TRANS-TEXAS WATER PROGRAM

West Central Study Area

Phase II

Guadalupe-San Antonio River Basin Model Modifications & Enhancements

San Antonio River Authority

San Antonio Water System

Edwards Aquifer Authority

Guadalupe-Blanco River Authority

Lower Colorado River Authority

Bexar Metropolitan Water District

Nueces River Authority

Canyon Lake Water Supply Corporation

Bexar-Medina-Atascosa Counties WCID No. 1

Texas Natural Resource Conservation Commission

Texas Parks and Wildlife Department

Texas Water Development Board

March 1998

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TRANS-TEXAS WATER PROGRAM

WEST CENTRAL STUDY AREA

PHASE 2

GUADALUPE - SAN ANTONIO RIVER BASIN MODEL MODIFICATIONS & ENHANCEMENTS

San Antonio River Authority
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GSA RIVER BASIN MODEL
MODIFICATIONS AND ENHANCEMENTS

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1.0 INTRODUCTION

The Guadalupe - San Antonio River Basin Model (GSA Model) was originally developed for the Edwards Underground Water District to perform recharge calculations, simulate recharge reservoir operations, and estimate water available for diversion below Comal and San Marcos Springs subject to downstream water rights.[1] Following the development of the original model, significant additional capabilities have been added to the GSA Model to facilitate evaluation of numerous water supply alternatives considered in the Trans-Texas Water Program. Some of these additional capabilities include calculation of: a) Water availability on a monthly timestep at locations throughout the river basin subject to original Trans-Texas Environmental Assessment criteria;[2] b) Canyon Reservoir firm yield using daily inflow sequences for consideration of downstream hydropower and Federal Energy Regulatory Commission (FERC) requirements;[3] c) Water availability subject to alternative environmental criteria for instream flows and freshwater inflows to bays & estuaries which includes reductions of desired flow goals during drought based on moving averages of streamflow;[4] and d) Water availability at selected locations on a daily timestep subject to Environmental Water Needs Criteria from the Consensus Planning Process which also includes reductions of desired flow goals during drought.[5] Hence, the development of the GSA Model is an ongoing, evolutionary process with each new capability necessary to more accurately assess water supply alternatives of particular interest.

The GSA Model and database enhancements described in this Technical Memorandum were completed in preparation for technical analyses likely to be required in Phase 2 of the Trans-Texas Water Program and/or other regional planning efforts in the Guadalupe - San Antonio River Basin. Database enhancements completed in the course of this effort include: a) Development of natural daily streamflow sets and statistics representative of the 1934-89 historical period at twenty locations throughout the river basin; and b) Refinement

[1] HDR Engineering, Inc. (HDR), "Guadalupe - San Antonio River Basin Recharge Enhancement Study, Phase 1," Vols. I, II, and III, Edwards Underground Water District, September 1993.
[2] HDR, "Trans-Texas Water Program, West Central Study Area Phase I Interim Report," Vol. II, San Antonio River Authority, et al., May 1994.
[3] HDR, "Trans-Texas Water Program, West Central Study Area Phase I Interim Report," Vol. III, San Antonio River Authority, et al., November 1994.
[4] HDR, "Evaluation of Alternative Instream and Bay & Estuary Flow Criteria for Run-of-the-River Diversions," Technical Memorandum, Trans-Texas Water Program, West Central Study Area, San Antonio River Authority, et al., June 1995.
[5] HDR, "Trans-Texas Water Program, West Central Study Area Phase II Report, Letter of Intent Analysis," San Antonio River Authority, et al., October 1996.

of historical streamflow estimates and the channel loss rate function for the Guadalupe River at/above Lake Wood (Hydropower Dam H-5). Enhanced capabilities of the GSA Model include: a) A post-processor program which computes fisheries harvest and salinity estimates for the Guadalupe Estuary; b) Automated simulation of run-of-the-river diversions made firm by storage in Canyon Reservoir; and c) Computation of water available under individual water rights considering priority relative to other rights. Each of these enhancements is described in greater detail in the following sections of the memorandum. Sections which describe enhanced capabilities of the GSA Model also include an example application to illustrate the utility of the new capability.

2.0 NATURAL DAILY STREAMFLOWS AND STATISTICS

The GSA Model was originally developed using a monthly computational timestep for assessment of water availability for diversion and recharge enhancement. More detailed consideration of water supply alternatives involving run-of-the-river diversions, Canyon Reservoir operations, and recharge enhancement reservoir performance, however, has necessitated the use of daily streamflow sequences at some locations. Furthermore, the proposed Environmental Water Needs Criteria of the Consensus Planning Process[1] (Consensus Environmental Criteria) for both Direct Diversions and New Reservoirs are based on consideration of natural daily streamflows and the statistics derived therefrom. Hence, natural daily streamflow databases and statistics based on the 1934-89 historical period were completed as a part of this work effort. Methods and assumptions applied in the development of these databases, selected summary statistics, and related items of interest are described in this section.

2.1 Natural Streamflow Development

Natural streamflows are generally defined to be the streamflows which would have occurred absent man's influences which typically include reservoirs, diversions, and return flows. Monthly estimates of natural streamflow at numerous locations throughout the Guadalupe - San Antonio River Basin were developed in a previous study[2] by adjustment of gaged streamflow records for diversions reported to the Texas Natural Resource Conservation Commission (TNRCC), treated effluent discharges, and recorded changes in reservoir contents. In this basin, man's influence also includes pumpage of the Edwards Aquifer which, in turn, affects the discharge of major springs including Comal, San Marcos, San Antonio, and San Pedro Springs. Streamflows have not been naturalized with respect to the historical effects of pumpage on springflow because performance of the Edwards Aquifer without pumping stress has yet to be successfully simulated.[3]

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[1] Texas Water Development Board (TWDB), Texas Parks & Wildlife Department (TPWD), and Texas Natural Resource Conservation Commission (TNRCC), "Environmental Water Needs Criteria of the Consensus Planning Process," Draft, 1996.

[2] HDR, September 1993, op. cit.

[3] TWDB, Personal Communication, 1992.

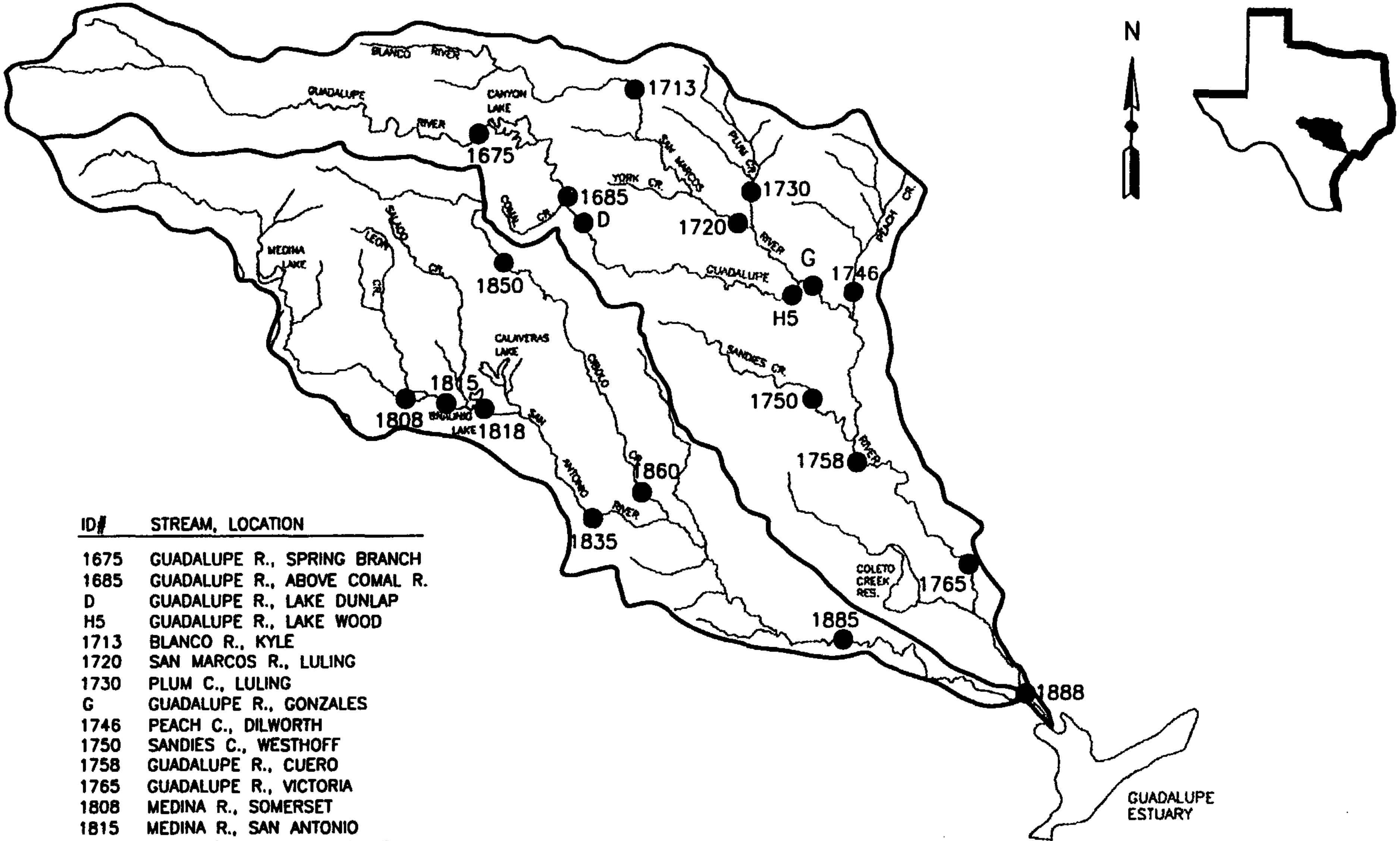
Monthly natural streamflows for the Guadalupe River at Lake Wood, Cuero, Victoria, and Tivoli were revised in this study to account for the refinement of streamflow estimates at and channel loss rates above H-5 described in Section 3. In addition, monthly natural streamflows for the Guadalupe River at Tivoli were revised to account for TWDB estimates of ungaged runoff below the Guadalupe River at Victoria, the San Antonio River at Goliad, and Coleto Creek Reservoir (see Section 4). These revised monthly natural streamflows are included as Appendix A.

Natural daily streamflows and statistics representative of the 1934-89 historical period were completed for the twenty locations identified in Figure 2-1. In general, disaggregation of natural monthly streamflows to natural daily streamflows at a given location was based on available gaged daily streamflow records for that location. If gaged streamflow records were unavailable for a location during a portion of the historical period, then available records from one or more proximate gages were used. Prior to use in disaggregation of monthly natural streamflows at and below the Medina River at San Antonio (ID# 1815), historical municipal treated effluent discharges from the San Antonio area[4] were subtracted from the gaged daily streamflow records assuming uniform effluent discharge throughout the month. Gaged streamflows used for disaggregation of monthly natural streamflow estimates were not adjusted for historical diversions and return flows (other than San Antonio's municipal effluent) as these were assumed to have a relatively minor effect on the resultant streamflow statistics. On an annual basis, maximum historical surface water use in the Guadalupe - San Antonio River Basin would represent less than ten percent of the average freshwater inflow to the Guadalupe Estuary during the 1934-89 historical period. The daily streamflow gage(s) used to disaggregate natural streamflows from a monthly to a daily timestep are summarized in Table 2-1.

2.2 Statistical Summaries and Related Items of Interest

The Consensus Environmental Criteria references the natural median, 25th percentile, and the seven-day, two-year low flow (7Q2) as key streamflow statistics. The median streamflow is that which is equaled or exceeded 50 percent of the time. The 25th percentile or lower quartile

[4] Koch, C. Thomas, Inc., "Historical Streamflow Components, Medina & San Antonio Rivers," Alamo Water Conservation & Reuse District, November 1990.



ID#	STREAM, LOCATION
1675	GUADALUPE R., SPRING BRANCH
1685	GUADALUPE R., ABOVE COMAL R.
D	GUADALUPE R., LAKE DUNLAP
H5	GUADALUPE R., LAKE WOOD
1713	BLANCO R., KYLE
1720	SAN MARCOS R., LULING
1730	PLUM C., LULING
G	GUADALUPE R., GONZALES
1746	PEACH C., DILWORTH
1750	SANDIES C., WESTHOFF
1758	GUADALUPE R., CUERO
1765	GUADALUPE R., VICTORIA
1808	MEDINA R., SOMERSET
1815	MEDINA R., SAN ANTONIO
1818	SAN ANTONIO R. ELMENDORF
1835	SAN ANTONIO R., FALLS CITY
1850	CIBOLO C., SELMA
1860	CIBOLO C., FALLS CITY
1885	SAN ANTONIO R., GOLIAD
1888	GUADALUPE R., TIVOLI

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SELECTED LOCATIONS WITH NATURAL STREAMFLOW STATISTICS

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FIGURE 2-1

TABLE 2-1

REFERENCE GAGES FOR
DAILY STREAMFLOW ESTIMATION

ID#	Stream	Location	Reference Gage(s) ID#	Period	Comments
1675	Guadalupe R.	Spring Branch	1675	1/34 - 12/89	
1685	Guadalupe R.	Above Comal R.	1685	1/34 - 6/62	
			1675	7/62 - 12/89	Regulation by Canyon Lake since 7/62.
D	Guadalupe R.	Lake Dunlap	1685, 1690	1/34 - 12/89	
H5	Guadalupe R.	Lake Wood	1685, 1690	1/34 - 12/89	
1713	Blanco R.	Kyle	1710	1/34 - 5/56	Adjusted for uniform recharge rate.
			1713	6/56 - 12/89	
1720	San Marcos R.	Luling	1700, 1710	1/34 - 4/39	Adjusted for uniform recharge rate.
			1720	5/39 - 12/89	
1730	Plum C.	Luling	1730	1/34 - 12/89	
G	Guadalupe R.	Gonzales	1685, 1690	1/34 - 4/39	
			1685, 1690, 1720, 1730	5/39 - 12/89	
1746	Peach C.	Dilworth	1730	1/34 - 7/59	
			1746	8/59 - 9/79	
			1730	10/79 - 12/89	
1750	Sandies C.	Westhoff	1860	1/34 - 12/59	
			1750	1/60 - 12/89	
1758	Guadalupe R.	Cuero	1685, 1690	1/34 - 11/34	
			1765	12/34 - 12/63	
			1758	1/64 - 12/89	
1765	Guadalupe R.	Victoria	1685, 1690	1/34 - 11/34	
			1765	12/34 - 12/89	
1808	Medina R.	Somerset	1835	1/34 - 12/39	Adjusted for San Antonio return flows.
			1815	1/40 - 9/70	Adjusted for San Antonio return flows.
			1808	10/70 - 12/89	
1815	Medina R.	San Antonio	1835	1/34 - 12/39	Adjusted for San Antonio return flows.
			1815	1/40 - 12/89	Adjusted for San Antonio return flows.
1818	San Antonio R.	Elmendorf	1835	1/34 - 12/62	Adjusted for San Antonio return flows.
			1818	1/63 - 12/89	Adjusted for San Antonio return flows.
1835	San Antonio R.	Falls City	1835	1/34 - 12/89	Adjusted for San Antonio return flows.
1850	Cibolo C.	Selma	1690	1/34 - 3/46	Adjusted for Comal springflow.
			1850	4/46 - 12/89	
1860	Cibolo C.	Falls City	1860	1/34 - 12/89	
1885	San Antonio R.	Goliad	1835	1/34 - 2/39	Adjusted for San Antonio return flows.
			1885	3/39 - 12/89	Adjusted for San Antonio return flows.
1888	Guadalupe R.	Tivoli	1685, 1690, 1835	1/34 - 11/34	Adjusted for San Antonio return flows.
			1765, 1835	12/34 - 2/39	Adjusted for San Antonio return flows.
			1765, 1885	3/39 - 12/89	Adjusted for San Antonio return flows.

streamflow is that which is equaled or exceeded 75 percent of the time. Finally, the 7Q2 is the lowest streamflow not exceeded for seven consecutive days within a calendar year and having a 2-year return period (50 percent chance of occurrence in any given year). More simply stated, the 7Q2 is the median annual seven-day low flow. For the 20 selected locations shown in Figure 2-1, median and 25th percentile streamflows for each month of the year are summarized along with the 7Q2 streamflow in Tables 2-2 and 2-3.

Figure 2-2 presents natural streamflow statistics for four selected locations in the Guadalupe River Basin plotted to the same scale to illustrate the accumulation of flows moving downstream through the basin. Note that streamflows are less variable throughout the year at Lake Dunlap and Luling due to the relatively steady discharges from Comal and San Marcos Springs. The significant influence of springflow is also apparent in the fact that the 7Q2 exceeds the 25th percentile flow in many months.

Figure 2-3 presents natural streamflow statistics for four selected locations in the San Antonio River Basin plotted to the same scale to illustrate the accumulation of flows moving downstream through the basin. Without the steady influence of San Antonio return flows, differences between the median and 25th percentile flows and between the 25th percentile flows and the 7Q2 are greater for the San Antonio River than for the Guadalupe River.

Figure 2-4 summarizes natural streamflow statistics for the most downstream full service gage locations on the Guadalupe and San Antonio Rivers along with those for the Saltwater Barrier near Tivoli. This figure illustrates the relative contributions of each major river to the Guadalupe Estuary under natural conditions. In general terms, the Guadalupe River contributes three units of natural inflow for each unit contributed by the San Antonio River.

While the original Trans-Texas Environmental Assessment criteria and other screening criteria used in the past have been based on statistics derived from monthly streamflow volumes, the Consensus Environmental Criteria is explicitly keyed to daily streamflows. Use of daily statistics provides a more reasonable indication of the streamflow regime typically observed at a location. This is because monthly statistics are often skewed by flood flows passing the gage for only a few days which may represent the majority of the streamflow volume passing the gage for the entire month. Figure 2-5 provides a comparison of median natural streamflows derived from

TABLE 2-2

GUADALUPE RIVER BASIN
NATURAL DAILY STREAMFLOW STATISTICS (CFS)

MEDIAN

MONTH	1675	1685	DUNLAP	H5	1713	1720	1730	GONZALES	1746	1750	1758	1765	1888
JAN	170.5	243.6	567.5	589.8	39.2	206.0	13.9	820.6	9.9	16.5	983.4	1045.4	1476.9
FEB	178.1	260.0	592.0	625.8	51.1	226.4	17.9	887.5	12.0	19.5	1050.9	1122.8	1670.4
MAR	191.5	291.7	598.7	627.6	45.3	219.3	14.6	867.3	9.9	17.3	1046.1	1145.7	1483.2
APR	181.6	268.9	606.6	610.4	67.7	252.6	11.9	923.5	5.1	16.3	1078.7	1147.2	1513.0
MAY	235.8	348.8	717.9	710.5	76.3	276.4	15.9	1068.6	13.0	20.0	1295.4	1371.7	1962.7
JUN	192.6	299.3	644.1	657.5	68.9	253.8	12.0	944.9	7.8	17.3	1170.0	1238.0	1814.6
JUL	118.7	198.0	507.5	536.4	36.3	193.7	4.9	755.3	0.8	9.7	865.0	916.9	1278.8
AUG	88.4	134.4	435.4	474.7	15.7	164.5	2.2	641.0	0.2	7.0	676.5	721.8	1022.4
SEP	115.0	173.0	472.8	495.4	23.2	176.0	4.0	691.8	0.2	10.5	749.0	806.0	1223.5
OCT	147.4	200.4	518.0	513.9	28.4	175.5	5.7	733.1	0.5	11.6	837.2	899.4	1360.9
NOV	148.1	212.4	515.1	541.6	28.6	183.5	8.1	742.6	3.4	13.9	866.5	917.2	1364.8
DEC	170.1	228.1	569.1	580.0	40.0	201.0	9.9	793.7	5.2	15.3	897.9	952.5	1355.7

25th PERCENTILE

MONTH	1675	1685	DUNLAP	H5	1713	1720	1730	GONZALES	1746	1750	1758	1765	1888
JAN	91.0	118.0	390.1	430.1	9.2	135.4	7.3	580.4	0.3	10.6	603.6	652.7	899.5
FEB	97.9	133.0	409.3	453.5	16.3	145.4	8.2	610.0	2.0	11.0	661.5	732.4	998.7
MAR	93.5	131.5	396.9	444.8	12.2	137.0	6.7	585.9	0.3	10.8	637.0	696.4	927.4
APR	102.5	138.7	399.4	434.3	14.2	129.7	5.5	581.1	0.0	8.2	625.9	688.7	913.6
MAY	95.2	134.0	406.3	437.5	21.1	153.6	5.7	625.8	1.1	7.7	694.8	747.9	1038.0
JUN	79.4	107.8	370.1	414.6	25.9	144.3	4.2	576.5	0.0	6.8	624.0	667.6	962.1
JUL	49.3	81.2	300.8	326.1	2.9	113.8	1.5	455.8	0.0	2.9	490.9	537.3	648.2
AUG	38.0	55.3	281.7	317.1	0.0	100.4	0.4	427.4	0.0	1.2	361.2	399.5	606.4
SEP	51.2	70.2	335.1	378.3	0.0	107.0	1.1	500.8	0.0	3.9	432.3	469.6	726.0
OCT	61.5	80.1	339.3	384.7	0.6	109.3	2.1	500.0	0.0	5.0	496.0	543.7	745.8
NOV	73.1	94.0	349.8	377.7	4.0	115.9	4.1	521.8	0.0	7.2	552.4	594.2	861.3
DEC	85.5	103.1	369.8	400.0	5.4	129.5	5.2	547.0	0.1	9.1	581.8	606.6	836.7

7Q2

1675	1685	DUNLAP	H5	1713	1720	1730	GONZALES	1746	1750	1758	1765	1888
52.64	77.30	371.0	375.3	4.5	120.9	1.1	545.0	0.0	3.4	540.4	584.6	742.0

TABLE 2-3

SAN ANTONIO RIVER BASIN
NATURAL DAILY STREAMFLOW STATISTICS (CFS)

MEDIAN

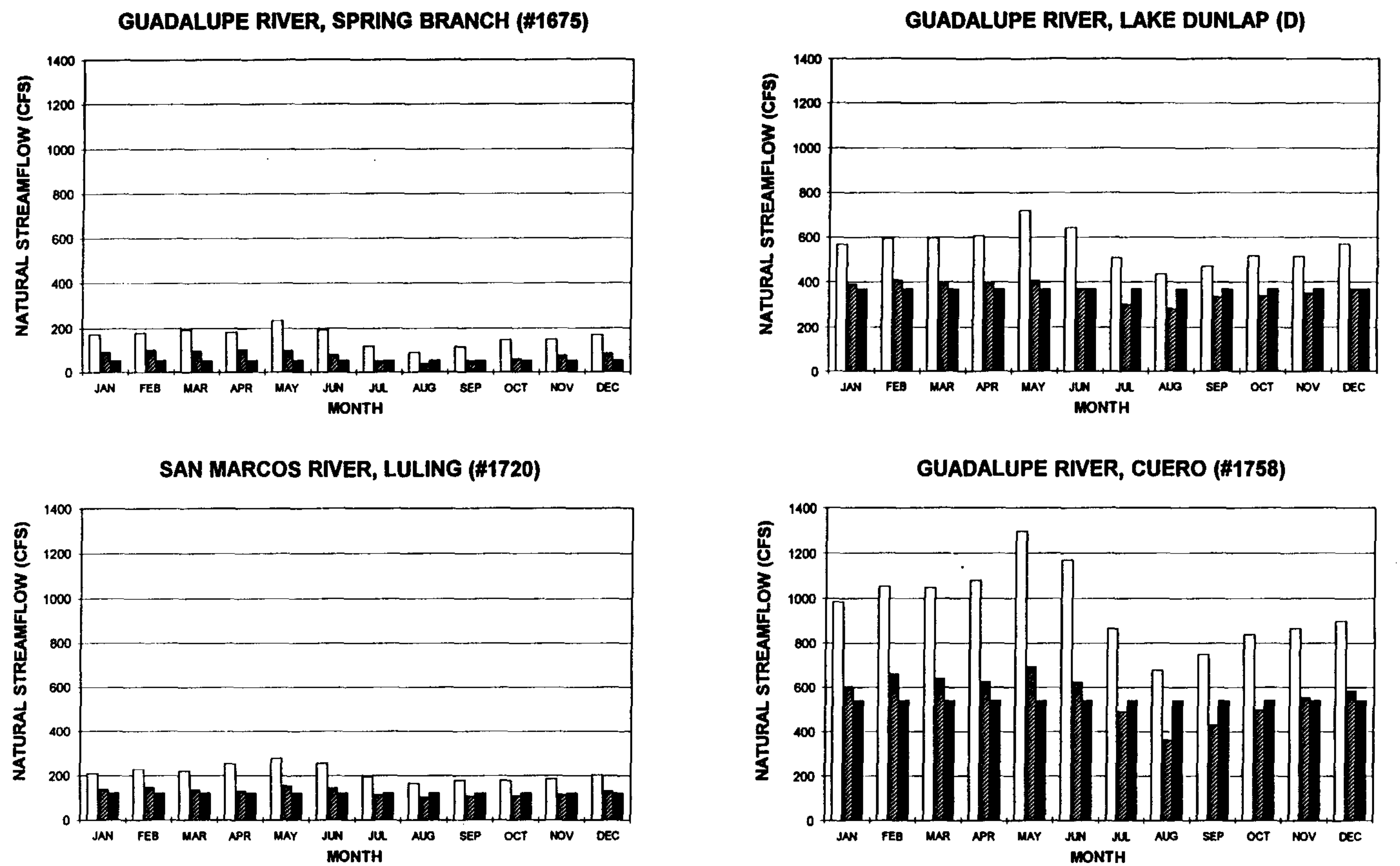
MONTH	1808	1815	1818	1835	1850	1860	1885
JAN	99.8	114.0	190.8	229.2	0.0	26.9	294.2
FEB	104.6	118.8	192.4	231.6	0.0	27.1	306.6
MAR	97.0	112.2	202.4	231.0	0.0	26.9	306.8
APR	103.3	118.8	191.8	217.1	0.0	26.0	305.8
MAY	115.5	125.5	209.3	258.2	0.0	30.0	371.0
JUN	123.9	129.8	190.6	236.3	0.0	29.2	346.3
JUL	71.1	89.2	125.9	154.4	0.0	20.0	241.9
AUG	61.4	81.4	109.0	137.0	0.0	16.1	199.4
SEP	76.1	93.5	139.2	165.0	0.0	19.0	239.9
OCT	96.1	104.3	152.2	174.0	0.0	22.1	258.0
NOV	85.7	104.5	160.3	191.2	0.0	26.0	283.1
DEC	95.3	114.7	178.3	208.8	0.0	26.2	288.9

25th PERCENTILE

MONTH	1808	1815	1818	1835	1850	1860	1885
JAN	48.0	64.5	97.2	124.2	0.0	19.2	183.3
FEB	59.4	75.9	108.0	137.6	0.0	19.3	197.4
MAR	55.3	67.1	90.8	126.3	0.0	19.0	176.1
APR	57.3	64.3	84.7	114.6	0.0	17.0	157.0
MAY	59.9	73.7	84.4	115.4	0.0	15.9	175.4
JUN	42.2	53.9	45.8	82.3	0.0	13.4	145.9
JUL	21.2	31.8	0.8	43.6	0.0	9.9	89.9
AUG	15.1	31.2	2.0	42.0	0.0	7.4	77.3
SEP	30.8	41.2	35.8	65.5	0.0	10.1	103.4
OCT	58.3	68.6	57.9	85.7	0.0	13.0	134.0
NOV	48.7	63.0	65.3	90.6	0.0	15.2	140.3
DEC	51.7	66.0	81.0	108.6	0.0	16.7	150.8

7Q2

1808	1815	1818	1835	1850	1860	1885
34.1	43.0	27.2	51.1	0.0	11.0	77.0



MEDIAN
25TH PERCENTILE
7Q2

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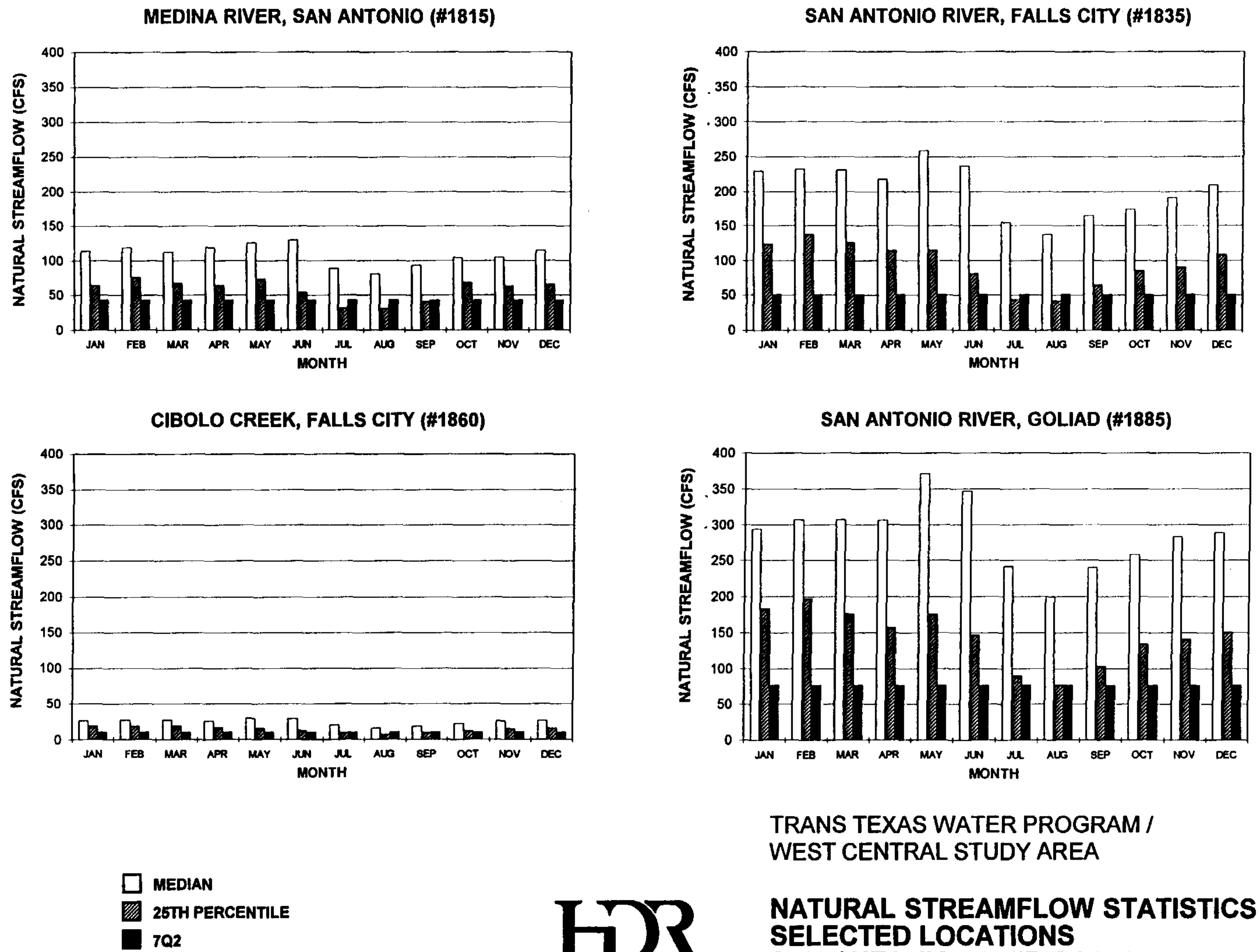
NATURAL STREAMFLOW STATISTICS
SELECTED LOCATIONS
GUADALUPE RIVER BASIN

