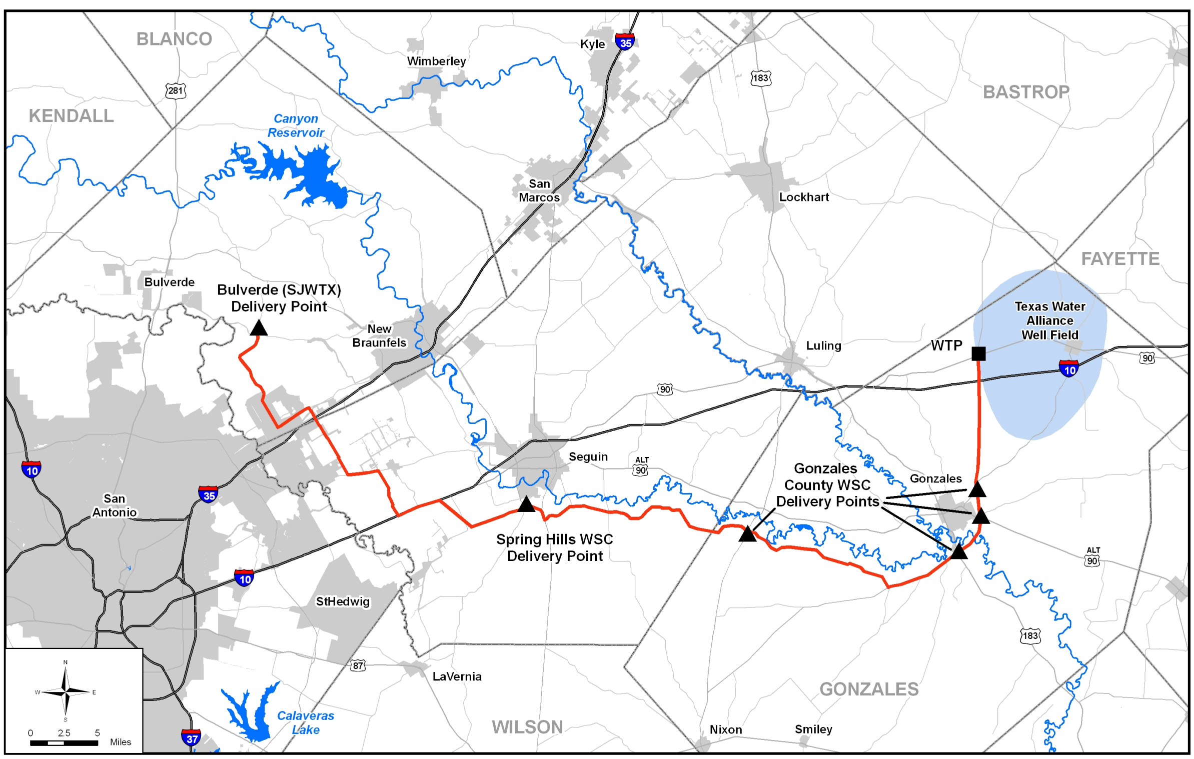


Figure 4C.36-1. Location of the TWA Regional Carrizo WMS

4C.36.2 Groundwater Availability

According to GCUWCD rules, 27,000 acres would need to be leased or purchased for the project (i.e., 1 acft per acre allowable production rate) and wells of this capacity would be subject to a setback of 6,000 feet from existing registered Carrizo wells. The proposed well field was selected based on aquifer parameters including depth to water bearing zone, minimizing drawdown interference among wells, and spacing setbacks from existing Carrizo wells in the Gonzales County Underground Water Conservation District (GCUWCD) registered well database. Groundwater modeling was not part of this water management strategy. However, a similar strategy (Regional Carrizo for Guadalupe Basin) included modeling. Results can be found in Section 4C.17.

4C.36.3 Environmental Issues

Environmental issues for the proposed groundwater TWA Regional Carrizo water management strategy are described below. This project includes the development of a well field in Gonzales County, an associated water treatment plant, additional pump and booster stations, and an approximately eighty-six mile transmission pipeline. Implementation of this project would require field surveys by qualified professionals to document vegetation/habitat types, waters of the U.S. including wetlands, and cultural resources that may be impacted. Where impacts to protected species habitat or significant cultural resources cannot be avoided, additional studies would be necessary to evaluate habitat use and/or value, or eligibility for inclusion in the National Register of Historic Places, respectively. Compensation would be required for unavoidable adverse impacts involving net losses of wetlands.

The proposed pipeline would cross the San Marcos and Guadalupe Rivers and their associated tributaries, and a number of creeks including Cibolo Creek. The Texas Parks & Wildlife Department (TPWD) has identified a number of stream segments throughout the state as ecologically significant on the basis of biological function, hydrologic function, riparian conservation, exceptional aquatic life uses, and/or threatened or endangered species.[1] Currently, 21 stream segments in Region L have been designated as ecologically significant by the Regional Water Planning Group. The portion of the San Marcos River crossed by the proposed pipeline is listed by the state as ecologically significant. This portion of the San Marcos River includes

[1]TPWD, "Ecologically Significant River and Stream Segments," http://www.tpwd.state.tx.us/landwater/water/environconcerns/water_quality/sigsegs/index.phtml accessed February, 2010.

one of the only four populations known of the Golden Orb freshwater mussel, a species listed as threatened by the State. Coordination with the U.S. Army Corps of Engineers would be required for construction within any waters of the U.S. Impacts from this proposed project which result in a loss of less than 0.5 acres of waters of the U.S. could be covered under Nationwide Permit #12 for Utility Line Activities.

The TWA Regional Carrizo water management strategy involves the construction of approximately 86 miles of pipeline from a well field in northeast Gonzales County to a delivery point near Canyon Lake in Comal County. The pipeline traverses through the East Central Texas Plains, Texas Blackland Prairie, and Edwards Plateau Ecoregions[2] and lies within portions of the Texan, Tamaulipan and Balconian Biotic Provinces[3].

Vegetation within the project transmission pipeline area includes a mosaic of Live-Oak Mesquite-Ashe Juniper Parks, Live-Oak Ash Juniper Woods, and Live-Oak Ashe Juniper Parks near its westernmost termination point. The central portion of the pipeline route crosses primarily cropland, and the eastern portion of the transmission pipeline and the well field area includes areas of Post Oak-Wood, Forest and Grassland Mosaic; and Post Oak Woods/Forest vegetation.[4]

Table 4C.36-1 lists the 24 state listed endangered or threatened species, and the 10 federally listed endangered or threatened species along with species of concern that may occur in Caldwell, Comal, Gonzales, or Guadalupe Counties. This information comes from the county lists of rare species published by Texas Parks and Wildlife Department (TPWD) online in the "Annotated County Lists of Rare Species." Inclusion in this table does not mean that a species will occur within the project area, but only acknowledges the potential for its occurrence in the project area counties.

In addition to the county lists, data received from the Natural Diversity Database (NDD), which is maintained by TPWD, was reviewed for known occurrences of listed species within or near the project area. This database documents occurrences of the Cagle's Map Turtle, Cascade Caverns salamander, and Comal blind salamander; all state listed threatened species near the

[2] Griffith, G.E., Bryce, S.A., Omernik, J.M., Comstock, J.A., Rogers, A.C., Harrison, B., Hatch, S.L., and Bezanson, D., 2004, Ecoregions of Texas (color poster with map, descriptive text, and photographs): Reston, Virginia, U.S. Geological Survey (map scale 1:2,3000,000).
[3] Blair, W. Frank, "The Biotic Provinces of Texas," Texas Journal of Science 2(1):93-117, 1950.
[4] McMahan, Craig A., Roy G. Frye and Kirby L. Brown. 1984. The Vegetation Types of Texas Including Cropland. Wildlife Division, Texas Parks and Wildlife Department, Austin, Texas.

Table 4C.36-1. Threatened and Endangered Species in Caldwell, Comal, Gonzales, and Guadalupe Counties

Common Name	Scientific Name	Impact Value	Multiplier Based on Status	Adjusted Impact	Summary of Habitat Preference	Listing Entity		Potential Occurrence in County
						USFWS	TPWD	
AMPHIBIANS								
Cascade Caverns salamander	*Eurycea latitans complex*	1	2	2	Endemic, subaquatic in Edwards Aquifer Area		T	Resident
Comal blind salamander	*Eurycea tridentifera*	1	2	2	Endemic; springs and waters of caves in Bexar County.		T	Resident
Comal Springs salamander	*Eurycea sp. 8*	0	1	0	Endemic to Comal Springs			Resident
Edwards Plateau spring salamander	*Eurycea sp.7*	0	1	0	Endemic to springs and waters of some caves of this region			Resident
BIRDS								
American Peregrine Falcon	*Falco peregrinus anatum*	0	2	0	Resident and local breeder in West Texas. Migrant across the state.	DL	T	Possible Migrant
Arctic peregrine falcon	*Falco peregrinus tundrius*	0	1	0	Migrant throughout the state.	DL		Possible Migrant
Bald eagle	*Haliaeetus leucocephalus*	0	2	0	Found primarily near rivers and large lakes, migrant.	DL	T	Possible Migrant
Black-capped Vireo	*Vireo atricapillus*	0	3	0	Oak-juniper woodlands,	LE	E	Resident
Golden-cheeked Warbler	*Dendroica chrysoparia*	1	3	3	Juniper-oak woodlands.	LE	E	Resident
Henslow's Sparrow	*Ammodramus henslowii*	0	1	0	Wintering individuals found in weedy or cut-over areas.			Possible Migrant
Interior least tern	*Sterna antillarum athalassos*	0	3	0	Nests along sand and gravel bars in braided streams	LE	E	Resident
Mountain Plover	*Charadrius montanus*	1	1	1	Non-breeding, shortgrass plains and fields			Nesting/Migrant
Western Burrowing Owl	*Athene cunicularia hypugaea*	0	1	0	Open grasslands, especially prairie, plains and savanna			Resident
Whooping Crane	*Grus americana*	0	3	0	Potential migrant	LE	E	Potential Migrant
Wood Stork	*Mycteria americana*	0	2	0	Forages in prairie ponds, ditches, and shallow standing water formerly nested in TX		T	Migrant
Zone-tailed Hawk	*Buteo albonotatus*	0	2	0	Arid open country, often near watercourses		T	Resident
CRUSTACEANS								
Ezell's cave amphipod	*Stygobromus flagellatus*	0	1	0	Known only from artesian wells.			Resident
Long-legged cave amphipod	*Stygobromus longipes*	1	1	1	Subaquatic crustacean, subterranean obligate found in subterranean streams			Resident
Peck's cave amphipod	*Stygobromus pecki*	0	1	0	Small aquatic crustacean. Lives underground in the Edwards Aquifer. Collected at Comal and Hueco Springs.			Resident

Table 4C.36-1 (Continued)

Common Name	Scientific Name	Impact Value	Multiplier Based on Status	Adjusted Impact	Summary of Habitat Preference	Listing Entity USFWS	Listing Entity TPWD	Potential Occurrence in County
FISH								
Blue sucker	*Cycleptus elongatus*	0	2	*0*	Found in larger portions of major rivers in Texas.		T	Resident
Fountain darter	*Etheostoma fonticola*	0	3	*0*	Known only from the San Marcos and Comal rivers. Found in springs and spring-fed streams in dense beds of aquatic plants.	E	E	Resident
Guadalupe Bass	*Micropterus treculi*	*1*	*1*	*1*	Endemic to perennial streams of the Edwards Plateau region.			Resident
Guadalupe darter	*Percina sciera apristis*	*1*	*1*	*1*	Guadalupe River basin, found over gravel and sand raceways of larger streams and rivers.			Resident
INSECTS								
A mayfly	*Campurus decolaratus*	*0*	*1*	*0*	Found in Texas and Mexico, possibly in clay substrates.			Resident
A mayfly	*Pseudocentroptiloides morihari*	*0*	*1*	*0*	Mayflies are distinguished by an aquatic larval stage. Adults are generally found in shoreline vegetation.			Resident
Comal Springs diving beetle	*Comaldessus stygius*	*0*	*1*	*0*	Known only from the outrlows at Comal Springs.			Resident
Comal Springs dryopid beetle	*Stygoparnus comalensis*	*0*	*3*	*0*	These beetles usally cling to objects in streams.	LE		Resident
Comal Springs riffle beetle	*Heterelmis comalensis*	*0*	*3*	*0*	Found in Comal and San Marcos Springs.	LE		Resident
Edwards Aquifer diving beetle	*Haideoporus texanus*	*0*	*1*	*0*	Habitat poorly known, found in an artesian well in Hays County.			Resident
Rawson's metalmark	*Calephelis rawsoni*	*1*	*1*	*1*	Moist areas in shaded limestone outcrops			Resident
MAMMALS								
Black Bear	*Ursus americanus*	0	2	*0*	Inhabits bottomland hardwoods	T/SA;NL	T	Historic Resident
Cave Myotis Bat	*Myotis velifer*	0	1	*0*	Roosts colonially in caves, rock crevices			Resident
Jaguarundi	*Herpailurus yaguarondi*	0	3	*0*	Prefers thick brushlands near water.	LE	E	Possible Migrant
Plains Spotted Skunk	*Spilogale putorius interrupta*	1	1	*1*	Prefers wooded, brushy areas.			Resident
Red Wolf	*Canis rufus*	0	3	*0*	Extirpated.	LE	E	Historic Resident
MOLLUSKS								
Creeper (squawfoot)	*Strophitus undulates*	0	1	*0*	Small to large streams			Resident
False spike mussel	*Quincuncina mitchelli*	1	2	*2*	Substrates of cobble and mud with water lilies present. Rio Grande, Brazos, Colorado and Guadalupe river basins.		T	Resident
Golden orb	*Quadrula aurea*	1	2	*2*	Sand and gravel, Guadalupe, San Antonio, and Nueces River basins		T	Resident
Horsehoe liptooth snail	*Daedalochila hippocrepis*	0	1	*0*	Terrestrial snail known only from Landa Park in New Braunfels.			Resident

Table 4C.36-1 (Continued)

Common Name	Scientific Name	Impact Value	Multiplier Based on Status	Adjusted Impact	Summary of Habitat Preference	Listing Entity		Potential Occurrence in County
						USFWS	TPWD	
Palmetto pill snail	*Euchemotrema leai cheatumi*	0	1	*0*	Terrestrial snail known only from Palmetto State Park.			Resident
Pistolgrip	*Tritogonia verrucosa*	0	1	*0*	Aquatic, stable substrate. Red through San Antonio river basins.			Resident
Rock pocketbook	*Arcidens confragosus*	1	1	*1*	Mud and sand, Red through Guadalupe River basins.			Resident
Texas fatmucket	*Lampsilis bracteata*	1	2	*2*	Streams and rivers on sand, mud and gravel, Colorado and Guadalupe River basins.		T	Resident
Texas pimpleback	*Quadrula petrina*	1	2	*2*	Mud, gravel and sand substrates, Colorado and Guadalupe river basins		T	Resident
PLANTS								
Big red sage	*Salvia penstemonoides*	1	1	*1*	Endemic; moist to seasonally wet clay or silt soils in creek beds.			Resident
Bracted twistflower	*Streptanthus bracteatus*	1	1	*1*	Endemic: found in shallow, well-drained gravelly clays and clay loams over limestone.			Resident
Canyon mock-orange	*Philadelphus ernestii*	1	1	*1*	Texas endemic, usually found on outcrops of limestone.			Resident
Comal snakewood	*Colubrina stricta*	0	1	*0*	Found in El Paso County, historic in Comal County.			Historic Resident
Elmendorf's onion	*Allium elmendorfii*	1	1	*1*	Endemic, in deep sands			Resident
Hill Country wild-mercury	*Argythamnia aphoroides*	1	1	*1*	Endemic: found in grasslands associated with oak woodlands.			Resident
Park's jointweed	*Polygonella parksii*	1	1	*1*	Endemic; deep loose sands of Carrizo and similar Eocene formations.			Resident
Sandhill woolywhite	*Hymenopappus carrizoanus*	1	2	*2*	Found south of the Guadalupe River and the Balcones Escarpment. Prefers dense riparian corridors.		T	Resident
Shinner's sunflower	*Helianthus occidentalis ssp.*	1	1	*1*	Found mostly in prairies on the Coastal Plain, Pineywoods and South Texas Brush County.			Resident
Texas mock-orange	*Philadelphus texensis*	*0*	*1*	0	Found on limestone outcrops on cliffs and rocky slopes.			Resident
REPTILES								
Cagle's map turtle	*Graptemys caglei*	1	2	*2*	Endemic to the Guadalupe River System. Found in short stretches of shallow water.		T	Resident
Spot-tailed earless lizard	*Holbrookia lacerata*	1	1	*1*	Moderately open prairie-brushland.			Resident
Texas Garter Snake	*Thamnophis sirtalis annectens*	1	1	*1*	Wet or moist microhabitats			Resident
Texas Horned Lizard	*Phrynosoma cornutum*	1	2	*2*	Varied, sparsely vegetated uplands.		T	Resident

Table 4C.36-1 (Concluded)

Common Name	Scientific Name	Impact Value	Multiplier Based on Status	Adjusted Impact	Summary of Habitat Preference	Listing Entity		Potential Occurrence in County
						USFWS	TPWD	
Texas Tortoise	*Gopherus berlandieri*	1	2	*2*	Open brush w/ grass understory.		T	Resident
Timber/Canebrake Rattlesnake	*Crotalus horridus*	1	2	*2*	Floodplains, upland pine, deciduous woodlands, riparian zones.		T	Resident

LE/LT=Federally Listed Endangered/Threatened
DL, PDL=Federally Delisted/Proposed for Delisting
T/SA=Listed as Threatened by Similarity of Appearance
E, T=State Listed Endangered/Threatened T*= in process of being listed as threatened by State
Blank= Species of concern, but no regulatory listing status
Source: TPWD, 2010. Annotated County List of Rare Species – Caldwell County. Revised May 7, 2009.
Comal County. Revised Sept. 24, 2009. Gonzales County Revised May 4, 2009. Guadalupe County, Revised May 7, 2009.

pipeline route. In addition, the endangered Golden-cheeked Warbler, a species listed both by the federal and state governments as endangered, has documented occurrences near the western terminus of the pipeline. Other species of concern which are documented near the well field or pipeline area include the Guadalupe bass, Sinner's sunflower, mountain plover, bracted twistflower, big red sage, and Texas mock-orange which are all species of concern but with no regulatory status. A survey of the project area may be required prior to pipeline construction to determine whether populations of or potential habitats used by listed species occur in the area to be affected. Coordination with TPWD and USFWS regarding threatened and endangered species with potential to occur in the project area should be initiated early in project planning.

