Hydrologic Conditions and Quality of Rainfall and Runoff in Agricultural Areas in the Oso Creek Watershed

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Prepared in cooperation with the Texas Soil and Water Conservation Board, Coastal Bend Bays and Estuaries Program, and Texas AgriLife Research & Extension Center at Corpus Christi

Hydrologic Conditions and Quality of Rainfall and Storm Runoff in Agricultural Areas in the Oso Creek Watershed, Nueces County Texas, 2005-07

By D. J. Ockerman

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Hydrologic Conditions and Quality of Rainfall and Storm Runoff in Agricultural Areas in the Oso Creek Watershed, Nueces County Texas, 2005–07

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Abstract

The U.S. Geological Survey, in cooperation with the Texas State Soil and Water Conservation Board, Coastal Bend Bays and Estuaries Program, and Texas AgriLife Research and Extension Center at Corpus Christi, studied the hydrologic and water-quality conditions of two agricultural areas in the Oso Creek watershed, in Nueces County, Texas. One area, the upper West Oso Creek watershed is 5,145 acres. The other area, a watershed drained by an unnamed Oso Creek tributary, is 5,287 acres. For two years, October 2005–September 2007, rainfall and runoff on each study area were continually monitored. Fourteen rainfall samples were collected and analyzed for selected trace elements and nutrients. A total of nineteen event-composite runoff samples were collected at two stations that monitored runoff from the study watersheds. Runoff samples were analyzed for nutrients, major ions, trace elements, and pesticides. Also, 21 suspended-sediment samples and 12 bacteria samples were collected at the two runoff-monitoring stations. Rainfall, runoff, and water-quality data were used to estimate loads of selected constituents entering the study watersheds in rainfall and exiting the study areas in runoff. Data on applications of fertilizers and pesticides to croplands in the study watersheds also were compiled and compared with quantities of nutrients and pesticides exiting the watersheds in runoff.

During the study, average annual rainfall on the study areas was 37.50 inches, which was greater than the long-term average rainfall of 32.12 inches. Runoff from the study areas was intermittent, and more than 75 percent of the runoff at each site occurred during two wet periods: September 18–October 1,

2006 and July 2–August 8, 2007. During these periods, multiple rainfall events and prolonged wet soil conditions contributed to substantial runoff. Most of the nutrient, sediment, and pesticide constituent loads associated with runoff also occurred during these periods. 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 the Oso Creek tributary watershed.

During the 2-year study, the average total nitrogen yield in runoff from the overall study area was 1.77 pounds per acre per year, compared with an average of 67.1 pounds per acre per year of nitrogen applied as fertilizer and 5.50 pounds per acre per year of total nitrogen from rainfall deposition. The average runoff yield of total nitrogen represents approximately 2.4 percent of nitrogen applied as fertilizer and entering the study areas through rainfall deposition.

Total phosphorus runoff yield from the overall study area averaged 0.63 pounds per acre per year, compared with 14.3 pounds per acre per year of phosphorus applied as fertilizer. Rainfall deposition of phosphorus was less than 0.13 pounds per acre per year. The average runoff yield of total phosphorus represents approximately 4.2 percent of phosphorus applied as fertilizer.

Suspended-sediment yield from the study areas averaged 417 pounds per acre per year. However, because of higher peak flows and greater runoff volume, the sediment yield was much higher in the West Oso Creek watershed than the Oso Creek tributary watershed. The West Oso Creek watershed suspended-sediment yields averaged 582 pounds per acre per year and the Oso Creek tributary watershed yield averaged 257 pounds per acre per year.

Twenty-six pesticide compounds were detected in runoff samples with varying degrees of frequency. Most of the pesticides detected were detected in only a few samples and at relatively low concentrations (near the laboratory reporting limit). The herbicides atrazine and glyphosate were detected in all runoff samples. Runoff yields of atrazine and glyphosate were substantially greater than the other pesticides. During the study period, an average of 0.58 pounds per acre per year of atrazine were applied to study areas croplands. During the same period, 0.002 pounds per acre per year of atrazine exited the study areas in runoff, or about 0.3 percent of the applied atrazine. The average annual application and runoff yield for glyphosate were 1.58 pounds per acre and 0.007 pounds per acre, respectively (about 0.4 percent of applied glyphosate detected in runoff).

Bacteria concentrations in runoff samples indicated a potential water-quality concern as most fecal coliform, *Escherichia coli*, and *enterococci* concentrations were substantially greater than Texas Surface Water Quality Standards for receiving waters of Oso Creek and Oso Bay. However, runoff and associated bacteria concentrations occur during relatively brief and infrequent conditions, and the resulting effect on quality of receiving waters is not known.

INTRODUCTION

The Coastal Bend bays and estuaries system of Texas is one of 28 estuaries in the United States that have been designated as "Estuaries of National Significance" (Texas Natural Resources Conservation Commission, 1996). The Coastal Bend bays and estuaries are affected by non-point source runoff from agricultural land, which comprises about 88 percent of the Coastal Bend area (figure 1). The Oso Creek watershed, drains to Oso Bay and includes approximately 234 square miles (sq mi). Agricultural land (pasture and cropland) accounts for about 69 percent of the Oso Creek watershed. Oso Bay, situated along the southern shore of Corpus Christi Bay, is relatively shallow, with an average depth of about 2.3 ft and a surface area of approximately 7 sq mi (Quenzer, and others, 1998). Ecologically, Oso Bay provides habitat for many plants and animals, and plays an important role in water purification and storm protection (Texas Commission on Environmental Quality, 2007).

From October 2005 to September 2007, the U.S. Geological Survey (USGS), in cooperation with the Texas State Soil and Water Conservation Board (TSSWB), Coastal Bend Bays and Estuaries Program (CBBEP), and Texas AgriLife Research and Extension Center at Corpus Christi (formerly Texas Agricultural Experiment Station – Corpus Christi and henceforth referred to as Texas AgriLife Research) studied the hydrology and water quality of two primarily agricultural areas in the Oso Creek watershed (fig.1).

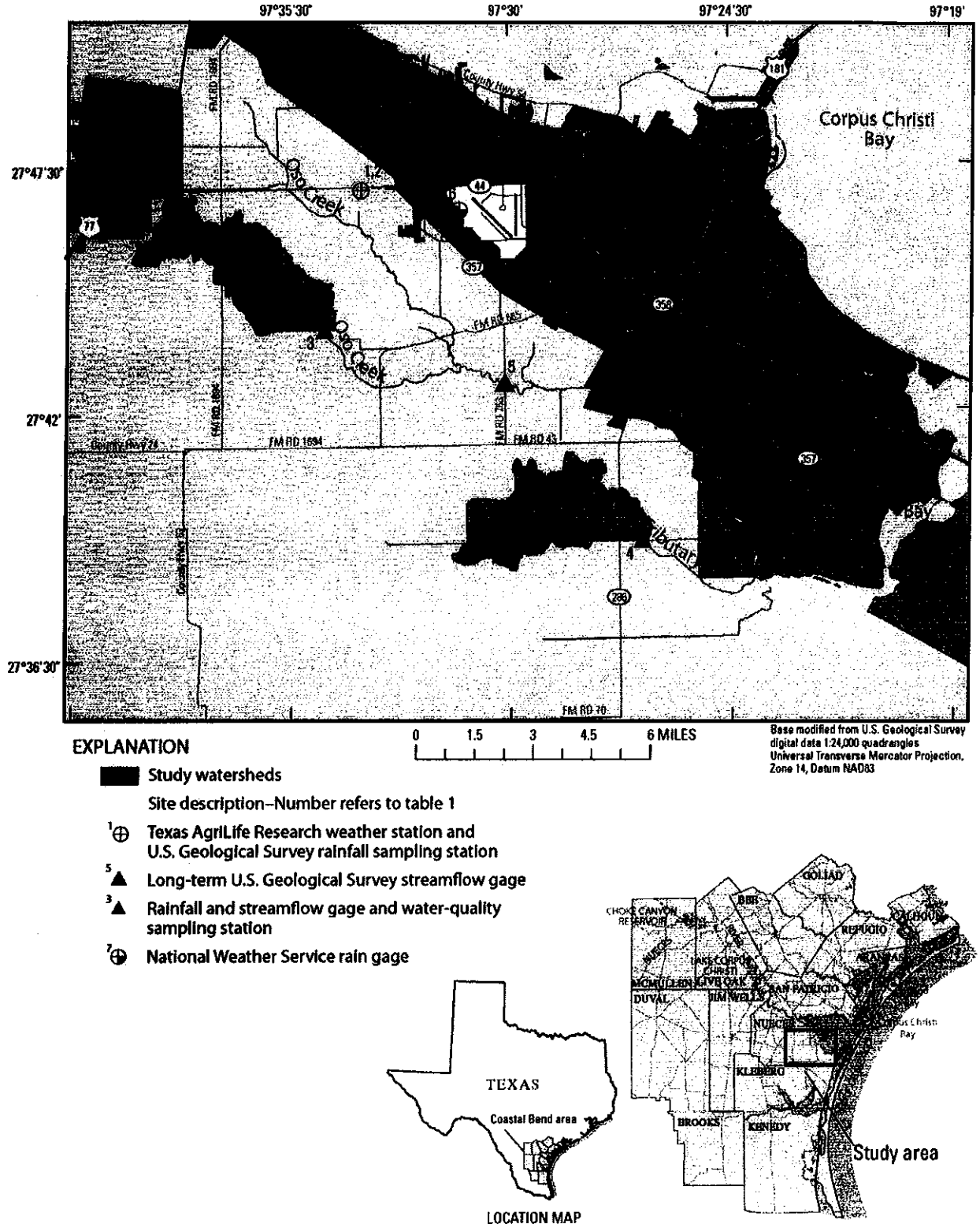

Figure 1. Coastal Bend area of South Texas and Oso Creek watershed study area.

Purpose and Scope

The purpose of the study was to characterize hydrologic and water-quality conditions from two agricultural dominated areas in the Oso Creek watershed in the Coastal Bend area of South Texas. This report presents the results of collection and analysis of hydrologic data and water-quality samples of rainfall and runoff. During the two-year data-collection period from October 2005 to September 2007, continuous rainfall and streamflow data were collected at monitoring stations located at the outlets of the study watersheds. Fourteen rainfall samples were collected and analyzed for nutrients and major ions. Rainfall nutrient analyses and daily rainfall totals were used to estimate rainfall nutrient loads to the study watersheds. Nineteen runoff samples were collected during storm-runoff events. These samples were analyzed for nutrients, major inorganic ions, and pesticides. Also, 21 sediment samples were collected and analyzed for sediment size and concentration. Twelve discrete bacteria samples were collected and analyzed for fecal coliform, *Escherichia coli* (*E. coli*), and *enterococcus*. From streamflow data and water-quality sample analyses, constituent event-mean concentrations and runoff loads and yields were determined. Quantities of fertilizers and pesticides were obtained from producers in the watersheds and compared with loads of nutrients and pesticides in rainfall and runoff.

Description of Study Area

The two watersheds that comprise the study area are delineated in fig. 1. One watershed is located in the upstream reaches of West Oso Creek and drains approximately 5,145 acres. The other watershed is drained by an unnamed tributary, ultimately draining to the downstream reach of Oso Creek. The Oso Creek tributary watershed is approximately 5,287 acres. The topography of the area is flat with altitudes ranging from about 15 feet above mean sea level at the outlet of the Oso Creek tributary watershed to about 65 feet above mean sea level in the upland areas of the West Oso Creek watershed. Because of the limited relief, the Oso Creek tributary watershed might include some non-contributing drainage area. The study watershed streams are ephemeral, producing runoff lasting from a few hours, up to several weeks in duration, depending on rainfall duration and intensity and antecedent soil moisture. The main stem of Oso Creek maintains a continuous flow from wastewater discharges by the cities of Robstown and Corpus Christi. The study watersheds do not include any wastewater discharges.

The study area is described as having a subtropical, sub-humid climate, characterized by hot summers and mild, dry winters (Larkin and Bomar, 1983). Heaviest rainfall tends to occur in spring, early summer, and fall but can occur anytime during the year. The following meteorological statistics are from the National Weather Service station at the Corpus Christi International Airport (U.S. Department of Commerce, 2006). Average annual rainfall (1971-2000) in the study area is 32.92 inches per year. Rainfall greater than 0.01 inches occurs, on average, 82 days per year. The average monthly low temperatures range from 46.2 degrees Fahrenheit (°F) in January to 74.5 °F in August. Average monthly high temperatures range from 66.0 °F in January to 93.4 °F in August. Mean annual temperature is 71.5 °F.

Besides climate and rainfall, the type and nature of the soils affect the rainfall-runoff process. Victoria Association clays are the dominant soil in the study watersheds. During dry periods these soils crack and are able absorb water rapidly, limiting runoff. However, once the soils are wet, water infiltrates slowly (U.S. Department of Agriculture, 1965), increasing runoff potential.

During 2006–07, the primary crops in the West Oso Creek and Oso Creek tributary watersheds were cotton and grain sorghum, accounting for about 92 percent of the total agricultural land. Corn and wheat accounted for about 6 percent of the acreage. The remaining 2 percent was fallow or pasture. Impervious land in the watersheds is about 2 percent and consists mostly of roads. The crop season begins during late-July to early September with shredding of crop residue from the previous crop and plowing out stubble, or killing crop residue with herbicides (in the conservation tillage systems), to prepare the ground to absorb fall and winter rains. The soil is re-tilled or re-sprayed during September and October to destroy winter weeds and to prepare the seedbed for the succeeding crop. Pre-plant fertilizers and broadcast pre-emergent herbicides are usually applied during the low rainfall months of November and December. During January to mid February, additional tilling might be done. Planting begins in early- to late-March, depending on the available soil moisture, soil temperature, and type of crop. After crops have emerged from the soil, production practices throughout the season consist of pesticide application and row cultivation. From mid- to late-April to early-July, few field operations are required for grain sorghum. However, for cotton, this is a period involving insect control. Grain sorghum usually is harvested in early to mid-July. Cotton harvest usually begins with application of harvest aids (defoliants) around mid-July and ends around mid-August to early September (Dr. Bobby Eddleman, Texas AgriLife Research and Extension Center at Corpus Christi, written commun., 2007).

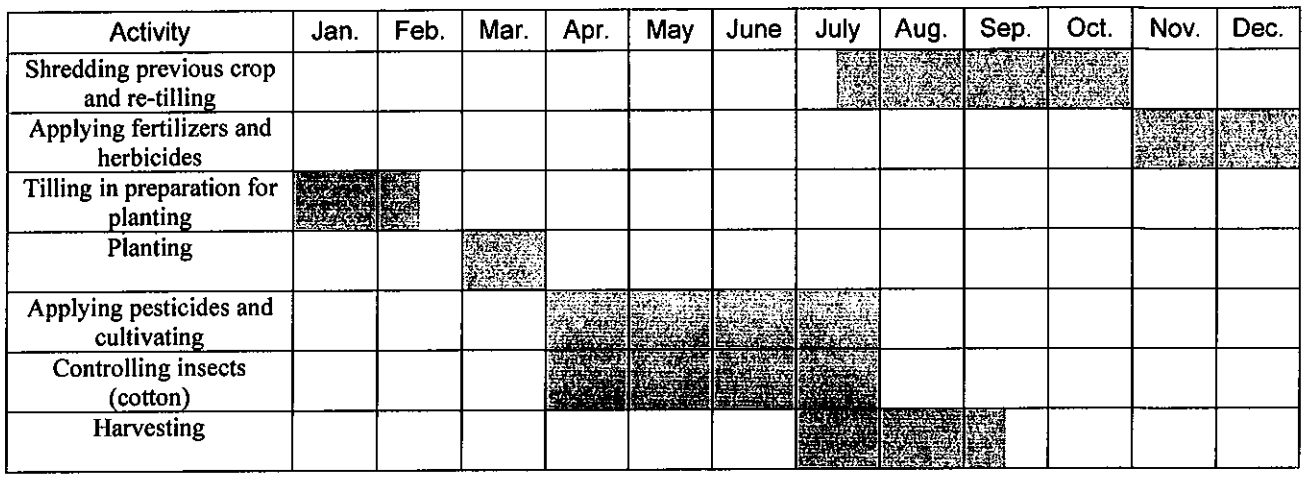

Figure 2. Typical timing of agricultural activities in Nueces County, Texas

Texas Surface Water-Quality Standards

The Texas Commission on Enivironmental Quality (TCEQ) has designated water-quality standards and appropriate uses (such as aquatic life, contact or non-contact recreation, or drinking water) for specific stream, estuary, and bay segments. Water-quality standards have not been established for the specific streams or watersheds in this study (West Oso Creek and Unamed Oso Creek Tributary). However, these watersheds drain to Oso Creek and Oso Bay, receiving water bodies for which water-quality standards have been established. Water quality standards are defined by a combination of designated uses and criteria necessary to maintain the designated uses. The designated uses for Oso Bay are contact recreation and aquatic life. Oso Creek (TCEQ segment 2485A) is considered an unclassified water body associated with a classified segment, Oso Bay (TCEQ segment 2485). Oso Creek, segment 2485A, includes all of Oso Creek to the confluence with Oso Bay. Oso Creek and Oso Bay have been placed on the 2004 Texas Water Quality Inventory and the 303d list of impaired waters for not meeting criteria for the indicator bacteria *enterococcus*. Also, Oso Bay has failed to meet standards for dissolved oxygen (Texas Commission on Environmental Quality, 2005).

Acknowledgments

Special thanks are extended to Dr. Bobby Eddleman and Carlos Correa with Texas AgriLife Research, for their substantial support to this project. Dr. Eddleman provided valuable project oversight and technical assistance, including compilation of pesticide and fertilizer application information obtained from producers in the study area. Carlos Correa assisted with station and equipment maintenance and sample collection activities. Thanks are also extended to the Nueces County Soil and Water Conservation District and U.S. Department of Agriculture, Natural Resources Conservation Service, personnel for assisting in delineating the study areas and providing contacts with agricultural producers in the two study areas.

DATA-COLLECTION METHODS

Monitoring stations providing data for this study are listed in table 1 and included: an hourly weather station with rain gage operated by Texas AgriLife Research (site 1, table 1), a USGS rainfall-quality sampling station (site 2, table 1), two USGS rainfall, streamflow, and water-quality sampling stations located at the outlets of the study watersheds (sites 3 and 4, table 1), a long-term USGS streamflow-gaging station located on the main-stem of Oso Creek (site 5, table 1), and three National Weather Service rain gages (sites 6, 7, and 8, table 1). Information related to the monitoring stations are shown in table 1.

Rainfall

Rainfall amounts in the study area were obtained from six monitoring stations in the area (figure 1 and table 1). Hourly rainfall was recorded at the Texas AgriLife Research weather station (site 1, table 1). Two tipping-bucket rain gages were installed at the watershed study outlet monitoring stations (sites 3 and 4, table 1). These stations recorded 15 minute rainfall totals. Also, daily precipitation data were obtained from three NWS rain gages (sites 6, 7, and 8, table 1). Daily rainfall on the West Oso Creek study watershed was estimated using a Thiessen-weighted average (Wanielista, 1990) of rainfall measured at sites 1, 3, and 8 in table 1. Rainfall on the Oso Creek tributary watershed was estimated using rainfall primarily from site 4 (table 1). The NWS Corpus Christi Botanical Garden station (site 7, table 1) was used for estimating daily rainfall on the Oso Creek tributary watershed for several days

when data were not available from site 4. The NWS Corpus Christi International Airport station (site 6, table 1) was used for long-term analysis of rainfall conditions in the area.

Table 1. Monitoring stations providing data used for analysis of hydrologic and water-quality conditions of agricultural areas in the Oso Creek watershed.