FIGURE 2-2



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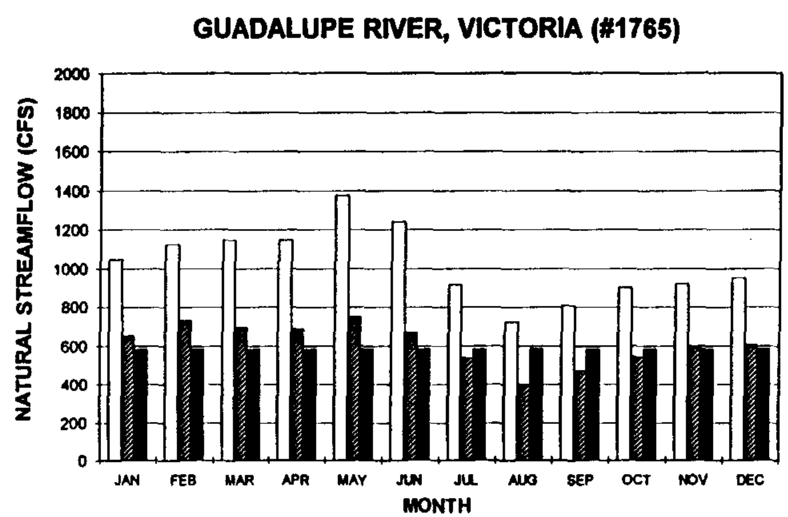
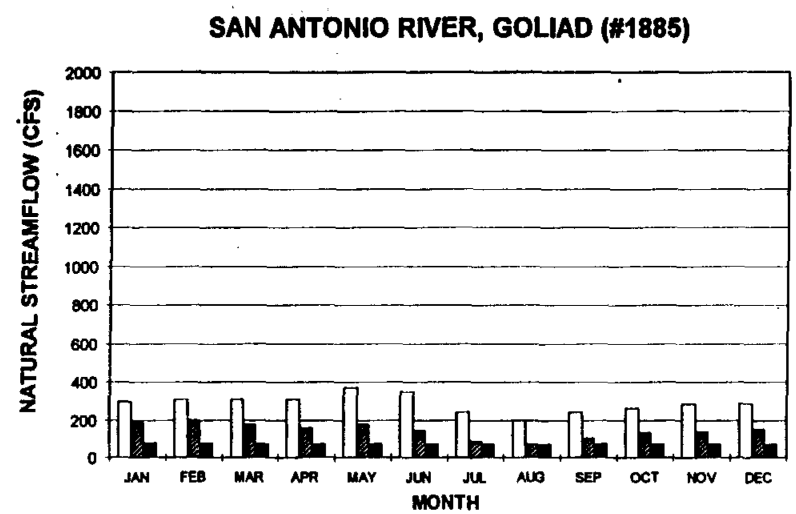
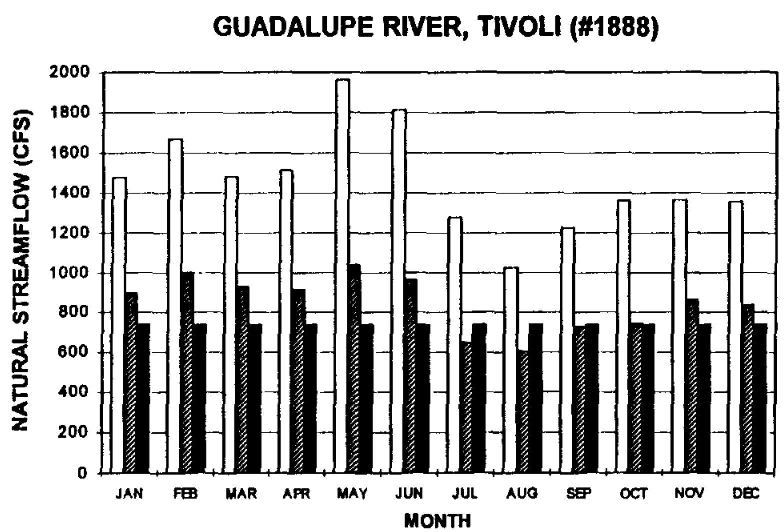
NATURAL STREAMFLOW STATISTICS
SELECTED LOCATIONS
SAN ANTONIO RIVER BASIN

FIGURE 2-3







MEDIAN
25TH PERCENTILE
7Q2

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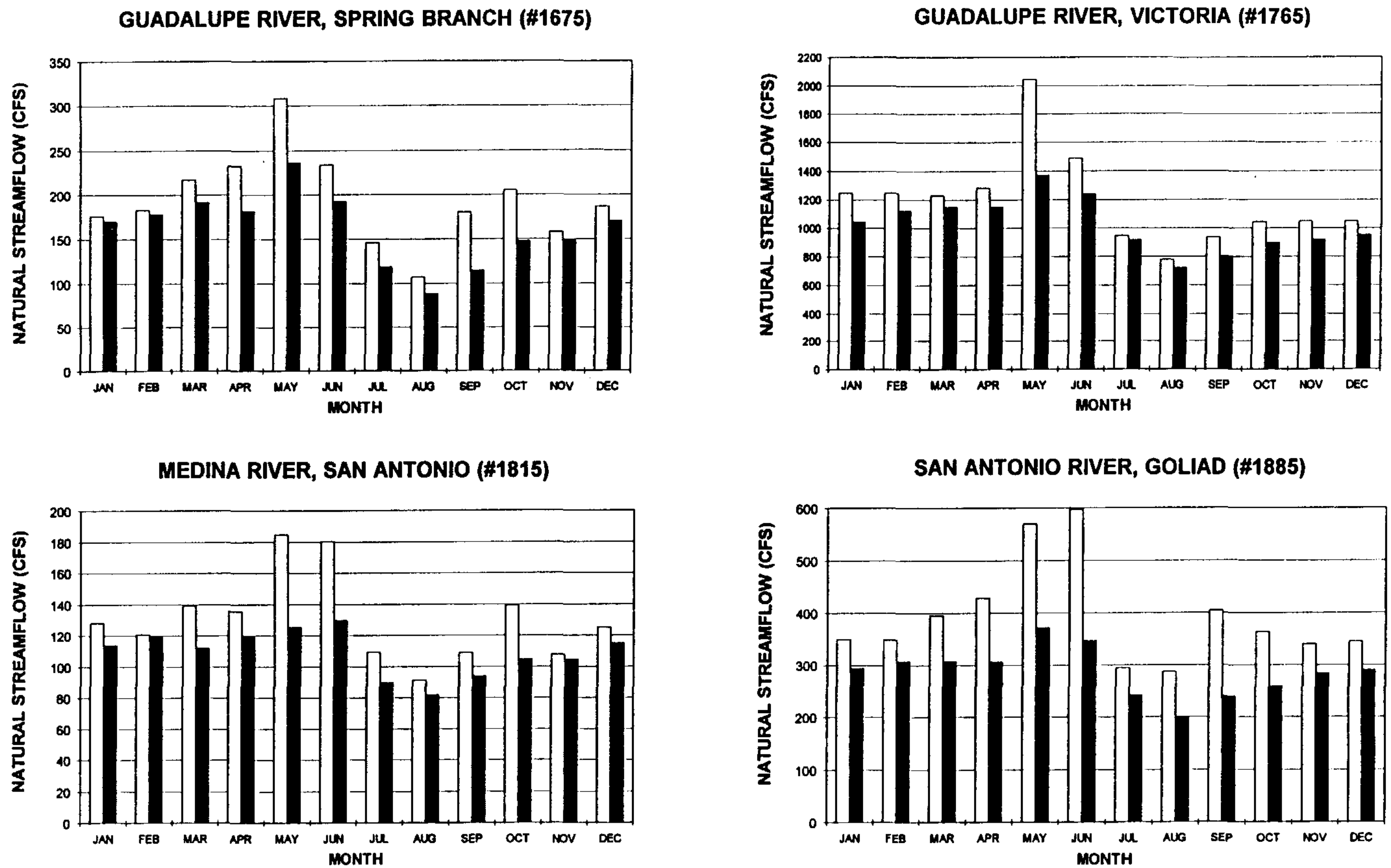
**NATURAL STREAMFLOW STATISTICS
SELECTED LOCATIONS
GUADALUPE-SAN ANTONIO RIVER BASIN**

FIGURE 2-4



MONTHLY
DAILY

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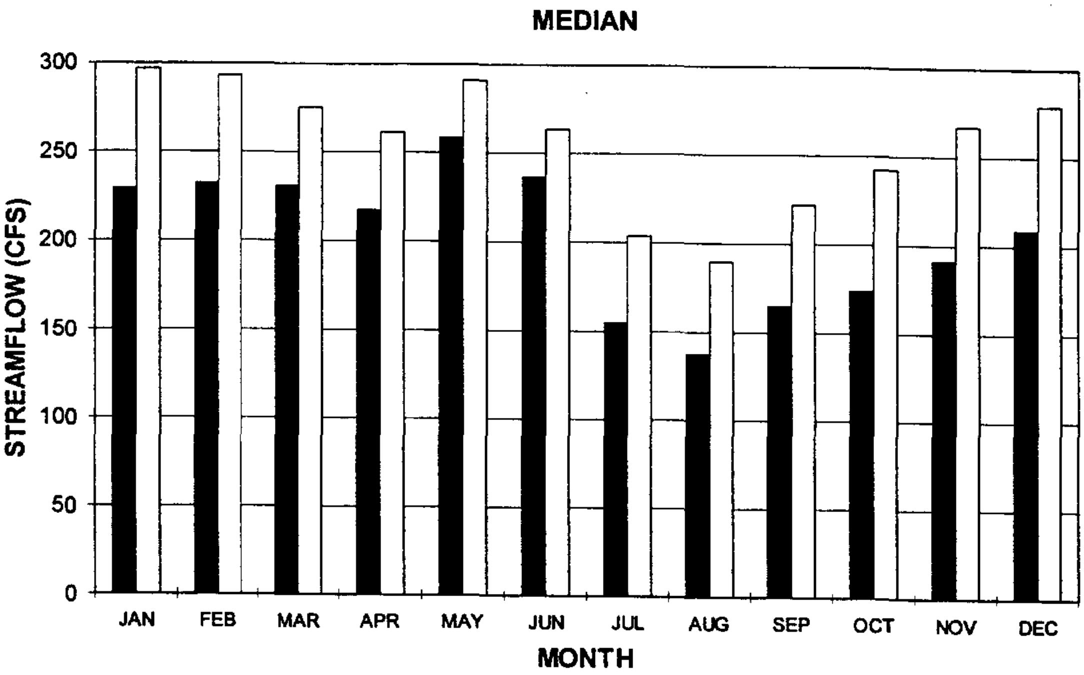
NATURAL STREAMFLOW STATISTICS
DAILY VS. MONTHLY MEDIANS

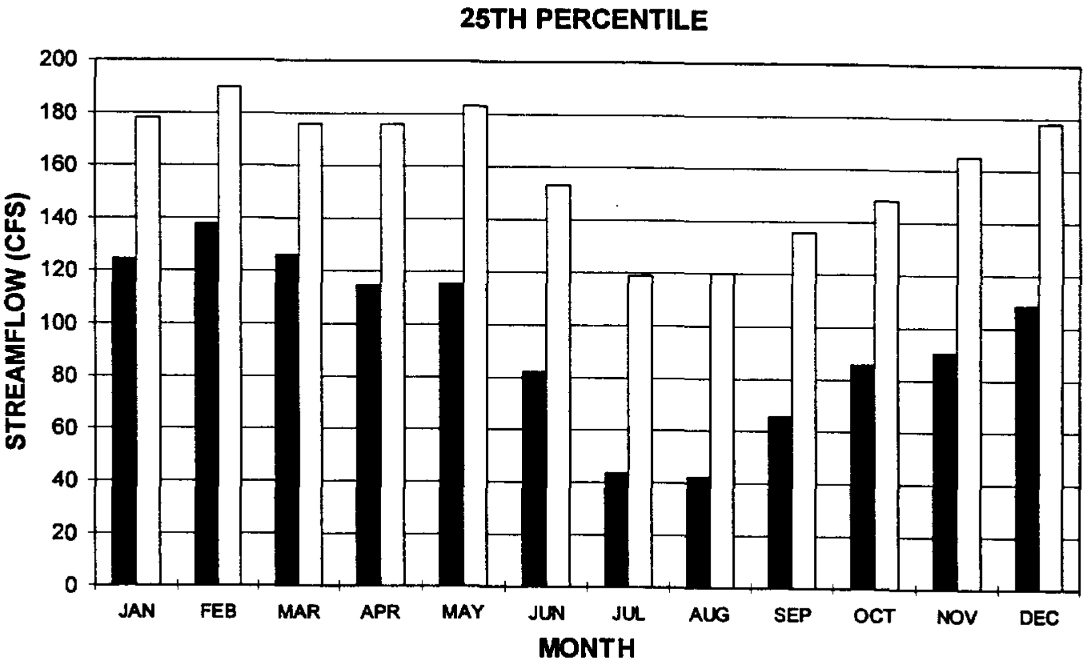
FIGURE 2-5

monthly and daily databases for four locations in the Guadalupe - San Antonio River Basin. As is apparent in Figure 2-5, medians derived from daily streamflow data are lower in all months and, especially, in the months of May, June, September, and October when flood flows are most likely.

Natural and gaged streamflow statistics for the San Antonio River at Falls City (ID# 1835) are compared in Figure 2-6 to illustrate the historical influence of treated municipal effluent discharge from the San Antonio area on downstream flows. This influence becomes more significant in lower flow conditions, but is perhaps most striking when comparing the 7Q2 estimates derived from natural (51.1 cfs) and gaged (140.5 cfs) streamflows for the 1934-89 historical period. According to the Consensus Environmental Criteria, the 7Q2 is only to be used as a minimum desired instream flow in the absence of an established water quality standard for the reach in question. The TNRCC has often used the 7Q2 to establish water quality standards, however, they have generally based their statistical calculations on recent gaged (rather than long-term natural) streamflow records. For example, the TNRCC uses a 7Q2 standard of 197.3 cfs for the San Antonio River at Falls City[5] based on gaged streamflows for the 1969-89 historical period. This standard is almost four times the natural 7Q2 and 40 percent greater than the 7Q2 derived from long-term gaged streamflows.

[5] TNRCC, "Texas Surface Water Quality Standards, 307.1 - 307.10, Permanent Rule Changes, Appendix B: Low Flow Criteria," Effective July 13, 1995.





NATURAL 7Q2 = 51.08 CFS

GAGED 7Q2 = 140.50 CFS

■ NATURAL

□ GAGED

TRANS TEXAS WATER PROGRAM /
WEST CENTRAL STUDY AREA

HDR Engineering, Inc.

STREAMFLOW STATISTICS
SAN ANTONIO R., FALLS CITY (#1835)
NATURAL VS. GAGED

FIGURE 2-6

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3.0 REFINED LAKE WOOD STREAMFLOW ESTIMATES

The Guadalupe-Blanco River Authority (GBRA) operates a series of six hydropower dams on the Guadalupe River between New Braunfels and Gonzales. The most downstream of these dams is called H-5 and impounds Lake Wood. The dam is constructed primarily of earthfill with a floating crest spillway comprised of two 85-foot roof-weir gates. Power generation facilities were installed in 1931 and include one S. Morgan Smith variable pitch Kaplan turbine (nameplate capacity = 2,400 kilowatts) for which both guide vanes and blade pitch are controlled by a governor. GBRA maintains microfilm copies of handwritten Hydro Logs and Spill Logs summarizing daily/hourly H-5 operations in terms of governor setting, power generation, gate setting, headwater, tailwater, etc.

Because of its key location immediately upstream of the San Marcos River confluence and the availability of hydrologic records, Lake Wood was selected as a control point in the original development of the GSA Model.[1] Streamflow records were originally estimated for the 1980-89 historical period using records of water use reported to the TNRCC for hydroelectric power generation and microfilmed Spill Logs. The Spill Logs contain detailed records of gate settings and headwater and tailwater depths during flood events which exceeded turbine capacity and resulted in flow over the gates. Combining these computed spill volumes with estimated leakage and reported flows through the turbine, estimated gaged flows were obtained for the Guadalupe River at H-5 for the 1980-89 historical period. These estimated gaged flows were used to develop a channel loss rate function representative of the Guadalupe River between New Braunfels and Lake Wood and to develop regression equations ultimately used to estimate natural streamflows passing H-5 for the entire 1934-89 historical period.

In 1996, GBRA staff began a careful review of methods applied to estimate flows passing H-5 because their experience indicated that previous flow estimates might be low resulting in a typical channel loss rate greater than expected. This review concluded that methods used to estimate spills appeared reasonable while methods previously used to estimate flow through the turbine might be improved. Previously reported turbine flow estimates were computed as the product of monthly power generation and a factor based on operating head and efficiency

[1] HDR, September 1993, op. cit.

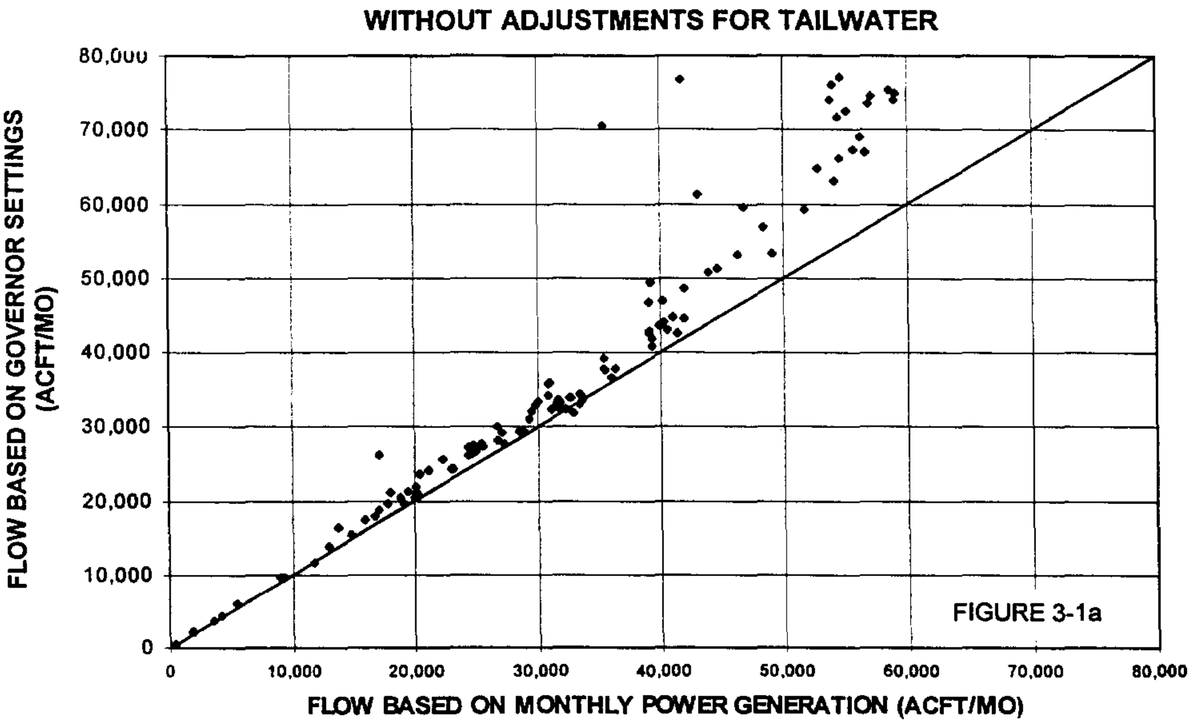
approaching their respective design values. Because H-5 sometimes operates at heads and/or efficiencies less than the design values (and more water must be passed through the turbine to generate each unit of power), the decision was made to re-estimate flows through the turbine considering hourly governor settings and power generation recorded in the daily Hydro Logs for the 1980-89 period. This data was entered into computer spreadsheets or data files by GBRA staff with periodic support from HDR personnel.

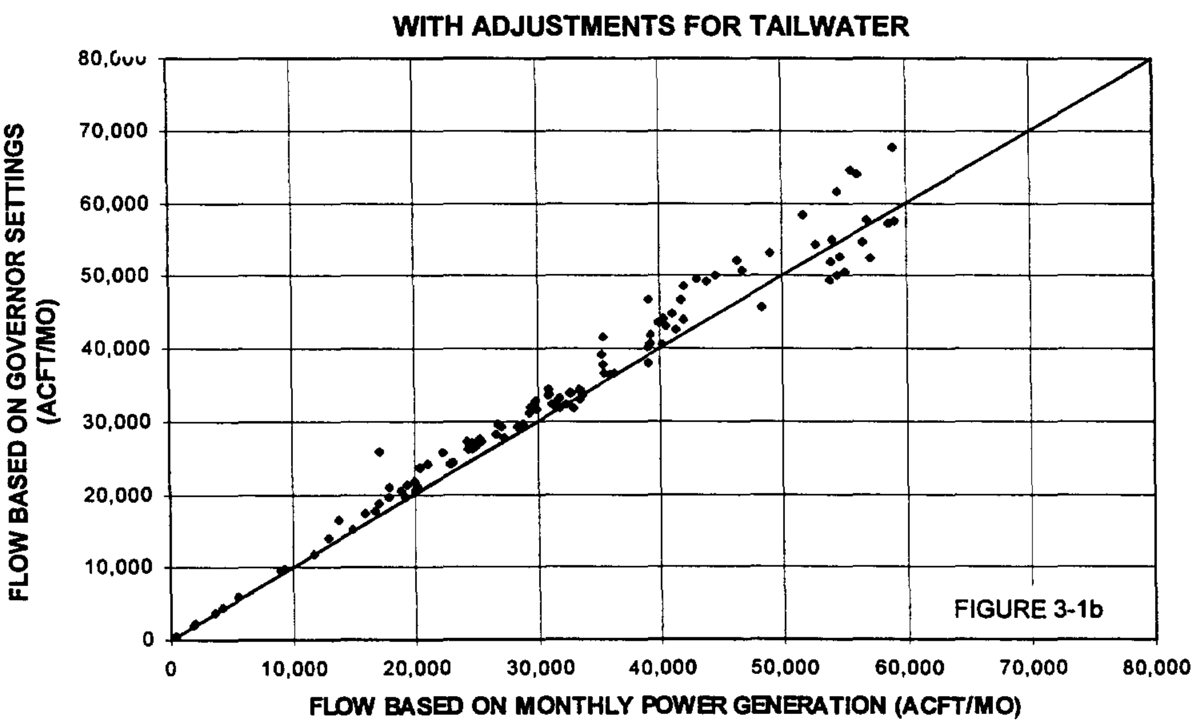
3.1 Turbine Flow Estimation Procedure

The first new estimates of historical flow through the turbine at H-5 were computed directly from governor setting using spreadsheet operations (GBRA) or a utility program (HDR) to perform linear interpolation from a rating table. These first estimates based on governor settings are compared to the originally reported amounts based on monthly power generation in Figure 3-1a. It is clear that the new estimates consistently exceed the original estimates and that the new estimates might be somewhat questionable under high flow conditions (in excess of about 45,000 acft/mo). As is apparent in Figure 3-1b, turbine flow estimates based on governor setting appear more consistent over the range of flows experienced after empirical adjustment for tailwater effects under high flow conditions.

Review of GBRA records indicates that a governor setting of 100 is typically used during spills or other high flow periods. Hence, an empirical relationship between head and power was developed using available headwater and tailwater information from the Spill Logs and concurrent power generation records from the Hydro Logs. Figure 3-2a shows an empirical rating curve for the Kaplan turbine at H-5 operating at a governor setting of 100 along with the specific data points considered in its derivation. Subject to the design head of 29 feet, the empirical curve predicts approximately 2,100 kilowatts generation which is the "plant capability under normal conditions" according to the GBRA Operations Manual.

Referencing a standard chart relating percentage of design power, percentage of design head, and efficiency for adjustable blade turbines, H-5 turbine efficiency was plotted versus percentage of rated power (nameplate capacity). The resulting efficiency curve is presented in Figure 3-2b. The curve indicates a maximum efficiency of about 88.5 percent at about 65 percent of rated power and relatively high efficiency between 50 and 80 percent of rated





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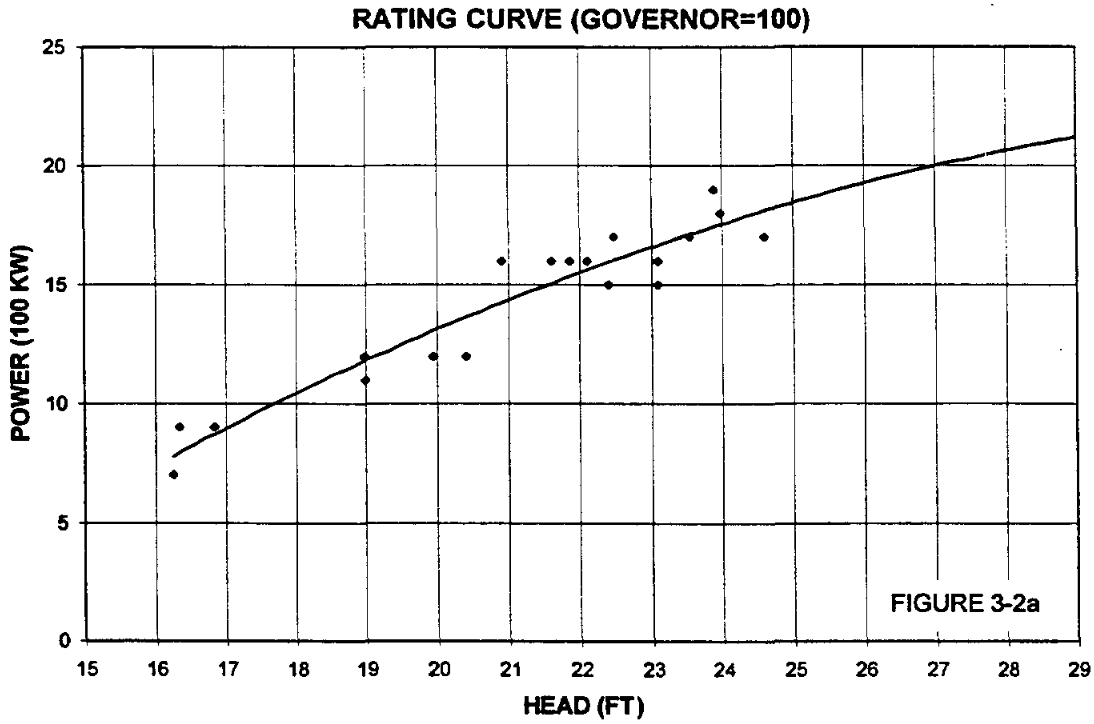
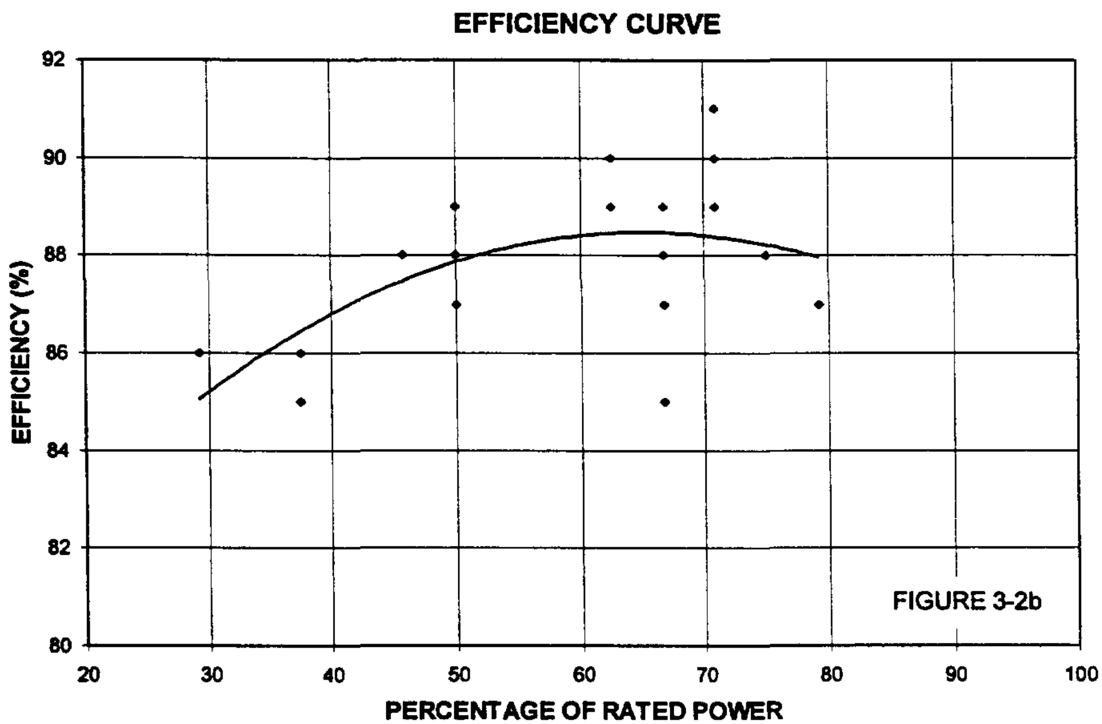
LAKE WOOD (HYDRO DAM H-5) TURBINE FLOW COMPARISONS

FIGURE 3-1





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EMPIRICAL H-5
RATING AND EFFICIENCY CURVES

HDR

HDR Engineering, Inc.

FIGURE 3-2

power. This is generally consistent with the GBRA Operations Manual which identifies 65 as the "most efficient governor setting" and notes "90 percent efficiency and above on governor settings from 53 to 85." The reduced efficiencies indicated by the empirical data may be due to the age of the equipment.

The empirical relationship between head and power shown in Figure 3-2a was used in combination with the standard horsepower equation relating power to both discharge and head to solve for revised estimates of turbine flow under high flow conditions when the governor was set to 100. Turbine flow estimates could be further refined by adjustment for tailwater influences at governor settings less than 100, but such adjustments would not likely be significant relative to the total flow and overall accuracy of spill calculations. These revised estimates of turbine flow were then combined with previous estimates of spills and leakage to obtain new estimates of total ("gaged") flow passing H-5 during the 1980-89 historical period. The new estimates of total flow passing H-5 generally exceed the previous estimates by about 4.5 percent.

3.2 New Channel Losses and Natural Streamflows

After adjusting the H-5 total flows to account for historical diversions and return flows below New Braunfels, a revised channel loss rate function for the Guadalupe River above H-5 was derived using methods identical to those in original database development.[2] The revised channel loss rate function is:

$$Q_{LOSS} = .0221\ (QG_1)^{1.1462}$$

where:

Q_{LOSS} = Channel Loss (acft/mo); and

QG_1 = Upstream Gaged Streamflow (acft/mo).

Under the original channel loss rate function, between 86 and 89 percent of the combined upstream flow would typically be delivered from New Braunfels to H-5. Under the revised channel loss rate function, however, between 89 and 95 percent of the combined upstream flow would typically be delivered.

[2] HDR, September 1993, op. cit.

New regression equations were developed for estimation of H-5 streamflow for the remainder of the 1934-89 historical period. These equations are presented as follows:

$$QNH_{H5} = 0.79967Q_{1685} + 1.24622Q_{1690} \qquad (1/34 - 12/59)$$

$$QNH_{H5} = 0.76308Q_{1685} + 1.18412Q_{1690} + 0.26594QI_{H5} \qquad (1/60 - 12/79)$$

where:

QNH_{H5} = Gaged Streamflow Adjusted for Local Diversions and Return Flows;

Q_{1685} = Gaged Streamflow, Guadalupe River Above Comal River;

Q_{1690} = Gaged Streamflow, Comal River at New Braunfels; and

QI_{H5} = Potential Intervening Runoff Above H-5 and Below New Braunfels.

Application of these regression equations along with the revised channel loss rate function ultimately resulted in revised natural streamflow estimates for H-5 and for downstream locations on the Guadalupe River including Gonzales (ID# G), Cuero (ID# 1758), Victoria (ID# 1765), and Tivoli (ID# 1888). Monthly summaries of revised natural streamflows are included as Appendix A.

4.0 GUADALUPE ESTUARY HARVEST AND SALINITY EQUATIONS

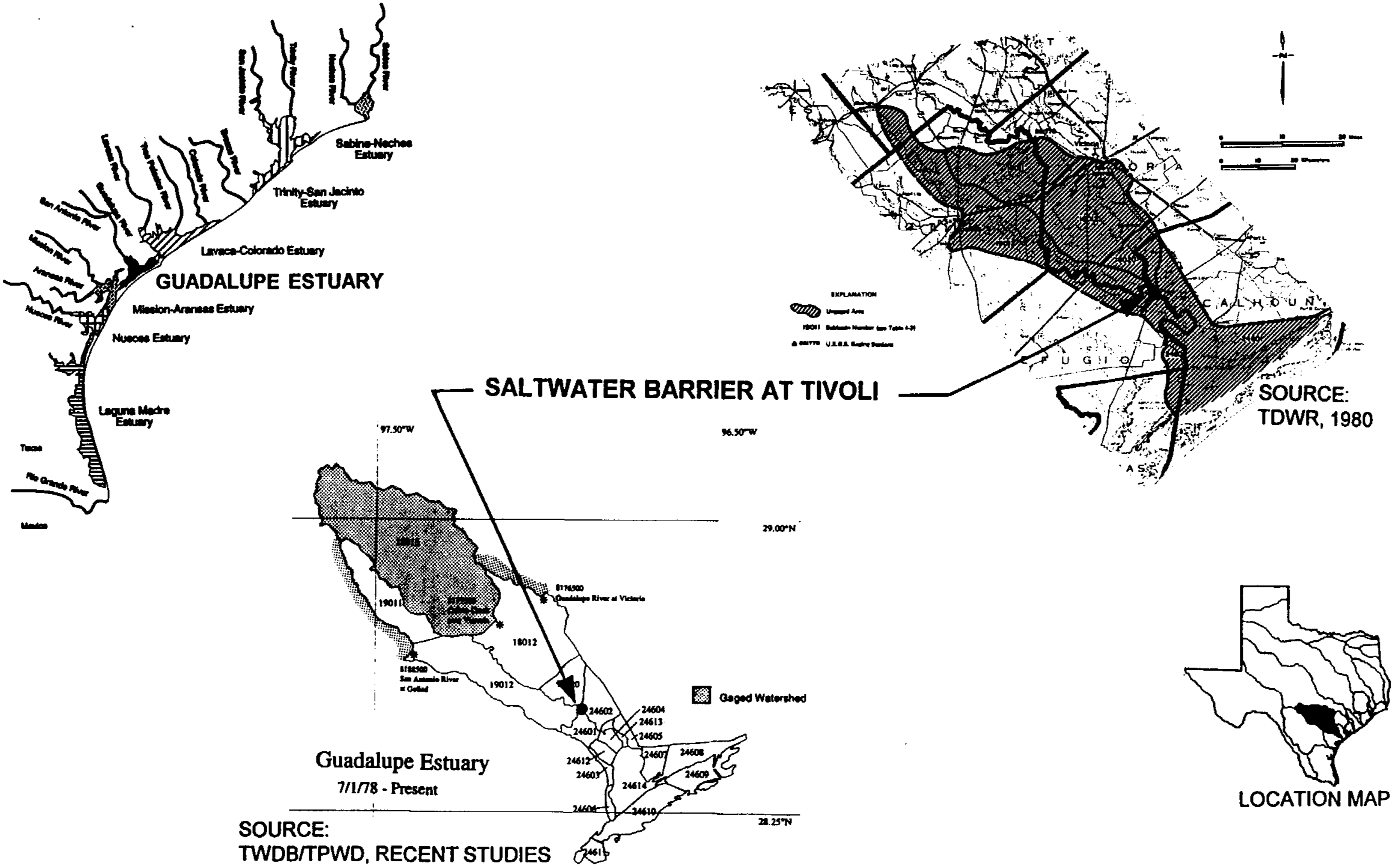
The Texas Water Development Board (TWDB), Texas Parks & Wildlife Department (TPWD), Texas Natural Resource Conservation Commission (TNRCC), and numerous other institutions have been studying freshwater inflow needs of Texas' major estuarine systems for more than 30 years. The scope of these studies has been quite broad ranging from basic hydrology and data collection to the application of multi-objective optimization techniques using quantitative relationships between inflow, salinity, and reported fishery harvest to calculate freshwater inflow needs based on defined management objectives. Perhaps the most comprehensive summaries of pertinent findings with respect to the Guadalupe Estuary may be found in a recent report completed by the TWDB and TPWD[1] and an earlier report prepared by the Texas Department of Water Resources.[2] These reports and continuing studies reflect ongoing efforts to more quantitatively define the role of freshwater inflows in maintaining the ecological health of Texas estuaries and related marine resources.