Cultural resources protection on public lands in Texas is afforded by the Antiquities Code of Texas (Title 9, Chapter 191, Texas Natural Resource Code of 1977), the National Historic Preservation Act (Pl96-515), and the Archeological and Historic Preservation Act (PL93-291).
A review of the Texas Historical Commission Texas Historic Sites Atlas database indicated that there are a number of historical markers, National Register Properties, and cemeteries listed near the proposed pipeline route and well field areas. Avoidance of these areas should be possible by careful selection of the pipeline route and well field areas.

A review of archaeological resources in the proposed project area should be conducted during the project planning phase. The owner or controller of the project will likely be required to coordinate with the Texas Historical Commission regarding whether the project will affect waters of the United States or wetlands. The project sponsor will also be required to coordinate with the U.S. Army Corps of Engineers regarding impacts to cultural resources.

4C.36.4 Engineering and Costing

Conceptual planning-level engineering and cost estimates are prepared for the TWA Regional Carrizo and include groundwater lease fees at an estimated $100/acft/yr (combined minimum annual and production fees). The total annual cost includes the debt service for the project cost, the operation and maintenance costs, power costs, Gonzales County Underground Water Conservation District (GCUWCD) fees estimated at $10/acft/yr, and groundwater lease annual minimum and production fees at $50/acft/yr each. The total annual unit cost in dollars per acft is the total annual cost divided by the associated dependable, firm water supply of 27,000 acft/yr.

The transmission pipeline will require two booster pump stations and will cross the Guadalupe River downstream of the confluence with the San Marcos River. The transmission pipeline is assumed to be sized at 42 inches in diameter for the segment from the well field to the Gonzales County WSC delivery point. From the Gonzales County delivery point to the second booster pump location, the pipeline will be sized at a 36-in diameter. The diameter of remaining section from the second booster pump station to the Bulverde delivery point is reduced to 33-in.

The costs are estimated for the annual costs, including debt service for a 20-year loan at 6 percent interest and operation and maintenance costs, including power. The total project costs for the TWA Regional Carrizo is $313,060,000 (Table 4C.36-2). The annual costs for this option under average conditions are $41,130,000 with a unit cost of $1,523/acft.

4C.36.5 Implementation Issues

Part or all of the water needed by this Water Management Strategy (WMS) is anticipated to be supplied from locations within the jurisdiction of a groundwater conservation district (District) and may exceed the amount of available water identified in the District's approved management plan, or may for other reasons not be permitted by the District.

The amount of water needed by this WMS that exceeds the available water in the District's management plan, or for other reasons is not permitted by the District, cannot be implemented as part of this WMS unless and until all necessary permits are received from the District.

Table 4C.36-2.
Cost Estimate Summary
Regional Carrizo for Guadalupe Basin
Sept 2008 Prices

Item	Estimated Costs for Facilities
Capital Costs	
Transmission Pipeline (89 miles)	$113,218,000
Transmission Pump Station	$8,596,000
Booster Pump Stations	$17,566,000
Well Fields	$35,819,000
Water Treatment Plant (24.1 MGD)	$5,610,000
Integration	$31,981,000
Total Capital Cost	**$212,790,000**
Engineering, Legal Costs and Contingencies	$68,815,000
Environmental & Archaeology Studies and Mitigation	$2,572,000
Land Acquisition and Surveying (367 acres)	$3,378,000
Interest During Construction (2 years)	$2,500,000
Groundwater Lease Signing Fee	$23,005,000
Total Project Cost	**$313,060,000**
Annual Costs	
Debt Service (6 percent, 20 years)	$27,294,000
Operation and Maintenance	
Intake, Pipeline, Pump Station	$2,437,000
Water Treatment Plant	$1,763,000
Pumping Energy Costs (74,077,000 kW-hr @ 0.09 $/kW-hr)	$6,666,000
Gonzales County Fees ($110/acft)	$2,970,000
Total Annual Cost	**$41,130,000**
Available Project Yield (acft/yr)	27,000
Annual Cost of Water ($ per acft)	$1,523
Annual Cost of Water ($ per 1,000 gallons)	$4.67

The amount of water needed by this WMS that exceeds the available water in the District's management plan, or for other reasons is not permitted by the District, introduces an added element of uncertainty to reliance upon this WMS and, therefore, additional management supplies may be needed for this WMS.

- GCUWCD permits:
  - Analyses of pumping impacts on groundwater levels.
  - Mitigation of impacts on existing well owners.
  - Drought and Water Conservation Plans, and
  - Needs assessments.
- Impact on:
  - Endangered and threatened wildlife species,
  - Water levels in the aquifer, including dewatering of the current artesian part of the aquifer,
  - Baseflow in streams, and
  - Wetlands.
- Securing groundwater leases.
- Competition with others in the area for groundwater.
- Regulations by the GCUWCD, including periodic renewal of permits and potential pumping cutbacks.
- Obtaining TCEQ permits.

Appendix A
Cost Estimation Procedures
South Central Texas Region

Appendix A
Cost Estimation Procedures
South Central Texas Region

The cost estimates of this study are expressed in three major categories: (1) construction costs or capital (structural) costs, (2) other (non-structural) project costs, and (3) annual costs. Construction costs are the direct costs incurred in constructing facilities, such as those for materials, labor, and equipment. “Other” project costs include expenses associated with implementation activities of the project, such as costs for engineering, legal counsel, land acquisition, contingencies, environmental studies and mitigation, and interest during construction. Capital costs and other project costs comprise the total project cost. Operation and maintenance (O&M), energy costs, and debt service payments are examples of annual costs. Major components that may be part of a preliminary cost estimate are listed in Table A-1. Cost estimating procedures used in the technical evaluation of water management strategies for the South Central Texas Region are summarized in the following sections.

Table A-1.
Major Project Cost Categories

<table>
<tr><th colspan="2">Cost Elements</th></tr>
<tr><th>Capital Costs (Structural Costs)</th><th>Other Project Costs (Non-Structural Costs)</th></tr>
<tr><td rowspan="3">1. Pump Stations
2. Pipelines
3. Water Treatment Plants
4. Water Storage Tanks
5. Off-Channel Reservoirs
6. Well Fields
a. Public
b. Irrigation
c. ASR Wells
7. Dams and Reservoirs
8. Relocations
9. Water Distribution System Improvements
10. Other Items</td><td>1. Engineering (Design, Bidding and Construction Phase Services, Geotechnical, Legal, Financing, and Contingencies)
2. Land and Easements
3. Environmental - Studies and Mitigation
4. Interest During Construction</td></tr>
<tr><th>Annual Project Costs</th></tr>
<tr><td>1. Debt Service
2. Operation and Maintenance (excluding pumping energy)
3. Pumping Energy Costs
4. Purchase Water Cost (if applicable)</td></tr>
</table>

A.1 Capital Costs

Capital costs for elements of a water management strategy are determined from reliable cost information. Cost tables are a useful method for estimating the construction costs for a project element quickly and efficiently. Cost tables have been created for planning cost estimates and are presented and discussed throughout this section. The cost tables report all-inclusive costs to construct. For example, the pump station cost table values include the building, pumps, control equipment, all other materials, labor, and installation costs.

The costs for a project element are typically computed by applying a unit cost from the cost tables to a specific unit quantity. Estimates are reported to the nearest thousand dollars. If previous cost estimates are used, a ratio of the Engineering News Record's Construction Cost Index (ENR CCI)[1] values is applied to update the cost to September 2008. For example, based on an average of the monthly index value September 2008 the representative index value would be 8557. The ENR CCI values are based on construction costs, including labor and materials, averaged over 20 cities. The index measures how much it would cost to purchase a hypothetical package of goods and services compared to what it was in a base year. The index values are reported monthly from 1977 to present. Average annual index values are reported from 1908 to 1976.

Capital cost data and cost estimating procedures are presented and discussed for pumping stations, pipeline, water treatment plants, storage tanks, off-channel reservoirs, well fields, dams and reservoirs, relocations, water distribution system improvements, and settling basins.

A.1.1 Pumping Stations

Intake and transmission pump station construction costs vary according to the discharge and pumping head requirement, and structural requirements for housing the equipment and providing proper flow conditions at the pump suction intake. The cost tables provided herein are based on the station size (in horsepower) necessary to deliver the peak flow rate. Pump station costs are listed in millions of dollars in Table A-2 for a range of horsepower requirements. The costs include those for pumps, housing, motors, electric control, site work, and all materials needed. The costs in Table A-2 were estimated using generalized cost data related to station horsepower from actual construction costs of equipment installed. The cost for an intake

[1] ENR: Engineering News Record, http://www.enr.com/.

Table A-2.
Pumping Station Construction Costs* (Without Intake Structures)

Pump Station (HP)	Pump Station Cost ($-millions)	Pump Station (HP)	Pump Station Cost ($-millions)
< 300	2.07	6,000	11.29
300	2.07	7,000	12.27
400	2.62	8,000	13.19
1,000	4.29	9,000	14.05
2,000	6.24	10,000	14.87
3,000	7.76	15,000	18.51
4,000	9.07	20,000	21.63
5,000	10.23	> 20,000	See Note

*Values are current as of September 2008.
NOTE: Pump Stations larger than 20,000 HP necessitate an individual cost estimate.

structure is included when pumping from a raw water source, such as a river or reservoir. Based on costs of actual projects, the intake structure cost is estimated as 50 percent of the intake pump station cost. The cost of bringing power to each pump station is estimated as $135/HP, with a minimum cost of $50,000. Power connection costs are calculated for each pump station and for well pumps. Costs for pump stations located at water treatment plants are included in the capital cost table for water treatment plants (Table A-5).

A.1.2 Pipelines

Pipeline construction costs are influenced by pipe materials, bedding requirements, geologic conditions, urbanization, terrain, and special crossings. For technical evaluation of water management strategies, pipeline costs are obtained from Table A-3, which shows unit costs based on the pipe diameters from 12-inches to 120-inches, soil type, and level of urban development. In the case of a high-pressure pipeline (>150 psi), the unit cost is increased by 13 percent for the length of pipe designated as high-pressure class pipe. The unit costs listed in Table A-3 represent the installed cost of the pipeline and appurtenances, such as markers, valves, thrust restraint systems, corrosion monitoring and control equipment, air and vacuum valves, blow-off valves, erosion control, revegetation of right-of-way, fencing, and gates.

Table A-3.
*Pipeline Unit Construction Cost within Various Soil Environments**

Pipe Diameter (inches)	Soil		Combination Rock and Soil		Rock	
	Rural ($/ ft)	Urban ($/ ft)	Rural ($/ ft)	Urban ($/ ft)	Rural ($/ ft)	Urban ($/ ft)
12	51	80	62	96	75	113
14	57	91	71	109	86	127
16	64	102	80	123	94	140
18	72	112	89	134	105	153
20	82	119	94	144	112	166
24	110	135	105	162	136	202
27	132	155	119	184	163	240
30	155	173	134	203	190	281
33	179	201	155	239	222	331
36	204	228	178	273	248	372
42	256	291	224	348	315	468
48	312	361	277	433	370	554
54	371	441	336	525	435	654
60	434	521	399	620	500	749
64	478	578	443	688	545	815
66	501	609	469	728	570	852
72	571	700	538	835	645	970
78	645	799	605	954	740	1,107
84	723	905	697	1,079	837	1,251
90	804	1,023	787	1,219	946	1,415
96	888	1,148	885	1,370	1,063	1,566
102	977	1,275	981	1,520	1,175	1,763
108	1,068	1,409	1,085	1,680	1,302	1,952
114	1,164	1,549	1,190	1,849	1,430	2,144
120	1,263	1,698	1,307	2,024	1,568	2,349
132	1,600	2,144	1,648	2,560	1,984	2,960
144	1,900	2,546	1,957	3,040	2,356	3,515

* * Values as of September 2008.

NOTE: Add 13 percent to unit price for length of pipe with pressure class > 150 psi.

Additional costs are included for pipeline installation when crossing roads, streams, or rivers. Some form of trenchless technology will likely be used to install the pipeline when obstructions (e.g., larger streams, major roads, railways, rivers, and structures) are encountered. The two trenchless technologies included herein are: (1) pipe jacking utilizing boring and/or tunnel techniques to excavate the soil, and (2) horizontal directional drilling. Table A-4 shows costs that are used to estimate pipeline borings and tunneling.

Table A-4.
Crossing Costs with Boring or Tunneling Construction*

Pipe Diameter (inches)	Tunneling Cost ($/inch diameter/ft)
≤48	23
54	22
60	21
66	20
72	19
78	18
≥84	17

* Values current as of September 2008.

A.1.3 Water Treatment Plants

Water treatment plant construction costs shown in Table A-5 are based on plant capacity for seven different types or levels of treatment. It is not the intent of these cost estimating procedures to establish an exact treatment process, but rather to estimate the cost of a general process appropriate for bringing the source water quality to the required standard of the receiving system (i.e., potable water distribution system, a stream in an aquifer recharge zone, or an aquifer injection well). Table A-6 gives a description of the processes involved in each treatment level. The costs in Table A-5 include costs for all processes required, site work, buildings, storage tanks, sludge handling and disposal, clearwell, pumps, and equipment. The costs assume pumping through the plant as follows: Levels 2 through 6 treatment plants include raw water pumping into the plant for a total pumping head of 100 feet, and finished water pumping for 300 feet of total head. Levels 0 and 1 treatments include only finished water pumping at 300 feet of head.

Table A-5.
Water Treatment Plant Construction Costs*

Capacity (MGD)	Level 0 Capital Cost ($)	Level 1 Capital Cost ($)	Level 2 Capital Cost ($)	Level 3 Capital Cost ($)	Level 4 Capital Cost ($)	Level 5 Capital Cost ($)	Level 6 Capital Cost ($)
1	61,901	806,582	4,086,505	5,064,198	8,630,163	3,028,033	4,796,619
10	186,773	3,356,695	10,986,401	19,659,747	33,563,470	16,011,061	24,907,583
50	550,941	9,748,927	27,768,136	66,497,646	103,889,408	59,046,648	91,510,915
75	737,715	14,065,482	35,760,670	95,408,275	143,846,718	84,637,548	133,447,835
100	909,884	17,232,725	42,472,587	115,648,118	191,795,088	111,461,099	173,040,039
150	1,226,889	26,371,758	54,939,241	173,469,377	287,691,962	163,420,005	251,782,301
200	1,519,242	30,367,288	61,333,081	213,945,378	383,590,175	214,695,594	329,224,921

* Values current as of September 2008.

