Nueces BBASC Work Plan Study

Re-Examination of the 2001 Agreed Order Monthly Targets: Phase 2

Texas Water Development Board

Contract #1600012014

August 2017

PURSUANT TO HOUSE BILL 1 AS APPROVED BY THE 84TH TEXAS LEGISLATURE, THIS STUDY REPORT WAS FUNDED FOR THE PURPOSE OF STUDYING ENVIRONMENTAL FLOW NEEDS FOR TEXAS RIVERS AND ESTUARIES AS PART OF THE ADAPTIVE MANAGEMENT PHASE OF THE SENATE BILL 3 PROCESS FOR ENVIRONMENTAL FLOWS ESTABLISHED BY THE 80TH TEXAS LEGISLATURE. THE VIEWS AND CONCLUSIONS EXPRESSED HEREIN ARE THOSE OF THE AUTHOR(S) AND DO NOT NECESSARILY REFLECT THE VIEWS OF THE TEXAS WATER DEVELOPMENT BOARD.

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Nueces BBASC Work Plan Study

Re-Examination of the 2001 Agreed Order Monthly Targets: Phase 2

Prepared for:

Texas Water Development Board

Nueces River and Corpus Christi and Baffin Bays Basin and Bay Area Stakeholder Committee (Nueces BBASC)

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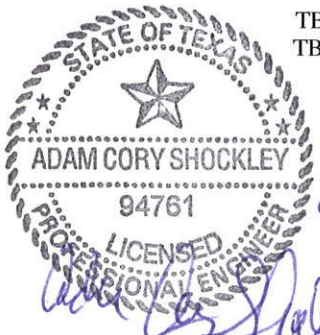
August 2017



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List of Commonly Used Acronyms

BBASC – Basin and Bay Area Stakeholder Committee

BBEST – Basin and Bay Area Expert Science Team

CCR – Choke Canyon Reservoir

CCR/LCC System – describes the City of Corpus Christi Water Supply System which includes Choke Canyon Reservoir, Lake Corpus Christi, Lake Texana and Colorado River Water

CCWSM – Corpus Christi Water Supply Model

CoCC – City of Corpus Christi

FWI – Freshwater Inflow

LCC – Lake Corpus Christi

MaxH – Maximum Harvest

MGD – Million Gallons per Day

MinQ – Minimum Flow

NEAC – Nueces Estuary Advisory Council

TCEQ – Texas Commission on Environmental Quality

TNRCC – Texas Natural Resource Conservation Commission

TxEMP – Estuarine Mathematical Programming or Optimization Model

TWDB – Texas Water Development Board

1 Introduction

The City of Corpus Christi (CoCC or City) operates the Choke Canyon Reservoir / Lake Corpus Christi / Lake Texana System (CCR/LCC System) as its primary water supply for a population of over 500,000 (in the area), 300,000 of which reside in Corpus Christi. In the operation of this system, the City is subject to the terms and conditions of the 2001 Texas Commission on Environmental Quality (TCEQ) Agreed Order (Agreed Order; attached as Appendix A) that defines the monthly freshwater inflow targets for Nueces Bay which, in turn, govern the passage of inflows through the reservoir system. The monthly targets in the Agreed Order are generally based on the MaxH (Maximum Harvest) and MinQ (Minimum Flow) solutions obtained from the TWDB's TxEMP Model for the Nueces Estuary.[1,2] These solutions are based, in part, on functional relationships relating freshwater inflow volumes over two-month consecutive periods to reported commercial harvests of seven selected species (recognizing that other factors such as temperature, fuel cost, economics, harvest pressure, Gulf stock, etc. may affect harvest also).

The Nueces Basin and Bay Area Stakeholder Committee (Nueces BBASC) recommended a study be performed to re-examine the monthly pass-through targets that are part of the Agreed Order. As described in Section 4.1 of the Nueces Basin and Bay Expert Science Team report (Nueces BBEST 2011), it is believed that there has been a seasonal shift in inflows to Nueces Bay and the CCR/LCC System that serves as the CoCC primary water supply. The Nueces BBASC report (Nueces BBASC, August 2012), in Section 2.3, suggests that opportunities to better manage limited freshwater inflows may be identified by reviewing new data that were not available during development of the 1995 Agreed Order (TCEQ 1995), which is the pre-cursor to the 2001 Agreed Order, for current pass-through operations of the reservoir system. This research was recommended to see what modifications to the Agreed Order might be considered for ecological purposes and to quantify the associated impact of any such modifications on the reliable water supply of the City and its customers.

Recent hydrologic trends, driven by more frequent and severe drought cycles, suggest that the timing of freshwater inflows may no longer correspond to the timing of these events as defined in the Agreed Order. Phase 1 of this study, completed in 2015, examined recent hydrologic data to identify possible shifts in the hydrologic regime specific to bay and estuary inflows. The findings from Phase 1 are presented in the 2015 HDR report[3] and are summarized as follows.

- Some of the data provided an indication of wetter Julys for the recent period. However, the visual trends in the data were not statistically significant to indicate a wetter July shift. In fact, no months exhibited wetter short-term or recent period averages that were determined to be statistically significant. The observed change is likely due to natural variation in the hydrologic cycles.
- The months of April, May, June, August, and December did show short-term and recent reductions in precipitation and flow indicating drier conditions than the long-term average.
- Overall, the short-term period (1986-2014) showed to be generally drier than the long-term average.

[1] TWDB, TPWD, & TNRCC, *Texas Bays and Estuaries Program, Determination of Freshwater Inflow Needs*, September 1998.

[2] TPWD & TWDB, *Freshwater Inflow Recommendation for the Nueces Estuary*, September 2002.

[3] HDR for the Nueces BBASC and the TWDB, *Reexamination of the 2001 Agreed Order Monthly Targets and Safe Yield versus Current Demand Evaluations*, August 2015.

- Short-term and recent drier conditions do not suggest lowering of the Agreed Order targets since the target can only be met by passing inflows. If it is truly dry then there are generally limited inflows to pass.
- The data do show a potential difference in monthly contribution for some of the months when looking at precipitation and stream flow. The data presented indicate less contribution in June and more in July when looking at precipitation and stream flow, which appears to be a shift from historical patterns. The data also suggest less contribution in August with more in the fall, but these are not a shift as much as they appear to be a strengthening of an existing pattern.
- Three alternative monthly pass-through target scenarios were evaluated to determine the potential effects of modifying the Agreed Order monthly targets on yield and freshwater inflows (FWI).
- Changes associated with evaluating these different scenarios are small for both yield and FWI. Generally, increases in yield result in reductions in average and median annual Nueces Bay inflows and vice versa. Each scenario including modification of monthly Agreed Order pass-through targets resulted in increased yield and decreased FWI.
- While the analysis does not suggest a need to change the Agreed Order targets to accommodate a shift in the in the monthly occurrence of inflows, there is potential for modifying the Agreed Order targets to provide more opportunities to deliver freshwater inflows to Nueces Bay with minimal impact to system yield.

This study (Phase 2) considers the findings of the Phase 1 and input from area stakeholders to identify new alternative scenarios for the Agreed Order monthly targets for additional evaluation. This report describes the analyses performed to achieve the goals of Phase 2 and contains a brief summary of the potential changes to reservoir system yield and FWI to Nueces Bay from modifying the Agreed Order monthly targets. Additionally, this report provides recommendations for additional investigation. The primary goals of Phase 2 of this study are as follows.

- Identify potential alternative monthly target scenarios from stakeholders input.
- Evaluate identified scenarios and compare results of system yield and FWI to Nueces Bay for each scenario.

A copy of the presentation delivered to the NEAC on 1 May 2017 is contained in Appendix B. The original scope of work is contained in Appendix C.

2 Corpus Christi Water Supply Model Description

The Corpus Christi Water Supply Model (CCWSM) was the primary tool used to perform this study and evaluate the effects of changes in monthly bay inflow targets on yield and frequency and magnitude of Nueces Bay inflows. The CCWSM is a multi-basin water supply model that includes operations of Choke Canyon Reservoir (CCR), Lake Corpus Christi (LCC; including reservoir "pass-throughs" for Nueces Bay), Lake Texana, and water supplies from the Lower Colorado River (i.e. Garwood water). The CCWSM is a planning / operational model that uses historical hydrologic data (natural inflows and evaporation) to simulate reservoir operations on a monthly time-step under various demands / environmental flow scenarios.

The model was originally developed as a tool to evaluate the effects of reservoir operation and environmental flow policies on system yield and FWI. Computations in the model simulate evaporation losses in the reservoirs, as well as channel losses in the rivers associated with water delivery from CCR to LCC, and from LCC to the City's water supply intake near the Calallen Diversion Dam. In addition, to account for sediment deposition in the reservoirs, the model includes elevation-area-capacity relationships representative of different decades including 2020, 2030, 2060, and 2070. The history of CCWSM development and applications is summarized in a series of HDR project reports[4,5,6,7,8] dating back to 1991 (HDR, et al., May 1991, November 1991, 1993, January 1999, and 2006).

For the 2006 Coastal Bend Regional Water Plan[9] (2006 Plan), the CCWSM was updated (HDR 2006) to include hydrology for the drought of the 1990s, which resulted in the simulation period of the model covering from 1934 to 2003. This version of the model was used in Phase 1 of the study to evaluate system yields and FWI to Nueces Bay for the various scenarios. Since the completion of Phase 1, the CCWSM was again updated by HDR[10] in 2016 (HDR 2017) for the CoCC to extend the hydrology through 2015 and to update elevation-area-capacity-relationships for reservoirs in the model, where applicable. According to the Texas Administrative Code (30 TAC 297.1(19)), a new drought of record is defined as the historical period of record for a watershed in which the lowest flows were known to have occurred based on naturalized streamflow. For purposes of this study this same definition was applied to define the new drought. The new drought is also shown through the modeling such that a new firm yield of the reservoir system results from application of the updated naturalized flows in the model. The definition of firm yield is similar to the

[4] HDR and Geraghty & Miller, Inc., *Nueces River Basin Regional Water Supply Planning Study*, Nueces River Authority, City of Corpus Christi, Edwards Underground Water District, South Texas Water Authority, Texas Water Development Board, May 1991.

[5] HDR, Naismith Engineers, Inc., Shiner, Moseley, & Associates, Inc., and University of Texas Marine Science Institute, Nueces Estuary Regional Wastewater Planning Study, Phase I, City of Corpus Christi, Port of Corpus Christi Authority, Corpus Christi Board of Trade, South Texas Water Authority, Texas Water Development Board, November 1991.

[6] HDR, Naismith Engineers, Inc., and University of Texas Marine Science Institute, *Nueces Estuary Regional Wastewater Planning Study, Phase II*, City of Corpus Christi, Port of Corpus Christi Authority, Corpus Christi Board of Trade, South Texas Water Authority, Texas Water Development Board, June 1993.

[7] HDR, *Water Supply Update for City of Corpus Christi Service Area*, City of Corpus Christi, January 1999.

[8] HDR, *Updates and Enhancements to Lower Nueces River Basin Bay and Estuary Model and Corpus Christi Water Supply Model*, City of Corpus Christi, January 2006.

[9] Texas Water Development Board, 2006 *Coastal Bend Regional Water Plan*, January 2006.

[10] HDR, *Corpus Christi Water Supply Model Updates, City of Corpus Christi*, January 2017.

definition used in the 2016 Region N Study[11] (TWDB 2016) as well as other water supply planning efforts which states firm yield is the annual diversion that may be withdrawn from a reservoir system every year through a repeat of the drought of record such that there are no shortages and the remaining volume of water in storage is zero or equal to the dead pool volume of the reservoir. The new drought was evidenced by showing a new critical drawdown for the simulated reservoir system storage. The 2016 updated version of the CCWSM was used to evaluate system yields and FWI to Nueces Bay for Phase 2 of the study.

[11] Texas Water Development Board, 2016 *Coastal Bend Regional Water Plan,* December 2015.

3 Identification of Alternative Agreed Order Monthly Target Scenarios

Table 3-1 summarizes the monthly inflow targets by zone for the 2001 Agreed Order and Figure 3-1 visually shows the monthly targets by zone. The 2001 Agreed Order Monthly targets serve as the baseline scenario for this study. Zone 1 is defined as system storage (combined storage in CCR and LCC divided by total combined capacity) down to 70%. Zone 2 is defined as system storage between 70% and 40%, while Zone 3 is 40%-30%. There are no pass-through targets when the reservoir system drops below 30% of conservation capacity (Zone 4). For Zones 1 and 2 the Agreed Order targets vary by month, whereas in Zone 3 they are uniform across all months.

Table 3-1. 2001 Agreed Order Monthly Targets (acre-feet) by Zone

Month	Zone 1 (100%-70% System Storage)	Zone 2 (70%-40% System Storage)	Zone 3 (40%-30% System Storage)	Zone 4 (30%-0% System Storage)
JAN	2,500	2,500	1,200	0
FEB	2,500	2,500	1,200	0
MAR	3,500	3,500	1,200	0
APR	3,500	3,500	1,200	0
MAY	25,500	23,500	1,200	0
JUN	25,500	23,000	1,200	0
JUL	6,500	4,500	1,200	0
AUG	6,500	5,000	1,200	0
SEP	28,500	11,500	1,200	0
OCT	20,000	9,000	1,200	0
NOV	9,000	4,000	1,200	0
DEC	4,500	4,500	1,200	0
ANN	**138,000**	**97,000**	**14,400**	**0**