The TWDB and TPWD have recently developed new equations using combined freshwater inflows to the Guadalupe Estuary to estimate expected annual commercial fisheries harvest of representative shellfish and finfish species.[3] Because these new equations are functions of seasonal freshwater inflow only, they may be readily linked to the GSA Model which computes estimates of streamflow passing the Saltwater Barrier on the Guadalupe River near Tivoli (see Figure 4-1). This linkage facilitates direct approximation of the impacts of a proposed water supply alternative on selected marine species rather than simple reliance on changes in freshwater inflow statistics for assessment of potential environmental impacts. The steps involved in the development of a post-processor program for the GSA Model capable of expediently computing seasonal freshwater inflows, annual fisheries harvests, variations in salinity, and convenient statistical summary tables are described in the following sections.

4.1 Ungaged Runoff Estimates

The first step in linking the TWDB/TPWD fisheries harvest and salinity equations to the GSA Model was to obtain estimates of runoff from ungaged areas tributary to the Guadalupe

[1] TWDB and TPWD, "Freshwater Inflows to Texas Bays and Estuaries: Ecological Relationships and Methods for Determination of Needs," Joint Estuarine Research Study, 1994.
[2] Texas Department of Water Resources (TDWR), "Guadalupe Estuary: A Study of the Influence of Freshwater Inflows," LP-107, August 1980.
[3] TWDB, Personal Communication, September, 1996.



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WEST CENTRAL STUDY AREA

HDR Engineering, Inc.

UNGAGED AREAS TRIBUTARY TO THE GUADALUPE ESTUARY

FIGURE 4-1

Estuary. As indicated in Figure 4-1, these ungaged areas are located both above and below the Saltwater Barrier near Tivoli. The original database for the GSA Model included estimates of ungaged runoff for the area above the Saltwater Barrier and below the Guadalupe River at Victoria (ID# 1765), Coleto Creek Reservoir, and the San Antonio River at Goliad (ID# 1885) obtained primarily from a study completed by Espey, Huston & Associates, Inc. (EH&A).[4] Ungaged runoff estimates for areas below the Saltwater Barrier have not previously been included in the database for the GSA Model. In order to ensure consistency with the fisheries harvest and salinity equations provided by the TWDB, the EH&A estimates were discarded and the databases revised to include TWDB estimates of ungaged runoff. Dr. Ruben Solis of the TWDB provided significant assistance both in compiling ungaged runoff estimates for the numerous subwatersheds identified in Figure 4-1 and in researching variable assumptions in their derivation over the years. Dr. Solis provided composite estimates of ungaged runoff above and below the Saltwater Barrier for the 1941-89 historical period which, after minor adjustments for drainage area, were used to develop regression equations for estimation of ungaged runoff for the 1934-40 period based on HDR estimates monthly areal precipitation. Annual ungaged runoff above and below the Saltwater Barrier is summarized in Figure 4-2 and included in tabular form as Appendix B.

A baseline series of monthly freshwater inflows to the Guadalupe Estuary was developed by combining the ungaged runoff estimates for the area downstream of the Saltwater Barrier with simulated streamflows from the GSA Model. The Baseline freshwater inflows reflect full utilization of consumptive water rights throughout the Guadalupe - San Antonio River Basin, subordination of hydropower rights to Canyon Lake, springflows associated with a fixed Edwards Aquifer pumpage of 400,000 acft/yr, and perennial discharge of return flows reported for calendar year 1989. Annual Baseline inflows for the 1934-89 historical period are presented along with monthly medians in Figure 4-3. Freshwater inflow levels deemed adequate to satisfy nutrient and sediment constraints for the Guadalupe Estuary[5] are plotted for reference in Figure 4-3.

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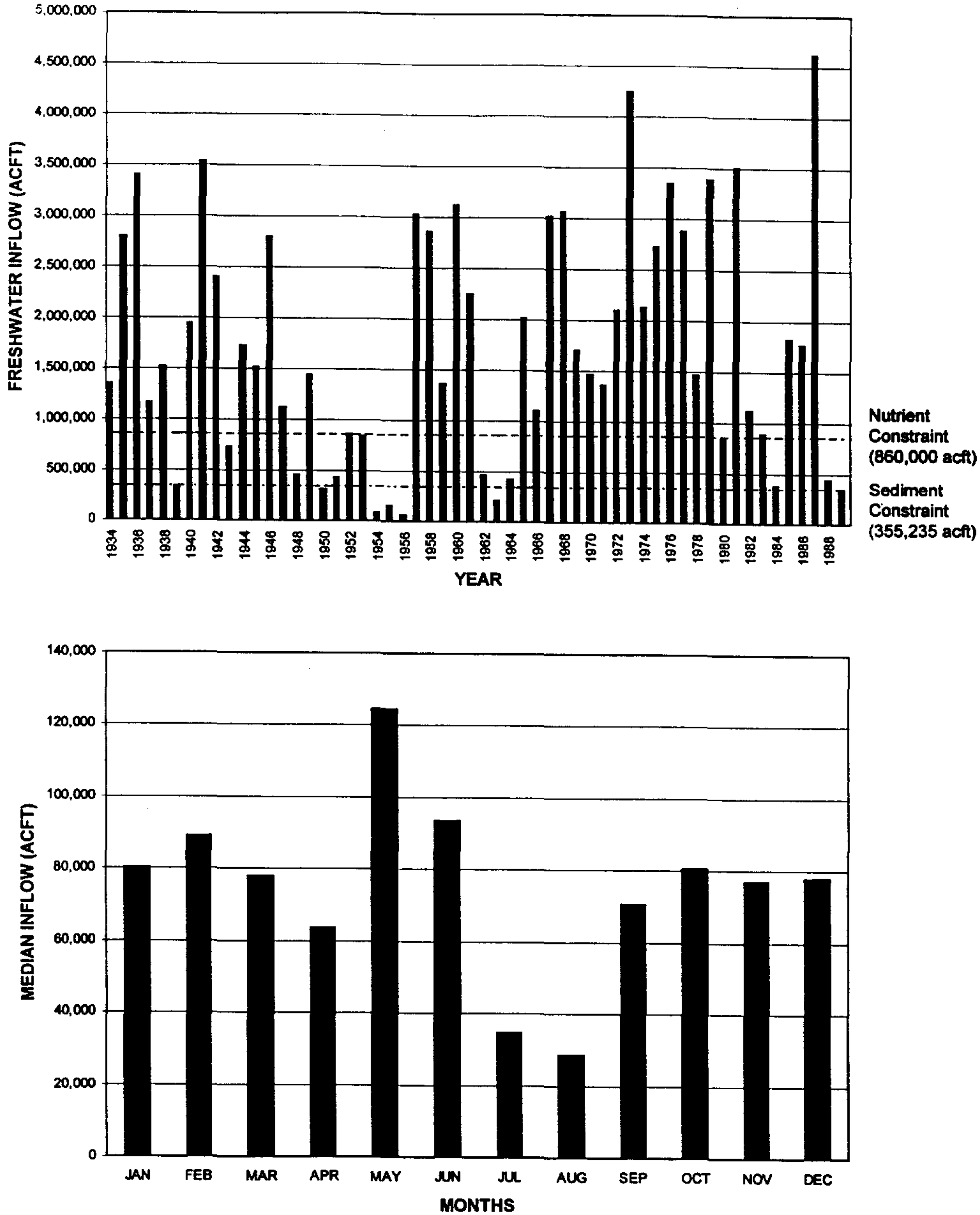
[4] Espey, Huston & Associates, Inc. (EH&A), "Water Availability Study for the Guadalupe and San Antonio River Basins," San Antonio River Authority, Guadalupe-Blanco River Authority, City of San Antonio, February, 1986.

[5] TWDB and TPWD, 1994, op. cit.



Baseline=Full Water Rights, Hydropower Subordination, 400 kacft/yr Edwards Pumpage, 1989 Return Flows

TRANS TEXAS WATER PROGRAM / WEST CENTRAL STUDY AREA

BASELINE FRESHWATER INFLOW GUADALUPE ESTUARY

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FIGURE 4-3

4.2 Fisheries Harvest Equations

In cooperation with the TPWD, the TWDB has recently developed commercial fisheries harvest equations applicable to the Guadalupe Estuary for white shrimp, brown shrimp, blue crabs, eastern oysters, black drum, red drum, and spotted seatrout. These equations differ somewhat from previous equations in that they are based solely on seasonal freshwater inflow and exclude other potential independent variables such as effort and temperature. Guadalupe Estuary fisheries harvest equations used in this study (Table 4-1) were provided by Dr. Gary Powell and Dr. Junji Matsumoto of the TWDB along with significant technical guidance regarding their application. As statistical analyses have shown that species harvest in one calendar year may be affected by seasonal inflows during one or more preceding years, flow values used in the equations are actually averages of bimonthly sums during the pertinent antecedent period for the species of interest. Base historical periods from which the harvest equations were derived are identified in Table 4-1 along with applicable upper and lower seasonal average freshwater inflow bounds representing the range of observations during the base historical periods.

The equations in Table 4-1 provide some general insights into the biological characteristics of different species. For example, black drum apparently "like" higher freshwater inflows in the colder months while other finfish (red drum and spotted seatrout) do not. This is because black drum prefer to spawn in the winter. While harvest of most species is positively correlated to inflows in the hottest summer months, none seem to "like" the higher flood flows associated with hurricanes in September and October. TWDB personnel caution, however, that one should not draw conclusions regarding biological preferences based solely on seasonal coefficients in the harvest equations as the commercial harvest observations are both limited in number and sensitive to unquantified economic influences such as fuel cost and market price. Ultimately, the TWDB and TPWD hope to move away from commercial harvest data and towards the use of population/density data based on systematic sampling for assessment of freshwater inflow needs.

Significant care must be exercised in the application of the harvest equations to seasonal average freshwater inflows outside the range of the historical inflows on which the equations are based. Estimated annual harvest for a given species was initially discarded if any one of the

TABLE 4-1

GUADALUPE ESTUARY
FISHERIES HARVEST EQUATIONS
AND SEASONAL INFLOW BOUNDS

		Seasonal Terms									
Species	Constant	Jan & Feb	Mar & Apr	May & Jun	Jul & Aug	Sep & Oct	Nov & Dec	Year (t-3)	Year (t-2)	Year (t-1)	Harvest Year (t)
White Shrimp		Base Period =	1959-87								
Upper Bound (kacft)		1026.3		2698.0	910.6		1080.1				
H =	**545.59**	**+ 160.9 $\ln Q_{JF}$**		**+ 279.1 $\ln Q_{MJ}$**	**- 155.1 $\ln Q_{JA}$**		**- 277.9 $\ln Q_{ND}$**				Harvest
Lower Bound (kacft)		102.0		60.6	32.7		117.4				
Brown Shrimp		Base Period =	1959-87								
Upper Bound (kacft)					910.6	1607.5					
lnH =	**6.5679**				**+ .6707 $\ln Q_{JA}$**	**- .7486 $\ln Q_{SO}$**					Harvest
Lower Bound (kacft)					45.5	109.5					
Blue Crab		Base Period =	1962-87								
Upper Bound (kacft)		725.1			554.9	1528.4					
H =	**110.64**	**- 145.3 $\ln Q_{JF}$**			**+ 332.5 $\ln Q_{JA}$**	**- 141.4 $\ln Q_{SO}$**					Harvest
Lower Bound (kacft)		147.9			58.5	102.7					
Eastern Oyster		Base Period =	1962-87								
Upper Bound (kacft)			874.6	1615.2	597.2	1528.4					
H =	**3000.7**		**+ 180.4 $\ln Q_{MA}$**	**- 963.3 $\ln Q_{MJ}$**	**+ 710.0 $\ln Q_{JA}$**	**- 231.5 $\ln Q_{SO}$**					Harvest
Lower Bound (kacft)			132.4	136.0	58.5	129.3					
Black Drum		Base Period =	1962-87								
Upper Bound (kacft)		592.0	738.4				786.4				
H =	**-18.087**	**+ .2411 Q_{JF}**	**- .1734 Q_{MA}**				**+ .0850 Q_{ND}**				Harvest
Lower Bound (kacft)		153.3	148.3				152.8				
Red Drum		Base Period =	1962-81								
Upper Bound (kacft)				1074.5	537.2		786.4				
H =	**32.786**			**+ .0797 Q_{MJ}**	**+ .2750 Q_{JA}**		**- .2010 Q_{ND}**				Harvest
Lower Bound (kacft)				139.6	76.2		152.8				
Spotted Seatrout		Base Period =	1962-81								
Upper Bound (kacft)			738.4	1074.5			786.4				
lnH =	**2.6915**		**- .7185 $\ln Q_{MA}$**	**+ 1.860 $\ln Q_{MJ}$**			**- 1.086 $\ln Q_{ND}$**				Harvest
Lower Bound (kacft)			148.3	139.6			152.8				
H = Estimated Harvest (1000 lbs)				**Q = Seasonal Average Freshwater Inflow**							

Source: Texas Water Development Board

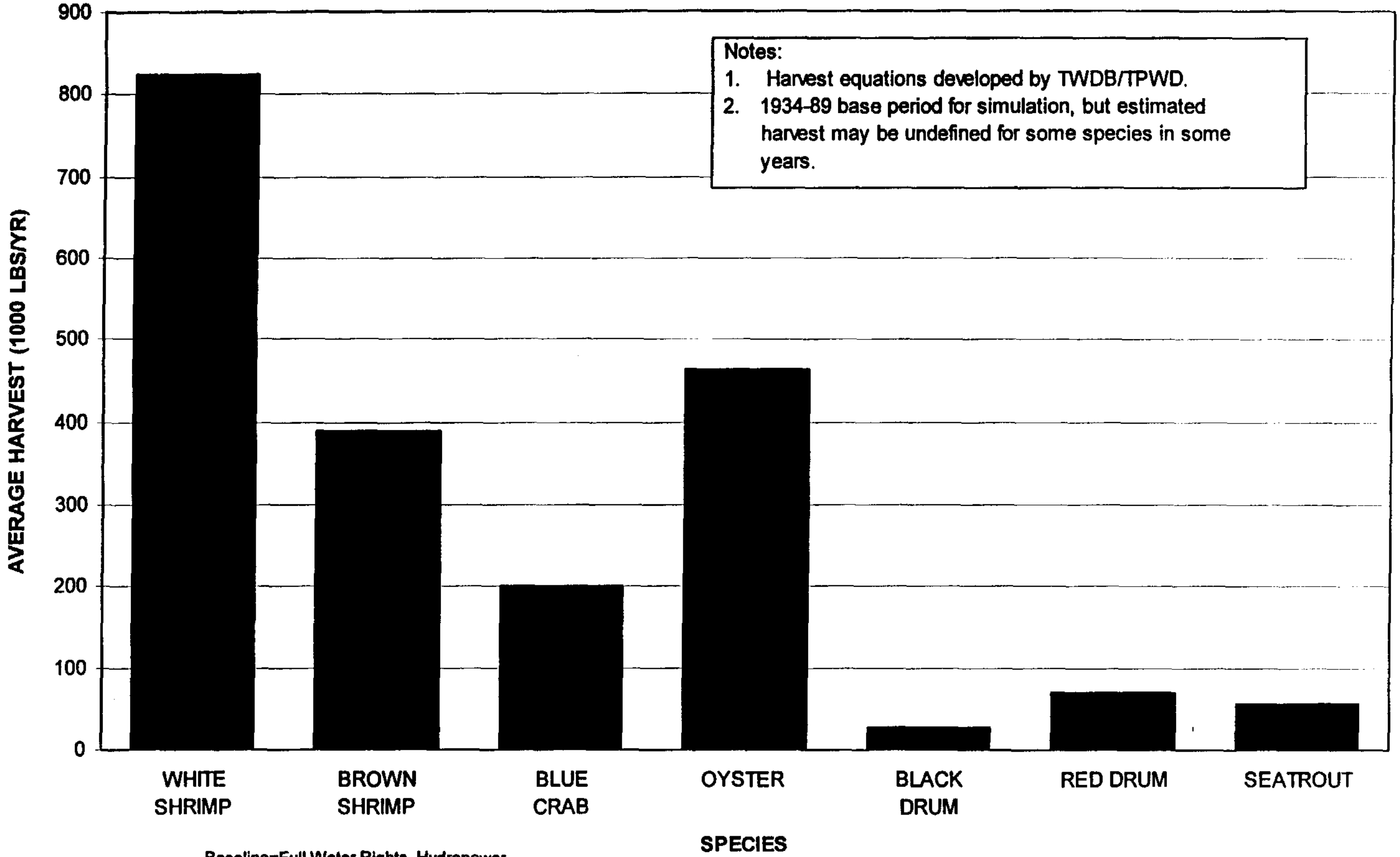
seasonal average freshwater inflow terms fell outside of the historical bounds. Unfortunately, application of this procedure subject to the Baseline freshwater inflow sequence resulted in valid harvest estimates for less than half of the years during the 1934-89 historical period for most species. This difficulty was mitigated in part by an alternative bounding procedure which involves setting average seasonal inflows outside the historical bounds to the appropriate bound, counting the bound excursions, and identifying the resultant estimated harvest as a minimum (+) or a maximum (-). When two or more seasonal terms within one harvest equation were bounded resulting in offsetting effects, however, the annual harvest was reported as unknown (-9999). All annual harvest estimates were also bounded by the minimum and maximum annual harvest observed during the base historical period.

The fisheries harvest equations and bounding procedures were encoded in the program ESTUARY1 and compiled using Microsoft FORTRAN Version 5.1. An annual summary of estimated harvest by species (ESTUARY1 output) subject to Baseline freshwater inflows is included as Table 4-2 and corresponding estimates of average annual harvest are plotted in Figure 4-4. ESTUARY1 produces additional statistical summary tables for freshwater inflows, harvest by species, and salinity for selected locations in the estuary. Examples of these tables are included in Appendix D.

Upon review of Table 4-2, it is apparent that reasonable harvest estimates can be computed for the late 1960's, 1970's, and 1980's when most of the commercial harvest data was being assembled and freshwater inflows were relatively high. On the other hand, many annual harvests are reported as unknown in Table 4-2 during the drought periods of the 1950's and 1960's when seasonal freshwater inflows were often lower than those observed during the base periods from which the harvest equations were developed. Figure 4-5 helps to explain this problem by comparison of Baseline and Historical freshwater inflow averages for the entire 1934-89 period to those for the 1958-87 base period for the harvest equations. The 1958-87 Baseline average exceeds the long-term Baseline average simply because wetter hydrologic conditions prevailed in the latter period. In addition, the 1958-87 Historical average exceeds the 1958-87 Baseline average because surface water diversions were significantly less than the permitted amounts, hydropower rights were not subordinated to Canyon Lake, and average Edwards Aquifer pumpage was less than 400,000 acft/yr. Updating the harvest equations based

TRANS-TEXAS WATER PROGRAM, WEST CENTRAL STUDY AREA
HDR JOB# = 07755-016-036 DATE = 6/30/97
SCENARIO: GUADALUPE ESTUARY *** BASELINE ***

YEAR	INFLOW (ACFT)	WHITE SHRIMP HARVEST (KLBS)	BROWN SHRIMP HARVEST (KLBS)	BLUE CRAB HARVEST (KLBS)	EASTERN OYSTER HARVEST (KLBS)	BLACK DRUM HARVEST (KLBS)	RED DRUM HARVEST (KLBS)	SEATROUT HARVEST (KLBS)	TOTAL HARVEST (KLBS)
1934	1355380	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999
1935	2798813	1040	623	110	-9999	-9999	-9999	-9999	-9999
1936	3402270	613	571	536	392	-9999	-9999	-9999	-9999
1937	1165186	796	91	609	970	31	-9999	-9999	-9999
1938	1522840	1026	325	41	54	16	179	115	1756
1939	342851	-9999	353	58	531	0	164	61	-9999
1940	1947614	-9999	1316	590	-9999	0	35	26	-9999
1941	3536521	736	1089	572	751	18	75	32	3273
1942	2408404	242	1167	493	1034	18	81	51	3087
1943	733335	747	67	572	1937	19	143	45	3531
1944	1726438	1260	360	41	54	0	109	36	1861
1945	1525650	560	515	213	831	12	120	40	2292
1946	2799270	1009	607	87	1186	7	49	30	2974
1947	1128496	771	67	41	148	7	73	54	1162
1948	459288	654	311	41	251	11	49	22	1338
1949	1446622	-9999	391	41	982	16	42	37	-9999
1950	326939	-9999	104	-9999	619	0	37	20	-9999
1951	438712	-9999	-9999	-9999	531	0	-9999	15	-9999
1952	863977	-9999	178	-9999	-9999	0	-9999	25	-9999
1953	840676	583	242	41	550	-9999	-9999	29	-9999
1954	85513	-9999	142	139	-9999	-9999	-9999	36	-9999
1955	154570	-9999	-9999	-9999	-9999	-9999	-9999	17	-9999
1956	63362	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999
1957	3031212	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999
1958	2867671	1061	67	41	54	0	-9999	75	-9999
1959	1368655	570	167	41	112	48	58	83	1078
1960	3123775	748	487	183	1049	61	39	50	2618
1961	2254128	586	163	214	599	121	38	24	1744
1962	471423	-9999	140	166	296	80	33	22	-9999
1963	211214	-9999	-9999	-9999	-9999	72	29	28	-9999
1964	431565	-9999	-9999	-9999	-9999	-9999	24	13	-9999
1965	2020540	1415	-9999	41	-9999	-9999	-9999	-9999	-9999
1966	1107085	798	276	41	-9999	30	-9999	60	-9999
1967	3017277	-9999	-9999	41	-9999	40	48	92	-9999
1968	3077264	1103	114	41	54	48	49	100	1509
1969	1709105	1117	140	47	54	72	45	64	1539
1970	1470553	1060	318	41	54	63	54	63	1654
1971	1369022	-9999	386	41	588	49	62	75	-9999
1972	2099411	973	141	146	54	0	46	42	1404
1973	4249744	802	1116	378	193	15	65	115	2683
1974	2134380	689	69	297	578	11	130	115	1888
1975	2730716	815	361	201	54	36	108	108	1684
1976	3356651	849	650	373	232	42	109	70	2326
1977	2884173	741	174	221	270	60	73	66	1604
1978	1472195	350	702	172	665	15	38	38	1979
1979	3392499	1144	308	251	562	3	31	21	2320
1980	848837	972	132	180	91	6	39	27	1447
1981	3511322	1038	909	306	87	24	93	83	2539
1982	1129014	924	67	232	54	24	147	115	1562
1983	897355	489	585	95	54	25	85	115	1447
1984	389092	-9999	203	123	1085	19	82	115	-9999
1985	1828614	905	661	157	1176	-9999	24	20	-9999
1986	1769707	806	186	110	489	0	44	13	1649
1987	4629321	976	657	358	54	24	31	28	2125
1988	444127	360	207	490	54	43	107	115	1375
1989	352799	-9999	-9999	-9999	-9999	44	87	115	-9999
ANNUAL AVERAGES									
	1727200	824	389	201	463	27	71	56	1982
SIMULATED LOWER SEASONAL FLOW BOUND EXCURSIONS									
		61	36	41	51	34	36	28	
SIMULATED UPPER SEASONAL FLOW BOUND EXCURSIONS									
		4	3	4	3	0	3	1	



Baseline=Full Water Rights, Hydropower Subordination, 400 kacft/yr Edwards Pumpage, 1989 Return Flows

TRANS TEXAS WATER PROGRAM / WEST CENTRAL STUDY AREA

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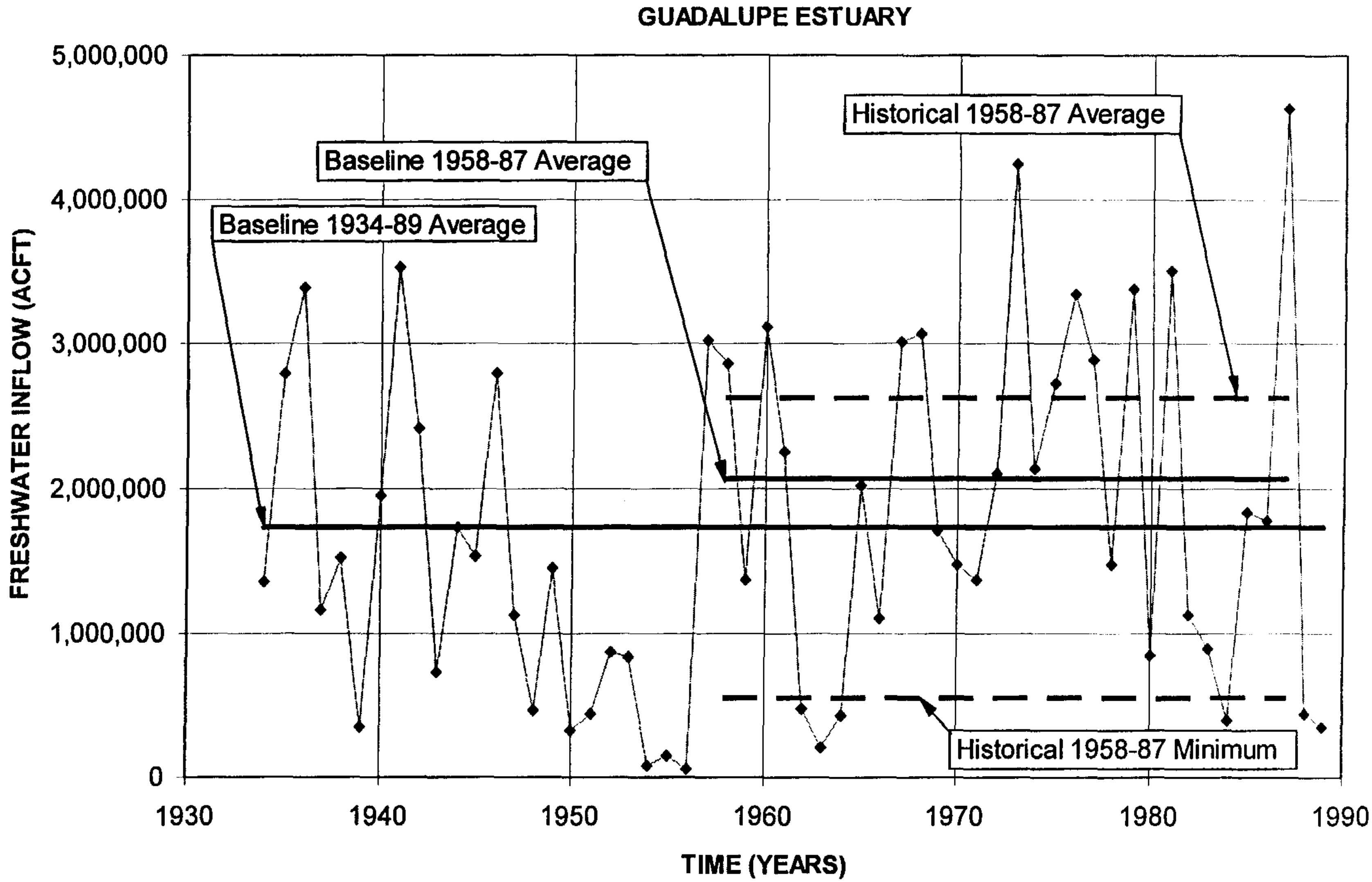
BASELINE FISHERIES HARVEST GUADALUPE ESTUARY

FIGURE 4-4



Baseline=Full Water Rights, Hydropower Subordination, 400 kacft/yr Edwards Pumpage, 1989 Return Flows

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BASELINE AND HISTORICAL FRESHWATER INFLOW AVERAGES BY PERIOD

FIGURE 4-5

on available data from recent drought periods including 1988-89 and 1994-96 might result in more reasonable harvest estimates when freshwater inflows are limited.

4.3 Salinity Equations

Equations for computation of salinity as a function of freshwater inflow were provided by the TWDB for the Seadrift Area, Lower San Antonio Bay, and Espiritu Santo Bay within the Guadalupe Estuary. These equations and the referenced areas for which they are applicable are shown in Figure 4-6. Salinity estimates from these equations represent an end-of-month value and are bounded at 0 ppt and 45 ppt. In a manner similar to that for the harvest equations, the salinity equations were included in ESTUARY1 along with programming code to accumulate summary statistics and simulated violations of upper and lower salinity viability limits (bounds) provided by the TWDB.[6] Subject to Baseline freshwater inflows as described in Section 4.1, Figures 4-7 and 4-8 illustrate monthly median salinity variations and accumulated violations of monthly salinity bounds, respectively. ESTUARY1 produces additional statistical summary tables (see Appendix D) for salinity at selected locations in the estuary.

4.4 Example Application

The intended use of ESTUARY1 is as a post-processor for the GSA Model which readily facilitates assessment of potential environmental impacts associated with proposed water supply alternatives in terms of estuarine fisheries harvest and salinity variations in addition to changes in freshwater inflow. In order to illustrate its utility, ESTUARY1 was applied to the modified streamflows for the Guadalupe at the Saltwater Barrier subject to both the run-of-river diversion of 75,000 acft/yr from the Guadalupe River near Gonzales firmed-up as necessary by stored water from Canyon Lake and to diversion of the balance of the uncommitted firm yield of Canyon Lake near Gonzales. Assumptions pertinent to water rights utilization, hydropower subordination, Edwards Aquifer pumpage, and return flows were identical to the Baseline. No adjustments for periodically subordinated water rights near the Saltwater Barrier were included, therefore effects of the project on freshwater inflow are overestimated in some years. Graphics comparing With Project to Baseline fisheries harvest by species, median salinity variations, and salinity bound violations are included as Figures 4-9, 4-10, and 4-11, respectively. Tabular statistical summaries for additional comparisons are included in Appendix D.

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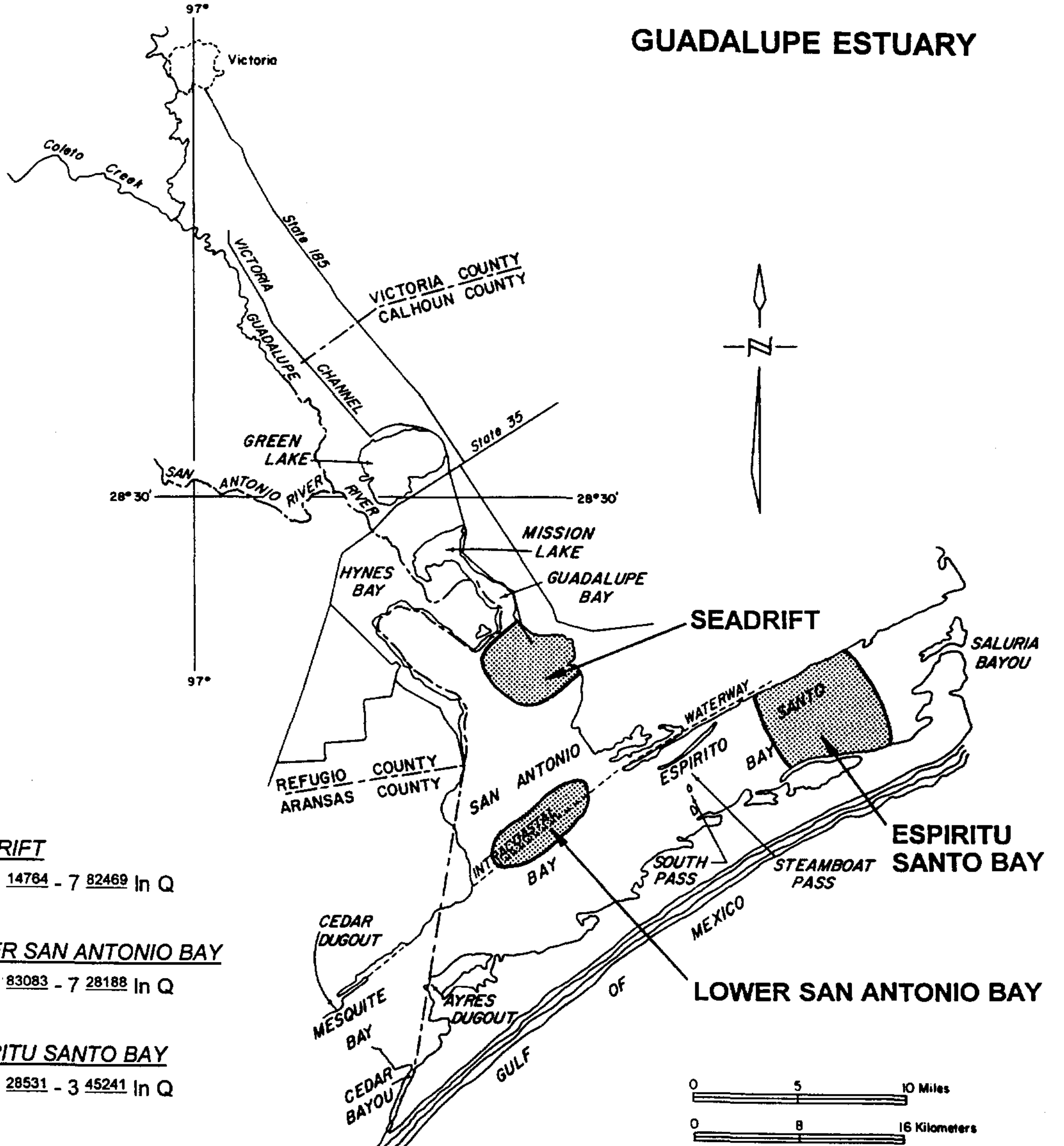
[6] TWDB, September, 1996, op. cit.