A.1.4 Storage Tanks

Ground storage tanks may be used for stand-alone storage, as part of a distribution system, or as part of a pumping station. The construction costs for storage tanks are listed in Table A-7 as cost per million gallons of capacity. A storage tank should be included at each transmission pump station along a pipeline. It is assumed that storage tanks at these stations will provide storage for 5 percent of the daily flow.

A.1.5 Off-Channel Reservoirs

An off-channel reservoir is a reservoir located away from a main river channel that receives little or no natural inflow. Off-channel reservoirs are built by placing a dam across a minor tributary or by constructing a ring dike that has no associated tributary. The capacity of these reservoirs is typically used for storing water that is pumped from another location, such as a nearby river. Because natural inflow is an insignificant factor, spillway requirements are minimal. The values in Table A-8 are used for a construction cost estimate for an off-channel reservoir. In this regional water plan, the cost of ring dikes is used for all off-channel reservoirs.

Table A-6.
Water Treatment Level Descriptions

Level 0:	Disinfection Only - This treatment process will be used for groundwater with no contaminants that exceed the regulatory limits. Assumes groundwater does not require treatment for taste and odor reduction and groundwater is stable and requires no treatment for corrosion stabilization. With this treatment, the groundwater is suitable for public water system distribution, aquifer injection, or delivery to the recharge zone.
Level 1:	Groundwater Treatment - This treatment process will be used for groundwater to lower the iron and manganese content and to disinfect. The process includes application of an oxidant and addition of phosphate to sequester iron and manganese. Chlorine disinfection is the final treatment. With this treatment, the groundwater is suitable for public water system distribution, aquifer injection, or delivery to the recharge zone.
Level 2:	Direct Filtration Treatment - This treatment process will be used for treating groundwater from sources where iron, manganese, or other constituent concentrations exceed the regulatory limit and require filtration for solids removal. Assumes turbidity and taste and odor levels are low. In the direct filtration process, low doses of coagulant and polymer are used and settling basins are not required as all suspended solids are removed by filters. The process includes alum and polymer addition, rapid mix, flocculation, filtration, and disinfection. Water treatment with this process is suitable for aquifer injection or for delivery to the recharge zone.
Level 3:	Surface Water Treatment - This treatment process will be used for treating all surface water sources to be delivered to a potable water distribution system. The process includes coagulant and polymer addition, rapid mix, flocculation, settling, filtration, and disinfection with chlorine. This treatment process also applies for difficult to treat groundwater containing high concentrations of iron (greater than 3 mg/l) and manganese requiring settling before filtration.
Level 4:	Reclaimed Water Treatment - This process will be used for treatment where wastewater effluent is to be reclaimed and delivered to a supply system or injected to an aquifer. The concept includes increased treatment of wastewater effluent by phosphorous removal, storage in a reservoir, blending with surface runoff from the reservoir catchment, followed by conventional water treatment. Phosphorous will be removed from the effluent by lime softening including lime feed, rapid mix, flocculation, settling, recarbonation, and filtration. The final treatment assumes ozonation, activated carbon, addition of coagulant and polymer, rapid mix, flocculation, sedimentation, second application of ozone, filtration and disinfection with chlorine. This treatment results in water than can be delivered to a public water system for distribution or injection to the aquifer.
Level 5:	Brackish Groundwater Desalination - Note: This treatment cost does not include pretreatment for solids removal prior to RO membranes. For desalination of a surface water or groundwater containing high solids concentrations, additional solids removal treatment should be included in addition to desalination. (Example: add level 3 treatment costs for a turbid surface water source). This treatment process will be used for treatment of groundwater with total dissolved solids (TDS) exceeding the regulatory limit of 1,000 mg/l. Costs are based on reverse osmosis (RO) membrane desalination of a groundwater with 3,000 mg/l of TDS to lower the treated water TDS below the regulatory limit. The desalination concept includes minimal pretreatment (cartridge filtration, antiscalent addition, acid addition), reverse osmosis membrane system, and disinfection with chlorine. Costs assume desalination concentrate will be discharged to surface water adjacent to treatment plant. With this treatment, the groundwater is suitable for public water system distribution, aquifer injection, and delivery to the recharge zone.
Level 6:	Seawater Desalination - Note: This treatment cost does not include pretreatment for solids removal prior to RO membranes. For desalination of a surface water or groundwater containing high solids concentrations, additional solids removal treatment should be included in addition to desalination. (Example - For desalination of seawater with an intake located on the coast drawing turbid water, cost estimate should include Level 3 treatment plus Level 6). This treatment process will be used for treatment of seawater with total dissolved solids (TDS) exceeding the regulatory limit of 1,000 mg/l. Costs are based on reverse osmosis (RO) membrane desalination of a water with 32,000 mg/l of TDS to lower the treated water TDS below the regulatory limit. The desalination concept includes minimal pretreatment (cartridge filtration, antiscalent addition, acid addition), reverse osmosis membrane system, and disinfection with chlorine. Costs assume desalination concentrate will be discharged to surface water adjacent to treatment plant. With this treatment, the ground water is suitable for public water system distribution, aquifer injection, and delivery to the recharge zone.

Table A-7.
Ground Storage Tank Construction Costs*

Tank Volume (MG)	Cost ($)
0.01	22,777
0.05	79,050
0.10	133,984
0.50	455,545
1.00	777,106
2.00	1,313,041
4.00	2,277,724
6.00	3,081,627
7.50	3,617,562
9.00	4,153,497
* Values current as of September 2008.	

Table A-8.
Off Channel Storage Construction Costs*

Storage Volume (ac-ft)	Off-Channel Reservoir – Ring Dike (Flat) Capital Cost ($)	Off-Channel Reservoir – Rolling Capital Cost ($)	Off-Channel Reservoir – Canyons Capital Cost ($)
500	$3,870,784	$5,416,950	$5,416,950
1,000	$5,419,365	$7,605,944	$7,605,944
2,500	$8,491,988	$11,949,244	$11,949,244
4,000	$10,706,620	$15,079,732	$15,274,239
5,000	$11,954,776	$16,844,061	$17,417,971
10,000	$16,851,907	$23,766,391	$25,188,984
12,500	$18,825,419	$26,556,045	$28,270,633
15,000	$20,609,611	$29,078,085	$31,218,277
17,500	$22,250,345	$31,397,341	$34,031,918
19,000	$23,178,787	$32,709,738	$35,907,752
20,000	$23,777,503	$33,556,052	$36,845,559
22,000	$24,931,611	$35,187,440	$38,855,397
25,000	$26,568,473	$37,501,221	$41,535,034
* Values current as of September 2008.			

A.1.6 Well Fields

The construction costs for public water supply wells are summarized in Table A-9. The costs include well completion, pumps, and other necessary facilities, such as access roads, fencing, and site improvements. The costs for irrigation wells are estimated to be 55 percent of public water supply well costs. Aquifer storage and recovery (ASR) well costs are estimated using the values represented in Table A-10.

Table A-9.
Public and Irrigation Well Construction Costs

Table A-9(a): Public Supply Well Construction Costs*

Well Depth (ft)	Well Capacity (gpm)					
	100	175	350	700	1000	1800
150	$111,207	$168,820	$288,065	$325,581	$405,971	$593,548
300	$150,062	$214,374	$342,998	$392,572	$485,021	$687,337
500	$194,276	$267,968	$407,311	$468,943	$577,470	$799,883
700	$234,472	$316,202	$464,924	$538,615	$660,540	$899,031
1000	$308,163	$404,631	$572,111	$665,899	$814,621	$1,083,929
1500	$431,428	$553,353	$748,969	$878,934	$1,069,190	$1,389,412
2000	$554,693	$700,735	$925,828	$1,091,968	$1,325,099	$1,696,235

* Values current as of September 2008.

Table A-9(b): Irrigation Well Construction Costs*

Well Depth (ft)	Well Capacity (gpm)					
	100	175	350	700	1000	1800
150	$61,633	$95,128	$162,120	$186,237	$235,811	$340,319
300	$81,730	$121,925	$198,296	$234,472	$297,444	$415,350
500	$101,828	$152,741	$237,151	$286,725	$364,436	$502,439
700	$117,906	$175,519	$270,647	$330,940	$423,389	$577,470
1000	$154,081	$226,433	$340,319	$422,049	$539,955	$724,852
1500	$215,714	$313,522	$455,545	$573,451	$732,891	$968,703
2000	$276,007	$397,932	$570,771	$723,512	$927,168	$1,213,893

* Values current as of September 2008.

Table A-10.
ASR Well Construction Costs*

Well Depth (ft)	Well Capacity (gpm)					
	100	175	350	700	1000	1800
150	$123,265	$190,257	$330,940	$373,815	$466,264	$687,337
300	$162,120	$235,811	$385,873	$440,807	$545,314	$782,465
500	$206,335	$290,745	$450,185	$517,177	$639,103	$893,672
700	$247,870	$338,979	$509,138	$586,849	$720,833	$994,160
1000	$320,221	$427,408	$614,986	$714,133	$874,914	$1,177,717
1500	$444,826	$574,790	$791,844	$927,168	$1,129,483	$1,483,200
2000	$566,751	$722,173	$968,703	$1,140,202	$1,385,392	$1,790,023

* Values current as of September 2008.

A.1.7 Dams and Reservoirs

Construction costs for dams and reservoirs are handled individually. Since each reservoir site is unique, costs are based on the specific project requirements. Items included in the estimate consist of the capital (structural) and "other" (non-structural) costs listed in Table A-1. Previous cost estimates are updated to September 2008 prices, using the ENR CCI.

A.1.8 Relocations

Large-scale projects, such as reservoirs, may require the use of lands that contain existing improvements or facilities such as utilities, roads, homes, businesses, and cemeteries. The cost estimating procedures account for either the cost of relocation or outright purchase of these types of improvements and facilities. Because the type of improvements and facilities needing relocation vary significantly from project to project, estimating the costs for relocation items is addressed on an individual project basis.

A.1.9 Water Distribution System Improvements

Introducing treated water to a city or other entity may require improvements to the entity's water distribution system, which is comprised of piping, valves, storage tanks, pump stations, and other equipment used to distribute water throughout the entity's service area.

Cost estimate guidelines were developed specifically for distribution system improvements for the City of San Antonio during the Trans-Texas Water Program, which was completed in 1996. These costs were obtained from a 1991 Black and Veatch report to the San

Antonio City Water Board entitled *"Report on Master Plan for Water Works Improvements"* and include estimated costs for improvements to San Antonio's distribution system to convey treated water from the proposed Applewhite project. For strategies producing up to 50-MGD the annual costs were estimated at $1,327,000 per MGD of capacity (September 2008). Above 50-MGD capacity, the unit cost is estimated at $819,915 per MGD (September 2008).

A.1.10 Stilling Basins

If a water management strategy involves discharging into a water body or perhaps into a recharge structure, it may require a stilling basin. Stilling basin costs, when applicable, were estimated as $3,025 per cfs discharge.

A.2 Other Project Costs

As previously mentioned, "other" (non-structural) project costs are costs incurred in order to implement a project. These include costs for engineering, legal counsel, financing, contingencies, land, easements, surveying and legal fees for land acquisition, environmental and archaeology studies, permitting, mitigation, and interest during construction. These costs are added to the capital costs to obtain the total project cost. The major components of these costs are described below.

A.2.1 Engineering, Legal, Financing, and Contingencies

A percentage applied to the capital costs is used to calculate a combined cost that includes engineering, financial, legal services, and contingencies. The contingency allowance accounts for unforeseen costs and for variances in design elements. In accordance with TWDB guidelines, the percentages used are 30 percent of the total construction costs for pipelines and 35 percent for all other facilities.

A.2.2 Land Acquisition

Land-related costs for a project can typically be divided into two categories: (1) land purchase costs and (2) easement costs. Land areas acquired for various facility types are considered based upon previous project experience. Two types of easements are usually acquired for pipeline construction – temporary and permanent. Permanent easements are those in which the pipeline will reside once constructed. These permanent easements provide access for maintenance and protection from other parallel underground utilities. Temporary easements provide extra working space during construction for equipment movement, material storage, and related construction activities. Pipeline easement costs are estimated using a value of $8,712 per acre ($0.20 per sq-ft), based in large part on recent experience with the Mary Rhodes Pipeline extending from Lake Texana to Corpus Christi. The pipeline area considered in the acquisition cost includes a permanent easement width of 30 to 40 feet, depending upon the pipe size. This value includes costs for the temporary easement.

Land costs vary significantly with location and economic factors. Land costs in Texas are estimated using *"Rural Land Values in the Southwest"*, by Charles E. Gilliland, published biannually by the Real Estate Center at Texas A&M University, College Station, Texas. Other sources of land values, such as county appraisal district records, are also utilized. The land acquisition area estimated for reservoirs includes the acreage inundated by the 100-year or standard project flood.

A.2.3 Surveying and Legal Fees

Ten percent (10 percent) is added to the total land and easement costs to account for surveying and legal fees associated with land acquisition, except for reservoirs and large well fields. The surveying cost for reservoirs is estimated at $50 per acre of inundation.

A.2.4 Environmental and Archaeology Studies, Permitting, and Mitigation

Costs for environmental studies, permitting, and mitigation, as well as archaeological recovery are project-dependent and are estimated on an individual basis using information available and the judgment of qualified professionals. In the case of reservoir strategies, environmental studies and mitigation costs were generally based on 100 percent of the land value for the acreage purchased. The environmental studies and mitigation costs for pipelines were estimated at $25,000 per mile of pipeline.

A.2.5 Interest During Construction

Interest during construction (IDC) is calculated as the cost of interest on the borrowed amount less the return on the proportion of borrowed money invested during construction. In accordance with TWDB guidelines, IDC is calculated as the total of interest accrued at the end of the construction period using a 6 percent annual interest rate on total borrowed funds, less a 4 percent rate of return on investment of unspent funds.

A.3 Annual Costs

Annual costs are those that the project owner can expect to incur if the project is implemented. These costs include repayment of borrowed funds (debt service), operation and maintenance costs of the project facilities, pumping power costs, and water purchase costs, when applicable.

A.3.1 Debt Service

Debt service is the estimated annual payment that can be expected for repayment of borrowed funds based on the total project cost (present worth), an assumed finance rate, and the finance period in years. As specified in TWDB Exhibit B, Section 1.71, debt service for all projects was calculated assuming an annual interest rate of 6 percent and a repayment period of 40 years for reservoir projects and 30 years for all other projects. The debt service factor of 0.06646 or 0.07265 for 40- or 30-year repayment periods is applied, respectively, to the total estimated project costs.

A.3.2 Operation and Maintenance

Operation and maintenance (O&M) costs for dams, pump stations, pipelines, and well fields (excluding pumping power costs) include labor and materials required to operate the facilities and provide for regular repair and/or replacement of equipment. In accordance with TWDB guidelines, O&M costs are calculated at 1 percent of the total estimated construction costs for pipelines, distribution, facilities, tanks and wells, at 1.5 percent of the total estimated construction costs for dams and reservoirs, and at 2.5 percent for intake and pump stations.

Water treatment plant O&M is estimated using Table A-11. The O&M costs listed in Table A-11 include labor, materials, replacement of equipment, process energy, building energy, chemicals, and pumping energy.

Table A-11.
Operation and Maintenance Costs for Water Treatment Plants*

Capacity (MGD)	Level 0 O&M Cost ($)	Level 1 O&M Cost ($)	Level 2 O&M Cost ($)	Level 3 O&M Cost ($)	Level 4 O&M Cost ($)	Level 5 O&M Cost ($)	Level 6 O&M Cost ($)
1	28,137	160,513	287,663	396,016	559,382	340,319	797,203
10	83,472	894,878	1,198,351	1,547,218	4,156,043	2,639,480	6,993,953
50	313,522	3,356,695	5,114,428	6,328,737	18,380,564	12,339,905	33,804,105
75	453,401	5,114,428	7,671,643	9,846,159	28,769,933	18,328,980	50,418,093
100	591,806	6,312,779	9,748,927	12,306,115	38,358,482	24,412,784	66,485,310
150	865,267	10,228,857	14,384,900	17,580,627	57,538,392	36,324,401	97,825,323
200	1,136,048	11,986,724	19,179,911	22,854,992	76,718,303	48,169,023	128,937,554

* Values current as of September 2008..