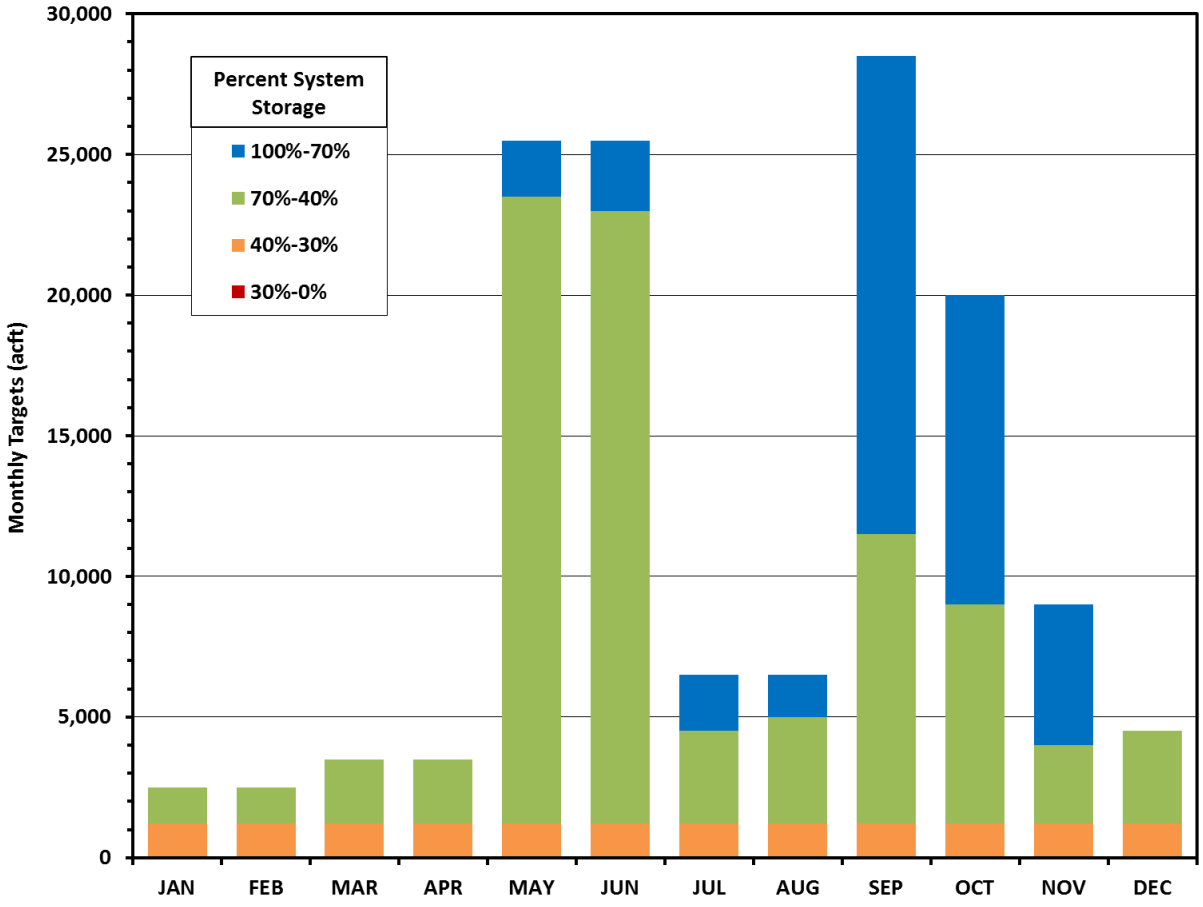

Figure 3-1. 2001 Agreed Order Monthly Targets (acre-feet) by Zone

Task 1 of this study included soliciting feedback from stakeholders to identify alternative monthly target patterns for the Agreed Order. Stakeholders of the NEAC and the Nueces BBASC were asked to provide input on alternative target scenarios. Input was formally requested in a 13 April 2017 email from HDR to Stakeholders and at a 1 May 2017 meeting of the NEAC. HDR received eight suggestions from Stakeholders for alternative monthly target scenarios. One Stakeholder suggestion included a dedicated release from reservoir storage to maintain a minimum FWI to the Nueces Bay in all months. The current version of the CCWSM does not have the capability to properly simulate dedicated releases from storage to meet minimum flow targets; therefore, this suggested scenario was omitted from the evaluation. HDR identified one additional scenario during the evaluation analysis and included the three scenarios identified in Phase 1 of the study for a total of 12 scenarios. The scenarios and a brief description of each is provided in the following text and shown in tabular form in Table 3-2 with targets shown in acre-feet per month. The alternative scenarios are represented visually in Appendix D.

Baseline (Existing Targets) - The monthly inflow targets by zone for the 2001 Agreed Order, the baseline scenario for this study.

Stakeholder 1 – The Baseline June and July targets and the May and October targets for Zones 1 and 2 are swapped.

Stakeholder 2 – The Baseline Zone 1 and 2 targets are averaged for each month.

Stakeholder 3 – The Baseline Zone 1 and 2 targets are swapped.

Stakeholder 4 – The Baseline monthly pattern for Zones 1 and 2 is flattened thus reducing the peak months and increasing the smaller value months.

Stakeholder 5 - The Baseline monthly pattern for Zones 1 and 2 is flattened in a different manner than the Stakeholder 4 scenario.

Stakeholder 6 – The Baseline monthly pattern is changed to a uniform pattern that keeps the annual total target amount the same.

Stakeholder 7 – The targets are given a uniform pattern and reduced from the Baseline. An additional target is added for drought periods when system storage is in Zone 4 between 15% and 30%.

HDR – The Baseline monthly pattern is changed to a uniform pattern that keeps the annual total target amount the same similar to the Stakeholder 6 scenario but Zones 1 and 2 are swapped.

Phase 1 Uniform - The Baseline monthly target volumes are spread uniformly through the traditionally "wetter" months of April through Nov for Zones 1 and 2.

Phase 1 MJJ (May-June-July) - This scenario shifts the higher Baseline May and June targets to July to attempt to capture any effects of the apparent trend identified in Phase 1 showing July to be wetter than the long-term average. Changes are applied to both the Zone 1 and Zone 2 values.

Phase 1 AMJJAD (April-May-June-July-August-December) - This scenario attempts to capture any effects of the trends found in Phase 1 showing some of these months to be drier while others are wetter than the long-term averages. Changes were applied to both the Zone 1 and Zone 2 values.

Table 3-2. Baseline (Existing) and Identified Alternative Monthly Target Scenarios for Agreed Order

BASELINE (EXISTING TARGETS)

MONTH	SYSTEM STORAGE EXCEEDING		
	70%	40%	30%
JAN	2,500	2,500	1,200
FEB	2,500	2,500	1,200
MAR	3,500	3,500	1,200
APR	3,500	3,500	1,200
MAY	25,500	23,500	1,200
JUN	25,500	23,000	1,200
JUL	6,500	4,500	1,200
AUG	6,500	5,000	1,200
SEP	28,500	11,500	1,200
OCT	20,000	9,000	1,200
NOV	9,000	4,000	1,200
DEC	4,500	4,500	1,200
ANN	138,000	97,000	14,400

STAKEHOLDER 1

MONTH	SYSTEM STORAGE EXCEEDING		
	70%	40%	30%
JAN	2,500	2,500	1,200
FEB	2,500	2,500	1,200
MAR	3,500	3,500	1,200
APR	3,500	3,500	1,200
MAY	20,000	9,000	1,200
JUN	6,500	4,500	1,200
JUL	25,500	23,000	1,200
AUG	6,500	5,000	1,200
SEP	28,500	11,500	1,200
OCT	25,500	23,500	1,200
NOV	9,000	4,000	1,200
DEC	4,500	4,500	1,200
ANN	138,000	97,000	14,400

STAKEHOLDER 2

MONTH	SYSTEM STORAGE EXCEEDING		
	70%	40%	30%
JAN	2,500	2,500	1,200
FEB	2,500	2,500	1,200
MAR	3,500	3,500	1,200
APR	3,500	3,500	1,200
MAY	24,500	24,500	1,200
JUN	24,250	24,250	1,200
JUL	5,500	5,500	1,200
AUG	5,750	5,750	1,200
SEP	20,000	20,000	1,200
OCT	14,500	14,500	1,200
NOV	6,500	6,500	1,200
DEC	4,500	4,500	1,200
ANN	117,500	117,500	14,400

STAKEHOLDER 3

MONTH	SYSTEM STORAGE EXCEEDING		
	70%	40%	30%
JAN	2,500	2,500	1,200
FEB	2,500	2,500	1,200
MAR	3,500	3,500	1,200
APR	3,500	3,500	1,200
MAY	23,500	25,500	1,200
JUN	23,000	25,500	1,200
JUL	4,500	6,500	1,200
AUG	5,000	6,500	1,200
SEP	11,500	28,500	1,200
OCT	9,000	20,000	1,200
NOV	4,000	9,000	1,200
DEC	4,500	4,500	1,200
ANN	97,000	138,000	14,400

STAKEHOLDER 4

MONTH	SYSTEM STORAGE EXCEEDING		
	70%	40%	30%
JAN	7,000	5,000	1,200
FEB	7,000	5,000	1,200
MAR	7,000	5,000	1,200
APR	11,000	7,000	1,200
MAY	18,000	15,000	1,200
JUN	18,000	15,000	1,200
JUL	16,000	9,000	1,200
AUG	7,000	5,000	1,200
SEP	18,000	15,000	1,200
OCT	15,000	8,000	1,200
NOV	7,000	5,000	1,200
DEC	7,000	3,000	1,200
ANN	138,000	97,000	14,400

STAKEHOLDER 5

MONTH	SYSTEM STORAGE EXCEEDING		
	70%	40%	30%
JAN	9,000	5,000	1,200
FEB	7,000	5,000	1,200
MAR	7,000	5,000	1,200
APR	9,000	5,000	1,200
MAY	15,000	12,000	1,200
JUN	12,000	8,000	1,200
JUL	20,000	20,000	1,200
AUG	6,000	4,000	1,200
SEP	25,000	17,000	1,200
OCT	15,000	8,000	1,200
NOV	7,000	5,000	1,200
DEC	6,000	3,000	1,200
ANN	138,000	97,000	14,400

STAKEHOLDER 6

MONTH	SYSTEM STORAGE EXCEEDING		
	70%	40%	30%
JAN	11,500	8,083	1,200
FEB	11,500	8,083	1,200
MAR	11,500	8,083	1,200
APR	11,500	8,083	1,200
MAY	11,500	8,083	1,200
JUN	11,500	8,083	1,200
JUL	11,500	8,083	1,200
AUG	11,500	8,083	1,200
SEP	11,500	8,083	1,200
OCT	11,500	8,083	1,200
NOV	11,500	8,083	1,200
DEC	11,500	8,083	1,200
ANN	138,000	96,996	14,400

STAKEHOLDER 7

MONTH	SYSTEM STORAGE EXCEEDING		
	70%	40%	30%	15%
JAN	6,500	3,500	2,000	500
FEB	6,500	3,500	2,000	500
MAR	6,500	3,500	2,000	500
APR	6,500	3,500	2,000	500
MAY	6,500	3,500	2,000	500
JUN	6,500	3,500	2,000	500
JUL	6,500	3,500	2,000	500
AUG	6,500	3,500	2,000	500
SEP	6,500	3,500	2,000	500
OCT	6,500	3,500	2,000	500
NOV	6,500	3,500	2,000	500
DEC	6,500	3,500	2,000	500
ANN	78,000	42,000	24,000	6,000

HDR

MONTH	SYSTEM STORAGE EXCEEDING		
	70%	40%	30%
JAN	8,083	11,500	1,200
FEB	8,083	11,500	1,200
MAR	8,083	11,500	1,200
APR	8,083	11,500	1,200
MAY	8,083	11,500	1,200
JUN	8,083	11,500	1,200
JUL	8,083	11,500	1,200
AUG	8,083	11,500	1,200
SEP	8,083	11,500	1,200
OCT	8,083	11,500	1,200
NOV	8,083	11,500	1,200
DEC	8,083	11,500	1,200
ANN	96,996	138,000	14,400

PHASE1 UNIFORM

MONTH	SYSTEM STORAGE EXCEEDING		
	70%	40%	30%
JAN	1,500	1,250	1,200
FEB	1,500	1,250	1,200
MAR	1,500	1,250	1,200
APR	16,500	11,500	1,200
MAY	16,500	11,500	1,200
JUN	16,500	11,500	1,200
JUL	16,500	11,500	1,200
AUG	16,500	11,500	1,200
SEP	16,500	11,500	1,200
OCT	16,500	11,500	1,200
NOV	16,500	11,500	1,200
DEC	1,500	1,250	1,200
ANN	138,000	97,000	14,400

PHASE1 MJJ

MONTH	SYSTEM STORAGE EXCEEDING		
	70%	40%	30%
JAN	2,500	2,500	1,200
FEB	2,500	2,500	1,200
MAR	3,500	3,500	1,200
APR	3,500	3,500	1,200
MAY	13,750	12,750	1,200
JUN	13,750	12,500	1,200
JUL	30,000	25,750	1,200
AUG	6,500	5,000	1,200
SEP	28,500	11,500	1,200
OCT	20,000	9,000	1,200
NOV	9,000	4,000	1,200
DEC	4,500	4,500	1,200
ANN	138,000	97,000	14,400

PHASE1 AMJJAD

MONTH	SYSTEM STORAGE EXCEEDING		
	70%	40%	30%
JAN	2,500	2,500	1,200
FEB	2,500	2,500	1,200
MAR	3,500	3,500	1,200
APR	3,325	3,325	1,200
MAY	22,950	21,150	1,200
JUN	22,950	20,700	1,200
JUL	12,875	10,275	1,200
AUG	5,850	4,500	1,200
SEP	28,500	11,500	1,200
OCT	20,000	9,000	1,200
NOV	9,000	4,000	1,200
DEC	4,050	4,050	1,200
ANN	138,000	97,000	14,400

4 Evaluation of Alternative Agreed Order Monthly Targets

The second task of this study evaluates the alternative target scenarios using the CCWSM. This evaluation includes a comparison of outputs from the model, specifically the system yield and volume and frequency of freshwater inflow events to Nueces Bay.

4.1 Evaluation Assumptions

The identified scenarios are based on the same set of operating assumptions with only the volume and timing of the inflow targets in the Agreed Order being modified between simulations. While the baseline scenario utilizes monthly targets and trigger levels described in the 2001 Agreed Order, the other eleven scenarios utilize alternative monthly inflow targets that result in different bay inflow regimes.

HDR utilized the CCWSM to simulate the CoCC water supply system under the following list of assumptions. Note that all results presented in this study are based on model simulations and not actual storage levels, reservoir operations, and FWI.

- 2020 reservoir conditions (2020 elevation – area – capacity relationships)
    - 2020 reservoir conditions were estimated by adjusting the most recent bathymetric surveys for LCC (2016), CCR (2012), and Lake Texana (2010) for the expected sediment accumulation from the time of the survey to the year 2020.
- Full use of the Lake Texana system (41,840 acre-feet/yr firm plus 12,000 acre-feet/yr interruptible)
- Lake Corpus Christi Target Stabilization Level of 74 ft-msl
- 5.35 MGD municipal & industrial effluent to Nueces Bay
    - This represents the 500 acre-foot return flow credit that is part of the Daily Reservoir System and Pass-Through Status Report maintained by the Nueces River Authority.[12] The return flow credit is representative of discharges into Nueces Bay not originating from the Rincon Pipeline.
- 52% return flow factor applied to all CoCC demands with discharges to the Nueces Estuary (in the model the Nueces Estuary includes both Nueces and Corpus Christi Bay)
- No use of Mary Rhodes Phase 2 (Garwood water)
- Firm Yield was chosen as the system yield being solved
    - The results between firm yield and safe yield are similar with firm yield being slightly more conservative as the system storage draws down below 30% more often, but the following results can be considered applicable to safe yield runs as well.
    - The results are shown as volume changes in firm yield compared to the baseline scenario.

[12] Nueces River Authority Website. https://www.nueces-ra.org/CP/CITY/passthru/index.php

4.2 Comparison of System Yield

Table 4-1 summarizes changes in the system yield compared to the baseline scenario for the eleven alternative scenarios. Results of the simulations indicate that changes to the firm yield from altering the monthly targets are generally small and when compared to the baseline scenario are all less than an absolute value of three percent.