GUADALUPE ESTUARY



SEADRIFT

$S = 47^{\underline{14764}} - 7^{\underline{82469}} \ln Q$

LOWER SAN ANTONIO BAY

$S = 53^{\underline{83083}} - 7^{\underline{28188}} \ln Q$

ESPIRITU SANTO BAY

$S = 42^{\underline{28531}} - 3^{\underline{45241}} \ln Q$

WHERE:

S= SALINITY (PPT)

Q= FRESH WATER INFLOW (1000 ACFT/MO)

APPROXIMATE AREAS FOR WHICH SALINITY EQUATIONS ARE REPRESENTATIVE

TRANS TEXAS WATER PROGRAM / WEST CENTRAL STUDY AREA

SALINITY EQUATIONS AND APPLICABLE AREAS

Base by U. S. Geological Survey, 1956

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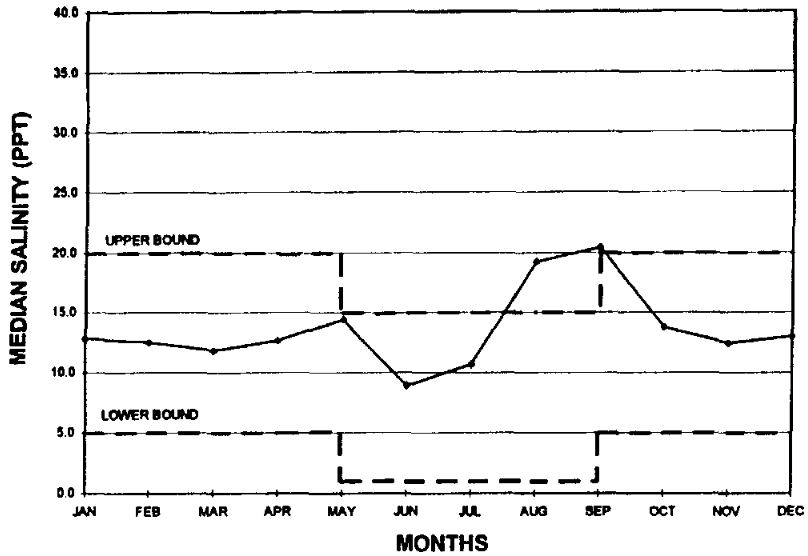
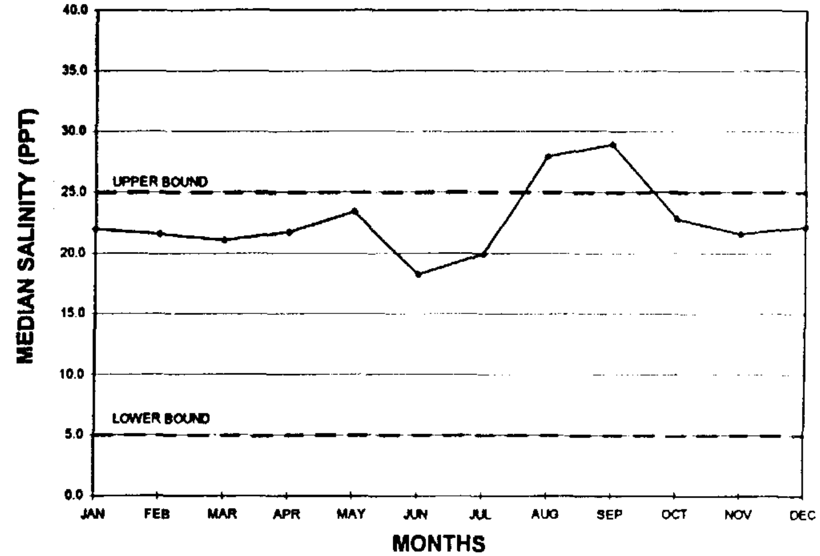
FIGURE 4-6

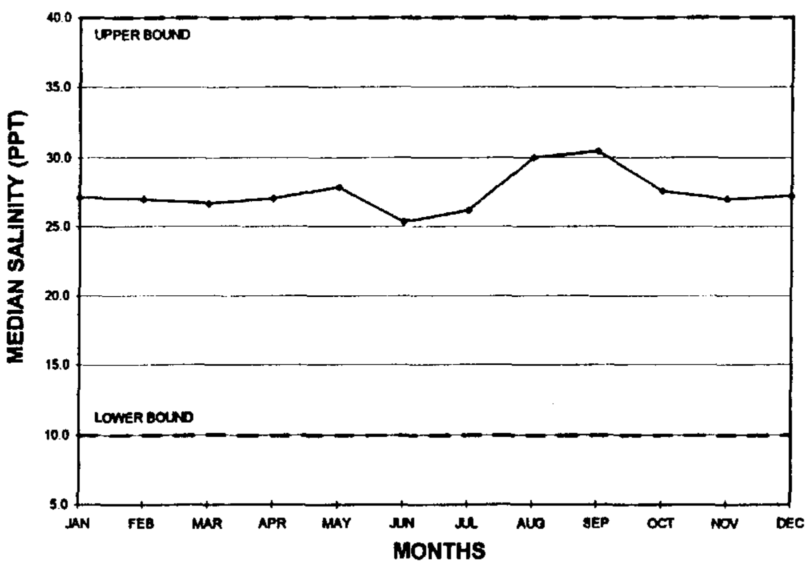
UPPER SAN ANTONIO BAY



LOWER SAN ANTONIO BAY



ESPIRITU SANTO BAY



Equations for salinity as a function of freshwater inflow developed by TWDB and TPWD.

Monthly upper and lower salinity bounds selected by TWDB and TPWD.

Baseline=Full Water Rights, Hydropower Subordination, 400 kacft/yr Edwards Pumpage, 1989 Return Flows

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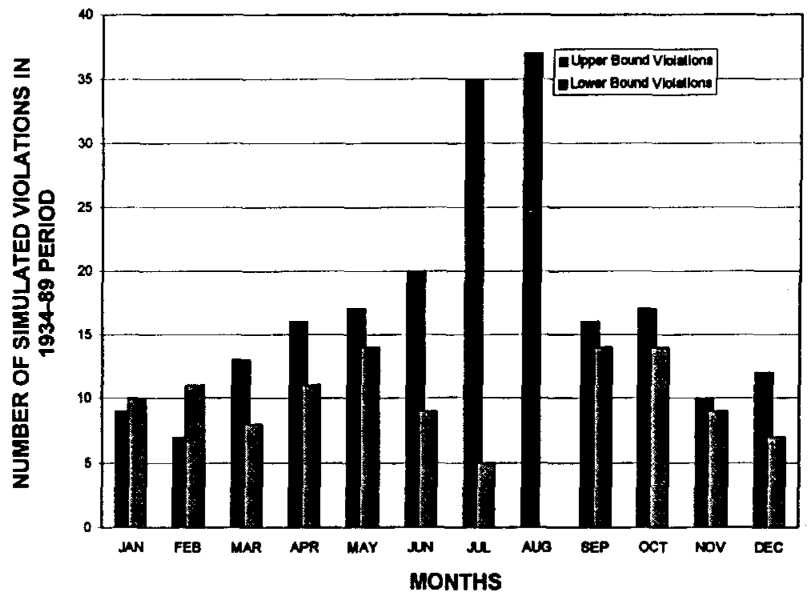
TRANS TEXAS WATER PROGRAM / WEST CENTRAL STUDY AREA

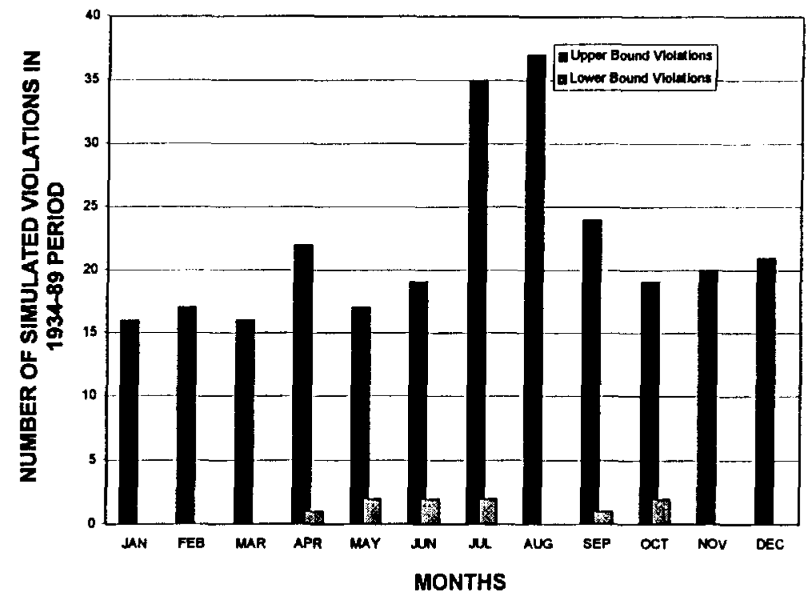
MONTHLY MEDIAN SALINITY SELECTED LOCATIONS GUADALUPE ESTUARY

FIGURE 4-7

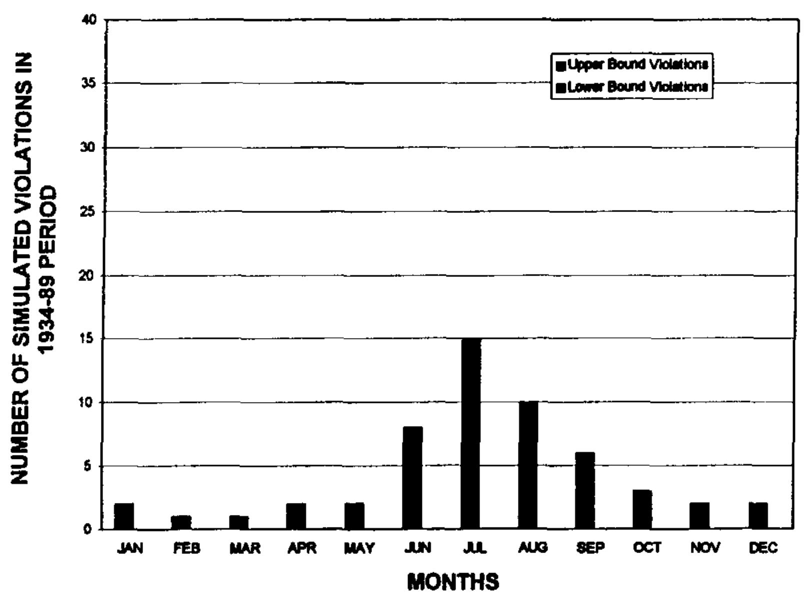
UPPER SAN ANTONIO BAY



LOWER SAN ANTONIO BAY



ESPIRITU SANTO BAY



Equations for salinity as a function of freshwater inflow developed by TWDB and TPWD.

Monthly upper and lower salinity bounds selected by TWDB and TPWD.

Baseline=Full Water Rights, Hydropower Subordination, 400 kacft/yr Edwards Pumpage, 1989 Return Flows

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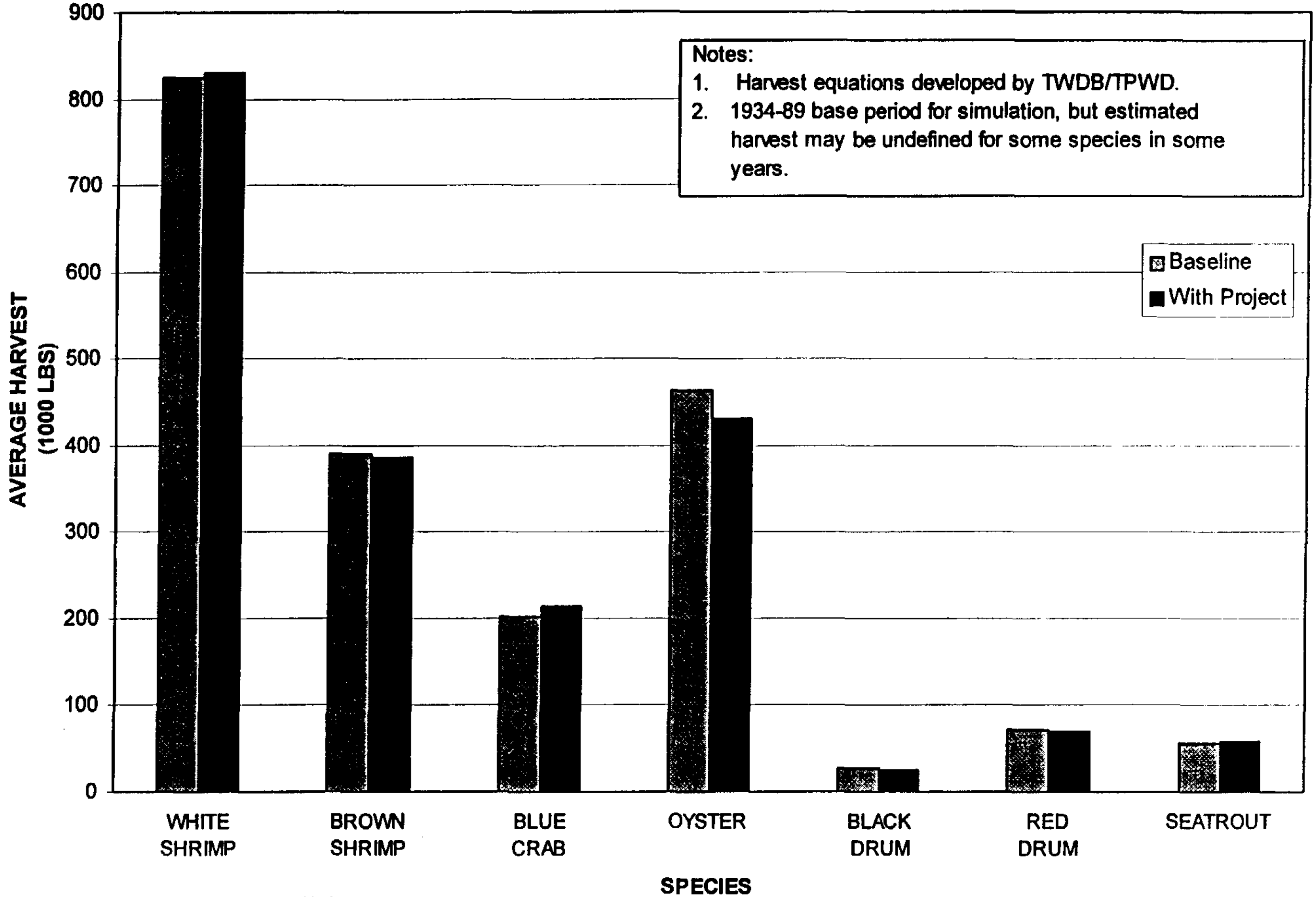
SALINITY BOUND VIOLATIONS
SELECTED LOCATIONS
GUADALUPE ESTUARY

FIGURE 4-8



Baseline=Full Water Rights, Hydropower Subordination, 400 kacft/yr Edwards Pumpage, 1989 Return Flows

With Project=75,000 acft/yr Run-of-River Diversion at Gonzales Firmed-Up by Canyon Lake, Uncommitted Canyon Firm Yield Diverted at Gonzales.

TRANS TEXAS WATER PROGRAM / WEST CENTRAL STUDY AREA

FISHERIES HARVEST COMPARISON GUADALUPE ESTUARY

HDR

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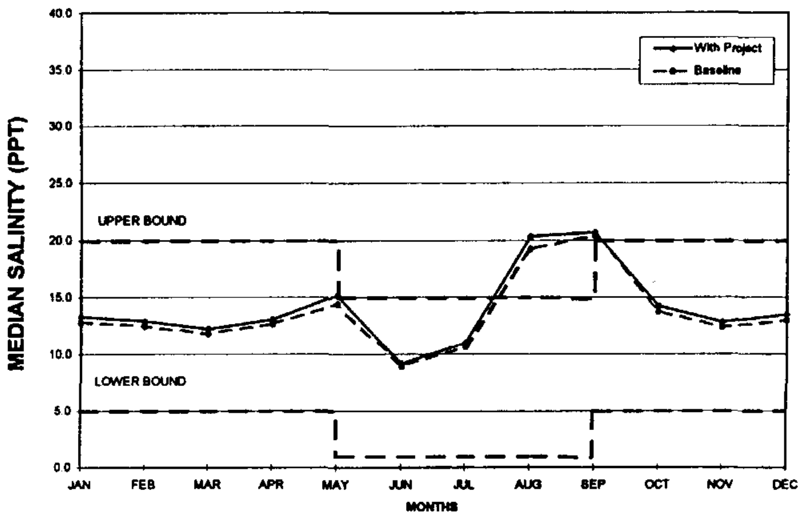
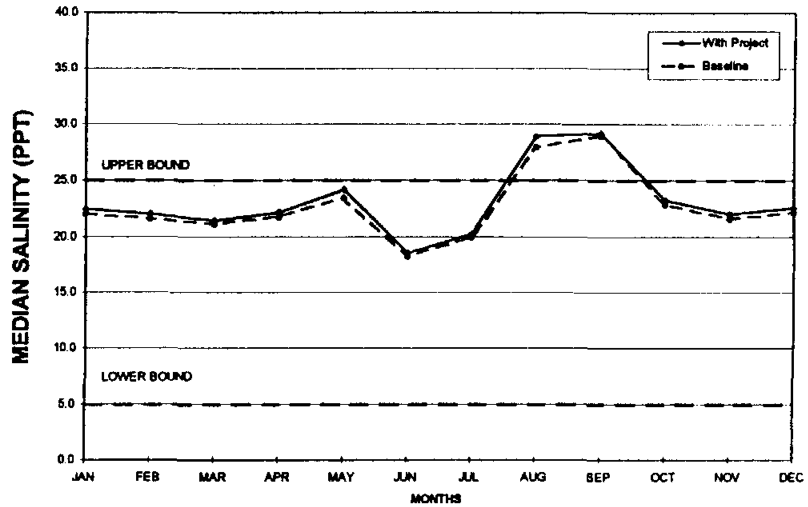
FIGURE 4-9

UPPER SAN ANTONIO BAY



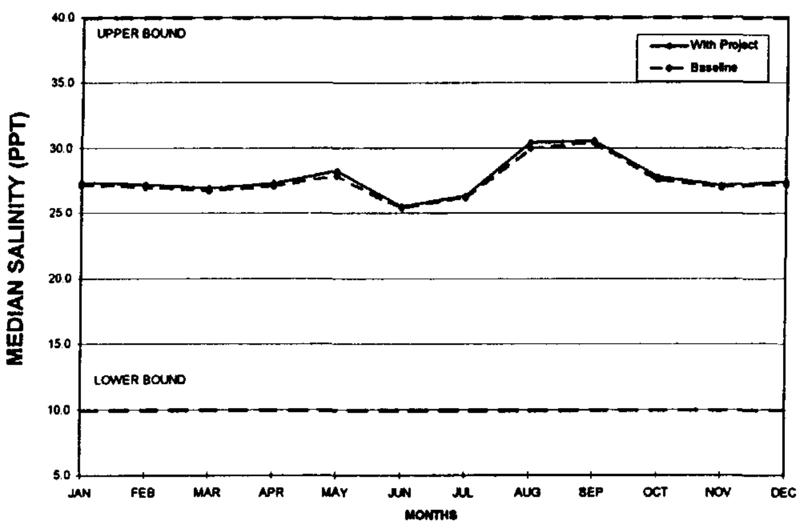
MONTHS

LOWER SAN ANTONIO BAY



MONTHS

ESPIRITU SANTO BAY



MONTHS

Equations for salinity as a function of freshwater inflow developed by TWDB and TPWD.

Monthly upper and lower salinity bounds selected by TWDB and TPWD.

Baseline=Full Water Rights, Hydropower Subordination, 400 kacft/yr Edwards Pumpage, 1989 Return Flows

With Project=75,000 acft/yr Run-of-River Diversion at Gonzales Firmed-Up by Canyon Lake, Uncommitted Canyon Firm Yield Diverted at Gonzales.

TRANS TEXAS WATER PROGRAM /
WEST CENTRAL STUDY AREA

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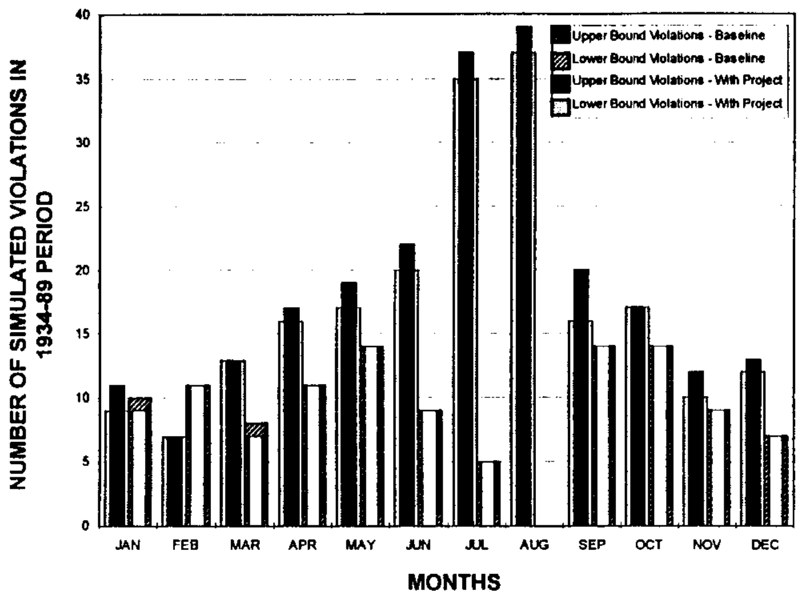
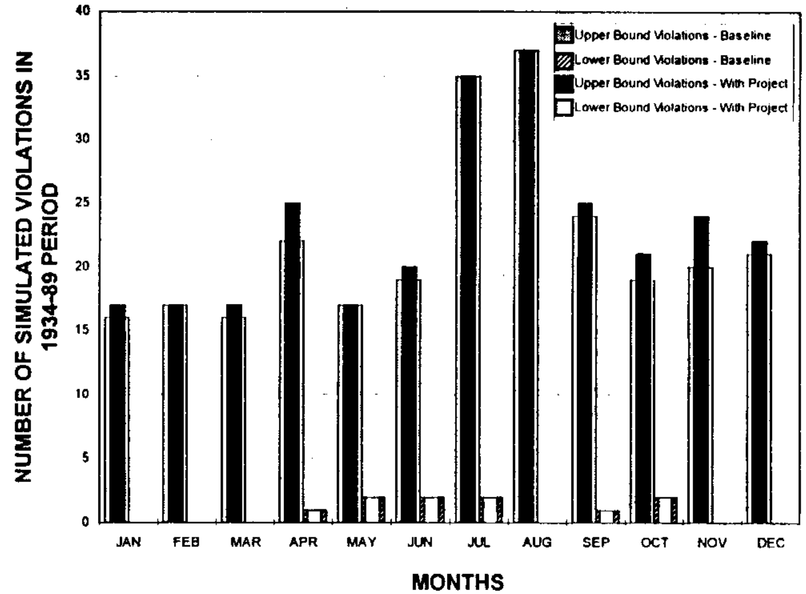
MONTHLY MEDIAN SALINITY COMPARISON
SELECTED LOCATIONS
GUADALUPE ESTUARY

FIGURE 4-10

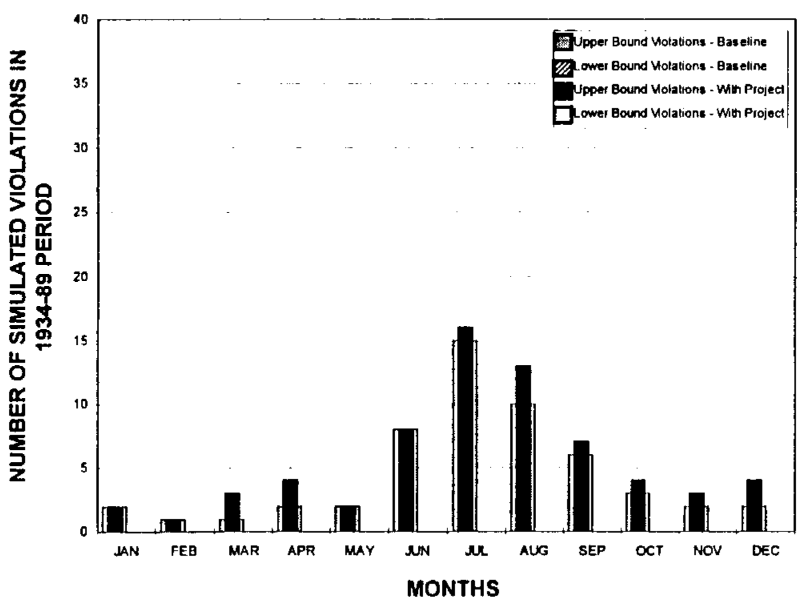
UPPER SAN ANTONIO BAY



LOWER SAN ANTONIO BAY



ESPIRITU SANTO BAY



Equations for salinity as a function of freshwater inflow developed by TWDB and TPWD.

Monthly upper and lower salinity bounds selected by TWDB and TPWD.

Baseline=Full Water Rights, Hydropower Subordination, 400 kacft/yr Edwards Pumpage, 1989 Return Flows

With Project=75,000 acft/yr Run-of-River Diversion at Gonzales Firmed-Up by Canyon Lake, Uncommitted Canyon Firm Yield Diverted at Gonzales.

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SALINITY BOUND VIOLATION COMPARISON SELECED LOCATIONS GUADALUPE ESTUARY

FIGURE 4-11

Appendix A

5.0 GUADALUPE RUN-OF-RIVER WATER FIRMED-UP BY CANYON LAKE

Recent studies have examined the conjunctive use of new run-of-river diversions and stored water from Canyon Lake to obtain a preliminary estimate of firm availability subject to an assumed monthly diversion pattern. In these studies, the concept of storage banking in Canyon Lake during the critical drought was simulated by spreadsheet calculations which did not directly account for evaporation of bank storage, reduced contractual releases and the impact on meeting the FERC requirements, and the potential for spills that may result during the critical drought period due to the accumulation of banked storage. In order to more accurately model the conjunctive management of these water sources, the GSA Model was enhanced to automate the analysis. The model enhancement will allow for more efficient simulation of monthly diversion patterns reflecting base-loading of downstream surface water sources or other water supplies including the Edwards Aquifer.

The automated analysis allows the user to directly simulate variable Canyon Lake stored water releases to provide a firm supply of water at any downstream location. The model user supplies the water availability data for the run-of-river diversion and the location for the diversion. The user also inputs the total firm availability and seasonal demand pattern for the proposed combined diversion of available run-of-river water made firm by releases from Canyon Lake. Water availability for the run-of-river water may be calculated by the GSA Model prior to execution of the firm-up analysis or may be supplied as specified input to the model. Using the run-of-river water availability, total firm desired availability, and seasonal demand pattern, the model computes the balance of water to be delivered to the diversion point from Canyon Lake for each month of the simulation period. Canyon Lake operations are simulated by treating the variable monthly balance as a contractual obligation to be delivered to the downstream diversion point. If the desired firm availability is satisfied by the run-of-river diversion, no stored water is released from Canyon Lake and it is accumulated in the reservoir less required releases. The model will iteratively solve for the uncommitted portion of Canyon Lake firm yield remaining with the run-of-river firm-up operation. The difference between the uncommitted firm yield with the run-of-river firm-up operation and the uncommitted firm yield without the firm-up operation is defined as the firm yield impact of the project. Following execution of the GSA Model, summaries may be printed including Canyon Lake operations, streamflows, and run-of-river and stored water diversions for the simulation period.

5.1 Example Application

An example application of the automated analysis was completed as part of this study to demonstrate the benefits of the model enhancement. Based on selected assumptions used in the previous Letter of Intent Analysis[1], a simulation of Canyon Lake operations necessary to firm up run-of-river diversions from the Guadalupe River near Gonzales was performed. The selected application was the development of a firm supply of 75,000 ac-ft/yr from the Guadalupe River near Gonzales. Run-of-river availability from the Guadalupe River near Gonzales was computed in the Letter of Intent Analysis and was utilized as input to the GSA Model. Hydrologic assumptions for this application include the following:

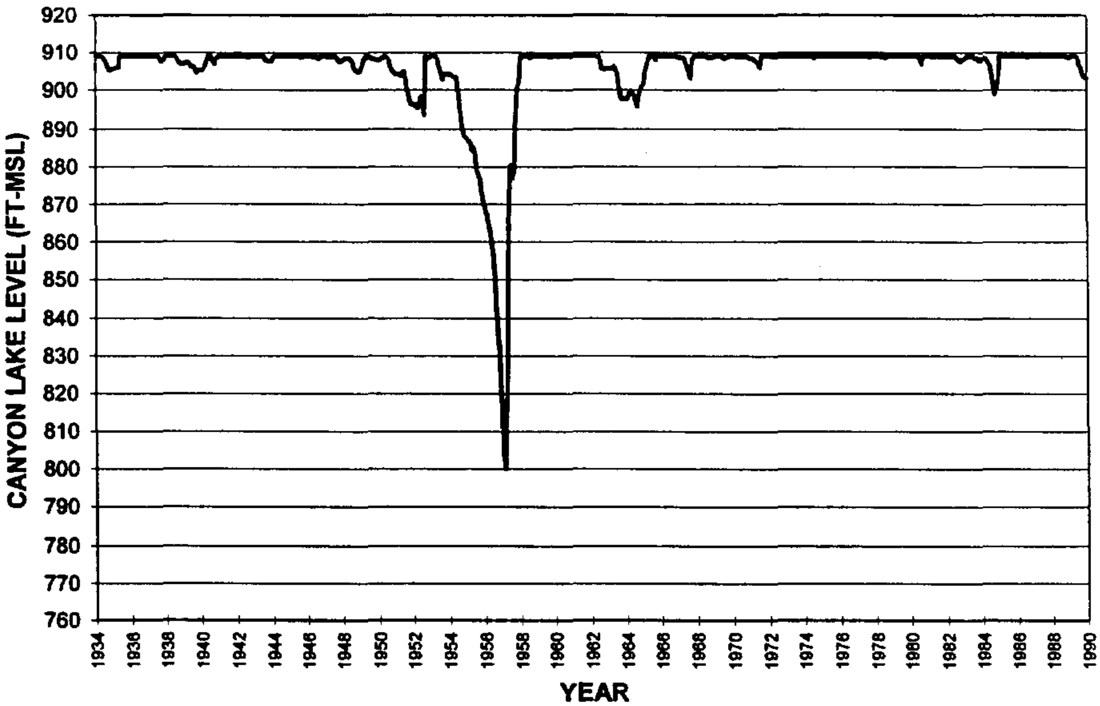
- Uncommitted firm yield of Canyon Lake diverted at Gonzales. Existing Canyon Lake contracts diverted at their full contractual amounts (38,438 ac-ft/yr).
- All water rights were included at their full permitted amounts.
- Return flows were set at 1989 levels.
- Edwards Aquifer pumpage scenario of 400,000 ac-ft/yr.
- Hydropower and once-through cooling water rights downstream of Canyon Lake subordinated to Canyon Lake.

Run-of-river water availability under the assumptions in the Letter of Intent Analysis provided 75,000 ac-ft/yr in 77 percent of the years simulated for the 1934-89 period as shown in Figure 5-1. Stored water releases from Canyon Lake were required in the drought years of 1951 to 1957, 1962 to 1964, 1984, and 1989 with the maximum volume of stored water release of 57,895 ac-ft in 1956. Figure 5-2 shows a trace of Canyon Lake levels and total annual stored water releases for the run-of-river firm-up operation and existing GBRA contracts. The total firm annual supply of water generated from Canyon Lake based on existing GBRA contracts and the run-of-river firm-up operation was determined to be 119,482 ac-ft/yr.