A.3.3 Pumping Energy Costs

In accordance with TWDB guidelines, power costs are calculated on an annual basis using the appropriate calculated power load and a power rate of $0.06 per kWh. The amount of energy consumed is based on the pumping horsepower required.

A.3.4 Purchase of Water

The purchase cost, if applicable, is included if the water management strategy involves purchase of raw or treated water from an entity or a landowner. This cost varies by source.

A.4 Cost Estimate Presentation

For each individual water management strategy total capital costs, total project costs, and total annual costs are presented. The level of detail is dependent on the characteristics of the water management strategy. Additionally, a summary is calculated, showing the cost per unit of water provided by the management strategy, reported as costs per acft and cost per 1,000 gallons of water developed. The individual management strategy cost tables specify the point within the region at which the cost applies (e.g., raw water at the lake, treated water at the municipal and industrial demand center, or elsewhere as appropriate).

Appendix B
General Assumptions for
Applications of Hydrologic Models

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General Assumptions for Applications of Hydrologic Models

Following are general assumptions for applications of hydrologic models in the technical evaluations of water management strategies for the South Central Texas Regional Water Planning Group. Pertinent exceptions to, or clarifications of, these general assumptions are enumerated in the subsection of Section 4C summarizing the technical evaluation of each water management strategy.

1. Full exercise of surface water rights.
2. Edwards Aquifer permitted pumpage consistent with Senate Bill 3 (80th Texas Legislature). Breakdown of use type and geographical distribution of pumpage is based on EAA permits (including permanent transfers). Minimum permitted Edwards Aquifer supply of 320,000 acft/yr during drought.
3. Operation of Canyon Reservoir at firm yield in accordance with Certificate of Adjudication No. 18-2074E, including subordination of all senior Guadalupe River hydropower permits to Canyon Reservoir.
4. Delivery of GBRA's present contractual obligations from Canyon Reservoir (about 86,000 acft/yr) to points of diversion. Uncommitted yield assumed to be diverted at Lake Dunlap.
5. Effluent discharge / return flow in the Guadalupe - San Antonio River Basin is assumed equal to that reported for 2006, adjusted for current SAWS direct recycled water commitments. Smaller reuse deliveries by San Marcos, New Braunfels, Seguin, Kyle, San Antonio River Authority, and Cibolo Creek Municipal Authority in 2006 are reflected in analyses of cumulative effects of plan implementation.
6. Operation of power plant reservoirs (Braunig, Calaveras, and Coleto Creek) subject to authorized consumptive uses at the reservoir, with makeup diversions as needed to maintain full conservation storage to the extent possible subject to senior water rights, instream flow constraints, and/or applicable contractual provisions.
7. Desired San Antonio River flows at Falls City gage of 55,000 acft/yr under current SAWS/SARA/CPS draft agreement (reporting purposes only).
8. Operation of Choke Canyon Reservoir/Lake Corpus Christi (CCR/LCC) System at firm yield subject to the Corpus Christi Phase 4 (maximum yield) policy and TCEQ Agreed Order regarding freshwater inflows to the Nueces Estuary.
9. Historical Edwards Aquifer recharge estimates developed by EUWD/HDR.[1,2]

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[1] HDR, "Nueces River Basin Regional Water Supply Planning Study, Phase I," Nueces River Authority, May 1991.
[2] HDR, "Guadalupe – San Antonio River Basin Recharge Enhancement Study, Phase I," Edwards Underground Water District, September 1993.

10. Period of record for simulations: Guadalupe-San Antonio River Basin (1934-89, Critical Drought = 1950s) and Nueces River Basin (1934-97, Critical Drought = 1990s).

The following hydrologic models were used in the technical evaluation of water supply, water management strategies, and/or the cumulative effects analyses for the 2011 South Central Texas Regional Water Plan:

- Guadalupe – San Antonio River Basin Water Availability Model (GSA WAM)[3]
- Guadalupe – San Antonio River Basin Water Availability Model, as modified for Regional Planning
- Nueces River Basin Water Availability Model (Nueces WAM)[4]
- Lower Nueces River Basin & Estuary Model (NUBAY)[5]
- Edwards Aquifer (Balcones Fault Zone) Model (GWSIM-IV)[6]
- Southern Carrizo-Wilcox Aquifer Groundwater Availability Model (SCW GAM)[7]
- Central Carrizo-Wilcox Aquifer Groundwater Availability Model (CCW GAM)[8]
- Southern Central Carrizo System Groundwater Model[9]
- Central Gulf Coast Aquifer Groundwater Availability Model (CGC GAM)[10]
- Hydrologic Simulation Package - Fortran[11]

[3] HDR, "Water Availability in the Guadalupe – San Antonio River Basin," Texas Natural Resource Conservation Commission, December 1999.
[4] HDR, "Water Availability in the Nueces River Basin," Texas Natural Resource Conservation Commission, October 1999.
[5] HDR, "Water Supply Update for the City of Corpus Christi Service Area," City of Corpus Christi, January 1999.
[6] Texas Water Development Board, "Summary of a GWSIM-IV Model Run Simulating the Effects of the Edwards Aquifer Authority Critical Period Management Plan for the Regional Water Planning Process," July 1999.
[7] INTERA, Inc., "Groundwater Availability Models for the Queen City and Sparta Aquifers," Texas Water Development Board, October 2004.
[8] Bureau of Economic Geology, "Groundwater Availability Model for the Central Part of the Carrizo Aquifer in Texas," Texas Water Development Board, February 2003.
[9] HDR, "South Central Carrizo System Groundwater Model, SAWS Gonzales-Carrizo Project," San Antonio Water System, November 2004.
[10] TWDB, "Groundwater Availability Model of the Central Gulf Coast Aquifer System: Numerical Simulations through 1999," September 2004.
[11] USGS, "Hydrologic Simulation Program – Fortran User's Manual for Release 11," September 1996.

Appendix C
Technical Evaluation Procedures for Edwards Aquifer Recharge Enhancement

Appendix C
Technical Evaluation Procedures
for Edwards Aquifer Recharge Enhancement

C.1 Introduction

One recommended water management strategies in the 2011 South Central Texas Regional Water Plan involve the enhancement of recharge to the Edwards Aquifer: Edwards Recharge – Type 2 Project (Section 4C.4). Such recharge enhancement is intended not only to increase springflows protecting endangered species and downstream water uses, but also to enhance the reliability of the Edwards Aquifer as a regional water supply. With regard to enhanced water supply, the Edwards Aquifer Authority (EAA) has adopted rules regarding recharge recovery permits, which define the amount of additional authorized pumpage to which the developer of a recharge enhancement project might be entitled.

For the purposes of regional water supply planning under rules set forth by the Texas Water Development Board (TWDB), recharge enhancement strategies are evaluated herein based on the reliable supply available during the drought of record. In this way, recharge enhancement strategies may be considered by the South Central Texas Regional Water Planning Group (SCTRWPG) on the same basis as surface water supply strategies, such as reservoirs and run-of-river diversions. While numerous studies quantifying recharge enhancement on both long-term and drought average bases have been completed in recent years, the quantification of additional reliable supply based on maintenance of springflows during the drought of record has not always been a part of these studies. Hence, the TWDB's model of the Edwards Aquifer is used in this regional water supply planning effort to simulate aquifer performance subject to recharge enhancement, quantify the associated increase in reliable supply, and allow for more direct comparisons between recharge enhancement and other water management strategies. The following paragraphs provide a brief summary of the technical procedures used for evaluation of Edwards Aquifer recharge enhancement strategies.

C.2 Edwards Aquifer Model

In order to simulate aquifer response to recharge enhancement, the TWDB GWSIM4 Edwards Aquifer groundwater flow model (Figure C-1) is used to make the necessary calculations. It is designed to simulate aquifer response in terms of water levels and springflows for specified recharge and pumping rates. The model was developed by the TWDB in the 1970s[1] as a tool for use in developing a water resources management program for the Nueces and Guadalupe - San Antonio River Basins. Originally, the model operated on an annual timestep and was calibrated to data collected from 1947 to 1971. Major assumptions in the model include: (1) no lateral movement of water from the Glen Rose formation in the Hill Country (Trinity Aquifer-Edwards Plateau); (2) no water movement across the so-called 'bad-water line'; and (3) no leakage from underlying or overlying formations except in an area southeast of Uvalde near Leona Springs.

The TWDB recalibrated the model in the early 1990s[2] with information compiled between 1971 and 1989 and refined the timestep to monthly intervals. The recalibration was based on comparisons of water levels and springflows for 1947 to 1959 and "verified" with 1978 to 1989 data. During the process of adjusting the aquifer parameters for recalibration, the model developers gave special emphasis to minimum flow periods at Comal and San Marcos Springs

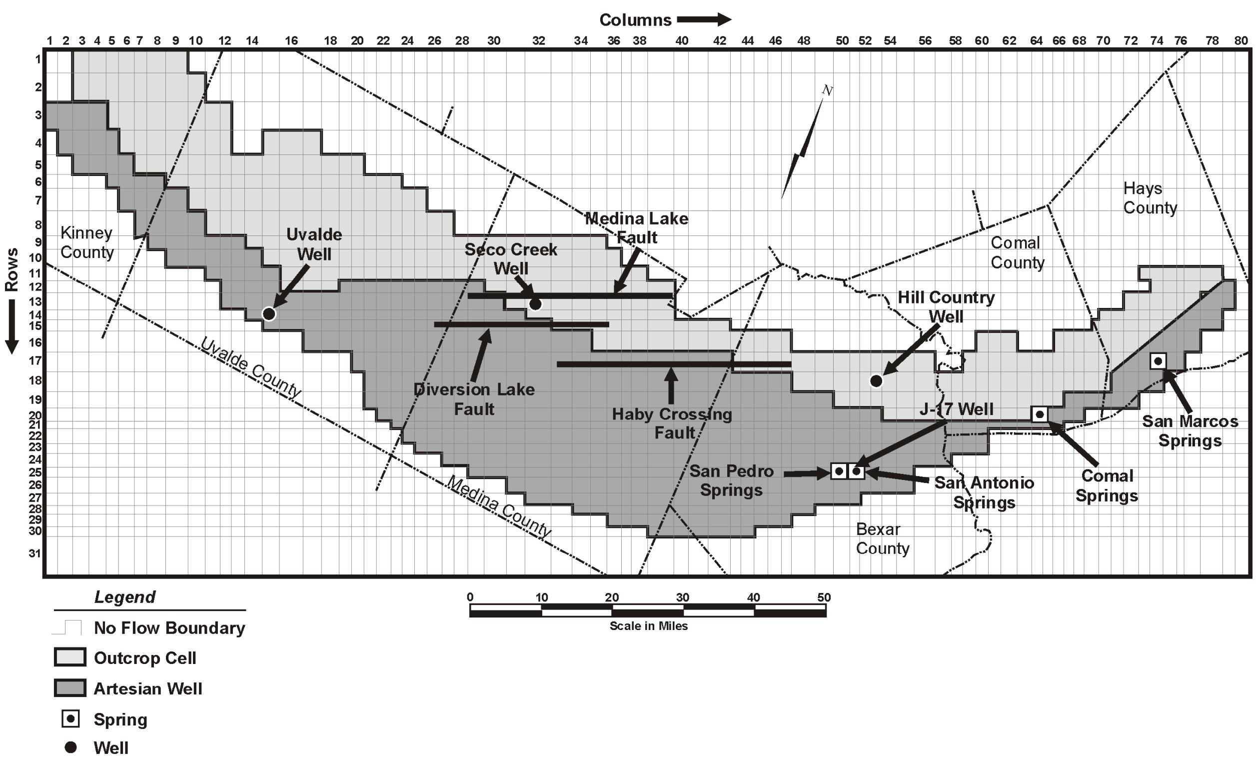


Figure C-1. GWSIM 4 Model for Edwards Aquifer

[1] Klemt, W.B., Knowles, T.R., Elder, G.R., and Sieh, T.W., "Ground-water Resources and Model Applications for the Edwards (Balcones Faulty Zone) Aquifer in the San Antonio Region, Texas," Texas Water Development Board Report 239, 88p., 1979.

and water levels at observation well J-17 in San Antonio. The recalibration did not revise any of the major assumptions used in the original model.

All model simulations for this study are for the 1934 through 1989 historical period and have monthly timesteps. The simulation period includes a severe drought in the 1950s (1947 to 1956) and wetter than normal conditions in much of the 1970s and 1980s, except for short, intense droughts in 1984 and 1989. Historical recharge to the Edwards Aquifer is based upon monthly estimates developed by HDR.[3,4] For the most recent version of GWSIM4, the TWDB used estimates of baseline recharge, developed by HDR, that reflect full utilization of current water rights and recharge enhancement associated with all existing projects as if they existed throughout the 1934 to 1989 historical period. The distributions to specific cells in GWSIM4 were made by the TWDB. Annual estimates of baseline recharge are shown in Figure C-2.

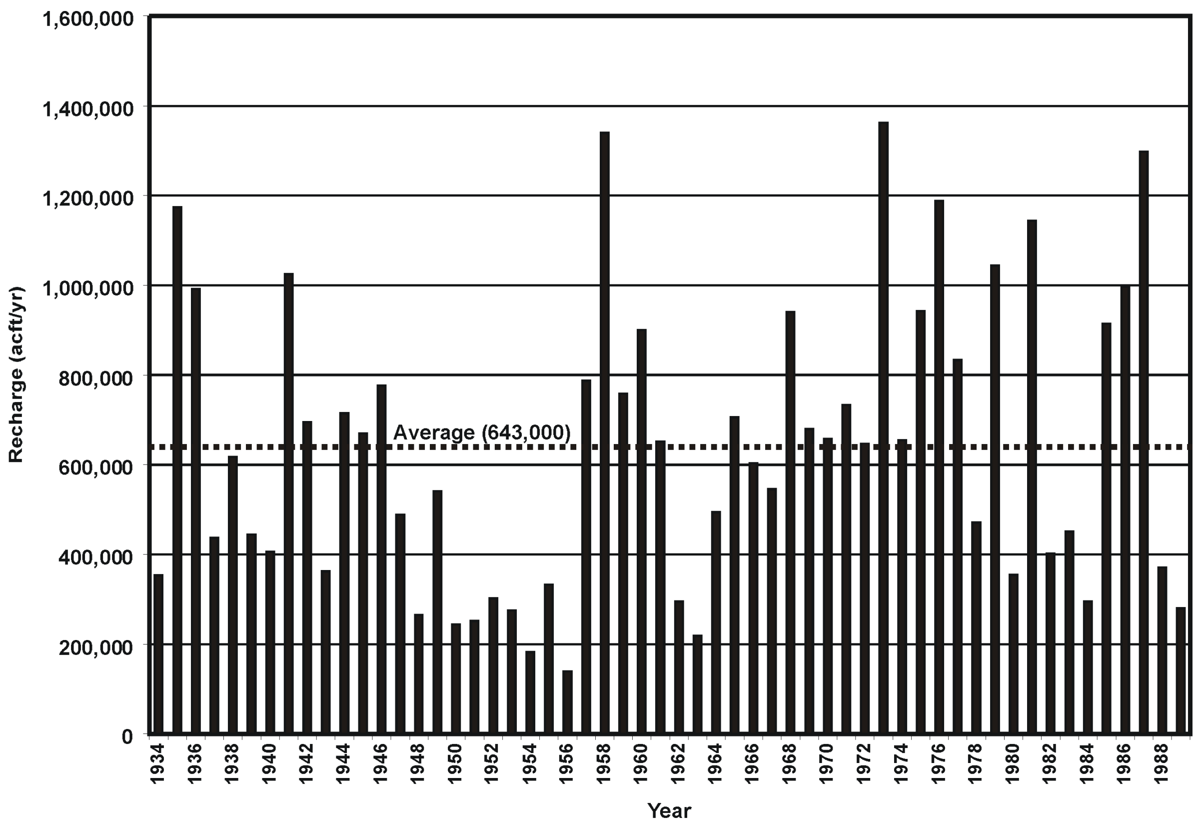


Figure C-2. Edwards Aquifer Recharge

[2] Thorkildsen, D. and McElhaney, P.D.., "Model Refinement and Applications for the Edwards (Balcones Fault Zone) Aquifer in the San Antonio Region, Texas," Texas Water Development Board Report 340, 33p., 1992.
[3] HDR, "Guadalupe-San Antonio River Basin Recharge Enhancement Study," Edwards Underground Water District, September 1993.
[4] HDR, "Nueces River Basin Regional Water Supply Planning Study," Nueces River Authority, et al., May 1991.