Table 4-1. Summary of Change in Firm Yields from Baseline for Identified Alternative Scenarios

Scenario	Change in Firm Yield Compared to Baseline (acre-feet/yr)	Percent Change in Firm Yield compared to Baseline
Stakeholder 1	1,720	1.0%
Stakeholder 2	-1,864	-1.1%
Stakeholder 3	-1,815	-1.0%
Stakeholder 4	-1,015	-0.6%
Stakeholder 5	-94	-0.1%
Stakeholder 6	1,149	0.7%
Stakeholder 7	4,689	2.7%
HDR	-1,070	-0.6%
Phase 1 UNIFO	-74	0.0%
Phase 1 MJJ	646	0.4%
Phase 1 AMJJAD	-312	-0.2%

Figure 4-1 provides the simulated system storage trace as a percent of total system storage for the firm yield and the simulated annual pass-throughs to Nueces Bay for the baseline scenario. The annual pass-through volumes in the figure represent the amount of inflow passed through the reservoir system to meet the monthly targets and not the total Nueces Bay inflow. The figure illustrates the severity of the recent and new critical drought of record by showing no significant pass-throughs from 2012 through 2015, as the simulated reservoir system spends the majority of this time below 30% system storage (Zone 4) of the Agreed Order targets. As discussed in the Phase 1 study, the last 20 years appears to be drier than the overall period of record from 1934 to 1994. The simulated storage traces and annual pass-throughs for the other scenarios follow similar trends as the baseline scenario with little variability. **This is indicative of a system that is driven more by the inflows into the reservoir system than by the actual monthly inflow targets.** In other words, what drives to a large extent system yield and FWI to the bay is the natural runoff into the reservoirs, not the targets in the Agreed Order. This is important because the ability to manage the FWI pass-throughs will likely be more controlled by what inflows are generated in the system, especially during drought, not by the operating parameters contained in the Agreed Order.

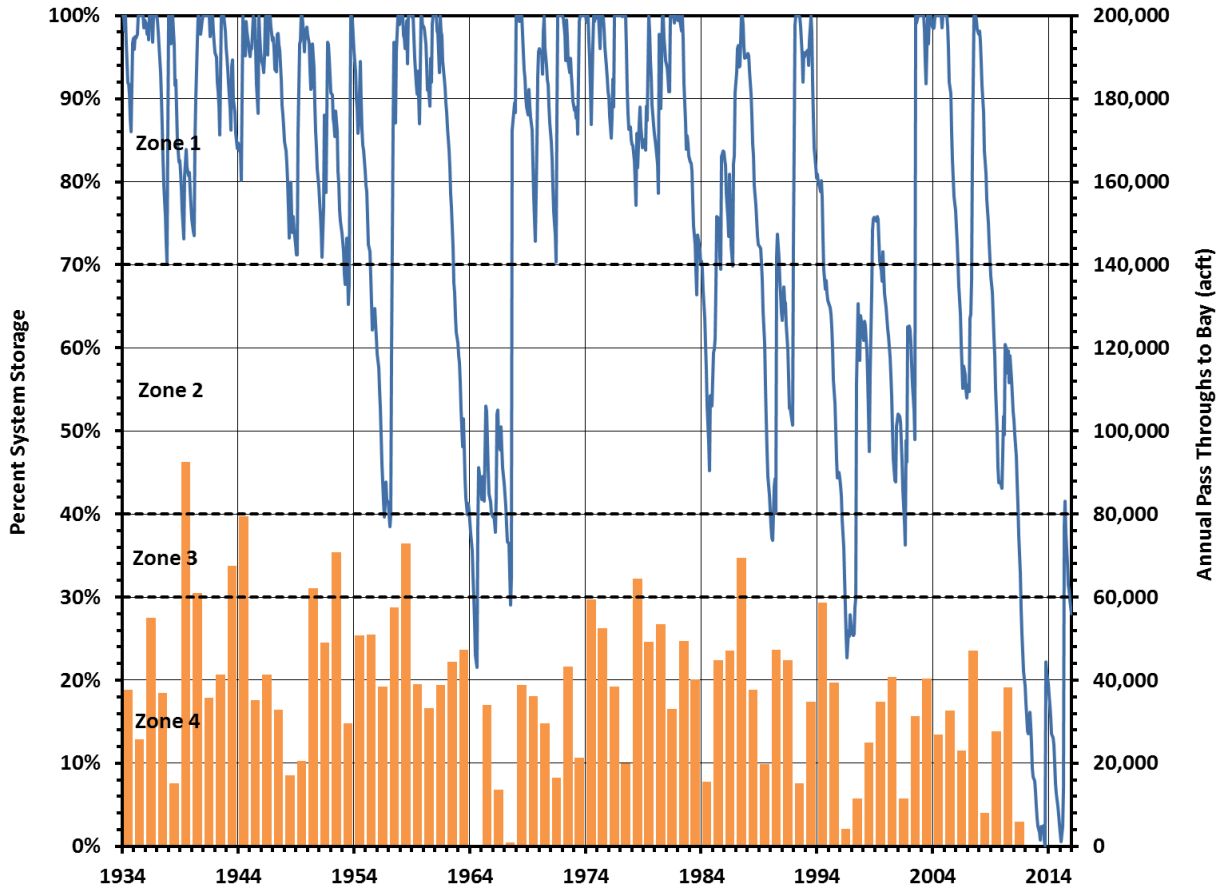

Figure 4-1. Simulated Percent System Storage Trace (blue line; left vertical axis) and Annual Pass-throughs to Nueces Bay (orange bars; right vertical axis) for Baseline Scenario

Figure 4-2 highlights the recent drought for the baseline scenario firm yield simulation. During the recent drought from 2008 to about mid-2011, inflows into the system are limited with only about 7 out of 42 months showing significant pass-throughs during this time. This indicates that the drought is driving the reduction in pass-throughs to Nueces Bay and not the Agreed Order pass-through targets.

Inflow events into the reservoir system during the drought are represented by the inflection points in the simulated storage trace followed by a positive slope, see April and September of 2013 as examples. During the drought when the reservoir system is below 30 percent (mid-2011 to mid-2015), there are about 7 of these events until significant recovery occurs (March and April of 2015) pushing the storage back above 30%. During this time there are no pass-through targets since the system is in Zone 4 and any limited inflow events are important to providing adequate water supply contributing to the yield of the system. Note that the model takes into account runoff originating downstream of Lake Corpus Christi and any return flows entering Nueces Bay and reduces the amount of inflow to be passed accordingly, as these flows count toward meeting the monthly targets. These factors result in the monthly targets having a generally small influence on system yield when compared to the impact of the drought.

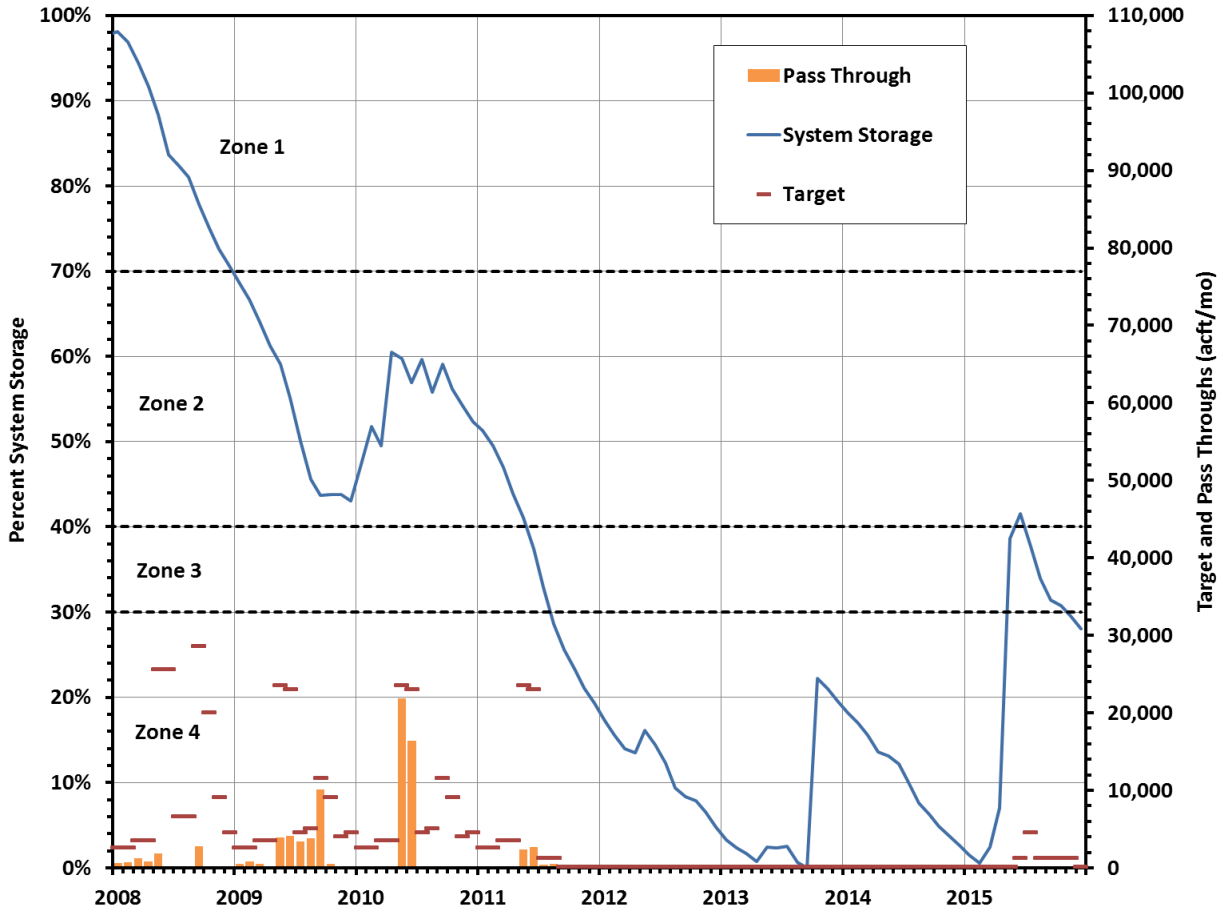

Figure 4-2. Simulated Percent System Storage Trace (blue line; left vertical axis), Monthly Pass-throughs to Nueces Bay (orange bars; right vertical axis) and Monthly Targets (red dashes; right vertical axis) during Recent and New Drought of Record for Baseline Scenario

4.3 Comparison of Freshwater Inflows

Table 4-2 summarizes annual and monthly FWI statistics for the twelve scenarios simulated with the CCWSM. Note that freshwater inflows to Nueces Bay are comprised of reservoir pass-throughs, return flows discharged to the bay, and runoff originating below Lake Corpus Christi and upstream of Nueces Bay. A comparison of the annual median shows less than a 1.1 percent absolute value change in FWI for all scenarios when compared to the baseline scenario. The minimum annual FWI for all but one of the scenarios is 15,902 acre-feet and occurs in 2014.

Table 4-2. Summary of Freshwater Inflow Statistics for All Scenarios

Scenario	Annual FWI to Nueces Bay (acre-feet)				Monthly FWI to Nueces Bay (acre-feet)			
	Median	Percent Change from Baseline	Min	Percent Change from Baseline	Median	Percent Change from Baseline	Min	Percent Change from Baseline
Baseline (Existing Targets)	404,517	---	15,902	---	3,005	---	499	---
Stakeholder 1	402,807	-0.4%	15,902	0.0%	3,182	5.9%	499	0.0%
Stakeholder 2	406,283	0.4%	15,902	0.0%	3,156	5.0%	499	0.0%
Stakeholder 3	406,228	0.4%	15,902	0.0%	2,906	-3.3%	499	0.0%
Stakeholder 4	405,773	0.3%	15,902	0.0%	3,840	27.8%	499	0.0%
Stakeholder 5	404,605	0.0%	15,902	0.0%	3,844	27.9%	499	0.0%
Stakeholder 6	403,571	-0.2%	15,902	0.0%	4,359	45.1%	499	0.0%
Stakeholder 7	400,061	-1.1%	15,902	0.0%	3,324	10.6%	499	0.0%
HDR	405,495	0.2%	15,902	0.0%	4,237	41.0%	499	0.0%
Study 1 Uniform	404,595	0.0%	15,541	-2.3%	4,290	42.7%	499	0.0%
Study 1 MJJ	403,880	-0.2%	15,902	0.0%	3,128	4.1%	499	0.0%
Study 1 AMJJAD	404,807	0.1%	15,902	0.0%	3,182	5.9%	499	0.0%

Figure 4-3 provides the frequency curves of annual FWI for all of the scenarios. The figure shows little variation among the scenarios below the 60th percentile. When the annual FWI are greater than the 60th percentile, all of the scenarios are similar with the exception of the Stakeholder 7 scenario which shows slightly lower flows when compared to the other scenarios. For comparison purposes, the TCEQ adopted standards for annual targets for FWI are also shown on the figure as the red diamonds. All scenarios exceed the 12th and 47th percentile TCEQ annual standards and all scenarios closely match the 95th percentile target.

