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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

Hydrologic Conditions and Water Quality of Rainfall and Storm Runoff for Two Agricultural Areas of the Oso Creek Watershed, Nueces County, Texas, 2005–08

Scientific Investigations Report 2010–5136

U.S. Department of the Interior
U.S. Geological Survey

Cover: Rainfall on field of grain sorghum, September 2, 2003.

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Conversion Factors, Datum, and Water-Quality Abbreviations

Inch/Pound to SI

Multiply	By	To obtain
	Length	
inch (in.)	25.4	millimeter (mm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
	Area	
acre	0.4047	hectare (ha)
square mile (mi^2)	2.590	square kilometer (km^2)
	Volume	
acre-foot (acre-ft)	1,233	cubic meter (m^3)
	Flow rate	
cubic foot per second (ft^3/s)	0.02832	cubic meter per second (m^3/s)
million gallons per day (Mgal/d)	0.04381	cubic meter per second (m^3/s)
inch per year (in/yr)	25.4	millimeter per year (mm/yr)
	Mass	
pound, avoirdupois (lb)	0.4536	kilogram (kg)
ton, short (2,000 lb)	0.9072	megagram (Mg)
ton per day (ton/d)	0.9072	megagram per day (Mg/d)
	Application rate	
pound per acre (lb/acre)	1.121	kilogram per hectare (kg/ha)
pound per acre per year [(lb/acre)/yr]	1.121	kilogram per hectare per year [(kg/ha)/yr]

Temperature in degrees Fahrenheit (°F) may be converted to degrees Celsius (°C) as follows:

$$°C=(°F-32)/1.8$$

Datum

Horizontal coordinate information is referenced to the North American Datum of 1983 (NAD 83).

Water-Quality Abbreviations

CFU/100 mL, colony forming units per 100 milliliters

mg/L, milligrams per liter

µg/L, micrograms per liter

µm, micrometers

µS/cm, microsiemens per centimeter at 25 degrees Celsius

mm, millimeters

Hydrologic Conditions and Water Quality of Rainfall and Storm Runoff for Two Agricultural Areas of the Oso Creek Watershed, Nueces County, Texas, 2005–08

By Darwin J. Ockerman[1] and Carlos J. Fernandez[2]

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 hydrologic conditions and water quality of rainfall and storm runoff of two primarily agricultural subwatersheds of the Oso Creek watershed in Nueces County, Texas. One area, the upper West Oso Creek subwatershed, is about 5,145 acres. The other area, a subwatershed drained by an unnamed tributary to Oso Creek (hereinafter, Oso Creek tributary), is about 5,287 acres. Rainfall and runoff (streamflow) were continuously monitored at the outlets of the two subwatersheds during the study period October 2005–September 2008. Seventeen rainfall samples were collected and analyzed for nutrients and major inorganic ions. Twenty-four composite runoff water-quality samples (12 at West Oso Creek, 12 at Oso Creek tributary) were collected and analyzed for nutrients, major inorganic ions, and pesticides. Twenty-six discrete suspended-sediment samples (12 West Oso Creek, 14 Oso Creek tributary) and 17 bacteria samples (10 West Oso Creek, 7 Oso Creek tributary) were collected and analyzed. These data were used to estimate, for selected constituents, rainfall deposition to and runoff loads and yields from the two subwatersheds. Quantities of fertilizers and pesticides applied in the two subwatersheds were compared with quantities of nutrients and pesticides in rainfall and runoff.