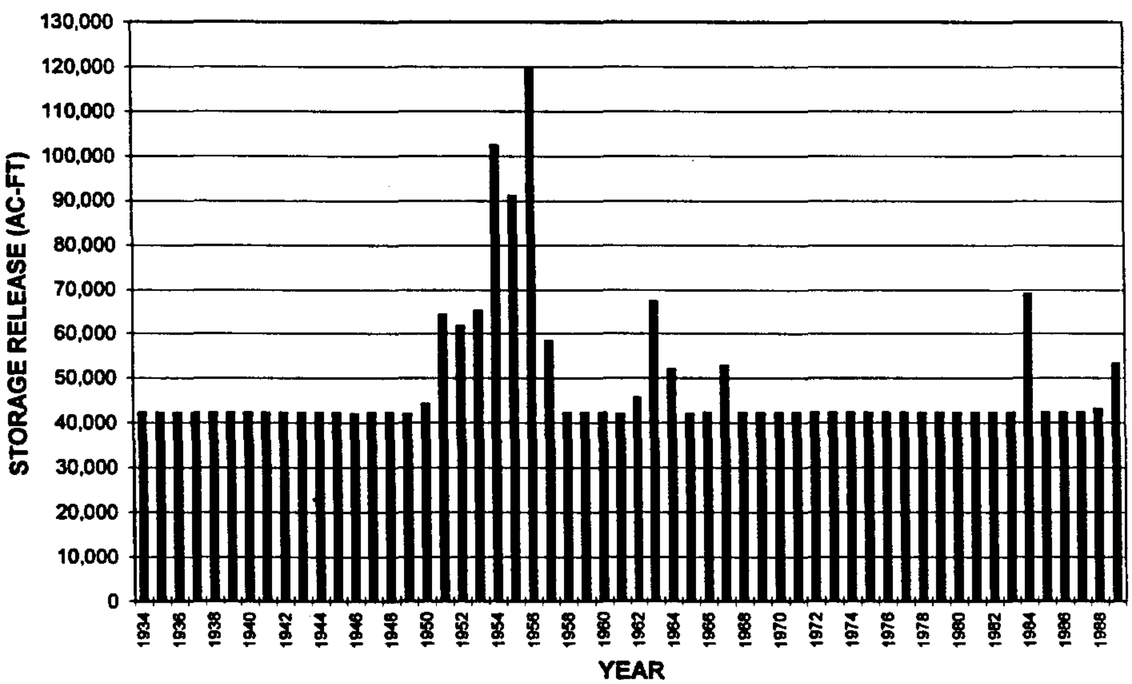
A second simulation of Canyon Lake operations was performed without the run-of-river firm-up operation. Figure 5-3 shows a trace of Canyon Lake levels and annual stored water

[1] HDR, "Trans-Texas Water Program, West Central Study Area Phase II Report, Letter of Intent Analysis," San Antonio River Authority, et al., October 1996.

CANYON LAKE LEVEL



CANYON LAKE STORAGE RELEASES



Assumptions:
Uncommitted firm yield of Canyon Lake diverted at Gonzales. Existing Canyon Lake contracts diverted at their full contractual amounts (38,438 acft/yr.).

All water rights were included at their full permitted amounts.

Return flows were set at 1989 levels.

Edwards Aquifer pumpage scenario of 400,000 acft/yr.

Hydropower and once-through cooling water rights downstream of Canyon Lake subordinated to Canyon Lake.

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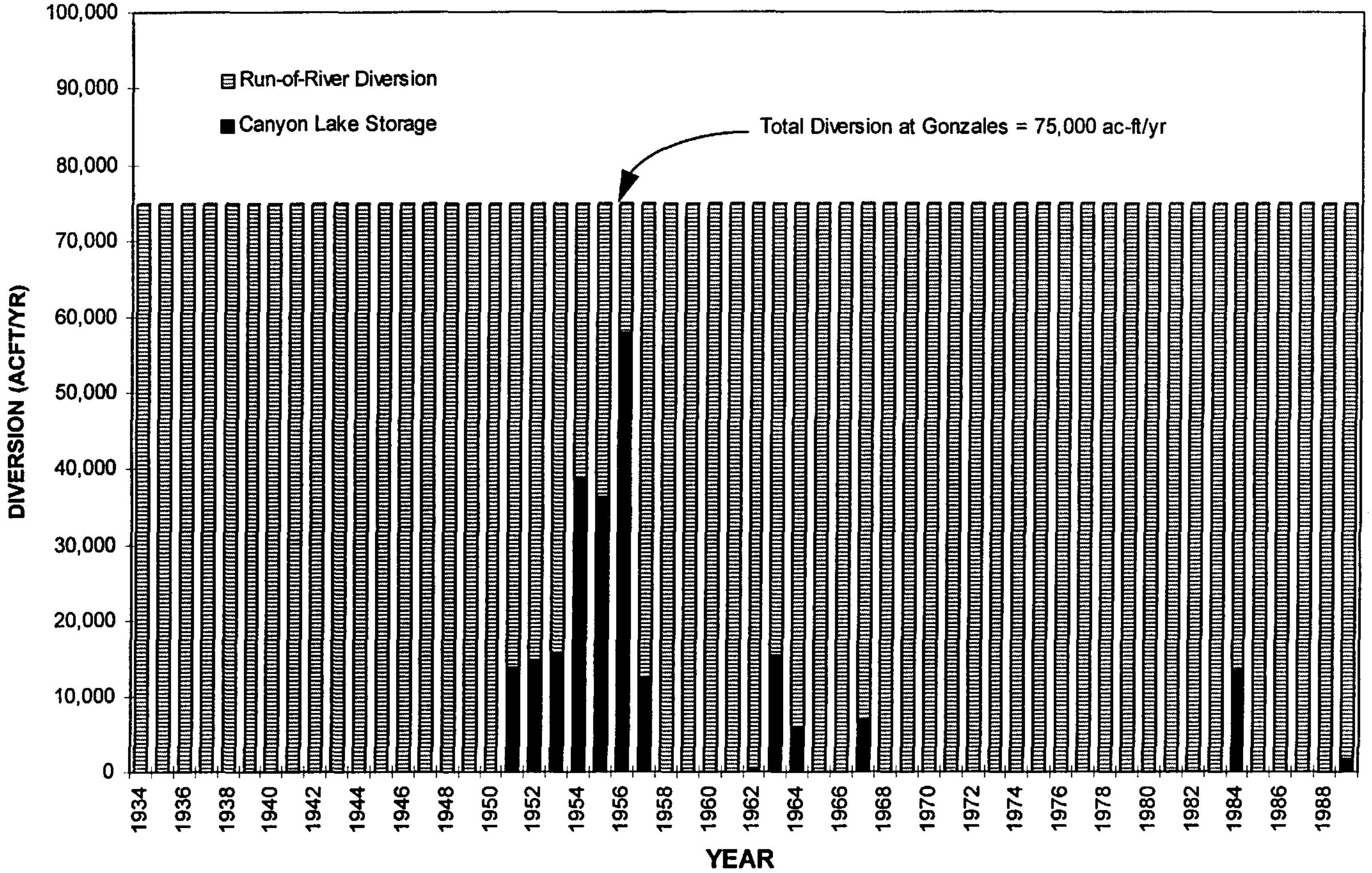
CANYON LAKE OPERATION WITH RUN-OF-RIVER FIRM-UP OF 75,000 ACFT/YR NEAR GONZALES

FIGURE 5-2



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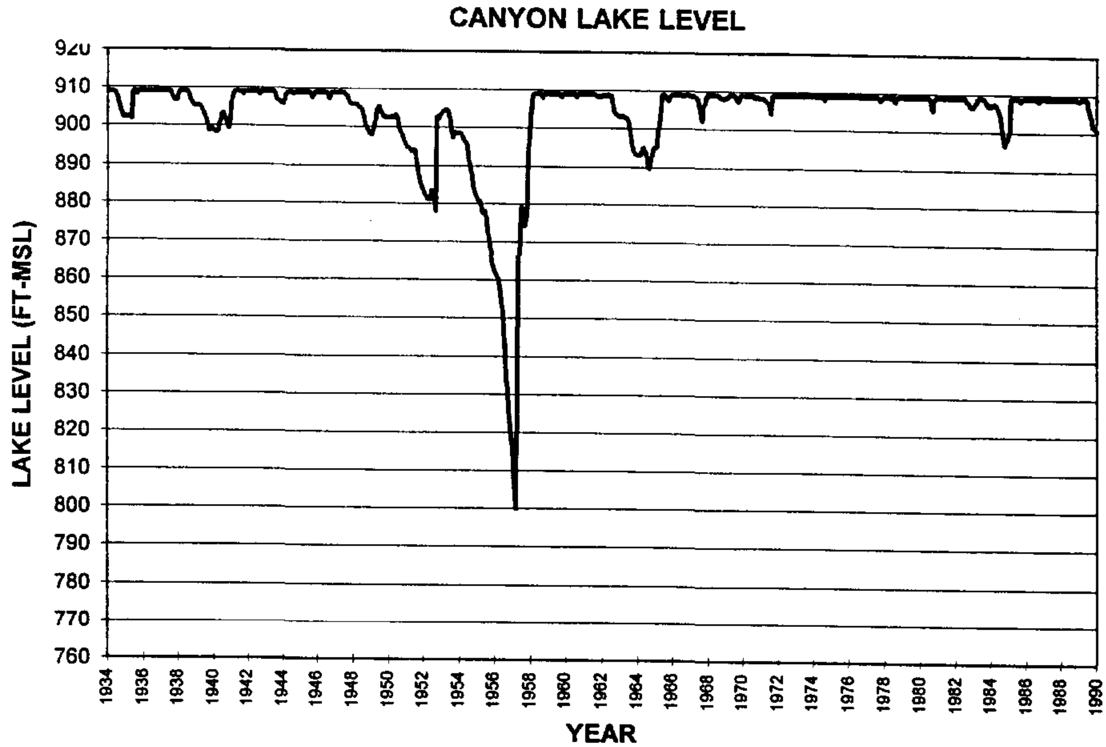
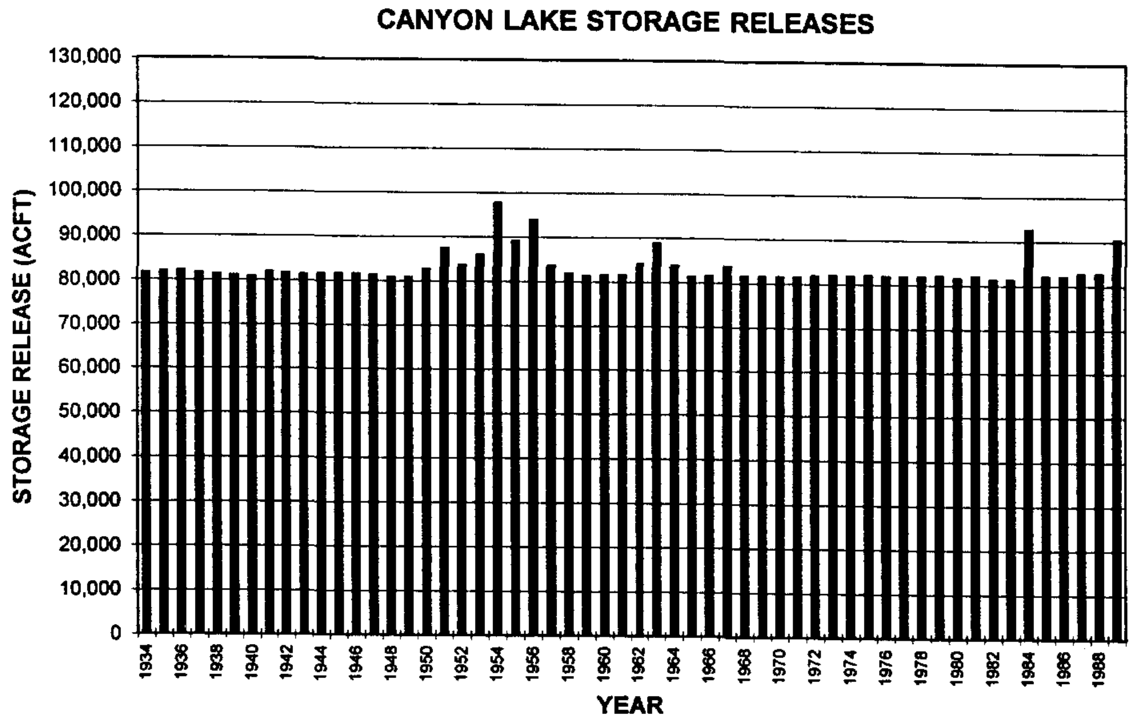
RUN-OF RIVER DIVERSION OF 75,000 ACFT/YR NEAR GONZALES WITH CANYON LAKE FIRM-UP

FIGURE 5-1





Assumptions:
Uncommitted firm yield of Canyon Lake diverted at Gonzales. Existing Canyon Lake contracts diverted at their full contractual amounts (38,438 acft/yr.).

All water rights were included at their full permitted amounts.

Return flows were set at 1989 levels.

Edwards Aquifer pumpage scenario of 400,000 acft/yr.

Hydropower and once-through cooling water rights downstream of Canyon Lake subordinated to Canyon Lake.

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CANYON LAKE OPERATION WITH UNCOMMITTED FIRM YIELD DIVERTED AT GONZALES

FIGURE 5-3

releases assuming the uncommitted firm yield of Canyon Lake is diverted based on a typical municipal demand pattern near Gonzales. The total firm annual supply of water generated from Canyon Lake based on this analysis was determined to be 79,148 ac-ft/yr.

The results of the two simulations show that an additional 40,334 ac-ft/yr of firm supply can be developed with the run-of-river diversion operated in conjunction with Canyon Lake. The firm yield impact on Canyon Lake was found to be 34,666 ac-ft/yr which is higher than the firm yield impact of 25,000 ac-ft/yr estimated in previous studies using the spreadsheet analysis. The spreadsheet analysis was not easily adaptable to simulation of revised Canyon Lake releases needed to meet FERC requirements nor was it convenient to simulate the revised reservoir storage levels during the simulation period. The automated firm-up analysis using the GSA Model revealed that the critical drought period was shortened from approximately ten years to five years. The large volume of spills that occurred during the early part of the 1950's drought, as a result of lower stored water releases from Canyon Lake for the firm-up operation, escaped the reservoir. The lost storage in combination with releases needed to meet the FERC requirements produced a higher firm yield impact than previously estimated.

Appendix B

6.0 WATER AVAILABLE UNDER WATER RIGHTS SENIOR TO CANYON LAKE

The GSA Model was originally developed to estimate unappropriated water and water available for recharge enhancement after the needs of all existing water rights were satisfied. Therefore, the inclusion of priority dates for individual water rights was not necessary. In order to facilitate calculation of water potentially available under a specific right, the GSA Model was enhanced to access a master listing of water rights, grouped by control point, which includes priority dates as well as authorized diversion amounts and types of use. The model sorts and appropriately groups all water rights senior to Canyon Lake (priority date of March 19, 1956) and computes monthly estimates of water availability for any selected senior water right. This capability allows the user to expediently evaluate quantities of water available under many of the larger water rights in the Guadalupe – San Antonio River Basin.

The model user supplies the priority date of the water right of interest to a pre-processor program, called WRSORT. WRSORT accesses a database of individual water rights and produces a standard format water rights input file (RIGHTS) for the GSA Model that includes only those water rights senior in priority to the specified water right. The GSA Model is then executed and the user interactively specifies the annual diversion amount, type of use (i.e., municipal, industrial, irrigation, uniform), model control point location, and maximum diversion rate associated with the water right of interest. Using the water availability subroutine, the GSA Model computes total water available on a daily time step at the point of interest subject to senior water rights and the maximum diversion rate. The model will then limit the water available to the specified water right for each month of the simulation period based on the annual diversion amount and type of use specified. Water availability results for the existing water right are formatted such that they can be used as input for a subsequent Canyon Lake firm-up simulation, if desired (Section 5.0).

6.1 Example Application

An example application of the automated water right availability analysis capability was completed as part of this study to demonstrate the utility of the model enhancement. Two water rights senior to Canyon Lake were selected for computation of water availability both with and without consumptive reuse of a portion of SAWS treated effluent. The water rights selected were Certificate of Adjudication (CA) No. 5177 and CA No. 5178, owned by the

Guadalupe – Blanco River Authority, et al. CA No. 5177 includes a total authorized annual diversion of 51,247 acft/yr and CA No. 5178 authorizes 106,000 acft/yr. Table 6-1 provides a summary of the two water rights in terms of authorized type of use, priority date, and annual diversion.

Table 6-1
Water Rights Summary

Water Right	Type of Use	Priority Date	Annual Diversion (acft/yr)
CA No. 5177	Irrigation Irrigation Industrial	January 26, 1948 January 3, 1944 January 3, 1944	8,632 32,615 10,000
CA No. 5178	Municipal Industrial Irrigation	May 5, 1954	106,000

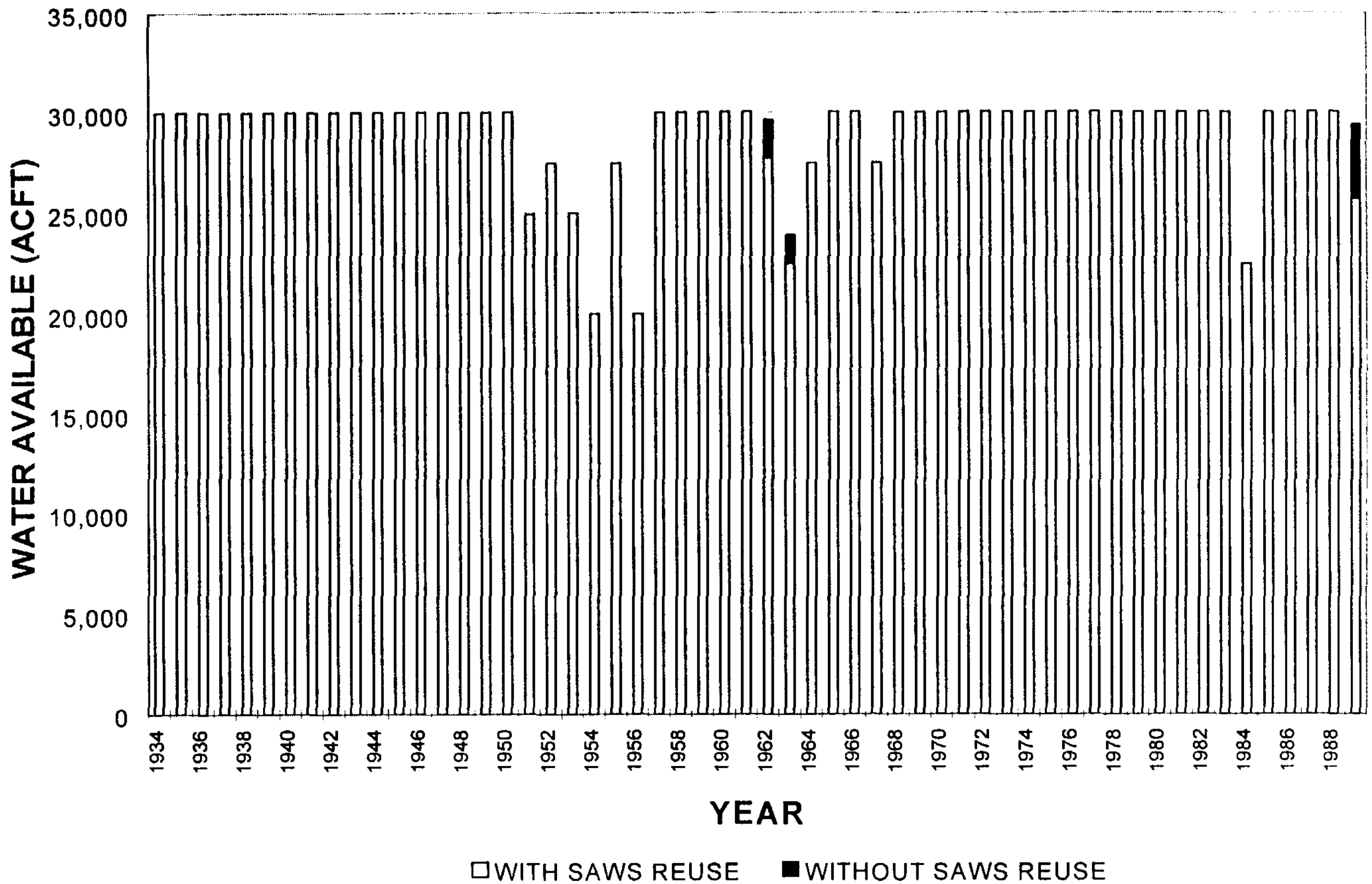
For CA No. 5177, a total of 30,000 acft/yr was diverted in a uniform monthly demand pattern under the most junior portion of the water right authorized with a January 3, 1944 priority date. For CA No. 5178, a total of 30,000 acft/yr was diverted in a uniform monthly demand pattern under the most junior portion of the 106,000 acft/yr water right.

To assess the impact of proposed consumptive reuse of treated effluent on water availability, two scenarios were analyzed for each water right. Preliminary SAWS plans[1] include reuse/recycling of about 35,000 acft/yr from the Leon Creek and Salado Creek wastewater treatment plants. It was estimated that only 26,200 acft/yr (14,000 acft/yr industrial, 12,200 acft/yr irrigation) would be consumed with the remainder entering the San Antonio River and Salado creek. Water availability was analyzed assuming return flows at 1989 levels with and without the consumptive reuse of 26,200 acft/yr. Hydrologic assumptions for the example applications included the following:

- Uncommitted firm yield of Canyon Lake diverted at Lake Dunlap. Canyon Lake contracts diverted at their full contracted amounts (38,438 acft/yr).
- Edwards Aquifer pumpage of 400,000 acft/yr.
- Hydropower and once-through cooling water rights downstream of Canyon Lake subordinated to Canyon Lake.

[1] Brinkmann, M., Personal Communication, June 19, 1997.

For CA No. 5177, the annual diversion of 30,000 acft was found to be a firm supply with or without reuse of treated effluent in the San Antonio area. For CA No. 5178, the annual diversion of 30,000 acft was fully available in 44 years of the 56-year simulation period without reuse of SAWS treated effluent. The minimum annual water available was estimate to be 19,980 acft in 1954 and 1956. With reuse of SAWS treated effluent, the 30,000 acft annual diversion was also fully available in 42 years of the 56-year simulation period. Water availability did not change during the critical drought period for 1947 to 1956 (Figure 6-1). Water availability decreased slightly in the years of 1962, 1963, and 1989. For the most part, the total water right demand was available in a particular month or no water was available. There were very few months when the reuse of treated effluent in the San Antonio area, in the quantities analyzed in this example application, made a significant difference in water availability to the two selected downstream senior water rights.



ASSUMPTIONS

- Maximum Annual Diversion of 30,000 acft/yr.
- Annual Diversion of 30,000 acft/yr is junior in priority to remaining portion of Certificate of Adjudication No. 5178 with a priority date of May 5, 1954.
- Uniform Monthly Diversion Pattern.
- SAWS Reuse of 26,200 acft/yr (consumptive).
- Edwards Aquifer pumpage scenario of 400,000 acft/yr.
- Hydropower and once-through cooling water rights downstream of Canyon Lake subordinated to Canyon Lake.

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WATER AVAILABILITY UNDER EXISTING WATER RIGHTS

CERTIFICATE OF ADJUDICATION NO. 5178

FIGURE 6-1

GUADALUPE - SAN ANTONIO RIVER BASIN MODEL - NATURAL STREAMFLOW IN ACRE-FEET

1758 - GUADALUPE RIVER AT CUERO

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
1934	81464	71264	131661	99061	44466	28368	42366	28967	23568	25018	59955	103864	740022
1935	39263	100860	38834	61328	510051	581950	110259	70371	315055	91150	58301	119348	2096770
1936	81388	55484	60463	44902	281648	130806	1081471	75470	182994	253546	98879	89406	2436458
1937	80924	70343	164930	76053	54812	153844	53442	38702	35544	46018	35934	66241	876787
1938	153193	89873	83818	295829	287613	76243	54484	43848	38419	33911	34915	37763	1229907
1939	40291	33140	34362	32392	40510	39871	43825	23080	22192	28759	23995	27551	389967
1940	28581	38188	35569	53738	42226	61610	388282	29258	24617	35405	362231	331829	1431534
1941	149413	208772	256863	266905	761794	270460	146582	81270	64583	78270	66338	53298	2404549
1942	49243	41133	45072	147398	92385	50633	368188	53310	247684	161437	99001	84042	1439528
1943	81346	57251	64876	57159	51666	77348	53681	37851	41418	37094	35435	41441	636564
1944	76971	88866	172883	84836	198243	171707	69548	51040	98367	49148	70077	123645	1255332
1945	188491	171287	160696	315290	87827	74471	52485	40122	35150	72937	44000	59294	1302051
1946	72668	96357	179734	86115	119932	132016	45986	59935	273457	241598	206869	130110	1644777
1947	209281	112054	125569	122732	125432	64901	51927	77999	37914	32731	34689	40717	1035947
1948	37830	43781	43725	30065	81787	30725	42638	31083	21138	25939	21061	23569	433340
1949	27136	51549	90570	231755	161249	62933	51199	37538	31270	158994	47037	56688	1007916
1950	39990	46177	38192	71699	52181	131845	33401	20482	20270	19314	18539	22419	514509
1951	21553	20935	23706	24612	31939	128562	17245	9948	20035	12528	16364	17608	345035
1952	18181	20476	18235	32280	78130	76045	26757	9642	225782	40050	53210	109185	707972
1953	95524	42671	36793	40262	148741	18061	17767	27486	97105	97422	37821	50451	710103
1954	32624	25246	22880	26313	40155	13103	7791	5463	4831	5691	9909	12637	206644
1955	13635	48863	17954	15298	44177	44425	11805	11521	7742	4466	4565	9162	233614
1956	9872	12545	7938	7899	12136	2335	1679	478	1039	7679	2051	27072	92722
1957	5416	20169	66864	234294	407243	300914	38814	20030	218236	465309	237737	115207	2130234
1958	237527	457208	228894	113136	250908	99296	72226	42619	112948	107172	125030	83509	1930472
1959	72941	102593	74885	186265	96877	64335	75605	48231	40614	145497	72145	63734	1043722
1960	82351	81176	69004	72576	139238	163021	154747	105738	60567	540239	439664	191504	2099824
1961	223515	244538	143089	90739	66519	388749	153330	67549	106761	59264	125411	56798	1726261
1962	51647	46234	44376	52360	42643	48805	29148	19006	40526	36855	37306	45536	494443
1963	39648	54122	38423	42150	29450	22179	19346	11756	11443	11708	42860	26376	349459
1964	26495	46372	78805	41550	25710	36770	16513	15411	64274	38820	52111	27683	470514
1965	98225	289208	71978	81402	349687	291706	64281	42258	34416	82023	118234	171233	1694651
1966	75769	99306	100744	132609	161207	69013	50936	51151	57424	51200	39456	34979	923794
1967	35869	29648	32689	28043	23363	15674	15124	19018	537513	104784	126791	57447	1025963
1968	525542	145652	118632	172574	244857	327165	85219	52491	91327	46719	55708	124176	1990062
1969	52313	185313	176828	193186	187394	86060	49302	43242	47046	106184	62393	98319	1287580
1970	89222	99692	169555	101354	221552	139388	71547	49250	44411	66171	40079	40700	1132921
1971	37971	32049	34501	26230	23656	26294	17217	135186	132092	94304	76646	118218	754364
1972	78313	69724	58601	42918	789807	143096	73372	69207	47812	49986	51906	49531	1524273
1973	67438	88568	146675	288038	117441	418576	272387	131605	128222	630235	161030	113430	2563645
1974	213493	90445	81517	66318	128332	86316	44607	90075	222917	78660	275726	153475	1531881
1975	113838	255804	127505	133515	636351	321265	175797	98465	75075	67540	59687	58497	2123339
1976	54677	49946	54329	300726	390339	167748	141108	83238	83652	267877	305152	385673	2284465
1977	161053	247504	119612	694199	256219	130368	86816	64728	61324	58427	89929	55521	2025700
1978	54568	54956	57332	56165	39880	81732	33237	267687	155262	69238	104017	74682	1048756
1979	282793	208230	244937	330163	413052	350654	136449	98984	73357	58487	53292	58319	2308717
1980	63252	54384	52895	49063	154491	51750	32348	28762	84777	63570	47911	52884	736087
1981	52799	49026	91630	106558	101879	595654	190413	130001	664319	159127	231152	87739	2460297
1982	74305	77947	61382	54013	324267	76079	45827	32071	28319	30778	44015	42070	891073
1983	45402	69659	118918	69113	99090	85184	56245	39469	46961	39305	49004	34827	753177
1984	41843	33834	41009	27028	20041	16738	6918	8302	6635	41079	28254	50572	322253
1985	134208	82958	125381	107729	92062	208446	144228	53649	40974	115777	227448	162637	1495497
1986	93081	92523	67491	50726	102217	188922	66545	42617	87087	150833	139279	372045	1453366
1987	207153	192585	245438	113399	176174	1473281	276093	160351	102385	86979	90183	80868	3204889
1988	67310	58506	68980	49787	54528	59288	83120	52778	37514	31967	28374	31708	623860
1989	41089	36540	40302	38571	84315	36975	18347	10234	8194	13878	20388	21542	370375
AVG	91606	94527	91224	113757	171427	160602	99465	54465	96867	98734	91062	85335	1249071

GUADALUPE - SAN ANTONIO RIVER BASIN MODEL - NATURAL STREAMFLOW IN ACRE-FEET

H5 - GUADALUPE RIVER AT H5 DAM

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
1934	32374	28695	39356	42748	31955	26595	30243	27251	23542	24617	23944	25596	356916
1935	25897	27095	26173	25682	93942	244379	61867	42964	78294	49207	40107	48044	763650
1936	43871	36881	39653	33378	64427	66207	124382	42273	227092	91082	60606	54035	883884
1937	50869	44077	55166	45530	40148	73316	37653	31018	29732	30526	28448	43173	509655
1938	66921	46180	42341	62227	63988	39798	34113	30444	30289	29386	28660	29897	504243
1939	30922	26775	28471	27165	27446	24238	27869	25214	24193	32146	23559	25165	323163
1940	25363	25410	29094	40451	33189	40069	32465	24915	22751	23313	32797	69425	399242
1941	37505	83916	88591	118603	150716	70080	57988	42317	40634	54660	39269	36976	821256
1942	35543	31581	33567	61643	66489	36528	38848	31294	71950	75619	51773	49945	584781
1943	45293	36563	38821	38250	34177	42358	36950	28922	30513	28686	27618	29406	417557
1944	41646	46396	71562	51584	127611	72465	43784	41412	45417	39942	35055	60949	677824
1945	80121	79413	94384	83124	56115	42705	38101	32970	36708	50101	34419	45878	674040
1946	41831	43421	55271	42399	60573	52719	36094	32684	58084	63512	89246	71140	646974
1947	95364	66903	61661	54245	52801	48855	35698	33719	28036	27778	27242	28941	561241
1948	28080	27119	27875	26385	27338	29732	26407	21482	21117	23032	21765	22636	302968
1949	23906	34506	37270	50370	48280	35005	29923	30816	26736	31468	25613	26927	400820
1950	26962	28381	27288	27055	31396	27448	24420	20518	20341	20893	19615	20525	294842
1951	20310	18429	21545	20328	25570	23972	15700	14214	13999	14463	15219	17551	221299
1952	16654	14637	15944	20425	32636	24524	14712	10937	195730	22478	21289	33004	422969
1953	33964	23539	23856	24635	19355	14336	12751	11318	33087	24872	20680	23887	266278
1954	20504	17497	15778	12760	17033	10219	8448	6874	6020	9122	10689	11015	145958
1955	12270	13173	11698	8896	14388	9109	11079	6156	4790	5505	5994	8233	111289
1956	8307	8197	6411	3926	3156	908	256	671	531	753	2770	4228	40114
1957	4637	5222	21936	116952	77803	71076	20805	10947	34959	102103	63713	51585	581737
1958	71012	88920	95963	60839	134342	63691	42560	30568	63483	55335	60135	48274	815122
1959	43738	40488	42690	45343	40039	53902	39638	31186	27074	98426	38585	40257	541364
1960	46722	42517	40454	40754	37148	44814	35819	68035	36572	140576	75751	82403	691565
1961	79607	104028	73055	49942	39396	67219	45575	35309	31123	33264	35808	32313	626638
1962	31073	27056	28450	29135	27074	27933	21130	16170	20467	22152	22313	26977	299929
1963	24393	23428	23911	26810	22256	17123	15452	12200	11768	14559	18698	18274	228873
1964	19066	24531	30544	21999	18425	21974	14391	17784	37448	25307	28520	22462	282451
1965	25406	64766	42354	48212	145114	90102	36579	26594	21773	37710	33498	67266	639372
1966	38351	40269	43260	47722	49807	34839	30655	39102	37610	30126	26418	24094	442252
1967	25237	20159	22796	18092	14257	7954	11574	9592	81043	33751	45655	33752	323862
1968	171305	73688	70580	71671	78368	62567	43780	33767	30213	29319	29156	35570	729983
1969	30052	41575	42121	53711	61965	41149	28403	26148	29695	83094	38358	59344	535615
1970	48906	46930	77749	52119	96327	61481	38215	30957	27307	31377	27349	29539	568254
1971	26879	22456	22201	19174	17390	11963	13042	109182	44386	76188	56956	64002	483816
1972	46888	39867	39622	29569	213912	63109	38217	42116	34617	35064	36443	35493	654917
1973	40174	44438	54350	62978	48702	88376	160176	61511	66345	158059	68568	55777	909452
1974	59984	45639	45884	40002	78766	42066	31771	63152	66585	48677	94226	63078	679829
1975	61714	127689	73131	62487	159398	105644	79851	47249	39523	40765	36684	38373	872508
1976	35116	32469	31973	74768	86120	58111	75265	43875	44276	84425	71819	78893	717109
1977	69815	72500	60757	191646	105766	65832	47765	39418	35632	40573	42859	37960	810522
1978	35235	33091	34343	32480	29088	36955	23283	247444	76218	45531	53223	50789	697679
1979	89970	86015	117986	115297	109632	121063	71923	54205	42598	39318	34426	37970	920401
1980	38978	34449	34011	31233	43780	28212	20089	17501	56061	47336	31270	36035	418955
1981	34836	32435	68057	65585	52721	233034	63633	56459	56309	101065	54662	46878	865674
1982	42967	34636	36827	34795	77225	47085	26661	21105	19403	23815	27563	28403	420485
1983	27752	29654	44606	34292	41453	45628	29901	21966	27225	22230	25221	19884	369812
1984	23898	21798	22847	15566	10522	8038	1524	3838	1625	17388	19799	30321	177164
1985	83502	52133	70971	54120	52093	119241	64640	31932	27406	82168	52965	55584	746755
1986	52233	54460	42181	31990	49598	73177	38708	23423	58199	84521	64163	140430	713082
1987	88334	75633	85611	59226	98898	413791	148039	75174	35573	45904	51130	48707	1226020
1988	44490	39670	41122	34548	39404	32854	69248	34986	28335	24961	21951	24955	436524
1989	31053	28937	32296	30595	26978	14905	8043	4146	3733	8759	13776	15507	218728
AVG	43532	42149	44757	46883	59045	59473	39573	35311	41503	45304	37286	40495	535311

