

Assessment of NPS Pollution from Cropland in the Oso Bay Watershed

TSSWCB Project 07-07

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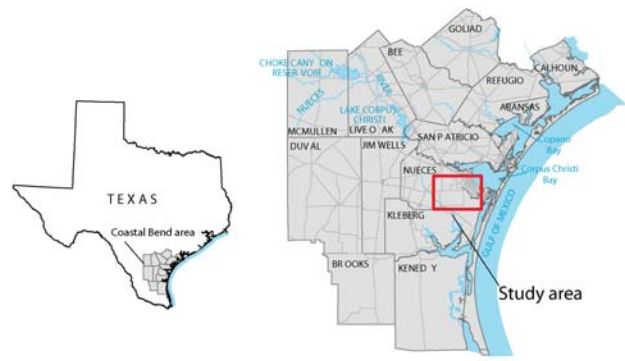
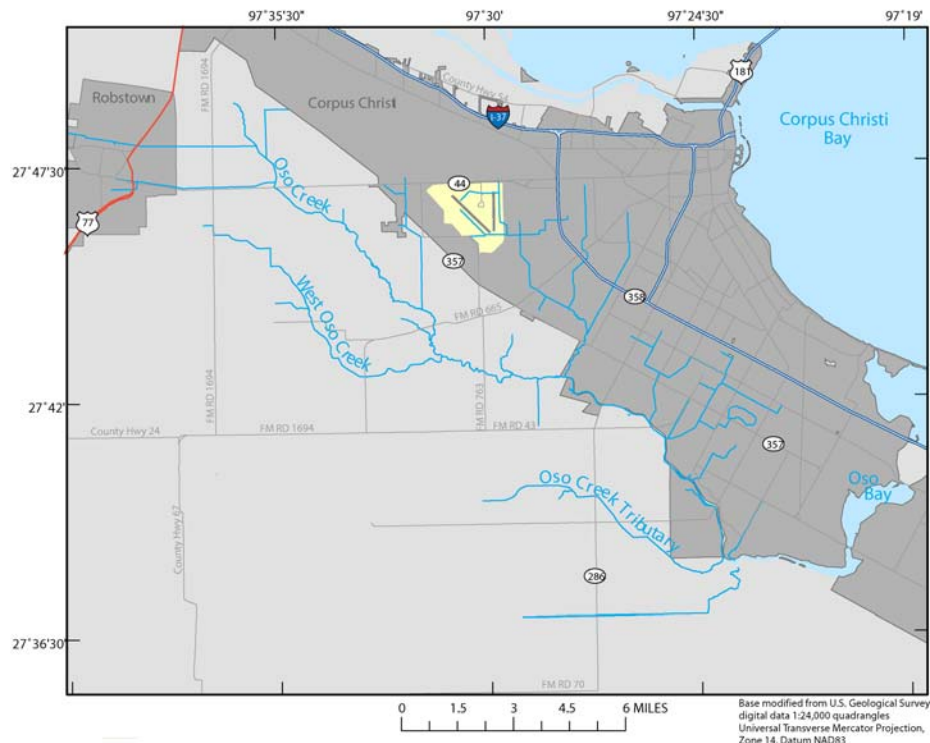
Dr. Joanna Mott, Texas A&M University - Corpus Christi

Oso Creek TMDL Meeting - June 26, 2008, Corpus Christi, TX

Introduction

Oso Bay (Segment 2485) is a secondary bay of approximately 7 square miles that exchanges water with the Corpus Christi Bay and receives freshwater inflows from **Oso Creek** (Segment 2485A). Oso Bay provides habitat for many plant and animal species, and plays important role in water purification and storm protection.

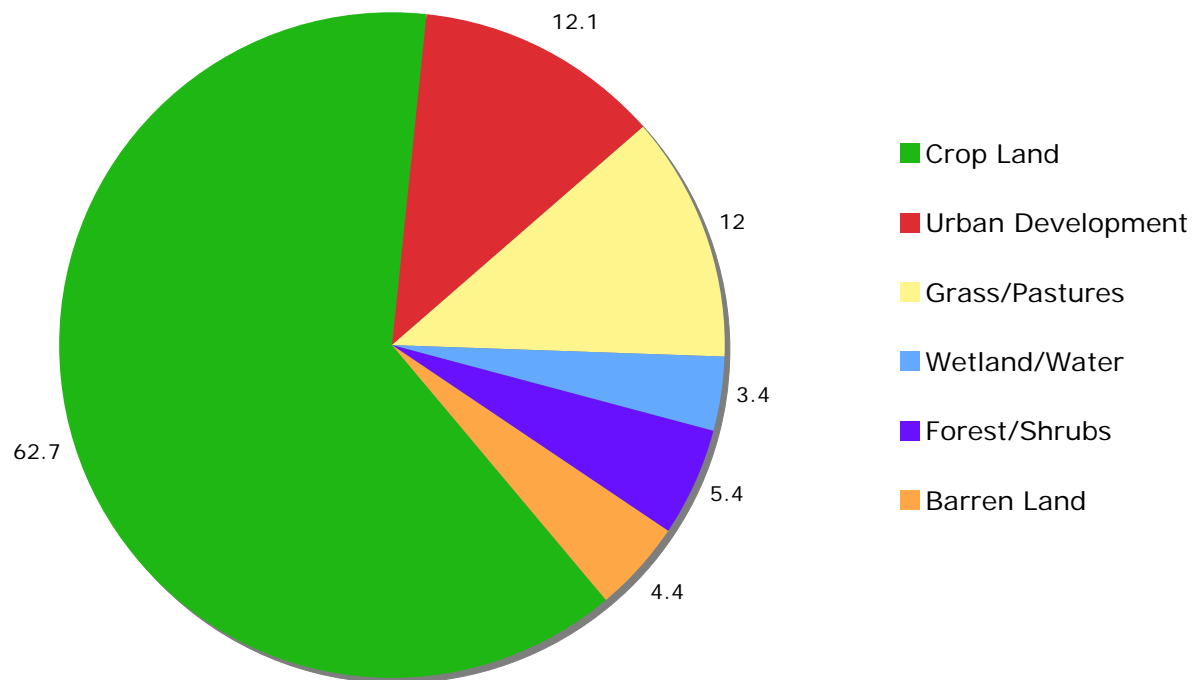
Oso Creek is a stream about 28 miles long whose lower half is tidal and dominated by permitted discharges. The Oso Creek watershed is approximately 234 square miles.