[USGS, U.S. Geological Survey; NWS, National Weather Service; --, unknown, dd, degrees; mm, minutes; ss, seconds; FM, farm-market road; TX, Texas]

Site number (fig.1)	Station name, number	Latitude (ddmmss)	Longitude (ddmmss)	Type of data	Period of record used
1	Texas AgriLife Research, Corpus Christi weather station – WS1	27° 46' 57"	97° 33' 43"	Hourly, daily rainfall	October 2005 – September 2007
2	USGS Texas AgriLife Research and Extension Center at Corpus Christi, TX – 08211511	27° 46' 57"	97° 33' 43"	Rainfall quality	October 2005 – September 2007
3	USGS West Oso Creek at Merrett Road, near Corpus Christi, TX – 08211517	27° 43' 50"	97° 34' 37"	Rainfall, streamflow, water quality	October 2005 – September 2007
4	USGS Unamed Oso Creek tributary at FM 2444, near Corpus Christi, TX – 08211525	27° 39' 07"	97° 26' 40"	Rainfall, streamflow, water quality	October 2005 – September 2007
5	USGS Oso Creek at Corpus Christi, TX – 08211520	27° 42' 40"	97° 30' 06"	Streamflow	October 1972 – September 2007
6	NWS at Corpus Christi International Airport – 412015	27° 46' --"	97° 31' --"	Hourly, daily rainfall	January 1972 – September 2007
7	NWS at Corpus Christi Botanical Gardens – 412013	27° 39' --"	97° 24' --"	Daily rainfall	October 2005 – September 2007
8	NWS at Robstown – 417677	27° 47' --"	97° 40' --"	Daily rainfall	October 2005 – September 2007

Runoff

Water-surface elevation (stage) was continuously monitored (at 15-minute intervals) at the study watershed stations (sites 3 and 4, table 1) by uplooking acoustic transducers mounted on the bottom of the stream channels. At each station, relations between stage and runoff (discharge) were developed from discharge measurements made during various flow conditions during runoff events (Buchanan and Somers, 1969). From these relations, continuous runoff was calculated for each study watershed (Kennedy, 1984).

Water Quality

Water-quality samples were collected from two sources. Rainfall samples were collected to determine nutrient concentrations and nutrient loads to the cropland study areas. Runoff samples were collected to characterize runoff quality and to estimate constituent loads and yields of selected nutrients, suspended-sediment, and pesticides transported from the study watersheds. Also, runoff samples were collected during runoff events and analyzed for fecal coliform, *E. coli*, and *enterococci* bacteria.

Rainfall

Rainfall samples were collected at the USGS rainfall sampling station, site number 2 (table 1) by an automatic rainfall sampler. The sampler is equipped with a polyethylene bucket that is covered when rainfall is not occurring, to prevent contamination of the bucket and sample. A moisture sensor activates a mechanism to uncover the sample collection bucket when rainfall begins and to cover the sample when rainfall ends. Rainfall samples were collected as a single composite sample for rainfall events. Results of the analyses of the composite samples represent the total rainfall deposition divided by the total rainfall, or the average constituent concentrations during rainfall events. Samples were retrieved as soon as possible after rainfall events, chilled, and shipped overnight to the USGS National Water Quality Laboratory (NWQL) in Denver, Colorado, for analysis.

Runoff

Automatic water samplers at the runoff-monitoring stations (sites 3 and 4, table 1) collected runoff samples during storm events. When runoff was detected by the streamflow-gaging instrumentation (fig 3.), automatic water-quality samplers were activated to collect samples. Discrete aliquots (water-quality subsamples) were collected hourly during a period of runoff. Near, or at the end of the runoff event, sampling was completed and the aliquots from each site were combined into a single discharge-weighted composite sample (separate composite samples from each station). For example, an aliquot collected when streamflow measured 10 cubic feet per second (ft^3/s) would have twice as much volume included in the composite sample as an aliquot that was collected when streamflow measured 5 ft^3/s. In this way, analysis of the composite sample represents the event mean concentration (EMC) during

runoff (Huber, 1993, p. 14.1). Figure 4 shows a rainfall-discharge hydrograph at West Oso Creek during March 14, 2007, including the subsample-collection timing during the event. Runoff samples collected by automatic sampler were retrieved, chilled, and shipped overnight to the USGS NWQL for analysis.

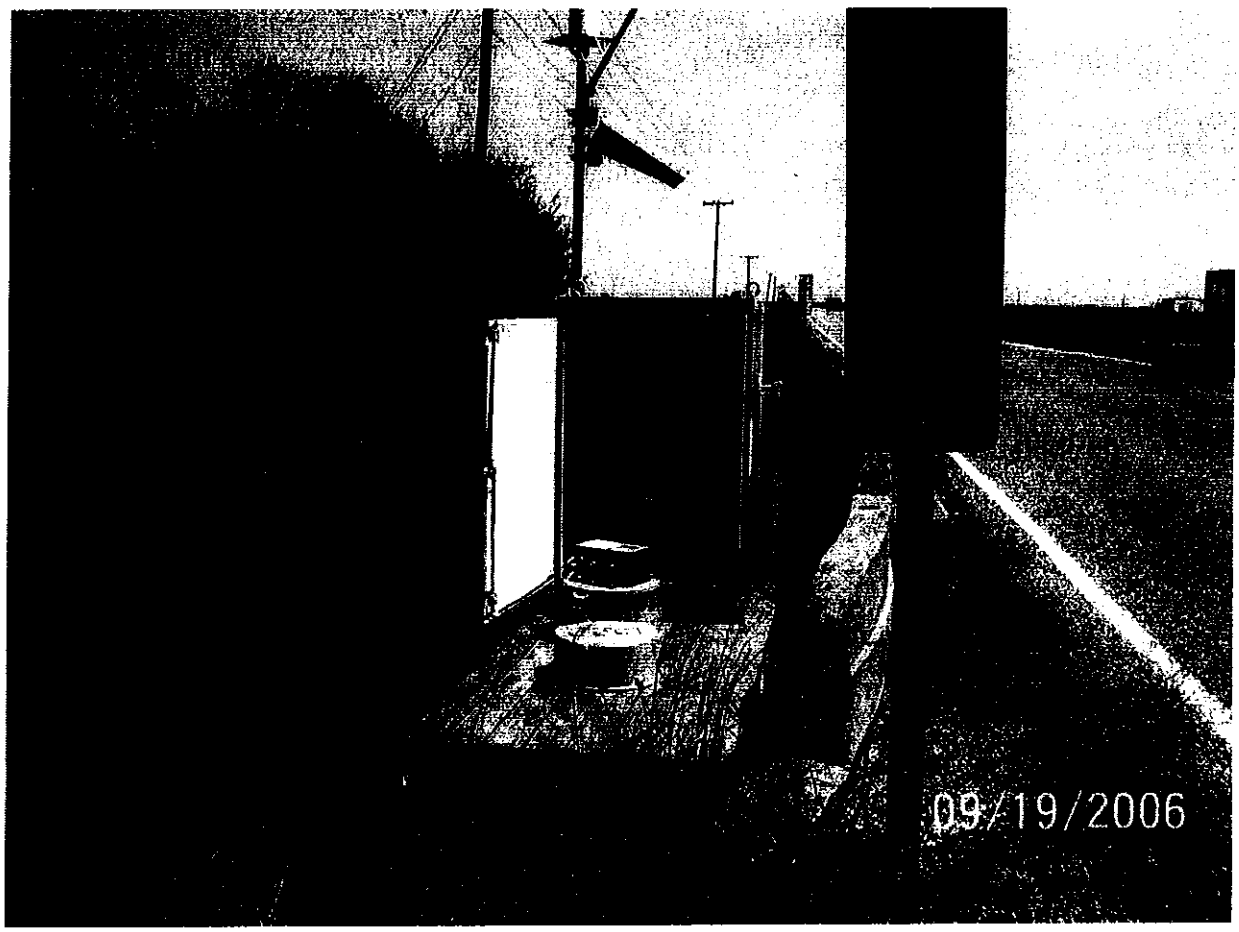

Figure 3. Streamflow-gaging and water-quality monitoring station at 08211525 – Unamed Oso Creek tributary at FM 2444, near Corpus Christi, TX, September 19, 2006

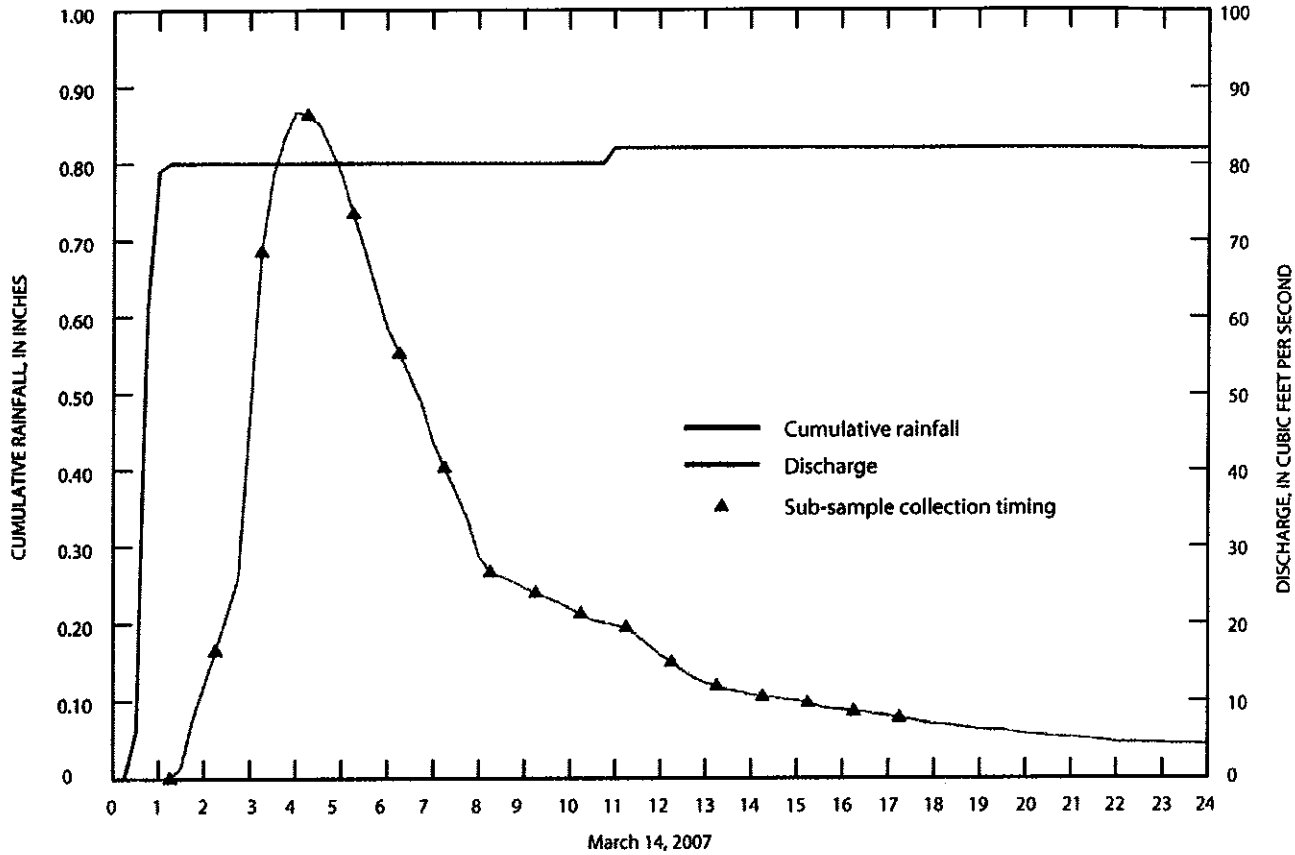

Figure 4. Hydrograph showing rainfall, discharge, and sub-sample collection timing at 08211517 - West Oso Creek at Merrett Road, near Corpus Christi, TX, during storm runoff of March 14, 2007

Suspended-sediment samples also were collected during storm-runoff events. Suspended-sediment samples were collected as discrete samples during various discharge conditions. Samples were collected by a depth-integrating, equal-width increment method (sampler is raised and lowered through the water column at equal intervals across the stream) (U.S. Geological Survey, 2006) using isokinetic sampling devices. An isokinetic sampler collects a water-sediment sample from the stream at a rate such that the velocity of the intake nozzle is equal to the incident stream velocity at the nozzle entrance. The water-sediment sample collected is thus representative of the suspended sediment load throughout the channel cross-section and is appropriate for use in estimating sediment load carried by the stream (Davis, 2005). Suspended-sediment samples were collected by wading (fig 5) or from bridge-suspended equipment during higher streamflow rates. Suspended-sediment samples were analyzed by the USGS sediment laboratory in Iowa City, Iowa. Samples were analyzed for suspended-sediment concentration and sand-break analysis. Sand-break analysis gives the percentage of sediment, by weight, that is finer than 0.062

millimeter (mm). Particle sizes less than 0.62 mm in diameter are defined as silt and clay. Particles greater than 0.062 mm are defined as sand.

Figure 5. Suspended-sediment sample collection at 08211517 – West Oso Creek at Merrett Road, near Corpus Christi, TX, June 2006

Bacteria samples were collected during several events at each of the sampling stations. Samples were collected by USGS and Texas AgriLife Research personnel and analyzed by the Texas A&M University – Corpus Christi Environmental Microbiology Laboratory. Bacteria samples were collected as grab samples during runoff and analyzed for fecal coliform, *E. col.i* and *enterococci*. The objective for bacteria sampling was a single sample, collected as soon as possible after runoff began. So, samples were collected within several hours of the beginning of runoff and do not necessarily represent average concentrations during the entire runoff event.

HYDROLOGIC CONDITIONS

Rainfall

Long-term (1972–2006) rainfall data from the NWS station at Corpus Christi International Airport (site 6, table 1) were compared with study area rainfall during 2006–07 water years (October 2005 to September 2007) as shown in table 2. Average annual rainfall in the Corpus Christi area during 1972–2006 was 32.12 in. per year. Area-weighted, average annual rainfall on the two study watersheds during water years 2006–07 was 37.50 in. Rainfall during the 2006 water year was less than normal. Rainfall during the 2007 water year was much greater than normal. A few periods of heavy rainfall, interspersed between relatively dry periods, accounted for much of the rainfall during the study period.

Table 2. Comparison of annual (October 2005–September 2007) study-area rainfall and long-term area rainfall

Study watershed	October 2005 to September 2006 rainfall (inches)	October 2006 to September 2007 rainfall (inches)	Average annual study area rainfall (inches)	[1]1972 – 2006 average annual rainfall (inches)
West Oso Creek	27.91	44.87	36.39	32.12
Oso Tributary	31.97	45.19	38.58	32.12
Area-weighted mean study area rainfall	29.97	45.03	37.50	32.12

[1] long-term rainfall measured at Corpus Christi International airport

A comparison of average monthly rainfall from the National Weather Service station at the Corpus Christi International Airport with monthly rainfall from the study watershed is shown in figure 6. Although rainfall was greater than average during the 24 month study period, monthly rainfall was below normal during 15 of the months.

Runoff

The USGS, in cooperation with the Texas Water Development Board, has operated a streamflow gaging station on Oso Creek at FM 763 since 1972 (station 5 in table 1 and fig 1., 08211520–Oso Creek at Corpus Christi, TX). Data from this station were used to estimate long-term annual runoff volumes for comparison with study watershed runoff volumes. Land use in the 90.3 sq. mi watershed, upstream of the gaging station, is largely cropland, similar to the study watersheds. However, a substantial amount

of impervious land cover, associated with the town of Robstown, is located in the upstream part of the Oso Creek watershed. Average streamflow during water years 1973–2006 was 29.6 cubic feet per second. Excluding an estimated wastewater treatment discharge of approximately 3 million gallons per day (MGD) from the town of Robstown, long-term average annual runoff at the Oso Creek station was 3.76 in. per year. During the study, runoff from the Oso Creek station was 7.63 in. per year, or about twice as much runoff as normal. A comparison of runoff from the Oso Creek station with runoff from from each of the study watersheds is shown in table 3.

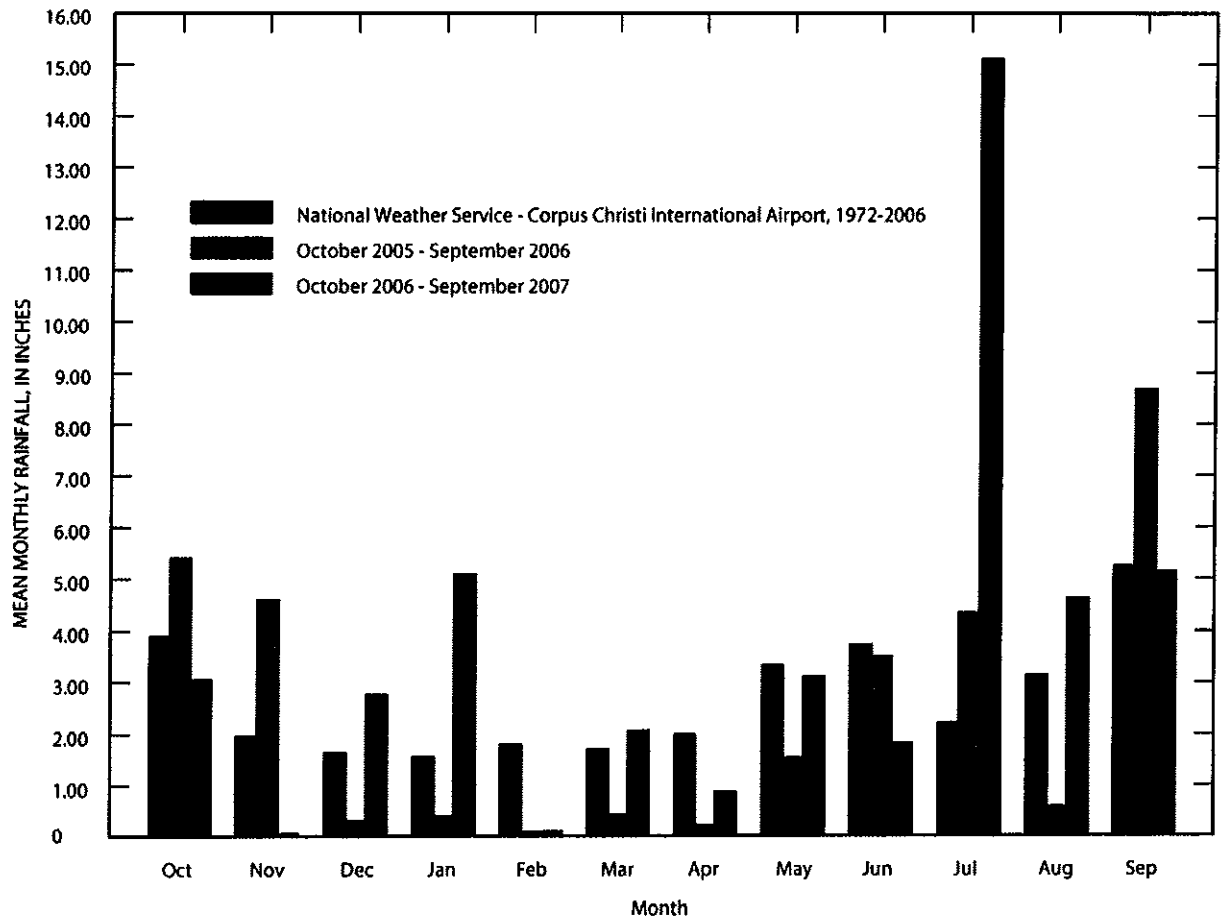

Figure 6. Mean monthly rainfall at National Weather Service - Corpus Christi International Airport, 1972 - 2006, compared with monthly study-area rainfall, October 2005 - September 2007.