GUADALUPE - SAN ANTONIO RIVER BASIN MODEL - NATURAL STREAMFLOW IN ACRE-FEET

1888 - GUADALUPE RIVER AT TIVOLI

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
1934	276063	99431	177886	173445	64783	42908	145494	47210	59338	42281	153870	154997	1437705
1935	67610	146818	82659	124013	680944	842836	153736	93781	480289	157930	91449	186676	3108740
1936	111680	80365	93606	80578	573892	210909	1381798	119099	387605	352526	151406	137215	3680678
1937	128177	101782	212914	104332	78180	310029	87308	68787	66348	81797	62755	186795	1489203
1938	220087	122048	125491	460240	398495	109733	75884	75291	66445	51090	57670	78391	1840866
1939	70607	53478	51160	46931	65049	58606	104316	39250	61099	37455	29420	42704	660074
1940	39233	63180	48599	79703	68125	197227	498031	66249	35914	111334	595075	489979	2292649
1941	193999	323719	369455	488682	1190133	408782	310607	118371	133864	164312	102040	102013	3905977
1942	66200	110079	77407	187972	128159	67564	864210	145133	572084	298495	139256	115580	2772140
1943	130577	87475	124825	79275	102293	162664	100413	50952	71217	50352	72923	81943	1114909
1944	210566	112599	290254	103278	464203	207833	85267	95346	165522	82582	92484	187887	2097818
1945	235519	222827	212902	439961	114847	136366	83805	166725	47601	110767	56602	74784	1902705
1946	94852	158172	225574	129566	238166	269182	70905	165033	558853	773689	284678	164220	3132890
1947	268799	141412	160506	168199	295399	101131	83832	97431	50865	45847	60317	57848	1531585
1948	63799	82578	80831	46557	135552	38819	64559	88431	82756	42945	28181	30562	785569
1949	35759	78544	115039	506462	208504	123101	117545	56996	43146	333858	64691	98033	1781677
1950	58250	62234	50347	93449	65140	181385	44549	32426	33037	24507	23146	27577	696047
1951	26228	28767	32038	33278	110549	211734	22181	12962	179323	25950	26468	23972	733449
1952	23276	37356	33440	80537	187687	102475	41279	13564	482821	46323	98782	131645	1279182
1953	109051	59184	44311	56164	240042	21511	22169	147289	196016	127097	45309	61063	1129204
1954	39432	29503	26924	34389	56556	18271	11072	7555	8284	36341	17901	16364	302590
1955	19268	76514	25541	19560	70195	53152	16831	34979	51767	16465	8497	15626	408394
1956	13543	16384	13992	15013	34894	4576	4569	3880	10273	34263	14007	52404	217798
1957	9846	29466	210283	588597	691393	513768	46886	24913	358791	560151	408916	134795	3577804
1958	439679	826292	290366	140619	401167	148937	100931	50842	265490	279695	216074	158613	3318705
1959	99272	242514	95945	255441	155052	111827	92526	98014	54290	298948	96534	96437	1696799
1960	102651	125599	106564	90293	163597	266144	199494	241390	76372	1053191	610984	345617	3381894
1961	318806	392032	182441	125255	79597	533573	279125	87026	200957	85734	188720	72294	2545557
1962	66090	60075	54004	78159	58130	130896	37701	22363	77646	48111	54678	86517	774369
1963	48481	79282	45463	49462	34953	32420	24326	13929	15006	23833	68286	38543	473983
1964	42644	90153	111415	45411	33561	60668	18963	76088	140681	61019	80644	45000	806246
1965	139796	428834	95326	106891	539251	367055	76136	49176	42374	152111	145409	267221	2409580
1966	105217	137810	106441	177281	297536	105953	88548	71799	92004	84276	61872	54122	1382857
1967	62808	51500	50349	53253	50490	38859	20523	56121	2007964	433273	232720	158780	3216641
1968	763778	294745	187083	229789	535558	464171	243093	94321	166450	128548	94552	168381	3370466
1969	121505	249290	260456	361056	330547	152475	56237	57555	63108	144639	91272	140600	2028738
1970	146834	122518	256962	156686	298049	342290	96173	62156	77124	97388	50048	50281	1756508
1971	47234	38321	41504	40130	49692	37841	35710	272434	408434	324713	187182	231475	1714669
1972	125668	130194	90209	76834	1053116	265895	111803	115921	80992	130472	144769	66754	2392626
1973	86124	124436	180496	427329	173305	772842	510425	294372	265297	1200915	324313	198817	4558670
1974	258008	175767	143324	99090	238274	121429	59637	144300	328675	169842	321853	318271	2378469
1975	189454	346916	219928	193282	709731	560216	279914	146671	138786	90735	108158	106039	3089829
1976	98908	61347	68342	516602	547421	286150	223173	113198	134026	384238	514955	664903	3613261
1977	263640	350927	181201	891029	435470	358010	126049	92692	107718	92029	180123	83959	3162846
1978	82819	94053	80614	90031	65530	155343	43813	383758	475441	108997	168309	95391	1844100
1979	421404	267063	303178	478790	660176	530882	228762	145619	264040	74588	70309	75019	3519829
1980	125282	74970	61365	57611	272479	69031	39104	95379	152752	85465	64874	68956	1167269
1981	77134	62168	111371	139010	237809	1021768	335195	164887	801493	306718	380558	118384	3756493
1982	94794	178600	90718	74644	469108	97920	53740	39433	33761	59576	154583	59913	1406791
1983	59433	112311	179990	82402	109743	96412	140869	50538	90647	95166	80309	40016	1137834
1984	70915	48426	74899	34994	36404	24223	11246	14575	8381	107475	61940	76537	570015
1985	187371	105463	221735	262706	126379	276404	210916	62260	64404	172749	260817	217659	2168863
1986	117795	112861	82026	62136	140786	376506	93417	52643	111825	251577	176094	522349	2100014
1987	318512	267370	354536	151969	256990	2472372	414050	229934	144925	113620	144073	113107	4981458
1988	89632	76909	90683	66585	64329	71366	108755	58250	45905	38381	33273	43696	787765
1989	64426	52380	55814	60357	105117	61049	21220	19498	12896	28387	34774	31412	547330
AVG	138367	144733	131442	175273	267724	264384	157479	93728	199163	184549	144445	133360	2034645

GUADALUPE - SAN ANTONIO RIVER BASIN MODEL - NATURAL STREAMFLOW IN ACRE-FEET

1765 - GUADALUPE RIVER AT VICTORIA

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
1934	86497	75827	139006	104904	47796	30958	45599	31585	25938	27455	63997	102534	782096
1935	48137	107429	46528	66279	483315	537313	113927	71572	273019	121430	63953	126126	2059028
1936	86419	59322	64531	48254	295906	138113	1132597	80229	192706	266509	104716	94807	2564109
1937	85934	74866	173810	80838	58620	162213	57186	41768	38465	49421	38873	70575	932569
1938	161529	95292	88958	310738	302142	81031	58269	47143	41468	36753	37805	40784	1301912
1939	43431	35952	37229	35167	43658	42988	47123	25426	24499	31368	26387	30105	423333
1940	31183	41231	38490	57494	45452	65727	407450	31885	27034	38319	380203	348400	1512868
1941	157580	219675	269981	280485	798185	284202	154615	86296	68842	83160	70679	57040	2530740
1942	52791	44309	48427	155463	97915	54237	386423	57034	260370	170151	104839	89191	1521150
1943	86377	61172	69147	61072	55326	82187	57428	40870	44606	40085	38352	44634	681256
1944	81797	94241	182126	90021	208652	180889	74020	54659	104172	52690	74585	130620	1328472
1945	198460	180463	169382	331098	93154	79179	56179	43248	38052	77580	47314	63311	1377420
1946	77299	102080	189296	91361	126734	139371	49373	63966	287333	254008	217682	137386	1735889
1947	220203	118497	132631	129660	132482	69156	55579	82852	40933	35517	37568	43874	1098952
1948	40846	47072	47002	32702	86803	33372	45826	33739	23364	28400	23304	25929	468359
1949	29664	55204	96014	243702	169942	67087	54803	40512	33975	167589	50479	60575	1069546
1950	43114	49587	41221	76259	55836	139159	36166	22654	22465	21480	20676	24736	553353
1951	23826	23181	26061	26993	34649	135711	19245	11609	22209	14376	18397	19701	375958
1952	20307	22707	20346	35023	82979	80781	29210	11300	237445	43168	56943	115497	755706
1953	101207	45923	39760	43377	156849	20129	19812	29981	102840	103185	40846	54061	757970
1954	35410	27694	25198	28770	43242	14916	9345	6914	6307	7229	11646	14506	231177
1955	15553	52398	20051	17254	47455	47694	13546	13261	9352	5948	6067	10878	259457
1956	11618	14401	9572	9488	13925	3675	3074	1883	2479	9387	3410	29595	112507
1957	6954	22388	71236	246380	427289	316038	41821	22156	229542	488039	249985	121807	2243635
1958	249767	479571	240733	119625	263744	105109	76795	45814	119437	113405	132087	88654	2034741
1959	77601	108621	79618	196134	102619	68406	80213	51581	43748	153492	76768	67969	1106770
1960	87444	86217	73483	77179	146910	171587	163006	111758	64626	566405	461221	201625	2211461
1961	235113	257105	150946	96171	70813	407904	161678	71930	112934	63273	132482	60717	1821066
1962	55309	49657	47696	56028	45842	52300	31689	21022	43645	39816	40331	48935	532270
1963	42726	57860	41350	45163	31802	24112	21107	13114	13024	13427	46075	28859	378619
1964	27478	46216	74162	41160	28905	36488	18385	19630	57600	45457	54549	32640	482670
1965	99326	285777	82916	87000	336207	277299	70321	46907	39037	84717	117652	180348	1707507
1966	75054	92024	97333	128022	171241	69213	54054	50680	55377	50331	40294	36476	920099
1967	37208	30547	33042	28533	23545	16839	14746	18507	573708	131588	128840	66777	1103880
1968	527908	164295	129176	175690	305603	362496	104156	60305	99114	51607	56451	127253	2164054
1969	56700	183066	181597	226311	202450	89754	53018	46633	53592	107232	65498	102815	1368666
1970	96141	99240	181527	104192	235384	155113	69743	52127	48932	66556	43482	43558	1195995
1971	40942	34492	37325	28910	25888	24419	20960	129618	159146	106409	80400	123834	812343
1972	85390	75022	63149	45376	786062	162588	86066	78835	56281	57319	57440	53913	1607441
1973	71766	95675	158103	308591	129215	464120	281398	150428	127681	687780	180567	118558	2773882
1974	217718	98298	86683	71507	147666	94542	52801	87523	232477	87892	279854	177890	1634851
1975	125349	258658	134994	132246	584578	349398	200660	108326	79521	75084	63841	78081	2190736
1976	57164	50814	55493	317402	391727	191330	152112	88247	91087	263656	309510	417238	2385780
1977	178399	262106	132522	646408	272776	146008	93197	72757	65218	61230	94352	60124	2085097
1978	57651	58414	58532	59316	48193	91660	38781	266187	207896	80568	113536	73453	1154187
1979	298434	210157	237660	323182	453535	350746	132901	110297	96523	59781	53542	54304	2381062
1980	69772	55103	49969	44479	168683	58481	35530	27798	86024	63155	47954	52783	759731
1981	52650	48794	90052	106253	123449	635165	218605	94905	671866	174735	248208	89007	2553689
1982	76138	90795	66135	57312	349666	79980	46492	32148	29904	36649	63328	44409	972956
1983	42939	82117	133811	74161	96160	82042	78456	37086	44728	45415	50659	31999	799573
1984	48044	38076	48291	28408	23527	19406	7747	7608	7116	42955	34031	54597	359806
1985	140445	88957	144795	145629	99845	209772	155333	56257	43434	121478	202563	194681	1603189
1986	104292	99002	75515	57273	105279	197113	68621	41899	83051	151727	137712	376466	1497950
1987	243052	182989	283343	119171	170376	1601364	307157	185206	103300	91741	96067	86146	3469912
1988	67972	59022	72305	52752	55116	58938	79123	53708	38007	33560	29162	33676	633341
1989	46251	42161	46712	45885	90372	38385	18660	12264	8337	14054	20376	23716	407173
AVG	97112	98960	97053	118719	178491	169611	106467	57208	102032	105638	95492	90860	1317642

GUADALUPE - SAN ANTONIO RIVER BASIN MODEL - STREAMFLOW IN ACRE-FEET

UNGAGED RUNOFF UPSTREAM OF GAGE 1888 (TIVOLI)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
1934	110732	8621	17160	27143	2987	707	48661	4079	21029	2226	49266	17861	310471
1935	4627	16317	21450	22045	20279	31980	9231	1755	97125	5772	4881	22908	258371
1936	3218	1220	7556	12765	140304	29325	66770	14175	34734	12217	6150	7325	335760
1937	11344	1382	13534	1925	2579	21704	10623	10623	11677	13747	8863	42111	150112
1938	8024	6870	592	47102	56541	8863	1797	15865	12490	2358	6369	21704	188576
1939	11211	2850	1382	1301	11014	5987	33090	5933	33293	2053	902	8380	117396
1940	3981	9542	5087	2402	10046	63591	17237	11744	4526	52221	34010	36413	250799
1941	7582	41267	47603	96247	143563	29353	91761	9760	17666	50438	8118	30051	573409
1942	523	51384	18435	3867	348	576	207927	68696	58415	12737	2763	2323	427994
1943	21907	9834	30648	100	22657	32540	19368	433	12615	203	21304	24834	196443
1944	105751	3918	75795	1151	128804	1066	331	16807	33058	18156	8392	36269	429498
1945	248	3546	13368	43712	2656	34222	17703	114785	983	12841	0	84	244148
1946	3634	39198	18018	4041	19647	66690	11611	53642	52416	113486	13191	179	395753
1947	5815	320	1628	18286	92855	10457	17638	1352	207	2674	12632	2705	166569
1948	13020	23571	23806	4750	34752	2079	986	17280	47964	490	105	0	168803
1949	199	6546	7970	142361	2204	1958	21691	2708	1307	102760	1918	16182	307804
1950	4146	5910	118	7796	906	17182	2362	2148	5177	120	0	0	45865
1951	32	0	203	0	46107	19734	0	0	104181	6893	3532	178	180860
1952	0	7630	6864	29276	64031	15472	5325	1277	49412	0	26182	8065	213534
1953	415	10035	1	7140	29935	148	0	83553	18396	13113	480	1778	164994
1954	586	0	0	1584	1485	278	28	0	1201	25684	1811	0	32657
1955	705	7804	23	0	4989	610	476	14062	32702	7179	372	1694	70616
1956	35	0	2331	2674	11976	0	0	1042	0	5621	0	3305	26984
1957	0	3167	111468	159670	93156	62173	0	23	25893	17574	84317	592	558033
1958	79025	131773	4221	2617	11302	732	42	0	89515	96781	7942	41830	465780
1959	944	103870	0	11523	17669	27124	498	41158	4807	107584	4846	16964	336987
1960	412	26492	17356	970	9461	70511	14172	87666	3396	300164	56887	89720	677207
1961	42423	71807	218	7873	3	59533	70178	1602	78125	0	21023	25	352810
1962	0	0	0	9985	5943	43133	2939	0	20232	5127	9097	23063	119519
1963	498	8882	4	54	345	6424	156	773	0	16	11517	2316	30985
1964	8944	19656	18401	41	2318	14816	4	29299	50542	1525	71	5852	151469
1965	9974	43268	512	93	44391	39113	260	0	1005	38888	25014	57210	259728
1966	21007	34582	0	28309	92274	27386	27134	7406	17340	27950	18515	13601	315504
1967	20930	17710	12880	19320	21735	21735	0	19320	450800	169855	53935	75670	883890
1968	805	78085	20930	22540	69230	34615	112700	24955	5635	66815	28980	18515	483805
1969	52325	22540	57155	61180	26565	18515	0	6440	0	4830	17710	23345	290605
1970	29785	6440	37030	39445	0	122360	21735	5635	24955	24150	2415	2415	316365
1971	0	0	0	8050	20930	0	11270	0	165025	136850	64400	70035	476560
1972	11270	35420	10465	8050	1610	53935	4830	14490	805	46690	71645	0	259210
1973	0	4830	1610	0	20125	3542	0	78085	28175	33810	67620	36225	274022
1974	0	49910	29785	6440	38640	6440	0	0	15295	52325	0	113505	312340
1975	30590	2415	44275	28175	0	103040	37030	13685	39445	0	32200	0	330855
1976	21735	0	0	89355	5635	66815	15295	0	0	0	92575	141680	433090
1977	12767	15216	1577	17503	37042	150146	1314	3451	8872	11615	15158	970	275631
1978	5051	13388	427	2422	184	19403	2264	2423	142001	1761	9462	567	199353
1979	24566	6935	9859	11632	57988	27808	46503	6092	144738	4387	4156	2928	347592
1980	20067	3105	1264	271	30610	548	1223	38319	10988	9029	3024	967	119415
1981	8649	980	447	1253	52030	112862	44372	21090	16998	41919	77802	6381	384783
1982	494	38973	1465	1220	42023	671	279	687	121	3483	47148	379	136943
1983	3013	13474	13987	425	1962	1999	49021	3758	11410	33110	8540	1013	141712
1984	9533	889	2101	160	6936	1486	1489	5158	740	14660	4181	1717	49050
1985	11696	1601	26688	71444	5485	24402	11901	3298	6402	5563	1960	5693	176133
1986	2122	930	237	306	19322	20390	794	5831	4859	28906	7697	13100	104494
1987	8213	14198	1933	350	5586	75973	27363	10885	13041	7328	25579	2780	193229
1988	335	121	334	244	224	1740	2516	360	523	1122	208	5599	13326
1989	7403	191	62	1918	6732	13192	1220	3603	2934	11599	2594	582	52030
AVG	13613	18368	13219	19473	28538	29055	19520	15843	36343	31579	19455	18921	263926

GUADALUPE - SAN ANTONIO RIVER BASIN MODEL - STREAMFLOW IN ACRE-FEET

UNGAGED RUNOFF DOWNSTREAM OF GAGE 1888 (TIVOLI)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
1934	33764	3781	6901	10221	1439	361	16776	1922	8219	1091	16953	7143	108570
1935	2158	6608	8360	8558	7967	11751	4017	870	30183	2639	2266	8843	94219
1936	1543	613	3362	5340	41374	10916	21939	5850	12605	5139	2795	3270	114747
1937	4817	692	5619	950	1254	8444	4547	4547	4940	5696	3875	14841	60222
1938	3547	3088	303	16319	19052	3875	890	6449	5240	1152	2884	8444	71244
1939	4767	1377	692	653	4694	2728	12096	2706	12160	1010	457	3687	47026
1940	1879	4137	2353	1172	4329	21049	6928	4965	2114	17811	12381	13120	92238
1941	56	11919	9567	21023	25071	4627	38529	3257	270	11322	2694	14781	143116
1942	0	21357	2226	0	0	1	42615	7712	2807	5508	1189	1690	85105
1943	11639	5560	6999	0	516	8	72	0	45	0	157	2941	27937
1944	33849	86	13497	481	14088	0	0	2358	10859	12703	327	6989	95237
1945	0	339	2423	6296	28	6617	8135	69574	0	2686	0	0	96098
1946	513	7535	13881	1864	6560	17611	953	17812	34768	13469	3727	10	118703
1947	835	7	78	8860	11930	5147	0	3578	160	3469	13534	4265	51863
1948	10334	13038	7426	341	1	0	0	2776	29767	22	0	0	63705
1949	1	2396	2320	46319	979	5	9329	1782	2010	61187	418	1708	128454
1950	6	8025	27	1460	83	133	0	39	1958	0	0	0	11731
1951	0	0	1	0	60	0	0	0	35791	2538	0	0	38390
1952	0	1152	0	9184	8874	0	107	36	12261	0	2322	1521	35457
1953	0	1357	0	0	10905	169	0	54294	5223	3656	310	2037	77951
1954	196	0	0	137	246	0	0	0	0	15013	3140	0	18732
1955	1143	1232	0	0	1448	0	0	3950	18880	131	0	562	27346
1956	29	0	606	3651	3312	0	0	87	0	0	0	506	8191
1957	0	0	3713	44912	17759	11388	0	0	9189	393	6007	170	93531
1958	19347	21563	933	0	1196	0	4	0	21421	2068	2189	17764	86485
1959	1169	27888	0	1263	2921	5908	475	30705	2855	42228	120	1151	116683
1960	1118	12052	11053	268	2302	26499	0	29470	1214	46906	15858	39917	186657
1961	17750	27898	0	1437	0	38663	14004	185	25811	0	3834	0	129582
1962	0	0	0	581	1671	8286	0	0	1057	3423	329	13034	28381
1963	52	2842	0	0	0	6	4	0	0	0	1987	0	4891
1964	1413	4393	1330	0	0	2576	0	0	8671	349	31	5357	24120
1965	938	6827	6	1	2657	2500	0	0	0	4832	5270	13956	36987
1966	22504	11141	19	17234	37274	12780	2493	0	2860	1180	0	4	107489
1967	1374	1481	0	0	23679	0	6290	9583	106029	5294	311	0	154041
1968	12973	6955	5765	248	7224	81217	7943	1761	7577	4401	141	228	136433
1969	0	4817	4605	27146	8476	576	0	166	71	1018	6854	12302	66031
1970	6124	1684	12598	1345	2342	10876	6404	6	23699	36707	0	0	101785
1971	0	0	0	604	3448	68	0	5073	44279	31698	2554	40889	128613
1972	10741	11038	440	1312	23600	1156	1414	8484	21784	19931	17363	0	117263
1973	369	893	1	8592	23	26087	38	654	36247	35623	470	0	108997
1974	1428	0	3175	9	52096	10440	0	3816	18432	1243	64032	2345	157016
1975	1643	1716	0	0	1683	3819	863	12957	20353	708	116	414	44272
1976	0	0	0	1095	15378	1424	70767	0	2949	9321	17631	36531	155096
1977	6523	2820	832	13357	23546	28425	522	1520	10513	8143	31062	482	127745
1978	2324	9752	221	1996	282	8452	1003	839	18725	5593	5523	3392	58102
1979	23710	12518	8615	8371	18985	4671	48004	6076	128744	1017	1751	2531	264993
1980	6960	501	1812	272	8491	156	481	10251	9887	2205	615	559	42190
1981	3747	875	316	3405	44956	62338	20061	10806	6010	18489	16228	6952	194183
1982	372	39949	509	1756	14824	627	339	1112	3284	703	12522	395	76392
1983	5231	11901	6991	208	120	5219	38871	1613	10868	6720	7986	302	96030
1984	9366	332	3154	81	2566	92	605	5217	1857	31514	8801	574	64159
1985	6434	2447	25358	18311	988	1738	3177	423	2686	4348	1495	2736	70141
1986	1674	182	43	264	8174	7274	232	1626	1485	40582	29385	7708	98629
1987	6913	17450	1562	166	2756	13417	14200	4573	3319	3502	3847	215	71920
1988	257	62	46	245	492	1947	2480	371	3434	922	19	55	10330
1989	8635	297	41	118	104	19893	11279	4546	357	2917	10291	538	59016
AVG	5217	6010	3210	5311	8825	8785	7480	6186	14034	9647	6144	5480	86330

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C***********************************************************************
C*******  GUADALUPE - SAN ANTONIO RIVER BASIN MODEL   *****************
C*******  POST-PROCESSOR PROGRAM = ESTUARY1.FOR       *****************
C*******  DATE OF MOST RECENT MODIFICATION = 6/30/97  *****************
C***********************************************************************
C** PROGRAM DEVELOPED AS A PART OF THE TRANS-TEXAS WATER PROGRAM,     **
C** WEST CENTRAL STUDY AREA, GSA MODEL MODIFICATIONS & ENHANCEMENTS **
C** HDR JOB# = 07755-016-036                                        **
C***********************************************************************
C** PROGRAM IS ESSENTIALLY A POST-PROCESSOR FOR THE GSA BASIN MODEL **
C** DEVELOPED FOR THE COMPUTATION OF GUADALUPE ESTUARY FISHERIES    **
C** HARVEST AND SALINITY ESTIMATES AS FUNCTIONS OF ESTUARINE INFLOW.**
C** FUNCTIONAL RELATIONSHIPS WERE DEVELOPED BY THE TEXAS WATER      **
C** DEVELOPMENT BOARD IN CONSULTATION WITH THE TEXAS PARKS &         **
C** WILDLIFE DEPARTMENT.                                             **
C***********************************************************************
C** GUADALUPE - SAN ANTONIO RIVER BASIN MODEL FORTRAN CODE           **
C** (INCLUDING THIS PROGRAM, ESTUARY1.FOR) SHALL NOT BE MODIFIED IN **
C** ANY WAY WITHOUT PRIOR WRITTEN NOTIFICATION OF HDR ENGINEERING.  **
C***********************************************************************
C** HDR ENGINEERING, INC.          CONTACT:                          **
C** 2211 SOUTH IH35, SUITE 300     SAMUEL K. VAUGH, P.E.             **
C** AUSTIN, TEXAS  78741           KELLY J. KAATZ, P.E.              **
C** PH# 512-912-5100               KENNETH L. CHOFFEL, P.E.          **
C***********************************************************************
C     PROGRAM:  ESTUARY1.FOR
C***********************************************************************
C
      COMMON /A/ I,J,NYRS,IYR1,MAX,SCNR1,SCNR2,SCNR3,MO(12),X(56)
      COMMON /B/ QUNGD(56,12),QM38(56,12),QEST(56,12),AQEST(56)
     1 ,QAVG(12),Q10(12),Q25(12),Q50(12),Q75(12),Q90(12),QCNUTR,QCSDMT
      COMMON /C/ S(3,56,12),SUB(3,12),SLB(3,12),ISUBV(3,12),ISLBV(3,12)
     1 ,SAVG(3,12),S10(3,12),S25(3,12),S50(3,12),S75(3,12),S90(3,12)
     2 ,USABSBL,USABSBU,LSABSBL,LSABSBU,ESBSBL,ESBSBU
      COMMON /D/ HWS(56),HBS(56),HBC(56),HEO(56),HBD(56),HRD(56)
     1 ,HST(56),HTOTAL(56),BCHBL,BCHBU,EOHBL,EOHBU,RDHBL,RDHBU
     2 ,BDHBL,BDHBU,STHBL,STHBU,BSHBL,BSHBU,WSHBL,WSHBU
      COMMON /E/ QBL(7,6),QBU(7,6),IQBL(7),IQBU(7),IQB(8),NN(8),SIGN
      REAL LSABSBL,LSABSBU
      CHARACTER SCNR1*70,SCNR2*70,SCNR3*70,SIGN(8)
C
      OPEN (1,FILE='QUNGAGED')
      OPEN (2,FILE='OTEMP')
      OPEN (5,FILE='GEDATA')
      OPEN (6,FILE='OQSM')
      OPEN (7,FILE='OSUM')
      OPEN (8,FILE='OQHA')
C
      CALL READIN
      CALL QSALT
      CALL HARVEST
C
      END
C
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C*****************************************************************************
      SUBROUTINE READIN
C*****************************************************************************
C
      COMMON /A/ I,J,NYRS,IYR1,MAX,SCNR1,SCNR2,SCNR3,MO(12),X(56)
      COMMON /B/ QUNGD(56,12),QM38(56,12),QEST(56,12),AQEST(56)
     1 ,QAVG(12),Q10(12),Q25(12),Q50(12),Q75(12),Q90(12),QCNUTR,QCSDMT
      COMMON /C/ S(3,56,12),SUB(3,12),SLB(3,12),ISUBV(3,12),ISLBV(3,12)
     1 ,SAVG(3,12),S10(3,12),S25(3,12),S50(3,12),S75(3,12),S90(3,12)
     2 ,USABSBL,USABSBU,LSABSBL,LSABSBU,ESBSBL,ESBSBU
      COMMON /D/ HWS(56),HBS(56),HBC(56),HEO(56),HBD(56),HRD(56)
     1 ,HST(56),HTOTAL(56),BCHBL,BCHBU,EOHBL,EOHBU,RDHBL,RDHBU
     2 ,BDHBL,BDHBU,STHBL,STHBU,BSHBL,BSHBU,WSHBL,WSHBU
      COMMON /E/ QBL(7,6),QBU(7,6),IQBL(7),IQBU(7),IQB(8),NN(8),SIGN
      REAL LSABSBL,LSABSBU
      CHARACTER SCNR1*70,SCNR2*70,SCNR3*70,SIGN(8)
C
C*****READ 3-LINE SCENARIO DESCRIPTION & CONTROL OPTIONS
C
      READ (5,5) SCNR1,SCNR2,SCNR3,NYRS,IYR1
    5 FORMAT(A70,/,A70,/,A70,/,2I5)
C
      READ (5,8) (MO(J),J=1,12)
    8 FORMAT(12A5)
C
C*****READ UPPER & LOWER MONTHLY SALINITY VIABILITY LIMITS IN PPT
C*****  FOR UPPER SA BAY (SEADRIFT), LOWER SA BAY, & ESPIRITU SANTO BAY
C
      DO 12 K=1,3
      READ (5,10) (SUB(K,J),J=1,12)
      READ (5,10) (SLB(K,J),J=1,12)
   10 FORMAT(12F5.0)
   12 CONTINUE
C
C*****READ UPPER & LOWER BOUNDS IN PPT FOR VALIDITY OF SALINITY EQUATIONS
C*****  FOR UPPER SA BAY (SEADRIFT), LOWER SA BAY, & ESPIRITU SANTO BAY
C
      READ (5,15) USABSBL,USABSBU,LSABSBL,LSABSBU,ESBSBL,ESBSBU
   15 FORMAT(2(2F10.2,/),2F10.2)
C
C*****READ UPPER & LOWER BOUNDS IN KLBS FOR VALIDITY OF ANNUAL HARVEST
C*****  EQUATIONS FOR BLUE CRAB, EASTERN OYSTER, RED DRUM, BLACK DRUM,
C*****  SEATROUT, BROWN SHRIMP, AND WHITE SHRIMP
C
      READ (5,20) BCHBL,BCHBU,EOHBL,EOHBU,RDHBL,RDHBU,BDHBL,BDHBU
     1  ,STHBL,STHBU,BSHBL,BSHBU,WSHBL,WSHBU
   20 FORMAT(6(2F10.1,/),2F10.1)
C
C*****READ ANNUAL NUTRIENT & SEDIMENT CONSTRAINTS (BASED ON INFLOW IN
ACFT/YR)
C
      READ (5,25) QCNUTR,QCSDMT
   25 FORMAT(2F10.0)
C
C*****READ HISTORICAL SEASONAL INFLOW BOUNDS BY SPECIES
C
      DO 35 K=1,7
      READ (5,30) (QBL(K,L),L=1,6),(QBU(K,L),L=1,6)
   30 FORMAT(1X,/,6F10.3,/,6F10.3)
   35 CONTINUE
C
C*****ZERO HISTORICAL SEASONAL INFLOW BOUND VIOLATION COUNTERS
C*****  AND UNDEFINED ANNUAL HARVEST COUNTERS
C
      READ (5,40) (IQBL(K),K=1,7)
      READ (5,40) (IQBU(K),K=1,7)
      READ (5,40) (IQB(K),K=1,8)
   40 FORMAT(8I1)
C
C*****READ TWDB ESTIMATED UNGAGED RUNOFF BELOW TIVOLI
C
```

```
      READ (1,50) ((QUNGD(I,J),J=1,12),I=1,NYRS)
   50 FORMAT(4X,12F9.0)
C
C*****READ MODIFIED STREAMFLOW @ TIVOLI
C
      DO 100 I=1,NYRS
      DO 99 J=1,12
      READ (2,60) QM38(I,J)
   60 FORMAT(1X,37(/),25X,F10.0)
   99 CONTINUE
  100 CONTINUE
C
      RETURN
      END
C
```

