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Cover photo: Anzelduas Dam in Hidalgo County. Photo courtesy of the Texas Water Development Board.

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Spatial and temporal effects of the Rincon Bayou Pipeline on hypersaline conditions in the Lower Nueces Delta, Texas, USA

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Abstract: The Rincon Bayou Pipeline became operational in 2007 and delivers Nueces River water to the Nueces Delta via the Rincon Bayou. Salinity was monitored during 3 pumping events to identify the spatial and temporal effects of the pumped freshwater to the Rincon Bayou Channel and to areas outside of the channel proper. The spatial extent of the pumped freshwater lowered salinity beyond the Rincon Bayou Channel to connecting marsh areas and salinities remained below hypersaline levels 8 to 16 days after pumping ceased. The results of this new and innovative way of delivering freshwater to the Nueces Delta has proved to be a valuable management tool for minimizing the duration of hypersaline conditions within the estuary. Water resource management decision-makers can use this information for developing strategies to optimize freshwater inflow needs to the estuary while balancing the freshwater demands for humans.

Keywords: freshwater management, freshwater inflow, hypersalinity, estuary

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Terms used in paper

Short name or acronym	Descriptive name
BOR	U.S. Bureau of Reclamation
NEAC	Nueces Estuary Advisory Council
NOC	Nueces River Outflow Channel
RBP	Rincon Bayou Pipeline
ROC	Rincon Bayou Overflow Channel
USGS	U.S. Geological Survey

INTRODUCTION

Restoring freshwater to the Nueces Delta and Nueces Estuary has continued to be an environmental challenge since the negative ecological and biological effects of hypersaline conditions were identified in the shrimp populations in the 1990s within the Nueces Estuary (Matthews and Mueller 1987; Whitledge and Stockwell 1995; Montagna et al. 2009; Hill et al. 2011; Nueces BBEST 2011; Nueces BBASC 2012). The lack of freshwater inflow into the Nueces Delta and Nueces Estuary, coupled with a semiarid climate and frequent drought conditions, has resulted in hypersaline conditions (Figure 1) (Montagna et al. 2002; Knowles 2002). The lack of freshwater inflows to the delta and estuary is the result of reservoir embankments, riverbank modifications, and increased urbanization and industrialization along the Nueces River. The state of Texas, alongside stakeholders, has worked rigorously toward finding solutions to increase flows into the estuary and delta through management of reservoir operations to include inflow requirements to the estuary and delta. The background and history of the establishment of inflow requirements to the Nueces Estuary follows in the next section.

History of management of freshwater inflows to the Nueces Estuary

Two reservoirs are located on the Nueces River: (1) Choke Canyon Reservoir (Choke Canyon Dam), built in 1982, is located on the Frio River approximately 16 kilometers above the Frio River's confluence with the Nueces River, and (2) Lake Corpus Christi (Wesley Seale Dam), built in 1958, is located on the Nueces River approximately 48 kilometers farther downstream (Figure 2). After Choke Canyon Reservoir was built, the state of Texas started to develop an inflow criterion in 1990s for freshwater inflows for the Nueces Estuary (BOR 2000; Montagna et al. 2002; Palmer et al. 2002).

The Texas Natural Resource Conservation Commission, now the Texas Commission on Environmental Quality, addressed the lack of freshwater inflows into the Nueces Estuary through a series of amendments to the initial May 1990 Agreed Order to manage inflows into the estuary. The May 1990 Agreed Order required inflows to the estuary for May and June 1990 and stated a Technical Advisory Committee would be established to assist in the development of a permanent inflow operation procedure for the estuary. The Agreed Order was

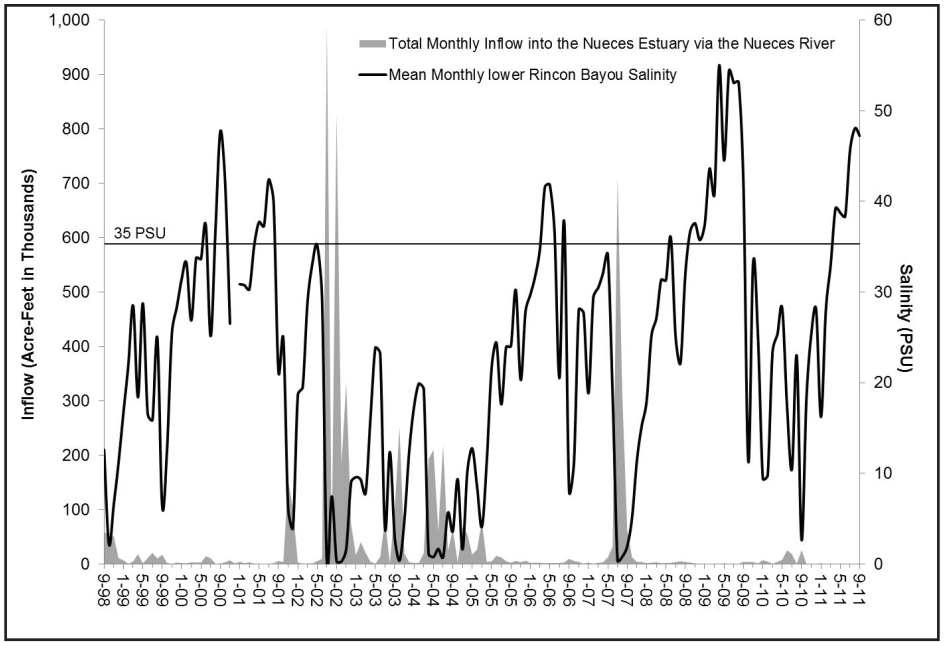

Figure 1. Total monthly inflow into the Nueces Estuary via the Nueces River and mean monthly salinity in the lower Rincon Bayou, September 1998–September 2011. Salinity data was collected monthly by the Center for Coastal Studies, Texas A&M University–Corpus Christi and flow data from USGS gauge (No. 08211500) at Calallen, Texas. Reference line showing 35 practical salinity units.

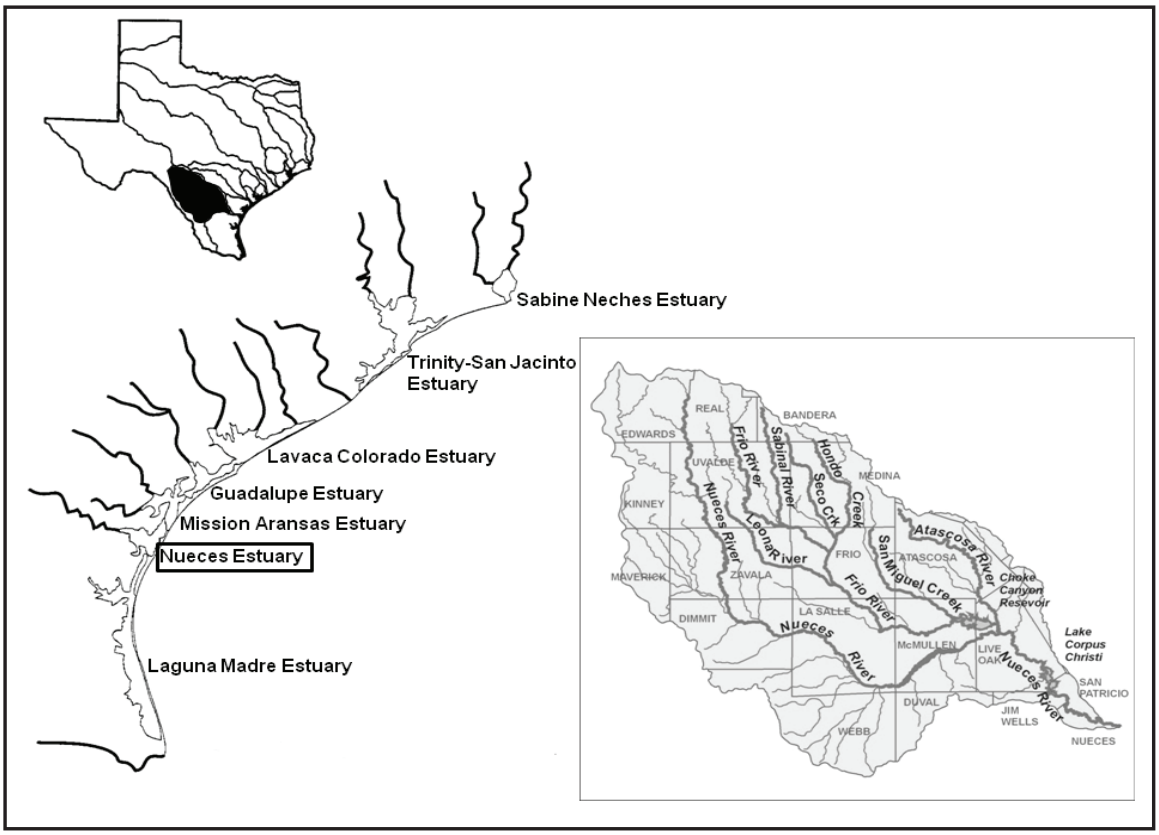

Figure 2. Main estuaries along the Texas coast with the shaded area indicating the Nueces River Basin, Texas USA (Hill et al. 2011).

amended again in August 1990 and expanded operations to now provide for monthly inflow requirements to the estuary (Ray Allen personal Communication; unreferenced).

The Agreed Order was amended again in 1992 and established (1) the Nueces Estuary Advisory Council (NEAC), (2) defined credits for monthly excess inflow and salinity, and (3) required the city of Corpus Christi to maintain at least 2 salinity monitoring stations in Nueces Bay (currently maintained by the Conrad Blucher Institute at Texas A&M University–Corpus Christi). The NEAC was created to provide recommendations for freshwater inflow management into the Nueces Estuary under the Special Condition 5.B, Certificate of Adjudication No. 21-3214 (TCEQ 1992).