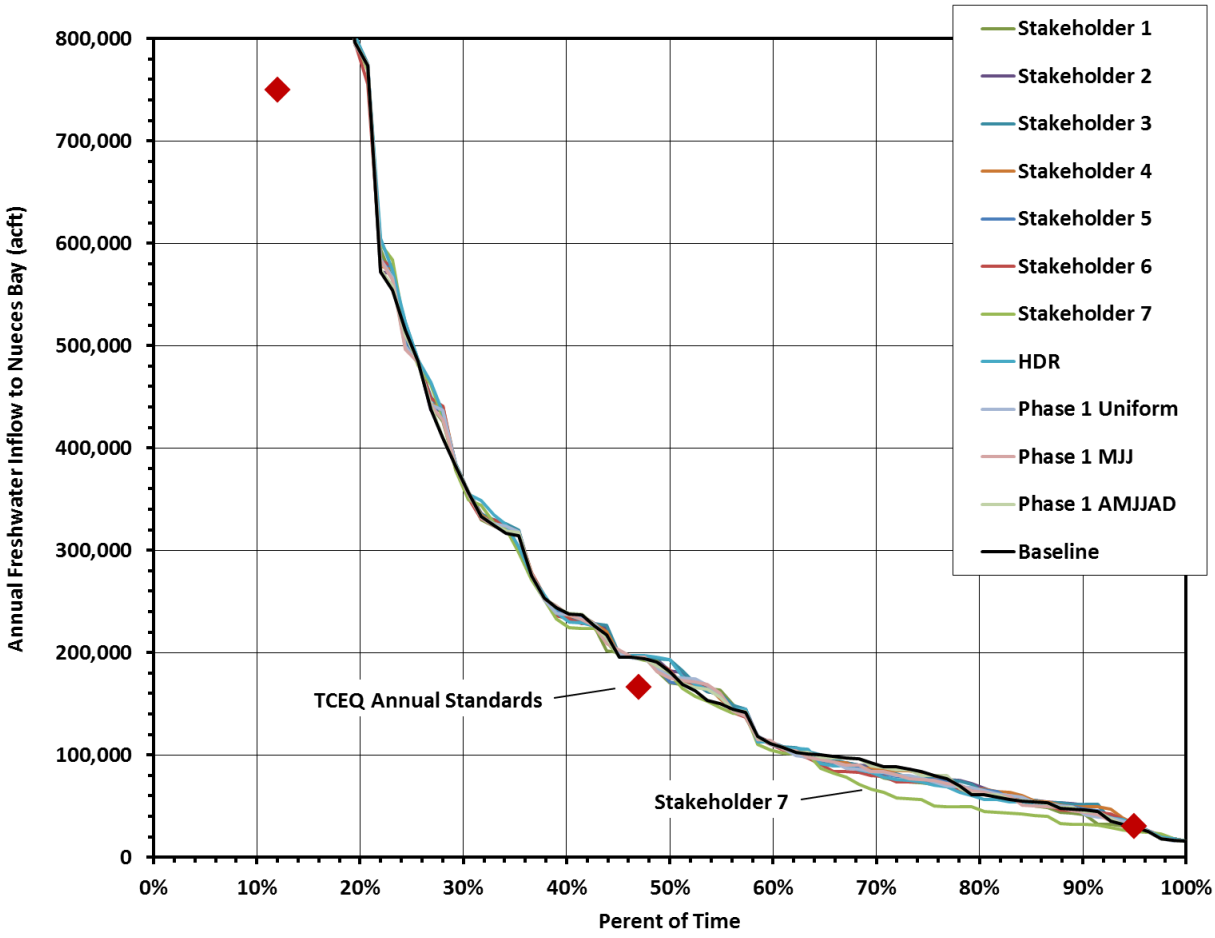

Figure 4-3. Frequency of Annual Freshwater Inflows for All Scenarios

The effects of changes to the monthly patterns among the different scenarios become more apparent when monthly FWI statistics are compared to the baseline as shown in Table 4-2. The change in median monthly FWI for the alternative scenarios ranges from an increase of 45.1 percent to a decrease of 3.3 percent when compared to the baseline scenarios. There is no difference in the minimum monthly FWI of 499 acre-feet per month among the scenarios as this represents a month with no inflow pass-through or ungaged runoff and only the 5.35 MGD of return flows contributing to meeting the monthly target.

Figure 4-4 shows the frequency curves of monthly FWI for all of the scenarios when all the months of the year are considered together. The curves indicate that there is little variability among the scenarios below the 15th percentile as these months are driven by wet periods and likely spill events from the reservoirs. Between the 15th and 30th percentiles, most of the scenarios have lower monthly FWI volumes when compared to the Baseline scenario likely due to the lowering of the targets in months with the larger targets in the baseline. This trend is reversed above the 30th percentile as most of the scenarios have greater monthly FWI volumes compared to the baseline, likely from increasing the targets in more months above the targets in the baseline. These trends are a result of the flatter monthly patterns contained in most of the identified alternative scenarios in which the high targets in some months are reduced and the lower targets in other months are increased.

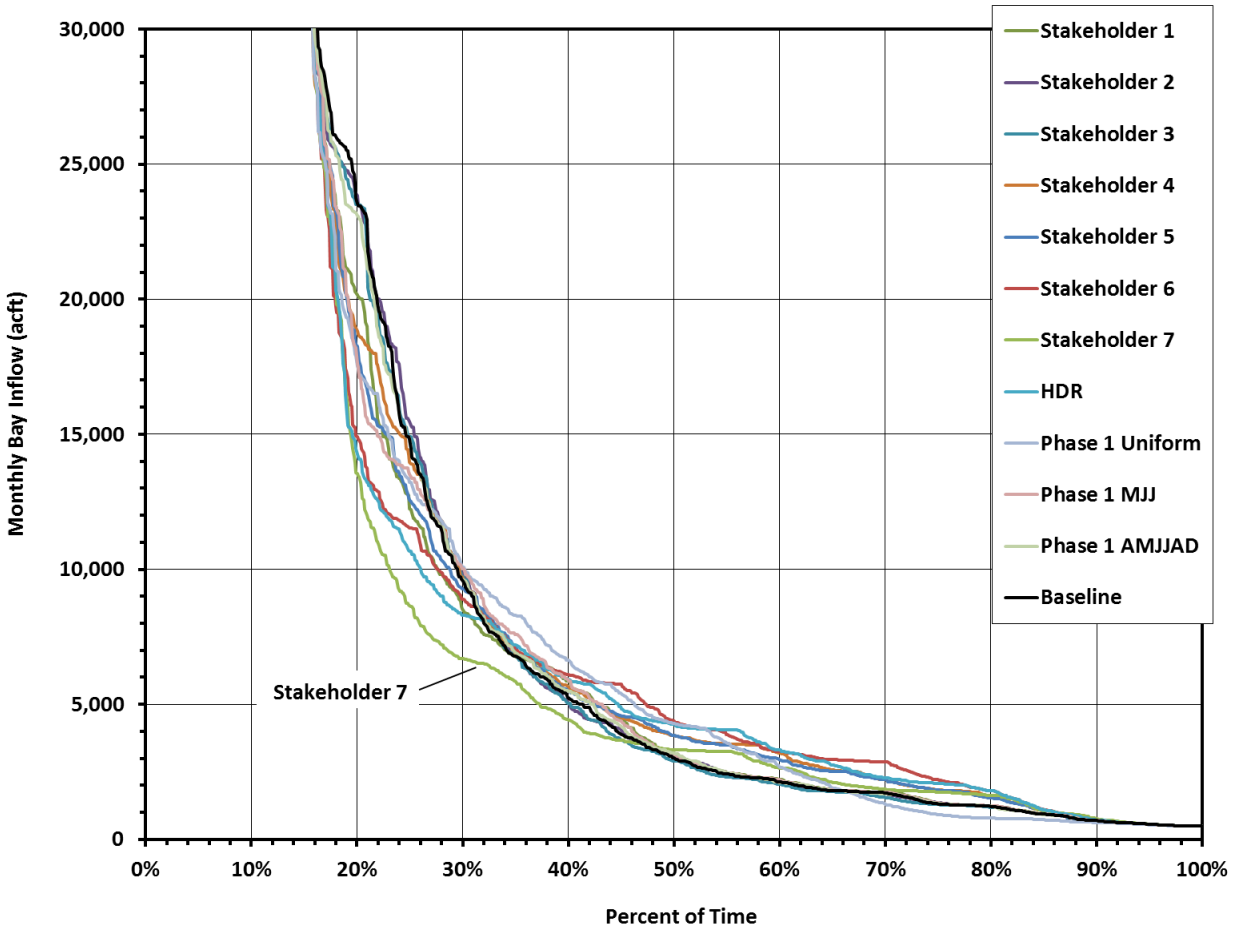

Figure 4-4. Frequency of Monthly Inflows for All Scenarios

Tables D-1 and D-2 in Appendix D provide a comparison of the median FWI by month for all the alternative scenarios to the baseline, also listing a percent change from the baseline. Figure 4-5 is a graphical representation of the median monthly data shown in the Appendix D tables. Whereas Figure 4-4 represents all the months combined, Figure 4-5 presents a comparison of median monthly inflow by month. If a scenario is above the black line representing the baseline then the median monthly inflow for that month is higher than the baseline and vice-versa if it is below the baseline.

For example, in Table 4-2 the Stakeholder 6 scenario shows an overall monthly increase in median monthly inflow of 45%. However when you consider the data presented in Appendix Table D-1, the months with increases bigger than 30% are January – April and November with smaller increases occurring in July, August and September. For this same scenario May, June, and October all have decreases greater than 30% with September decreasing by 17%. These results are represented graphically by the red line in Figure 4-5. Generally the increases come in lower target months and the decreases occur in higher target months. There is no question that changing the Agreed Order targets can change the FWI to the Nueces Bay. However, the question, “Is the change beneficial?” remains to be answered and is outside the scope of this study.

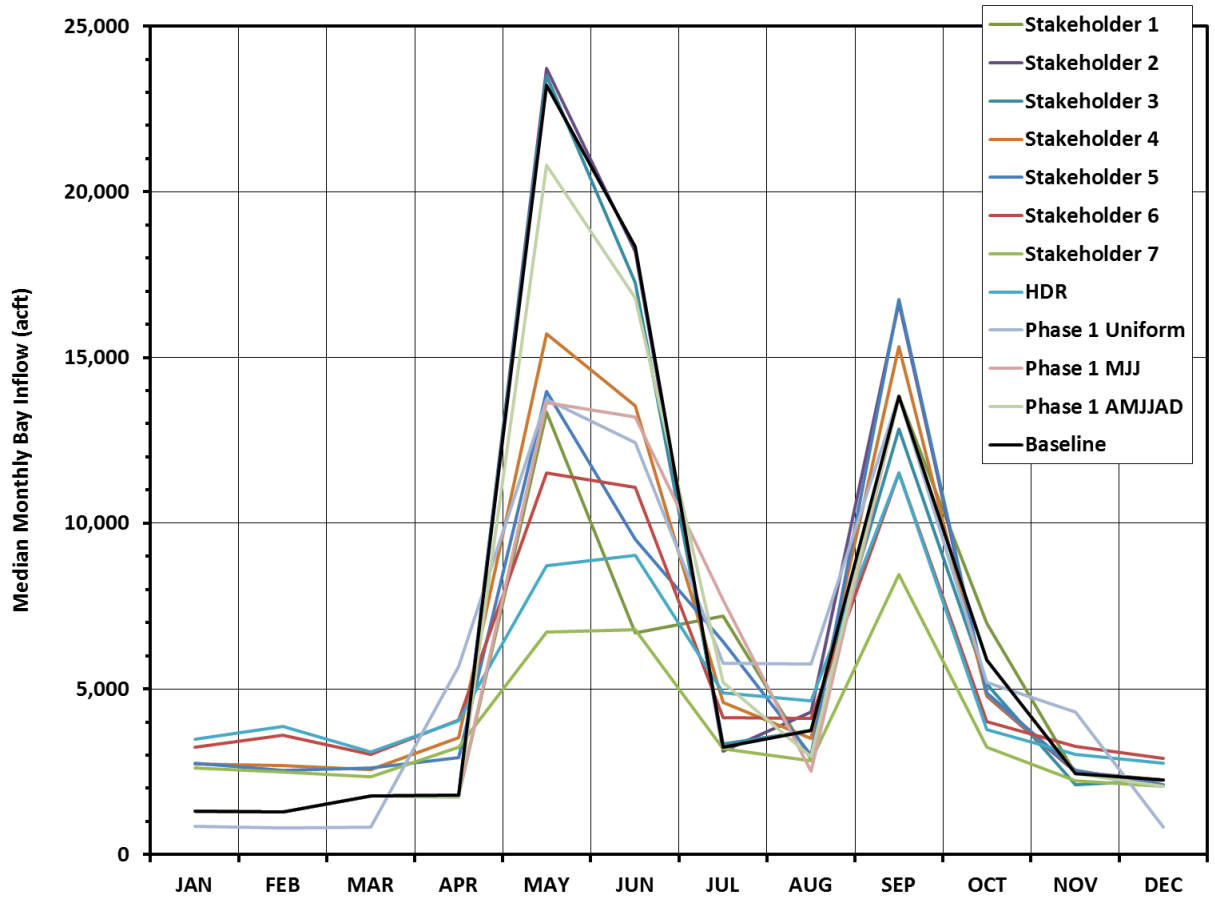

Figure 4-5. Median Freshwater Inflows to Nueces Bay by Month for All Simulated Scenarios

5 Conclusions / Recommendations

This report describes the analyses performed to achieve the goals of the Phase 2 study which are:

- Identify potential alternative monthly target scenarios for the Agreed Order, and
- Evaluate identified scenarios and compare results of system yield and FWI to Nueces Bay for each scenario.

Eleven alternative scenarios of Agreed Order monthly targets and patterns were identified by Stakeholders and HDR. Generally the alternative scenarios redistributed the current annual targets to different monthly patterns and retained the same trigger zones as the existing Agreed Order targets. One scenario added low flow targets in Zone 4 when system storage is greater than 15%.

The CCWSM was used to simulate operations under the existing Agreed Order and the alternative targets from the additional scenarios. The model output was evaluated with a focus on the impacts to system yield and FWI to Nueces Bay. These analyses resulted in the following conclusions.

a) Varying the monthly target amounts and pattern has a small effect (less than an absolute value change of 3%) on the firm yield of the system.

b) Varying the monthly target amounts and pattern has little effect on median annual FWI volumes (range = -1.1% to 0.4%) but does alter the monthly volumes and frequencies.

c) Adding pass-through targets for times when system storage is below 30% results in minimal improvement to FWI as these targets would take effect during times of extreme drought when little inflow occurs.

During the critical drought period which determines the firm yield, inflows into the system are limited, reducing the influence of the Agreed Order pass-through targets on the system yield. During the most critical part of the drought period, system storage is below 30 percent and pass-throughs are not required during this time for all but one of the identified scenarios (Stakeholder 7). This scenario includes a monthly pass-through target of 500 acre-feet when system storage is between 15% and 30%. However, the simulations assume a monthly return flow of 499 acre-feet to the Nueces Bay which meets this target and negates any impact to the firm yield.

A more uniform monthly pattern decreases FWI volumes below the 30th percentile (higher flows) and increases volumes above the 30th percentile (lower flows) when compared to the baseline (as shown in Figure 4-4). Implementing this pattern change in the Agreed Order could increase FWI volume amounts during drier conditions when inflow is available to pass. Adding pass-through targets in excess of 500 acre-feet/month to Zone 4 would likely result in increased reductions in system yield.

5.1 Potential for a Pilot Study for Altering the Agreed Order Targets

One potential stakeholder-suggested action based on the results of this study is the development of a pilot study to evaluate implementation of modified Agreed Order monthly targets. Based on the findings of this study, it is challenging to recommend a pilot study to modify the monthly targets contained in the Agreed Order solely on the basis of volume of water delivered to Nueces Bay as pass-through of inflow. However, the results of this study show the timing and quantities of water delivered as pass-throughs to Nueces Bay which may inform future modification of the Agreed Order targets. What is missing is a biological link from FWI to species abundance / biological productivity. The results of this study indicate that there could be opportunities to adaptively manage the system in such a way to provide flow when it is potentially more critically needed, but without data indicating a high likelihood of desirable biological response to the

modified flows, a pilot study would be based on an incomplete hypothesis lacking an expected outcome. The results show that the ability to impact median bay flow on an annual basis is small, but on a monthly basis for a given scenario (Stakeholder 6, for example) there are months that show increases in the monthly median of 181% and other months that show decreases of 50%. It seems premature to make a recommendation for a specific modification to the monthly Agreed Order targets for a pilot study without a linkage to indicate how these modifications correlate to a biological response.