Table 3. Comparison of annual and long-term unit runoff from study watersheds and Oso Creek watershed

Study watershed	October 2005 to September 2006 runoff (inches)	October 2006 to September 2007 runoff (inches)	Average annual study area runoff (inches)	Water year 1973 – 2006 average annual runoff (inches)
West Oso Creek	3.19	8.19	5.69	--
Oso Ck Tributary	2.60	4.67	3.64	--
Oso Creek at FM 763 - 08211520	4.37	10.89	7.63	3.76

Runoff at 08211520 excludes an estimated annual 3.0 million gallons per day of wastewater discharge

Runoff in the study area during water years 2006–07 corresponded to rainfall patterns, with runoff events interspersed between periods of no runoff. The West Oso Creek watershed produced more runoff than the Oso Creek tributary watershed. Unit runoff for both study watersheds was less than the overall unit runoff for the Oso Creek watershed. Selected runoff events are listed in table 4, including dates, rainfall totals, runoff volume, and runoff coefficients (ratio of runoff volume, in inches to rainfall volume, in inches). Minor runoff events, for which both study watersheds had less than 0.001 inches of runoff are not listed separately but are included in the study totals in table 4 (at end of report). Table 4 also indicates whether runoff water-quality samples were collected during the event.

Runoff is highly dependent on antecedent conditions. Rainfall in the amount of 2 to 3 inches during May 25 - 29, 2007 resulted in only minor runoff quantities at both sites. Less rainfall during January 24 – February 3, 2007 produced substantially more runoff because of antecedent wet conditions from rainfall in early January.

The West Oso Creek watershed produced more runoff than the Oso Creek tributary watershed, 10.83 inches compared with 7.28 inches. The West Oso Creek watershed also exhibited a more rapid runoff response with higher peak flows than the Oso Creek tributary watershed. Differences in hydrologic response of the watersheds might be explained by slightly greater land slopes in the West Oso Creek watershed and possible non-contributing areas in the Oso Creek tributary watershed. Figure 7 shows a comparison of the rainfall/runoff runoff response for both watersheds during the March 14 – 16 event.

Most of the study-area runoff occurred during a few events. More than 75 percent of the runoff at each site occurred during two wet periods: September 18–October 1, 2006 and July 2–August 8, 2007. During both of these periods, multiple rainfall events and prolonged wet soil conditions contributed to substantial runoff.

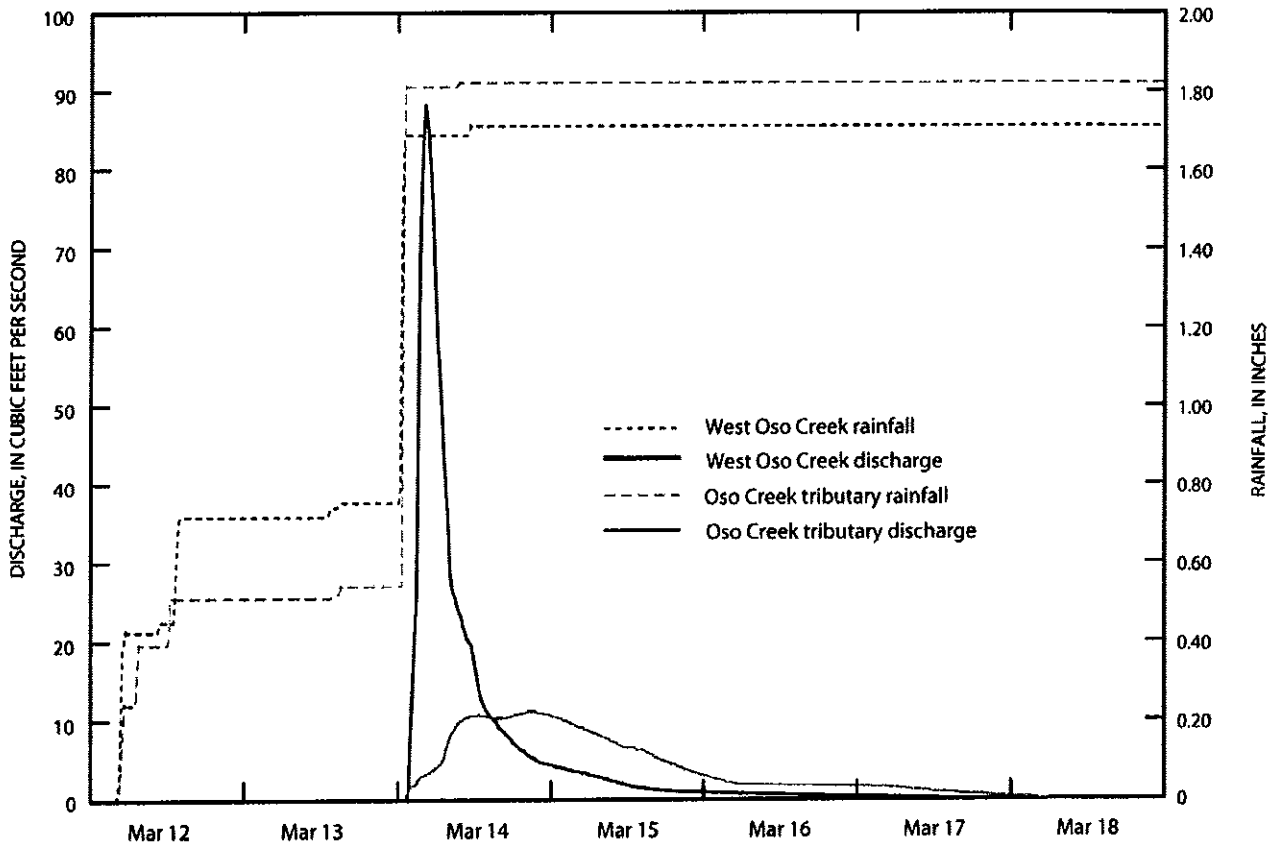

Figure 7. Comparison of rainfall/runoff response for West Oso Creek and Oso Creek tributary watersheds during March 12-18, 2007

WATER QUALITY

The two water-year study period represents two cycles of agricultural activity in the study watersheds. Water year 2006 was very dry, especially during the planting and pre-harvest periods. In fact, some producers did not plant or abandoned crops because of lack of rainfall. The harvest/post-harvest period

of 2006 included several major runoff events. Water year 2007 was relatively wet during most of the year.

Water-quality sample collection was fairly well distributed between the two crop cycles. Fifty seven percent of the rainfall samples were collected in water year 2006 and forty three percent were collected in water year 2007. Runoff samples were distributed 47 percent to 53 percent between water years 2006 and 2007, respectively. Also, rainfall/runoff events (and collection of samples) were well distributed by season. Distribution of rainfall samples between the pre-harvest period (November – May) and the harvest/post-harvest period (July – October) was 50 percent and 50 percent, respectively. No samples were collected in the months of February, April, August, November, or December.

Rainfall

Fourteen rainfall samples were collected and analyzed during the study. During October 2005 to September 2007, 70.62 in. of rainfall were recorded at the Texas AgriLife Research station (site 1). The 14 rainfall samples represent 28.00 in. of rainfall (recorded at the Texas AgriLife Research station), or about 40% of total rainfall that fell during the study period. Rainfall samples were analyzed for major inorganic ions and nutrients. Ten samples were collected during rainfall that resulted in runoff events that were sampled. Four rainfall samples were collected during events for which no runoff occurred. These four samples were collected during rainfall events with less than about 0.5 in. of rainfall. These samples provided only enough sample volume to perform the nutrient analyses. Results of sample analyses are shown in table 5 (at end of report).

Summary statistics were computed for selected rainfall nutrient concentrations and are shown in table 6 (at end of report). Most of the rainfall nitrogen is in the form of dissolved ammonia and dissolved nitrate, which were detected in all of the samples. Median concentrations of ammonia and nitrate were 0.16 mg/L and 0.19 mg/L, respectively. Organic forms of nitrogen were detected in all of the samples at relatively low concentrations; the median value of total organic nitrogen was 0.08 mg/L. Nitrite was detected in about one-half of the samples at low concentrations; the median concentration was 0.002 mg/L. Total phosphorus was detected in about one-half of the samples at relatively small concentrations (median concentration less than 0.008 mg/L).

The deposition of rainfall constituents, in pounds (lbs) per acre, can be defined as the product of the EMC and rainfall volume and a conversion factor. For rainfall events during which rainfall samples were collected and analyzed, thus providing EMCs, daily deposition of total nitrogen was computed as:

$$D_{TN} = EMC_{TN} \times R \times Cf, \quad (1)$$

where

D_{TN} = daily deposition of total nitrogen, in pounds per acre;

EMC_{TN} = total nitrogen rainfall event mean concentration, in milligrams per liter;

R = daily rainfall on the study watershed, in inches;

Cf = conversion factor of 0.2266.

For unsampled rainfall events, for which nitrogen concentration data were not available, daily deposition of total nitrogen was estimated using regression equations that relate daily rainfall and daily nitrogen deposition. Least-squares regression was used with the computed event deposition from sampled events to develop a relation between deposition and rainfall. A comparison of total nitrogen deposition computed from rainfall and EMCs with deposition estimated by regression is shown in figure 8. The resulting regression equation was

$$D_{TN} = 0.116 \times R^{0.484} \quad (2)$$

where

D_{TN} = estimated daily deposition of total nitrogen, in pounds per acre;

R = daily rainfall on the study watershed, in inches.

Rainfall deposition of total phosphorus was very small compared to total nitrogen. Many of the rainfall total phosphorus concentrations were below the minimum laboratory reporting limit. Considering all rainfall samples, the median total phosphorus concentration was less than 0.008 mg/L (table 6). Using the laboratory minimum reporting limit (0.008 mg/L) to estimate an upper limit of annual total phosphorus deposition resulted in an estimate of less than 0.13 lbs/acre per year. Monthly and annual sums of total nitrogen are shown in table 7 (at end of report). The average annual total nitrogen deposition for both watersheds over the two-year study was 5.50 lbs/acre per year, compared with less than 0.13 lbs/acre per year for total phosphorus.

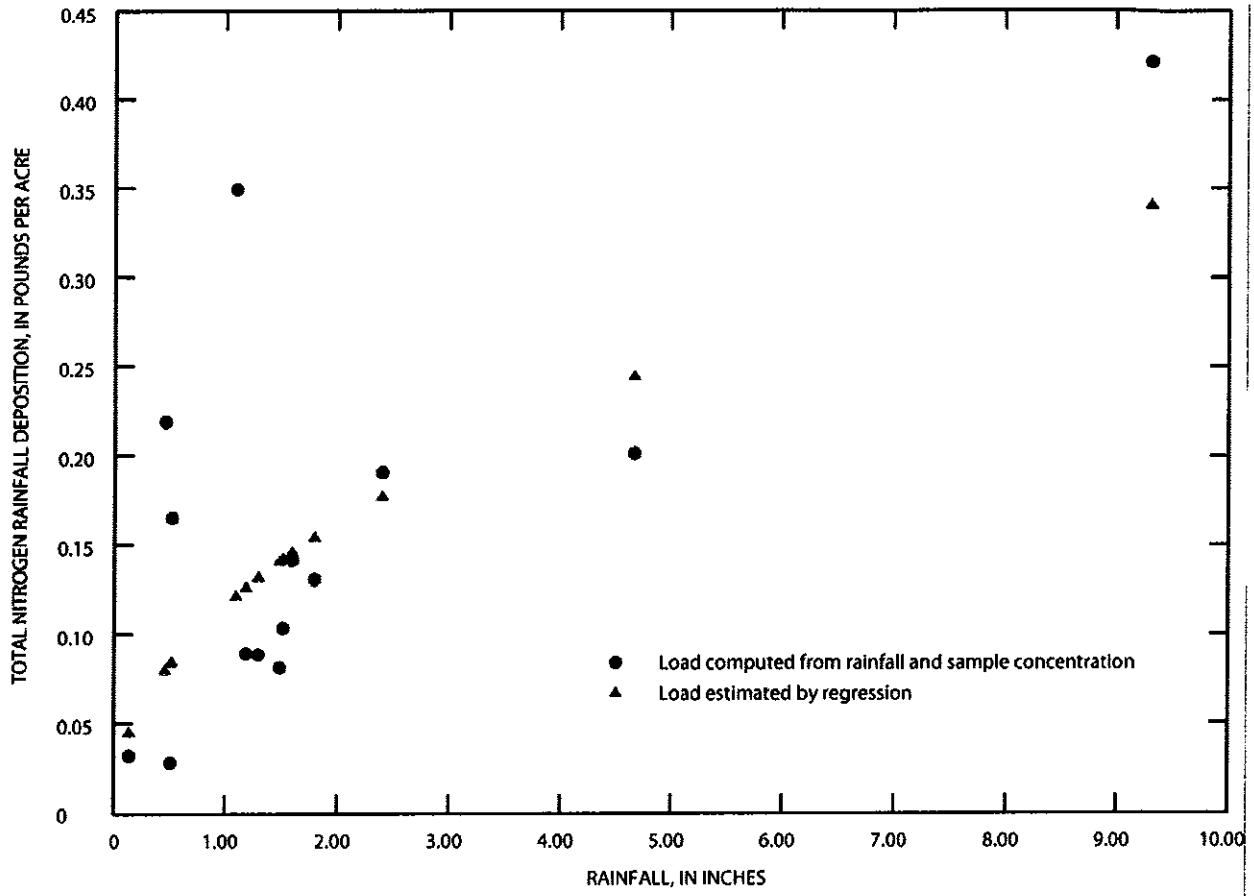

Figure 8. Comparison of computed total nitrogen deposition loads and loads estimated by regression, for sampled rainfall events, Nueces County, Texas, 2006 - 07

Runoff

During June 2006 to September 2007, nineteen event-composite runoff samples were collected between the two monitoring stations; 10 samples at West Oso Creek and 9 samples at Oso Creek tributary. Samples were analyzed to characterize quality of storm runoff from the study watersheds. Analyses results for West Oso Creek samples and constituents are shown in appendix 1 (at end of report). Oso Creek tributary analyses results are shown in appendix 2 (at end of report).

Nutrients and major inorganic ions

Descriptive statistics were computed for selected nutrient and major inorganic ion EMCs for each site and are shown in table 8 (at end or report). Statistical tests were performed to determine if differences exist in runoff concentrations between sites and between seasons (table 9, at end of report). The Wilcoxon rank-sum test (Helsel and Hirsch, 1992, p. 118), a non-parametric test, compares two groups to determine whether the groups have the same median (null hypothesis), or whether at least one group tends to produce observations that are greater than the other group (alternative hypothesis). The Wilcoxon rank-sum test was performed for concentrations (EMCs) of selected nutrients and major inorganic ions from each monitoring site. The p-values of each test are shown in table 9. The p-value is the "attained level of significance" (the significance level attained by the data), which is the probability of obtaining the computed test statistic, or one even less likely, when the null hypothesis is true (Helsel and Hisrsch, 1992, p. 108). A statistical difference in concentrations was deemed to exist when p-values were less than about 0.05.
Nitrogen runoff concentrations were greater at the West Oso Creek site. Phosphorus and inorganic ion concentrations were greater at the Oso Creek tributary site.

Additional statistical tests were performed to determine if runoff concentrations of nutrients varied by season. Data from both sites were grouped into pre-harvest and harvest/post-harvest seasons. Pre-harvest season includes January – June. Harvest/post-harvest season includes July – September. There were no samples collected during October – December. Median concentrations and results from Wilcoxon rank-sum tests are shown in table 10 (at end of report).

Significant seasonal differences are apparent in ammonia, nitrite + nitrate, and total nitrogen. This difference is likely because of timing of application of ammonia and nitrate fertilizers. The median organic nitrogen concentration was higher in pre-harvest samples, but not significantly. Likewise, the median total phosphorus concentration was higher for pre-harvest samples, but not significantly.

The impact of constituents on a water body can be influenced by both the concentration and by the load. The load of a constituent in runoff is the mass of a given constituent transported past a site during a specified time (Huber, 1993, p.14.2). Daily nutrient loads were computed at the study watershed outlets

from runoff and concentration data. For runoff events that were sampled and for which EMCs were determined, the daily constituent load at a particular site is:

$$L = EMC \times R \times Cf, \quad (3)$$

where

L = constituent load, in pounds per day;

EMC = event mean concentration during runoff event, in milligrams per liter or micrograms per liter;

R = daily runoff, in acre-feet;

Cf = conversion factor, 2.719 for concentrations in milligrams per liter or 0.00272 for concentrations in micrograms per liter.

Median constituent concentrations from samples at each site, by season (pre-harvest or post-harvest) were used to estimate runoff loads for unsampled events at each site, as shown in table 11 (at end of report). During water years 2006–07, sampled runoff events represent approximately 41 percent of total runoff from the West Oso Creek watershed. About 59 percent of the runoff was unsampled. Sampled and unsampled runoff percentages from the Oso Creek tributary watershed were approximately 74 percent and 26 percent, respectively.

Constituent yield, a measure of the load-producing characteristics of a watershed, is computed by dividing the runoff load by the drainage area of the watershed:

$$Y = L / DA, \quad (4)$$

where

Y = constituent yield, in pounds per acre per month (or year);

L = constituent load, exiting the watershed, in pounds per month (or year); and

DA = contributing drainage area of the watershed, in acres.

Monthly and annual loads of selected nutrients in runoff from each of the study watersheds are listed in table 12 (at end of report), and the corresponding annual runoff yields are listed in table 13 (at end of report). Monthly and annual nutrient loads of nutrients were highly variable, depending on storm runoff. About 52 percent of the entire total nitrogen runoff load and 58 percent of the entire total phosphorus load occurred during July 2007.

Nutrient yields from the West Oso Creek watershed were greater than yields from the Oso Creek tributary watershed for two reasons. First, West Oso Creek runoff was greater. Second, nutrient concentrations generally were greater at West Oso Creek. The total nitrogen yield from West Oso Creek was 1.57 lbs/acre and 3.65 lbs/acre, respectively, during water years 2006 and 2007. In comparison, runoff yields of total nitrogen from the Oso Creek tributary watershed were less than half of the West Oso totals; 0.661 lbs/acre and 1.27 lbs/acre, respectively, during water years 2006–07.

Information on fertilizer nutrient application in the study area croplands during 2006–07 were compiled by AgriLife Research and the NRCS (Dr. Bobby Eddleman, Texas AgriLife Research and Extension Center at Corpus Christi, written commun., 2007). Annual runoff yields of total nitrogen and total phosphorus were compared to nutrient inputs from fertilizer applications and rainfall deposition, as shown in table 14 (at end of report).

Nitrogen input from fertilizer is much larger than input from rainfall deposition or outputs from runoff. Average (area-weighted for both study areas) annual application of fertilizer-based nitrogen was 67.1 lb/acre per year, compared to 5.50 lb/acre per year from rainfall deposition and 1.77 lb/acre per year in runoff. Annual rainfall deposition of nitrogen exceeds runoff yields because most rainfall does not contribute to runoff, even though for most periods of runoff, nitrogen runoff yields do exceed rainfall nitrogen deposition. The average annual runoff yield of total nitrogen represents approximately 2.4 percent of nitrogen applied as fertilizer and nitrogen entering the study area through rainfall deposition. Also, nearly all of the nitrogen applied as fertilizer and entering the study area through rainfall deposition is in the form of ammonia and nitrate. Nitrogen exiting the study watersheds in runoff is mostly organic nitrogen (table 13).

As with nitrogen, fertilizer inputs of phosphorus are much greater than phosphorus runoff yields. Average annual fertilizer input of phosphorus was 14.3 lbs/acre per year. Average runoff of total phosphorus was 0.63 lbs/acre per year, or about 4.4 percent of the phosphorus applied as fertilizer. Phosphorus input from rainfall was relatively small, averaging less than 0.13 lbs/acre per year. Fertilizer is applied as soluble orthophosphate. Most of the runoff phosphorus also was in the form of orthophosphate (table 13).