The Agreed Order was amended again in 1995 to establish operational procedures relating to releases and spills from Lake Corpus Christi and Choke Canyon Reservoir. The 1995 Agreed Order changed the inflow requirements from mandatory to a pass-through plan based on inflows to the reservoir system. Pass-throughs during drought conditions were now contingent upon the city of Corpus Christi's implementation of the Drought Contingency Plan. The NEAC also began identifying areas in the delta where freshwater inflow would be most beneficial in increasing biological productivity.

The current Agreed Order, amended in April 2001, established specific monthly inflow targets for the estuary to maximize biological productivity. The monthly targets take in consideration the reservoir levels and drought contingency measures. Under the 2001 Agreed Order, the city was required to (1) re-open the Nueces River Overflow Channel, making it a permanent feature of the Rincon Bayou, (2) build and operate a system to deliver up to 3,000 acre-feet per month into the Upper Rincon Bayou, (3) continue the salinity monitoring stations in Nueces Bay, and (4) implement an on-going biological monitoring and assessment program for "adaptive management" for freshwater inflows into the Nueces Estuary.

The monthly inflow targets were developed by the Texas Water Development Board and Texas Parks and Wildlife Department and require the city of Corpus Christi to provide no less than 151,000 acre-feet per year (186,106 cubic meters) to the Nueces Estuary (TCEQ 1995). Each month the city is required to "pass through" inflow to the Nueces Estuary equal to the measured instream flows into the Choke Canyon Reservoir/Lake Corpus Christi Reservoir System up to a target amount (TCEQ 1995). The target amount varies by month and is calculated based on the combined storage volume of the reservoir system. The city receives 500 acre-feet per month

return flow credits and may receive additional credits for excess inflow from the previous month or from relief credits based on salinity measured in Nueces Bay (Montagna et al. 2009).

The city addressed the lack of freshwater inflow and hypersaline conditions in the Nueces Delta by building the Rincon Bayou Pipeline (RBP) to deliver up to 3,000 acre-feet of water directly to the Rincon Bayou during a pass-through. The RBP is the conveyer system that delivers water to the interior delta to manage salinity levels. The Salinity Monitoring and Real Time Inflow Management program currently being developed uses salinity monitoring stations in Nueces Bay and Rincon Bayou for the management of water releases during high salinity periods.

Restoring freshwater to the Rincon Bayou

The first attempt to restore freshwater to the Nueces Delta was the Rincon Bayou Demonstration Project that was initiated in 1993 by the U.S. Bureau of Reclamation (BOR) (BOR 2000; Montagna et al. 2002; Palmer et al. 2002). Two man-made diversion channels were dug in 1995 to connect the delta to the Nueces River: (1) the Nueces River Overflow Channel (NOC), approximately 60 meters downstream of Interstate Highway 37, connects the Nueces River to the Rincon Bayou, and (2) the Rincon Bayou Overflow Channel (ROC) further downstream connects the Rincon Bayou to the NOC (Figure 3). Because land modifications were made to increase inflow into the delta, monitoring activities were conducted from October 1994 to December 1999 to measure biological productivity in response to the freshwater inflows (BOR 2000). Once the project was complete, in 2000 the NOC was filled in, due to project requirements and land easement contracts. However, the NOC was reopened in 2001 by the city of Corpus Christi prior to the RBP, which became operational in 2007 (Hill et al. 2012).

Figure 3. Map showing placement of the Nueces Overflow Channel and Rincon Overflow Channel on the Nueces River (BOR 2000).

Before the BOR project, the Nueces Delta only received inflows during locally heavy rainfall events or flood events that caused over-banking of the Nueces River (BOR 2000; Pulich et al. 2002; Hill et al. 2011). The overflow channels increased the chance of water reaching the delta when ample inflow could move through the man-made Rincon Bayou diversion channels. The 2 overflow diversion channels increased freshwater inflow to the historical river channel Rincon Bayou by lowering the minimum flood threshold of the upper Nueces Delta from 1.64 above meters mean sea level to approximately 0 meters mean sea level (BOR 2000).

The second attempt to restore freshwater to the Rincon Bayou was the RBP study funded by the city of Corpus Christi. The RBP study followed the 2001 Texas Commission on Environmental Quality Agreed Order requiring the construction and operation of a 1.5 meter-diameter pipeline to deliver up to 3.7 x 106 cubic meters per day (3000 acre-feet) of freshwater to the Rincon Bayou in accordance with the 1995 Texas Commission on Environmental Quality pass-through order (Hill et al. 2011).

This study evaluates the freshwater management effort of the RBP to alleviate hypersaline conditions in the Nueces Delta and its effectiveness in creating a typical estuarine salinity gradient where seaward-moving water transitions from fresh to saline. The spatial and temporal extent of freshwater coming into Rincon Bayou via the RBP was measured at salinity stations downstream of the pipeline and in areas adjacent to the main channel. Each RBP pumping event is described independently, with no salinity comparisons between events, since station locations were not fixed points outside the main channel. A descriptive analysis of the distribution of RBP freshwater inflows in the lower Nueces Delta for 3 RBP inflow events that occurred November 2011, March 2012, and June 2012 will be discussed.

STUDY SITE

Nueces Delta region

The Nueces Delta is located in the Texas Coastal Bend and is part of the Nueces Estuary. Historically, the Nueces River emptied into the delta via the Rincon Bayou Channel but now completely bypasses the delta and flows along the southern edge of the delta and empties into Nueces Bay (Figure 4).

The Nueces Delta is 75 square kilometers of vegetated marshes, mudflats, and open water habitats and is located in a convergence zone of subtropical and semiarid climates characteristic of the Texas Coastal Bend. Summers are hot and humid,

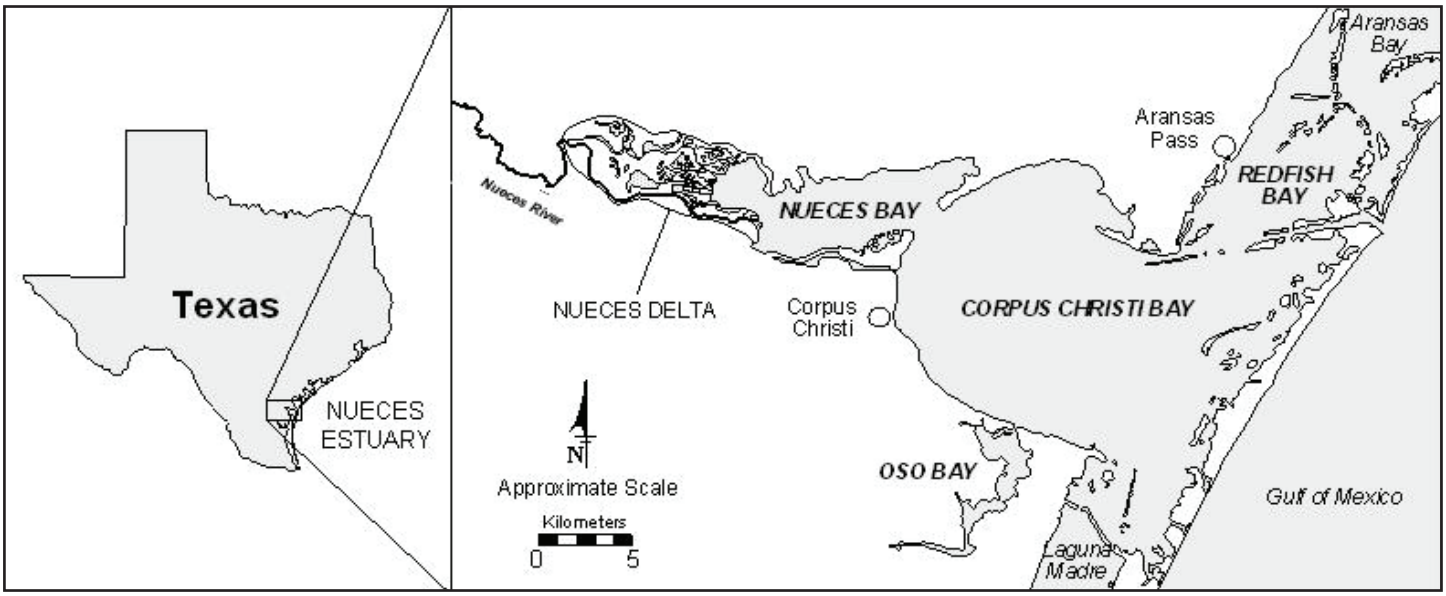

Figure 4. Nueces Estuary, Corpus Christi, Texas, USA (BOR 2000).

and winters are typically moderate with an occasional freeze following strong northerly fronts that pass through the area. Mean annual rainfall in the region is approximately 77.6 centimeters per year (NOAA 2010) with evaporation rates ranging from 90 to 115 centimeters per year but can be as high as 150 centimeters per year (TWC 1991). Wind direction is predominately southeast and is the primary source of atmospheric humidity. Tropical storms and hurricanes are possible during late summer and early fall, which brings substantial amounts of precipitation during these events.

Rincon Bayou Pipeline system

The RBP pump station is located on the Nueces River and diverts up to the first 3,000 acre-feet of required water "pass through" to the RBP outfall located in the man-made Rincon Bayou diversion channel (Figure 5). The RBP became operational in November 2007 and includes 3 350-horsepower mixed-flow submersible pumps capable of moving up to 60,000 gallons per minute with all 3 pumps operating (Table 1; Figure 6). The number of days to deliver a given volume of freshwater through the RBP depends on the number of pumps used.