For the study period, total rainfall was greater than average. Most of the runoff from the two subwatersheds occurred in response to a few specific storm periods. The West Oso Creek subwatershed produced more runoff during the study period than the Oso Creek tributary subwatershed, 13.95 inches compared with 9.45 inches. Runoff response was quicker and peak flows were higher in the West Oso Creek subwatershed than in the Oso Creek tributary subwatershed. Total nitrogen runoff yield for the 3-year study period averaged 2.62 pounds per acre per year from the West Oso Creek subwatershed and 0.839 pound per acre per year from the Oso Creek tributary subwatershed. Total phosphorus yields from the West Oso Creek and Oso Creek tributary subwatersheds for the 3-year period were 0.644 and 0.419 pound per acre per year, respectively. Runoff yields of nitrogen and phosphorus were relatively small compared to inputs of nitrogen in fertilizer and rainfall deposition. Average annual runoff yield of total nitrogen (subwatersheds combined) represents about 2.5 percent of nitrogen applied as fertilizer to cropland in the watershed and nitrogen entering the subwatersheds through rainfall deposition. Average annual runoff yield of total phosphorus (subwatersheds combined) represents about 4.0 percent of the phosphorus in applied fertilizer and rainfall deposition. Suspended-sediment yields from the West Oso Creek subwatershed were more than twice those from the Oso Creek tributary subwatershed. The average suspended-sediment yield from the West Oso Creek subwatershed was 522 pounds per acre per year and from the Oso Creek tributary subwatershed was 139 pounds per acre per year. Twenty-four herbicides and eight insecticides were detected in runoff samples collected at the two subwatershed outlets. At the West Oso Creek site, 19 herbicides and 4 insecticides were detected; at the Oso Creek tributary site, 18 herbicides and 6 insecticides were detected. Fourteen pesticides were detected in only one sample at low concentrations (near the laboratory reporting level). Atrazine and atrazine degradation byproduct 2-chloro-4-isopropylamino-6-amino-s-triazine (CIAT) were detected in all samples. Glyphosate and glyphosate byproduct aminomethylphosphonic acid (AMPA) were detected in all samples collected and analyzed during water years 2006–07 but were not included in analysis for samples collected in water year 2008. Of all pesticides detected in runoff, the highest runoff yields were for glyphosate, 0.012 and 0.001 pound per acre per year for the West Oso Creek and Oso Creek tributary subwatersheds, respectively. About 0.9 percent of glyphosate applied to the West Oso Creek subwatershed was detected in runoff and for the Oso Creek tributary subwatershed, about 0.08 percent. At both subwatershed outlet sites, most sample concentrations of fecal coliform, *Escherichia coli*, and *Enterococci* were greater than Texas surface-water-quality standards for

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those bacteria established for the receiving waters of Oso Creek and Oso Bay. Because runoff and associated bacteria concentrations represent relatively brief and infrequent conditions, the resulting effect on Oso Creek and Oso Bay is not known.

Introduction

The Coastal Bend Bays and Estuaries of South Texas is 1 of 28 estuaries or groups of estuaries in the United States that have been designated nationally important and as such are part of the National Estuaries Program of the U.S. Environmental Protection Agency (2008). The Coastal Bend Bays and Estuaries Program (CBBEP) area (fig. 1) encompasses the 12 counties of the Coastal Bend Council of Governments extending from the land cut in the Laguna Madre north along the coast to the Aransas National Wildlife Refuge (Coastal Bend Bays and Estuaries Program, 2008). The bays and estuaries of the CBBEP are affected by nonpoint-source runoff from agricultural land that constitutes about 88 percent of the CBBEP area.

The Oso Creek watershed drains about 234 square miles (mi^2) to Oso Bay. Agricultural land (pasture and cropland) accounts for about 69 percent of the Oso Creek watershed. Oso Bay, along the southern shore of Corpus Christi Bay, is relatively small (surface area about 7 mi^2) and shallow (average depth about 2.3 feet [ft]) (Quenzer and others, 1998). Ecologically, Oso Bay provides habitat for many plants and animals and is important for water purification and storm protection (Texas Commission on Environmental Quality, 2007).

Previous Study and Report

The U.S. Geological Survey (USGS), in cooperation with the Texas State Soil and Water Conservation Board (TSSWCB), CBBEP, and Texas AgriLife Research and Extension Center at Corpus Christi (formerly Texas Agricultural Experiment Station–Corpus Christi and hereinafter referred to as Texas AgriLife Research), conducted a study of hydrologic conditions and quality of rainfall and storm runoff of two primarily agricultural subwatersheds of the Oso Creek watershed (fig. 1) during the period October 2005–September 2007. As a result of the study, a USGS Scientific Investigations Report (SIR) (Ockerman, 2008) was published documenting hydrologic conditions and water quality of rainfall and storm runoff for the agricultural study areas during water years 2006–07 (October 2005–September 2007). (A water year is defined as the 12-month period October 1, for any given year, through September 30, of the following year; the water year is designated by the calendar year in which it ends.)

As an extension of the 2005–07 study, the USGS, in cooperation with the TSSWCB, CBBEP, and Texas AgriLife Research continued data collection at the Oso Creek study subwatersheds during October 2007–September 2008 to further characterize hydrologic and water-quality conditions in the Oso Creek watershed.