Suspended-sediment

Analysis results for twenty-one suspended-sediment samples are shown in table 15 (at end of report). Ten samples were collected at West Oso Creek and eleven samples were collected at Oso Creek tributary. The samples were analyzed for concentration and for percent silt and clay, by weight (particle size less than 0.62 mm). The sediment concentrations from these samples are not EMCs but represent sediment concentrations at the time of sample collection. Sediment concentrations, loads, and yields are a function of stream discharge and other factors, including soil erodibility, rainfall intensity and duration, and crop growth stage and tillage practices (U.S. Department of Agriculture, 2007). Generally, the West Oso Creek watershed exhibited higher suspended-sediment concentrations, loads, and yields than the Oso Creek tributary site. Also, both sites exhibited higher concentrations during runoff that occurred when fields were bare (before crops emerged or after harvest). Considering all samples, from both sites, 19 of the 21 samples had percent silt and clay values above 96 percent. The other two samples were 72 and 73 percent, by weight, less than 0.62 mm in particle diameter.

For each site two regression equations were developed relating suspended-sediment load (instantaneous tons per day) to stream discharge (cubic feet per second). The first equation was developed from samples collected when fields were bare (before crops emerged or after harvest) and the second equation was developed from samples collected during periods when crops provided some degree of soil cover. Generally, both sites exhibited greater suspended-sediment loads during periods when fields were bare. The equations from each site are shown in figure 9 and in table 16 (at end of report).

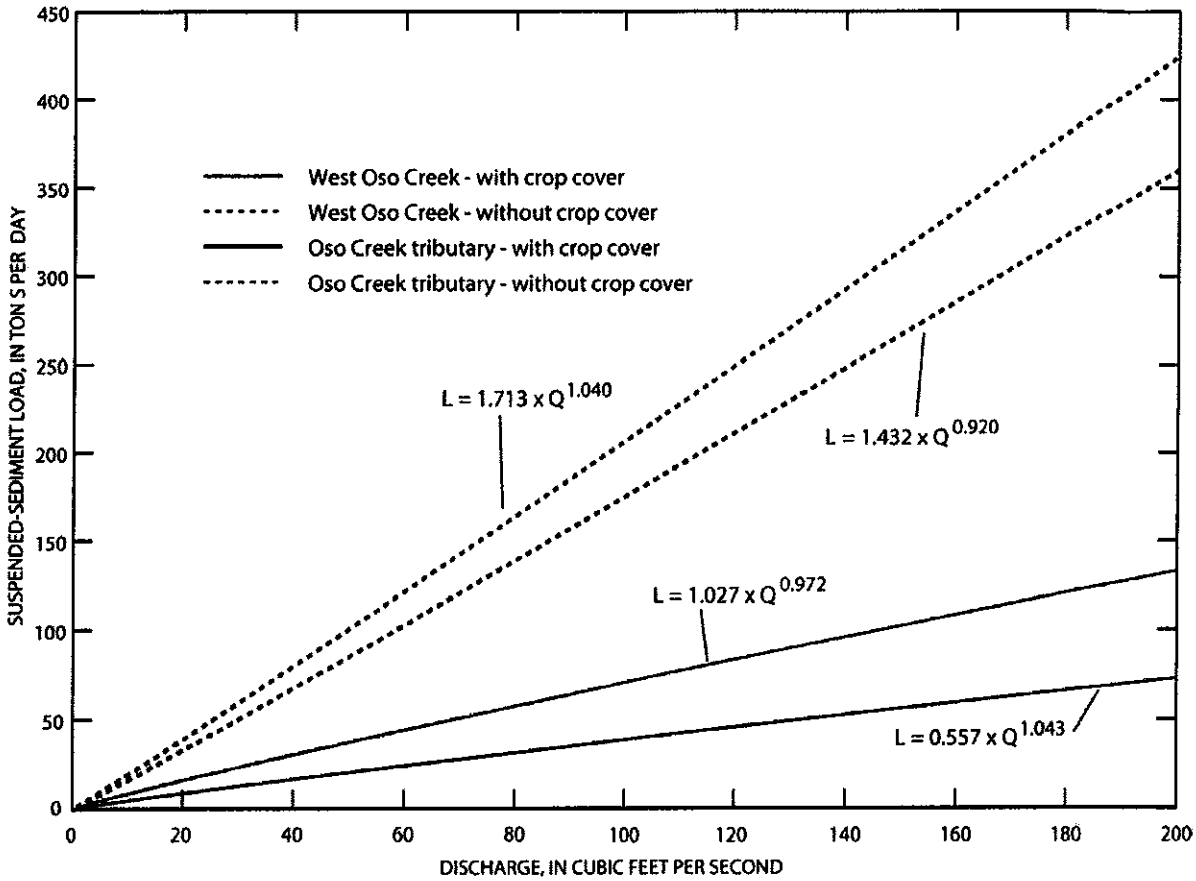

Figure 9. Relation between suspended-sediment load (L) and discharge (Q)

From these equations, instantaneous sediment loads were calculated for each site. Aggregated monthly and annual loads are shown in table 17 (at end of report). Annual and average-annual suspended-sediment yields are shown in table 18 (at end of report).

As with runoff and nutrient loads, suspended-sediment loads were highly variable by month. Most of the entire sediment load, from each site, occurred during September 2006 and July 2007.

Suspended-sediment yields from the West Oso Creek watershed were more than twice as much as the Oso Creek tributary watershed. The average suspended-sediment yield from the West Oso Creek watershed was 582 lbs/acre per year. The average suspended-sediment yield from the Oso Creek tributary watershed was 257 lbs/acre per year. One reason why the West Oso Creek sediment yield is greater is that the watershed produced more runoff than the Oso Creek tributary watershed. Also, because West Oso Creek has a more rapid runoff response than the Oso Creek tributary, higher peak

flows can generate higher stream velocities and potentially, greater sediment concentrations and loads. The West Oso Creek monitoring site is located on the edge of an agricultural field with no pasture buffer or structural controls to mitigate sediment runoff to the monitoring site. Also, part of West Oso Creek upstream of the sampling station is not a well defined channel, but flows through (over) cultivated cropland. In contrast, the Oso Creek tributary upstream of the monitoring site is surrounded by more grassland buffer area along the sides of the channel.

Pesticides

Runoff samples were analyzed for a suite of 88 pesticides. The pesticide analysis schedules requested from the USGS NWQL included some pesticides not used in the study area. Also, some pesticides used in the study area were not included in the 88 requested analyses because some analyses were not available through the NWQL and also a complete list of pesticides used by agricultural users in the area was not available at the beginning of the study. Texas AgriLife Research, with assistance from the NRCS – Nueces County, compiled information on pesticide application rates to the study area watersheds during 2005–07. The pesticides that were reportedly applied on the study watersheds during 2005–07 are listed in table 19 (Dr. Bobby Eddleman, Texas AgriLife Research and Extension Center at Corpus Christi, written commun., 2007). Table 19 (at end of report) also indicates pesticides which were not included in the laboratory analyses of runoff samples.

Pesticides detected in runoff samples are listed in table 20 (at end of report), along with concentration summary statistics. Pesticide analyses results for all samples are included in appendixes 1 and 2.
In 19 runoff samples collected among the two sites, laboratory analyses indicated detection of 30 pesticide compounds (22 herbicides and 8 insecticides). At the West Oso site, 22 pesticides were detected (18 herbicides and 4 insecticides). At the Oso Creek tributary site, 23 pesticides were detected (17 herbicides and 6 insecticides). Thirteen pesticides were detected in only 1 sample, at low concentrations (near the laboratory reporting limit). Five herbicides were detected in all samples: atrazine, atrazine degradation byproducts, CIAT and OIET, glyphosate, and glyphosate byproduct AMPA. Pesticides 2, 4-D, and pendimethalin were detected in more than 50 percent of the samples.

Pesticide runoff loads and yields were calculated, using equations 3 and 4, respectively, for atrazine, glyphosate, and pendimethalin. Similar to nutrients, pesticide concentrations also demonstrated seasonal

trends, as expected, because of timing of pesticide applications. Sample analysis concentrations were used to estimate runoff loads for sampled events. For unsampled runoff, the pre-harvest median and post-harvest median concentrations were used to estimate runoff loads. Table 21 (at end of report) shows seasonal median concentrations from each site, used to estimate pesticide runoff loads. Table 22 (at end of report) shows monthly and annual estimates of pesticide runoff loads.

Annual runoff yields of selected pesticides are shown in table 23 (at end of report). Table 23 also compares pesticide yields with pesticide application rates for the study area watersheds.

Runoff yields of atrazine, glyphosate, and pendimethalin were greater at West Oso Creek than Oso Creek tributary, by roughly an order of magnitude. The overall area-weighted average annual runoff yields for both watersheds of atrazine, glyphosate, and pendimethalin were 0.0015, 0.07 and 0.0002 lbs/acre per year. Comparison of applications and runoff yields in table 21 indicate that for 2006–07 about 0.5 percent of atrazine applied to the West Oso Creek watershed croplands was detected in runoff. For the Oso Creek tributary watershed, about 0.02 percent of applied atrazine was detected in runoff. The percentage of applied glyphosate in runoff was estimated to be 0.8 percent and 0.06 percent, respectively, in the West Oso Creek and Oso Creek tributary watersheds. Applied pendimethalin in runoff was estimated to be 0.08 percent and 0.02 percent respectively, in the West Oso Creek and Oso Creek tributary watersheds.

Bacteria

Thirteen bacteria samples were collected during the study, including 8 samples at West Oso Creek and 5 samples at Oso Creek Tributary. Table 22 (at end of report) lists analysis results for all samples, including analysis results for quality assurance samples, including field duplicate and split samples, and lab duplicate samples. Where multiple analyses are available for a particular sample, the average or weighted-average concentration also was calculated. Summary statistics of bacteria sample analysis results are shown in table 23. Table 23 also shows Texas surface water-quality standards (TSWQS) for bacteria in Oso Bay and Oso Creek, TCEQ segments 2485 and 2485A, respectively (Texas Commission on Environmental Quality, 2006).

Similar to other constituents, bacteria concentrations were greater at the West Oso Site than at Oso Creek tributary. Bacteria loads and yields were not estimated because bacteria samples were collected near the beginning of runoff events and concentrations do not necessarily represent bacteria conditions for the entire periods of runoff. Most sample concentrations were greater than TSWQS listed in table 23 (at end of report). The TSWQS in table 23 apply to Oso Bay and Oso Creek and are not technically applicable to the tributary watersheds in this study. Also, because runoff and associated bacteria concentrations represent relatively brief and infrequent conditions, the effect of runoff and associated bacteria concentrations on downstream receiving waters (Oso Bay and Oso Creek) is not known. However, the relatively large bacteria concentrations (compared to TSWQS) indicate that runoff from these watersheds is a potential source of bacteria to receiving streams and bays.

SUMMARY

During water years 2006–07 (October 2005 to September 2007), the U.S. Geological Survey (USGS) in cooperation with the Texas State Soil and Water Conservation Board (TSSWB), Coastal Bend Bays and Estuaries Program (CBBEP), and Texas AgriLife Research and Extension Center at Corpus Christi, studied the hydrology and water quality of two agricultural areas in the Oso Creek watershed, in Nueces County, Texas. One area, the upper West Oso Creek watershed, is 5,145 acres. The other area, a watershed drained by an unnamed Oso Creek tributary, is 5,287 acres.

Rainfall and runoff were continuously monitored at USGS gaging stations located at the outlet of the study watersheds. Rainfall samples were collected and analyzed for selected trace elements and nutrients. Composite runoff samples were collected during periods of runoff and analyzed for nutrients, major ions, trace elements, and pesticides. Also, discrete suspended-sediment samples and bacteria samples were collected. These rainfall, streamflow, and water-quality data were used to estimate loads of selected constituents entering the study watersheds in rainfall and exiting the study areas in runoff. Data on applications of fertilizers and pesticides to croplands in the study watersheds also were compiled and compared with quantities of nutrients and pesticides exiting the watersheds in runoff.

For the overall study period, total rainfall was greater than normal, although rainfall during the 2006 water year was less than normal and monthly rainfall was less than normal during 15 of the 24 months. Runoff in the study area during water years 2006–07 corresponded to rainfall patterns, with periods of runoff interspersed between periods of no runoff. Most of the study-area runoff at both sites occurred in response to a few specific storm periods. More than 75 percent of the runoff at each site occurred during two wet periods: September 18–October 1, 2006 and July 2–August 8, 2007. During both of these periods, multiple rainfall events and wet soil conditions contributed to substantial runoff. During the entire study period, the West Oso Creek watershed produced more runoff than the Oso Creek tributary watershed, 10.83 inches compared with 7.28 inches. The West Oso Creek watershed also exhibited a more rapid runoff response with higher peak flows than the Oso Creek tributary watershed.

Fourteen rainfall samples were collected and analyzed for nutrients and major inorganic ions. Most of the rainfall nitrogen is in the form of dissolved ammonia and dissolved nitrate, which were detected in all of the samples. Median concentrations of ammonia and nitrate were 0.16 mg/L and 0.19 mg/L, respectively. Organic forms of nitrogen were detected in all of the samples at relatively low concentrations; the median value of total organic nitrogen was 0.08 mg/L. Nitrite was detected in about one-half of the samples at low concentrations; the median concentration was 0.002 mg/L. Total phosphorus was detected in about one-half of the samples at relatively small concentrations; the median concentration was less than 0.008 mg/L.

Based on rainfall data and sample analysis results, daily total nitrogen and total phosphorus deposition were computed for each study area. The average (area-weighted) annual total nitrogen deposition for both watersheds over the two-year study was 5.50 lbs/acre per year, compared with less than 0.13 lbs/acre per year for total phosphorus.

During June 2006 to September 2007, nineteen composite runoff samples were collected among the two monitoring stations; 10 samples at West Oso Creek and 9 samples at Oso Creek tributary. Statistical tests indicated that nitrogen concentrations in runoff were higher at West Oso Creek than Oso Creek tributary. Phosphorus and major ion concentrations were higher at Oso Creek tributary. Runoff loads and yields were calculated for selected nutrients. Total nitrogen in runoff averaged 2.61 lbs/acre per year from the West Oso Creek watershed and 0.96 lbs/acre per year from the Oso Creek tributary watershed. Runoff yields of nitrogen were relatively small compared to inputs of nitrogen fertilizer and

rainfall nitrogen deposition. The average annual (both watersheds) total nitrogen runoff yield was about 2.4 percent of the combined fertilizer and rainfall deposition inputs of nitrogen. Average runoff yields of total phosphorus were 0.78 lbs/acre per year the West Oso Creek watershed and 0.50 lbs/acre per year from the Oso Creek tributary watershed. The average annual (both watersheds) total phosphorus runoff yield was about 4.4 percent of the fertilizer input of phosphorus. Rainfall deposition of phosphorus was small (less than 0.13 lbs/acre per year), compared with fertilizer applications and runoff yields.

West Oso Creek exhibited suspended-sediment loads and yields that were more than twice as much as the Oso Creek tributary watershed. The average suspended-sediment yield from the West Oso Creek watershed was 582 lbs/acre per year. The average suspended-sediment yield from the Oso Creek tributary watershed was 257 lbs/acre per year. The area-weighted, annual average sediment yield from both watersheds was 417 lbs/acre per year.

In 19 runoff samples collected between the two sites, laboratory analyses indicated detection of 30 pesticide compounds (22 herbicides and 8 insecticides). At the West Oso site, 22 pesticides were detected (18 herbicides and 4 insecticides). At the Oso Creek tributary site, 23 pesticides were detected (17 herbicides and 6 insecticides). Thirteen pesticides that were detected were detected in only 1 sample, at relatively low concentrations (near, or below the laboratory reporting limit). Five herbicides were detected in all samples: atrazine (and two atrazine degradation byproducts) and glyphosate (and a glyphosate byproduct). Pesticides 2, 4-D, and pendimethalin were detected in more than 50 percent of the samples.

Runoff yields of glyphosate, atrazine, and pendimethalin were greater at West Oso Creek than at Oso Creek tributary, by roughly an order of magnitude. Of all pesticides detected in runoff, the herbicide glyphosate had the highest runoff yields, 0.013 lbs/acre per year from the West Oso Creek watershed and 0.001 lbs/acre per year from the Oso Creek tributary watershed. Average annual runoff yields of atrazine were .003 and 0.0001 lbs/acre per year, respectively from the West Oso Creek and Oso Creek tributary watershed. Comparison of applications and runoff yields of selected pesticides indicate that about 0.4 percent of glyphosate applied to the study area croplands was detected in runoff (area-weighted average of both watersheds). The percentage of applied atrazine detected in runoff was estimated to be 0.3 percent of the amount applied to the study watersheds.

Thirteen bacteria samples were collected during the study. Eight samples were collected at West Oso Creek and 5 samples were collected at Oso Creek tributary. At both sites, most sample concentrations of fecal coliform, *E. coli*, and *enterococci* were greater than TSWQS established for the receiving waters of Oso Creek and Oso Bay. Because runoff and associated bacteria concentrations represent relatively brief and infrequent conditions, the effect of runoff and associated bacteria concentrations on downstream receiving waters (Oso Bay and Oso Creek) is not known. However, the relatively large bacteria concentrations (compared to TSWQS) indicate that runoff from the study watersheds is a potential source of bacteria to receiving streams and bays.

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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	--

Table 5. Concentrations of selected constituents in rainfall samples, 08211511 – Texas AgriLife Research and Extension Center at Corpus Christi, TX, 2006-07

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

Sample Date	Event rainfall, inches	Calcium water, fltrd, mg/L	Magnesium, water, fltrd, mg/L	Potassium, water, fltrd, mg/L	Sodium, water, fltrd, mg/L	Chloride, water, fltrd, mg/L	Sulfate, water, fltrd, mg/L	Ammonia + org-N, water, fltrd, mg/L as N	Ammonia + org-N, water, unfltrd, mg/L as N	Ammonia, water, fltrd, mg/L as N
May 10, 2006	1.10	1.20	1.10	0.127	0.142	1.15	2.69	1.1	1.0	0.82
May 14, 2006	.52	--	--	--	--	--	--	2.3	1.1	.75
June 1, 2006	9.30	<.02	<.008	<.010	<.20	.16	.16	.17	<.10	.04
July 3, 2006	1.60	.14	.040	.029	.32	.56	.69	.28	.26	.22
July 6, 2006	1.30	.11	.027	.018	.20	.35	.67	.18	.18	.16
July 26, 2006	2.40	.38	.109	.046	.73	1.29	.95	.29	.20	.21
September 11, 2006	.46	--	--	--	--	--	--	.13	2.0	.10
September 24, 2006	1.80	.04	.010	.031	.47	.76	.64	<.10	.10	.08
October 14, 2006	.14	--	--	--	--	--	--	.75	.75	.71
January 3, 2007	1.49	.09	.035	.024	.34	.47	.59	.17	.17	.13
January 24, 2007	.51	--	--	--	--	--	--	.18	.18	.07
March 14, 2007	1.19	.23	.044	.047	.39	.54	.88	.24	.24	.17
May 25, 2007	1.52	.13	.048	.046	.49	1.46	.71	.20	.20	.20
July 2, 2007	4.67	.07	.028	.014	.20	.35	.38	.08	.08	.05

Table 5. Concentrations of selected constituents in rainfall samples, 08211511 – Texas AgriLife Research and Extension Center at Corpus Christi, TX, 2006-07 (cont.)