METHOD

Salinity was measured during 3 events to determine spatial and temporal effects of RBP freshwater inflows to habitats connected to the main Rincon Bayou channel (i.e. small tidal channels, mudflats, and ephemeral ponds) (Figure 7; Table 2). Stations consisted of one 6920 YSI® datasonde attached to a PVC bipod and programmed to sample salinity (practical salinity unit) every 15 minutes *in situ*. Datasondes were deployed up to 3 weeks prior to the RBP release and recovered up to 3 weeks after the RBP stopped discharging water so temporal effects could be quantified. Field maintenance occurred every 2 weeks during the RBP release and included data downloads to a field computer. Calibration and post-calibration of datasondes were performed and all quality control forms were retained in the laboratory. Each RBP event is independent in this study, since no fixed stations occurred outside the main channel. For each RBP event, stations were randomly chosen to determine the extent of freshwater to adjacent.

Salinity data from the Conrad Blucher Institute for Surveying and Science at Texas A&M University–Corpus Christi were

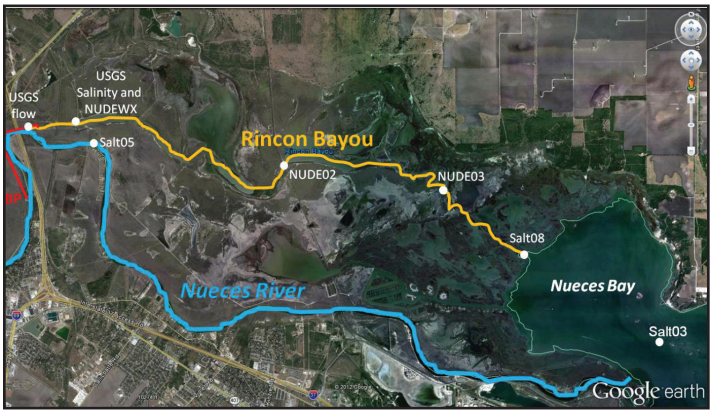

Figure 5. Map of the Nueces Delta and locations of Conrad Blucher Institute at Texas A&M University–Corpus Christi salinity monitoring stations and United States Geological Survey flow gauge.

Table 1. Capacity of the Rincon Bayou Pipeline.

	Rincon Bayou Pumps		
	1	2	3
Flow, gallons per minute	28,000	46,000	60,000
Flow, cubic feet per second	62	102	134
Flow, acre-feet per day	124	203	265
Total kilowatts	230	455	675

also used (http://www.cbi.tamucc.edu/cbi/data). Data from the following Conrad Blucher Institute stations were used in this study (see Figure 3): NUDE02, located in the middle reach of Rincon Bayou (27.888611°N, -97.569444°W); NUDE03 located in the lower tidally influenced reach of Rincon Bayou (27.883774°N, -97.533188°W); Salt08 located in the lower Rincon Bayou at the confluence of Nueces Bay (27.870428°N, -97.517090°W); Salt03 (27.851561°N, -97.482028°W) located in the middle of Nueces Bay near the mouth of the Nueces River and Salt05 (27.891601°N, -97.610684°W) located in the upper tidal reach of the Nueces River. Salt03 and Salt05 salinity data are used as references in this study to compare Nueces Bay and Nueces River salinity, respectively, to Rincon Bayou salinity. Data from the weather station NUDEWX located on Rincon Bayou downstream from the RBP outfall included rainfall (millimeters]).

Data analysis

Salinity data were binned based on the RBP pumping event period (n = days in period): Pre-RBP, During-RBP, and Post-RBP. IBM SPSS version 19 (IBM SPSS, 2012) was used to analyze salinity data. For each event, a one-way ANOVA was used to determine mean salinity differences between Pre-RBP, During-RBP, and Post-RBP to identify the spatial and temporal extent of the RBP in the Rincon Bayou and adjacent stations. A first-order variant of local polynomial interpolation method with barriers was used to determine salinity changes: Pre-RBP, During-RBP, and Post-RBP using ArcGIS software (version 10; ESRI, 2011). Refer to Figure 7 for station locations for each RBP release and Table 2 for the latitude and longitude for each station and station distance from Rincon Bayou. The distance was measured using instream distance from the closest inlet connecting to Rincon Bayou. Salt03 and Salt05 salinity data were included in tables as a reference to salinity in the middle of Nueces Bay and Nueces River, but these values were not included in statistical analyses. No salinity comparisons between RBP events were done since station locations changed for each event.

RESULTS

Event 1

A total of 2,031 acre-feet of water was pumped to the Rincon Bayou from 2 November 2011 through 22 November 2011. Widespread hypersaline conditions (> 35 practical salinity units) were observed in the Rincon Bayou and in areas outside of the channel prior to the RBP event (Table 3). A total of 8 millimeters of rainfall was recorded at the NUDEWX station

Figure 6a-b. a) RBP pumps located on the Nueces River above the Calallen Dam and b) RBP outfall in the Rincon Bayou.

Figure 7. Location of Center for Coastal Studies (CCS) satellite stations, NUDE03, and Salt08. Green pins = Event 1, yellow pins = Event 2, and blue pins = Event 3 (Map modified from Google Earth 2012).

during Event 1. The lack of rainfall during the RBP event indicates salinity changes observed in the Rincon Bayou were likely a direct result from the RBP. The RBP freshwater signal was recognized at all stations in the Rincon Bayou during Event 1.

Once the RBP pumping event was complete, hypersaline conditions (>35 practical salinity units) were still observed at CCS5 and Salt08 in the Rincon Bayou (See Figure 7; Table 3). An ANOVA identified the significant decrease in salinity between Pre-RBP (n=8), During-RBP (n=21), and Post-RBP (n=24) conditions (Table 4). CCS1 was not included in the ANOVA analysis since Pre-RBP data does not exist. Mean

Table 2. Location of CCS stations and distance from the Rincon Bayou main channel by event.

Event	Station	Latitude	Longitude	Distance from Rincon Bayou Channel (m)
1	CCS1	27.89266°N	-97.54141°W	655
1	CCS2	27.87786°N	-97.52623°W	150
1	CCS3	27.87533°N	-97.52688°W	182
1	CCS4	27.87310°N	-97.52758°W	393
1	CCS5	27.87001°N	-97.52511°W	593
2	CCS6	27.88987°N	-97.53815°W	191
2	CCS7	27.87895°N	-97.52806°W	83
2	CCS8	27.87439°N	-97.51834°W	278
2	CCS9	27.88208°N	-97.52672°W	4043
3	CCS10	27.88966°N	-97.53556°W	361
3	CCS11	27.88195°N	-97.5353°W	104
3	CCS12	27.88335°N	-97.53186°W	110
3	CCS13	27.87411°N	-97.52293°W	555

Table 3. Pre-RBP, During-RBP, and Post-RBP mean salinity, Event 1.

Mean Practical Salinity Units	CCS1	CCS2	CCS3	CCS4	CCS5	NUDE2	NUDE3	Salt08	Salt03	Salt05
Pre-RBP		51.63	50.25	50.07	46.48	63.83	41.63	49.06	45.76	11.00
During-RBP	32.35	41.24	37.81	40.00	40.87	21.11	30.70	41.33	45.50	8.74
Post-RBP	30.37	33.44	30.28	31.89	37.86	23.05	31.35	38.58	44.13	7.39

salinity During-RBP and Post-RBP were significantly lower compared to the Pre-RBP conditions. Tukey HSD tests identified Pre-RBP mean salinity statistically significantly higher compared to During-RBP and Post-RBP at all CCS stations. Salt08 mean salinity was not statistically different from Pre-RBP, During-RBP, and Post-RBP salinity. Overall, the volume of freshwater released was not enough to offset the hypersaline conditions in the lower Rincon Bayou during this event.

Spatial interpolation of salinity in the Rincon Bayou Pre-RBP identified a classic negative estuarine system with salinity increasing as you move upstream from Nueces Bay (Figure 8). Once the 21-day RBP release started, salinity began decreasing in the channel. Even though salinity measured outside the channel proper During-RBP decreased by 10 practical salinity units, Rincon Bayou remained hypersaline. Post-RBP mean salinity in the channel ranged from 23.05 practical salinity units at NUDE2 to 38.58 practical salinity units at Salt08 located at the mouth of Nueces Bay. Mean salinity outside the channel was below hypersaline conditions except at CCS5 located closest to Nueces Bay (mean 37.86 practical salinity units). After pumping was complete, hypersalinity returned within 10 days at stations CCS1, CCS2, CCS3, and CCS4. Salinity at CCS5 had no temporal change during Event 1. See Appendix I for all salinity data.

Event 2

A total of 1,309 acre-feet of water was pumped to the Rincon Bayou from 7 March through 19 March 2012. Salinity in the Rincon Bayou channel ranged from 20 to 30 practical salinity units, and ranged from 24 to 36 practical salinity units at stations outside of the Rincon Bayou channel prior to the March 2012 RBP event. A total of 40 millimeters of rainfall was recorded at NUDEWX during Event 2, with most of the rainfall during the Post-RBP period (39.0 millimeters). Rainfall coupled with the RBP event lowered salinity to below hypersaline conditions establishing a typical estuarine salinity gradient.

Mean salinities in the Rincon Bayou channel and adjacent stations were not hypersaline prior to the RBP March 2012 event (Table 5). An ANOVA identified a significant difference in salinity means between Pre-RBP (n=5), During-RBP (n=13), and Post-RBP (n=22) conditions (Table 6). Mean salinity During-RBP and Post-RBP were significantly lower compared to the Pre-RBP conditions. Because Pre-RBP salinity in the Rincon Bayou was not hypersaline, the changes between event periods at CCS7, NUDE3, and Salt08 were not significant.