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Introduction (cont.)

Oso Creek Watershed Land Use (%)



Adapted from National Land Cover Dataset Classifications in Oso Creek Basin - 2003 (as reported by R. Hay and J. Mott. 2005. Oso Creek and Oso Bay Bacteria Total Maximum Daily Load Model. Final Report TCEQ Contract 582-5-725. Texas A&M University - Corpus Christi.)

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Introduction (cont.) Water Quality Impairments

The Texas Commission on Environmental Quality (TCEQ) identified the Oso Bay and Oso Creek as water bodies that do not meet applicable water quality standards. *Water quality impairments* identified are:

- Low concentration of dissolved O₂ (Oso Bay)
- Elevated concentrations of bacteria (Oso Bay and Oso Creek)

Concern: nutrient enrichment from the Oso Creek watershed may affect the concentration of dissolved oxygen in Oso Bay.

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This project (07-07) extends from Oct. 2007 to Sep. 2009 and is a continuation of a preceding project (TSSWCB Project 02-13 “Estimation of Water Quality Constituents Loadings from Agricultural Croplands in the Oso Creek Watershed.”) conducted cooperatively between the Texas AgriLife Research Center at Corpus Christi and the USGS from Oct. 2005 to Sep. 2007.

A parallel and simultaneous assessment of bacteria (*Enterococcus*) and pesticide loads was conducted with support from the Coastal Bend Bays and Estuaries Program (CBBEP Project 0539 “Estimation of Pesticide and Bacteria Loadings in Surface Water Runoff from Agricultural Croplands in the Oso Creek Watershed”), which involved the cooperation of TAMU-Corpus Christi (bacteria assessment).

Both projects (TSSWCB 02-13 and 07-07) were funded through federal Clean Water Act §319(h) NPS grants from the TSSWCB and USEPA.

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Short-Term Goals

- To assess runoff-related loadings of nutrients, selected inorganic ions, suspended sediments, and bacteria (*Enterococcus*) from the Oso Creek watershed,
- To develop a better understanding of the role of these runoff-related loadings on the dynamics of water quality properties in these water bodies.

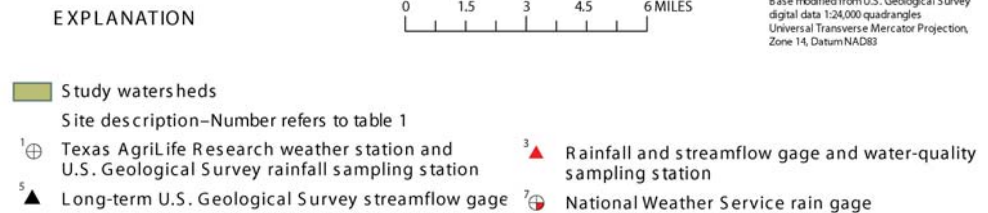
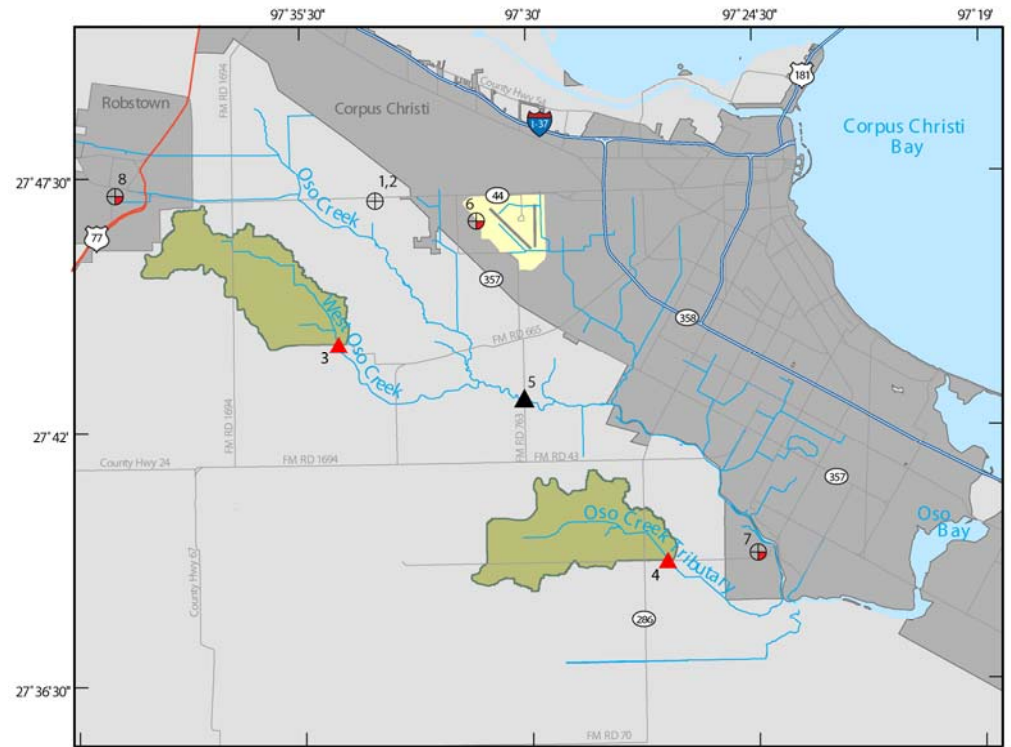
Long-Term Goal:

To support program implementation efforts of TSSWCB, Nueces SWCD, and TCEQ to protect and restore water quality of the Oso Bay and Oso Creek water bodies.

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Specific Objectives

- To collect, analyze and characterize hydrologic and water quality data from two tributaries that drain agricultural sub watersheds in the Oso Creek watershed.
- To estimate annual loadings of nutrients and selected ions applied by farmers to croplands in the watersheds and compare these loadings with annual runoff loadings of related constituents.



The two sub watersheds where runoff water quality monitoring was conducted are: (1) upper reaches of West Oso Creek at CR-30 (Merrett Rd.), draining 5,145 acres of croplands, and (2) Oso Creek tributary at FM 2444, draining 5,287 acres predominantly croplands.

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Instrumentation and Data Collection

- Automated stations installed at the outlets of each sub watershed continuously monitor rainfall, water level, stream velocity, and stream discharge.
- Automatic water samplers collect runoff water samples during runoff events.
- Discrete manual water samples are also collected from a cross section of the stream during runoff events.
- Rainfall samples are also collected during rainfall events with an automated rainfall sampler.



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Instrumentation and Data Collection (cont.)

- Continuous rainfall - (weather station at AgriLife Research Center and monitoring stations at watershed outlets)
- Rainfall water quality - (automated sampler at AgriLife Research Center)
- Continuous water surface elevation (stage) and discharge - (monitoring stations at watersheds)
- Automated runoff water sampling for determination of constituent loads (N, nitrate, nitrite, ammonia, phosphorus, calcium, potassium, chloride, sulfate) - (monitoring stations at watersheds)
- Manual runoff water sampling during runoff events for determination of concentrations of suspended sediments and bacteria (fecal coliform, enterococci, and E. coli)

(Constituent loads are calculated from mean concentrations and runoff or mean concentrations and rainfall.)

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Results from the two preceding projects (TSSWCB 02-13 and CBBEP 0539) are shown in the next slides.

The results to be presented are part of the publication by D.J. Ockerman. 2008. Hydrologic Conditions and Quality of Rainfall and Storm Runoff in Agricultural Areas in the Oso Creek Watershed, Nueces County Texas, 2005-07. U.S. Geological Survey Scientific Investigations Report 2008-xxxx. (in press)

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Results From Project TSSWCB 02-13