Natural water losses from the Edwards Aquifer model are springflow at Leona, San Pedro, San Antonio, Comal, and San Marcos Springs. Springflow is calculated from aquifer heads at the springs and an aquifer head-springflow rating curve for each spring. Another natural loss is cross-formational leakage in an area southeast of Uvalde. This loss is calculated similarly to springflow. The current version of GWSIM4 includes an estimate of discharge to the Guadalupe River (largely associated with Hueco Springs) and is considered a negative (rejected) recharge by the model. The discharge is estimated from a regression equation of streamflow gains and water levels in observation well J-17.

Pumpage is assigned by category to specific cells in the model by the TWDB, based on the locations of permitted wells. For the baseline permitted pumpage, the total pumpage for irrigation, industrial, and municipal purposes in Kinney, Uvalde, Medina, Bexar, Atascosa, Comal, and Hays Counties, is 572,000 acft/yr. Domestic, livestock, and Federal pumpage does not require permits and totals 20,449 acft/yr. Thus, the total annual pumpage used in the model is 592,449 acft/yr. Annual pumpage is distributed to monthly pumpage values by multiplying the annual pumpage for each category by a monthly distribution factor in accordance with type of use.

C.3 Technical Evaluation Procedure

The technical evaluation procedure used in determining the increase in water supply attributable to a recharge enhancement strategy is based on the definitions, assumptions, and steps summarized in the following paragraphs.

Definitions:

- *Baseline Pumpage:* The sum of the regular permitted industrial, municipal, and irrigation pumpage categories adjusted to 572,000 acft/yr plus the unpermitted domestic, livestock, and Federal pumpage. The total is 592,449 acft/yr.
- *Baseline Sustained Yield:* The portion of baseline pumpage that will maintain a minimum monthly flow at Comal Springs of 60 (cfs) in one and only one month of the simulation period. This simulation is performed merely to obtain a baseline estimate of aquifer yield for the "no enhanced recharge" case.
- *Sustained Yield with Recharge Enhancement Project(s)*: The sum of the pumpages for the baseline sustained yield scenario plus an across the board increase in pumpage such that the minimum monthly flow at Comal Springs is 60 cubic feet per second (cfs) in one and only one month of the simulation period.
- *Additional Dependable Supply:* The increase in sustained yield attributable to the recharge enhancement project(s).

Assumptions:

- The GWSIM4 Model provides a reasonable simulation of Edwards Aquifer response (in terms of springflow and water levels) to enhanced recharge and various pumpage rates. Note that the EAA, in cooperation with regional, state, and federal interests, has nearly completed the development of a new model of the Edwards Aquifer.
- Minimum Comal Springs discharge of 60 cfs (in one and only one month of the 56-year simulation period) provides a reasonable point of reference for assessment of potential changes in sustained yield of the Edwards Aquifer associated with recharge enhancement. Note that the selection of 60 cfs as a minimum discharge simply provides a point of reference for consistent computations and does not necessarily imply acceptability under the law.
- The increase in sustained yield of the Edwards Aquifer during the drought of record provides a reasonable basis for consideration of recharge enhancement strategies in a manner consistent with other water management strategies in the regional water planning process.

Steps:

1. Make a baseline GWSIM4 simulation with baseline pumpage and baseline recharge. Count the number of months when flow at Comal Springs (Figure C-3) is less than specified value of interest (60 cfs).
2. Make a series of trial and error GWSIM4 simulations with reductions in baseline pumpage until the flow at Comal Springs is 60 cfs in one and only one month of the simulation period. The final run provides the baseline sustained yield of the Edwards Aquifer (Figure C-3).
3. Calculate the enhanced recharge provided by the water management strategy using a surface water model.
4. Add the baseline recharge and the enhanced recharge.
5. Make a series of trial and error GWSIM4 simulations (including enhanced recharge) with the baseline sustained yield pumpage plus across the board increases in pumpage until the flow at Comal Springs is 60 cfs in one and only one month of the simulation period. The final run provides the sustained yield with the recharge enhancement strategy.

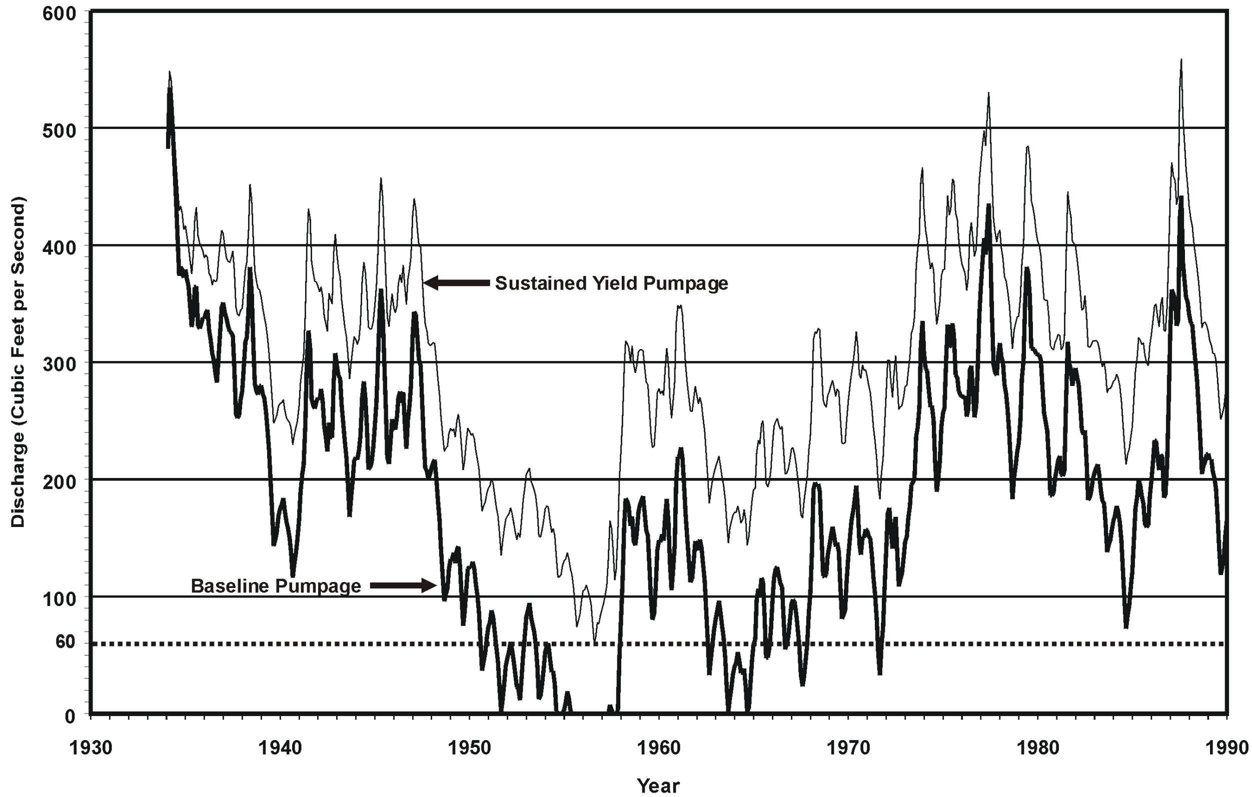


Figure C-3. Comal Springs Discharge Subject to Pumpage Scenarios

6. Calculate the amount of additional dependable supply available during a repeat of the drought of record by subtracting the baseline sustained yield from the sustained yield with recharge enhancement.

Appendix D
The Influence of Juniper Control
in the Upper Guadalupe Watershed
of Region L on Water Yield and Costs

THE INFLUENCE OF JUNIPER CONTROL IN THE UPPER GUADALUPE WATERSHED OF REGION L ON WATER YIELD AND COSTS

Richard Conner, Brad Wilcox, Wayne Hamilton

Abstract

The UGWS encompasses parts of Bandera, Comal, Kendall, Kerr, and Gillespie Counties in the Edwards Plateau MLRA. Our assessment of the influence of juniper (*Juniperus ashei*) control on water yield and costs is based on available literature, surveys of the area and interviews with landowners, River Authorities, Federal and State Agency personnel, other stakeholders and our own experience in the region. In the major regions of the Edwards Plateau (Balcones and Edwards Plateau woodland), Ashe juniper was once largely confined to oak motte understories and sheltered canyons until fire suppression and overgrazing created conditions suitable for invasion elsewhere. During the last century, Ashe juniper has invaded former grasslands and savannas and it is these areas that are targeted for juniper control. Technically feasible mechanical, chemical, prescribed fire and biological juniper control practices and associated costs are included in the report. On the basis of literature available, our current best estimate is that control of juniper in the targeted areas would result in an average increase in water yield (streamflow and recharge) of around 2 inches/year if rainfall is average or above average. Potential watershed monitoring methods and costs are also discussed in the report at different scales. Depending on the level of cost-share from 60 to 95%, we estimate a sponsor's share of total cost (implementation costs plus administrative and monitoring costs) for all counties to range from approximately $12.4million to $43.4 million, respectively. This equates to an estimated $109.75 to $142.82 cost per acre-foot of estimated additional water yield.

JUNIPER CONTROL TECHNOLOGIES FOR USE IN THE UPPER GUADALUPE WATERSHED OF REGION L

Ashe juniper is the dominant brush species of concern in the UGWS and is in mixed stands with oaks (*Quercus spp.*). Selection of the brush control treatment alternatives used depends on the size and density of Ashe juniper and proximity to oak species. Landowners may remove some oak with brush control practices, but oaks are not generally considered in management scenarios. In this report we examine the most technically feasible juniper control practices for the UGWS and their average cost per acre. Mechanical juniper control alternatives are used almost exclusively in the region. Chemical alternatives have very limited application. Biological control of juniper seedlings with goats and prescribed fire are commonly used maintenance-type practices. See Appendix C for descriptions and discussion of the mechanical, chemical, prescribed fire and biological technologies.

POTENTIAL TO AUGMENT RECHARGE AND STREAMFLOW BY JUNIPER CONTROL FOR THE UPPER GUADALUPE WATERSHED: AN ASSESSMENT OF CURRENT LITERATURE

The Upper Guadalupe Watershed is within the Edwards Plateau Region where juniper woodlands and shrublands are the major land cover types. In this report, we summarize the scientific literature addressing the potential for increasing water yield by reducing the cover of juniper dominated woodlands and shrublands.

There is a significant body of work examining how Ashe juniper affects the water cycle. We summarize these findings for the following spatial scales: (1) individual tree or small plot (the space occupied by a single tree); (2) hillslope or stand (large enough to encompass many trees, and thereby to manifest important hillslope processes such as overland flow, depression storage, and sediment deposition); (3) small catchment (large enough to incorporate channel and groundwater flow processes); and (4) landscape (encompasses watersheds of 10 mi^2 or larger).

Tree Scale

Evergreen shrubs such as juniper have a large capacity for capturing precipitation, not only because they retain their leaves year round, but because they have a high leaf area per tree (Hicks and Dugas 1998). Owens *et al.* (2006) estimated that the canopy and litter layer of an Ashe juniper tree together intercept about 40% of the precipitation that falls on the tree annually. At the same time, the percentage varied dramatically depending on the size of the storm: close to 100% of the rainfall from small storms (<0.5in) was captured by interception, whereas a much smaller percentage (around 10%) was intercepted and evaporated during large storms. Transpiration from an Ashe juniper community should be greater than that from an herbaceous community because Ashe juniper transpires throughout the year, typically has a much greater community leaf area, and can access water at greater depths. Owens and Ansley (1997), on the basis of direct measurement of Ashe juniper transpiration rates, concluded that a mature Ashe juniper tree transpired as much as 40 gal/d, which they estimated would be equivalent to 16 in/yr. In summary, dense stands of juniper intercept and transpire large quantities of water. In regions where juniper cover is extensive and dense, therefore, this species can have a major impact on the water cycle at the tree scale. However, because removal of juniper may result in increased growth and density of other vegetation, which would also transpire and intercept water, it is uncertain how much water would be “saved” by juniper removal. As discussed below, larger-scale studies are required to make such an assessment.

Stand Scale

At this scale, the primary measurements of evapotranspiration have been direct estimates made by means of micrometeorological technology. We know of only one such study for Ashe juniper communities: Dugas *et al.* (1998) measured evapotranspiration from an Ashe juniper community using the Bowen ratio/energy balance method. Two paired areas, each 200 x 600 yards in size, were selected for measurement over a 5-year period. After the first 2 years, all Ashe juniper trees were removed from one of the areas by hand-cutting and burning. For the 2-year period following this treatment, the difference in evapotranspiration between the two areas was about

1.6 in/yr; but this treatment effect disappeared in the third year of the study, after which evapotranspiration was similar in the treated and untreated areas.

Small Catchment Scale

Small catchments with springs. Over the past 150 years, many springs in Texas have dried up, perhaps owing to increased groundwater pumping (Brune 2002) and/or the spread of woody plant cover. There are many anecdotal accounts of springs drying following the encroachment of woody plants, and of spring flow returning after woody plant cover was removed or reduced. Increases in discharge from springs or spring-fed catchments following the removal of Ashe juniper have been documented in two studies. Wright (1996), working on a 7.2-ac catchment in the Seco Creek Watershed of central Texas, reported an increase in spring flow from 3 gal/min during the 2-year pre-treatment period to 3.8 gal/min following partial removal of Ashe juniper—this despite the fact that precipitation was lower in the post-treatment period. This increase in flow translates to about 1.6 in/yr of additional water. Similarly, Huang et al. (2006) estimate that runoff from a small spring-fed catchment increased by about 1.8 in/yr after reducing Ashe juniper and other wood canopy cover to approximately 40% of the catchment.

Small catchments without springs. A few studies have examined the effect of juniper removal on small catchments where no springs were present. Richardson et al. (1979) compared runoff from two 9 acre catchments for an 11-year period. Juniper was removed from one of the catchments the fifth year, by root plowing. Surface runoff (presumably generated as Horton overland flow) was about 20% (0.5 in/yr) lower following this treatment, but this was attributed to increased surface roughness that enhanced shallow surface storage. In another paired-catchment study (in the Seco Creek watershed), Dugas *et al*. (1998) found that when juniper cover was removed by hand-cutting, the treatment had little influence on surface runoff from these small (15- and 10-ac) catchments. Runoff accounted for about 5% of total precipitation and occurred only when precipitation intensity was high. Similarly, Wilcox *et al.* (2005) concluded that changes in density of Ashe juniper had little influence on streamflow from small catchments in the western portion of the Edwards Plateau.

Landscape Scale

For Ashe juniper rangelands, no large-scale experiments have been conducted. However, we may be able to infer information from analysis of historical streamflow.

Streamflow data going back to the early 1900s are available for many of the major rivers in Texas. These long-term data can provide insight into the nature and variability of streamflow and the relationship of streamflow to climate. In addition, such records may shed light on the sensitivity of streamflow to landscape-scale changes in vegetation cover. For example, we have good evidence that woody plant cover on the Edwards Plateau increased dramatically during the last century (Smeins et al. 1997). Therefore, if there is indeed a strong connection between streamflow and woody plant cover, we should be able to detect a decrease in streamflow that is independent of precipitation differences.

To date, only a few attempts at such analysis have been made for the Edwards Plateau. One of these studies, by the Lower Colorado River Authority, examined flow from 1939 to 2000 on one of the major rivers in the region, the Pedernales, which drains an area of over 2300 km^2 (LCRA 2000). The results showed no evidence of changes in streamflow that were independent of changes in climate during this period. If woody plant cover has increased in this basin, as it has throughout much of the Edwards Plateau (Smeins et al. 1997), then these results would indicate that at very large scales, rivers are relatively insensitive to changes in woody plant cover. Unfortunately, since there has been no detailed assessment of vegetation change in the Pedernales basin, we cannot definitively say to what extent woody plant cover has changed during the last 60 years—if it has changed at all.

Estimate of Water Savings by Juniper Control

The influence of Ashe juniper on the water budget remains the subject of some confusion and disagreement, in part because the implications of the scale at which measurements were made have not been fully considered. For example, at the tree scale, the most common measurement is some index of evapotranspiration by trees. After removal of trees, these numbers have often been extrapolated up without taking into account the compensatory effects of regrowth of trees or replacement by other vegetation. These measurements do not take into account water use by replacement vegetation, as the larger-scale studies do. For example, at the tree scale, for an area with an average annual precipitation of 30 in/yr, an individual tree will intercept and transpire virtually all of the available water. At the stand scale, however, as estimated by Dugas *et al.* (1998), the difference in water consumption between a woodland and a grassland is between 1.6-2 inches/yr. Newer work suggests differences at about the same magnitude (James Heilman—personal communication). Water balance studies at the small-catchment scale (where springs exist) indicate water savings of around 2 in/yr. (Huang et al. 2006).