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

Sample Date	Event rainfall, inches	Nitrate + Nitrite, water, fltrd, mg/L as N	Nitrite, water, fltrd, mg/L as N	Organic nitrogen water, fltrd, mg/L as N	Organic nitrogen water, unfltrd, mg/L as N	Total nitrogen water, fltrd, mg/L as N	Total nitrogen water, unfltrd, mg/L as N	Phosphorus water, fltrd, mg/L as P	Phosphorus water, unfltrd, mg/L as P	Ortho-Phosphate water, fltrd, mg/L as P
May 10, 2006	1.10	0.378	0.004	0.31	0.18	1.5	1.4	<0.004	0.006	<0.006
May 14, 2006	.52	.338	.003	1.6	.31	2.6	1.4	.21	.043	<.006
June 1, 2006	9.30	.029	<.002	.14	--	.20	--	<.004	.007	<.006
July 3, 2006	1.60	.135	<.002	.06	.04	.41	.39	.006	<.004	<.006
July 6, 2006	1.30	.122	<.002	.02	.02	.30	.30	<.004	<.004	<.006
July 26, 2006	2.40	.149	<.002	.08	--	.44	.35	.004	.005	<.006
September 11, 2006	.46	.091	<.002	.03	1.9	.22	2.1	<.004	<.004	<.006
September 24, 2006	1.80	.078	<.002	.16	--	.32	--	<.004	<.004	<.006
October 14, 2006	.14	.250	.004	.01	.04	.96	1.0	.018	.028	.013
January 3, 2007	1.49	.064	.002	.03	.04	.22	.24	.005	<.008	.003
January 24, 2007	.51	.066	.002	.05	.10	.19	.24	<.006	<.008	<.006
March 14, 2007	1.19	.092	.001	.05	.07	.31	.33	<.006	.005	<.006
May 25, 2007	1.52	.102	.002	.09	.005	.39	.30	<.006	<.008	<.006
July 2, 2007	4.67	.057	<.002	.08	.03	.19	--	<.006	.004	<.006

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]

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, mg/L	14	.23	.08	.02	1.6
Nitrogen, total, mg/L	14	.63	.32	.19	2.10
Phosphorus, dissolved, mg/L as P	14	<.006	<.006	<.004	.021
Phosphorus, total, mg/L as P	14	<.006	<.008	<.004	.028
Phosphorus, Ortho-phosphate, dissolved, mg/L as P	14	<.006	<.006	<.006	.013

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

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

Table 9. Comparison of median event-mean concentrations and results of Wilcoxon rank-sum test for statistical differences in nutrient and major inorganic ion concentrations in runoff samples between sampling sites.

[mg/L, milligrams per liter]

Constituent	West Oso Creek – 08211517 median concentration (mg/L)	Oso Creek tributary – 08211525 median concentration (mg/L)	p-value	Is difference in concentrations between sites significantly different statistically ?
Nitrogen, total	3.15	1.23	0.02	Yes
Ammonia nitrogen, dissolved	.040	.021	.05	Yes
Nitrate + nitrite nitrogen, dissolved	.61	.20	.07	Maybe
Nitrogen, organic, total	2.08	1.06	.05	Yes
Phosphorus, total	.28	.42	.03	Yes
Calcium, dissolved	14.2	18.3	.05	Yes
Potassium, dissolved	4.07	7.65	.003	Yes
Chloride, dissolved	1.58	8.79	.0006	Yes
Sulfate, dissolved	1.50	5.56	.01	Yes

Table 10. Comparison of median event-mean concentrations and results of Wilcoxon rank-sum tests for seasonal differences in nutrient runoff concentrations.

[mg/L, milligrams per liter]

Constituent	Pre-harvest median concentration (mg/L)	Harvest/Post-harvest median concentration (mg/L)	p-value	Is difference in concentrations between sites significantly different statistically ?
Nitrogen, total	3.5	1.36	0.008	Yes
Ammonia nitrogen, dissolved	.148	.024	.018	Yes
Nitrate + nitrite nitrogen, dissolved	.81	.24	.0008	Yes
Nitrogen, organic, total	2.06	1.15	.142	No
Phosphorus, total	.78	.64	.29	No

Table 11. Median concentrations of selected nutrients used to estimate constituent loads for unsampled runoff events, water years 2006–07

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

Station/Constituent	Pre-harvest (Jan. – June) Median	Post-harvest (July – September) Median	Median, all samples
08211517 – West Oso Creek			
Nitrogen, total, mg/L	4.5	2.6	3.2
Nitrogen, ammonia, dissolved, mg/L as N	.15	.04	.04
Nitrogen, nitrate + nitrite, dissolved, mg/L as N	.78	.49	.61
Nitrogen, organic, total, mg/L	2.1	2.1	2.1
Phosphorus, total, mg/L as P	.78	.66	.71
Orthophosphate, dissolved, mg/L as P	.31	.25	.26
08211525 – Oso Creek tributary at FM 2444			
Nitrogen, total, mg/L	1.8	1.1	1.2
Nitrogen, ammonia, dissolved, mg/L as N	.03	.02	.02
Nitrogen, nitrite + nitrate, dissolved, mg/L as N	.66	.18	.24
Nitrogen, organic, total, mg/L	1.4	.97	1.1
Phosphorus, total, mg/L as P	.80	.61	.61
Orthophosphate, dissolved, mg/L as P	.35	.43	.37

Table 12. Estimated monthly and annual runoff loads of selected nutrients, water years 2006–07

[In pounds; N, nitrogen; P, phosphorus]

Nutrient constituent	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Annual
08211517 –West Oso Creek													
Water year 2006													
Nitrogen, total	0	744	0	0	0	0	0	0	1,140	79	22	6,080	8,060
Ammonia nitrogen, dissolved, as N	0	11	0	0	0	0	0	0	13	1.1	0.5	105	131
Nitrite + nitrate nitrogen, dissolved, as N	0	140	0	0	0	0	0	0	190	13	4.2	1,320	1,66
Nitrogen, organic, total, as N	0	601	0	0	0	0	0	0	910	65	17	4,760	6,350
Phosphorus, total	0	189	0	0	0	0	0	0	356	36	5.6	1,640	2,220
Orthophosphate, dissolved, as P	0	123	0	0	0	0	0	0	127	8.9	3.7	929	1,190
08211517 –West Oso Creek													
Water year 2007													
Nitrogen, total	4.8	0	0	851	0.5	688	0	10	0	13,990	587	2,640	18,770
Ammonia nitrogen, dissolved, as N	0.1	0	0	11	0	27	0	0.4	0	231	9.0	41	320
Nitrite + nitrate nitrogen, dissolved, as N	0.9	0	0	583	0.4	105	0	2.2	0	2,760	563	498	4,510
Nitrogen, organic, total, as N	3.9	0	0	251	0.1	566	0	7.4	0	11,100	474	2,135	14,540
Phosphorus, total	1.2	0	0	102	0.1	205	0	2.9	0	4,620	149	671	5,750
Orthophosphate, dissolved, as P	0.8	0	0	48	0.03	48	0	1.0	0	3,260	97	437	3,890

Table 12. Estimated monthly and annual runoff loads of selected nutrients, water years 2006–07 (cont.)

[In pounds; N, nitrogen; P, phosphorus]

Nutrient constituent	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Annual
08211525 – Oso Creek tributary													
Water year 2006													
Nitrogen, total	179	54	0	0	0	0	0	0	162	26	0	3,080	3,500
Ammonia nitrogen, dissolved, as N	3.3	1.0	0	0	0	0	0	0	2.3	0.3	0	63	70
Nitrite + nitrate nitrogen, dissolved, as N	29	8.9	0	0	0	0	0	0	24	1.3	0	538	602
Nitrogen, organic, total, as N	158	48	0	0	0	0	0	0	135	25	0	2,540	2,910
Phosphorus, total	100	30	0	0	0	0	0	0	88	17	0	1,460	1,690
Orthophosphate, dissolved, as P	70	21	0	0	0	0	0	0	057	12	0	887	1,050
08211525 – Oso Creek tributary													
Water year 2007													
Nitrogen, total	96	0	0	749	14	333	0	34	0	4,660	190	633	6,710
Ammonia nitrogen, dissolved, as N	1.9	0	0	9.0	0.3	16	0	0.6	0	74	3.3	12	117
Nitrite + nitrate nitrogen, dissolved, as N	16	0	0	311	6.2	95	0	12	0	662	28	103	1,230
Nitrogen, organic, total, as N	85	0	0	426	7.4	228	0	26	0	4,110	166	558	5,610
Phosphorus, total	53	0	0	194	3.4	93	0	15	0	2,780	80	343	3,570
Orthophosphate, dissolved, as P	38	0	0	118	2.2	35	0	6.5	0	2,330	59	302	2,890

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

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

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

Table 15. Suspended-sediment analysis results, water years 2006 – 2007

[ft^3/s, cubic feet per second; mg/L, milligrams per liter;]

Station/Date/Time	Discharge (ft^3/s)	Concentration (mg/L)	Percent silt and clay, by weight
08211517 – West Oso Creek			
June 1, 2006 – 14:00	129	745	96
June 2, 2006 – 11:40	27	447	99
June 2, 2006 – 16:00	24	315	97
July 3, 2006 – 17:17	0.81	1,400	99
January 4, 2007 – 11:45	2.8	1,005	100
January 4, 2007 – 15:30	2.5	1,070	100
January 25, 2007 – 09:00	9.2	383	97
March 14, 2007 – 14:30	10	2,560	99
July 2, 2007 – 18:45	108	234	72
July 3, 2007 – 09:45	230	136	73
08211525 – Oso Creek tributary at FM 2444			
June 1, 2006 – 17:10	25	923	97
September 15, 2006 – 14:00	22.4	293	99
September 15, 2006 – 15:05	22.5	311	99
September 15, 2006 – 17:30	22.1	234	99
September 15, 2006 – 19:30	20.3	239	96
September 16, 2006 – 07:30	13.5	163	96
January 4, 2007 – 14:15	8.1	484	97
January 25, 2007 – 7:00	24.8	200	100
March 14, 2007 – 17:00	10	1,504	98
July 3, 2007 – 19:30	32	50	99
July 4, 2007 – 08:30	56	76	100
August 30, 2007 – 08:00	11	44	99

Table 16 . Equations relating suspended-sediment load (L) with discharge (Q)

Site/condition	Equation	Correlation coefficient (R^2)
West Oso Creek -- without crop cover	$L = 1.713 \times Q^{1.040}$	0.966
West Oso Creek – with crop cover	$L = 1.027 \times Q^{0.972}$	0.972
Oso Creek Tributary – without crop cover	$L = 1.432 \times Q^{0.920}$	0.956
Oso Creek Tributary – with crop cover	$L = 0.557 \times Q^{1.043}$	0.972

Table 17. Estimated monthly and annual runoff suspended-sediment loads, water years 2006–07

[In tons]

Site/Year	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Annual
08211517 – West Oso Creek													
Water year 2006	0	107	0	0	0	285	5.4	0.8	0	0	0.8	1000	1,400
Water year 2007	0.5	0	0	6.4	0.02	48	0	0.9	0	1,270	40	227	1,590
08211525 – Oso Creek Tributary													
Water year 2006	33	12	0	0	0	0	0	0	20	2.4	0	547	614
Water year 2007	21	0	0	91	2.1	22	0	1.9	0	524	18	67	747

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

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

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

Table 20. Summary statistics of concentrations of pesticides detected in runoff samples, 08211517 – West Oso Creek and 08211525 – Oso Creek Tributary, 2006–07 (cont.)

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

08211525 – Oso Creek Tributary

Constituent	Number of Samples	[1] Number of Detections	Mean	Median	Minimum	Maximum
Herbicides						
2,4-D	9	6	--	<0.04	<0.04	1.23
2-Chloro-4-isopropylamino-6-amino-s-triazine (CIAT)	9	9	0.058	0.029	0.011	0.184
2-Chloro-6-ethylamino-4-amino-s-triazine (CEAT)	9	2	--	<0.08	<0.08	0.11
2-Hydroxy-4-isopropylamino-6-ethylamino-s-triazine (OIET)	9	9	0.26	0.10	0.021	0.902
Aminomethylphosphonic acid (AMPA)	8	8	0.90	0.60	0.35	1.94
Atrazine	9	9	1.32	.042	.012	9.42
Bromacil	9	1	--	<.04	<.02	0.05
Carbaryl	9	1	<.02	<.02	<.02	<.02
DCPA	9	1	--	<0.003	<0.003	0.004
Dicamba	9	1	--	<.08	<.04	.97
Diuron	9	2	<0.04	<0.04	<0.02	0.04
Glyphosate	8	8	2.56	1.08	0.59	10.6
Metolachlor	9	3	--	<.01	<.006	0.008
Pendimethalin	9	6	--	.052	<0.02	.144
Simazine	9	4	--	<0.006	<0.005	0.064
Terbuthylazine	9	1	--	<0.01	<0.01	0.02
Trifluralin	9	3	--	<0.009	<0.009	0.054
Insecticides						
Azinphos-methyl	9	1	<0.05	<0.05	<0.05	<0.08
Dicrotophos	9	1	<0.08	<0.08	<0.08	<0.08
Malathion	9	2	--	.018	<0.016	2.64
Fipronil Sulfide	9	1	--	<.013	<.013	<.013
Malaoxon	9	1	--	<.039	<.039	.049
Myclobutanil	9	3	<0.033	<0.033	<0.01	<0.033

[1] Some reported detections were less than the laboratory minimum reporting level (mrl). In these cases, the minimum value is listed as less than the mrl.

Table 21. Median seasonal concentrations used to estimate runoff pesticides loads for unsampled runoff, 08211517 – West Oso Creek and 08211525 Oso Creek Tributary, water years 2006–07

[all values in micrograms per liter]

Station/Pesticides	Pre-harvest (Jan. – June) Median	Post-harvest (July – September) Median	Median, all samples
08211517 – West Oso Creek			
Atrazine	0.144	0.097	0.120
Glyphosate	5.10	12.6	8.51
Pendimethalin	2.14	0.21	1.18
08211525 –Oso Creek tributary			
Atrazine	0.95	.042	.042
Glyphosate	1.34	1.08	1.08
Pendimethalin	.112	.027	.052

Table 22. Estimated monthly and annual runoff loads of selected pesticides, water years 2006–07

[In pounds]

Pesticide	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Annual
08211517 –West Oso Creek													
Water year 2006													
Atrazine	0	0.029	0	0	0	0	0	0	0.755	0.002	0.001	0.182	0.97
Glyphosate	0	3.60	0	0	0	0	0	0	1.37	0.581	0.104	21.5	27.2
Pendimethalin	0	0.612	0	0	0	0	0	0	0.015	0.043	0.002	0.728	1.40
Water year 2007													
Atrazine	0.0002	0	0	0.010	0	0.034	0	0.0004	0	28.4	.023	.102	28.6
Glyphosate	0.023	0	0	0.448	0	0.703	0	0.153	0	92.5	2.85	12.8	109
Pendimethalin	0.0004	0	0	0.483	0	0.003	0	0.007	0	1.20	0.05	0.21	1.95
08211525 – Oso Creek tributary													
Water year 2006													
Atrazine	0.007	0.002	0	0	0	0	0	0	0.170	0.007	0	0.086	0.272
Glyphosate	0.176	0.053	0	0	0	0	0	0	0.055	0.014	0	2.34	2.64
Pendimethalin	0.004	0.001	0	0	0	0	0	0	0.002	0.001	0	0.162	0.170
Water year 2007													
Atrazine	0.004	0	0	0.009	0	0.897	0	0.001	0	0.24	.063	.083	1.29
Glyphosate	0.096	0	0	0.335	0.005	0.364	0	0.024	0	8.24	.234	.677	10.0
Pendimethalin	0.002	0	0	0.056	0.001	0.013	0	0	0	.112	0.063	0.075	0.322

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	
West Oso Creek	Application	Runoff yield	Application	Runoff yield	Application	Runoff yield
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

Table 24. Bacteria analyses results, water years 2006–07

[CFU, colony forming units; *E. coli*, *Escherichia coli*; mL, milliliter]

Site/Date	Collection Time	Fecal Coliforms (CFU/100 mL)	E. Coli (CFU/100 mL)	Enterococci (CFU/100 mL)
08211517 – West Oso Creek				
07/07/2006 (primary sample)	10:15	320	46	59,000
07/07/2006 (lab duplicate)	10:15	--	--	107,000
07/07/2006 (average concentration)	10:15	320	46	83,000
07/27/2006 (primary sample)	9:35	31,000	4,700	127,000
07/27/2006 (field split)	9:35	42,000	9,000	154,000
07/27/2006 (lab duplicate of primary sample)	9:35	--	--	145,000
07/27/2006 (weighted-average concentration)	9:35	36,500	6,850	138,000
9/18/2006 (primary sample)	9:18	60,000	84,000	96,000
9/18/2006 (field split sample)	9:18	46,000	100,000	88,000
9/18/2006 (average concentration)	9:18	53,000	92,000	92,000
1/4/2007 (primary sample)	11:54	6,000	7,600	21,000
1/4/2007 (lab duplicate)	11:54	14,000	--	--
1/4/2007 (average concentration)	11:54	10,000	7,600	21,000
1/25/2007 (primary sample)	9:00	44,000	39,000	64,000
1/25/2007 (lab duplicate)	9:00	45,000	--	--
1/25/2007 (average concentration)	9:00	44,500	39,000	64,000
5/25/2007 (primary sample)	15:12	304	391	5,200
5/25/2007 (lab duplicate)	15:12	761	--	--
5/25/2007 (average concentration)	15:12	532	391	5,200
7/2/2007 (primary sample)	11:50	--	15,600	45,000
7/2/2007 (field split)	11:50	--	5,800	83,000
7/2/2007 (lab duplicate of primary sample)	11:50	--	7,200	49,000
7/2/2007 (average concentration)	11:50	--	11,050	55,500
8/30/2007 (primary sample)	15:40	82,000	12,500	145,000
8/30/2007 (field split)	15:40	69,000	69,000	143,000
8/30/2007 (lab duplicate of primary sample)	15:40	--	30,000	--
8/30/2007 (average concentration)	15:40	75,500	31,000	144,000

Table 24. Analysis results of bacteria samples, water years 2006–07 (cont.)