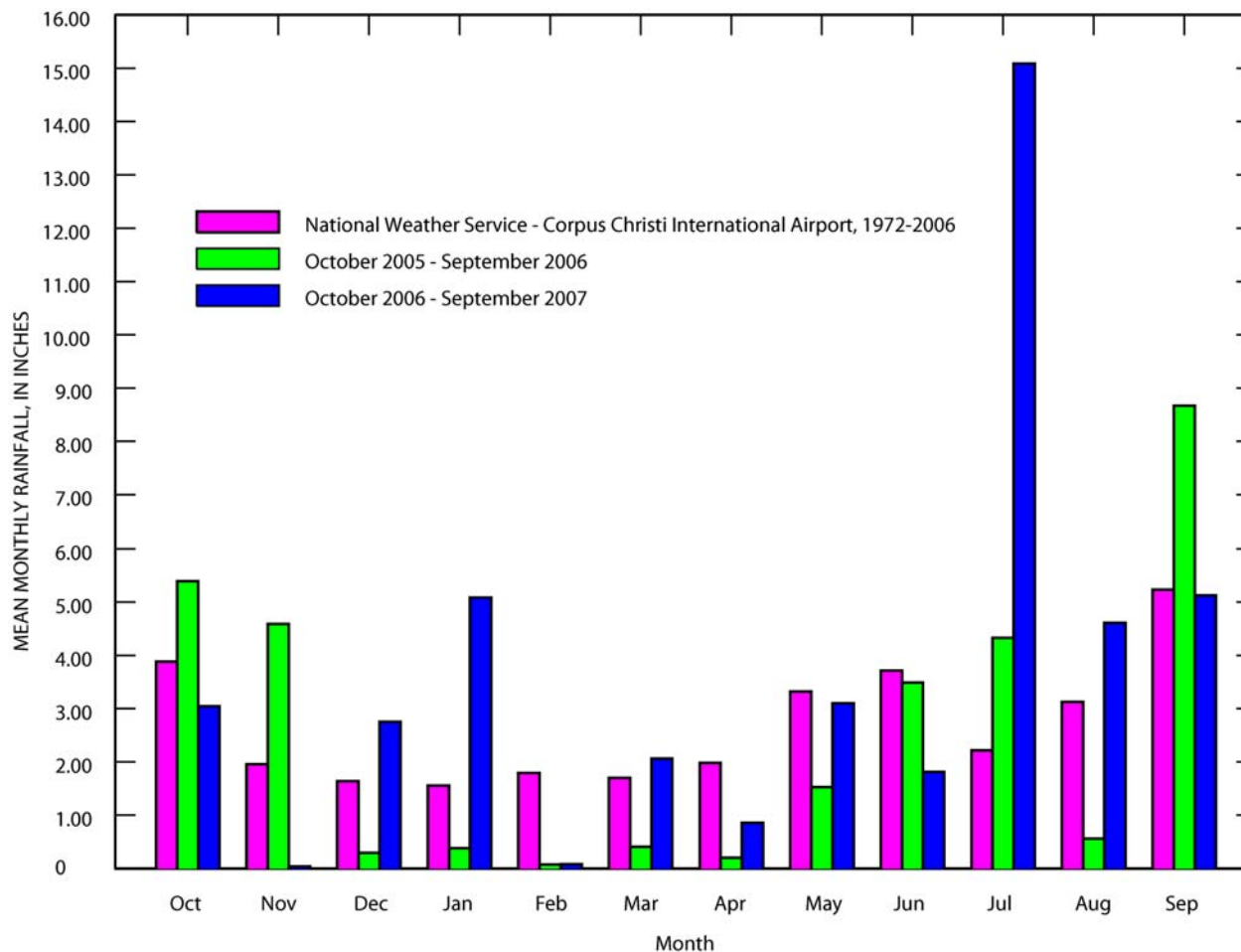


Figure 6. Mean monthly rainfall at National Weather Service - Corpus Christi International Airport, 1972 - 2006, compared with monthly study-area rainfall, October 2005 - September 2007.

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Results From Project TSSWCB 02-13