```
C***************************************************************************
      SUBROUTINE QSALT
C***************************************************************************
C
      COMMON /A/ I,J,NYRS,IYR1,MAX,SCNR1,SCNR2,SCNR3,MO(12),X(56)
      COMMON /B/ QUNGD(56,12),QM38(56,12),QEST(56,12),AQEST(56)
     1 ,QAVG(12),Q10(12),Q25(12),Q50(12),Q75(12),Q90(12),QCNUTR,QCSDMT
      COMMON /C/ S(3,56,12),SUB(3,12),SLB(3,12),ISUBV(3,12),ISLBV(3,12)
     1 ,SAVG(3,12),S10(3,12),S25(3,12),S50(3,12),S75(3,12),S90(3,12)
     2 ,USABSBL,USABSBU,LSABSBL,LSABSBU,ESBSBL,ESBSBU
      COMMON /D/ HWS(56),HBS(56),HBC(56),HEO(56),HBD(56),HRD(56)
     1 ,HST(56),HTOTAL(56),BCHBL,BCHBU,EOHBL,EOHBU,RDHBL,RDHBU
     2 ,BDHBL,BDHBU,STHBL,STHBU,BSHBL,BSHBU,WSHBL,WSHBU
      COMMON /E/ QBL(7,6),QBU(7,6),IQBL(7),IQBU(7),IQB(8),NN(8),SIGN
      REAL LSABSBL,LSABSBU
      CHARACTER SCNR1*70,SCNR2*70,SCNR3*70,SIGN(8)
C
C*****WRITE MONTHLY SALINITY SERIES HEADER
C
      WRITE (6,5) SCNR1,SCNR2,SCNR3
    5 FORMAT(A70,/,A70,/,A70,/)
      WRITE (6,7)
    7 FORMAT(20X,30H  USAB EOM  LSAB EOM   ESB EOM,/,10X
     1,40H    INFLOW  SALINITY  SALINITY  SALINITY,/,10H YEAR    MO,
     2 40H    (ACFT)     (PPT)     (PPT)     (PPT),/,10H ****    **,
     3 40H    ******  ********  ********  ********)
C
      NCNUTR=0
      NCSDMT=0
C
      DO 100 I=1,NYRS
C
      AQEST(I)=0.
      IYR=IYR1+I-1
C
      DO 99 J=1,12
C
C*****COMBINE MODIFIED FLOW @ USGS#1888 (CP38) WITH TWDB UNGAGED
C*****  RUNOFF BELOW TIVOLI FOR MONTHLY ESTUARINE INFLOW
C*****TRACK CALENDAR YEAR ESTUARINE INFLOW
C
      QEST(I,J)=QUNGD(I,J)+QM38(I,J)
      IF (QEST(I,J).EQ.0.) QEST(I,J)=0.00001
      AQEST(I)=AQEST(I)+QEST(I,J)
C
C*****CALCULATE SALINITY ESTIMATES AND CHECK BOUNDS
C
C*****UPPER SAN ANTONIO BAY (SEADRIFT)
      K=1
      S(K,I,J)=47.14764-7.82469*ALOG(QEST(I,J)/1000)
      IF (S(K,I,J).GT.USABSBU) S(K,I,J)=USABSBU
      IF (S(K,I,J).LT.USABSBL) S(K,I,J)=USABSBL
C*****LOWER SAN ANTONIO BAY
      K=2
      S(K,I,J)=53.83083-7.28188*ALOG(QEST(I,J)/1000)
      IF (S(K,I,J).GT.LSABSBU) S(K,I,J)=LSABSBU
      IF (S(K,I,J).LT.LSABSBL) S(K,I,J)=LSABSBL
C*****ESPIRITU SANTO BAY
      K=3
      S(K,I,J)=42.28531-3.45241*ALOG(QEST(I,J)/1000)
      IF (S(K,I,J).GT.ESBSBU) S(K,I,J)=ESBSBU
      IF (S(K,I,J).LT.ESBSBL) S(K,I,J)=ESBSBL
C
C*****WRITE OUT MONTHLY FLOW AND SALINITY ESTIMATES
C
      WRITE (6,10) IYR,J,QEST(I,J),(S(K,I,J),K=1,3)
   10 FORMAT(2I5,F10.0,3F10.2)
C
   99 CONTINUE
C
C*****CHECK FOR ANNUAL NUTRIENT & SEDIMENT CONSTRAINT VIOLATIONS
```

```
C
      IF (AQEST(I).LT.QCNUTR) NCNUTR=NCNUTR+1
      IF (AQEST(I).LT.QCSDMT) NCSDMT=NCSDMT+1
C
  100 CONTINUE
C
C
C*****COMPUTE MONTHLY FRESHWATER INFLOW STATISTICS
C
C*****WRITE STATISTICAL SUMMARY HEADER
      WRITE (7,5) SCNR1,SCNR2,SCNR3
      WRITE (7,110)
  110 FORMAT(45HFRESHWATER INFLOWS (ACFT) - GUADALUPE ESTUARY,/,
     1       45H*********************************************,//,
     259HMONTH  AVERAGE     10%<     25%<     50%<     75%<     90%<,/,
     3 59H*****  *******     ****     ****     ****     ****     ****)
C
      DO 200 J=1,12
C
      EX=0.
C
      DO 199 I=1,NYRS
      N=I
      X(N)=QEST(I,J)
      EX=EX+X(N)
  199 CONTINUE
C
C*****COMPUTE MONTHLY AVERAGE INFLOW
      QAVG(J)=EX/NYRS
C*****RANK AND EXTRACT MONTHLY DECILES, QUARTILES, & MEDIAN
      MAX=NYRS
      CALL BUBBLE
      Q10(J)=X(MAX/10)
      Q25(J)=X(MAX/4)
      Q50(J)=X(MAX/2)
      Q75(J)=X(3*MAX/4)
      Q90(J)=X(9*MAX/10)
C*****WRITE MONTHLY INFLOW STATISTICS
      WRITE (7,120) MO(J),QAVG(J),Q10(J),Q25(J),Q50(J),Q75(J),Q90(J)
  120 FORMAT(A5,6F9.0)
C
  200 CONTINUE
C
C*****COMPUTE MONTHLY SALINITY STATISTICS FOR THREE LOCATIONS
C
      DO 300 K=1,3
C
C*****WRITE SUMMARY HEADERS
      WRITE (7,209)
  209 FORMAT(1X,/)
      IF (K.EQ.1) WRITE (7,210)
      IF (K.EQ.2) WRITE (7,211)
      IF (K.EQ.3) WRITE (7,212)
  210 FORMAT(36HUPPER SAN ANTONIO BAY SALINITY (PPT),/,
     1       36H************************************,/)
  211 FORMAT(36HLOWER SAN ANTONIO BAY SALINITY (PPT),/,
     1       36H************************************,/)
  212 FORMAT(33HESPIRITU SANTO BAY SALINITY (PPT),/,
     1       33H*********************************,/)
      WRITE (7,213)
  213 FORMAT(14HMONTH  AVERAGE,
     1 45H     10%<     25%<     50%<     75%<     90%<,
     2 18H   #V SUB   #V SLB,/,
     3 59H*****  *******     ****     ****     ****     ****     ****,
     4 18H   ******   ******)
C
      DO 299 J=1,12
C
      ISUBV(K,J)=0
      ISLBV(K,J)=0
      EX=0.
```

```
C
      DO 298 I=1,NYRS
C*****TRACK VIOLATIONS OF MONTHLY SALINITY VIABILITY LIMITS
      IF (S(K,I,J).GT.SUB(K,J)) ISUBV(K,J)=ISUBV(K,J)+1
      IF (S(K,I,J).LT.SLB(K,J)) ISLBV(K,J)=ISLBV(K,J)+1
      N=I
      X(N)=S(K,I,J)
      EX=EX+X(N)
  298 CONTINUE
C*****COMPUTE MONTHLY AVERAGE SALINITY
      SAVG(K,J)=EX/NYRS
C*****RANK AND EXTRACT MONTHLY DECILES, QUARTILES, & MEDIAN
      MAX=NYRS
      CALL BUBBLE
      S10(K,J)=X(MAX/10)
      S25(K,J)=X(MAX/4)
      S50(K,J)=X(MAX/2)
      S75(K,J)=X(3*MAX/4)
      S90(K,J)=X(9*MAX/10)
C
      WRITE (7,220) MO(J),SAVG(K,J),S10(K,J),S25(K,J),S50(K,J)
     1,S75(K,J),S90(K,J),ISUBV(K,J),ISLBV(K,J)
  220 FORMAT(A5,6F9.2,2I9)
C
  299 CONTINUE
C
  300 CONTINUE
C
C*****WRITE OUT NUTRIENT & SEDIMENT CONSTRAINT VIOLATIONS
C
      WRITE (7,330) QCNUTR,NCNUTR,QCSDMT,NCSDMT
  330 FORMAT(1X,//,40HANNUAL NUTRIENT AND SEDIMENT CONSTRAINTS,/,
     1              40H****************************************,//,
     2 60HSIMULATED FRESHWATER INFLOWS LESS THAN NUTRIENT CONSTRAINT (,
     3 F10.0,12H ACFT/YR) IN,I4,6H YEARS,/,
     4 60HSIMULATED FRESHWATER INFLOWS LESS THAN SEDIMENT CONSTRAINT (,
     5 F10.0,12H ACFT/YR) IN,I4,6H YEARS)
C
      RETURN
      END
C
```

```
C***********************************************************************
      SUBROUTINE HARVEST
C***********************************************************************
C
      COMMON /A/ I,J,NYRS,IYR1,MAX,SCNR1,SCNR2,SCNR3,MO(12),X(56)
      COMMON /B/ QUNGD(56,12),QM38(56,12),QEST(56,12),AQEST(56)
     1 ,QAVG(12),Q10(12),Q25(12),Q50(12),Q75(12),Q90(12),QCNUTR,QCSDMT
      COMMON /C/ S(3,56,12),SUB(3,12),SLB(3,12),ISUBV(3,12),ISLBV(3,12)
     1 ,SAVG(3,12),S10(3,12),S25(3,12),S50(3,12),S75(3,12),S90(3,12)
     2 ,USABSBL,USABSBU,LSABSBL,LSABSBU,ESBSBL,ESBSBU
      COMMON /D/ HWS(56),HBS(56),HBC(56),HEO(56),HBD(56),HRD(56)
     1 ,HST(56),HTOTAL(56),BCHBL,BCHBU,EOHBL,EOHBU,RDHBL,RDHBU
     2 ,BDHBL,BDHBU,STHBL,STHBU,BSHBL,BSHBU,WSHBL,WSHBU
      COMMON /E/ QBL(7,6),QBU(7,6),IQBL(7),IQBU(7),IQB(8),NN(8),SIGN
      REAL LSABSBL,LSABSBU
      CHARACTER SCNR1*70,SCNR2*70,SCNR3*70,SIGN(8)
C
C*****WRITE OUTPUT HEADER
C
      WRITE (8,5) SCNR1,SCNR2,SCNR3
    5 FORMAT(A70,/,A70,/,A70,/)
      WRITE (8,10)
   10 FORMAT(20X, 45HWHITE     BROWN      BLUE   EASTERN     BLACK,
     1  10H       RED,/,  15X,
     2        50H    SHRIMP    SHRIMP      CRAB    OYSTER      DRUM,
     3  30H      DRUM  SEATROUT     TOTAL,/,  5X,10H    INFLOW,
     4        50H   HARVEST   HARVEST   HARVEST   HARVEST   HARVEST,
     5  30H   HARVEST   HARVEST   HARVEST,/,15H YEAR     (ACFT),
     6        50H     (KLBS)    (KLBS)    (KLBS)    (KLBS)    (KLBS),
     7  30H    (KLBS)    (KLBS)    (KLBS),/,15H ****     ******,
     8        50H     *****     *****     *****     *****     *****,
     9  30H     *****     *****     *****)
C
      WRITE (*,198) 'SUPPRESS + AND - ON HARVEST (YES=1.,NO=0.)?'
  198 FORMAT(A50)
      READ (*,199) SUPPRESS
  199 FORMAT(F10.0)
C
      EAQEST=0.
      EHWS=0.
      EHBS=0.
      EHBC=0.
      EHEO=0.
      EHBD=0.
      EHRD=0.
      EHST=0.
      EHTOTAL=0.
C
      DO 1000 I=1,NYRS
C
      IYR=IYR1+I-1
      EAQEST=EAQEST+AQEST(I)
C
C*****ESTIMATE WHITE SHRIMP HARVEST APPLYING SEASONAL FLOW BOUNDS
C*****  AND TRACKING HISTORICAL SEASONAL FLOW BOUND EXCURSIONS
C
      K=1
      IFBL=0
      IFBU=0
      ISN=0
      SIGN(K)=' '
      IF (I.GT.1) THEN
        QJF=(QEST(I,1)+QEST(I,2))/1000
          IF (QJF.LT.QBL(K,1)) THEN
            IFBL=IFBL+1
            IQBL(K)=IQBL(K)+1
            ISN=ISN-1
            QJF=QBL(K,1)
          END IF
          IF (QJF.GT.QBU(K,1)) THEN
            IFBU=IFBU+1
```

```
               IQBU(K)=IQBU(K)+1
               ISN=ISN+1
               QJF=QBU(K,1)
             END IF
           QMJ=(QEST(I,5)+QEST(I,6))/1000
             IF (QMJ.LT.QBL(K,3)) THEN
               IFBL=IFBL+1
               IQBL(K)=IQBL(K)+1
               ISN=ISN-1
               QMJ=QBL(K,3)
             END IF
             IF (QMJ.GT.QBU(K,3)) THEN
               IFBU=IFBU+1
               IQBU(K)=IQBU(K)+1
               ISN=ISN+1
               QMJ=QBU(K,3)
             END IF
           QJA=(QEST(I,7)+QEST(I,8))/1000
             IF (QJA.LT.QBL(K,4)) THEN
               IFBL=IFBL+1
               IQBL(K)=IQBL(K)+1
               ISN=ISN+1
               QJA=QBL(K,4)
             END IF
             IF (QJA.GT.QBU(K,4)) THEN
               IFBU=IFBU+1
               IQBU(K)=IQBU(K)+1
               ISN=ISN-1
               QJA=QBU(K,4)
             END IF
           QND=(QEST(I-1,11)+QEST(I-1,12))/1000
             IF (QND.LT.QBL(K,6)) THEN
               IFBL=IFBL+1
               IQBL(K)=IQBL(K)+1
               ISN=ISN+1
               QND=QBL(K,6)
             END IF
             IF (QND.GT.QBU(K,6)) THEN
               IFBU=IFBU+1
               IQBU(K)=IQBU(K)+1
               ISN=ISN-1
               QND=QBU(K,6)
             END IF
           HWS(I)=545.59+160.9*ALOG(QJF)+279.1*ALOG(QMJ)-155.1*ALOG(QJA)
     1              -277.9*ALOG(QND)
           IF (HWS(I).LT.WSHBL) HWS(I)=WSHBL
           IF (HWS(I).GT.WSHBU) HWS(I)=WSHBU
           IF (IFBL.GT.0.AND.ISN.EQ.0.OR.IFBU.GT.0.AND.ISN.EQ.0.
     1      OR.IFBL.GT.2.OR.IFBU.GT.2) THEN
             HWS(I)=-9999.
             IQB(K)=IQB(K)+1
           ELSE
             EHWS=EHWS+HWS(I)
             IF (ISN) 15,16,17
   15          SIGN(K)='-'
   16          GO TO 18
   17          SIGN(K)='+'
   18        CONTINUE
           END IF
           IF (HWS(I).EQ.WSHBL.OR.HWS(I).EQ.WSHBU) SIGN(K)=' '
         ELSE
           HWS(I)=-9999.
         END IF
C
C*****ESTIMATE BROWN SHRIMP HARVEST
C*****  AND TRACK HISTORICAL SEASONAL FLOW BOUND EXCURSIONS
C
      K=2
      IFBL=0
      IFBU=0
      ISN=0
```

```
      SIGN(K)=' '
      IF (I.GT.1) THEN
        QJA=(QEST(I,7)+QEST(I,8))/1000
          IF (QJA.LT.QBL(K,4)) THEN
            IFBL=IFBL+1
            IQBL(K)=IQBL(K)+1
            ISN=ISN-1
            QJA=QBL(K,4)
          END IF
          IF (QJA.GT.QBU(K,4)) THEN
            IFBU=IFBU+1
            IQBU(K)=IQBU(K)+1
            ISN=ISN+1
            QJA=QBU(K,4)
          END IF
        QSO=(QEST(I-1,9)+QEST(I-1,10))/1000
          IF (QSO.LT.QBL(K,5)) THEN
            IFBL=IFBL+1
            IQBL(K)=IQBL(K)+1
            ISN=ISN+1
            QSO=QBL(K,5)
          END IF
          IF (QSO.GT.QBU(K,5)) THEN
            IFBU=IFBU+1
            IQBU(K)=IQBU(K)+1
            ISN=ISN-1
            QSO=QBU(K,5)
          END IF
        HBS(I)=EXP(6.5679+0.6707*ALOG(QJA)-0.7486*ALOG(QSO))
        IF (HBS(I).LT.BSHBL) HBS(I)=BSHBL
        IF (HBS(I).GT.BSHBU) HBS(I)=BSHBU
        IF (IFBL.GT.0.AND.ISN.EQ.0.OR.IFBU.GT.0.AND.ISN.EQ.0.
     1   OR.IFBL.GT.1.OR.IFBU.GT.1) THEN
          HBS(I)=-9999.
          IQB(K)=IQB(K)+1
        ELSE
          EHBS=EHBS+HBS(I)
          IF (ISN) 20,21,22
   20       SIGN(K)='-'
   21       GO TO 23
   22       SIGN(K)='+'
   23     CONTINUE
        END IF
        IF (HBS(I).EQ.BSHBL.OR.HBS(I).EQ.BSHBU) SIGN(K)=' '
      ELSE
        HBS(I)=-9999.
      END IF
C
C*****ESTIMATE BLUE CRAB HARVEST
C******  AND TRACK HISTORICAL SEASONAL FLOW BOUND EXCURSIONS
C
      K=3
      IFBL=0
      IFBU=0
      ISN=0
      SIGN(K)=' '
      IF (I.GT.1) THEN
        QJF=(QEST(I-1,1)+QEST(I,1)+QEST(I-1,2)+QEST(I,2))/2/1000
          IF (QJF.LT.QBL(K,1)) THEN
            IFBL=IFBL+1
            IQBL(K)=IQBL(K)+1
            ISN=ISN+1
            QJF=QBL(K,1)
          END IF
          IF (QJF.GT.QBU(K,1)) THEN
            IFBU=IFBU+1
            IQBU(K)=IQBU(K)+1
            ISN=ISN-1
            QJF=QBU(K,1)
          END IF
        QJA=(QEST(I-1,7)+QEST(I,7)+QEST(I-1,8)+QEST(I,8))/2/1000
```

```
          IF (QJA.LT.QBL(K,4)) THEN
            IFBL=IFBL+1
            IQBL(K)=IQBL(K)+1
            ISN=ISN-1
            QJA=QBL(K,4)
          END IF
          IF (QJA.GT.QBU(K,4)) THEN
            IFBU=IFBU+1
            IQBU(K)=IQBU(K)+1
            ISN=ISN+1
            QJA=QBU(K,4)
          END IF
        QSO=(QEST(I-1,9)+QEST(I,9)+QEST(I-1,10)+QEST(I,10))/2/1000
          IF (QSO.LT.QBL(K,5)) THEN
            IFBL=IFBL+1
            IQBL(K)=IQBL(K)+1
            ISN=ISN+1
            QSO=QBL(K,5)
          END IF
          IF (QSO.GT.QBU(K,5)) THEN
            IFBU=IFBU+1
            IQBU(K)=IQBU(K)+1
            ISN=ISN-1
            QSO=QBU(K,5)
          END IF
        HBC(I)=110.64-145.3*ALOG(QJF)+332.5*ALOG(QJA)-141.4*ALOG(QSO)
        IF (HBC(I).LT.BCHBL) HBC(I)=BCHBL
        IF (HBC(I).GT.BCHBU) HBC(I)=BCHBU
        IF (IFBL.GT.0.AND.ISN.EQ.0.OR.IFBU.GT.0.AND.ISN.EQ.0.
     1   OR.IFBL.GT.2.OR.IFBU.GT.2) THEN
          HBC(I)=-9999.
          IQB(K)=IQB(K)+1
        ELSE
          EHBC=EHBC+HBC(I)
          IF (ISN) 25,26,27
   25       SIGN(K)='-'
   26       GO TO 28
   27       SIGN(K)='+'
   28     CONTINUE
        END IF
        IF (HBC(I).EQ.BCHBL.OR.HBC(I).EQ.BCHBU) SIGN(K)=' '
      ELSE
        HBC(I)=-9999.
      END IF
C
C*****ESTIMATE EASTERN OYSTER HARVEST
C*****  AND TRACK HISTORICAL SEASONAL FLOW BOUND EXCURSIONS
C
      K=4
      IFBL=0
      IFBU=0
      ISN=0
      SIGN(K)=' '
      IF (I.GT.2) THEN
        QMA=(QEST(I-1,3)+QEST(I,3)+QEST(I-1,4)+QEST(I,4))/2/1000
          IF (QMA.LT.QBL(K,2)) THEN
            IFBL=IFBL+1
            IQBL(K)=IQBL(K)+1
            ISN=ISN-1
            QMA=QBL(K,2)
          END IF
          IF (QMA.GT.QBU(K,2)) THEN
            IFBU=IFBU+1
            IQBU(K)=IQBU(K)+1
            ISN=ISN+1
            QMA=QBU(K,2)
          END IF
        QMJ=(QEST(I-1,5)+QEST(I,5)+QEST(I-1,6)+QEST(I,6))/2/1000
          IF (QMJ.LT.QBL(K,3)) THEN
            IFBL=IFBL+1
            IQBL(K)=IQBL(K)+1
```

```
              ISN=ISN+1
              QMJ=QBL(K,3)
            END IF
            IF (QMJ.GT.QBU(K,3)) THEN
              IFBU=IFBU+1
              IQBU(K)=IQBU(K)+1
              ISN=ISN-1
              QMJ=QBU(K,3)
            END IF
          QJA=(QEST(I-1,7)+QEST(I,7)+QEST(I-1,8)+QEST(I,8))/2/1000
            IF (QJA.LT.QBL(K,4)) THEN
              IFBL=IFBL+1
              IQBL(K)=IQBL(K)+1
              ISN=ISN-1
              QJA=QBL(K,4)
            END IF
            IF (QJA.GT.QBU(K,4)) THEN
              IFBU=IFBU+1
              IQBU(K)=IQBU(K)+1
              ISN=ISN+1
              QJA=QBU(K,4)
            END IF
          QSO=(QEST(I-2,9)+QEST(I-1,9)+QEST(I-2,10)+QEST(I-1,10))/2/1000
            IF (QSO.LT.QBL(K,5)) THEN
              IFBL=IFBL+1
              IQBL(K)=IQBL(K)+1
              ISN=ISN+1
              QSO=QBL(K,5)
            END IF
            IF (QSO.GT.QBU(K,5)) THEN
              IFBU=IFBU+1
              IQBU(K)=IQBU(K)+1
              ISN=ISN-1
              QSO=QBU(K,5)
            END IF
          HEO(I)=3000.7+180.4*ALOG(QMA)-963.3*ALOG(QMJ)+710.0*ALOG(QJA)
     1          -231.5*ALOG(QSO)
          IF (HEO(I).LT.EOHBL) HEO(I)=EOHBL
          IF (HEO(I).GT.EOHBU) HEO(I)=EOHBU
          IF (IFBL.GT.0.AND.ISN.EQ.0.OR.IFBU.GT.0.AND.ISN.EQ.0.
     1     OR.IFBL.GT.2.OR.IFBU.GT.2) THEN
            HEO(I)=-9999.
            IQB(K)=IQB(K)+1
          ELSE
            EHEO=EHEO+HEO(I)
            IF (ISN) 30,31,32
   30         SIGN(K)='-'
   31         GO TO 33
   32         SIGN(K)='+'
   33       CONTINUE
          END IF
          IF (HEO(I).EQ.EOHBL.OR.HEO(I).EQ.EOHBU) SIGN(K)=' '
        ELSE
          HEO(I)=-9999.
        END IF
C
C*****ESTIMATE BLACK DRUM HARVEST
C*****  AND TRACK HISTORICAL SEASONAL FLOW BOUND EXCURSIONS
C
        K=5
        IFBL=0
        IFBU=0
        ISN=0
        SIGN(K)=' '
        IF (I.GT.3) THEN
          QJF=(QEST(I-3,1)+QEST(I-2,1)+QEST(I-1,1)
     1          +QEST(I-3,2)+QEST(I-2,2)+QEST(I-1,2))/3/1000
            IF (QJF.LT.QBL(K,1)) THEN
              IFBL=IFBL+1
              IQBL(K)=IQBL(K)+1
              ISN=ISN-1
```

```
            QJF=QBL(K,1)
          END IF
          IF (QJF.GT.QBU(K,1)) THEN
            IFBU=IFBU+1
            IQBU(K)=IQBU(K)+1
            ISN=ISN+1
            QJF=QBU(K,1)
          END IF
        QMA=(QEST(I-3,3)+QEST(I-2,3)+QEST(I-1,3)
     1        +QEST(I-3,4)+QEST(I-2,4)+QEST(I-1,4))/3/1000
          IF (QMA.LT.QBL(K,2)) THEN
            IFBL=IFBL+1
            IQBL(K)=IQBL(K)+1
            ISN=ISN+1
            QMA=QBL(K,2)
          END IF
          IF (QMA.GT.QBU(K,2)) THEN
            IFBU=IFBU+1
            IQBU(K)=IQBU(K)+1
            ISN=ISN-1
            QMA=QBU(K,2)
          END IF
        QND=(QEST(I-3,11)+QEST(I-2,11)+QEST(I-1,11)
     1        +QEST(I-3,12)+QEST(I-2,12)+QEST(I-1,12))/3/1000
          IF (QND.LT.QBL(K,6)) THEN
            IFBL=IFBL+1
            IQBL(K)=IQBL(K)+1
            ISN=ISN-1
            QND=QBL(K,6)
          END IF
          IF (QND.GT.QBU(K,6)) THEN
            IFBU=IFBU+1
            IQBU(K)=IQBU(K)+1
            ISN=ISN+1
            QND=QBU(K,6)
          END IF
        HBD(I)=-18.087+0.2411*QJF-0.1734*QMA+0.0850*QND
        IF (HBD(I).LT.BDHBL) HBD(I)=BDHBL
        IF (HBD(I).GT.BDHBU) HBD(I)=BDHBU
        IF (IFBL.GT.0.AND.ISN.EQ.0.OR.IFBU.GT.0.AND.ISN.EQ.0.
     1   OR.IFBL.GT.2.OR.IFBU.GT.2) THEN
          HBD(I)=-9999.
          IQB(K)=IQB(K)+1
        ELSE
          EHBD=EHBD+HBD(I)
          IF (ISN) 35,36,37
   35       SIGN(K)='-'
   36       GO TO 38
   37       SIGN(K)='+'
   38     CONTINUE
        END IF
        IF (HBD(I).EQ.BDHBL.OR.HBD(I).EQ.BDHBU) SIGN(K)=' '
      ELSE
        HBD(I)=-9999.
      END IF
C
C*****ESTIMATE RED DRUM HARVEST
C*****  AND TRACK HISTORICAL SEASONAL FLOW BOUND EXCURSIONS
C
      K=6
      IFBL=0
      IFBU=0
      ISN=0
      SIGN(K)=' '
      IF (I.GT.4) THEN
        QMJ=(QEST(I-3,5)+QEST(I-2,5)+QEST(I-1,5)
     1        +QEST(I-3,6)+QEST(I-2,6)+QEST(I-1,6))/3/1000
          IF (QMJ.LT.QBL(K,3)) THEN
            IFBL=IFBL+1
            IQBL(K)=IQBL(K)+1
            ISN=ISN-1
```

```
            QMJ=QBL(K,3)
          END IF
          IF (QMJ.GT.QBU(K,3)) THEN
            IFBU=IFBU+1
            IQBU(K)=IQBU(K)+1
            ISN=ISN+1
            QMJ=QBU(K,3)
          END IF
        QJA=(QEST(I-3,7)+QEST(I-2,7)+QEST(I-1,7)
     1        +QEST(I-3,8)+QEST(I-2,8)+QEST(I-1,8))/3/1000
          IF (QJA.LT.QBL(K,4)) THEN
            IFBL=IFBL+1
            IQBL(K)=IQBL(K)+1
            ISN=ISN-1
            QJA=QBL(K,4)
          END IF
          IF (QJA.GT.QBU(K,4)) THEN
            IFBU=IFBU+1
            IQBU(K)=IQBU(K)+1
            ISN=ISN+1
            QJA=QBU(K,4)
          END IF
        QND=(QEST(I-4,11)+QEST(I-3,11)+QEST(I-2,11)
     1        +QEST(I-4,12)+QEST(I-3,12)+QEST(I-2,12))/3/1000
          IF (QND.LT.QBL(K,6)) THEN
            IFBL=IFBL+1
            IQBL(K)=IQBL(K)+1
            ISN=ISN+1
            QND=QBL(K,6)
          END IF
          IF (QND.GT.QBU(K,6)) THEN
            IFBU=IFBU+1
            IQBU(K)=IQBU(K)+1
            ISN=ISN-1
            QND=QBU(K,6)
          END IF
        HRD(I)=32.786+0.0797*QMJ+0.2750*QJA-0.2010*QND
        IF (HRD(I).LT.RDHBL) HRD(I)=RDHBL
        IF (HRD(I).GT.RDHBU) HRD(I)=RDHBU
        IF (IFBL.GT.0.AND.ISN.EQ.0.OR.IFBU.GT.0.AND.ISN.EQ.0.
     1   OR.IFBL.GT.2.OR.IFBU.GT.2) THEN
          HRD(I)=-9999.
          IQB(K)=IQB(K)+1
        ELSE
          EHRD=EHRD+HRD(I)
          IF (ISN) 40,41,42
   40       SIGN(K)='-'
   41       GO TO 43
   42       SIGN(K)='+'
   43     CONTINUE
        END IF
        IF (HRD(I).EQ.RDHBL.OR.HRD(I).EQ.RDHBU) SIGN(K)=' '
      ELSE
        HRD(I)=-9999.
      END IF
C
C*****ESTIMATE SEATROUT HARVEST
C*****  AND TRACK HISTORICAL SEASONAL FLOW BOUND EXCURSIONS
C
      K=7
      IFBL=0
      IFBU=0
      ISN=0
      SIGN(K)=' '
      IF (I.GT.4) THEN
        QMA=(QEST(I-3,3)+QEST(I-2,3)+QEST(I-1,3)
     1        +QEST(I-3,4)+QEST(I-2,4)+QEST(I-1,4))/3/1000
          IF (QMA.LT.QBL(K,2)) THEN
            IFBL=IFBL+1
            IQBL(K)=IQBL(K)+1
            ISN=ISN+1
```

```
            QMA=QBL(K,2)
          END IF
          IF (QMA.GT.QBU(K,2)) THEN
            IFBU=IFBU+1
            IQBU(K)=IQBU(K)+1
            ISN=ISN-1
            QMA=QBU(K,2)
          END IF
        QMJ=(QEST(I-3,5)+QEST(I-2,5)+QEST(I-1,5)
     1       +QEST(I-3,6)+QEST(I-2,6)+QEST(I-1,6))/3/1000
          IF (QMJ.LT.QBL(K,3)) THEN
            IFBL=IFBL+1
            IQBL(K)=IQBL(K)+1
            ISN=ISN-1
            QMJ=QBL(K,3)
          END IF
          IF (QMJ.GT.QBU(K,3)) THEN
            IFBU=IFBU+1
            IQBU(K)=IQBU(K)+1
            ISN=ISN+1
            QMJ=QBU(K,3)
          END IF
        QND=(QEST(I-4,11)+QEST(I-3,11)+QEST(I-2,11)
     1       +QEST(I-4,12)+QEST(I-3,12)+QEST(I-2,12))/3/1000
          IF (QND.LT.QBL(K,6)) THEN
            IFBL=IFBL+1
            IQBL(K)=IQBL(K)+1
            ISN=ISN+1
            QND=QBL(K,6)
          END IF
          IF (QND.GT.QBU(K,6)) THEN
            IFBU=IFBU+1
            IQBU(K)=IQBU(K)+1
            ISN=ISN-1
            QND=QBU(K,6)
          END IF
        HST(I)=EXP(2.6915-0.7185*ALOG(QMA)+1.860*ALOG(QMJ)
     1       -1.086*ALOG(QND))
        IF (HST(I).LT.STHBL) HST(I)=STHBL
        IF (HST(I).GT.STHBU) HST(I)=STHBU
        IF (IFBL.GT.0.AND.ISN.EQ.0.OR.IFBU.GT.0.AND.ISN.EQ.0.
     1   OR.IFBL.GT.2.OR.IFBU.GT.2) THEN
          HST(I)=-9999.
          IQB(K)=IQB(K)+1
        ELSE
          EHST=EHST+HST(I)
          IF (ISN) 45,46,47
   45       SIGN(K)='-'
   46       GO TO 48
   47       SIGN(K)='+'
   48     CONTINUE
        END IF
        IF (HST(I).EQ.STHBL.OR.HST(I).EQ.STHBU) SIGN(K)=' '
      ELSE
        HST(I)=-9999.
      END IF
C
C*****CALCULATE TOTAL ANNUAL HARVEST (ALL SPECIES)
C
      IF (HWS(I).LT.0..OR.HBS(I).LT.0..OR.HBC(I).LT.0..OR.HEO(I).LT.0.
     1.OR.HBD(I).LT.0..OR.HRD(I).LT.0..OR.HST(I).LT.0.) THEN
        HTOTAL(I)=-9999.
        IQB(8)=IQB(8)+1
      ELSE
        HTOTAL(I)=HWS(I)+HBS(I)+HBC(I)+HEO(I)+HBD(I)+HRD(I)+HST(I)
        EHTOTAL=EHTOTAL+HTOTAL(I)
      END IF
C
C*****WRITE ANNUAL HARVEST SUMMARY
C
      IF (SUPPRESS.LT.0.5) THEN
```