[CFU, colony forming units; *E. coli*, *Escherichia coli*; mL, milliliter]

Site/Date	Collection Time	Fecal Coliforms (CFU/100 mL)	E. Coli (CFU/100 mL)	Enterococci (CFU/100 mL)
08211525 –Oso Creek tributary				
07/07/2006 (primary sample)	11:10	145	80	4,800
07/07/2006 (field duplicate)	11:10	253	77	5,200
07/07/2006 (lab duplicate)	11:10	--	53	--
07/07/2006 (lab duplicate of primary sample)	11:10	83	--	--
07/07/2006 (weighted-average concentration)	11:10	156	72	5,000
9/15/2006 (primary sample)	10:00	3,600	16,000	25,000
9/15/2006 (field split sample)	10:00	8,000	21,000	28,000
9/15/2006 (lab duplicate of primary sample)	10:00	--	--	25,000
9/15/2006 (average concentration)	10:00	5,800	18,500	25,800
1/4/2007 (primary sample)	12:17	4,300	5,300	31,000
1/4/2007 (field split)	12:17	2,775	3,000	39,000
1/4/2007 (average concentration)	12:17	3,538	4,150	35,000
1/25/2007 (primary sample)	9:20	14,900	4,100	22,000
7/2/2007 (primary sample)	11:50	--	5,000	75,000

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)

Appendix 1. Runoff water-quality data for 08211517 – West Oso Creek at Merrett Road near Corpus Christi, Texas, water years 2006–07

[<,less than; E, estimated, --, not available; µg/L, micrograms per liter; mg/L, milligrams per liter; fltrd, filtered; unfltrd, unfiltered; µS/cm, microsiemens per centimeter, N, nitrogen; P, phosphorus; CaCO3, calcium carbonate]

Date	pH, water, unfltrd field, standard units	pH, water, unfltrd lab, standard units	Specific conductance, unfltrd, lab, µS/cm @ 25 deg C	Specific conductance, unfltrd, field, µS/cm @ 25 deg C	Hardness, water, mg/L as CaCO3	Calcium water, fltrd, mg/L	Magnesium, water, fltrd, mg/L	Potassium, water, fltrd, mg/L
June 1-2, 2006	6.6	7.7	88	89	29	10.4	0.821	3.48
July 1-2, 2006	6.8	8.0	147	149	51	18.4	1.34	4.07
July 6, 2006	7.5	8.0	135	130	49	17.6	1.33	4.15
Sep 9-10, 2006	7.4	8.3	124	122	38	13.5	.958	3.24
Sep 18-19, 2006	7.2	8.0	139	130	50	17.8	1.38	6.57
Jan 3-5, 2007	7.0	8.3	125	142	40	14.2	1.16	3.86
Jan 24-25, 2007	6.8	7.6	136	141	45	15.7	1.49	4.24
Mar 14-15, 2007	8.2	8.0	127	104	--	--	--	--
May 25, 2007	7.3	8.3	98	85	30	10.7	.807	3.60
Jul 2-3, 2007	6.7	7.3	86	77	26	8.91	1.20	6.74

Appendix 1. Runoff water-quality data for 08211517 – West Oso Creek at Merrett Road near Corpus Christi, Texas, water years 2006–07 — continued

[<,less than; E, estimated, --, not available; µg/L, micrograms per liter; mg/L, milligrams per liter; fltrd, filtered; unfltrd, unfiltered; µS/cm, microsiemens per centimeter, N, nitrogen; P, phosphorus; CaCO3, calcium carbonate]

Date	Sodium, water, fltrd, mg/L	Chloride, water, fltrd, mg/L	Fluoride, water, fltrd, mg/L	Silica, water, fltrd, mg/L	Sulfate water, fltrd, mg/L	Ammonia + organic-N, water, fltrd, mg/L as N	Ammonia + organic-N, water, unfiltered, mg/L as N	Ammonia water, fltrd, mg/L	Ammonia water, fltrd, mg/L as N
June 1-2, 2006	2.33	1.17	0.1	6.4	0.9	0.42	1.2	0.02	0.017
July 1-2, 2006	7.38	1.58	.4	15.4	2.2	.49	2.1	.03	.027
July 6, 2006	5.82	1.61	.3	13.6	1.6	.75	2.4	.04	.032
Sep 9-10, 2006	6.65	1.54	.5	11.2	1.5	2.7	3.3	.16	.121
Sep 18-19, 2006	4.23	2.72	.2	10.9	1.3	.47	1.4	.05	.039
Jan 3-5, 2007	6.33	2.24	.27	8.4	2.64	.56	2.3	.29	.228
Jan 24-25, 2007	7.80	3.11	.20	8.1	3.65	.47	1.3	.05	.041
Mar 14-15, 2007	--	--	--	--	--	.65	4.3	.26	.200
May 25, 2007	2.87	.97	.19	8.2	1.39	.55	2.8	.19	.148
Jul 2-3, 2007	1.81	1.52	.13	8.6	.93	.46	.75	--	<.020

Appendix 1. Runoff water-quality data for 08211517 – West Oso Creek at Merrett Road near Corpus Christi, Texas, water years 2006–07 — continued

[<,less than; E, estimated, --, not available; µg/L, micrograms per liter; mg/L, milligrams per liter; fltrd, filtered; unfltrd, unfiltered; µS/cm, microsiemens per centimeter, N, nitrogen; P, phosphorus; CaCO3, calcium carbonate]

Date	Nitrate water, filtered, mg/L as N	Nitrite + nitrate water filtered, mg/L as N	Nitrite water, fltrd, mg/L as N	Organic nitrogen, water, fltrd, mg/L	Organic nitrogen, water, unfltrd mg/L	Total nitrogen, water, fltrd, mg/L	Total nitrogen, water, unfltrd mg/L	Ortho-phosphate, water, fltrd, mg/L	Ortho-phosphate, water, fltrd, mg/L as P
June 1-2, 2006	0.23	0.25	0.017	0.41	1.2	0.67	1.5	0.511	0.167
July 1-2, 2006	.44	.49	.049	.47	2.1	.98	2.6	.661	.216
July 6, 2006	.36	.38	.026	.72	2.3	1.1	2.8	.808	.264
Sep 9-10, 2006	.65	.71	.058	2.6	3.2	3.4	4.0	.487	.159
Sep 18-19, 2006	.49	.51	.017	.43	1.4	.97	1.9	.769	.251
Jan 3-5, 2007	2.01	2.19	.178	.33	2.1	2.7	4.5	.950	.310
Jan 24-25, 2007	3.13	3.26	.123	.43	1.3	3.7	4.6	.772	.252
Mar 14-15, 2007	.72	.78	.057	.45	4.2	1.4	5.1	1.07	.350
May 25, 2007	.73	.77	.042	.40	2.6	1.3	3.5	1.05	.342
Jul 2-3, 2007	.21	.22	.008	--	--	.68	.98	1.42	.463

Appendix 1. Runoff water-quality data for 08211517 – West Oso Creek at Merrett Road near Corpus Christi, Texas, water years 2006–07 — continued

[<,less than; E, estimated, --, not available; µg/L, micrograms per liter; mg/L, milligrams per liter; fltrd, filtered; unfltrd, unfiltered; µS/cm, microsiemens per centimeter, N, nitrogen; P, phosphorus; CaCO3, calcium carbonate]

Date	Phosphorus, water, fltrd, mg/L	Phosphorus, water, unfltrd mg/L	1-Naphthol, water, fltrd µg/L	2,4-D methylester, water, fltrd, µg/L	2,4-D, water, fltrd, µg/L	2,4-DB, water, fltrd µg/L	2,6-Diethyl-aniline water, fltrd µg/L	2Chloro -2',6'- diethyl acetanilide water, fltrd µg/L	CIAT, water, fltrd, µg/L
June 1-2, 2006	0.189	0.47	<0.09	<0.190	E0.06	<0.02	<0.006	<0.006	E0.112
July 1-2, 2006	.25	.80	<.09	<.638	E6.24	<.02t	<.006	<.006	E.048
July 6, 2006	.28	.66	<.09	<.190	E3.35	<.02	<.006	<.006	E.030
Sep 9-10, 2006	.27	.75	<.09	<.190	<.04	<.02	<.006	<.006	E.109
Sep 18-19, 2006	.27	.57	<.09	<.190	.59	<.02	<.006	<.006	E.029
Jan 3-5, 2007	.35	.78	<.09	<.200	E.12	<.02	<.006	<.006	E.015
Jan 24-25, 2007	.257	.52	<.09	<.200	.16	<.02	<.006	<.006	E.020
Mar 14-15, 2007	.367	1.52	<.09	<.200	.04	<.02	<.006	<.006	E.021
May 25, 2007	.40	1.00	<.09	<.200	<.04	<.02	<.006	<.006	E.049
Jul 2-3, 2007	.49	.59	<.09	<.200	<.04	<.02	<.006	<.006	E.179

Appendix 1. Runoff water-quality data for 08211517 – West Oso Creek at Merrett Road near Corpus Christi, Texas, water years 2006–07 — continued

[<,less than; E, estimated, --, not available; µg/L, micrograms per liter; mg/L, milligrams per liter; fltrd, filtered; unfltrd, unfiltered; µS/cm, microsiemens per centimeter, N, nitrogen; P, phosphorus; CaCO3, calcium carbonate]

Date	CEAT, water, fltrd, µg/L	2-Ethyl-6-methyl-aniline water, fltrd, µg/L	OIET, water, fltrd, µg/L	3,4-Dichloro-aniline water, fltrd, µg/L	3-Hydroxy carbofuran, water, fltrd, µg/L	4-Chloro-2methyl phenol, water, fltrd, µg/L	Acetochlor, water, fltrd, µg/L	Acifluorfen, water, fltrd µg/L	Alachlor, water, fltrd, µg/L
June 1-2, 2006	<0.08	<0.010	0.242	<0.004	<0.008	<0.005	<0.006	<0.028t	<0.005
July 1-2, 2006	<.08	<.010	.100	<.004	<.008	<.005	<.006	<.028	<.005
July 6, 2006	<.08	<.010	.111	<.004	<.008	<.005	<.006	<.028	<.005
Sep 9-10, 2006	<.08	<.010	E.302	<.004	<.008	<.005	<.006	<.028	<.005
Sep 18-19, 2006	<.08	<.010	.106	<.004	<.008	<.005	<.006	<.028	<.005
Jan 3-5, 2007	<.08	<.010	E.063	<.004	<.020	<.005	<.006	<.006	<.005
Jan 24-25, 2007	<.08	<.010	E.065	<.004	<.020	<.005	<.006	<.006	<.005
Mar 14-15, 2007	<.08	<.010	.105	<.004	<.020	<.005	<.006	<.006	<.005
May 25, 2007	<.08	<.010	.149	<.006	<.020	<.005	<.006	<.006	<.005
Jul 2-3, 2007	E.07	<.010	.529	<.004	<.020	<.005	<.006	<.006	<.005

Appendix 1. Runoff water-quality data for 08211517 – West Oso Creek at Merrett Road near Corpus Christi, Texas, water years 2006–07 — continued

[<,less than; E, estimated, --, not available; µg/L, micrograms per liter; mg/L, milligrams per liter; fltrd, filtered; unfltrd, unfiltered; µS/cm, microsiemens per centimeter, N, nitrogen; P, phosphorus; CaCO3, calcium carbonate]

Date	Aldicarb sulfone water, fltrd µg/L	Aldicarb sulfoxide, water, fltrd µg/L	Aldicarb, water, fltrd µg/L	Amino-methyl-phosphonic acid, water, fltrd µg/L	Atrazine, water, fltrd, µg/L	Azinphos-methyl oxon, water, fltrd, µg/L	Azinphos-methyl, water, fltrd µg/L	Bendiocarb, water, fltrd, µg/L	Benfluralin, water, fltrd µg/L
June 1-2, 2006	<0.02	<0.100	<0.15	1.34	0.996	<0.04	<0.050	<0.08	<0.010
July 1-2, 2006	<.02	<.100	<.15	13.2	.097	<.04	<.050	<.08	<.010
July 6, 2006	<.02	<.100	<.15	4.69	.053	<.04	<.050	<.08	<.010
Sep 9-10, 2006	<.02	<.100	<.15	10.3	.192	<.04	<.050	<.08	<.010
Sep 18-19, 2006	<.02	<.100	<.15	1.13	.030	<.04	<.050	<.08	<.010
Jan 3-5, 2007	<.08	<.040	<.04	2.50	.022	<.04	<.080	<.04	E.007
Jan 24-25, 2007	<.08	<.040	<.04	1.33	.056	<.04	<.080	<.04	<.010
Mar 14-15, 2007	<.08	<.040	<.04	1.60	.252	<.04	<.080	<.04	<.010
May 25, 2007	<.08	<.040	<.04	10.1	.144	<.04	<.080	<.04	<.010
Jul 2-3, 2007	<.08	<.040	<.04	8.20	8.90	<.04	<.080	<.04	<.010

Appendix 1. Runoff water-quality data for 08211517 – West Oso Creek at Merrett Road near Corpus Christi, Texas, water years 2006–07 — continued

[<,less than; E, estimated, --, not available; µg/L, micrograms per liter; mg/L, milligrams per liter; fltrd, filtered; unfltrd, unfiltered; µS/cm, microsiemens per centimeter, N, nitrogen; P, phosphorus; CaCO3, calcium carbonate]

Date	Benomyl water, fltrd, µg/L	Bensulfuron methyl, water, fltrd, µg/L	Bentazon, water, fltrd µg/L	Bromacil, water, fltrd, µg/L	Bromoxynil, water, fltrd µg/L	Carbaryl, water, fltrd µg/L	Carbofuran, water, fltrd µg/L	Chloramben methyl ester, water, fltrd, µg/L
June 1-2, 2006	<0.022	<0.02	<0.02	<0.02	<0.04	<0.02	<0.016	<0.02
July 1-2, 2006	<.022	<.02	<.02	<.02	<.04	<.02	<.016	<.02
July 6, 2006	<.022	<.02	<.02	<.02	<.04	<.02	<.016	<.02
Sep 9-10, 2006	<.022	<.02	<.02	<.02	<.04	<.02	<.016	<.02
Sep 18-19, 2006	<.022	<.02	<.02	<.02	<.04	<.02	<.016	<.02
Jan 3-5, 2007	<.020	<.06	<.02	<.04	<.12	<.02	<.060	<.10
Jan 24-25, 2007	<.020	<.06	<.02	<.04	<.12	<.02	<.060	<.10
Mar 14-15, 2007	<.020	<.06	<.02	<.04	<.12	<.02	<.060	<.10
May 25, 2007	<.020	<.06	<.02	<.04	<.12	<.02	<.060	<.10
Jul 2-3, 2007	<.020	<.06	<.02	<.04	<.12	<.02	<.060	<.10

Appendix 1. Runoff water-quality data for 08211517 – West Oso Creek at Merrett Road near Corpus Christi, Texas, water years 2006–07 — continued

[<,less than; E, estimated, --, not available; µg/L, micrograms per liter; mg/L, milligrams per liter; fltrd, filtered; unfltrd, unfiltered; µS/cm, microsiemens per centimeter, N, nitrogen; P, phosphorus; CaCO3, calcium carbonate]

Date	Chlori-muron, water, fltrd, µg/L	Chloro-di-amino-s-triazine, water, fltrd, µg/L	Chlor-pyrifos-oxon, water, fltrd, µg/L	Chlorpyrifos water, fltrd, µg/L	cis-Permethrin water fltrd µg/L	Clopyralid, water, fltrd µg/L	Cycloate, water, fltrd, µg/L	Cyfluthrin, water, fltrd, µg/L	Cyper-methrin water, fltrd, µg/L
June 1-2, 2006	<0.032	<0.04	<0.06	<0.006	<0.006	<0.07	<0.01	<0.053	<0.046
July 1-2, 2006	<.032	<.04	<.06	<.005	<.006	<.07	<.01	<.053	<.046
July 6, 2006	<.032	<.04	<.06	<.005	<.006	<.07	<.01	<.053	<.046
Sep 9-10, 2006	<.032	<.04	<.06	<.005	<.006	<.07	<.01	<.053	<.046
Sep 18-19, 2006	<.032	<.04	<.06	<.005	<.006	<.07	<.01	<.053	<.046
Jan 3-5, 2007	<.080	<.12	<.06	<.005	<.010	<.06	<.06	<.053	<.046
Jan 24-25, 2007	<.080	<.12	<.06	<.005	<.010	<.06	<.06	<.053	<.046
Mar 14-15, 2007	<.080	<.12	<.06	<.005	<.010	<.06	<.06	<.053	<.046
May 25, 2007	<.080	<.12	<.06	<.011	<.010	<.06	<.06	<.053	<.046
Jul 2-3, 2007	<.080	<.12	<.06	<.005	<.010	<.06	<.06	<.053	<.046

Appendix 1. Runoff water-quality data for 08211517 – West Oso Creek at Merrett Road near Corpus Christi, Texas, water years 2006–07 — continued

[<,less than; E, estimated, --, not available; µg/L, micrograms per liter; mg/L, milligrams per liter; fltrd, filtered; unfltrd, unfiltered; µS/cm, microsiemens per centimeter, N, nitrogen; P, phosphorus; CaCO3, calcium carbonate]

Date	Dacthal mono-acid, water, fltrd µg/L	DCPA, water, fltrd µg/L	Desulfinyl-fipronil, water, fltrd, µg/L	Diazinon, water, fltrd, µg/L	Dicamba water, fltrd µg/L	Dichlorprop, water, fltrd µg/L	Dicrotophos, water, fltrd, µg/L	Dieldrin, water, fltrd, µg/L	Dimethoate, water, fltrd µg/L
June 1-2, 2006	<0.03	<0.003	<0.012	<0.005	<0.04	<0.03	<0.08	<0.009	<0.006
July 1-2, 2006	<.03	<.003	<.012	<.005	<.04	<.03	<.08	<.009	<.006
July 6, 2006	<.03	<.003	<.012	<.005	<.04	<.03	<.08	<.009	<.006
Sep 9-10, 2006	<.03	<.003	<.012	<.005	<.04	<.03	<.08	<.009	<.006
Sep 18-19, 2006	<.03	<.004	<.012	<.005	<.04	<.03	<.08	<.009	<.006
Jan 3-5, 2007	<.02	<.003	<.012	<.005	<.08	<.04	<.08	<.009	<.006
Jan 24-25, 2007	<.02	<.003	<.012	<.005	<.08	<.04	<.08	<.009	<.006
Mar 14-15, 2007	<.02	E.004	<.012	<.005	<.08	<.04	<.08	<.009	<.006
May 25, 2007	<.02	<.003	<.012	<.005	<.08	<.04	<.08	<.009	<.006
Jul 2-3, 2007	<.02	<.003	<.012	<.005	<.08	<.04	E.04	<.009	<.006

Appendix 1. Runoff water-quality data for 08211517 – West Oso Creek at Merrett Road near Corpus Christi, Texas, water years 2006–07 — continued

[<,less than; E, estimated, --, not available; µg/L, micrograms per liter; mg/L, milligrams per liter; fltrd, filtered; unfltrd, unfiltered; µS/cm, microsiemens per centimeter, N, nitrogen; P, phosphorus; CaCO3, calcium carbonate]

Date	Dinoseb water, fltrd µg/L	Diphenamid, water, fltrd, µg/L	Diuron, water, fltrd µg/L	Ethion monoxon water, fltrd, µg/L	Ethion, water, fltrd, µg/L	Fenamiphos sulfone water, fltrd, µg/L	Fenamiphos sulfoxide, water, fltrd, µg/L	Fenamiphos, water, fltrd, µg/L	Fenuron water, fltrd µg/L
June 1-2, 2006	<0.04	<0.01	<0.02	<0.02	<0.016	<0.053	<0.04	<0.03	<0.10
July 1-2, 2006	<.04	<.01	<.02	<.02	<.016	<.053	<.04	<.03	<.10
July 6, 2006	<.04	<.01	<.02	<.02	<.016	<.053	<.04	<.03	<.10
Sep 9-10, 2006	<.04	<.01	<.02	<.02	<.016	<.053	<.04	<.03	<.10
Sep 18-19, 2006	<.04	<.01	<.02	<.02	<.016	<.053	<.04	<.03	<.10
Jan 3-5, 2007	<.04	<.04	<.04	<.02	<.016	<.053	<.04	<.03	<.04
Jan 24-25, 2007	<.04	<.04	<.04	<.02	<.016	<.053	<.04	<.03	<.04
Mar 14-15, 2007	<.04	<.04	E.04	<.02	<.016	<.053	<.04	<.03	<.04
May 25, 2007	<.04	<.04	<.04	<.02	<.016	<.053	<.04	<.03	<.04
Jul 2-3, 2007	<.04	<.04	<.04	<.02	<.016	<.053	<.04	<.03	<.04

Appendix 1. Runoff water-quality data for 08211517 – West Oso Creek at Merrett Road near Corpus Christi, Texas, water years 2006–07 — continued

[<,less than; E, estimated, --, not available; µg/L, micrograms per liter; mg/L, milligrams per liter; fltrd, filtered; unfltrd, unfiltered; µS/cm, microsiemens per centimeter, N, nitrogen; P, phosphorus; CaCO3, calcium carbonate]