Purpose and Scope

The purpose of this report is to characterize hydrologic conditions and the water quality of rainfall and storm runoff for two primarily agricultural subwatersheds in the Oso Creek watershed in Nueces County. The report presents the results of collection and analysis of hydrologic data and water-quality samples of rainfall and runoff during the 3-year data-collection period during October 2005–September 2008. This report supersedes the previous report (Ockerman, 2008) and includes results and analysis of all data collected during the 2005–08 study period. Continuous rainfall and streamflow data were collected at monitoring stations at the outlets of the study subwatersheds. Seventeen rainfall samples were collected and analyzed for nutrients and major inorganic ions. Rainfall nutrient analyses and daily rainfall totals were used to estimate rainfall nutrient deposition to the study subwatersheds. Twenty-four runoff samples were collected by automatic sampling equipment during storm-runoff events. These samples were analyzed for nutrients, major inorganic ions, and pesticides. Twenty-six discrete samples of runoff suspended sediment were collected and analyzed for sediment size and concentration. Seventeen discrete samples of runoff were collected and analyzed for fecal coliform, *Escherichia coli* (*E. coli*), and *Enterococcus* bacteria. These data were used to estimate, for selected constituents, rainfall deposition to and runoff loads and yields from the study subwatersheds. Quantities of fertilizers and pesticides applied in the subwatersheds were compared with quantities of nutrients and pesticides in rainfall and runoff. Estimates of rainfall deposition and runoff constituent loads and yields for 2006–07 in the earlier report of the study watersheds (Ockerman, 2008) were revised in this report on the basis of collection and analysis of additional data.

Description of Study Areas (Subwatersheds)

Of the two subwatersheds studied (fig. 1), one surrounds the upstream reaches of West Oso Creek and drains about 5,145 acres to Oso Bay. The other surrounds the upstream reaches of an unnamed tributary to Oso Creek (hereinafter, Oso Creek tributary) and drains about 5,287 acres to Oso Bay. The topography of the areas is flat with elevations ranging from about 15 ft above sea level where Oso Creek enters Oso Bay to about 65 ft above sea level in the upland parts of the West Oso Creek subwatershed. Because of negligible relief, the Oso Creek tributary subwatershed might include some noncontributing drainage area. The streams of the study subwatersheds are ephemeral, producing runoff lasting from a few hours to several weeks, depending on rainfall duration and intensity and antecedent soil moisture.