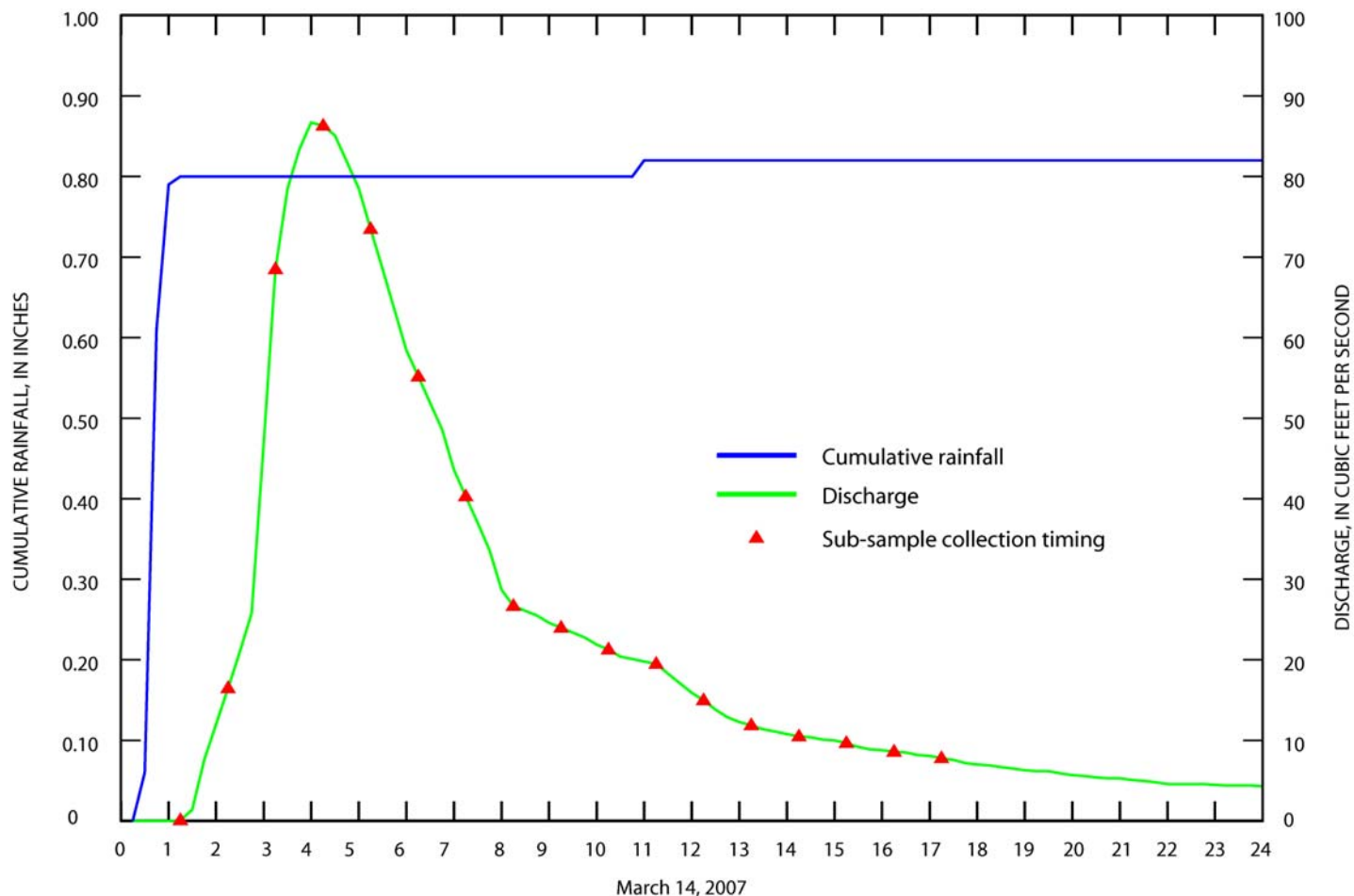


Figure 4. Hydrograph showing rainfall, discharge, and sub-sample collection timing at 08211517 - West Oso Creek at Merrett Road, near Corpus Christi, TX, during storm runoff of March 14, 2007

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Results From Project TSSWCB 02-13

Table 4. Rainfall, runoff volumes, and ratio of runoff to rainfall for selected runoff events and study totals, October 2005 – September 2007.

Event date	West Oso Creek				Oso Creek Tributary			
	Rainfall (in.)	Runoff (in.)	Runoff/ rainfall	Runoff water-quality samples collected?	Rainfall (in.)	Runoff (in.)	Runoff/ rainfall	Runoff water-quality samples collected?
2005								
Oct 11 – 13	0.92	0.000	0.000	no	7.18	0.136	0.019	no
Nov 16 – 17	.49	.008	.016	no	.95	.000	.000	no
Nov 26 – 29	2.62	.237	.090	no	3.80	.041	.011	no
2006								
Jun 1 – 4	3.90	.651	.167	yes	2.50	.075	.030	yes
Jul 1 – 7	3.48	.018	.005	yes	3.20	.019	.006	yes
Jul 26 – 27	1.34	.018	.013	no	.15	.000	.000	no
Aug 19 – 20	.60	.007	.017	no	0.00	.000	.000	no
Sept 9 – 17	2.79	.011	.004	yes	2.91	.182	.063	yes
Sept 18 – 23	3.17	.960	.303	yes	3.58	1.306	.365	yes
Sept 24 – Oct 1	2.82	1.288	.457	no	2.04	.846	.415	no
Oct 22 – 25	1.36	.001	.001	no	1.01	.055	.054	no
2007								
Jan 3 – 7	1.68	.016	.010	yes	2.13	.060	.028	yes
Jan 24 – Feb 3	2.29	.142	.062	yes	2.40	.290	.121	yes
March 14 – 18	1.71	.115	.067	yes	1.82	.080	.044	yes
May 25 – 29	2.48	.002	.001	yes	3.15	.015	.005	no
July 2 – 10	8.20	2.697	.329	yes	10.72	3.26	.304	yes
July 19 – 24	2.07	1.255	.606	no	1.76	.050	.028	no
July 26 – August 8	6.37	2.324	.365	no	2.13	.274	.469	no
Aug 30 – Sept 2	2.45	.000	.000	no	1.05	.101	.096	yes
Sept 3 – 13	1.29	.627	.486	no	1.67	.180	.108	no
Sept 29 – 30	3.21	.245	.076	no	2.43	.275	.113	no
Total – 21 events	55.24	10.622	.192	--	56.58	7.245	.128	--
Total – Oct 2005 to Sept 2007	72.78	10.827	.149	--	77.16	7.275	.094	--

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Results From Project TSSWCB 02-13

Table 6. Summary statistics of rainfall sample quantities and selected nutrient constituents in rainfall samples, water years 2006–07

[mg/L, milligrams per liter; N, nitrogen; P, phosphorus; unfltrd, unfiltered]