At a minimum, the results of these scenarios could be systematically evaluated using the harvest-inflow equations developed for the Nueces Estuary[13]. This would at least provide some quantitative measure of biological responses of key commercial / recreational species (serving as indicators of estuarine health) that could be expected from the implementation of alternative Agreed Order monthly targets.[14] For more robust relationships relating changes in FWI to biological responses, the harvest-inflow equations could be updated using more recent data or abundance-inflow relationships could be derived using decades of TPWD data. These equations or relationships could be developed as part of the Nueces BBASC Work Plan under some of the recommended, related studies such as: Relationships between salinity and fish/shellfish abundance; or Relationships between freshwater inflow and ecological health. Similar work is being performed to develop species abundance correlations to inflow for the Guadalupe Estuary which could be used in validation or refinement of freshwater inflow standards. Updated harvest equations and/or new abundance relationships for the Nueces Estuary, combined with the results of this study using updated hydrology could be the most efficient method to provide the biological linkage that should be established before proceeding with a pilot study. The CCWSM could readily be modified to include updated harvest (and/or abundance) - inflow relationships and then used to explore the potential biological ramifications of modifications to freshwater inflow targets in the Agreed Order, potentially leading to a pilot study.

One other component that is worth mentioning is the use of stored water from the water supply system. The results of the study indicate that during the most recent drought there were over four years with no significant pass-throughs to the bay (Figure 4-2). Some kind of adaptive management agreement that adequately protects the water supply interests of the CoCC while providing the potential for at least limited releases of water from storage in times of critical drought could provide much needed freshwater inflow to the bay during these critical times. The CCWSM could be updated to evaluate these types of stored water scenarios in future Nueces BBASC work plan studies. As suggested in the preceding paragraph, such updates could include relationships linking FWI to expected biological responses. A study could be completed to modify the CCWSM code to allow for this type of adaptive management using stored water and the evaluation of various scenarios. The benefit would be a better understanding of how stored water can be used to adaptively manage FWI as part of a modified Agreed Order.

There are other studies underway as part of the Nueces BBASC work plan effort to identify alternative sources of water for the Nueces Bay, which may prove to be a more economical and politically expedient than the use of stored water from the reservoir system. Additional study to look at the results of all the work plan study efforts should be undertaken to bring all the various pieces of work together to identify the consensus path forward with regards to modifying the Agreed Order targets and ultimately ways to manage the water resources of the Nueces Bay.

[13] TPWD & TWDB, *Freshwater Inflow Recommendation for the Nueces Estuary*, September 2002.

[14] For example, comparison of the baseline and stakeholder 6 scenario long-term average fisheries harvest, using the existing harvest-inflow equations for the Nueces Estuary, suggests that Brown Shrimp harvest might increase by 5.8% and Speckled Trout harvest might decrease by 8% with an overall harvest increase for the 7 species of 3.4% with implementation of scenario stakeholder 6.

6 References

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APPENDIX A – 2001 TCEQ Agreed Order

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FILE

TEXAS NATURAL RESOURCE CONSERVATION COMMISSION

WATER

APR 05 2001

ADMINISTRATION

AN AGREED ORDER Amending the operational procedures and continuing an Advisory Council pertaining to Special Condition 5.B., Certificate of Adjudication No. 21-3214; Docket No. 2001-0230-WR

On April 4, 2001, came to be considered before the Texas Natural Resource Conservation Commission ("Commission") the Motion by the City of Corpus Christi and Nueces River Authority for the adoption of an amendment to the Agreed Order issued April 28, 1995, establishing operating procedures pertaining to Special Condition 5.B., Certificate of Adjudication No. 21-3214, held by the City of Corpus Christi, the Nueces River Authority, and the City of Three Rivers" (the two cities and river authority shall be referred to herein as "Certificate Holders"). The Certificate Holders and the Executive Director of the Texas Natural Resource Conservation Commission have agreed to the provisions of this Agreed Order.

The City of Corpus Christi (managing entity) requests that Section 2 of this Agreed Order be amended to add further detail to the provisions regarding the use of water for bays and estuaries and to make changes in the required passage of inflows for the bays and estuaries automatic at 40 percent and 30 percent of total reservoir system capacity upon institution of mandatory outdoor watering restrictions. Additionally, Certificate Holders request the most recent bathymetric surveys be used for determining reservoir system storage capacity. The Certificate Holders request details be added regarding provisions for two projects to enhance/augment the amount of freshwater going into the receiving estuary and timelines for those projects.

After considering the proposals and the presentations of the parties, the Commission finds that it has authority to establish operational procedures under Special Condition 5.B. of Certificate of Adjudication No. 21-3214, and that operational procedures previously established should be amended. The Commission finds that, because of the need to continue to monitor the ecological environment and health of related living marine resources of the estuaries to assess the effectiveness of freshwater inflows provided by requirements contained in this Agreed Order relating to releases and spills from Choke Canyon Reservoir and Lake Corpus Christi (collectively referred to as the Reservoir System), as well as return flows, and to evaluate potential impacts which may occur to the reservoirs as well as to the availability of water to meet the needs of the Certificate Holders and their customers which may result from those operational procedures, the existing advisory council should be maintained to consider such additional information and related issues and to formulate recommendations for the Commission's review.

The Commission additionally finds that based on the preliminary application of the Texas Water Development Board's Mathematical Programming Optimization Model, (GRG-2), 138,000 acre-feet of fresh water is necessary to achieve maximum harvest in the Nueces Estuary; and, therefore, when water is impounded in the Lake Corpus Christi-Choke Canyon Reservoir System to the extent greater than 70 percent of the system's storage capacity, the delivery of 138,000

acre-feet of water to Nueces Bay and/or the Nueces Delta, by a combination of releases and spills, together with diversions and return flows noted below, should be accomplished; and that during periods when the reservoir system contains less than 70 percent storage capacity, reductions in releases and spills, along with diversions and return flows, are appropriate in that a satisfactory level of marine harvest will be sustained and the ecological health of the receiving estuaries will be maintained.

The Commission finds that return flows, other than to Nueces Bay and/or the Nueces Delta, that are delivered to Corpus Christi Bay and other receiving estuaries are currently in the assumed mount of 54,000 acre-feet per annum (per calendar year), and that they shall be credited at this amount until such time as it is shown that actual return flows to Corpus Christi Bay and other receiving estuaries exceed 54,000 acre-feet per annum.

The Commission finds that by contractual relationships, the City of Corpus Christi is the managing entity for operating the Reservoir System.

The Commission finds that the Motion by the City of Corpus Christi and Nueces River Authority to Amend this Agreed Order is reasonable and should be granted. Benefits of the proposed diversion project and operating changes will include increased water supply, increased reservoir storage levels, increased positive flow events for Rincon Bayou and the upper Nueces Delta, increased sources of nitrogen for the upper delta, and lower salinity levels in the upper delta.

When the Commission uses the word "release" in this Order, release means spills, inflow passage, intentional releases, and return flows; provided, however, under this Order no release from storage is required to meet conditions of this Order.

By consenting to the issuance of this Agreed Order, no party admits or denies any claim, nor waives with respect to any subsequent proceeding any interpretation or argument which may be contrary to the provisions of this Agreed Order.

NOW, THEREFORE, BE IT ORDERED BY THE TEXAS NATURAL RESOURCE CONSERVATION COMMISSION THAT:

1. a. The City of Corpus Christi, as operator of the Choke Canyon/Lake Corpus Christi reservoirs (the "Reservoir System"), shall provide not less than 151,000 acre-feet of water per annum (per calendar year) for the estuaries by a combination of releases and spills from the Reservoir System at Lake Corpus Christi Dam and return flows to Nueces and Corpus Christi Bays and other receiving estuaries (including such credits as may be appropriate for diversion of river flows and/or return flows to the Nueces Delta and/or Nueces Bay), as computed and to the extent provided for herein.

   b. When water impounded in the Reservoir System is greater than or equal to 70 percent of storage capacity, a target amount of 138,000 acre-feet is to be delivered to Nueces Bay and/or the Nueces Delta by a combination of releases and spills from

Delta. Inflow passage from the Reservoir System for the purpose of compliance with the monthly targeted amounts prescribed in subparagraphs 1.b. and 1.c. shall in no case exceed the estimated inflow to Lake Corpus Christi as if there were no impoundment of inflows at Choke Canyon Reservoir. The estimated inflow to Lake Corpus Christi as if there were no impoundment of inflows at Choke Canyon Reservoir shall be computed as the sum of the flows measured at the U.S. Geological Survey (USGS) STREAMFLOW GAGING STATIONS ON THE Nueces River near Three Rivers (USGS No. 08210000), Frio River at Tilden, Texas (USGS No. 08206600), and San Miguel Creek near Tilden, Texas (USGS No. 08206700) less computed releases and spills from Choke Canyon Reservoir.

e. The passage of inflow necessary to meet the monthly targeted allocations may be distributed over the calendar month in a manner to be determined by the City. Relief from the above requirements shall be available under subparagraphs (1) or (2) below and Section 2.(b) and 3.(c) at the option of the City of Corpus Christi. However, passage of inflow may only be reduced under one of those subparagraphs below, for any given month.

(1) Inflows to Nueces Bay and/or the Nueces Delta in excess of the required monthly targeted amount may be credited for up to fifty (50) percent of the targeted requirement for the following month, based on the amount received.

(2) When the mean salinity in Upper Nueces Bay (Lat. 27°51'02", Long. 97°28'52") for a 10-day period, ending at any time during the calendar month for which the reduction of the passage of inflow is sought, is below the SUB*, pass through of inflow from the reservoir system for that same calendar month may be reduced as follows:

(a) For any month other than May, June, September and October, if 5 parts per thousand (ppt) below the SUB for the month, a reduction of 25% of the current month's targeted Nueces Bay inflow;

(b) If 10 ppt below the SUB for the month, a reduction of 50 % of the current month's targeted Nueces Bay inflow except that credit under this provision is limited to 25 % during the months of May, June, September and October;

* "SUB" means "salinity upper bounds" as set forth more specifically in Section 3.b.

(c) If 15 ppt below the SUB for that month, a reduction of 75% of the current month's targeted Nueces Bay inflow.

f. The City of Corpus Christi shall submit monthly reports to the Commission containing daily inflow amounts provided to the Nueces Estuary in accordance with this Agreed Order through releases, spills, return flows and other freshwater inflows.

2. a. Certificate holders are to provide in any future contracts or any amendments, modifications or changes to existing contracts the condition that all wholesale customers and any subsequent wholesale customers shall develop and have in effect a water conservation and drought management plan consistent with Commission rule. The City of Corpus Christi shall solicit from its customers and report to the Commission annually the result of conservation under the City's plan, the customers' plans, and the feasibility of implementing conservation plans and programs for all users of water from the reservoir system. This report shall be submitted with the Certificate Holder's annual water use report as provided by 31 T.A.C. §295.202.

b. The Certificate Holders may reduce targeted Nueces Bay inflows during times of prolonged drought in accordance with this subparagraph 2.

(1) When the combined storage in the Choke Canyon/Lake Corpus Christi reservoir system (Reservoir System Storage) falls below 50% of the total system storage capacity, the City of Corpus Christi shall issue public notice advising and informing the water users of the region of voluntary conservation measures that are requested immediately and required drought management measures to be taken should the Reservoir System Storage fall to under 40% and/or 30% of total system storage capacity. To the extent of its legal authority, the City of Corpus Christi shall require its wholesale customers to issue public notice advising and informing the water users of the region of voluntary conservation measures that are requested immediately and required drought management measures to be taken should the Reservoir System Storage fall to under 40% and/or 30% of total system storage capacity.

(2) In any month when Reservoir System Storage is less than 40%, but equal to or greater than 30% of total system storage capacity, the City of Corpus Christi shall implement time of day outdoor watering restrictions and shall reduce targeted inflows to Nueces Bay to 1,200 acre-feet per month (1,200 acre-feet per month represents the quantity of water that is the median inflow into Lake Corpus Christi during the drought of record). Time of day outdoor watering restrictions prohibit lawn watering between the hours of 10:00 o'clock a.m. and 6:00 o'clock p.m. and are subject to additional conditions as described in the City of Corpus Christi's approved "Water Conservation and Drought Contingency Plan ("Plan")." To the extent of its legal authority, the City of Corpus Christi shall require its wholesale customers to implement time of day outdoor watering restrictions similar to those of the City.

(3) In any month when Reservoir System Storage is less than 30% of total system storage capacity, the City of Corpus Christi shall implement a lawn watering schedule in addition to time of day outdoor watering restrictions (see subparagraph 2.b.(2)) and shall suspend the passage of inflow from the Reservoir System for targeted inflows to Nueces Bay. However, return flows directed into Nueces Bay and/or the Nueces Delta shall continue. The lawn watering schedule shall allow customers to water lawns no oftener than every five days, subject to the time of day restrictions described in subparagraph 2.b.(2) and any additional conditions as described in the City's Plan.

(4) Certificate Holders' may implement whole or partial suspension of the passage of inflow through the reservoir as described above when the City implements, and requires its customers to implement, water conservation and drought management measures at diminished Reservoir System levels, as set forth in subparagraphs b.(2) and b.(3).

c. For purposes of this Agreed Order, Reservoir System storage capacity shall be determined by the most recently completed bathymetric survey of each reservoir. As of 2001, completed bathymetric surveys of each reservoir reports conservation storage capacities of 695,271 acre-feet (below 220.5 feet mean sea level) for Choke Canyon Reservoir (Volumetric Survey of Choke Canyon Reservoir, TWDB September 23, 1993) and 241,241 acre-feet (below 94 feet mean sea level) for Lake Corpus Christi (Regional Water Supply Planning Study-Phase I Nueces River Basin, HDR, December, 1990).

d. Percentage of the Reservoir System capacity shall be determined on a daily basis and shall govern, in part, the inflow to be passed through the reservoir during the remaining days of the month.

e. Within the first ten days of each month, the City of Corpus Christi shall submit to the Commission a monthly report containing the daily capacity of the Reservoir System in percentages and mean sea levels as recorded for the previous month as well as reservoir surface areas and estimated inflows to Lake Corpus Christi assuming no impoundment of inflows at Choke Canyon Reservoir. The report shall indicate which gages or measuring devices were used to determine Reservoir System capacity and estimate inflows to Lake Corpus Christi.

f. Concurrent with implementing subparagraphs 2.b.(1) through 2.b.(3), the City shall proceed to:

1. Acquire land rights to properties necessary to re-open the Nueces River Overflow Channel and make the Nueces River Overflow Channel and Rincon Bayou Overflow Channel permanent features of the Rincon Bayou Diversion;

2. Construct and operate a conveyance facility to deliver up to 3,000 acre-feet per month of required Reservoir System "pass-throughs" directly from the Calallen Pool into the Upper Rincon Bayou by use of one or two of the five authorized points of diversion under Certificate of Adjudication No. 2464, being the existing San Patricio Municipal Water District point of diversion and/or a point on the North bank of the Calallen Pool located at Latitude 27.8823°N, Longitude 97.6254°W, also bearing S 27° 24' W, 4,739 feet from the southwest corner of the J.H.W. Ottman Survey, Abstract No. 212, San Patricio County, Texas, where the water will be pumped at the maximum rate of 45,000 gpm; and

3. Implement an on-going monitoring and assessment program designed to facilitate an "adaptive management" program for freshwater inflows into the Nueces Estuary.