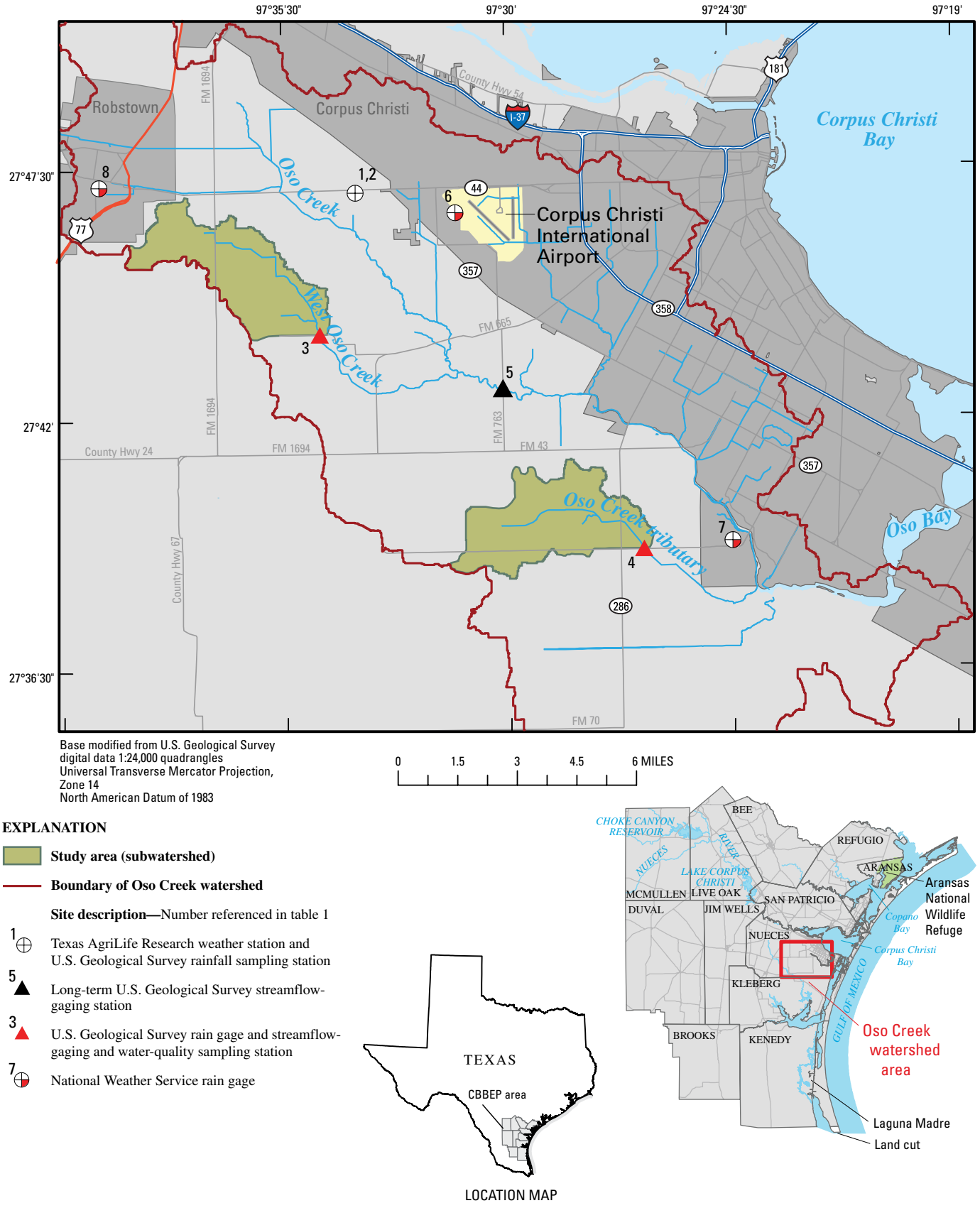

Figure 1. Coastal Bend Bays and Estuaries Program (CBBEP) area, South Texas, and Oso Creek watershed area, Nueces County, Texas.

Activity	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Shredding previous crop and retilling												
Applying fertilizers and herbicides												
Tilling in preparation for planting												
Planting												
Applying pesticides and cultivating												
Controlling insects (cotton)												
Harvesting (cotton)												

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

The main stem of Oso Creek maintains a continuous flow from wastewater discharges by the cities of Robstown and Corpus Christi. There are no wastewater discharges in the two subwatersheds.

The Oso Creek watershed area is described as having a subtropical, subhumid climate characterized by hot summers and mild, dry winters (Larkin and Bomar, 1983). Maximum annual 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 (NWS) station at the Corpus Christi International Airport (U.S. Department of Commerce, National Climatic Data Center, 2006). Average annual rainfall (1971–2000) is 32.92 inches (in.); rainfall greater than 0.01 in. occurs, on average, 82 days per year. The average monthly low temperatures range from 46.2 degrees Fahrenheit (ºF) in January to 74.5 ºF in August; average monthly high temperatures range from 66.0 ºF in January to 93.4 ºF in August; and mean annual temperature is 71.5 ºF.

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 subwatersheds (U.S. Department of Agriculture, Soil Conservation Service, 1965). During dry periods these soils crack and absorb water rapidly. These natural processes act to reduce runoff. However, once the soils are wet, water infiltrates slowly, which increases the potential for runoff. Thus moisture conditions prior to the onset of substantial rainfall are an important factor affecting runoff.

Agriculture is the predominant land use within each of the study subwatersheds. Land use in each subwatershed is similar, consisting almost entirely (about 98 percent) of cropland. Impervious land (mostly roads) in the study subwatersheds makes up about 2 percent of the total study area (Dr. Bobby Eddleman, Texas AgriLife Research, written commun., 2007). During 2006–08, the primary crops in the West Oso Creek and Oso Creek tributary subwatersheds 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 (Dr. Bobby Eddleman, Texas AgriLife Research, written commun., 2007; Dr. Carlos Fernandez, Texas AgriLife Research, written commun., 2009).

Beginning in late July through early September, crops are harvested and remaining crop residue is shredded and stubble is plowed. Postcrop emergents are controlled with herbicides (in the conservation tillage systems); any residual vegetation is killed as well. The process of tilling and spraying the fields after harvest helps prepare the ground to absorb fall and winter rains (fig. 2) (Dr. Bobby Eddleman, Texas AgriLife Research, written commun., 2007). The soil is retilled or resprayed during September and October to destroy winter weeds and to prepare the seedbed for the succeeding crop. Preplant fertilizers and broadcast preemergent herbicides usually are applied during the low-rainfall months of November and December. From January to mid-February, additional tilling might be done to prepare for planting. 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 through early July, few field operations are required for grain sorghum. In contrast, this period involves ongoing insect control for cotton. 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.