From these results, we are increasingly confident that conversion of regrowth and second growth Ashe juniper to grasslands or more open savannas will translate to increases in spring flow and/or groundwater recharge at the small catchment scale. But it remains uncertain whether similar results will be seen at larger scales. At the landscape scale we have not found evidence of water savings due to changes in vegetation cover. The reason for this lack of evidence is not yet clear—whether (1) there has been no net change in woody plant cover; (2) there has been a change in woody plant cover but this has no influence on streamflow; or (3) there has been a change in woody plant cover and it has affected streamflow, but the signal cannot be detected because of too much “noise” in the data.

On the basis of the literature available, our current best estimate is that conversion of regrowth and second growth juniper into open savannas would result in an average increase in water yield (streamflow and recharge) of around 2 in/year if rainfall is average or above average. For below average rainfall, it is doubtful that any additional recharge would occur.

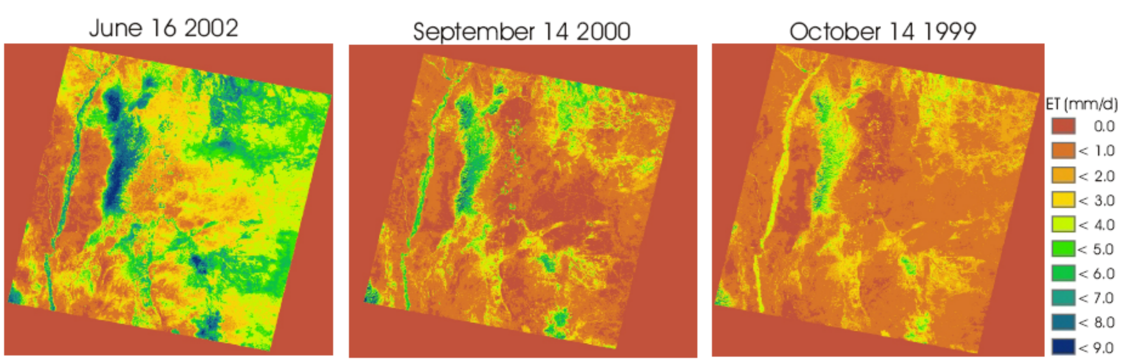
A PROPOSED MONITORING STRATEGY FOR DETERMINING THE WATER SAVINGS FROM LARGE SCALE SHRUB CONTROL ON THE UPPER GUADALUPE RIVER

The hydrology of the Edwards Plateau is exceedingly complex and the task of determining the quantity of water savings resulting from a large scale brush control program will require measurements at multiple scales over a long-term period (10 years or more). Here we lay out a prototype monitoring strategy that could be employed to evaluate the hydrological implications of a large scale juniper control program. Some components of the infrastructure for a monitoring program are already in place. By combining multiple monitoring approaches, confidence in the estimated change can be greatly increased. Below we outline potential components of a monitoring program along with rough estimates of what each component would cost. It is important to emphasize that the cost estimates here are approximate. Actual costs will depend on many externalities including (1) management structure (2) institutional overhead (3) travel requirements (4) location and number of monitoring sites. A summary of projected costs is included in Table 1 at the end of this section.

Regional Monitoring with Remote Sensing

Emerging technology now exits for estimating evapotranspiration using remote sensing imagery. There are many exciting potential applications but one that is particularly germane to the goals of the Edwards would be that of mapping evapotranspiration across the entire contributing and recharge zones of the Edwards Aquifer and relating evapotranspiration rates to vegetation cover. This approach has promise for evaluation of the potential for releasing more groundwater recharge through shrub control at the regional scale.

The technique has been successfully applied in New Mexico. An example from the Rio Grande Valley in New Mexico is presented below (Hong et al. 2009). This example provides a nice illustration of the spatial and temporal resolution that is possible.



Daily evapotranspiration rates for the Middle Rio Grand Region in New Mexico

Rational: Estimating evapotranspiration using remote sensing techniques would allow for comparisons of areas that have been cleared of brush with those that have not *at a regional scale*. We would hypothesize that evapotranspiration would be lower on the cleared areas.

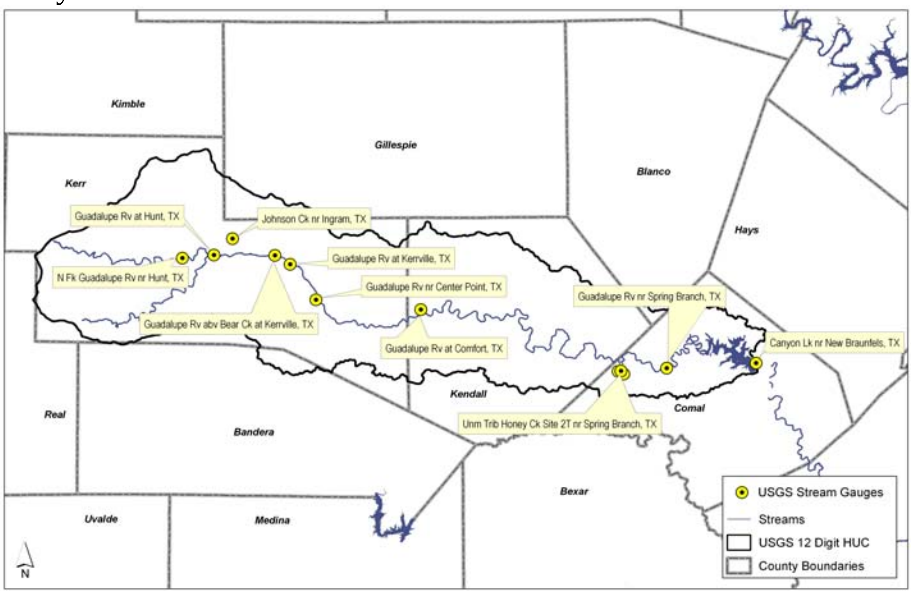
Expected Outcome: The expected output from a study such as this would be ET maps (daily, seasonal, annual) for Edwards Aquifer Region. This method has the potential to provide a measurement of water savings that may occur as a result of large scale shrub removal.

Timeline: At a minimum, the remote sensing analysis should be conducted for a 3 year period and should be conducted in the early or mid life of this project.

Estimated Direct Costs: **$450,000 over 3 years.** Monitoring of this type is at the cutting edge of current technology and requires advanced analytical techniques and should be conducted by a university. An approximate direct cost for a project such as this would be $150,000/yr which would go towards purchase of imagery and support of personnel (post-doc, graduate student, faculty support) (Table 1).

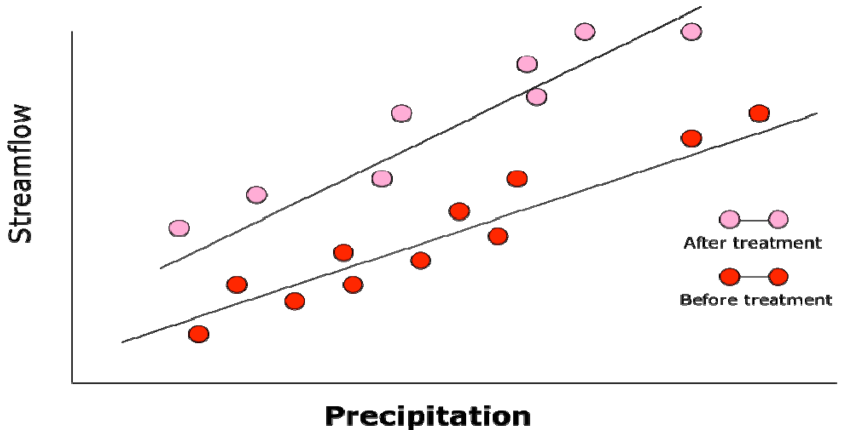
Monitoring Streamflow and Rainfall Across the Upper Guadalupe

The Upper Guadalupe River has been extensively monitored. For some locations records extend back into the 1930's. The USGS maintains seven permanent stream gauging stations for the Guadalupe above Canyon Dam (See figure below). In additions, smaller tributary streams are monitored at several other locations. Historical rainfall records for the region have been maintained at many locations within the watershed as well.



Upper Guadalupe Watershed with USGS Steam gauging stations highlighted

The long-term and high quality streamflow and rainfall data within the basin provide a solid foundation for determining the effect of large scale shrub clearing on streamflow. The basic approach would be to use the historical record to develop a predictive relationship between rainfall and streamflow. We anticipate that streamflow would be closely correlated with rainfall patterns and that there would be a strong predictive relationship. If regional scale shrub control has an influence on streamflow then the basic relationship between streamflow and rainfall will be altered (see figure below) and the change in the relationship could be used to estimate how much water savings has occurred as a result of vegetation management.



Hypothetical relationship between rainfall and streamflow before and after regional scale shrub control

Rationale: This kind of monitoring makes good sense because a good historical record of both streamflow and precipitation has already been developed. If large scale shrub management results in an increase in streamflow, then the fundamental relationship between precipitation and streamflow should change.

Timeline: These data will continue to be collected over the life of the project. At least 3-5 years of post treatment data will be required to evaluate to determine if brush clearing has resulted in any additional streamflow.

Expected Outcome: We expect, that using this approach, one could estimate how much and under what conditions, streamflow in increased by brush management.

Estimated Direct Costs: **$257,250 over 5 years.** The infrastructure for this kind of monitoring is already in place and as such there would be no additional infrastructure costs. However, there would be a cost in terms of personnel and time. An additional 5 years of data collection would be required to develop an adequate data set for analysis—depending on rainfall patterns possibly even more. Ideally this kind of monitoring would continue for the life of the project. For cost estimation purposes, we assume that data collection, compilation and analysis could be accomplished by a technician or full time graduate student. Additional costs include miscellaneous equipment, travel, and supervisory personnel (Table 1).

Small Catchment Monitoring

The large scale monitoring described above needs to be complimented by more detailed monitoring at the small catchment and field scales. The basic approach would be that of measuring the different components of the water budget at several different locations and for several different levels of shrub control. The components of the water budget that should directly monitored include evapotranspiration (evaporation, interception, and transpiration), runoff (surface runoff and springflow), and soil moisture. These measurements would need to be conducted at a minimum of two locations, each having a treated and untreated area.

A prudent strategy would be to take advantage of ongoing data collection programs in the Edwards Plateau region. The two main areas where detailed water budget information has been collected are at the Honey Creek State Natural Area and the Freeman Ranch site. The Honey Creek Site is particularly well instrumented. At this site, two small catchments have been instrumented and monitored since 2002. In 2004, most juniper was removed from one of the catchments. In addition to the runoff monitoring, data on water quality, rainfall and evapotranspiration (Bowen Ratio Towers) are being collected (http://tx.usgs.gov/projects/HoneyCreek/index.html). In addition, springflow has been monitored at one location within Honey Creek from a small catchment where Ashe juniper has been removed (Huang et al. 2006).

At the Freeman ranch, there is an ongoing effort in monitoring evapotranspiration using Bowen Ratio towers (Heilman et al. 2009). This study is comparing evapotranspiration differences between woodlands and grasslands.

Data from both of these ongoing studies will provide strong background information for any monitoring program within the Guadalupe basin.

Additional small catchment studies should be implemented in the Guadalupe watershed. In particular there is a need for better information on spring flow. With the exception of the 4 year study at Honey Creek (Huang et al., 2006) there is relatively little information related to spring flow in the Edwards Plateau and how removal of juniper may affect that. Accordingly, we are recommending that at least 2 additional small study areas be established, each with paired watersheds.

Rationale: Direct measurements of springflows and evapotranspiration at small catchments that have different levels of shrub control would provide independent estimates of water savings from brush management and contribute to a mechanistic understanding of how vegetation alters water flows in this landscape. These detailed field studies should be viewed as essential compliments to the regional analyses described above.

Timeline: Small catchment monitoring should continue over the life of the project.

Estimated Costs—Springflow Monitoring. **$650,800 over 10 years.** We recommend that the gauging stations be established and operated by the U.S. Geological Survey. In this way quality and reliability of the data are assured. Approximate costs for establishing and maintaining one USGS spring flow station are $25,000 installation and $15,300/yr for subsequent monitoring and data management. If four springs were monitored (two treated, two untreated) the costs would be $100,000 the first year and $61,200/ yr there after (Table 1).

Estimated Costs—Evapotranspiration Micrometeorological Towers. **$921,050 over 10 years**. Ideally a monitoring study such as this should include a network of Bowen Ratio or Eddie Correlation towers for measuring evapotranspiration. A Bowen ratio tower can be constructed and established for around $20,000/tower. The real costs for this kind of equipment however are associated with data management. Maintaining a group of towers would require a full time post-doctoral scientist or highly trained technician. In addition there are equipment, computer and travel costs as well as supervisory personnel (Table 1).

Estimated Costs—Soil Water and Transpiration. **$631,050 over 10 years.** Information on tree transpiration and soil water dynamics are useful complementary water balance information. Approximate costs for the soil monitoring and transpiration equipment would be around $10,000 per site. Maintenance of the sites would require a full time graduate student or technician. Other costs include miscellaneous equipment, travel, and supervisory personnel (Table 1).

Table 1. Projected direct costs for a comprehensive monitoring program

	Cost/year	Years	Total Costs
Remote Sensing-total	**$150,000**	**3**	**$450,000**
Supervisory Personnel	$28,000	3	$84,000
Post-Doc	$60,000	3	$180,000
Graduate Student	$35,000	3	$105,000
Misc Equipment, Computers, Travel, Software, Imagery	$27,000	3	$81,000
Streamflow Analysis-total	**$51,450**	**5**	**$257,250**
Technician/Graduate Student	$35,000	5	$175,000
Supervisory Personnel	$14,000	5	$70,000
Equipment, Travel	$2,450	5	$12,250
Small Catchments-total	**$424,410**	**10**	**$2,202,900**
Establishing gaging stations (4 stations)	$100,000	1	$100,000
Annual gaging costs (4)	$61,200	9	$550,800
ET tower Equipment (4 towers)	$80,000	1	$80,000
Post Doc/ Tech	$60,000	10	$600,000
Supervisory Personnel (2 months)	$28,000	10	$280,000
Soil Water/Transpiration Equipment (4 sites)	$40,000	1	$40,000
Graduate Student	$35,000	10	$350,000
Misc Equipment, Travel, Computers	$20,210	10	$202,100

Total Monitoring Costs **$2,910,150**

JUNIPER CONTROL COSTS USED FOR ANALYSIS IN REGION L UPPER GUADALUPE WATERSHED

This section of the report explains the estimated average cost per acre for initial and maintenance practices. Costs for initial juniper control practices used in this analysis were set at $150/ac. This rate is used because it is assumed that most of the acres enrolled in the program will tend toward "heavy" juniper canopy cover.

Based on our interviews with Texas State Soil and Water Conservation Board (TSSWCB) and Soil and Water Conservation District (SWCD) employees with experience in administering juniper control cost-share programs in the UGWS and other watersheds in the Edwards Plateau, and because of the large number of relatively small land ownerships (tracts); we think that relatively few landowners will use prescribed fire as a maintenance practice following the initial juniper control practice. The few owners that may use prescribed fire will most likely be owners of the larger tracts, located primarily in the western end of the UGWS. Most frequently, IPT will be applied with mechanical or manual practices and, infrequently, with use of chemical treatments. IPT for maintenance of juniper control following initial practices will cost $30-$40/ac. Assuming 1/3 of the acres are maintained with prescribed fire ($5/ac) and 2/3 with IPT ($35/ac), then an average cost would be $25.00/ac. Maintenance practices should be applied in approximately 5-year intervals throughout the life of the project (contract period).

To estimate the cost to the program sponsor(s) for implementing a cost-share juniper control/off-site water enhancement program, the length of the program must be selected. Based on precedent set in previous studies of this type (Bach and Conner 2000) ten years was selected as the initial program length. If needed, the costs can also be estimated for longer program periods.

For purposes of estimating program total cost, it was assumed that during the ten year contractual period the initial juniper control practice would be conducted in year 1, the first maintenance practice would be implemented in year 3 or 4 and the second maintenance practice would be implemented in year 7 or 8. Total cost for all of the practices would be $200/ac ($150 for the initial practice and $25 for each of the two maintenance practices).