4. Construction necessary to implement subparagraph 2.f.1. shall be accomplished by December 31, 2001 and work necessary to accomplish subparagraph 2.f.2. shall be accomplished by December 31, 2002.

5. In the event the City fails to timely complete the work set forth in subparagraphs 2.f.1. and 2.f.2., this amendment shall automatically terminate and the provisions of the Agreed Order of April 28, 1995 shall be reinstated and become operative despite this amendment, unless the Executive Director grants a modification after considering the recommendations of the Nueces Estuary Advisory Council.

g. The Executive Director is delegated authority to make modifications to subparagraph 2.f., after considering the recommendations of the Nueces Estuary Advisory Council. However, changes may be made through this process only with the City's consent if the changes result in increased costs to the City.

If the Executive Director makes modifications to subparagraph 2.f. as authorized in this paragraph, any affected person may file with the chief clerk a motion for reconsideration of the Executive Director's action no later than 23 days after the date the Executive Director mails notice of the modification to the City. This motion shall be considered under the provisions of 30 Texas Administrative Code § 50.39(d) and (e).

h. The City shall obtain all necessary permits from the Commission before beginning these projects. The deadlines set out above include time necessary to apply for, process and, if necessary, complete hearings on these permits.

3. a. The City of Corpus Christi, with the assistance and/or participation of federal, state and local entities, shall maintain a monitoring program to assess the effect of this

operating plan on Nueces Bay. The cornerstone of this program is the development of a salinity monitoring program. The program shall include at least two monitoring stations, one in upper Nueces Bay (Lat. 27°51'02", Long. 97°28'52") and one in mid Nueces Bay (Lat. 27°51'25", Long. 97°25'28") with the capability of providing continuous salinity and/or conductivity data, temperature, pH, and dissolved oxygen levels. Additional stations may be established at the recommendation of the Advisory Council (continued by paragraph 4 of this Agreed Order) to assess inflow effects throughout the estuarine system, but the City shall not be obligated to establish such additional stations except to the extent authorized by its City Council.

b. The City of Corpus Christi or its designated representatives shall monitor salinity levels in Upper and Mid-Nueces Bay. The lower (SLB) and upper (SUB) salinity bounds (in parts per thousand-ppt) developed for application of the Texas Estuarine Mathematical Programming Model and considered appropriate for use herein, are as follows:

	SLB	SUB		SLB	SUB
January	5	30	July	2	25
February	5	30	August	2	25
March	5	30	September	5	20
April	5	30	October	5	30
May	1	20	November	5	30
June	1	20	December	5	30

c. When the average salinity for the third week (the third week includes the seven days from the 15th through 21st) of any month is at or below the subsequent month's established SLB for upper Nueces Bay (Lat. 27°51'02", Long. 97°28'52"), no releases from the Reservoir System to satisfy targeted Nueces Bay inflow mounts shall be required for that subsequent month.

d. All data collected as a result of the monitoring program required by paragraph 3 of this Agreed Order shall be submitted monthly to the Commission within the first ten days of the immediately following month. The Nueces Estuary Advisory Council shall study the feasibility of developing a method of granting credits for inflows which exceed the required amounts to replace the credits that are set out in subparagraph 1.e.(1) and make recommendations to the Commission for possible implementation. That method shall have as its goal the maintenance of the proper ecological environment and health of related living marine resources and the provision of maximum reasonable credits towards monthly inflow requirements.

4. a. To assist the Commission in monitoring implementation of this Order and making recommendations to the Commission relating to any changes to this Agreed Order and the establishment of future operating procedures, the Nueces Estuary Advisory

Council shall be continued. Its members shall include, but are not limited to a qualified representative chosen by each of the following entities or groups: the Executive Director of the Texas Natural Resource Conservation Commission, whose representative shall serve as chair;the Texas Water Development Board; the Texas Parks and Wildlife Department; the Texas Department of Health; the General Land Office; the holders of Certificate of Adjudication No. 21-3214 (the Cities of Corpus Christi and Three Rivers and the Nueces River Authority; the University of Texas Marine Science Institute; Texas A&M University - Corpus Christi; Save Lake Corpus Christi; Corpus Christi Chamber of Commerce; the City of Mathis; Coastal Bend Bays and Estuaries Program, Inc.; a commercial bay fishing group; a conservation group (e.g. the Sierra Club and the Coastal Bend Bays Foundation); wholesale water suppliers who are customers of the Certificate Holders (e.g., the South Texas Water Authority and the San Patricio Municipal Water District); the Port of Corpus Christi Authority; and a representative of industry. The representatives should have experience and knowledge relating to current or future water use and management or environmental and economic needs of the Coastal Bend area.

b. No modification shall be made to this Order without the unanimous consent of the Certificate Holders, except to the extent provided by law.

c. Matters to be studied by the Nueces Estuary Advisory Council and upon which the Executive Director shall certify recommendations to the Commission shall include, but are not limited to:

(1) the effectiveness of the inflow requirements contained in this Agreed Order on Nueces Estuary and any recommended changes;

(2) the effect of the releases from the Reservoir System upon the aquatic and wildlife habitat and other beneficial and recreational uses of Choke Canyon Reservoir and Lake Corpus Christi;

(3) the development and implementation of a short and long-term regional water management plan for the Coastal Bend Area;

(4) the salinity level to be applied in Paragraphs 1.e. and 3.c., at which targeted inflows in the subsequent month may be suspended;

(5) the feasibility of discharges at locations where the increased biological productivity justifies an inflow credit computed by multiplying the amount of discharge by a number greater than one; and development of a methodology for granting credits for inflows which exceed the required amount to replace the credits that are set out in subparagraph 1.e. That methodology shall have as its goal the maintenance of the proper ecological

environment and health of related living marine resources and the provision of maximum reasonable credits towards monthly inflow requirements; and,

(6) any other matter pertinent to the conditions contained in this Agreed Order.

5. This Agreed Order shall remain in effect until amended or superseded by the Commission.

Issued date: APR 05 2001

TEXAS NATURAL RESOURCE
CONSERVATION COMMISSION

Robert J. Huston, Chairman

APPENDIX B – Presentation to NEAC

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NUECES BBASC STUDY

RE-EXAMINATION OF THE 2001 AGREED ORDER MONTHLY TARGETS – PHASE 2

NEAC – MAY 1, 2017
CORY SHOCKLEY

DISCUSSION

01 **SOW**

02 **Scenarios**

03 **New Drought of Record**

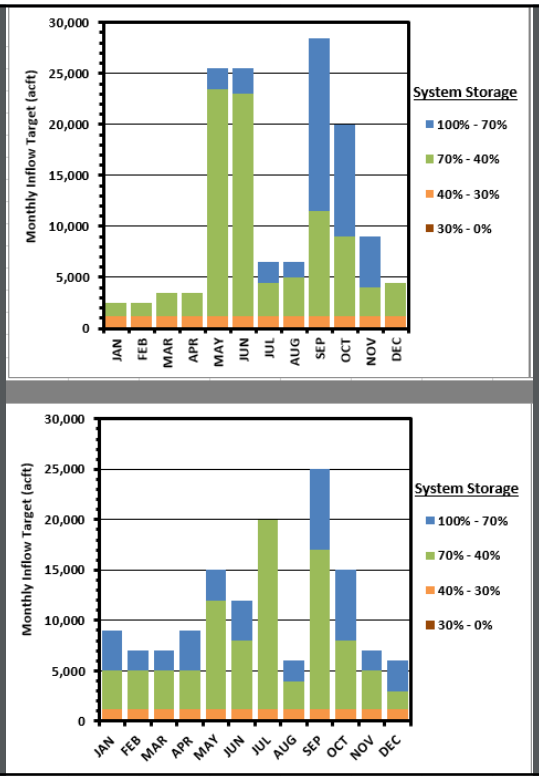
04 **Schedule**

SOW

- Re-examine the 2001 Agreed Order Monthly Targets
- How sensitive are the FWI and System Yield to the Targets in the Agreed Order?
  - Identify Scenarios
    - Stakeholder input
    - Results from Phase 1
  - Perform Scenario Simulations
    - CCWSM
    - Compare System Yields & FWI
  - Report
    - Recommendations for a 10-year pilot project

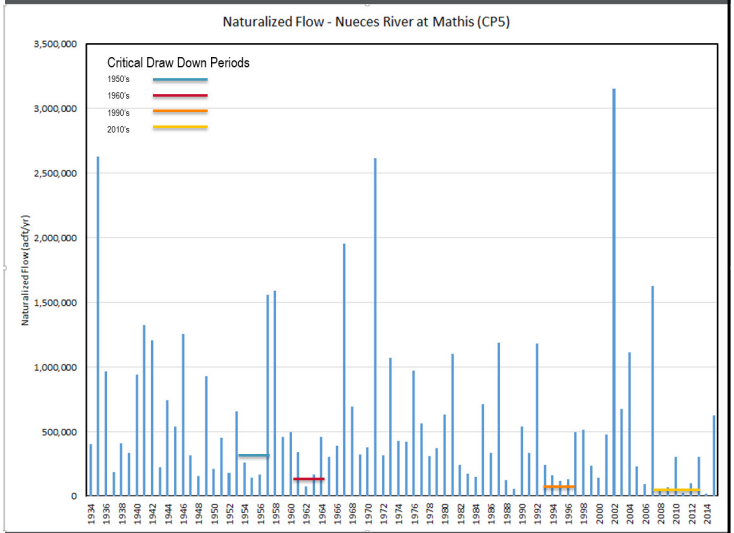
SCENARIOS

- Email Request – 13 April
  - 9 Responses
  - 10 Scenarios
- Two Themes
  - Shifting of High Flow Target Months
  - More Uniform Distribution
- Last Chance for "What-if" Requests
- Next Step: Simulation of Scenarios
  - Focus on
    - Yield
    - FWI



CCWSM HYDROLOGY UPDATES

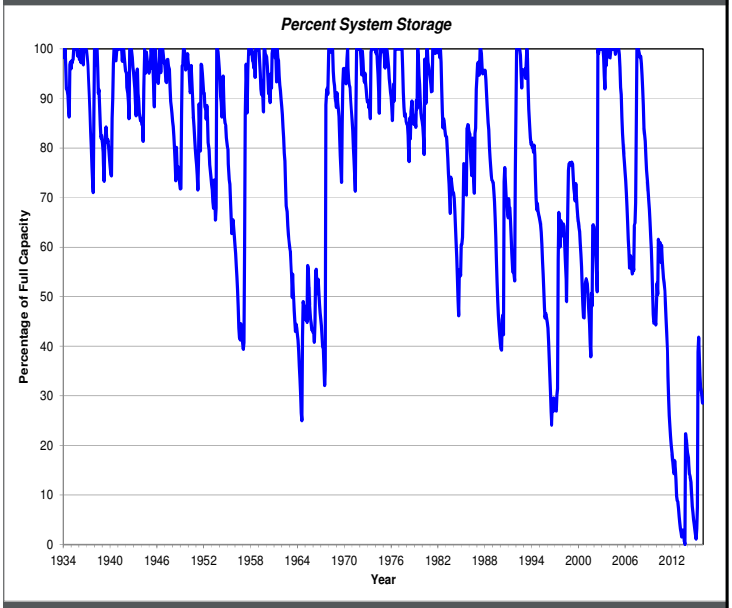
- Extend Period of Record Hydrology
  - 2004 – 2015
  - Naturalized Flows
  - Evaporation
  - Reservoir EAC's
  - Ungaged Runoff below LCC
- New Drought of Record
  - Nueces Basin
  - Colorado River
  - Evaporation
    - 2011 highest net evap year
    - CCR = 5.16', LCC = 4.66', Tex = 4.16'



CCWSM – NEW DROUGHT

- Recent Drought = Critical Drought
- System has not refilled yet

- For Scenario Evaluations
  - Longer Period of Record
  - More Severe Critical Period
  - Yield and FWI Sensitivity
    - Agreed Order Monthly Targets
    - System Storage Triggers



SCHEDULE

- Scenario Evaluation – May
- Draft Report – June
- Final Report – July / August

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APPENDIX C – Scope of Work for the Nueces BBASC Work Plan Study #1, Phase 2

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Texas Water Development Board (TWDB)

Nueces River and Corpus Christi and Baffin Bays Basin and Bay Area Stakeholder Committee (Nueces BBASC)

Re-Examination of the 2001 Agreed Order Monthly Targets: Phase 2 Scope of Work

July 26, 2016

HDR will perform the professional engineering services described in this Scope of Work. Services include re-examination of the 2001 Agreed Order Monthly Targets.

Background

The Nueces BBASC is requesting that this project be completed to re-examine the monthly pass-through targets that are part of the 2001 Agreed Order between the City of Corpus Christi (CoCC or City) and the Texas Commission on Environmental Quality (TCEQ). As described in Section 4.1 of the Nueces BBEST Report, it is believed that there has been a seasonal shift in inflows to Nueces Bay and the Choke Canyon Reservoir / Lake Corpus Christi (CCR/LCC) System that serves as the CoCC primary water supply. The Nueces BBASC report, in Section 2.3, suggests that opportunities to better manage limited freshwater inflows may be identified by reviewing new data that were not available during development of the 1995 Agreed Order, which is the basis for current pass-through operations of the reservoir system. Phase 1 of this work was completed in the previous round of BBASC work plan funding, and looked at current hydrologic data to identify possible shifts in the hydrologic regime specific to bay and estuary inflows. This phase will consider the results of the Phase 1 work and input from area stakeholders to identify and evaluate new scenarios for the Agreed Order Monthly Targets.

HDR developed the Corpus Christi Water Supply Model (CCWSM) for the CoCC and other regional interests to simulate operations of the City's water supply system under the Agreed Order. One use of the CCWSM is to determine the yield of the system under a variety of operating scenarios. Currently, the City uses a safe yield of 205,000 acft/yr (including Lake Texana), with a reserve of 125,000 acft in the CCR/LCC System, as its supply number for planning purposes. HDR is currently updating the CCWSM under separate contract with the CoCC to include hydrologic data through 2015, and to determine new safe yields of the system considering updated hydrologic information.