Spatial interpolation of salinity in the Rincon Bayou Pre-RBP identified an estuarine salinity gradient, atypical of the Rincon Bayou (Figure 9). Once the 13-day RBP event ended, salinity remained lower than seen in the pre-pumping at all stations. The CCS9 station was not included in the inter-

Table 4. ANOVA salinity analysis for Event 1 RBP pumping event. Tukey HSD means are arranged from low (left) to high (right); ns = not significant.

Station	df	F	p	TukeyTest
CCS2	2, 49	24.34	<0.001	PostRBP RBP PreRBP
CCS3	2, 51	13.21	<0.001	PostRBP RBP PreRBP
CCS4	2, 50	10.26	<0.001	PostRBP RBP PreRBP
CCS5	2, 51	22.39	<0.001	PostRBP RBP PreRBP
NUDE02	2, 35	13.42	<0.001	RBP PostRBP PreRBP
NUDE03	2, 44	1.56	0.222	ns
Salt08	2, 47	3.51	0.38	ns

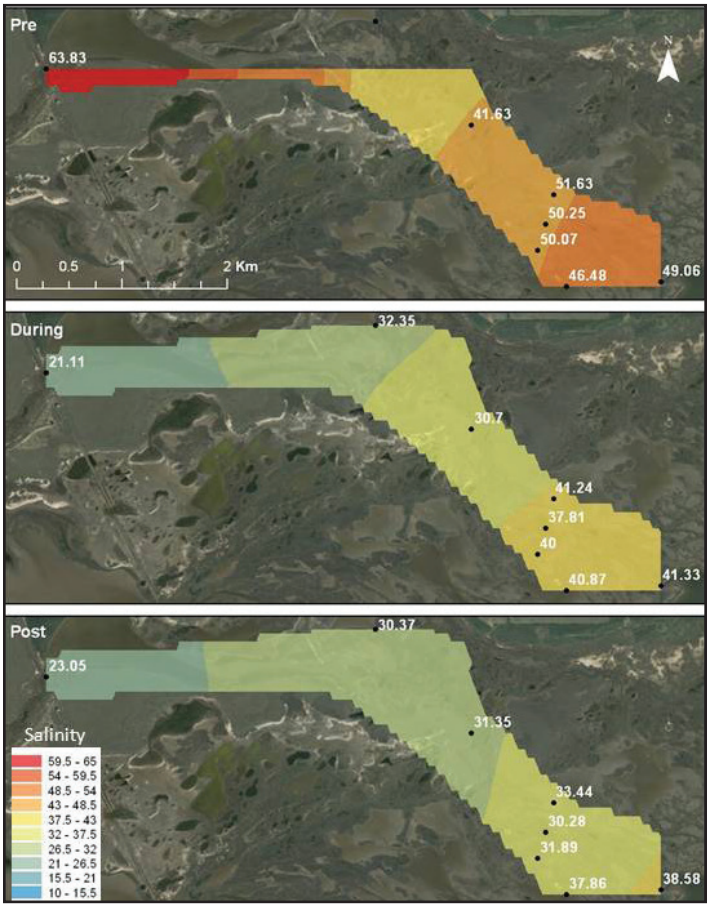

Figure 8. Spatial interpolation using the mean salinity of Pre-RBP, During-RBP, and Post-RBP for Event 1.

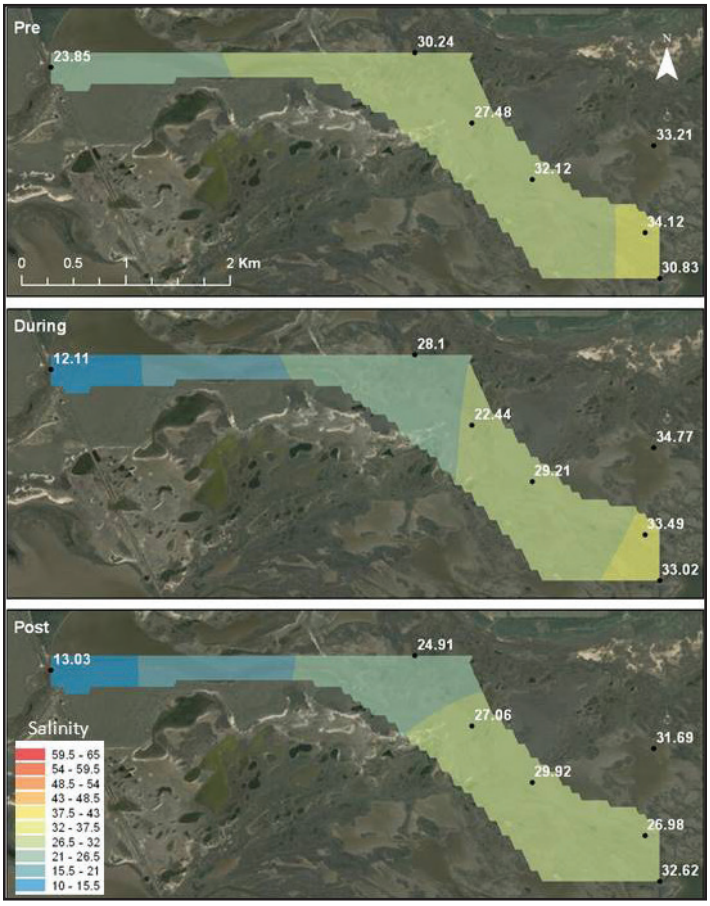

Figure 9. Spatial interpolation using the mean salinity of Pre-RBP, During-RBP, and Post-RBP for Event 2.

Table 5. Pre-RBP, During-RBP, and Post-RBP mean salinity, Event 2.

Mean Practical Salinity Units	CCS6	CCS7	CCS8	CCS9	NUDE2	NUDE3	Salt08	Salt03	Salt05
Pre-RBP	30.24	32.12	34.12	33.21	23.85	27.48	30.83	31.78	5.90
During-RBP	28.10	29.21	33.49	34.77	12.11	22.44	33.02	33.68	6.68
Post-RBP	24.91	29.92	26.98	31.69	13.03	27.06	32.62	34.35	7.90

Table 6. ANOVA salinity analysis for Event 2 RBP pumping event. Tukey HSD means are arranged from low (left) to high (right); ns = not significant.

Station	df	F	p	Turkey HSD Test
CCS6	2, 39	4.46	<0.05	PostRBP RBP PreRBP
CCS7	2, 39	0.49	0.62	ns
CCS8	2, 39	142.33	<0.001	PostRBP RBP PreRBP
CCS9	2, 39	7.51	<0.05	PostRBP PreRBP RBP
NUDE02	2, 27	2.80	0.08	RBP PostRBP PreRBP
NUDE03	2, 25	1.20	0.32	ns
Salt08	2, 31	1.28	0.29	ns

polation because of the distance from Rincon Bayou. Salinity at CCS9 fluctuated likely from rainfall during the event period and was not a result of the RBP. Overall, a typical estuarine salinity gradient was achieved Post-RBP in the Rincon Bayou. Temporal changes in salinity Post-RBP could not be quantified due to changes in salinity likely being from both rainfall and pumping. See Appendix II for all salinity data.

Event 3

A total of 2,354 acre-feet of water was pumped to the Rincon Bayou from 21 June through 13 July 2012. Salinity in the Rincon Bayou channel prior to the release ranged from 20 to 38 practical salinity units and from 2 to 119 practical salinity units at 4 stations outside of the channel prior to the June 2012 RBP event. The rain gauge on NUDEWX station failed 19 May 2012 resulting in no rain data being collected during Event 3.

Mean salinity in the Rincon Bayou and adjacent stations prior to the RBP March 2012 event was below hypersaline conditions except at CCS12 (Table 7). The RBP event lasted 23 days and Post-RBP mean salinity in the channel ranged from 14.57 practical salinity units at NUDE2 to 26.53 practical salinity units at Salt08. An ANOVA identified a significant difference in salinity means between Pre-RBP (n=15), During-RBP (n=23), and Post-RBP (n=16) conditions (Table 8). Mean salinity During-RBP and Post-RBP were significantly lower compared to Pre-RBP conditions for all stations, except at Salt08, which had significantly lower salinity Pre-RBP compared to Post-RBP. After pumping was complete, hypersalinity did not return during the Post-RBP sampling period (16 days) at stations CCS10, CCS11, and CCS13; however, CCS12 remained hypersaline during Post-RBP.

Spatial interpolation of salinity in the Rincon Bayou Pre-RBP identified a negative estuarine system with salinity increasing moving upstream from Nueces Bay, as seen in Event 1; hypersalinity was not observed at CCS13 (Figure 10). The RBP decreased salinity, relieving the reverse estuarine conditions in the channel and areas outside the channel. The area that remained hypersaline (CCS12) throughout most of Event 3 was a tidal pool cut off from exchange to the main Rincon Bayou because of water level and dry conditions. The decrease in salinity at CCS12 was likely due to rainfall; however, conditions remained hypersaline throughout the event. Tidal ponds and creeks located at higher elevations (e.g. CCS12) are restricted from the benefits of the reduced salinity in the Rincon Bayou Channel during RBP pumping events. The RBP inflows can only reach these elevated adjacent areas when water level in the channel proper breaches the threshold allowing for inundation. Overall, a typical estuarine salinity gradient in areas connected to the main Rincon Bayou channel Post-RBP was achieved during this event. See Appendix III for all salinity data.

Table 7. Pre-RBP, During-RBP, and Post-RBP mean salinity, Event 3.