```
        WRITE (8,400) IYR,AQEST(I),HWS(I),SIGN(1),HBS(I),SIGN(2),HBC(I)
     1     ,SIGN(3),HEO(I),SIGN(4),HBD(I),SIGN(5)
     2     ,HRD(I),SIGN(6),HST(I),SIGN(7),HTOTAL(I)
  400   FORMAT(I5,F10.0,1X,7(F8.0,A2),F10.0)
      ELSE
        WRITE (8,401) IYR,AQEST(I),HWS(I),HBS(I),HBC(I)
     1     ,HEO(I),HBD(I),HRD(I),HST(I),HTOTAL(I)
  401   FORMAT(I5,F10.0,1X,8F10.0)
      END IF
C
 1000 CONTINUE
C
C*****CALCULATE ANNUAL AVERAGES EXCLUDING YEARS WITH UNDEFINED HARVEST
C
      AAQEST=EAQEST/NYRS
      AHWS=EHWS/(NYRS-1-IQB(1))
      AHBS=EHBS/(NYRS-1-IQB(2))
      AHBC=EHBC/(NYRS-1-IQB(3))
      AHEO=EHEO/(NYRS-2-IQB(4))
      AHBD=EHBD/(NYRS-3-IQB(5))
      AHRD=EHRD/(NYRS-4-IQB(6))
      AHST=EHST/(NYRS-4-IQB(7))
      AHTOTAL=EHTOTAL/(NYRS-IQB(8))
C
      WRITE (8,50) AAQEST,AHWS,AHBS,AHBC,AHEO,AHBD,AHRD,AHST,AHTOTAL
   50 FORMAT(15HANNUAL AVERAGES,/,5X,F10.0,F9.0,6F10.0,F12.0)
C
      WRITE (8,51) (IQBL(K),K=1,7)
   51 FORMAT(46HSIMULATED LOWER SEASONAL FLOW BOUND EXCURSIONS,/,
     1    15X,I9,6I10)
      WRITE (8,52) (IQBU(K),K=1,7)
   52 FORMAT(46HSIMULATED UPPER SEASONAL FLOW BOUND EXCURSIONS,/,
     1    15X,I9,6I10)
C
C*****COMPUTE ANNUAL HARVEST STATISTICS BY SPECIES
C
C*****WRITE OUT HEADER
      WRITE (7,55)
   55 FORMAT(//,51HANNUAL FISHERIES HARVEST (KLBS) - GUADALUPE ESTUARY,
     1  /,      51H***************************************************,
     2   //, 48HSPECIES        AVERAGE     10%<      25%<      50%<,
     3                            27H     75%<      90%<     # YRS,
     4   /,  48H*******        *******     ****      ****      ****,
     5                            27H     ****      ****     *****)
C
      DO 2000 K=1,8
C
      IF (K.EQ.1.OR.K.EQ.2.OR.K.EQ.3) I1=2
      IF (K.EQ.4) I1=3
      IF (K.EQ.5) I1=4
      IF (K.GE.6) I1=5
C
      NN(K)=1
      DO 1600 I=I1,NYRS
      IF (K.EQ.1.AND.HWS(I).GT.0.) THEN
        X(NN(K))=HWS(I)
        NN(K)=NN(K)+1
      END IF
      IF (K.EQ.2.AND.HBS(I).GT.0.) THEN
        X(NN(K))=HBS(I)
        NN(K)=NN(K)+1
      END IF
      IF (K.EQ.3.AND.HBC(I).GT.0.) THEN
        X(NN(K))=HBC(I)
        NN(K)=NN(K)+1
      END IF
      IF (K.EQ.4.AND.HEO(I).GT.0.) THEN
        X(NN(K))=HEO(I)
        NN(K)=NN(K)+1
      END IF
      IF (K.EQ.5.AND.HBD(I).GT.0.) THEN
```

```
        X(NN(K))=HBD(I)
        NN(K)=NN(K)+1
      END IF
      IF (K.EQ.6.AND.HRD(I).GT.0.) THEN
        X(NN(K))=HRD(I)
        NN(K)=NN(K)+1
      END IF
      IF (K.EQ.7.AND.HST(I).GT.0.) THEN
        X(NN(K))=HST(I)
        NN(K)=NN(K)+1
      END IF
      IF (K.EQ.8.AND.HTOTAL(I).GT.0.) THEN
        X(NN(K))=HTOTAL(I)
        NN(K)=NN(K)+1
      END IF
 1600 CONTINUE
C
      MAX=NYRS-I1+1-IQB(K)
      IF (K.EQ.8) MAX=NYRS-IQB(K)
      CALL BUBBLE
      H10=X(MAX/10)
      H25=X(MAX/4)
      H50=X(MAX/2)
      H75=X(3*MAX/4)
      H90=X(9*MAX/10)
C*****ADJUST STATISTICS FOR SMALL SAMPLE SIZE
      IF (MAX.LT.10) THEN
        H10=-9999.
        H90=-9999.
        IF (MAX.LT.4) THEN
          H25=-9999.
          H75=-9999.
          IF (MAX.LT.3) H50=-9999.
        END IF
      END IF
C
      IF(K.EQ.1)WRITE(7,60)'WHITE SHRIMP',AHWS,H10,H25,H50,H75,H90,MAX
      IF(K.EQ.2)WRITE(7,60)'BROWN SHRIMP',AHBS,H10,H25,H50,H75,H90,MAX
      IF(K.EQ.3)WRITE(7,60)'BLUE CRAB   ',AHBC,H10,H25,H50,H75,H90,MAX
      IF(K.EQ.4)WRITE(7,60)'OYSTER      ',AHEO,H10,H25,H50,H75,H90,MAX
      IF(K.EQ.5)WRITE(7,60)'BLACK DRUM  ',AHBD,H10,H25,H50,H75,H90,MAX
      IF(K.EQ.6)WRITE(7,60)'RED DRUM    ',AHRD,H10,H25,H50,H75,H90,MAX
      IF(K.EQ.7)WRITE(7,60)'SEATROUT    ',AHST,H10,H25,H50,H75,H90,MAX
   60 FORMAT(A12,6F9.0,I9)
      IF (K.EQ.8) WRITE(7,70)'TOTAL       ',AHTOTAL
     1  ,H10,H25,H50,H75,H90,MAX
   70 FORMAT(50H**************************************************,
     1  25H*************************,/,A12,6F9.0,I9)
C
 2000 CONTINUE
C
      RETURN
      END
C
```

```
C***************************************************************************
      SUBROUTINE BUBBLE
C***************************************************************************
C
      COMMON /A/ I,J,NYRS,IYR1,MAX,SCNR1,SCNR2,SCNR3,MO(12),X(56)
      COMMON /B/ QUNGD(56,12),QM38(56,12),QEST(56,12),AQEST(56)
     1 ,QAVG(12),Q10(12),Q25(12),Q50(12),Q75(12),Q90(12),QCNUTR,QCSDMT
      COMMON /C/ S(3,56,12),SUB(3,12),SLB(3,12),ISUBV(3,12),ISLBV(3,12)
     1 ,SAVG(3,12),S10(3,12),S25(3,12),S50(3,12),S75(3,12),S90(3,12)
     2 ,USABSBL,USABSBU,LSABSBL,LSABSBU,ESBSBL,ESBSBU
      COMMON /D/ HWS(56),HBS(56),HBC(56),HEO(56),HBD(56),HRD(56)
     1 ,HST(56),HTOTAL(56),BCHBL,BCHBU,EOHBL,EOHBU,RDHBL,RDHBU
     2 ,BDHBL,BDHBU,STHBL,STHBU,BSHBL,BSHBU,WSHBL,WSHBU
      COMMON /E/ QBL(7,6),QBU(7,6),IQBL(7),IQBU(7),IQB(8),NN(8),SIGN
      REAL LSABSBL,LSABSBU
      CHARACTER SCNR1*70,SCNR2*70,SCNR3*70,SIGN(8)
C
   15 N=0
      ISWITCH=0
   20 N=N+1
      IF (N.GT.MAX-1.AND.ISWITCH.EQ.0) GO TO 50
      IF (N.GT.MAX-1) GO TO 15
      IF (X(N).LE.X(N+1)) GO TO 20
      ISWITCH=ISWITCH+1
      TEMP=X(N)
      X(N)=X(N+1)
      X(N+1)=TEMP
      GO TO 20
C
   50 RETURN
C
      END
```

Appendix D

TRANS-TEXAS WATER PROGRAM, WEST CENTRAL STUDY AREA
HDR JOB# = 07755-016-036 DATE = 6/30/97
SCENARIO: GUADALUPE ESTUARY *** BASELINE ***

FRESHWATER INFLOWS (ACFT) - GUADALUPE ESTUARY
****

MONTH	AVERAGE	10%<	25%<	50%<	75%<	90%<
*****	*******	****	****	****	****	****
JAN	126412.	8477.	49759.	80353.	144421.	250210.
FEB	131214.	20305.	43072.	89270.	145242.	274887.
MAR	109820.	10712.	36995.	78071.	168688.	241693.
APR	143957.	5091.	30388.	63832.	162212.	439856.
MAY	233526.	15203.	38796.	124621.	354313.	577987.
JUN	223870.	68.	23947.	93544.	261319.	495744.
JUL	117994.	0.	605.	34826.	131442.	289392.
AUG	54506.	0.	4089.	28523.	77208.	133742.
SEP	172847.	898.	15839.	70593.	187938.	411815.
OCT	164131.	4191.	25926.	80693.	151330.	364417.
NOV	130344.	7668.	41555.	77276.	165102.	302904.
DEC	118578.	9326.	38060.	77909.	149443.	252088.

UPPER SAN ANTONIO BAY SALINITY (PPT)
****

MONTH	AVERAGE	10%<	25%<	50%<	75%<	90%<	#V SUB	#V SLB
*****	*******	****	****	****	****	****	******	******
JAN	13.61	2.20	6.94	12.49	16.40	23.05	9	10
FEB	12.71	1.82	7.63	11.88	16.88	20.03	7	11
MAR	14.08	4.10	6.58	12.66	17.79	23.65	13	8
APR	15.04	.00	7.07	14.42	20.35	28.07	16	11
MAY	11.19	.00	.74	8.90	18.17	23.35	17	14
JUN	14.85	.00	2.51	10.65	20.59	45.00	20	9
JUL	22.74	.87	8.20	19.23	45.00	45.00	35	5
AUG	23.92	6.42	13.07	20.35	35.30	45.00	37	0
SEP	17.11	.00	4.67	13.76	22.24	41.89	16	14
OCT	14.78	.18	4.07	12.42	21.35	28.28	17	14
NOV	14.35	.75	6.82	13.05	17.97	27.97	10	9
DEC	14.37	2.55	7.85	12.88	18.52	22.89	12	7

LOWER SAN ANTONIO BAY SALINITY (PPT)
****

MONTH	AVERAGE	10%<	25%<	50%<	75%<	90%<	#V SUB	#V SLB
*****	*******	****	****	****	****	****	******	******
JAN	22.29	12.00	16.41	21.57	25.22	31.40	16	0
FEB	21.57	11.65	17.05	21.01	25.66	28.59	17	0
MAR	22.91	13.77	16.08	21.74	26.50	31.96	16	0
APR	23.46	9.32	16.53	23.37	28.89	36.08	22	1
MAY	19.52	6.99	10.64	18.24	26.86	31.68	17	2
JUN	22.23	8.26	12.28	19.86	29.11	45.00	19	2
JUL	29.02	10.76	17.58	27.85	45.00	45.00	35	2
AUG	30.91	15.92	22.11	28.89	42.80	45.00	37	0
SEP	24.64	9.07	14.30	22.76	30.65	45.00	24	1
OCT	22.95	10.12	13.74	21.51	29.82	36.27	19	2
NOV	22.90	10.65	16.30	22.10	26.67	35.98	20	0
DEC	22.97	12.32	17.26	21.94	27.18	31.26	21	0

ESPIRITU SANTO BAY SALINITY (PPT)
****

MONTH	AVERAGE	10%<	25%<	50%<	75%<	90%<	#V SUB	#V SLB
*****	*******	****	****	****	****	****	******	******
JAN	27.53	22.45	24.55	26.99	28.72	31.65	2	0
FEB	27.10	22.28	24.85	26.72	28.93	30.32	1	0
MAR	27.74	23.29	24.39	27.07	29.33	31.92	1	0
APR	28.15	21.18	24.60	27.84	30.46	33.87	2	0
MAY	26.26	20.08	21.81	25.41	29.50	31.78	2	0
JUN	28.25	20.68	22.59	26.18	30.56	45.00	8	0
JUL	32.30	21.86	25.10	29.97	42.27	45.00	15	0
AUG	32.64	24.31	27.25	30.46	37.06	45.00	10	0
SEP	29.14	21.06	23.54	27.56	31.30	39.97	6	0
OCT	28.03	21.56	23.28	26.96	30.90	33.96	3	0
NOV	27.89	21.81	24.49	27.24	29.41	33.82	2	0
DEC	27.89	22.61	24.95	27.16	29.65	31.58	2	0

ANNUAL NUTRIENT AND SEDIMENT CONSTRAINTS
****

SIMULATED FRESHWATER INFLOWS LESS THAN NUTRIENT CONSTRAINT (860000. ACFT/YR) IN 16 YEARS
SIMULATED FRESHWATER INFLOWS LESS THAN SEDIMENT CONSTRAINT (355235. ACFT/YR) IN 7 YEARS

ANNUAL FISHERIES HARVEST (KLBS) - GUADALUPE ESTUARY
****

SPECIES	AVERAGE	10%<	25%<	50%<	75%<	90%<	# YRS
*******	*******	****	****	****	****	****	*****
WHITE SHRIMP	824.	360.	613.	802.	1009.	1103.	38
BROWN SHRIMP	389.	67.	140.	308.	571.	702.	46
BLUE CRAB	201.	41.	41.	146.	251.	493.	46
OYSTER	463.	54.	54.	296.	619.	1034.	42
BLACK DRUM	27.	0.	6.	18.	42.	61.	45
RED DRUM	71.	31.	38.	54.	87.	120.	42
SEATROUT	56.	17.	26.	42.	75.	115.	49
********************							
TOTAL	1982.	1338.	1447.	1744.	2320.	2974.	30

TRANS-TEXAS WATER PROGRAM, WEST CENTRAL STUDY AREA
HDR JOB# = 07755-016-036 DATE = 6/30/97
SCENARIO: GUADALUPE ESTUARY *** BASELINE ***

YEAR	INFLOW (ACFT)	WHITE SHRIMP HARVEST (KLBS)	BROWN SHRIMP HARVEST (KLBS)	BLUE CRAB HARVEST (KLBS)	EASTERN OYSTER HARVEST (KLBS)	BLACK DRUM HARVEST (KLBS)	RED DRUM HARVEST (KLBS)	SEATROUT HARVEST (KLBS)	TOTAL HARVEST (KLBS)
****	******	*****	*****	*****	*****	*****	*****	*****	*****
1934	1355380.	-9999.	-9999.	-9999.	-9999.	-9999.	-9999.	-9999.	-9999.
1935	2798813.	1040.	623. +	110.	-9999.	-9999.	-9999.	-9999.	-9999.
1936	3402270.	613. -	571. +	536. +	392. +	-9999.	-9999.	-9999.	-9999.
1937	1165186.	796.	91.	609. +	970. +	31.	-9999.	-9999.	-9999.
1938	1522840.	1026.	325. +	41.	54.	16.	179.	115.	1756.
1939	342851.	-9999.	353. +	58. +	531. +	0.	164.	61.	-9999.
1940	1947614.	-9999.	1316. +	590. +	-9999.	0.	35. -	26.	-9999.
1941	3536521.	736.	1089. +	572.	751. +	18.	75. +	32. +	3273.
1942	2408404.	242.	1167. +	493. +	1034. +	18.	81.	51.	3087.
1943	733335.	747.	67.	572.	1937.	19.	143. +	45.	3531.
1944	1726438.	1260.	360. +	41.	54.	0.	109.	36.	1861.
1945	1525650.	560.	515.	213.	831. +	12.	120.	40.	2292.
1946	2799270.	1009. +	607. +	87.	1186.	7. -	49.	30.	2974.
1947	1128496.	771.	67.	41.	148.	7.	73. +	54. +	1162.
1948	459288.	654. +	311. +	41.	251.	11.	49.	22.	1338.
1949	1446622.	-9999.	391. +	41.	982. +	16.	42.	37.	-9999.
1950	326939.	-9999.	104. -	-9999.	619. -	0.	37. -	20.	-9999.
1951	438712.	-9999.	-9999.	-9999.	531. -	0.	-9999.	15. +	-9999.
1952	863977.	-9999.	178. -	-9999.	-9999.	0.	-9999.	25. +	-9999.
1953	840676.	583.	242.	41.	550. -	-9999.	-9999.	29. +	-9999.
1954	85513.	-9999.	142. -	139. +	-9999.	-9999.	-9999.	36. +	-9999.
1955	154570.	-9999.	-9999.	-9999.	-9999.	-9999.	-9999.	17. +	-9999.
1956	63362.	-9999.	-9999.	-9999.	-9999.	-9999.	-9999.	-9999.	-9999.
1957	3031212.	-9999.	-9999.	-9999.	-9999.	-9999.	-9999.	-9999.	-9999.
1958	2867671.	1061. +	67.	41.	54.	0.	-9999.	75. +	-9999.
1959	1368655.	570.	167.	41.	112.	48.	58. -	83.	1078.
1960	3123775.	748.	487.	183.	1049.	61.	39. -	50.	2618.
1961	2254128.	586.	163.	214.	599.	121.	38.	24.	1744.
1962	471423.	-9999.	140. -	166.	296.	80.	33.	22.	-9999.
1963	211214.	-9999.	-9999.	-9999.	-9999.	72.	29.	28.	-9999.
1964	431565.	-9999.	-9999.	-9999.	-9999.	-9999.	24.	13. +	-9999.
1965	2020540.	1415.	-9999.	41.	-9999.	-9999.	-9999.	-9999.	-9999.
1966	1107085.	798.	276.	41.	-9999.	30. +	-9999.	60. +	-9999.
1967	3017277.	-9999.	-9999.	41.	-9999.	40.	48. -	92.	-9999.
1968	3077264.	1103.	114. -	41.	54.	48. +	49. -	100. +	1509.
1969	1709105.	1117. +	140. -	47.	54.	72.	45.	64.	1539.
1970	1470553.	1060.	318.	41.	54.	63.	54.	63.	1654.
1971	1369022.	-9999.	386.	41.	588.	49.	62.	75.	-9999.
1972	2099411.	973.	141.	146.	54.	0.	46. -	42.	1404.
1973	4249744.	802.	1116.	378.	193.	15.	65.	115.	2683.
1974	2134380.	689.	69.	297.	578.	11.	130.	115.	1888.
1975	2730716.	815.	361.	201.	54.	36.	108.	108.	1684.
1976	3356651.	849.	650.	373.	232.	42.	109.	70.	2326.
1977	2884173.	741. -	174.	221.	270.	60.	73.	66.	1604.
1978	1472195.	350.	702.	172.	665.	15.	38.	38.	1979.
1979	3392499.	1144.	308.	251.	562.	3.	31.	21.	2320.
1980	848837.	972. +	132.	180.	91.	6.	39.	27.	1447.
1981	3511322.	1038. +	909.	306. +	87. -	24. -	93.	83.	2539.
1982	1129014.	924. +	67.	232.	54.	24.	147. +	115.	1562.
1983	897355.	489.	585. +	95. +	54.	25. +	85.	115.	1447.
1984	389092.	-9999.	203. -	123. +	1085. +	19.	82.	115.	-9999.

1985	1828614.	905. +	661.	157.	1176.	-9999.	24.	20. +	-9999.
1986	1769707.	806.	186.	110.	489.	0.	44. +	13. +	1649.
1987	4629321.	976.	657.	356.	54.	24.	31. -	28.	2125.
1988	444127.	360.	207.	490.	54.	43.	107. +	115.	1375.
1989	352799.	-9999.	-9999.	-9999.	-9999.	44.	87.	115.	-9999.
ANNUAL AVERAGES									
	1727200.	824.	389.	201.	463.	27.	71.	56.	1982.
SIMULATED LOWER SEASONAL FLOW BOUND EXCURSIONS									
		61	36	41	51	34	36	28	
SIMULATED UPPER SEASONAL FLOW BOUND EXCURSIONS									
		4	3	4	3	0	3	1	

TRANS-TEXAS WATER PROGRAM, WEST CENTRAL STUDY AREA
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SCENARIO: GUADALUPE ESTUARY *** WITH PROJECT ***

FRESHWATER INFLOWS (ACFT) - GUADALUPE ESTUARY
****

MONTH	AVERAGE	10%<	25%<	50%<	75%<	90%<
*****	*******	****	****	****	****	****
JAN	121018.	3986.	45107.	75447.	132155.	245083.
FEB	126920.	16410.	38794.	85258.	140713.	270319.
MAR	105150.	6483.	32293.	73145.	163686.	236611.
APR	139434.	3651.	25924.	56640.	157439.	434899.
MAY	228900.	10422.	34051.	119719.	349161.	572846.
JUN	219881.	6.	19429.	89079.	256473.	490767.
JUL	114725.	0.	481.	30308.	126820.	284533.
AUG	51270.	0.	2706.	24058.	72538.	128631.
SEP	168953.	357.	11540.	65968.	183229.	407044.
OCT	159575.	2538.	21385.	75822.	146278.	359340.
NOV	125358.	3354.	36988.	72674.	160198.	298029.
DEC	113614.	4770.	35173.	73173.	144392.	247028.

UPPER SAN ANTONIO BAY SALINITY (PPT)
****

MONTH	AVERAGE	10%<	25%<	50%<	75%<	90%<	#V SUB	#V SLB
*****	*******	****	****	****	****	****	******	******
JAN	14.46	2.33	7.18	12.95	17.18	24.88	11	9
FEB	13.34	1.93	7.86	12.27	17.60	21.12	7	11
MAR	15.08	4.27	6.81	13.13	18.71	25.67	13	7
APR	16.11	.00	7.29	15.22	21.56	31.94	17	11
MAY	11.84	.00	.84	9.20	19.14	25.15	19	14
JUN	15.35	.00	2.63	11.00	21.88	45.00	22	9
JUL	23.54	.98	8.46	20.33	45.00	45.00	37	5
AUG	25.11	6.63	13.52	20.62	36.40	45.00	39	0
SEP	17.83	.00	4.84	14.28	23.83	42.31	20	14
OCT	15.61	.28	4.23	12.89	22.82	29.34	17	14
NOV	15.17	1.24	7.04	13.53	18.87	31.76	12	9
DEC	15.36	2.68	8.11	13.38	19.21	24.67	13	7

LOWER SAN ANTONIO BAY SALINITY (PPT)
****

MONTH	AVERAGE	10%<	25%<	50%<	75%<	90%<	#V SUB	#V SLB
*****	*******	****	****	****	****	****	******	******
JAN	23.00	12.12	16.63	22.00	25.94	33.11	17	0
FEB	22.16	11.75	17.26	21.37	26.33	29.61	17	0
MAR	23.58	13.92	16.29	22.17	27.36	33.84	17	0
APR	24.26	9.40	16.74	24.12	30.02	39.68	25	1
MAY	20.14	7.04	10.74	18.51	27.76	33.36	17	2
JUN	22.72	8.33	12.40	20.19	30.32	45.00	20	2
JUL	29.65	10.86	17.83	28.87	45.00	45.00	35	2
AUG	31.74	16.12	22.54	29.14	43.83	45.00	37	0
SEP	25.19	9.15	14.45	23.24	32.13	45.00	25	1
OCT	23.61	10.21	13.89	21.95	31.19	37.26	21	2
NOV	23.58	11.11	16.51	22.54	27.51	39.51	24	0
DEC	23.68	12.45	17.50	22.40	27.83	32.91	22	0

ESPIRITU SANTO BAY SALINITY (PPT)
****

MONTH	AVERAGE	10%<	25%<	50%<	75%<	90%<	#V SUB	#V SLB
*****	*******	****	****	****	****	****	******	******
JAN	27.96	22.51	24.65	27.20	29.06	32.46	2	0
FEB	27.39	22.33	24.95	26.90	29.25	30.80	1	0
MAR	28.31	23.36	24.49	27.28	29.74	32.81	3	0
APR	28.73	21.22	24.70	28.20	31.00	35.57	4	0
MAY	26.56	20.10	21.85	25.54	29.93	32.58	2	0
JUN	28.49	20.71	22.64	26.33	31.14	45.00	8	0
JUL	32.72	21.91	25.22	30.45	44.02	45.00	16	0
AUG	33.29	24.41	27.45	30.58	37.54	45.00	13	0
SEP	29.50	21.10	23.62	27.78	32.00	40.15	7	0
OCT	28.42	21.60	23.35	27.17	31.55	34.43	4	0
NOV	28.32	22.03	24.59	27.45	29.81	35.50	3	0
DEC	28.40	22.67	25.06	27.38	29.96	32.37	4	0

ANNUAL NUTRIENT AND SEDIMENT CONSTRAINTS
****

SIMULATED FRESHWATER INFLOWS LESS THAN NUTRIENT CONSTRAINT (860000. ACFT/YR) IN 18 YEARS
SIMULATED FRESHWATER INFLOWS LESS THAN SEDIMENT CONSTRAINT (355235. ACFT/YR) IN 8 YEARS

ANNUAL FISHERIES HARVEST (KLBS) - GUADALUPE ESTUARY
****

SPECIES	AVERAGE	10%<	25%<	50%<	75%<	90%<	# YRS
*******	*******	****	****	****	****	****	*****
WHITE SHRIMP	831.	381.	611.	818.	1006.	1115.	38
BROWN SHRIMP	386.	67.	144.	274.	559.	726.	46
BLUE CRAB	213.	41.	41.	167.	295.	500.	42
OYSTER	430.	54.	54.	229.	591.	1052.	39
BLACK DRUM	26.	0.	4.	17.	41.	58.	45
RED DRUM	70.	30.	38.	54.	85.	119.	42
SEATROUT	58.	19.	27.	46.	86.	115.	48
********	********	********	********	********	********	********	********
TOTAL	2006.	1129.	1519.	1730.	2330.	2937.	28

TRANS-TEXAS WATER PROGRAM, WEST CENTRAL STUDY AREA
HDR JOB# = 07755-016-036   DATE = 6/30/97
SCENARIO: GUADALUPE ESTUARY *** WITH PROJECT ***

YEAR	INFLOW (ACFT)	WHITE SHRIMP HARVEST (KLBS)	BROWN SHRIMP HARVEST (KLBS)	BLUE CRAB HARVEST (KLBS)	EASTERN OYSTER HARVEST (KLBS)	BLACK DRUM HARVEST (KLBS)	RED DRUM HARVEST (KLBS)	SEATROUT HARVEST (KLBS)	TOTAL HARVEST (KLBS)
****	******	*****	*****	*****	*****	*****	*****	*****	*****
1934	1297390.	-9999.	-9999.	-9999.	-9999.	-9999.	-9999.	-9999.	-9999.
1935	2742700.	1050.	597. +	96.	-9999.	-9999.	-9999.	-9999.	-9999.
1936	3343993.	611. -	578. +	546. +	396. +	-9999.	-9999.	-9999.	-9999.
1937	1109038.	813.	84.	620. +	983. +	30.	-9999.	-9999.	-9999.
1938	1466002.	1053.	290. +	-9999.	54.	14.	179.	115.	-9999.
1939	293324.	-9999.	336. +	-9999.	-9999.	0.	162.	63.	-9999.
1940	1900411.	-9999.	1298. +	581. +	-9999.	0.	36. -	26.	-9999.
1941	3478032.	737.	1069. +	576.	739. +	17. -	72. +	31. +	3241.
1942	2351307.	242.	1204. +	500. +	1053. +	17.	80.	52.	3148.
1943	680640.	760.	67.	578.	1937.	18.	145. +	46.	3550.
1944	1669509.	1274. +	327. +	41.	54.	0.	107.	37.	1840.
1945	1472347.	557.	520.	204.	807. +	11.	119.	42.	2258.
1946	2741205.	1006. +	581. +	76.	1190.	6. -	48.	30.	2937.
1947	1072040.	787.	67.	41.	106.	6.	70. +	53. +	1129.
1948	409356.	657. +	274. +	-9999.	229. -	9.	47.	22.	-9999.
1949	1400334.	-9999.	366. +	-9999.	-9999.	14.	41.	38.	-9999.
1950	292875.	-9999.	105. -	-9999.	670. -	0.	38. -	20.	-9999.
1951	405602.	-9999.	-9999.	-9999.	582. -	0.	-9999.	14. +	-9999.
1952	807622.	-9999.	181. -	-9999.	-9999.	0.	-9999.	23. +	-9999.
1953	800141.	581.	251.	41.	587. -	-9999.	-9999.	27. +	-9999.
1954	66771.	-9999.	146. -	141. +	-9999.	-9999.	-9999.	34. +	-9999.
1955	136916.	-9999.	-9999.	-9999.	-9999.	-9999.	-9999.	-9999.	-9999.
1956	55803.	-9999.	-9999.	-9999.	-9999.	-9999.	-9999.	-9999.	-9999.
1957	2925985.	-9999.	-9999.	-9999.	-9999.	-9999.	-9999.	-9999.	-9999.
1958	2782991.	1112. +	67.	41.	54.	0.	-9999.	73. +	-9999.
1959	1312300.	571.	160.	41.	76.	43.	61. -	93.	1046.
1960	3065526.	756.	489.	177.	1052.	56.	43. -	54.	2627.
1961	2196291.	587.	160.	209.	591.	117.	41.	25.	1730.
1962	425542.	-9999.	144. -	167.	290.	78.	31.	22.	-9999.
1963	184041.	-9999.	-9999.	-9999.	-9999.	70. +	28.	28. +	-9999.
1964	389789.	-9999.	-9999.	-9999.	-9999.	-9999.	24.	13. +	-9999.
1965	1951340.	1415.	-9999.	41.	-9999.	-9999.	-9999.	-9999.	-9999.
1966	1051016.	819.	259.	41.	-9999.	27. +	-9999.	58. +	-9999.
1967	2969120.	-9999.	-9999.	41.	-9999.	39. +	50. -	99. +	-9999.
1968	3019009.	1115.	111. -	41.	54.	45. +	50. -	102. +	1519.
1969	1651955.	1118. +	144. -	41.	54.	70.	45.	67.	1540.
1970	1413654.	1085.	305.	41.	54.	61.	54.	66.	1666.
1971	1323073.	-9999.	392.	41.	566.	48.	61.	78.	-9999.
1972	2042777.	982.	136.	132. +	54.	0.	48. -	44.	1396.
1973	4190494.	806.	1148.	378.	185.	14.	64.	115.	2709.
1974	2076411.	697.	67.	295.	574.	10. -	129.	115.	1886.
1975	2672250.	818.	360.	194.	54.	35.	107.	111.	1680.
1976	3298021.	853.	661.	371.	224.	41.	108.	72.	2330.
1977	2826126.	748. -	167.	214.	254.	58.	71.	67.	1579.
1978	1420050.	336.	726.	167.	663.	13.	36.	38.	1980.
1979	3333824.	1156.	306.	249.	562.	1.	30.	21.	2324.
1980	797732.	965. +	128.	175.	78.	4.	38.	27.	1416.
1981	3452679.	1027. +	934.	298. +	86. -	24. -	93.	86.	2547.
1982	1083796.	918. +	67.	231.	54.	23.	144. +	115.	1551.
1983	841577.	482.	559. +	73. +	54.	22. +	84.	115.	1389.
1984	352928.	-9999.	213. -	109. +	-9999.	18.	82.	115.	-9999.

1985	1761806.	892. +	652. +	158.	1179. +	-9999.	24.	19. +	-9999.
1986	1711927.	833.	180. -	96.	457.	0.	41. +	13. +	1620.
1987	4570115.	979.	665.	355.	54.	21.	32. -	28.	2134.
1988	388843.	381. -	191.	496.	54.	41.	107. +	115.	1383.
1989	312369.	-9999.	-9999.	-9999.	-9999.	43.	85.	115.	-9999.
ANNUAL AVERAGES									
	1674798.	831.	386.	213.	430.	26.	70.	58.	2006.
SIMULATED LOWER SEASONAL FLOW BOUND EXCURSIONS									
		66	38	47	57	39	37	31	
SIMULATED UPPER SEASONAL FLOW BOUND EXCURSIONS									
		4	3	4	3	0	2	1	