Organization of Scope of Work

Under this Scope of Work, HDR will perform three major tasks to re-examine the 2001 Agreed Order monthly targets:

Task 1: This task will seek to identify scenarios of variations of the Agreed Order monthly targets, with a focus on moving target volumes from higher target months to lower target months. This task will rely upon the related Phase 1 work conclusions and on input from area stakeholders, such as the Nueces Estuary Advisor Council (NEAC), for identifying scenarios.

Task 2: This task will focus on performing the model simulations for the scenarios identified in Task 1 and summarizing the results with a focus on freshwater inflows to the Nueces Bay and resulting change on safe yield of the system.

Task 3: HDR anticipates providing a result presentation to the NEAC group, as well as delivering a draft report for review and then a final with incorporated comments. If project results are favorable, the report is expected to contain a plan for advising a 10-year pilot project with new, modified monthly inflow targets for the purpose of improving the management of freshwater resources of the Nueces Bay and Delta.

Task 1. Identify New Agreed Order Monthly Targets

Specific subtasks associated with this task are as follows.

Task 1.1 Identify potential Agreed Order Monthly Patterns

HDR will review the Phase 1 project to identify potential scenarios for evaluation. HDR will meet (1 meeting) with stakeholders of the NEAC and / or the Nueces BBASC to receive input on additional scenarios for simulation. This meeting may take place in person in the Corpus Christi area or over teleconference or email. HDR anticipates that up to fifteen (15) different scenarios may be identified for evaluation. This number could be fewer depending on the feedback received from stakeholders. It is possible that the scenario results will provide the potential for additional scenarios to be identified from the original set. HDR anticipates that ten (10) or so scenarios will be identified from stakeholders with another five (5) being identified during the evaluation analysis.

Task 2. Perform Scenario Simulations

HDR will perform model simulations and compare results for the scenarios identified in Task 1.

Task 2.1 Perform Scenario Evaluations

HDR will use the CCWSM to simulate the CoCC water supply system under different Agreed Order scenarios, identified in Task 1. Following is a list of assumptions that will be common to all scenarios:

- Approximate 2010 reservoir conditions (2010 elevation – area – capacity relationships),
    - Note new bathymetric survey results are pending at the Texas Water Development Board and if this information becomes available it will be incorporated into this analysis.
- Full use of the Lake Texana system (41,840 acft/yr firm plus 12,000 acft/yr interruptible),
- Lake Corpus Christi Target Stabilization Level = 74 ft-msl,
- 5.35 MGD municipal & industrial effluent returned to Nueces Bay, and
- 52% return flow factor applied to all CoCC demands with discharges to the Nueces Estuary.

Task 2.2 Compare Results from the Scenarios

From the scenarios simulated in Task 2.1, HDR will compare the outputs focusing on the volume and frequency of freshwater inflow events to Nueces Bay. HDR will develop graphs and tables that illustrate the similarities and differences of freshwater inflow events, reservoir storage, and system yields under the different scenarios.

Task 3. Participate in Meetings and Develop Technical Memorandum

Specific subtasks associated with this task are as follows.

Task 3.1 Present Results

Prepare for and participate in one (1) meeting involving TWDB staff, members of the NEAC, the City of Corpus Christi, and others to summarize analyses performed, results obtained, and recommendations for further study.

Task 3.2 Prepare a Draft Report

Prepare a draft Report summarizing analyses performed, results obtained, and recommendations for further study. The anticipated schedule is to submit these deliverables to the TWDB for review within four (4) months of receipt of the notice to proceed, but not later than June 30, 2017. If the results indicate potential for changing the Agreed Order monthly targets to allow for more effective management of freshwater inflow to the Nueces Bay, the report will contain a plan for advising a 10-year pilot project with the new modified monthly inflow targets.

Task 3.3 Prepare and Submit Final Technical Memorandum and Presentation

Prepare and submit a final Report to the TWDB within one (1) month of receipt of comments on the drafts, but not later than August 31, 2017.

Task 3.4 Deliverables include quarterly progress reports, draft report and final report

Prepare a progress report at least quarterly and provide to Contract Manager. A draft report is due no later than June 30, 2017. A final technical report that incorporates BBASC/TWDB comments is due August 31, 2017.

Project Schedule

The following are estimated time requirements for completion of the project tasks from date of notice to proceed. All work is anticipated to be completed in early 2017, but all final documents must be submitted no later than August 31, 2017. The extended duration of the schedule is to allow for at least two meetings of the Nueces Estuary Advisory Council, which generally occurs quarterly. The CCWSM is currently being upgraded under a separate contract with the City of Corpus Christi. The analysis described in this SOW should rely on the newly updated model. The new model should be available for use in September of 2016. The estimated weeks below can be based on notice to proceed or the data of the availability of the model, whichever is later.

Task	Task Description	Time for Completion (from Notice to Proceed)
1	Identify Alternative Agreed Order Monthly Targets	NTP + 8 weeks
2	Model Simulations and Result Summaries	NTP + 12 Weeks

3	**Meetings and Report**	**NTP + 16 Weeks**
	Anticipated Total Time to Complete Tasks 1 – 3	**~20 weeks**

Fee Estimate

The following tables summarize the fee estimated to be required to complete the above scope of work.

TASK BUDGET

TASK	DESCRIPTION	AMOUNT
1	**Identify Alternative Targets**	$2,850
2	**Model Simulations & Results**	$10,800
3	**Meetings and Report**	$6,350
Total		**$20,000**

EXPENSE BUDGET

CATEGORY	AMOUNT
Salaries & Wages[1]	$6,115
Fringe[2]	$2,986
Travel[3]	$400
Other Expenses[4]	$127
Subcontractor Services	$0
Overhead[5]	$8,372
Profit (10%)	$2,000
Total	**$20,000**

[1] Salaries and Wages is defined as the cost of salaries of engineers, draftsmen, stenographers, surveymen, clerks, laborers, etc., for time directly chargeable to this contract.
[2] Fringe is defined as the cost of social security contributions, unemployment, excise, and payroll taxes, workers' compensation insurance, retirement benefits, sick leave, vacation, and holiday pay applicable thereto.
[3] Travel is limited to the maximum amounts authorized for state employees by the General Appropriations Act, Tex. Leg. Regular Session, 2011, Article IX, Part 5, as amended or superseded.
[4] Other Expenses is defined to include computational technology, expendable supplies, communications, reproduction, postage, and costs of public meetings directly chargeable to this contract.
[5] Overhead is defined as the costs incurred in maintaining a place of business and performing professional services similar to those specified in this contract.

- Indirect salaries, including that portion of the salary of principals and executives that is allocable to general supervision;
- Indirect salary fringe benefits;
- Accounting and legal services related to normal management and business operations;
- Travel costs incurred in the normal course of overall administration of the business;
- Equipment rental not directly involved in collecting or analyzing contract data;
- Depreciation of furniture, fixtures, equipment, and vehicles;
- Dues, subscriptions, and fees associated with trade, business, technical, and professional organizations;
- Other insurance;
- Building rent and utilities; and
- Repairs and maintenance of furniture, fixtures, and equipment.

APPENDIX D – Additional Tables and Figures

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Figure D-1. Baseline (Existing) and Identified Alternative Monthly Target Scenarios for Agreed Order

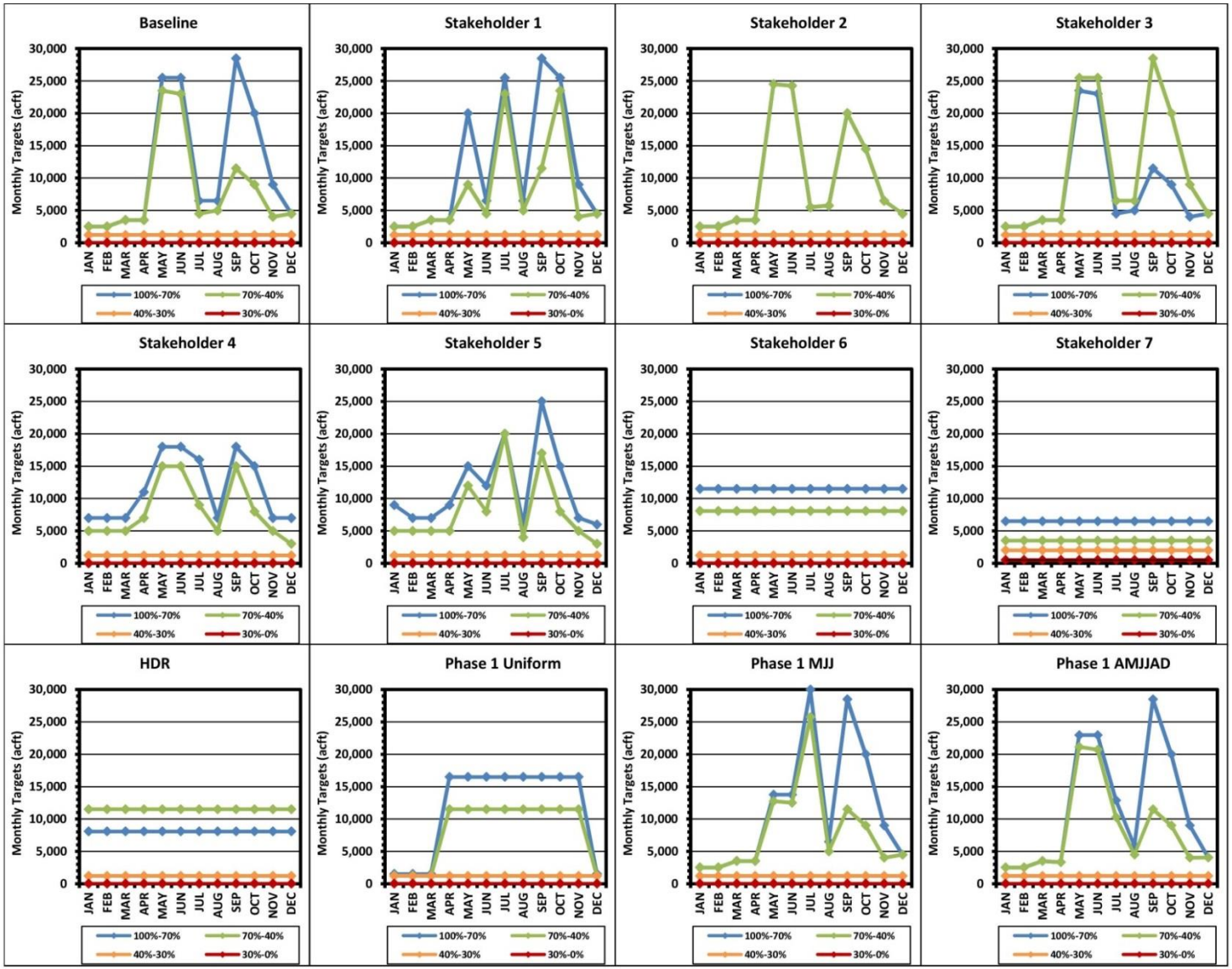

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Table D-1. Summary of Median Freshwater Inflow Statistics by Month for Existing Targets and Six Alternative Scenarios

Month	Baseline (Existing Targets)	Stakeholder 1		Stakeholder 2		Stakeholder 3		Stakeholder 4		Stakeholder 5		Stakeholder 6	
	Median	Median	Percent Change from Baseline	Median	Percent Change from Baseline	Median	Percent Change from Baseline	Median	Percent Change from Baseline	Median	Percent Change from Baseline	Median	Percent Change from Baseline
JAN	1,323	1,323	0.0%	1,323	0.0%	1,323	0.0%	2,724	105.9%	2,748	107.8%	3,233	144.4%
FEB	1,284	1,285	0.1%	1,284	0.0%	1,284	0.0%	2,682	108.9%	2,535	97.5%	3,612	181.4%
MAR	1,765	1,780	0.8%	1,765	0.0%	1,765	0.0%	2,562	45.2%	2,604	47.5%	3,027	71.5%
APR	1,799	1,801	0.1%	1,799	0.0%	1,799	0.0%	3,539	96.7%	2,916	62.1%	4,065	126.0%
MAY	23,212	13,360	-42.4%	23,712	2.2%	23,507	1.3%	15,714	-32.3%	13,980	-39.8%	11,507	-50.4%
JUN	18,338	6,688	-63.5%	18,205	-0.7%	17,268	-5.8%	13,552	-26.1%	9,510	-48.1%	11,083	-39.6%
JUL	3,230	7,209	123.2%	3,127	-3.2%	3,327	3.0%	4,585	41.9%	6,418	98.7%	4,126	27.7%
AUG	3,751	2,875	-23.4%	4,313	15.0%	3,750	0.0%	3,518	-6.2%	3,001	-20.0%	4,100	9.3%
SEP	13,843	13,843	0.0%	16,653	20.3%	12,843	-7.2%	15,316	10.6%	16,755	21.0%	11,508	-16.9%
OCT	5,876	6,987	18.9%	4,796	-18.4%	5,140	-12.5%	4,819	-18.0%	4,891	-16.8%	4,022	-31.6%
NOV	2,442	2,442	0.0%	2,492	2.0%	2,114	-13.4%	2,544	4.2%	2,544	4.2%	3,255	33.3%
DEC	2,257	2,257	0.0%	2,261	0.2%	2,257	0.0%	2,111	-6.5%	2,111	-6.5%	2,893	28.2%
ANN	**3,005**	**3,182**	**5.9%**	**3,156**	**5.0%**	**2,906**	**-3.3%**	**3,840**	**27.8%**	**3,844**	**27.9%**	**4,359**	**45.1%**

Table D-2. Summary of Median Freshwater Inflow Statistics by Month for Existing Targets and Five Alternative Scenarios

Month	Baseline (Existing Targets)	Stakeholder 7		HDR		Study 1 Uniform		Study 1 MJJ		Study 1 AMJJAD	
	Median	Median	Percent Change from Baseline	Median	Percent Change from Baseline	Median	Percent Change from Baseline	Median	Percent Change from Baseline	Median	Percent Change from Baseline
JAN	1,323	2,616	97.8%	3,482	163.3%	842	-36.3%	1,323	0.0%	1,323	0.0%
FEB	1,284	2,498	94.6%	3,857	200.5%	799	-37.8%	1,285	0.1%	1,284	0.0%
MAR	1,765	2,355	33.4%	3,090	75.0%	838	-52.5%	1,780	0.8%	1,765	0.0%
APR	1,799	3,251	80.7%	4,044	124.8%	5,667	215.0%	1,801	0.1%	1,713	-4.8%
MAY	23,212	6,724	-71.0%	8,724	-62.4%	13,730	-40.9%	13,633	-41.3%	20,801	-10.4%
JUN	18,338	6,788	-63.0%	9,019	-50.8%	12,427	-32.2%	13,211	-28.0%	16,797	-8.4%
JUL	3,230	3,192	-1.2%	4,879	51.0%	5,778	78.9%	7,682	137.8%	5,202	61.1%
AUG	3,751	2,838	-24.3%	4,633	23.5%	5,756	53.4%	2,523	-32.7%	2,943	-21.6%
SEP	13,843	8,451	-39.0%	11,514	-16.8%	13,843	0.0%	13,843	0.0%	13,843	0.0%
OCT	5,876	3,243	-44.8%	3,773	-35.8%	5,194	-11.6%	5,876	0.0%	5,876	0.0%
NOV	2,442	2,228	-8.8%	3,028	24.0%	4,293	75.8%	2,442	0.0%	2,442	0.0%
DEC	2,257	2,061	-8.7%	2,756	22.1%	838	-62.9%	2,257	0.0%	2,049	-9.2%
ANN	**3,005**	**3,324**	**10.6%**	**4,237**	**41.0%**	**4,290**	**42.7%**	**3,128**	**4.1%**	**3,182**	**5.9%**

APPENDIX E – Comments from TWDB on Draft Final Report

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AUG 21 2017

Texas Water Development Board

P.O. Box 13231, 1700 N. Congress Ave.
Austin, TX 78711-3231, www.twdb.texas.gov
Phone (512) 463-7847, Fax (512) 475-2053

Mr. Cory Shockley, P.E.
HDR Engineering, Inc.
4401 West Gate Blvd., Suite 400
Austin, TX 78745

RE: BBASC Contract between the Texas Water Development Board (TWDB) and HDR Engineering, Inc. (HDR) Contract No. 1600012014, Draft Report Comments on a Draft Report Entitled **"Re-Examination of the 2001 Agreed Order Monthly Targets: Phase 2"**

Dear Mr. Shockley:

Staff members of the Texas Water Development Board (TWDB) have completed a review of the draft report prepared under the above-referenced contract. ATTACHMENT 1 provides the comments resulting from this review. As stated in the TWDB contract, HDR Inc. (HDR) will consider revising the final report in response to comments from the Executive Administrator and other reviewers. In addition, HDR will include a copy of the Executive Administrator's draft report comments in the Final Report.