Mean Practical Salinity Units	CCS10	CCS11	CCS12	CCS13	NUDE2	NUDE3	Salt08	Salt03	Salt05
Pre-RBP	29.68	30.94	78.02	16.21	33.75	24.06	23.29	26.68	0.61
During-RBP	21.70	26.85	45.63	18.17	10.33	18.22	23.47	29.33	0.68
Post-RBP	18.00	24.25	58.27	12.42	14.57	26.44	26.53	30.73	0.68

Table 8. ANOVA salinity analysis for Event 3 RBP pumping event. Tukey HSD means are arranged from low (left) to high (right).

Station	df	F	p	Tukey HSD Test
CCS10	2, 53	26.76	<0.001	PostRBP RBP PreRBP
CCS11	2, 53	9.29	<0.001	PostRBP RBP PreRBP
CCS12	2, 53	13.89	<0.001	RBP PostRBP PreRBP
CCS13	2, 53	6.98	<0.05	PostRBP PreRBP RBP
NUDE02	2, 41	54.68	<0.001	RBP PostRBP PreRBP
NUDE03	2, 36	6.32	<0.05	RBP PreRBP PostRBP
Salt08	2, 48	4.83	<0.05	PreRBP RBP PostRBP

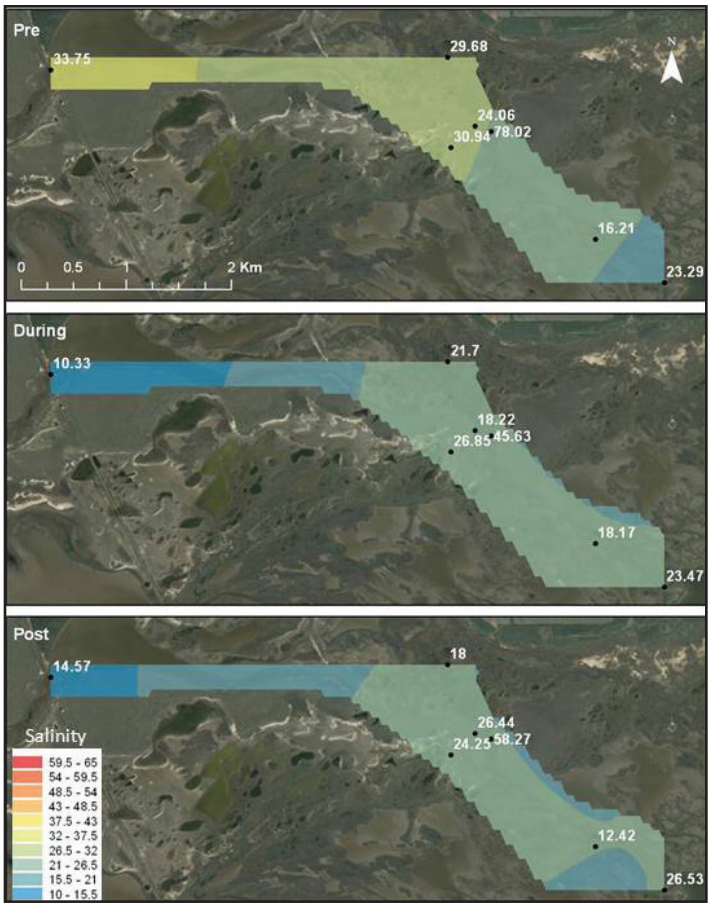

Figure 10. Spatial interpolation using the mean salinity of Pre-RBP, During-RBP, and Post-RBP for Event 3.

SUMMARY OF RINCON BAYOU PUMPING EVENTS

Nine pumping events have taken place since the RBP became operational in late 2007. During the 4-year pumping period, 14,709 acre-feet of water has been pumped into the upper Rincon Bayou (Table 9). Drought conditions occurred in late 2008 and persisted until fall 2009, which did not permit RBP pumping events to occur in Year 1. In Year 2, the RBP pumped a total of 6,017 acre-feet to the Rincon Bayou. Year 3 a total of 2,997 acre-feet was passed through and in Year 4 a total of 5,695 acre-feet was released into the Rincon Bayou. Figure 11 shows all 9 pumping events and their impact on salinity within the Rincon Bayou.

The Rincon Bayou has no distinct elevation gradient at the RBP outfall so water naturally flows both downstream to the Rincon Bayou and upstream back to the Nueces River. As cited in Tunnell and Lloyd (2011), during RBP operational testing phases the city installed a swing gate to prevent upstream flow. A U.S. Geological Survey (USGS) gauge (No. 08211503) has been in operation since 1996 and is located upstream of the RBP outfall. This gauge measures discharge rates of the RBP and natural flows through the Rincon Bayou. Data from this gauge were used to calculate the percentage of RBP backflow to the Nueces River and total water flowing downstream to the Rincon Bayou for each of the 3 pumping events during this study (Figure 12).

Table 9. RBP pumping events by water-year (1 September to 31 August) including pumping dates, duration, and acre-feet pumped.

Year	Pumping Event	Dates of Event	Duration (days)	Acre-Feet Pumped
1	-	No pumping occurred	-	-
2	1	28 September to 21 October 2009	24	2,987
2	2	6 January to 14 January 2010	9	742
2	3	10 May to 31 May 2010	21	2,288
3	4	21 March to 30 March 2011	10	1,001
3	5	3 May to 12 May 2011	10	1,002
3	6	13 June to 22 June 2011	10	994
4	7	2 November to 22 November 2011	21	2,031
4	8	7 March to 19 March 2012	13	1,310
4	9	21 June to 13 July 2012	23	2,354

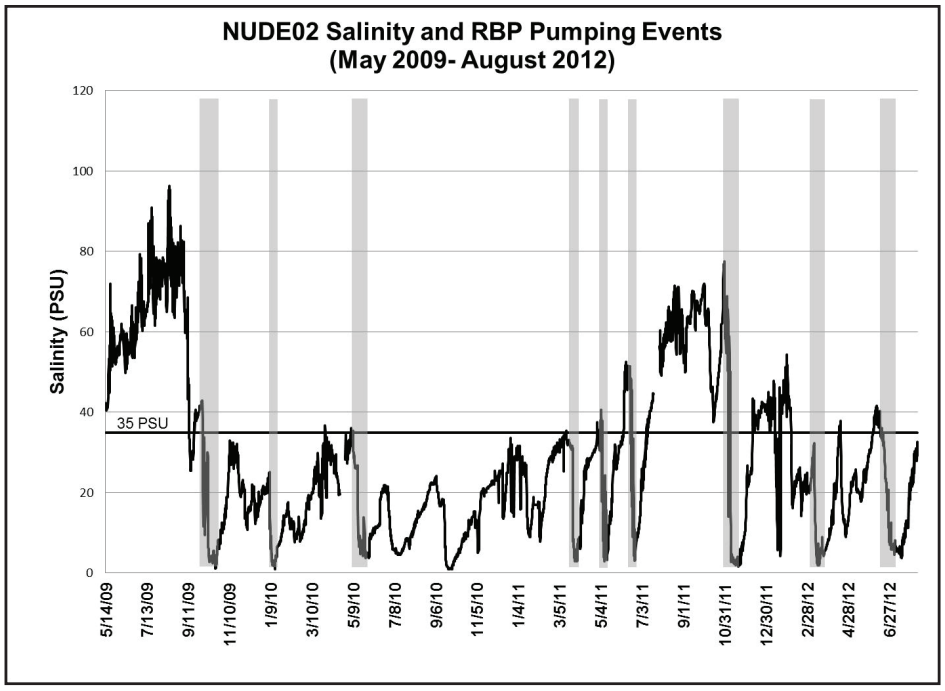

Figure 11. Upper Rincon Bayou salinity at NUDE02 during the 9 pumping events. Gray-shaded areas denote the 9 events that have occurred during the period of May 2009 to August 2012. Thickness of each shaded area represents days of pumping. Reference line showing 35 practical salinity units.

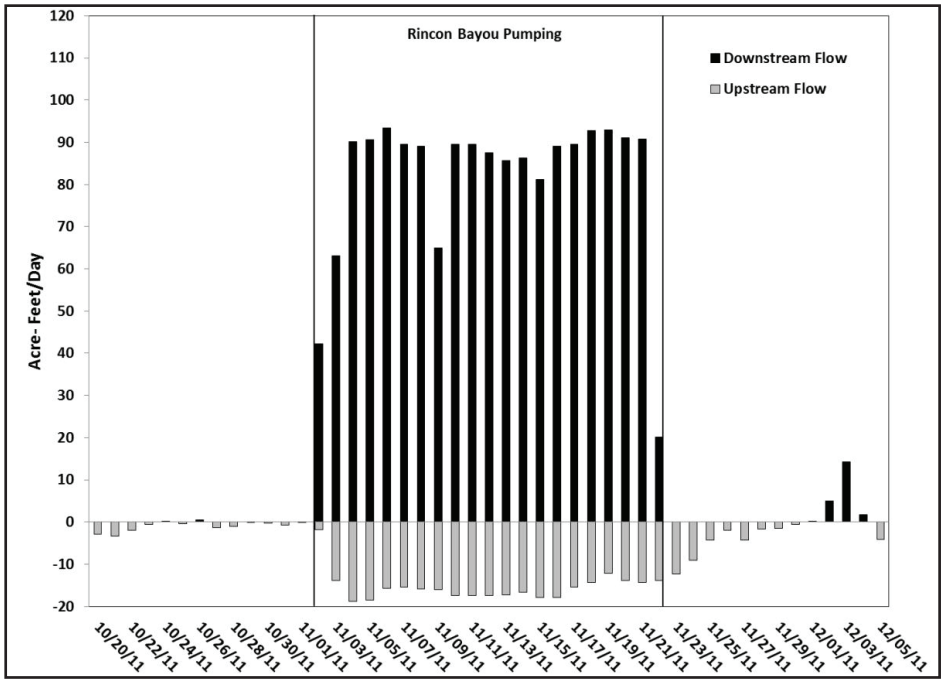

Figure 12a. Discharge rates of freshwater through the RBP during the a) November 2011 pumping event, b) March 2012 pumping event, and c) June-July 2012 pumping event showing the amount of water following downstream (black) through the Rincon Bayou or the loss (gray) upstream to the Nueces River measured at USGS gauge No. 08211503. Area between the thin lines depicts the RBP Event. (Figure 12b-c continued on next page.)