Results of spatial analysis: number of acres suitable for juniper control and number and size of landholdings

A detailed report of the spatial analysis by individual counties in the UGWS is provided in Appendix A. A summary of the statistics for the entire watershed is provided in Table 2. Ownership sizes were divided into five categories: 1=<50, 2=>50-<100, 3=>100-<200, 4=<200-<500, and 5=>500 acres. Category one (<50 ac) is indicative of the high degree of land fragmentation in the area, containing 93 percent of all rural landowners in the UGWS.

Table 2. Summary of the spatial analysis of the UGWS.

All Counties						
Owner Category	Owner Count	Owner Count (Land w/ Suitable Acreage)	Average Acres	Sum of Acres	Suitable Land Sum of Acres	Suitable Land Average Acres
1	69,727.00	45,226.00	3.0194683	210,538.47	79,151.88	1.75
2	1,300.00	1,269.00	71.933792	93,513.93	29,731.08	23.43
3	1,059.00	1,038.00	139.83732	148,087.73	47,116.57	45.39
4	800.00	781.00	309.35268	247,482.15	78,642.15	100.69
5	333.00	328.00	825.17507	274,783.30	76,876.78	234.38
Total	73,219.00	48,642.00	13.308097	974,405.57	311,518.46	6.40

Of the 974,406 acres of rural land in the UGWS, the results of the spatial analysis indicated that 31 percent (311,518 ac) were suitable for enrollment in a brush management program for enhanced water yield. To be suitable for enrollment the land must have a minimum of 10 percent brush canopy cover, have a slope less than 15 percent and not exhibit characteristics of habitat of the federally listed endangered species, Golden-cheeked Warbler (*Dendroica chrysoparia*).

It should be noted that the spatial analysis was conducted using remotely sensed satellite imagery and the resulting vegetation identification and classification are not 100 percent accurate. Therefore, the acres reported herein as suitable for inclusion in a juniper control program should be considered as an upper bound on the number of acres that are actually suitable for enrollment. If the juniper control program is implemented, then technical experts will inspect each tract submitted by the landowners for consideration of enrollment and the actual acres deemed suitable will be delineated for inclusion in the program. For some candidate tracts, the technical experts will designate fewer suitable acres than are reported by the spatial analysis. In some cases, technical experts may designate more suitable acres than reported by the spatial analysis. This is because the spatial analysis technology is not, in most cases, capable of differentiating between tree canopy of only juniper and canopy of mixed stands of juniper and other woody species, for example live oak. Depending on the amount of other species present, and the landowner's decision regarding the control of the other species, the technical expert will have to decide how much and specifically which of the candidate acres can be included in the juniper control program without compromising the program's added water yield goal.

Because of the small parcel size (avg. 3 ac) and the even smaller amount of suitable land per parcel (avg. 1.75 ac) land in category one (tracts <50 ac) was omitted from further consideration. This is justified because to try and include tracts of this size would increase program costs per acre of juniper controlled to unacceptably high levels, thus yielding the entire project infeasible. A summary of the statistics for the entire UGWS less the land and landowners in category one is provided in Table 3.

Table 3. Summary of the spatial analysis of the UGWS: excluding tracts <50 ac.

All Counties					
Owner Category	Owner Count	Owner Count (Land with Suitable Acreage)	Sum of Acres	Suitable Land Sum of Acres	Suitable Land Average Acres
2	1,300.00	1,269.00	93,513.93	31,819.14	25.07
3	1,059.00	1,038.00	148,087.73	48,961.34	47.17
4	800.00	781.00	247,482.15	85,498.59	109.47
5	333.00	328.00	274,783.30	76,098.18	232.01
Total	3,492.00	3,416.00	763,867.10	242,377.24	70.95

Removing the category one acres and landowners reduced the total rural land to be considered in the UGWS by 210,539 ac (22 %) and the number of land owners by 69,727 (95 %). Eliminating the category one tracts and landowners increased the average amount of land suitable for inclusion in the program from 6.4 acres per tract to 70.94 ac per tract. This increase in suitable acres per tract will increase the efficiency of program implementation and administration significantly.

Impact of level of cost-share provided to landowners on acreage enrolled in juniper control for enhanced water yield program

Numerous studies (Thurow et al., 2001; Kreuter, Tays and Conner, 2004; Olenick, Kreuter and Conner, 2005 and Sorice, 2008) have reported that a majority of rural landowners in the Edwards Plateau and similar regions of Texas would, if given the opportunity, enroll at least a part of their land in a cost-share brush management program. Without the financial support (cost-share), however, few landowners could afford to clear large areas of brush (Lee et al. 2001). Voluntary participation in a brush reduction program without cost-sharing is especially unlikely in semi-arid areas like the Edwards Plateau where the value of increased forage following brush clearing does not offset the associated costs of brush management (Bach & Conner, 2000).

Several studies have focused on factors influencing the landowner's decision regarding participation in a cost-share brush control program (Thurow et al., 2001; Kreuter, Tays and Conner, 2004; Olenick, Kreuter and Conner, 2005and Sorice, 2008). Several factors contribute to a landowner's decision regarding participation including the owner's goals and objectives related to land use, especially their proclivity toward livestock production, the length of the contractual agreement associated with the cost-share program, the extent and density of brush canopy on the landowner's property and, of course, the percent of total cost of implementing the brush control that is provided by the program sponsors.

Olenick, Kreuter and Conner (2005), reported that in their survey of Edwards Plateau (Kerr, Real, Bandera, Uvalde and Medina Counties) landowners 75% of the respondents indicated an initial interest in participating in a cost-share brush management program. Except for deriving a smaller percent of their annual household income from their land, the study did not find any significant socio-economic characteristics that would characterize a proclivity to not participate among the 25 % who indicated no interest in participation.

Of the 75 % indicating some interest in participating, less than half (38%) indicated a willingness to participate if the cost-share provided by the sponsoring agency were no more than 60% of the total implementation cost of the brush control program. A 70% cost share level would increase the percent of interested participants who would enroll to 55% and an 80 % cost-share would entice 81 % to enroll. To get all of the potentially interested participants to commit to enroll would require a greater than 90% cost-share.

Taking into account the landowners not interested in participation in a cost-share brush control program regardless of cost-share rate results in the following percentage of landowners who could be expected to participate at different cost share rates.

Cost-share %	**Landowner Participation %**
50	23
60	28
70	41
80	61
90+	75

There are many factors which could cause the percent landowner participation percentages reported by Olenick, Kreuter and Conner (2005) to vary. Sorice (2008) found that in addition to the previously mentioned factors influencing a landowner's decision to participate, the landowner's expectations regarding effectiveness of the brush control program and level of technical assistance to be provided in addition to the cost-share were influential in determining the participation level regardless of the cost-share rate.

Despite the possible influence of other factors, the landowner participation percentages for the various cost-share rates reported by Olenick, Kreuter and Conner (2005) will be used in this report to estimate landowner participation, acres likely to be enrolled and implementation cost for the UGWS cost-share juniper control program. This is justified in that the previous study involved landowners from two of the five counties in the UGWS.

Table 4 provides a summary of the number of landowners and acres likely to be enrolled from each size category for four cost share levels from 60 to 90+ percent.

Table 4. Expected number of landowners and acres to be enrolled at four levels of cost-share

All Counties - 60% Cost-Share			
Owner Category	Owner Count (Land with Suitable Acreage)	Suitable Land Sum of Acres	Suitable Land Average Acres
2	355.32	8,909.36	25.07
3	290.64	13,709.17	47.17
4	218.68	23,939.60	109.47
5	91.84	21,307.49	232.01
Total	956.48	67,865.63	70.95
All Counties - 70% Cost-Share			
Owner Category	Owner Count (Land with Suitable Acreage)	Suitable Land Sum of Acres	Suitable Land Average Acres
2	520.29	13,045.85	25.07
3	425.58	20,074.15	47.17
4	320.21	35,054.42	109.47
5	134.48	31,200.25	232.01
Total	1,400.56	99,374.67	70.95
All Counties - 80% Cost-Share			
Owner Category	Owner Count (Land with Suitable Acreage)	Suitable Land Sum of Acres	Suitable Land Average Acres
2	774.09	19,409.68	25.07
3	633.18	29,866.42	47.17
4	476.41	52,154.14	109.47
5	200.08	46,419.89	232.01
Total	2,083.76	147,850.12	70.95
All Counties - 90+% Cost-Share			
Owner Category	Owner Count (Land with Suitable Acreage)	Suitable Land Sum of Acres	Suitable Land Average Acres
2	951.75	23,864.36	25.07
3	778.50	36,721.00	47.17
4	585.75	64,123.94	109.47
5	246.00	57,073.63	232.01
Total	2,562.00	181,782.93	70.95

Table 4 shows that with a 60% cost-share, fewer than 1,000 landowners and less than 68,000 acres would be expected to enroll in the UGWS juniper control program. With an 80% cost-share, however, the expected numbers of participating landowners and acres enrolled more than double with 2,000+ landowners and almost 148,000 acres expected to enroll. An additional

500+ landowners and 33,000 acres would be expected to enroll if the cost-share were raised to 90+%.

Estimated cost to the sponsor to implement the juniper control program for various levels of cost-share

Applying the different cost-share percentages to the estimated $200/ac total cost from the cost estimation section of this report produces the sponsor's share of the per acre cost for the program at each cost-share level. In this report, 95% will be used for the 90+ % cost-share level referred to in the Olenick, Kreuter and Conner (2005) study.

Cost-share	**Sponsor's cost /acre**
%	**$**
60	120
70	140
80	160
95	190

Table 5 displays the sponsor's share of total cost of the program which is the result of multiplying the sponsor's $/ac cost for each level of cost-share by the number of acres expected to be enrolled in the program for each level of cost-share (from Table 4).

Table 5. Sponsor's share of total program implementation cost by rate of cost-share

All Counties - 60% Cost-Share			
Owner Category	Owner Count (Land with Suitable Acreage)	Suitable Land Sum of Acres	Sponsor's Share of Implementation Costs ($)
2	355.32	8,909.36	1,069,123.18
3	290.64	13,709.17	1,645,100.91
4	218.68	23,939.60	2,872,752.47
5	91.84	21,307.49	2,556,898.77
Total	956.48	67,865.63	8,143,875.33
All Counties - 70% Cost-Share			
Owner Category	Owner Count (Land with Suitable Acreage)	Suitable Land Sum of Acres	Sponsor's Share of Implementation Costs ($)
2	520.29	13,045.85	1,826,418.76
3	425.58	20,074.15	2,810,380.72
4	320.21	35,054.42	4,907,618.80
5	134.48	31,200.25	4,368,035.40
Total	1,400.56	99,374.67	13,912,453.69
All Counties - 80% Cost-Share			
Owner Category	Owner Count (Land with Suitable Acreage)	Suitable Land Sum of Acres	Sponsor's Share of Implementation Costs ($)
2	774.09	19,409.68	3,105,548.27
3	633.18	29,866.42	4,778,626.46
4	476.41	52,154.14	8,344,661.93
5	200.08	46,419.89	7,427,182.15
Total	2,083.76	147,850.12	23,656,018.81
All Counties - 95% Cost-Share			
Owner Category	Owner Count (Land with Suitable Acreage)	Suitable Land Sum of Acres	Sponsor's Share of Implementation Costs ($)
2	951.75	23,864.36	4,534,227.76
3	778.50	36,721.00	6,976,990.47
4	585.75	64,123.94	12,183,548.42
5	246.00	57,073.63	10,843,990.33
Total	2,562.00	181,782.93	34,538,756.97

As Table 5 indicates, as the level of cost-share increases, the sponsor's share of total cost increases exponentially. For example, at the 60% cost-share level, the sponsor's share of the total cost of juniper control on the 68,000 acres expected to be enrolled is just over $8M while at the 80% level of cost-share, the sponsor's share of the cost to control the 148,000 acres expected to be enrolled is $23.7M. In this example, the acres expected to be enrolled increased by 118% whereas the sponsor's share of the total cost increased by 196%. This exponential increase in the sponsor's share of cost is because as the cost-share level increases, the sponsor's cost per acre increases. Plus, the number of total acres expected to be enrolled also increases.

Estimated cost to a sponsor for implementation and maintenance of a brush control/off-site water enhancement program

To obtain information on administrative costs of implementing and maintaining a juniper control/off-site water enhancement program personnel from the Texas State Soil and Water Conservation Board (TSSWCB) and several Soil and Water Conservation Districts (SWCD) were interviewed. Currently, the TSSWCB and three SWCDs are administering small juniper control/off site water enhancement programs in the UGWS. In addition, over the past 10 years, these agencies have been involved in the administration of several million dollars worth of juniper control programs; beginning with the North Concho Watershed project in 1999.

Information from these agencies indicated that for small to modest sized projects ($7M or less per biennium) the TSSWCB and the SWCDs for the target watershed could administer the juniper control/off site water enhancement programs for 17% of the sponsor's share of the implementation cost. The 17% would consist of 5% for the TSSWCB and 12% for the SWCDs. For larger projects, which are rarely appropriated by the Texas Legislature, the administrative cost would likely be lower. Since there is very little precedent for biennial legislative appropriations for juniper control/off site water enhancement programs in excess of $7M, the 17% of sponsor implementation cost will be used as the estimated administrative cost in this study.

Table 6 shows the total sponsor cost of implementing and administering the juniper control/off-site water enhancement programs for the UGWS at various cost-share levels.

Table 6. Total sponsor costs of implementing and administering the UGWS juniper control/off-site water enhancement program at various cost-share levels

All Counties – Cost-Share (%)	Sponsor's Share of Implementation Costs ($)	Sponsor's Share of Total Costs ($)
60	8,143,875.33	9,528,334.13
70	13,912,453.69	16,277,570.81
80	23,656,018.81	27,677,542.01
95	34,538,756.97	40,410,345.66

The sponsor's share of total cost shown in Table 6 was obtained by multiplying the sponsor's share of implementation cost (center column in Table 6) by 1.17 to account for the 17% administrative cost described above.

Estimated attrition in landowners willing to participate in the UGWS juniper control/off-site water enhancement program 10 and 20 years after program initiation

Based on information from the Texas Land Trends website (www.texaslandtrends.org) (Wilkins *et al* 2009), there was an average 1.4% decrease in land used for agricultural purposes for all

Edwards Plateau counties between 1997 and 2007. This is twice the rate of loss reported for the period 1992 – 2001 which indicates that the rate of loss in agricultural lands is increasing significantly. Also noteworthy is the fact that during the 1997 – 2007 period the rate of loss of agricultural land was 9.5% for Comal county; more than 8 times the loss rate for the average of the Edwards Plateau counties during this same period.

Also noteworthy is the change in size class of Edwards Plateau farms and ranches during the 1997-2007 period. The only size category to increase in acres during the period was the smallest size class (1-100 ac) which gained about 72,000 acres (21%). All other size classes lost acres; totaling 1.77 M for a net loss over all size classes of almost 1.7 M acres. The 1.7 M acre loss represents a 9.3% decline over the 10 year period, or almost 1% per year. An additional and significant point is that the only size class to gain acres during the period is the class that encompasses the size class that was excluded from this analysis because they were deemed to have too few suitable acres to warrant inclusion based on program cost effectiveness considerations.

While the two indicators of change in acres of Edwards Plateau land for agricultural use provide differing estimates of the % change over the 1997 – 2007 period (1.4% versus 9.3%), there is no doubt that agricultural lands are being lost every year and, the rate of loss is most likely going to increase over time. In addition, as the population growth rate continues to remain at, or increase to, rates higher than the average rate for the state, the loss of land for agricultural uses will continue to increase.

While there is no way of being certain about the rate of loss of agricultural land over time, it is even less likely that one can precisely predict the rate of attrition of landowners willing to participate in the UGWS juniper control/off-site water enhancement program. For lack of a more definitive number, and based on the rate of loss in agricultural lands and the very high population growth rates in two of the primary counties (Comal and Kendall) in the UGWS we will use an annual loss rate of 1.0% to estimate the losses over 10 and 20 years in the number of acres likely to remain enrolled in the UGWS juniper control program.

Table 7 displays the number of landowners with suitable acres and the number of acres of suitable land for year 1, 10 and 20 of an assumed potential planning period for various levels of cost-share for the UGWS juniper control/off-site water enhancement program.