Date	Desulfinyl-fipronil amide, water, fltrd, µg/L	Fipronil sulfide water, fltrd, µg/L	Fipronil sulfone water, fltrd, µg/L	Fipronil, water, fltrd, µg/L	Flumetsulam, water, fltrd, µg/L	Fluo-meturon water, fltrd µg/L	Fonofos water, fltrd, µg/L	Glufosinate, water, fltrd µg/L	Glyphosate, water, fltrd µg/L
June 1-2, 2006	<0.029	<0.013	<0.024	<0.016	<0.04	<0.02	<0.005	<0.140	1.81
July 1-2, 2006	<.029	<.013	<.024	<.016	<.04	<.02	<.005	<.140	51.2
July 6, 2006	<.029	<.013	<.024	<.016	<.04	<.02	<.005	<.140	11.8
Sep 9-10, 2006	<.029	<.013	<.024	<.016	<.04	<.02	<.005	<.140	30.3
Sep 18-19, 2006	<.029	<.013	<.024	<.016	<.04	<.02	<.005	<.140	2.00
Jan 3-5, 2007	<.029	<.016	<.024	<.016	<.06	<.04	<.006	<.140	5.10
Jan 24-25, 2007	<.029	<.016	<.024	<.016	<.06	<.04	<.006	<.140	2.10
Mar 14-15, 2007	<.029	<.016	<.024	<.016	<.06	<.04	<.006	<.140	E5.22
May 25, 2007	<.029	<.016	<.024	<.016	<.06	<.04	<.006	.580	53.5
Jul 2-3, 2007	<.029	<.016	<.024	<.016	<.06	<.04	<.006	<.140	E12.6

Appendix 1. Runoff water-quality data for 08211517 – West Oso Creek at Merrett Road near Corpus Christi, Texas, water years 2006–07 — continued

[<,less than; E, estimated, --, not available; µg/L, micrograms per liter; mg/L, milligrams per liter; fltrd, filtered; unfltrd, unfiltered; µS/cm, microsiemens per centimeter, N, nitrogen; P, phosphorus; CaCO3, calcium carbonate]

Date	Hexazinone, water, fltrd, µg/L	Imazaquin, water, fltrd, µg/L	Imazethapyr, water, fltrd, µg/L	Imidacloprid water, fltrd, µg/L	Iprodione, water, fltrd, µg/L	Isofenphos, water, fltrd, µg/L	Linuron water, fltrd µg/L	Malaoxon, water, fltrd, µg/L	Malathion, water, fltrd, µg/L
June 1-2, 2006	<0.026	<0.04	<.04	<.020	<.026	<.011	<.01	<.039	<.027
July 1-2, 2006	<.026	<.04	<.04	<.020	<.026	<.011	<.01	<.039	<.027
July 6, 2006	<.026	<.04	<.04	<.020	<.026	<.011	<.01	<.039	<.027
Sep 9-10, 2006	<.026	<.04	<.04	<.020	<.026	<.011	<.01	<.039	<.027
Sep 18-19, 2006	<.026	<.04	<.04	<.020	<.026	<.011	<.01	<.039	<.027
Jan 3-5, 2007	<.026	<.04	<.04	<.060	<.026	<.011	<.04	<.039	<.016
Jan 24-25, 2007	<.026	<.04	<.04	<.060	<.026	<.011	<.04	<.039	<.016
Mar 14-15, 2007	<.026	<.04	<.04	.086	<.026	<.011	<.04	<.039	<.016
May 25, 2007	<.026	<.04	<.04	<.078	<.026	<.011	<.04	<.039	<.016
Jul 2-3, 2007	<.026	<.04	<.04	<.060	<.026	<.011	<.04	<.039	<.016

Appendix 1. Runoff water-quality data for 08211517 – West Oso Creek at Merrett Road near Corpus Christi, Texas, water years 2006–07 — continued

[<,less than; E, estimated, --, not available; µg/L, micrograms per liter; mg/L, milligrams per liter; fltrd, filtered; unfltrd, unfiltered; µS/cm, microsiemens per centimeter, N, nitrogen; P, phosphorus; CaCO3, calcium carbonate]

Date	MCPA, water, fltrd µg/L	MCPB, water, fltrd µg/L	Metalaxyl, water, fltrd, µg/L	Methialthion water, fltrd, µg/L	Methiocarb, water, fltrd µg/L	Methomyl, water, fltrd µg/L	Methyl paraoxon, water, fltrd, µg/L	Methyl parathion, water, fltrd µg/L	Metolachlor, water, fltrd, µg/L
June 1-2, 2006	<0.07	<0.10	<0.065	<0.009	<0.034	<0.070	<0.02	<0.015	<0.006
July 1-2, 2006	<.07	<.10	<.007	<.009	<.034	<.070	<.02	<.015	<.006
July 6, 2006	<.07	<.10	<.007	<.009	<.034	<.070	<.02	<.015	<.006
Sep 9-10, 2006	<.07	<.10	<.007	<.009	<.034	<.070	<.02	<.015	<.006
Sep 18-19, 2006	<.07	<.10	<.007	<.009	<.034	<.070	<.02	<.015	<.006
Jan 3-5, 2007	<.06	<.20	<.007	<.009	<.040	<.060	<.02	<.008	<.010
Jan 24-25, 2007	<.06	<.20	<.007	<.009	<.040	<.060	<.02	<.008	.228
Mar 14-15, 2007	<.06	<.20	<.011	<.009	<.040	<.060	<.02	<.008	.082
May 25, 2007	<.06	<.20	<.007	<.009	<.040	<.060	<.02	<.008	<.013
Jul 2-3, 2007	<.06	<.20	<.007	<.009	<.040	<.060	<.02	<.008	E.008

Appendix 1. Runoff water-quality data for 08211517 – West Oso Creek at Merrett Road near Corpus Christi, Texas, water years 2006–07 — continued

[<,less than; E, estimated, --, not available; µg/L, micrograms per liter; mg/L, milligrams per liter; fltrd, filtered; unfltrd, unfiltered; µS/cm, microsiemens per centimeter, N, nitrogen; P, phosphorus; CaCO3, calcium carbonate]

Date	Metribuzin, water, fltrd, µg/L	Metsulfuron, water, fltrd, µg/L	Myclobutanil water, fltrd, µg/L	N-(4-Chloro-phenyl)-N'-methyl-urea, µg/L	Neburon water, fltrd µg/L	Nicosul-furon, water, fltrd, µg/L	Norflurazon, water, fltrd µg/L	Oryzalin, water, fltrd µg/L	Oxamyl, water, fltrd µg/L
June 1-2, 2006	<0.028	<0.07	<0.033	<0.04	<0.01	<0.04	<0.02	<0.02	<0.05
July 1-2, 2006	<.028	<.07	<.033	<.04	<.01	<.04	<.02	<.02	<.05
July 6, 2006	<.028	<.07	<.033	<.04	<.01	<.04	<.02	<.02	<.05
Sep 9-10, 2006	<.028	<.07	<.033	<.04	<.01	<.04	<.02	<.02	<.05
Sep 18-19, 2006	<.028	<.07	<.033	<.04	<.01	<.04	<.02	<.02	<.05
Jan 3-5, 2007	<.012	<.14	<.033	<.06	<.02	<.10	<.04	<.04	<.04
Jan 24-25, 2007	<.012	<.14	<.033	<.06	<.02	<.10	<.04	<.04	<.04
Mar 14-15, 2007	<.012	<.14	<.033	<.06	<.02	<.10	<.04	<.04	<.04
May 25, 2007	<.012	<.14	E.013	<.06	<.02	<.10	<.04	<.04	<.04
Jul 2-3, 2007	<.012	<.14	<.033	<.06	<.02	<.10	<.04	<.04	<.04

Appendix 1. Runoff water-quality data for 08211517 – West Oso Creek at Merrett Road near Corpus Christi, Texas, water years 2006–07 — continued

[<,less than; E, estimated, --, not available; µg/L, micrograms per liter; mg/L, milligrams per liter; fltrd, filtered; unfltrd, unfiltered; µS/cm, microsiemens per centimeter, N, nitrogen; P, phosphorus; CaCO3, calcium carbonate]

Date	Pendimethalin, water, fltrd µg/L	Phorate oxon, water, fltrd, µg/L	Phorate water, fltrd µg/L	Phosmet oxon, water, fltrd, µg/L	Phosmet water, fltrd, µg/L	Picloram, water, fltrd µg/L	Prometon, water, fltrd, µg/L	Prometryn, water, fltrd, µg/L	Propyzamide, water, fltrd µg/L
June 1-2, 2006	<0.022	<0.03	<0.055	<0.05	<0.008	<0.03	<0.01	<0.006	<0.004
July 1-2, 2006	<.022	<.03	<.055	--	--	<.03	<.01	<.006	<.004
July 6, 2006	2.66	<.03	<.055	--	--	<.03	<.01	<.006	<.004
Sep 9-10, 2006	13.7	<.03	<.055	<.05	<.008	<.03	<.01	<.006	<.004
Sep 18-19, 2006	.210	<.03	<.055	<.05	<.008	<.03	<.01	<.006	<.004
Jan 3-5, 2007	6.53	<.03	<.020	<.05	<.008	<.12	<.01	<.006	<.004
Jan 24-25, 2007	2.14	<.03	<.020	<.05	<.008	<.12	<.01	<.006	<.004
Mar 14-15, 2007	<.020	<.03	<.020	<.05	<.008	<.12	<.01	<.006	<.004
May 25, 2007	2.46	<.03	<.020	<.05	<.008	<.12	<.01	<.006	<.004
Jul 2-3, 2007	.100	<.03	<.020	<.05	<.008	<.12	<.01	<.006	<.004

Appendix 1. Runoff water-quality data for 08211517 – West Oso Creek at Merrett Road near Corpus Christi, Texas, water years 2006–07 — continued

[<,less than; E, estimated, --, not available; µg/L, micrograms per liter; mg/L, milligrams per liter; fltrd, filtered; unfltrd, unfiltered; µS/cm, microsiemens per centimeter, N, nitrogen; P, phosphorus; CaCO3, calcium carbonate]

Date	Propham water, fltrd µg/L	Propi-conazole, water, fltrd, µg/L	Propoxur, water, fltrd µg/L	Siduron water, fltrd, µg/L	Simazine, water, fltrd, µg/L	Sulfomet-ruron, water, fltrd, µg/L	Tebuthiuron water, fltrd µg/L	Terbacil, water, fltrd, µg/L	Terbufos oxon sulfone water, fltrd, µg/L
June 1-2, 2006	<0.030	<0.01	<0.008	<0.02	0.009	<0.090	<0.02	<0.026	<0.04
July 1-2, 2006	<.030	<.01	<.008	<.02	<.005	<.090	<.02	<.026	<.04
July 6, 2006	<.030	<.01	<.008	<.02	<.005	<.090	<.02	<.026	<.04
Sep 9-10, 2006	<.030	<.01	<.008	<.02	<.010	<.090	<.02	<.026	<.04
Sep 18-19, 2006	<.030	<.01	<.008	<.02	<.005	<.090	<.02	<.026	<.04
Jan 3-5, 2007	<.060	<.06	<.040	<.04	<.006	<.060	<.02	<.040	<.04
Jan 24-25, 2007	<.060	<.06	<.040	<.04	<.006	<.060	<.02	<.040	<.04
Mar 14-15, 2007	<.060	<.06	<.040	<.04	E.006	<.060	<.02	<.040	<.04
May 25, 2007	<.060	<.06	<.040	<.04	<.006	<.060	<.02	<.040	<.04
Jul 2-3, 2007	<.060	<.06	<.040	<.04	.022	<.060	<.02	<.040	<.04

Appendix 1. Runoff water-quality data for 08211517 – West Oso Creek at Merrett Road near Corpus Christi, Texas, water years 2006–07 — continued

[<,less than; E, estimated, --, not available; µg/L, micrograms per liter; mg/L, milligrams per liter; fltrd, filtered; unfltrd, unfiltered; µS/cm, microsiemens per centimeter, N, nitrogen; P, phosphorus; CaCO3, calcium carbonate]

Date	Terbufos, water, fltrd µg/L	Terbuthyl-azine, water, fltrd, µg/L	Tribuphos, water, fltrd, µg/L	Triclopyr, water, fltrd µg/L	Trifluralin, water, fltrd µg/L	Dichlorvos, water, fltrd, µg/L
June 1-2, 2006	<0.02	<0.01	<0.035	<0.03	<0.009	<0.01
July 1-2, 2006	<.02	<.01	<.035	<.03	<.009	<.01
July 6, 2006	<.02	<.01	<.035	<.03	.028	<.01
Sep 9-10, 2006	<.02	<.01	<.035	<.03	<.012	<.01
Sep 18-19, 2006	<.02	<.01	<.035	<.03	<.009	<.01
Jan 3-5, 2007	<.01	<.01	<.035	<.04	<.009	<.01
Jan 24-25, 2007	<.01	<.01	<.035	<.04	<.009	<.01
Mar 14-15, 2007	<.01	<.01	<.035	<.04	.020	<.01
May 25, 2007	<.01	<.01	<.035	<.04	E.050	<.01
Jul 2-3, 2007	<.01	<.01	<.035	<.04	<.009	<.01

Appendix 2. Runoff water-quality data for 08211525 – Unamed Oso Creek tributary at FM 2444 near Corpus Christi, Texas, water years 2006–07

[<,less than; E, estimated, --, not available; µg/L, micrograms per liter; mg/L, milligrams per liter; fltrd, filtered; unfltrd, unfiltered; µS/cm, microsiemens per centimeter, N, nitrogen; P, phosphorus; CaCO3, calcium carbonate]

Date	pH, water, unfltrd field, standard units	pH, water, unfltrd lab, standard units	Specific conductance, unfltrd, lab, µS/cm @ 25 deg C	Specific conductance, unfltrd, field, µS/cm @ 25 deg C	Hardness, water, mg/L as CaCO3	Calcium water, fltrd, mg/L	Magnesium, water, fltrd, mg/L	Potassium, water, fltrd, mg/L
June 1-2, 2006	6.9	7.4	156	152	48	16.4	1.74	7.64
July 6-7, 2006	7.1	7.4	178	175	60	20.2	2.37	8.31
Sep 9-15, 2006	6.7	7.6	153	154	55	18.9	1.85	7.67
Sep 18-19, 2006	6.9	7.4	111	120	41	14.0	1.35	4.82
Jan 3-4, 2007	6.5	8.0	215	220	56	19.1	2.09	5.83
Jan 24-25, 2007	6.8	7.5	196	203	57	19.1	2.22	5.26
Mar 14-15, 2007	8.2	7.8	256	246	--	--	--	--
July 3-4, 2007	6.5	6.4	153	144	30	13.5	1.66	8.35
Aug 30-31, 2007	7.0	7.3	198	192	26	17.7	2.18	9.32

Appendix 2. Runoff water-quality data for 08211525 – Unamed Oso Creek tributary at FM 2444 near Corpus Christi, Texas, water years 2006–07

[<,less than; E, estimated, --, not available; µg/L, micrograms per liter; mg/L, milligrams per liter; fltrd, filtered; unfltrd, unfiltered; µS/cm, microsiemens per centimeter, N, nitrogen; P, phosphorus; CaCO3, calcium carbonate]

Date	Sodium, water, fltrd, mg/L	Chloride, water, fltrd, mg/L	Fluoride, water, fltrd, mg/L	Silica, water, fltrd, mg/L	Sulfate water, fltrd, mg/L	Ammonia + organic-N, water, fltrd, mg/L as N	Ammonia + organic-N, water, unfiltered, mg/L as N	Ammonia water, fltrd, mg/L	Ammonia water, fltrd, mg/L as N
June 1-2, 2006	7.26	5.99	0.15	15.4	4.28	0.67	1.5	0.03	0.026
July 6-7, 2006	9.16	6.58	.20	22.8	4.88	.55	1.2	.02	.012
Sep 9-15, 2006	6.15	3.20	.15	19.9	2.13	1.2	.92	.04	.028
Sep 18-19, 2006	3.46	1.97	.13	11.0	1.30	.66	.89	.03	.021
Jan 3-4, 2007	14.7	19.5	.12	11.0	12.8	.43	1.4	.03	.024
Jan 24-25, 2007	15.7	17.2	.14	12.4	11.0	.48	.99	.03	.021
Mar 14-15, 2007	--	--	--	--	--	1.1	2.5	.22	.171
July 3-4, 2007	9.75	11.0	.10	16.0	6.23	.64	.97	.19	E.013
Aug 30-31, 2007	13.1	21.6	E.10	18.3	7.63	.71	1.1	--	<.020

Appendix 2. Runoff water-quality data for 08211525 – Unamed Oso Creek tributary at FM 2444 near Corpus Christi, Texas, water years 2006–07

[<,less than; E, estimated, --, not available; µg/L, micrograms per liter; mg/L, milligrams per liter; fltrd, filtered; unfltrd, unfiltered; µS/cm, microsiemens per centimeter, N, nitrogen; P, phosphorus; CaCO3, calcium carbonate]

Date	Nitrate water, filtered, mg/L as N	Nitrite + nitrate water filtered, mg/L as N	Nitrite water, fltrd, mg/L as N	Organic nitrogen, water, fltrd, mg/L	Organic nitrogen, water, unfltrd mg/L	Total nitrogen, water, fltrd, mg/L	Total nitrogen, water, unfltrd mg/L	Ortho-phosphate, water, fltrd, mg/L	Ortho-phosphate, water, fltrd, mg/L as P
June 1-2, 2006	0.22	0.27	0.058	0.64	1.5	0.94	1.8	1.94	0.663
July 6-7, 2006	--	<.06	.002	.54	1.1	--	--	1.61	.525
Sep 9-15, 2006	.18	.20	.016	1.2	.89	1.4	1.1	1.32	.429
Sep 18-19, 2006	.19	.20	.005	.63	.87	.85	1.1	.702	.229
Jan 3-4, 2007	.49	.50	.015	.40	1.3	.93	1.9	1.01	.331
Jan 24-25, 2007	.80	.81	.014	.46	.97	1.3	1.8	.846	.276
Mar 14-15, 2007	.86	1.0	.144	.92	2.4	2.1	3.5	1.12	.366
July 3-4, 2007	.12	.13	.008	.40	2.6	.77	1.1	1.71	.557
Aug 30-31, 2007	.16	.17	.009	--	--	.88	1.2	.995	.311

Appendix 2. Runoff water-quality data for 08211525 – Unamed Oso Creek tributary at FM 2444 near Corpus Christi, Texas, water years 2006–07

[<,less than; E, estimated, --, not available; µg/L, micrograms per liter; mg/L, milligrams per liter; fltrd, filtered; unfltrd, unfiltered; µS/cm, microsiemens per centimeter, N, nitrogen; P, phosphorus; CaCO3, calcium carbonate]

Date	Phosphorus, water, fltrd, mg/L	Phosphorus, water, unfltrd mg/L	1-Naphthol, water, fltrd µg/L	2,4-D methylester, water, fltrd, µg/L	2,4-D, water, fltrd, µg/L	2,4-DB, water, fltrd µg/L	2,6-Diethyl-aniline water, fltrd µg/L	2Chloro -2',6'- diethyl acetanilide water, fltrd µg/L	CIAT, water, fltrd, µg/L
June 1-2, 2006	0.69	0.98	<0.09	<0.190	<0.04	<0.02	<0.006	<0.006	E0.184
July 6-7, 2006	.55	.74	<.09	<.190	.27	<.02	<.006	<.006	E.089
Sep 9-15, 2006	.53	.61	<.09	<.190	E.03	<.02	<.006	<.006	E.029
Sep 18-19, 2006	.26	.45	<.09	<.190	E.01	<.02	<.006	<.006	E.021
Jan 3-4, 2007	.38	.61	<.09	<.200	E.06	<.02	<.006	<.006	E.011
Jan 24-25, 2007	.30	.43	<.09	<.200	.09	<.02	<.006	<.006	E.009
Mar 14-15, 2007	.42	.98	<.09	.208	E1.23	<.02	<.006	<.006	E.119
July 3-4, 2007	.59	.66	<.09	<.200	<.04	<.02	<.006	<.006	E.049
Aug 30-31, 2007	.33	.41	<.09	<.200	<.04	<.02	<.006	<.006	E.014

Appendix 2. Runoff water-quality data for 08211525 – Unamed Oso Creek tributary at FM 2444 near Corpus Christi, Texas, water years 2006–07