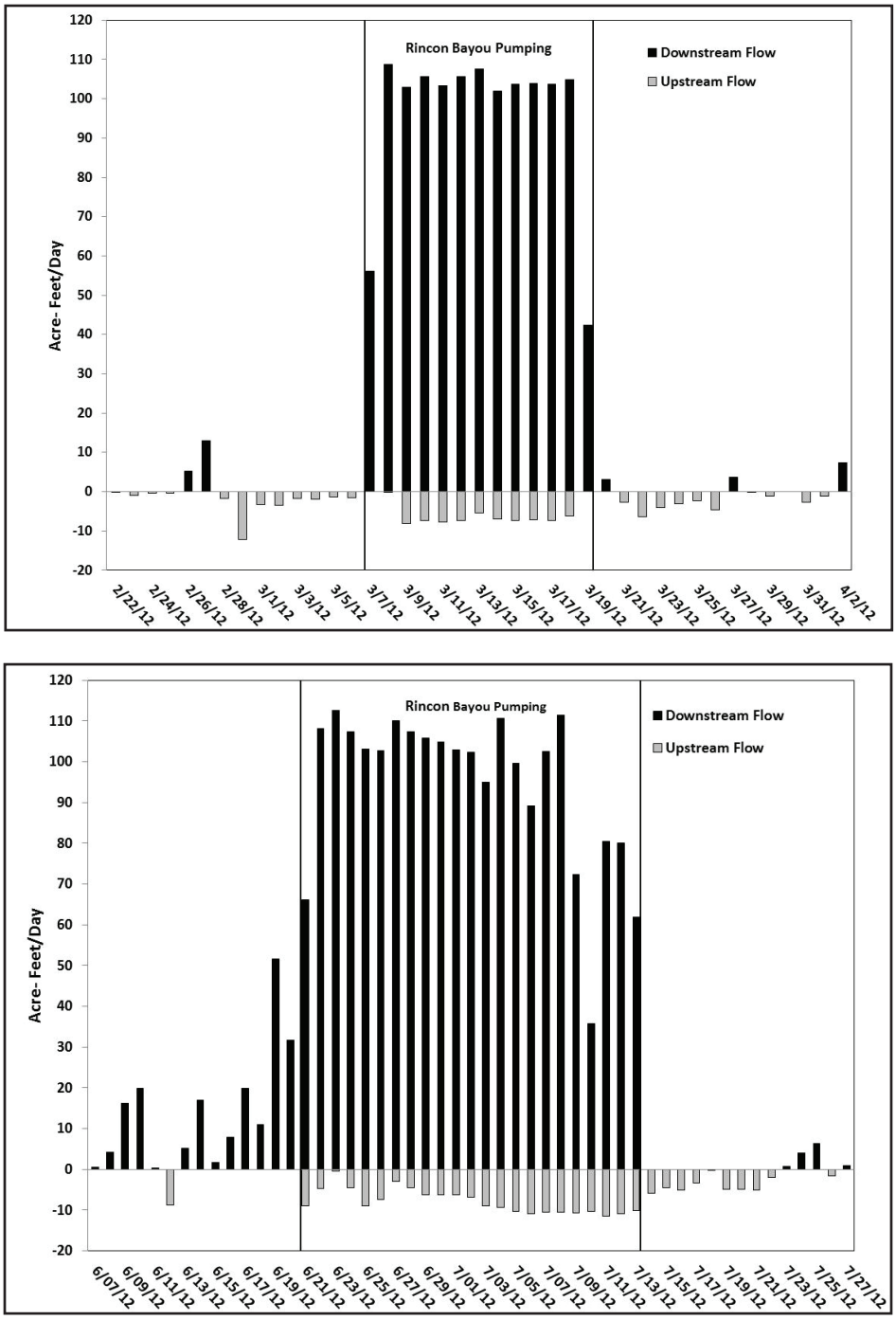

Figure 12b-c. Discharge rates of freshwater through the RBP during the a) November 2011 pumping event (Figure 12a on previous page.), b) March 2012 pumping event, and c) June-July 2012 pumping event showing the amount of water following downstream (black) through the Rincon Bayou or the loss (gray) upstream to the Nueces River measured at USGS gauge No. 08211503. Area between the thin lines depicts the RBP Event.

DISCUSSION

The physical, chemical, and biological behavior of the Nueces Delta is defined by its connectivity to the Gulf of Mexico and its river source, the Nueces River. The freshwater inflows from the Nueces River are the most significant factor of the 2 sources affecting water quality in the Nueces Delta and Nueces Estuary (BOR 2000). The Nueces River provides salinity relief as well as sediment and nutrients from processes occurring upstream in the watershed. Salinity fluctuations provide a useful index

in determining estuarine system interactions as salinity affects water chemistry and influences equilibrium and constant rates as well as diversity and survivability of estuarine fauna and flora (Knowles 2002).

The timing and volume of freshwater inflow to the Rincon Bayou is vital to system functioning (Montagna et al. 2002). The RBP can help manage salinity variability within the delta by reducing extreme salinity fluctuations during periods of low flow. The reduction in salinity variability and restoring the salinity gradient to the estuary should create conditions more favorable for biological productivity.

Salinity in the lower Nueces Delta during the 3 pumping events showed the RBP freshwater reduced salinity beyond the Rincon Bayou channel proper to the lower connecting marsh areas. Additional environmental factors influencing the spatial coverage and flow of the RBP include: quantity of freshwater pumped through the RBP, wind speed and direction, tide level, and rainfall. Management of the RBP pumping events must consider these factors when scheduling a release. Temporal effects on salinities outside the Rincon Bayou showed a reduction in salinity between 8 and 16 days after pumping had ceased. As with spatial coverage, other environmental factors, including wind, tide, and rainfall influenced these changes.

This project accomplished the goal of determining if freshwater from the RBP influences the lower Nueces Delta. The hot and dry climate of the Nueces Delta coupled with variable rainfall patterns often creates a negative estuary. The RBP pumping events relieved the hypersalinity conditions and created an estuarine salinity gradient in the Rincon Bayou Channel proper and in connecting habitats. This information will help to further refine the freshwater inflow management plan for the Nueces Delta and in developing an operational and scheduling plan for the RBP.

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Appendix I. Rincon Bayou Pipeline Event 1 daily mean salinity (practical salinity units). For reference, stations Salt05 located in the Nueces River and Salt03 located in Nueces Bay are included. Shaded areas: gray = time period of the RBP release and bold type = salinity < 35 practical salinity units.