Constituent	Number of Samples	Mean (mg/L)	Median (mg/L)	Minimum (mg/L)	Maximum (mg/L)
Rainfall, inches	14	2.00	1.40	0.14	9.30
Nitrogen, ammonia, dissolved, mg/L as N	14	.264	.163	.035	.820
Nitrogen, ammonia + organic, dissolved, mg/L as N	14	.45	.23	.12	2.30
Nitrogen, ammonia + organic, total, mg/L as N	14	.42	.19	.06	2.00
Nitrogen, nitrite + nitrate, dissolved, mg/L as N	14	.190	.112	.029	.780
Nitrite, dissolved, mg/L as N	14	.002	.002	<.002	.004
Organic nitrogen, total, unfltrd, mg/L as N	11	.25	.04	.005	1.9
Nitrogen, total, mg/L	11	.73	.35	.24	2.1
Phosphorus, dissolved, mg/L as P	14	<.006	<.006	<.004	.021
Phosphorus, total, unfltrd, mg/L as P	14	<.006	<.008	<.004	.028
Phosphorus, Ortho-phosphate, dissolved, mg/L as P	14	<.006	<.006	<.006	.013

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Results From Project TSSWCB 02-13

Table 7. Monthly and annual rainfall deposition of total nitrogen – Water years 2006–07

[In pounds per acre]

Year	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Annual
West Oso Creek Watershed													
2006	0.50	0.43	0.09	0.20	0.11	0.19	0.14	0.47	0.37	0.78	0.26	1.12	4.66
2007	.38	.04	.51	.78	.10	.29	.39	.60	.56	.81	.99	.79	7.22
Oso Creek Tributary Watershed													
2006	0.75	0.54	0.17	0.16	0	0.08	0	0.33	0.26	0.48	0.08	1.06	3.92
2007	.69	0	.54	.77	.06	.26	.29	.34	.42	1.34	.83	.65	6.21

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Results From Project TSSWCB 02-13

Table 8. Summary statistics of selected nutrients and major inorganic ions in runoff samples, water years 2006 – 07

Station/Constituent	Number of Samples	Mean	Median	Minimum	Maximum
08211517 – West Oso Creek					
Nitrogen, total, mg/L	10	3.15	3.15	0.98	5.10
Nitrogen, ammonia, dissolved, mg/L as N	10	.087	.040	.017	.228
Nitrogen, nitrate + nitrite, dissolved, mg/L as N	10	.96	.61	.22	3.26
Nitrogen, organic, total, mg/L	10	2.10	2.08	.73	4.20
Phosphorus, total, mg/L as P	10	.31	.28	.19	.49
Calcium, dissolved, mg/L	9	14.1	14.2	8.9	18.4
Potassium, dissolved, mg/L	9	4.44	4.07	3.24	6.74
Chloride, dissolved, mg/L	9	1.83	1.58	.97	3.11
Sulfate, dissolved	9	1.79	1.50	.90	3.65
08211525 – Oso Creek tributary at FM 2444					
Nitrogen, total, mg/L	9	1.63	1.23	1.10	3.50
Nitrogen, ammonia, dissolved, mg/L as N	9	.037	.021	.012	.171
Nitrogen, nitrite + nitrate, dissolved, mg/L as N	9	.37	.20	.06	1.0
Nitrogen, organic, total, mg/L	9	1.23	1.06	.87	2.4
Phosphorus, total, mg/L as P	9	.45	.42	.26	.69
Calcium, dissolved, mg/L	8	17.4	18.3	13.5	20.2
Potassium, dissolved, mg/L	8	7.15	7.65	4.82	9.32
Chloride, dissolved, mg/L	8	10.9	8.79	1.97	21.6
Sulfate, dissolved	8	6.28	5.56	1.30	12.8

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Results From Project TSSWCB 02-13

Table 13. Annual and average-annual runoff yields of selected nutrients, water years 2006–07

[lbs, pounds, N, nitrogen, P, phosphorus]

Watershed/Nutrient	2006 (lbs/acre)	2007 (lbs/acre)	2006 – 07 average (lbs/acre/year)
West Oso Creek watershed – 5,145 acres			
Nitrogen, total	1.57	3.65	2.61
Ammonia nitrogen, dissolved, as N	.025	.062	.044
Nitrite + nitrate nitrogen, dissolved, as N	.323	.876	.600
Organic nitrogen, total, as N	1.24	2.83	2.03
Phosphorus, total	.432	1.12	.78
Orthophosphate phosphorus, dissolved, as P	.231	.756	.494
Oso Creek tributary watershed – 5,287 acres			
Nitrogen, total	0.66	1.27	0.97
Ammonia nitrogen, dissolved, as N	.013	.022	.018
Nitrite + nitrate nitrogen, dissolved, as N	.114	.233	.174
Organic nitrogen, total, as N	.55	1.06	.80
Phosphorus, total	.320	.675	.50
Orthophosphate phosphorus, dissolved, as P	.198	.546	.372

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Table 14. Comparison of fertilizer applications, rainfall deposition, and runoff yields of total nitrogen and total phosphorus for study area watersheds, water years 2006–07

Results From Project TSSWCB 02-13

Site/year or period	Total Nitrogen		
	Fertilizer application	Rainfall deposition	Runoff Yield
West Oso Creek			
Water year 2006, lbs per acre	71.3	4.66	1.57
Water Year 2007, lbs per acre	65.6	7.22	3.65
2006 – 07 average, lbs per acre per year	68.4	5.94	2.61
Oso Creek tributary			
Water year 2006, lbs per acre	68.7	3.92	.66
Water Year 2007, lbs per acre	62.9	6.21	1.27
2006 – 07 average, lbs per acre per year	65.8	5.06	.96
Area-weighted average for both study watershed for 2006 – 07	67.1	5.50	1.77