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Date	CEAT, water, fltrd, µg/L	2-Ethyl-6-methyl-aniline water, fltrd, µg/L	OIET, water, fltrd, µg/L	3,4-Dichloro-aniline water, fltrd, µg/L	3-Hydroxy carbofuran, water, fltrd, µg/L	4-Chloro-2methyl phenol, water, fltrd, µg/L	Acetochlor, water, fltrd, µg/L	Acifluorfen, water, fltrd µg/L	Alachlor, water, fltrd, µg/L
June 1-2, 2006	0.11	<0.010	0.420	<0.004	<0.008	<0.005	<0.006	<0.028t	<0.005
July 6-7, 2006	E.07	<.010	.517	<.004	<.008	<.005	<.006	<.028	<.005
Sep 9-15, 2006	<.08	<.010	.272	<.004	<.008	<.005	<.006	<.028	<.005
Sep 18-19, 2006	<.08	<.010	.037	<.004	<.008	<.005	<.006	<.028	<.005
Jan 3-4, 2007	<.08	<.010	E.043	<.004	<.020	<.005	<.006	<.006	<.005
Jan 24-25, 2007	<.08	<.010	E.023	<.004	<.020	<.005	<.006	<.006	<.005
Mar 14-15, 2007	<.08	<.010	.902	<.004	<.020	<.005	<.006	<.006	<.005
July 3-4, 2007	<.08	<.010	.101	<.004	<.020	<.005	<.006	<.006	<.005
Aug 30-31, 2007	<.08	<.010	.021	<.004	<.020	<.005	<.006	<.006	<.005

Appendix 2. Runoff water-quality data for 08211525 – Unamed Oso Creek tributary at FM 2444 near Corpus Christi, Texas, water years 2006–07

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Date	Aldicarb sulfone water, fltrd µg/L	Aldicarb sulfoxide, water, fltrd µg/L	Aldicarb, water, fltrd µg/L	Amino-methyl-phosphonic acid, water, fltrd µg/L	Atrazine, water, fltrd, µg/L	Azinphos-methyl oxon, water, fltrd, µg/L	Azinphos-methyl, water, fltrd µg/L	Bendiocarb, water, fltrd, µg/L	Benfluralin, water, fltrd µg/L
June 1-2, 2006	<0.02	<0.100	<0.15	0.420	1.88	<0.04	<0.050	<0.08	<0.010
July 6-7, 2006	<.02	<.100	<.15	1.10	.313	<.04	<.050	<.08	<.010
Sep 9-15, 2006	<.02	<.100	<.15	.350	.042	<.04	<.050	<.08	<.010
Sep 18-19, 2006	<.02	<.100	<.15	.670	.022	<.04	<.050	<.08	<.010
Jan 3-4, 2007	<.08	<.040	<.04	1.78	.021	<.04	<.080	<.04	<.010
Jan 24-25, 2007	<.08	<.040	<.04	.410	.021	<.04	<.080	<.04	<.010
Mar 14-15, 2007	<.08	<.040	<.04	1.94	9.42	<.04	<.080	<.04	<.010
July 3-4, 2007	<.08	<.040	<.04	.530	.194	<.04	<.080	<.04	<.010
Aug 30-31, 2007	<.08	<.040	<.04	--	.012	<.04	.038	<.04	<.010

Appendix 2. Runoff water-quality data for 08211525 – Unamed Oso Creek tributary at FM 2444 near Corpus Christi, Texas, water years 2006–07

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Date	Benomyl water, fltrd, µg/L	Bensulfuron methyl, water, fltrd, µg/L	Bentazon, water, fltrd µg/L	Bromacil, water, fltrd, µg/L	Bromoxynil, water, fltrd µg/L	Carbaryl, water, fltrd µg/L	Carbofuran, water, fltrd µg/L	Chloramben methyl ester, water, fltrd, µg/L
June 1-2, 2006	<0.022	<0.02	<0.02	<0.02	<0.04	<0.02	<0.016	<0.02
July 6-7, 2006	<.022	<.02	<.02	.05	<.04	<.02	<.016	<.02
Sep 9-15, 2006	<.022	<.02	<.02	<.02	<.04	<.02	<.016	<.02
Sep 18-19, 2006	<.022	<.02	<.02	<.02	<.04	<.02	<.016	<.02
Jan 3-4, 2007	<.020	<.06	<.02	<.04	<.12	<.02	<.060	<.10
Jan 24-25, 2007	<.020	<.06	<.02	<.04	<.12	<.02	<.060	<.10
Mar 14-15, 2007	<.020	<.06	<.02	<.04	<.12	<.02	<.060	<.10
July 3-4, 2007	<.020	<.06	<.02	<.04	<.12	<.02	<.060	<.10
Aug 30-31, 2007	<.020	<.06	<.02	<.04	<.12	.010	<.060	<.10

Appendix 2. Runoff water-quality data for 08211525 – Unamed Oso Creek tributary at FM 2444 near Corpus Christi, Texas, water years 2006–07

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Date	Chlori-muron, water, fltrd, µg/L	Chloro-di-amino-s-triazine, water, fltrd, µg/L	Chlor-pyrifos-oxon, water, fltrd, µg/L	Chlorpyrifos water, fltrd, µg/L	cis-Permethrin water fltrd µg/L	Clopyralid, water, fltrd µg/L	Cycloate, water, fltrd, µg/L	Cyfluthrin, water, fltrd, µg/L	Cyper-methrin water, fltrd, µg/L
June 1-2, 2006	<0.032	<0.04	<0.06	<0.005	<0.006	<0.07	<0.01	<0.053	<0.046
July 6-7, 2006	<.032	<.04	<.06	<.005	<.006	<.07	<.01	<.053	<.046
Sep 9-15, 2006	<.032	<.04	<.06	<.005	<.006	<.07	<.01	<.053	<.046
Sep 18-19, 2006	<.032	<.04	<.06	<.005	<.006	<.07	<.01	<.053	<.046
Jan 3-4, 2007	<.080	<.12	<.06	<.005	<.010	<.06	<.06	<.053	<.046
Jan 24-25, 2007	<.080	<.12	<.06	<.005	<.010	<.06	<.06	<.053	<.046
Mar 14-15, 2007	<.080	<.12	<.06	<.005	<.010	<.06	<.06	<.053	<.046
July 3-4, 2007	<.080	<.12	<.06	<.005	<.010	<.06	<.06	<.053	<.046
Aug 30-31, 2007	<.080	--	<.06	<.005	<.010	<.06	<.06	<.053	<.046

Appendix 2. Runoff water-quality data for 08211525 – Unamed Oso Creek tributary at FM 2444 near Corpus Christi, Texas, water years 2006–07

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Date	Dacthal mono-acid, water, fltrd µg/L	DCPA, water, fltrd µg/L	Desulfinyl-fipronil, water, fltrd, µg/L	Diazinon, water, fltrd, µg/L	Dicamba water, fltrd µg/L	Dichlorprop, water, fltrd µg/L	Dicrotophos, water, fltrd, µg/L	Dieldrin, water, fltrd, µg/L	Dimethoate, water, fltrd µg/L
June 1-2, 2006	<0.03	<0.003	<0.012	<0.005	<0.04	<0.03	<0.08	<0.009	<0.006
July 6-7, 2006	<.03	<.003	<.012	<.005	<.04	<.03	<.08	<.009	<.006
Sep 9-15, 2006	<.03	<.003	<.012	<.005	<.04	<.03	<.08	<.009	<.006
Sep 18-19, 2006	<.03	E.004	<.012	<.005	<.04	<.03	<.08	<.009	<.006
Jan 3-4, 2007	<.02	<.003	<.012	<.005	<.08	<.04	<.08	<.009	<.006
Jan 24-25, 2007	<.02	<.003	<.012	<.005	<.08	<.04	<.08	<.009	<.006
Mar 14-15, 2007	<.02	<.003	<.012	<.005	.97	<.04	<.08	<.009	<.006
July 3-4, 2007	<.02	<.003	<.012	<.005	<.08	<.04	E.03	<.009	<.006
Aug 30-31, 2007	<.02	<.003	<.012	<.005	<.08	<.04	<.08	<.009	<.006

Appendix 2. Runoff water-quality data for 08211525 – Unamed Oso Creek tributary at FM 2444 near Corpus Christi, Texas, water years 2006–07

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Date	Dinoseb water, fltrd µg/L	Diphenamid, water, fltrd, µg/L	Diuron, water, fltrd µg/L	Ethion monoxon water, fltrd, µg/L	Ethion, water, fltrd, µg/L	Fenamiphos sulfone water, fltrd, µg/L	Fenamiphos sulfoxide, water, fltrd, µg/L	Fenamiphos, water, fltrd, µg/L	Fenuron water, fltrd µg/L
June 1-2, 2006	<0.04	<0.01	E0.02	<0.02	<0.016	<0.053	<0.04	<0.03	<0.10
July 6-7, 2006	<.04	<.01	.03	<.02	<.016	<.053	<.04	<.03	<.10
Sep 9-15, 2006	<.04	<.01	<.02	<.02	<.016	<.053	<.04	<.03	<.10
Sep 18-19, 2006	<.04	<.01	<.02	<.02	<.016	<.053	<.04	<.03	<.10
Jan 3-4, 2007	<.04	<.04	<.04	<.02	<.016	<.053	<.04	<.03	<.04
Jan 24-25, 2007	<.04	<.04	<.04	<.02	<.016	<.053	<.04	<.03	<.04
Mar 14-15, 2007	<.04	<.04	<.04	<.02	<.016	<.053	<.04	<.03	<.04
July 3-4, 2007	<.04	<.04	<.04	<.02	<.016	<.053	<.04	<.03	<.04
Aug 30-31, 2007	<.04	<.04	<.04	<.02	<.016	<.053	<.04	<.03	<.04

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Date	Desulfinyl-fipronil amide, water, fltrd, µg/L	Fipronil sulfide water, fltrd, µg/L	Fipronil sulfone water, fltrd, µg/L	Fipronil, water, fltrd, µg/L	Flumetsulam, water, fltrd, µg/L	Fluo-meturon water, fltrd µg/L	Fonofos water, fltrd, µg/L	Glufosinate, water, fltrd µg/L	Glyphosate, water, fltrd µg/L
June 1-2, 2006	<0.029	<0.013	<0.024	<0.016	<0.04	<0.02	<0.005	<0.140	0.610
July 6-7, 2006	<.029	<.013	<.024	<.016	<.04	<.02	<.005	<.140	.650
Sep 9-15, 2006	<.029	<.013	<.024	<.016	<.04	<.02	<.005	<.140	1.51
Sep 18-19, 2006	<.029	<.013	<.024	<.016	<.04	<.02	<.005	<.140	.590
Jan 3-4, 2007	<.029	<.016	<.024	<.016	<.06	<.04	<.006	<.140	2.02
Jan 24-25, 2007	<.029	<.016	<.024	<.016	<.06	<.04	<.006	<.140	.650
Mar 14-15, 2007	<.029	<.016	<.024	<.016	<.06	<.04	<.006	<.140	3.82
July 3-4, 2007	<.029	<.016	<.024	<.016	<.06	<.04	<.006	<.140	10.7
Aug 30-31, 2007	<.029	.005	<.024	<.016	<.06	<.04	<.006	--	--

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Date	Hexazinone, water, fltrd, µg/L	Imazaquin, water, fltrd, µg/L	Imazethapyr, water, fltrd, µg/L	Imidacloprid water, fltrd, µg/L	Iprodione, water, fltrd, µg/L	Isofenphos, water, fltrd, µg/L	Linuron water, fltrd µg/L	Malaoxon, water, fltrd, µg/L	Malathion, water, fltrd, µg/L
June 1-2, 2006	<0.026	<0.04	<0.04	<0.020	<0.026	<0.011	<0.01	<0.039	<0.027
July 6-7, 2006	<.026	<.04	<.04	<.020	<.026	<.011	<.01	<.039	E.018
Sep 9-15, 2006	<.026	<.04	<.04	<.020	<.026	<.011	<.01	<.039	<.027
Sep 18-19, 2006	<.026	<.04	<.04	<.020	<.026	<.011	<.01	<.039	<.027
Jan 3-4, 2007	<.026	<.04	<.04	<.060	<.026	<.011	<.04	<.039	<.016
Jan 24-25, 2007	<.026	<.04	<.04	<.060	<.026	<.011	<.04	<.039	<.016
Mar 14-15, 2007	<.026	<.04	<.04	<.060	<.026	<.011	<.04	<.039	<.016
July 3-4, 2007	<.026	<.04	<.04	<.060	<.026	<.011	<.04	<.039	<.016
Aug 30-31, 2007	<.026	<.04	<.04	<.060	<.026	<.011	<.04	.049	2.64

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Date	MCPA, water, fltrd µg/L	MCPB, water, fltrd µg/L	Metalaxyl, water, fltrd, µg/L	Methialthion water, fltrd, µg/L	Methiocarb, water, fltrd µg/L	Methomyl, water, fltrd µg/L	Methyl paraoxon, water, fltrd, µg/L	Methyl parathion, water, fltrd µg/L	Metolachlor, water, fltrd, µg/L
June 1-2, 2006	<0.07	<0.10	<0.065	<0.009	<0.034	<0.070	<0.02	<0.015	<0.006
July 6-7, 2006	<.07	<.10	<.007	<.009	<.034	<.070	<.02	<.015	E.06
Sep 9-15, 2006	<.07	<.10	<.007	<.009	<.034	<.070	<.02	<.015	<.006
Sep 18-19, 2006	<.07	<.10	<.007	<.009	<.034	<.070	<.02	<.015	<.006
Jan 3-4, 2007	<.06	<.20	<.007	<.009	<.040	<.060	<.02	<.008	<.010
Jan 24-25, 2007	<.06	<.20	<.007	<.009	<.040	<.060	<.02	<.008	E.008
Mar 14-15, 2007	<.06	<.20	<.007	<.009	<.040	<.060	<.02	<.008	E.007
July 3-4, 2007	<.06	<.20	<.007	<.009	<.040	<.060	<.02	<.008	<.010
Aug 30-31, 2007	<.06	<.20	<.007	<.009	<.040	<.060	<.02	<.008	<.010

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Date	Metribuzin, water, fltrd, µg/L	Metsulfuron, water, fltrd, µg/L	Myclobutanil water, fltrd, µg/L	N-(4-Chloro-phenyl)-N'-methyl-urea, µg/L	Neburon water, fltrd µg/L	Nicosul-furon, water, fltrd, µg/L	Norflurazon, water, fltrd µg/L	Oryzalin, water, fltrd µg/L	Oxamyl, water, fltrd µg/L
June 1-2, 2006	<0.028	<0.07	<0.033	<0.04	<0.01	<0.04	<0.02	<0.02	<0.05
July 6-7, 2006	<.028	<.07	E.012	<.04	<.01	<.04	<.02	<.02	<.05
Sep 9-15, 2006	<.028	<.07	E.010	<.04	<.01	<.04	<.02	<.02	<.05
Sep 18-19, 2006	<.028	<.07	<.033	<.04	<.01	<.04	<.02	<.02	<.05
Jan 3-4, 2007	<.012	<.14	<.033	<.06	<.02	<.10	<.04	<.04	<.04
Jan 24-25, 2007	<.012	<.14	<.033	<.06	<.02	<.10	<.04	<.04	<.04
Mar 14-15, 2007	<.012	<.14	<.033	<.06	<.02	<.10	<.04	<.04	<.04
July 3-4, 2007	<.012	<.14	<.033	<.06	<.02	<.10	<.04	<.04	<.04
Aug 30-31, 2007	<.012	<.14	<.033	<.06	<.02	<.10	<.04	<.04	<.04

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Date	Pendimethalin, water, fltrd µg/L	Phorate oxon, water, fltrd, µg/L	Phorate water, fltrd µg/L	Phosmet oxon, water, fltrd, µg/L	Phosmet water, fltrd, µg/L	Picloram, water, fltrd µg/L	Prometon, water, fltrd, µg/L	Prometryn, water, fltrd, µg/L	Propyzamide, water, fltrd µg/L
June 1-2, 2006	<0.022	<0.03	<0.055	<0.05	<0.008	<0.03	<0.01	<0.006	<0.004
July 6-7, 2006	.027	<.03	<.055	--	--	<.03	<.01	<.006	<.004
Sep 9-15, 2006	.131	<.03	<.055	<.05	<.008	<.03	<.01	<.006	<.004
Sep 18-19, 2006	.052	<.03	<.055	<.05	<.008	<.03	<.01	<.006	<.004
Jan 3-4, 2007	.091	<.03	<.020	<.05	<.008	<.12	<.01	<.006	<.004
Jan 24-25, 2007	.144	<.03	<.020	<.05	<.008	<.12	<.01	<.006	<.004
Mar 14-15, 2007	.133	<.03	<.020	<.05	<.008	--	<.01	<.006	<.004
July 3-4, 2007	<.020	<.03	<.020	<.05	<.008	<.12	<.01	<.006	<.004
Aug 30-31, 2007	<.020	<.03	<.020	--	--	<.12	<.01	<.006	<.004

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Date	Propham water, fltrd µg/L	Propi-conazole, water, fltrd, µg/L	Propoxur, water, fltrd µg/L	Siduron water, fltrd, µg/L	Simazine, water, fltrd, µg/L	Sulfomet-ruron, water, fltrd, µg/L	Tebuthiuron water, fltrd µg/L	Terbacil, water, fltrd, µg/L	Terbufos oxon sulfone water, fltrd, µg/L
June 1-2, 2006	<0.030	<0.01	<0.008	<0.02	0.019	<0.090	<0.02	<0.026	<0.04
July 6-7, 2006	<.030	<.01	<.008	<.02	E.007	<.090	<.02	<.026	<.04
Sep 9-15, 2006	<.030	<.01	<.008	<.02	<.005	<.090	<.02	<.026	<.04
Sep 18-19, 2006	<.030	<.01	<.008	<.02	<.005	<.090	<.02	<.026	<.04
Jan 3-4, 2007	<.060	<.06	<.040	<.04	E.005	<.060	<.02	<.040	<.04
Jan 24-25, 2007	<.060	<.06	<.040	<.04	<.006	<.060	<.02	<.040	<.04
Mar 14-15, 2007	<.060	<.06	<.040	<.04	.064	<.060	<.02	<.040	<.04
July 3-4, 2007	<.060	<.06	<.040	<.04	<.006	<.060	<.02	<.040	<.04
Aug 30-31, 2007	<.060	<.06	<.040	<.04	<.006	<.060	<.02	<.040	<.04

Appendix 2. Runoff water-quality data for 08211525 – Unamed Oso Creek tributary at FM 2444 near Corpus Christi, Texas, water years 2006–07

[<,less than; E, estimated, --, not available; µg/L, micrograms per liter; mg/L, milligrams per liter; fltrd, filtered; unfltrd, unfiltered; µS/cm, microsiemens per centimeter, N, nitrogen; P, phosphorus; CaCO3, calcium carbonate]

Date	Terbufos, water, fltrd µg/L	Terbuthyl-azine, water, fltrd, µg/L	Tribuphos, water, fltrd, µg/L	Triclopyr, water, fltrd µg/L	Trifluralin, water, fltrd µg/L	Dichlorvos, water, fltrd, µg/L
June 1-2, 2006	<0.02	<0.01	<0.035	<0.03	<0.009	<0.01
July 6-7, 2006	<.02	<.01	<.035	<.03	<.009	<.01
Sep 9-15, 2006	<.02	<.01	<.035	<.03	<.009	<.01
Sep 18-19, 2006	<.02	<.01	<.035	<.03	.011	<.01
Jan 3-4, 2007	<.01	<.01	<.035	<.04	E.007	<.01
Jan 24-25, 2007	<.01	<.01	<.035	<.04	<.009	<.01
Mar 14-15, 2007	.02	<.01	<.035	<.04	.054	<.01
July 3-4, 2007	<.01	<.01	<.035	<.04	<.009	<.01
Aug 30-31, 2007	<.01	<.01	<.035	<.04	<.009	<.01