Rain mm	RBP Date	RBP Flow Acre-feet	Date	CCS1	CCS2	CCS3	CCS4	CCS5	NUDE2	NUDE3	Salt 08	Salt 03	Salt 05
0			10/25/11		51.8	49.7	48.7	46.9	55.8	41.9	46.3	44.7	10.9
0			10/26/11		51.5	48.8	48.7	45.9			47.3	44.6	11.2
0			10/27/11		52.0	48.9	49.5	44.3					
0			10/28/11		51.6	53.2	50.6	47.2	75.6		53.9	46.5	11.1
0			10/29/11		53.1	53.8	52.6	48.4	75.4	43.3	49.3	46.3	11.1
0			10/30/11		51.1	50.8	50.6	47.4	61.3	41.2	47.9	46.2	11.3
0			10/31/11		51.2	48.9	50.0	46.8	60.2		49.6	46.0	11.2
0			11/1/11		50.7	47.9	49.8	44.9	54.7	40.1	49.1	46.0	10.2
0	11/2/11	44	11/2/11		48.9	46.5	49.2	42.5	57.4	39.0	47.4		9.9
1.0	11/3/11	77	11/3/11		48.7	49.8	48.9	41.9	64.0	42.8	54.5	45.6	8.9
0	11/4/11	109	11/4/11		37.1	52.4	54.2	45.0	62.2	44.8	51.0	45.8	9.1
0	11/5/11	109	11/5/11		**32.5**	50.9	51.1	44.3	40.5	42.3	48.4	45.8	9.0
0	11/6/11	109	11/6/11	43.9	35.6	44.2	48.3	44.1	54.2	38.8	46.3	45.5	9.1
0	11/7/11	105	11/7/11	44.6	44.5	44.8	47.7	41.1	49.5	37.6	46.1	45.0	9.1
0	11/8/11	105	11/8/11	45.7	46.3	46.9	47.2	45.7	**11.5**	39.1	45.8	44.0	8.6
0	11/9/11	81	11/9/11	47.8	47.0	41.1	46.6	41.8	**4.1**	**30.7**	44.2	46.1	
0	11/10/11	107	11/10/11	40.7	46.5	**27.0**	**33.3**	39.1		17.5			
0	11/12/11	105	11/11/11	**31.5**	44.9	**30.4**	**27.4**	38.7	**3.6**	**17.0**	44.0	45.0	8.7
0	11/13/11	103	11/12/11	**34.9**	41.8	39.6	39.9	39.3	**2.9**	**22.1**	43.6	46.5	8.8
0	11/14/11	103	11/13/11	**32.7**	40.2	40.1	41.2	40.4	**2.8**	**19.7**	38.8	46.1	8.0
0	11/15/11	99	11/14/11	**30.5**	39.5	41.1	41.3	40.5	**3.0**		**34.4**	45.6	8.7
4.0	11/16/11	107	11/15/11	**29.0**	39.5	**31.4**	39.7	40.7		**12.5**	**17.1**	45.4	5.9
0	11/17/11	105	11/16/11	**25.2**	39.3	**19.3**	**24.0**	40.1	**3.5**	**9.9**	**12.3**	45.5	6.5
0	11/18/11	107	11/17/11	**12.9**	38.7	**13.5**	**12.8**	**30.0**	**4.0**		**34.9**	46.3	11.6
0	11/19/11	105	11/18/11	**9.2**	37.0	**23.5**	**22.0**	37.9	**3.0**	**23.9**	41.5	46.3	9.3
0	11/20/11	105	11/19/11	**28.1**	38.6	36.9	40.3	41.7	**3.7**	43.2	45.2	45.1	
0	11/21/11	105	11/20/11	**32.1**	39.5	38.8	42.2	40.9	**4.0**	41.6	44.1	44.7	8.8
0	11/22/11	34	11/21/11	**28.9**	38.8	37.7	42.8	42.0	**6.0**	**30.1**	45.6	44.7	8.6
0			11/22/11	**30.4**	38.5	**32.0**	36.4	42.5	**2.5**	**14.0**	43.8	45.1	6.8
0			11/23/11	**30.9**	38.5	**16.4**	**19.7**	38.7	**4.6**	**9.2**	39.8	45.4	8.4
0			11/24/11	**29.3**	**34.1**	**13.7**	**13.0**	36.1	**7.2**	**10.0**	39.7	45.1	8.7
0			11/25/11	**20.0**	**34.5**	**33.6**	**34.5**	37.6	**6.5**	**12.4**	36.6	45.1	8.5
0			11/26/11	**29.8**	**27.4**	**33.7**	38.1	39.2	**7.5**	**18.0**	**32.5**	45.5	5.1
0			11/27/11	**14.2**	**18.5**	**11.1**	**18.0**	36.8		9.9		47.1	6.5
0			11/28/11			8.0	11.9	34.1		**11.5**	**13.8**	45.8	4.2
0			11/29/11			14.6		30.5				45.9	
0			11/30/11		**22.2**	**32.8**	**19.7**	37.3		**27.5**	40.3	44.7	
0			12/1/11	**33.9**	41.8	40.5	39.5	40.4		43.9	43.3	44.5	6.4

Appendix I (Continued). Rincon Bayou Pipeline Event 1 daily mean salinity (practical salinity units). For reference, stations Salt05 located in the Nueces River and Salt03 located in Nueces Bay are included. Shaded areas: gray = time period of the RBP release and bold type = salinity < 35 practical salinity units.

Rain mm	RBP Date	RBP Flow Acre-feet	Date	CCS1	CCS2	CCS3	CCS4	CCS5	NUDE2	NUDE3	Salt 08	Salt 03	Salt 05
0			12/2/11	41.7	42.1	42.3	42.2	40.0		41.9	43.0	43.7	6.5
0			12/3/11	40.9	40.1	42.2	42.4	37.1		42.3	42.9	43.7	6.2
0			12/4/11	40.1	41.1	42.1	42.4	36.0		42.7	42.7	42.8	
0			12/5/11	42.2	**27.6**	37.5	35.5	36.1		37.5	42.2	43.2	4.6
0			12/6/11	**29.9**	**19.5**	**24.2**	**23.0**	**30.6**		**34.6**	39.2		
0			12/7/11	**8.5**	**15.0**	**23.3**	**15.4**	**33.6**	**25.5**	**31.7**	44.2	43.8	
0			12/8/11	**5.5**	**20.2**	**24.1**	**15.3**	39.2	**25.8**	37.4	44.4	43.3	6.3
0			12/9/11	**29.5**	37.8	35.4	**34.9**	41.0		43.3	44.1	43.4	7.3
2.0			12/10/11	41.7	42.0	36.7	42.7	42.5	41.7	42.7	44.1	43.1	
1.0			12/11/11	40.6	40.0	37.8	42.3	41.7	39.4	43.7	43.7	42.9	11.3
0			12/12/11	39.8	39.3	36.4	41.7	40.4	38.8	42.2	42.2	42.4	10.3
0			12/13/11	38.7	38.5	35.9	41.1	41.1	38.2	41.0	41.4		
0			12/14/11	38.9	38.1	**34.3**	41.8	39.0	38.9	40.8	41.3	42.0	11.2
0			12/15/11	38.7	38.8	38.1	42.3	37.3		42.9	42.2	42.4	

Appendix II. Rincon Bayou Pipeline Event 2 daily mean salinity (practical salinity units). For reference, stations Salt05 located in the Nueces River and Salt03 located in Nueces Bay are included. Shaded areas: gray = time period of the RBP release and bold type = salinity < 35 practical salinity units.

Rain mm	RBP Date	RBP Flow Acre-feet	Date	CCS6	CCS7	CCS8	CCS9	NUDE2	NUDE3	Salt 08	Salt 03	Salt 05
0			3/2/12	**30.4**	35.9	**33.3**	35.1	**20.5**	26.9	30.9	30.8	
0			3/3/12	**29.7**	35.7	**33.5**	**24.4**	**23.1**	**25.4**	**28.6**	**31.9**	5.4
0			3/4/12	**26.3**	**29.6**	**34.1**	37.1	**23.7**		31.8	32.0	5.0
0			3/5/12	**29.0**	**30.6**	**34.6**	**33.0**		26.2		32.1	
0			3/6/12	35.7	**28.8**	35.0	36.5	**28.1**	**31.4**	**32.0**	**32.1**	7.3
0	3/7/12	52	3/7/12	35.2	37.2	**34.8**	36.8	**31.1**				
0	3/8/12	109	3/8/12	35.3	37.3	**34.8**	36.8	**32.3**		31.8	32.6	7.5
1.0	3/9/12	111	3/9/12	38.3	**8.0**	**31.8**	**29.9**	**17.9**		32.6		
0	3/10/12	113	3/10/12	**30.0**	**23.6**	**32.7**	36.2		21.7	**32.8**	**33.1**	6.6
0	3/11/12	111	3/11/12	**26.5**	**26.6**	**33.7**	35.1	5.3	27.2		33.1	
0	3/12/12	113	3/12/12	**25.5**	**27.1**	**33.5**	35.1	**3.5**		31.3	32.9	
0	3/13/12	113	3/13/12	**25.9**	**23.1**	32.2	34.1	3.1	27.5	31.5	32.6	
0	3/14/12	109	3/14/12	**27.7**	29.1	32.5	34.3	7.3	28.9	33.2	34.1	
0	3/15/12	111	3/15/12	26.4	33.9	33.7	34.8	1.9	22.9	33.8	34.1	
0	3/16/11	111	3/16/12	**23.9**	**33.8**	**34.4**	35.2		14.7	34.0	34.3	
0	3/17/12	111	3/17/12	**22.7**	**33.6**	**34.1**	35.0			34.4	34.5	
0	3/18/11	111	3/18/12	**16.8**	**33.5**	**33.6**	35.0		9.3	**34.1**	**34.7**	4.8
0	3/19/12	34	3/19/12	**31.2**	**33.1**	**33.6**	**33.8**	**6.6**	**27.3**	**33.7**	**34.5**	7.8
17.0			3/20/12	**30.5**	**31.4**	**32.1**	**33.1**			**31.9**	**34.3**	
0			3/21/12	**27.5**	**28.4**	**29.5**	**31.9**	**5.2**	**14.8**	**22.4**	**34.7**	5.2
0			3/22/12	**27.8**	**22.7**	**24.9**	**32.0**	**4.8**	**13.1**	**30.4**	**33.8**	
0			3/23/12	**21.2**	**23.9**	**27.2**	**32.3**			**32.0**	**34.4**	
0			3/24/12	**19.5**	**24.2**	**27.3**	**34.2**	**6.1**	**18.9**	**31.7**	**34.4**	
0			3/25/12	**19.4**	**24.2**	**27.2**	**33.5**		**19.3**	**31.5**		
0			3/26/12	**20.0**	**28.0**	**26.5**	**32.9**		**19.8**	**31.8**	**34.2**	

Appendix II. (Continued) Rincon Bayou Pipeline Event 2 daily mean salinity (practical salinity units). For reference, stations Salt05 located in the Nueces River and Salt03 located in Nueces Bay are included. Shaded areas: gray = time period of the RBP release and bold type = salinity < 35 practical salinity units.