Table 7. Number of landowners with suitable acres and the number of acres of suitable land for year 1, 10 and 20 of an assumed potential planning period for various levels of cost-share for the UGWS juniper control/off-site water enhancement program

All Counties - 60% Cost-Share		
	Owner Count (Land with Suitable Acreage)	Suitable Land Sum of Acres
Total Year 1	956.48	67,865.63
Total Year 10	865.02	61,376.46
Total Year 20	782.31	55,507.98
All Counties - 70% Cost-Share		
	Owner Count (Land with Suitable Acreage)	Suitable Land Sum of Acres
Total Year 1	1,400.56	99,374.67
Total Year 10	1,266.64	89,872.67
Total Year 20	1,145.53	81,279.54
All Counties - 80% Cost-Share		
	Owner Count (Land with Suitable Acreage)	Suitable Land Sum of Acres
Total Year 1	2,083.76	147,850.12
Total Year 10	1,884.52	133,713.00
Total Year 20	1,704.33	120,928.09
All Counties - 95% Cost-Share		
	Owner Count (Land with Suitable Acreage)	Suitable Land Sum of Acres
Total Year 1	2,562.00	181,782.93
Total Year 10	2,317.03	164,401.22
Total Year 20	2,095.49	148,682.08

The year 10 and 20 landowner count and number of suitable acres are obtained by multiplying the year 1 values by 0.90438 and 0.81791 respectively. These adjustments to the number of participating landowners and acres expected to be enrolled in the UGWS juniper control program are based on an average attrition rate of 1% per year.

Summarization of the cost/acre by component for various levels of cost-share for the UGWS juniper control/off-site water enhancement program

Costs for the UGWS juniper control/off-site water enhancement program are summarized in Appendix B. In addition to the costs per acre for initial and maintenance juniper control practices described previously, the sponsor's costs per acre for administration are shown to range from $20.40/ac for the 60% cost-share to $32.30/ac for the 95% cost-share example. Costs to the sponsor for long-term monitoring of changes in water yield after implementing the UGWS juniper control program range from $42.88/ac for the 60% cost-share to $16.01/ac for the 95% cost-share.

Estimated cost/acre foot of added water for the various levels of cost-share for the UGWS juniper control/off-site water enhancement program

As stated in a previous section, "…conversion of regrowth and second growth juniper into open savannas would result in an average increase in water yield (streamflow and recharge) of around 2 in/year if rainfall is average…" Note also, that all of the estimated costs associated with the UGWS brush control/off -site water enhancement program have been based on an initial ten-year program. Therefore, for a ten year period, the estimated increase in water yield of 2 inches per year would sum to 20 inches per acre of converted land (1.67 acre-feet/acre).

From Appendix B we can obtain the sponsor's share of the cost per acre for implementing the UGWS juniper control/off-site water enhancement program (performing the conversion) for the various levels of cost-share as:

Cost-share %	**Sponsor's share of cost/acre ($)**
60	183.28
70	193.00
80	206.88
95	238.51

The sponsor's estimated cost per acre-foot of increase in water yield is obtained by dividing the sponsor's share of the cost per acre for implementing the UGWS juniper control/off-site water enhancement program by the estimated 1.67 acre-feet per acre of estimated water yield from converted land. Therefore, the estimated cost per acre-foot to the sponsor for the estimated increase in water yield for the various levels of cost-share is:

Cost-share %	**Sponsor's cost per acre-foot ($)**
60	109.75
70	115.57
80	123.88
95	142.82

To determine which, if any, of the various cost-share - cost/acre-foot water enhancement options to select, The potential sponsor(s) will need to compare these cost estimates with costs of other available alternatives, relative severity of estimated future water needs, and a host of other political and fiscal considerations.

OTHER CONSIDERATIONS

Much of the woody plant cover in the UGWS is a mixed composition of oak species and juniper. The amount of each component in the mix varies widely, but frequently includes significant amounts of oak. If juniper is removed by a brush management treatment from such areas and a high percentage of the area remains under woody canopy cover, then water quantity gains will likely be diminished. For the program to be successful it must result in a net increase in the percent of the area made up of grasslands and savannas.

Interviews with GBRA and UGWS landowners, TSSWCB employees, NRCS personnel and experiences reported from other watersheds, indicate strongly that cost-share for maintenance practices should be included in brush management contracts. Some ranchers maintain initial cost-shared brush treatments at their own expense, but they are the exception. This failure to get maintenance practices applied significantly reduces longevity of benefits from the original treatment and economic performance as brush regrowth quickly recovers in the area. Conversely, relatively low cost maintenance practices applied at 3-5 year intervals can stretch initial treatment benefits over long term planning horizons and positively influence economic performance of the project. It is suggested that cost-share for maintenance practices be included in contracts at 50% or greater in order to get landowner participation.

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APPENDIX A

Report of the spatial analysis by individual counties in the UGWS

Kendall County						
Owner Category	Owner Count (Total)	Owner Count (Land with Suitable Acreage)	Average Acres	Sum of Acres	Suitable Land Sum of Acres	Suitable Land Average Acres
1	7394	5488	6.26	46,288.48	15,563.41	2.84
2	280	278	72.64	20,338.99	5,330.58	19.17
3	237	231	142.86	33,856.97	10,301.55	44.60
4	247	244	320.97	79,280.13	21,006.08	86.09
5	130	128	1,056.93	137,401.16	25,751.77	201.19
Total	8288	6369	1,599.66	317,165.73	77,953.40	12.24
Kerr County						
Owner Category	Owner Count (Total)	Owner Count (Land with Suitable Acreage)	Average Acres	Sum of Acres	Suitable Land Sum of Acres	Suitable Land Average Acres
1	28978	16278	3.53	102,379.75	35,406.37	2.18
2	741	725	71.83	53,229.25	16,405.40	22.63
3	632	626	138.84	87,746.28	27,095.48	43.28
4	442	436	306.54	135,490.16	47,273.80	108.43
5	176	176	685.01	120,562.44	46,750.29	265.63
Total	30969	18241	1,205.76	499,407.88	172,931.34	9.48
Comal County						
Owner Category	Owner Count (Total)	Owner Count (Land with Suitable Acreage)	Average Acres	Sum of Acres	Suitable Land Sum of Acres	Suitable Land Average Acres
1	32,517	22,812	1.68	54,677.03	25,342.11	1.11
2	209	199	71.80	15,006.36	6,363.16	31.98
3	148	140	139.52	20,649.28	7,683.07	54.88
4	67	65	307.10	20,575.92	7,123.75	109.60
5	9	7	656.16	5,905.47	1,171.58	167.37
Total	32,950	23,223	1,176.27	116,814.06	47,683.68	2.05

Bandera County						
Owner Category	Owner Count (Total)	Owner Count (Land with Suitable Acreage)	Average Acres	Sum of Acres	Suitable Land Sum of Acres	Suitable Land Average Acres
1	81	58	11.34	918.92	169.02	2.91
2	25	24	72.10	1,802.39	405.65	16.90
3	16	16	140.01	2,240.14	579.78	36.24
4	17	14	295.20	5,018.45	744.80	53.20
5	7	7	643.46	4,504.20	778.60	111.23
Total	146	119	1162.11	14484.09	2677.86	22.50
Gillespie County						
Owner Category	Owner Count (Total)	Owner Count (Land with Suitable Acreage)	Average Acres	Sum of Acres	Suitable Land Sum of Acres	Suitable Land Average Acres
1	757	590	8.29	6,274.29	2,670.96	4.53
2	45	43	69.71	3,136.94	1,226.29	28.52
3	26	25	138.27	3,595.06	1,456.69	58.27
4	27	22	263.61	7,117.49	2,493.71	113.35
5	11	10	582.73	6,410.03	2,424.55	242.45
Total	866	690	1,062.61	26,533.81	10,272.20	14.89

APPENDIX B

Costs per acre for the UGWS brush control/off-site water enhancement program by component

ITEM	Total cost ($/ac)	State's share of total cost ($/ac)
Initial brush control practice	150.00	
60% cost share		90.00
70% cost share		105.00
80% cost share		120.00
95% cost share		142.50
Brush control maintenance x 2	50.00	
60% cost share		30.00
70% cost share		35.00
80% cost share		40.00
95% cost share		47.70
Administrative Costs @ 17%*		
60% cost share		20.40
70% cost share		23.80
80% cost share		27.20
95% cost share		32.30
Monitoring costs**		
60% cost share		42.88
70% cost share		29.28
80% cost share		19.68
95% cost share		16.01
* Administrative costs are 17% of funds appropriated for Sponsor's share of initial and maintenance practice costs ** See Table 1 in text for detail		

APPENDIX C

JUNIPER CONTROL TECHNOLOGIES FOR USE IN THE UPPER GUADALUPE WATERSHED OF REGION L

Mechanical

Mechanical juniper control can be divided into two categories—broadcast and individual plant treatment (IPT). Broadcast methods are most often used when densities of plants are greater than approximately 300 plants per acre. Individual plant treatments (IPT) are used when plant densities are low enough and/or plants are small enough to justify treating individual plants.

Bulldozing (crawler tractor and front end blade) has been used for many years for clearing Edwards Plateau rangeland of unwanted woody plant species. When Ashe juniper is the target species, treated plants will suffer mortality if they are either uprooted or sheared off from their roots below the lowermost green growth. Conversely, any resprouting species present will produce multiple new growth from buds in the stem base and root crown area of the plant (Welch 1991).The bulldozer can place the cleared trees in piles or windrows. An undesirable aspect of bulldozing is the potential removal of topsoil and upheaval of large rocks on the soil surface. This practice provides for less discrimination on selection of targeted plants than others, such as the skid-steer loaders with sheers. Cost of bulldozing will vary depending on size and density of juniper and terrain, as well as access to juniper in stands mixed with oaks. See Table 1 for estimated cost ranges of juniper control.

Since Ashe juniper is a non-sprouting species, this allows top removal practices to be effective for control. One of the most popular of these methods is the use of a “skid-steer loader” equipped with a front-end attachment of hydraulically operated sheers. The sheers are placed with the skid-steer at the base of a target plant species and the shears are then closed hydraulically so that they cut entirely through the trunk of the tree. The hydraulic system on the skid-steer can be used also to place cut trees in piles or in windrows. Both bulldozing and sheering of Ashe juniper have been shown to produce enough soil disturbances to provide an adequate seedbed for seeding Mannel (2007) if revegetation of the treated area is desired. Skid-steer operators must be careful to insure that all of the green material is removed above the cut in order to prevent regrowth from Ashe juniper. Cost of skid-steer with hydraulic sheers will vary depending on size and density of juniper and terrain. See Table 1 for estimated cost ranges of juniper control.

Hydraulic shredders (sometimes called “mulchers”), such as the “Hydro Axe,” are also used for woody plant control and are effective on ashe juniper if the cut by the shredder is below the lowermost green plant material. A Hydro-Axe shredder has a horizontal rotary blade shredding unit powered by a hydraulic motor mounted on the front of a large rubber-tired, articulated tractor. An alternative type of shredder is the “flail-type”, or rotobeater. This type of shredder uses a rotating drum equipped with cutting edges on front of the tractor unit. While the shredders can take down larger trees, they are probably most economically efficient in brush with 3-6 inch stem diameters. An undesirable result from shredders is the mass of debris left on the soil surface. In thick brush stands, especially noted in Ashe juniper, the debris can be limiting to the post treatment emergence of herbaceous forage plants. Prescribed fire can be used as a follow-up to shredding to remove debris and suppress woody regrowth. Cost of hydraulic shredders will vary depending on size and density of the juniper and terrain. See Table C1 for estimated cost ranges for juniper control.

Individual plant treatment (IPT) mechanical practices include “lopping” with manual sheers of small Ashe juniper plants near ground level and result in a high level of control. Hand grubbing to remove these small plants is also an alternative. Hand cutting of larger regrowth (juniper that has replaced old mature stands that have been previously cut) with chain saws is also regularly practiced in the UGWS. This IPT practice is normally accomplished by a contracted crew that hand cuts the juniper. Stacking of the slash can be negotiated as part of the clearing process or done as a separate operation. Cost of the hand cutting alone varies according to the density and size of the juniper. See Table 1 for estimated cost ranges for juniper control.

In recent years the use of “track hoes” or “excavators”, large self-propelled backhoes on tracks that have a reach of about 25 feet in 180 degrees, has become popular, especially in the western Edwards Plateau where redberry juniper (*Juniperus pinchotii*), a sprouting species, requires removal below the bud zone (Wiedemann 2004). A survey of NRCS personnel in Kerr county indicates that there is an estimated 800-900 acres of redberry juniper in the northwestern portion of the county. These large grubbers can cover approximately 50 ft. in swath width when moving in a straight line and can be used for other resprouting species, as well as for ashe juniper if desired, particularly in areas where the size of trees or soils (primarily rockiness) may limit the use of smaller grubbing equipment. The equipment can also place cut junipers into piles or windrows (Wiedemann 2004). An undesirable feature of track hoes is the breaking of limbs of associated desirable species, such as live oak, when the grubbing unit is being rotated from side-to-side in areas where juniper and oaks are mixed in close proximity. An additional problem is that track hoes may cut through the roots of oaks or other desirable species while removing juniper plants. Cost of a track hoe per acre will vary according to the size and density of juniper and the terrain. See Table C1 for estimated cost ranges for juniper control.

Low-energy grubbing can also be used in some soils for juniper control when stem diameters are 5 inches or less. “Low–energy” grubbers are those that use hydraulic power in the grubbing unit to offset the need for tractor horsepower (Wiedemann 2004). Skid loader mounted grubbers can also be used effectively for juniper removal where soils permit. Cost of low-energy grubbing per acre and will vary according to the size and density of juniper. See Table C1 for estimated cost ranges for juniper control.

Chemical

There are no currently recommended broadcast chemical treatments for ashe juniper control. However, there are IPT practices that are recommended for use, including picloram (Tordon 22k), Hexazinone liquid (Velpar L) and Hexazinone pellets (Pronone Power Pellets). These chemicals are applied to the soil at recommended doses (eg., ml of herbicide per inch of stem diameter or foot of canopy diameter). All of these treatments will give a very high level of Ashe juniper mortality if properly applied. Texas Agrilife Extension Bulletin 1466 and the PestMan decision support software (http://pestman.tamu.edu) provide instructions for selection and application of herbicides. A significant concern in the use of soil applied herbicides for juniper control in the area is potential damage to desirable oak and other species. As density of juniper and tree size increases so will the cost per acre for chemical control. Soil applied herbicides should not be used in soil profiles that are conducive to percolation of the herbicide into ground water. See Table C1 for estimated cost ranges for juniper control.

Prescribed Fire

Perhaps the most economically effective treatment alternative for ashe juniper control is prescribed burning. When small, Ashe juniper can be effectively controlled with cool season prescribed burns that limit risk compared to hot summer burns. Fire can be very effective for causing mortality of small Ashe juniper plants that are 3-4 feet tall and even taller if the fine fuel load is adequate in amount and continuity to carry an effective fire. The use of prescribed burning as a maintenance practice following mechanical control treatments is recommended to stretch benefits of the high cost initial practices over the planning horizon with low-cost maintenance practices. A discussion on the use of fire in juniper ecosystems can be found in Blair et al. (2004). Cost of prescribed burning will vary based on fire lane construction required and size of the area burned. See Table C1 for estimated cost ranges for juniper control.

Biological

Biological control is accomplished in the MLRA via the use of goats. Meat goats, including Spanish and Boer goats and crosses thereof, as well as other meat breeds, have increased in the area as angora goats have declined. Goats will utilize seedling juniper plants or young regrowth until the plants have reached a threshold where the increased content of terpenoids diminishes use (Taylor 2000). Goats also utilize oak sprouts and harvest buds, leaves and small twigs of trees up to a browse line of about 6 feet. Goats can be concentrated in high densities and rotated through pastures to help suppress woody plants. They can also be used following mechanical brush management practices to browse woody plant regrowth when it is succulent and within reach. The Texas AgriLife Research Station at Sonora is experimenting with goats that will consume a higher than normal percent of juniper.

Table C1. Estimated costs ranges for juniper control practices

Species	Practice	Cost 100 plants	Cost/Acre
Ashe juniper	Tree Shear		$100-$250
	Hexazinone/picloram	$25-$40	
	Bulldozer		$75-$150
	Hand cutting		$75-$125
	Hydraulic shredders		$125-$225
	Excavator		$60-$120
	Low-energy grubbing		$30-$50
	Prescribed fire		$3-$8

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