Site/year or period	Total Phosphorus		
	Fertilizer application	Rainfall deposition	Runoff Yield
West Oso Creek			
Water year 2006, lbs per acre	15.4	< 0.06	0.43
Water Year 2007, lbs per acre	14.3	< .06	1.12
2006 – 07 average, lbs per acre per year	14.8	< .06	.78
Oso Creek tributary			
Water year 2006, lbs per acre	14.6	< .06	.32
Water Year 2007, lbs per acre	12.9	< .06	.68
2006 – 07 average, lbs per acre per year	13.8	< .06	.50
Area-weighted average for both study watershed for 2006 – 07	14.3	< .06	0.64

Results From Project TSSWCB 02-13

Table 18. Annual and average-annual runoff yields of suspended-sediment, water years 2006 – 07.

[all units in pounds per acre per year]

Site	2006	2007	2006 – 07 average
West Oso Creek	544	619	582
Oso Creek tributary	232	283	257

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Results From Project CBBEP 0539

Table 19. Pesticides used in the Oso Creek study areas, water years 2006–07

[* indicates chemical not included in runoff-sample lab analysis]

Herbicides	Insecticides	Defoliant, desiccant, growth regulators
2,4-D	Acephate*	Ethephon*
Atrazine	Acetamiprid*	Mepquat chloride*
Glyphosate	Diclotophos	Thidiazron*
Glufosinate-ammonium	Imidacloprid	Thidiazrom + diuron*
Prosulfuron*	Malathion	Paraquat chloride*
Pendimethalin	Myclobutanil (fungicide used primarily for residential applications)	
Prometryn		
Trifluralin		
	Propoxur (insecticide used primarily for residential applications)	
	Thiamethoxam*	
	Zeta-cypermethrin	

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Table 20. Summary statistics of concentrations of pesticides detected in runoff samples, water years, 2006–07

[µg/L, micrograms per liter; <, less than]

08211517 – West Oso Creek

Station/Constituent	Number of Samples	¹ Number of Detections	Mean (µg/L)	Median (µg/L)	Minimum (µg/L)	Maximum (µg/L)
Herbicides						
2,4-D	10	7	--	0.09	<0.04	6.24
2-Chloro-4-isopropylamino-6-amino-s-triazine (CIAT)	10	10	0.06	0.04	0.015	0.18
2-Chloro-6-ethylamino-4-amino-s-triazine (CEAT)	10	2	<0.08	<0.08	<0.08	<0.08
2-Hydroxy-4-isopropylamino-6-ethylamino-s-triazine (OIET)	10	10	0.28	0.13	0.063	1.11
Acifluorfen	10	1	<0.06	<0.06	<0.028	<0.06
Aldicarb Sulfoxide	10	1	<0.04	<0.04	<0.04	<0.04
Aminomethylphosphonic acid (AMPA)	10	10	5.44	3.60	1.13	13.2
Atrazine	10	10	1.07	0.12	0.02	8.90
Benfluralin	10	1	<0.01	<0.01	<0.01	<0.01
Dacthal monoacid	10	1	<0.02	<0.02	<0.02	<0.02
DCPA	10	1	--	<0.003	<0.003	0.0035
Diuron	10	2	<0.04	<0.04	<0.02	0.04
Glufosinate	10	2	--	<0.14	<0.14	<0.58
Glyphosate	10	10	17.6	8.51	1.81	53.5
Metolachlor	10	3	--	<.006	<.006	0.228
Pendimethalin	10	10	--	1.18	<0.02	13.7
Simazine	10	3	--	<0.005	<0.005	0.022
Trifluralin	10	3	--	<0.009	<0.009	0.05
Insecticides						
Dicrotophos	10	1	<0.08	<0.08	<0.08	<0.08
Imidacloprid	10	1	--	<0.02	<0.02	0.086
Myclobutanil	10	3	<0.033	<0.033	<0.033	<0.033
Propoxur	10	1	--	<0.008	<0.008	<0.04

Results From Project CBBEP 0539

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Results From Project CBBEP 0539

Table 23. Comparison of annual and average-annual application rates and runoff yields of selected pesticides, West Oso Creek and Oso Creek Tributary watersheds, water years 2006–07

[all values in pounds per acre per year]

Site/Pesticide	2006		2007		2006–07 average	
	Application	Runoff yield	Application	Runoff yield	Application	Runoff yield
West Oso Creek						
Atrazine	0.54	0.0002	0.58	0.006	0.56	0.003
Glyphosate	1.40	0.005	1.85	0.021	1.625	0.013
Pendimethalin	0.39	0.0003	0.36	0.0004	0.375	0.0003
Oso Creek Tributary						
Atrazine	0.54	0.00005	0.67	0.0002	0.605	0.0001
Glyphosate	1.42	0.0005	1.65	0.002	1.535	0.001
Pendimethalin	0.38	0.00003	0.27	0.00006	0.325	0.00005

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Results From Project CBBEP 0539

Table 25. Summary statistics of bacteria concentrations in runoff samples 2006–07