Rain mm	RBP Date	RBP Flow Acre-feet	Date	CCS6	CCS7	CCS8	CCS9	NUDE2	NUDE3	Salt 08	Salt 03	Salt 05
0			3/27/12	**22.3**	**31.8**	**27.8**	**33.1**	**7.1**		**34.7**		
6.0			3/28/12	**24.0**	**30.9**	**28.0**	**33.6**	**8.1**	**32.5**	**34.5**	**35.1**	
4.0			3/29/12	**23.5**	**29.9**	**27.1**	**32.6**	**8.3**		**33.8**	**34.1**	
0			3/30/12	**22.6**	**29.3**	**26.2**	**32.0**	**9.0**			**34.1**	
0			3/31/12	**24.0**	**25.5**	**26.4**	**32.7**	**9.8**				
0			4/1/12	**24.5**	**27.0**	**26.5**	**31.5**	**10.7**			**34.1**	
12.0			4/2/12	**27.5**	**32.6**	**26.1**	**30.8**				**34.0**	8.0
0			4/3/12	**28.3**	**34.1**	**25.9**	**31.4**	**14.8**	**32.0**	**35.0**	**34.7**	
0			4/4/12	**27.2**	**35.5**	**26.1**	**31.2**		**32.9**	**34.7**	**34.4**	
0			4/5/12	**26.7**	**35.9**	**26.4**	**30.8**		**30.5**	**34.7**	**34.5**	8.1
0			4/6/12	**26.4**	**36.4**	**26.5**	**31.0**	**20.9**	**30.3**		**33.8**	
0			4/7/12	**27.5**	**33.9**	**26.5**	**29.8**	**21.6**	**34.4**	**33.8**	**34.3**	
0			4/8/12	**26.7**	**33.2**	**26.6**	**29.3**	**21.4**	**33.2**	**34.1**	**34.6**	
0			4/9/12	**25.6**	**31.6**	**26.4**	**29.2**	**23.1**	**32.7**	**33.7**	**34.4**	9.0
0			4/10/12	**25.3**	**27.7**	**26.5**	**28.3**	**24.6**	**34.5**	**33.9**	**34.8**	9.2

Appendix III. Rincon Bayou Pipeline Event 3 daily mean salinity (practical salinity units). For reference, stations Salt05 located in the Nueces River and Salt03 located in Nueces Bay are included. Shaded areas: gray = time period of the RBP release and bold type = salinity < 35 practical salinity units.

Rain mm	RBP Date	RBP Flow Acre-feet	Date	CCS 10	CCS 11	CCS 12	CCS 13	NUDE 2	NUDE 3	Salt 08	Salt 03	Salt 05
			6/6/12	**32.2**	36.8	74.5	**2.7**	38.8	**28.3**	**28.0**	**30.2**	
			6/7/12	**33.2**	38.6	76.8	**8.3**	38.9	**27.3**		**30.5**	**0.7**
			6/8/12	**33.9**	36.4	80.0	**17.3**	36.9		**26.4**	**29.2**	
			6/9/12	**31.2**	**33.3**	83.2	**16.3**	38.4	**25.2**	**24.1**		**0.6**
			6/10/12	**26.0**	**29.0**	87.4	**15.7**	36.3	**27.0**	**26.7**	**27.2**	**0.6**
			6/11/12	**28.9**	**32.1**	90.5	**16.0**		**27.6**	**25.7**	**22.4**	
			6/12/12	**32.9**	**34.0**	94.0	**15.4**	34.0		**23.5**	**24.5**	
			6/13/12	**33.7**	**34.4**	102.2	**14.9**	33.7	**24.3**	**22.3**	**25.5**	**0.6**
			6/14/12	**28.4**	**29.4**	111.1	**13.7**	34.7		**20.9**	**23.1**	**0.6**
			6/15/12	**27.9**	**26.6**	118.5	**17.5**	**32.9**	**23.0**	**21.3**	**24.2**	
			6/16/12	**29.5**	**27.8**	119.8	**19.1**	**32.5**	**20.2**	**19.5**	**25.5**	**0.6**
			6/17/12	**26.5**	**24.3**	67.9	**20.9**	**31.6**	**20.4**	**20.4**	**28.2**	**0.6**
			6/18/12	**23.8**	**26.2**	**1.9**	**21.6**		**20.9**	**21.5**		**0.6**
			6/19/12	**26.3**	**27.5**	**13.1**	**21.4**	**26.5**	**20.5**	**22.3**		**0.6**
			6/20/12	**30.8**	**27.6**	49.5	**22.2**	**23.5**		**23.4**	**29.7**	**0.6**
	6/21/12	75	6/21/12	**27.6**	**24.3**	51.7	**21.3**	**22.4**		**21.6**	**29.5**	
	6/22/12	113	6/22/12	**23.9**	**23.2**	51.2	**21.0**	**20.4**	**20.1**	**21.7**	**29.0**	**0.6**
	6/23/12	113	6/23/12	**23.6**	**23.2**	47.0	**21.4**		**18.9**	**22.2**	**30.2**	
	6/24/12	112	6/24/12	**25.1**	**23.8**	46.7	**21.8**	**20.7**		**22.4**	**28.1**	**0.6**
	6/25/12	112	6/25/12	**25.3**	**25.9**	45.6	**23.4**			**22.4**	**28.1**	**0.6**
	6/26/12	110	6/26/12	**24.3**	**26.1**	44.1	**23.0**	**8.3**		**22.9**	**28.3**	**0.6**
	6/27/12	113	6/27/12	**24.4**	**24.6**	43.7	**23.1**	**12.3**	**21.4**	**23.3**	**29.2**	
	6/28/12	112	6/28/12	**25.2**	**27.5**	42.8	**23.6**	**12.5**	**26.8**	**26.4**	**28.9**	**0.7**
	6/29/12	112	6/29/12	**25.7**	**27.1**	43.5	**23.9**		**26.3**	**27.2**		**0.7**
	6/30/12	111	6/30/12	**24.7**	**25.2**	42.4	**22.0**	**7.0**	**24.4**		**30.3**	**0.7**
	7/1/12	109	7/1/12	**23.1**	**24.7**	41.0	**20.6**	**7.3**	**24.2**		**29.3**	**0.7**
	7/2/12	109	7/2/12	**22.4**	**24.7**	40.9	**20.9**	**6.6**	**24.8**	**25.9**	**29.9**	**0.7**
	7/3/12	104	7/3/12	**21.9**	**24.5**	41.5	**20.5**	**8.1**	**24.0**	**27.6**	**30.7**	**0.7**
	7/4/12	120	7/4/12	**21.1**	**23.8**	42.5	**19.9**	**6.7**	**23.2**	**27.3**	**30.0**	**0.7**
	7/5/12	110	7/5/12	**20.7**	**23.3**	43.4	**19.2**	**5.7**	**23.9**	**29.5**		**0.7**
	7/6/12	100	7/6/12	**18.4**	**22.0**	44.2	**17.7**	**5.9**		**26.9**	**29.7**	**0.7**
	7/7/12	113	7/7/12	**16.7**	**23.8**	45.4	**15.8**		**11.3**	**27.6**	**29.6**	
	7/8/12	122	7/8/12	**14.4**	**24.3**	46.7	**14.9**					

Appendix III. (Continued) Rincon Bayou Pipeline Event 3 daily mean salinity (practical salinity units). For reference, stations Salt05 located in the Nueces River and Salt03 located in Nueces Bay are included. Shaded areas: gray = time period of the RBP release and bold type = salinity < 35 practical salinity units.

Rain mm	RBP Date	RBP Flow Acre-feet	Date	CCS 10	CCS 11	CCS 12	CCS 13	NUDE 2	NUDE 3	Salt 08	Salt 03	Salt 05
	7/9/12	83	7/9/12	**14.4**	**28.2**	48.0	**13.8**		**9.2**	**26.3**	**29.1**	**0.7**
	7/10/12	46	7/10/12	**19.3**	37.0	48.8	**8.5**	**6.7**	**7.7**	**15.2**	**28.9**	
	7/11/12	92	7/11/12	**23.3**	36.8	49.2	**6.3**		**7.7**	**11.3**	**29.2**	
	7/12/12	91	7/12/12	**21.5**	38.7	49.6	**6.4**	**4.4**	**8.7**	**21.7**	**29.3**	**0.7**
	7/13/12	72	7/13/12	**12.1**	**34.8**	49.9	**8.7**		**7.2**	**19.9**		**0.7**
			7/14/12	**9.4**	**28.4**	50.4	**10.3**	**4.4**	**13.4**	**24.1**	**29.2**	**0.6**
			7/15/12	**10.6**	**27.8**	51.0	**11.8**	**8.6**		**24.8**	**29.0**	**0.6**
			7/16/12	**10.5**	**23.1**	51.7	**12.3**	**7.2**		**24.9**		**0.6**
			7/17/12	**11.2**	**22.7**	52.5	**13.1**	**7.6**		**24.9**	**30.5**	**0.6**
			7/18/12	**14.0**	**23.5**	53.1	**14.1**	**8.6**		**27.7**	**31.3**	**0.6**
			7/19/12	**15.4**	**23.9**	53.8	**14.5**	**9.0**		**26.2**	**29.9**	**0.6**
			7/20/12	**15.3**	**23.7**	54.2	**10.7**	**11.1**	**25.6**	**26.2**	**29.7**	**0.7**
			7/21/12	**15.7**	**24.3**	55.3	**8.3**	**12.7**	**25.1**	**25.9**	**29.4**	
			7/22/12	**17.1**	**19.7**	56.7	**9.4**					
			7/23/12	**20.7**	**17.6**	58.1	**12.0**	**18.8**	**26.8**	**27.1**		
			7/24/12	**22.3**	**20.6**	60.1	**12.5**	**22.3**	**26.8**	**27.5**		0.8
			7/25/12	**24.0**	**24.1**	62.6	**13.2**	**19.0**		**28.7**	**31.3**	
			7/26/12	**24.5**	**25.9**	65.3	**13.6**	**23.9**	**28.5**	**28.3**		
			7/27/12	**25.0**	**26.9**	66.8	**14.0**		**29.9**	**27.3**	**32.7**	**0.8**
			7/28/12	**26.2**	**27.5**	68.9	**14.4**	**25.4**	**31.0**	**27.2**	**32.9**	
			7/29/12	**26.0**	**28.2**	71.7	**14.4**	**25.4**	**30.9**	**27.2**	**32.1**	**0.9**