The TWDB looks forward to receiving one (1) electronic copy of the entire Final Report in Portable Document Format (PDF) and six (6) bound double-sided copies. **Please further note, that in compliance with Texas Administrative Code Chapters 206 and 213 (related to Accessibility and Usability of State Web Sites), the digital copy of the final report must comply with the requirements and standards specified in statute. For more information, visit http://www.sos.state.tx.us/tac/index.shtml.** If you have any questions on accessibility, please contact David Carter with the Contract Administration Division at 512-936-6079 or David.Carter@twdb.texas.gov.

HDR shall also submit one (1) electronic copy of any computer programs or models, and, if applicable, an operations manual developed under the terms of this Contract.

Please feel free to contact Dr. Evan Turner of our Surface Water staff at 512-936-0820 or evan.turner@twdb.texas.gov if you have any questions or need any further information.

Sincerely,

Robert E. Mace, Ph.D., P.G.
Deputy Executive Administrator
Water Science and Conservation

Date: 8/14/17

Attachment

c w/o att.: Dr. Evan Turner, Surface Water

Attachment 1
HDR, Inc.
"Re-Examination of the 2001 Agreed Order Monthly Targets: Phase 2"
Contract No. 1600012014
TWDB Comments to Draft Report

REQUIRED CHANGES

General Draft Final Report Comments:

The goal of this study was to investigate alternative freshwater inflow delivery scenerios within the framework of the 2001 Agreed Order. The draft report adequately meets the two main tasks identified in the scope of work to identify and evaluate new scenarios of Agreed Order monthly targets, comparing the impacts on system yield and freshwater inflow to Nueces Bay. Although the different scenarios of monthly target amounts and patterns had little effect on the firm yield of the system and on annual freshwater inflow volumes to Nueces Bay, improvements to median monthly inflow can be increased by as much as 45%. Given this important result and the fact that a 10-year pilot project for altering the Agreed Order targets was not recommended, the reviewers request that additional discussion be provided describing what information would be needed to recommend a 10-year pilot project (see specific comment #9 below).

1. Please add the following statement to the cover page of the final report:

   PURSUANT TO HOUSE BILL 1 AS APPROVED BY THE 84TH TEXAS LEGISLATURE, THIS STUDY REPORT WAS FUNDED FOR THE PURPOSE OF STUDYING ENVIRONMENTAL FLOW NEEDS FOR TEXAS RIVERS AND ESTUARIES AS PART OF THE ADAPTIVE MANAGEMENT PHASE OF THE SENATE BILL 3 PROCESS FOR ENVIRONMENTAL FLOWS ESTABLISHED BY THE 80TH TEXAS LEGISLATURE. THE VIEWS AND CONCLUSIONS EXPRESSED HEREIN ARE THOSE OF THE AUTHOR(S) AND DO NOT NECESSARILY REFLECT THE VIEWS OF THE TEXAS WATER DEVELOPMENT BOARD.

2. Please add the TWDB Contract #1600012014 to the front cover of the report.

3. Please proofread the report before submitting, looking for spelling and grammatical errors. Although definitions are provided in the text, numerous acronyms make readability difficult. Please remove acronyms from the body of the text and/or include a table or list of definitions for acronyms used in the report.

Specific Draft Final Report Comments:

1. Page 2, Section 1 Introduction, paragraph 1: Please clarify whether 'bimonthly' refers to 'twice a month' or 'every two months.'

2. Page 2, Section 1, Introduction, paragraph 1: Capitalize "Gulf" when referring to the Gulf of Mexico.

3. Page 4, Section 2, Corpus Christi Water Supply Model Description: Citations referenced in the text for the CCWSM and the 2006 Coastal Bend Regional Water Plan should also be listed in the footer to be consistent with the report style throughout the manuscript. Please also refer to Exhibit D of the TWDB Contract for formatting guidelines. Verify that all works listed in the reference section are consistently cited in the text throughout the report.

4. Page 4, Section 2, Corpus Christi Water Supply Model Description, paragraph 3: The study references a new drought of record as modeled under the CCWSM. The definition used by the author for a new drought of record should be included in the report because differing definitions and/or criteria are used by state agencies (e.g. 31 TAC 357.10(11) and 30 TAC 297.1(19)).

5. Page 8, Section 4.1, Evaluation Assumptions: Please expand the discussion on the concept and definition of returned flows to the Nueces Estuary. As stated in the conclusion, Scenario 7 defined 500 acre-feet at low system storage; however, the model assumed return flows of 499 acre-feet monthly which "*..meets this target and negates any impact to the firm yield.*" It is unclear if the 499 acre-feet of return flow is pumped through the Rincon Bayou Pipeline, which is the only entry mechanism for flows entering the delta other than from surrounding runoff or direct precipitation. Please describe sources and pathways of return flow to the delta, if any.

6. Page 9, Section 4.2, Comparison of System Yield, paragraph 1: Please expand the discussion to describe why the following bolded statement is an important result: *"This is indicative of a system that is driven more by the inflows into the reservoir system than by the actual monthly inflow targets. In other words, what drives to a large extent system yield and FWI to the bay is the natural runoff into the reservoirs, not the targets in the Agreed Order."*

7. Page 11, Section 4.3, Comparison of Freshwater Inflows: Since the recommended scenarios of inflow targets are based on a monthly release pattern, an analysis of freshwater inflow by month is important to this study. The authors should provide results of freshwater inflow per month (e.g. Jan, Feb, March...) in addition to the average monthly results presented in Table 4-2.

8. Page 15, Section 5, Conclusions/Recommendations: Please provide additional details regarding the effort that would be needed to modify the CCWSM capabilities to include the ability to model scenarios that are not currently defined by the Agreed Order and that were omitted for consideration from the current study (i.e., dedicated releases from storage). Please describe what additional beneficial information would be provided from such an effort.

9. Page 15, Section 5.1, Recommendation for a Pilot Study for Altering the Agreed Order Targets: Please expand the discussion describing why a 10-year pilot project was not recommended. On page 15, under section 5.1, it is stated that "*The results show that the ability to impact median bay flow on an annual basis is small, but on a monthly basis the results indicate that improvements to median monthly flow can be increased by as much as 45% (1,350 acre-feet/mo.*)." This is the outcome that stakeholders had hoped for – a scenario that would not impact safe yield, but would have positive impacts on the delta, particularly during critical spring months when the targets are currently low. Alternatively, some reviewers commented that the findings do not appear to be significant enough to support a recommendation to modify the Agreed Order or undertake a 10-year pilot project. Please consider revising the report to make a recommendation for a scenario that could be discussed by stakeholders for possible implementation into a 10-year pilot project, or add clarification regarding why a recommendation was not made.

Figures and Tables Comments:

1. All Figures: Please provide descriptive figure and table captions instead of (or in addition to) describing figure details in the body of the manuscript. For example, page 9, paragraph 1: *"The blue line represents the percent system storage and corresponds to the left vertical axis."* Rather than describing the figure in the text, the figure title can be changed to *"Figure 4-1. Percent System Storage Trace (blue line; left vertical axis) and Annual Pass-throughs to Nueces Bay for Baseline Scenario (orange bars; right vertical axis)."* The goal of a figure or table caption is to produce a fully stand-alone object that conveys the purpose of the graphic for the reader separate from the manuscript body.

2. Pages 10 – 11, Figures 4.1 and 4.2: Please describe why the system storage drops to 0% during the drought of 2012 – 2015, within which it was understood that the system dropped to just below 30%.

3. Pages 13 and 14, Figures 4-3 and 4-4: The baseline line size is larger than the other scenarios and covers up the other lines. Please use the same line size or a dashed line for the 'baseline' run to improve graphic clarity.

SUGGESTED CHANGES

Specific Draft Final Report Comments:

1. Page 8, Section 4.1: Please include the date for which the volumetric data was used for each reservoir. For example, the City of Corpus Christi began using the new volumetric survey data for Lake Corpus Christi and Choke Canyon Reservoir for the pass-through report requirements on June 24, 2017.

2. Page 14: Please consider describing the effect of the Lake Texana system on the Lake Corpus Christi and Choke Canyon Reservoir storage system, and the frequency of release, percent of time, and additional water available for environmental flows, per the Agreed Order targets. Additionally, reviewers request to see how the Lake Texana system affects the results. Specifically, please describe how the curves in Figure 4-4 would change without the influence of the Texana supply.

3. Pages 14 – 15, Section 5, Conclusions/Recommendations: Please consider a different format for summarizing the conclusion, such that the sub-bullet items are moved to paragraph text form, with full grammar and paragraph formatting. Then, the bulleted summary of the study becomes:

   a. Varying the monthly target amounts and pattern has a small effect (less than an absolute value change of 3%) on the firm yield of the system.

   b. Varying the monthly target amount and pattern has little effect on annual freshwater inflow volumes but does alter the monthly freshwater inflow volumes.

   c. Adding pass-through targets for times when system storage is below 30% results in minimal improvement to FWI as these targets would take effect during times of extreme drought when little inflow occurs.

4. Sections 3, 4, and 5: Although the Corpus Christi Water Supply Model (CCWSM) model has the ability to run Scenario 7, the scenario itself falls outside the scope of the Agreed Order, much like the suggestion for dedicated releases from reservoir storage. Please consider moving the results of Scenario 7 from the main body of the report to a separate section that describes scenarios that garnered attention from stakeholders but did not fall within the Agreed Order – to include both Scenario 7 and the discussion regarding dedicated releases.

Figures and Tables Comments:

1. Page 5, Table 3-1: Please consider also presenting the data in Table 3-1 as a bar graph to provide for visualization of the Agreed Order monthly targets.

2. Page 7, Table 3-1: Please consider also presenting the data in Table 3-2 as a bar graph to visualize the difference of the scenarios tested.

3. Page 10, Figure 4-1: Please provide additional clarification in the figure caption describing graph features. For example, the figure caption can be changed to *"Percent System Storage Trace (blue line; left vertical axis) and Annual Pass-throughs to Nueces Bay for Baseline Scenario (orange bars; right vertical axis)."*

Additionally, the figure caption should reference the new drought of record for the model as requested for Page 4, Paragraph 3.

APPENDIX F –Response to Comments from TWDB on Draft Final Report

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Re-Examination of the 2001 Agreed Order Monthly Targets: Phase 2

Adam Cory Shockley, P.E., Zach Stein, P.E
Contract # 1600012014
Responses to TWDB/BBASC Comments to Final Report

Required Changes

General Draft Final Report Comments

1. HDR added the provided statement to the cover and title pages of the final report.
2. HDR added the contract number to the cover of the final report.
3. Document was checked for grammar, spelling, and typographical errors such as missing words and a list of definitions for acronyms was added to the table of contents.

Specific Draft Report Comments

1. The term ‘bimonthly’ was removed and text was added clarifying that the relationship is based on inflows occurring over a consecutive two month period.
2. ‘Gulf’ was capitalized when referring to the Gulf of Mexico.
3. Citations for the CCWSM and 2016 Coastal Bend Regional Water Plan were added to the footer of the appropriate page and all works cited were verified for consistency throughout the text.
4. A definition for a new drought of record was added to the text.
5. Additional text was added to the report to explain the return flow credit.
6. Further explanation of the bolded statement is provided in the following paragraphs and figures.
7. Results of freshwater inflows by month have been added in Appendix D and further discussion including a figure has been added to the final report.
8. Additional discussion on modifying the CCWSM to be able to simulate release of stored water was added to the section.
9. Additional discussion on implementing a pilot program was added to the conclusion section.

Figures and Tables Comments

1. Descriptions of figures have been added to the captions.
2. Text has been added clarifying that results presented in the report are from firm yield simulations and not actual lake level data.

3. The baseline line size has been reduced in the appropriate figures to match the line size of the other lines.

Suggested Changes

Specific Draft Final Report Comments

1. Text has been added to the report that 2020 sediment conditions were used for model simulation and were estimated from the most recent bathymetric surveys. Date of TWDB bathymetric report noted in parentheses in the text.
2. A sensitivity analysis of Lake Texana supplies on FWI to the Nueces Bay is not included in the scope of work for this contract.
3. The conclusions/recommendations have been reformatted to the requested style.
4. HDR's opinion is that Scenario 7 has adequate similarities in structure to the Agreed Order targets and other alternative scenarios for comparison in the main body of the report. Even though the author of stakeholder 7 intended the 500 acft target in a lower zone of storage (outside the scope of the Agreed Order) the provisions could still be simulated within the scope of the Agreed order by acknowledging that the 500 acre-feet/month in the 30-15% storage zone is addressed by the return flow credit essentially negating the monthly target when reservoir storage is in that zone. No changes made to the text.

Figures and Tables Comments

1. A figure presenting the data in Table 3-1 has been added to the report.
2. Figures representing the different scenarios have been added to Appendix D.
3. Text has been added to the figure caption clarifying that this is the time period in which the new drought of record occurred.

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We practice increased use of sustainable materials and reduction of material use.