[TSWQS, Texas Surface Water Quality Standard; all concentrations in colonies per 100 milliliters of sample]

Station/Constituent	Number of Samples	Mean	Median	Minimum	Maximum	TSWQS
08211517 – West Oso Creek						
Fecal Coliform	7	31,480	36,500	320	75,500	¹ 200/400
E.Coli	8	23,490	9,325	46	92,000	² 126/394
Enterococci	8	75,340	73,500	5,200	144,000	³ 35/89
08211525 – Oso Creek tributary						
Fecal Coliform	4	6,100	4,670	156	14,900	¹ 200/400
E.Coli	5	6,360	4,150	72	18,500	² 126/394
Enterococci	5	32,560	25,800	5,000	75,000	³ 35/89

¹ Geometric mean of Fecal Coliform should not exceed 200 colonies per 100 milliliters. Single samples should not exceed 400 colonies per 100 ml (freshwater, contact recreation criteria)

² Geometric mean of E Coli should not exceed 200 colonies per 100 milliliters. Single samples should not exceed 400 colonies per 100 ml (freshwater, contact recreation criteria)

³ Geometric mean of Enterococci should not exceed 35 colonies per 100 milliliters. Single samples should not exceed 89 colonies per 100 ml (saltwater, contact recreation criteria)

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Conclusions From Project TSSWCB 02-13

Rainfall and Runoff

- Total rainfall amount during the study was 17% above the long-term average, with a few rainfall events much higher than average and an unusual 5-month period in 2006 with severe low precipitation.
- Although rainfall on the study watersheds was similar, runoff volume, peak flows, and runoff constituent loads were all greater in the West Oso Creek watershed than in the Oso Creek tributary watershed. Runoff totals as % of rainfall were 14.9 and 9.4% for West Oso Creek and Oso Creek tributary watersheds, respectively. A possible explanation of this difference is that the primary stream channel in the Oso Creek tributary watershed features grassland buffers for a considerable distance upstream of the monitoring station, while runoff in the West Oso Creek watershed is routed through a cultivated field immediately upstream of the monitoring station.
- 75% of the runoff at each site occurred during two wet periods one in 2006 and another in 2007.

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Conclusions From Project TSSWCB 02-13

Nutrients and sediment

- Most of the nutrient, sediment, and pesticide runoff constituent loads occurred during the two wet periods that produced 75% of the runoff.
- During the 2-year study, the average total N yield in runoff was 1.77 lbs/acre, which represents about 2.4% of all N entering the area as fertilizer (67 lbs/acre) and rainfall deposition (5.5 lbs/acre).
- During the 2-year study, the average total P yield in runoff was 0.63 lbs/acre, which represents about 4.2% of the P entering the area as fertilizer (14.9 lbs/acre) and rainfall deposition (0.06 lbs/acre).
- Suspended-sediment runoff yield was much higher in the West Oso Creek watershed (582 lbs/acre/yr) than in the Oso Creek tributary (257 lbs/acre/yr).

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Conclusions From Project CBBEP 0539

Pesticides

- 24 out of 26 pesticides found in runoff samples were detected in only a few samples and at relatively low concentrations
- The herbicides Glyphosate and Atrazine were detected, however, in all samples at concentrations substantially greater than the other pesticides.
- During the 2-year study, the average total runoff yield of Atrazine was 0.002 lbs/acre/yr, which represents about 0.3% of the amount applied by farmers (0.58 lbs/acre/yr).
- During the same period, the average total runoff yield of Glyphosate was 0.007 lbs/acre/yr, which represents about 0.4% of the amount applied by farmers (1.58 lbs/acre/yr).

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Conclusions From Project CBBEP 0539

Bacteria

- Most fecal coliform, Enterococcus, and E. coli bacteria concentrations in runoff samples were substantially greater than the Texas Surface Water Quality Standards for receiving waters of Oso Creek and Oso Bay, and substantiates the impairment during high flow events. However, they are associated with brief and infrequent conditions and the effect on downstream water quality is not known.
- Bacteria concentrations in runoff water samples of the West Oso Creek were about twice those of the Oso Creek tributary.

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Final Remarks

Projects TSSWCB 02-13 and CBBEP 0539 both produced quality data indicating relatively small amounts of nutrients, pesticides, and sediments but fairly large amounts of bacteria emerging from the study watersheds. The impact of these runoff constituent loads on the ecology of Oso Creek and Oso Bay, however, is not known.

The data obtained, nonetheless, may not be fully representative of an average year. While crop production conditions in 2007 were reasonably adequate, the cropping season in 2006 was highly unusual and characterized by a prolonged severe deficient rainfall during winter and spring, which led to crop stand failures. One of the two significant runoff events occurred in September 2006 when both watersheds were dominated by bare lands. The other significant runoff event in 2007 was unusually high with runoff:rainfall ratios in the range of 0.5 to 0.6.

Furthermore, the differences observed between the two study watersheds with respect to runoff ratios and runoff constituent loads, however, are not clear and need further investigation.

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*Special thanks to TSSWCB
for supporting this project!
and
Thank you for your
attention!*

Questions?

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