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

[Texas AgriLife Research, Texas AgriLife Research and Extension Center at Corpus Christi; USGS, U.S. Geological Survey; NWS, National Weather Service; --, unknown]

Site number (fig. 1)	Station name, number	Latitude (degrees minutes seconds)	Longitude (degrees minutes seconds)	Type of data	Period of record used
1	Weather station WS1, Texas AgriLife Research at Corpus Christi, Tex.	27°46'57"	97°33'43"	Hourly and daily rainfall	Oct. 2005–Sept. 2008
2	USGS station 08211511, Texas AgriLife Research at Corpus Christi, Tex.	27°46'57"	97°33'43"	Rainfall quality	Oct. 2005–Sept. 2008
3	USGS station 08211517, West Oso Creek at Merrett Road near Corpus Christi, Tex.	27°43'50"	97°34'37"	Rainfall, streamflow, water quality	Oct. 2005–Sept. 2008
4	USGS station 08211525, Unnamed Oso Creek tributary at Farm Road 2444 near Corpus Christi, Tex.	27°39'07"	97°26'40"	Rainfall, streamflow, water quality	Oct. 2005–Sept. 2008
5	USGS station 08211520, Oso Creek at Corpus Christi, Tex.	27°42'40"	97°30'06"	Streamflow	Oct. 1972–Sept. 2008
6	NWS station 412015, Corpus Christi International Airport	27°46'--"	97°31'--"	Hourly and daily rainfall	January 1972–Sept. 2008
7	NWS station 412013, Corpus Christi Botanical Gardens	27°39'--"	97°24'--"	Daily rainfall	Oct. 2005–Sept. 2008
8	NWS station 417677, Robstown, Tex.	27°47'--"	97°40'--"	Daily rainfall	Oct. 2005–Sept. 2008

Texas Surface-Water-Quality Standards

The Texas Commission on Environmental Quality (TCEQ) has designated Texas surface-water-quality standards (TSWQS) and appropriate uses (such as aquatic life, contact or noncontact recreation, or drinking water) for specific stream, estuary, and bay segments (Texas Commission on Environmental Quality, 2006). TSWQS have not been established for either specific streams or subwatersheds in this study (West Oso Creek and Oso Creek tributary). However, the two subwatersheds drain to Oso Creek and Oso Bay, which are water bodies with TSWQS. The TSWQS 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 its confluence with Oso Bay. Oso Creek and Oso Bay are on the "2008 Texas Water Quality Inventory and 303d List" (Texas Commission on Environmental Quality, 2008) for elevated bacteria counts. Oso Bay also is listed for depressed dissolved oxygen concentration.

Data Collection

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

Rainfall

Rainfall amounts in the Oso Creek watershed area were obtained from six monitoring stations (fig. 1; table 1). Hourly and daily rainfall data were recorded at the Texas AgriLife Research weather station (site 1). Two tipping-bucket rain gages were installed, one at each monitoring station at the outlet of each study subwatershed (sites 3, 4). These stations recorded 15-minute rainfall totals. Also, daily rainfall data were obtained from three NWS rain gages (sites 6, 7, 8). Daily rainfall in the West Oso Creek study subwatershed was estimated by using a Thiessen-weighted average (Wanielista, 1990) of rainfall measured at sites 1, 3, and 8. Daily rainfall in the Oso Creek tributary subwatershed was estimated by using rainfall primarily from site 4. The NWS Corpus Christi Botanical Gardens station (site 7) was used for estimating daily rainfall on the Oso Creek tributary subwatershed for days when data were not available from site 4, including all of the period October 2007–September 2008. Rainfall data from the NWS Corpus Christi International Airport station (site 6) were used to represent long-term rainfall conditions in both subwatersheds.

Streamflow

Water-surface elevation (stage) was continuously monitored (at 15-minute intervals) at the study subwatershed stations (sites 3, 4, table 1) by up-looking acoustic transducers mounted on the streambeds (SonTek, 2010). At each station, relations between stage and runoff (streamflow) were developed from streamflow measurements made during various flow conditions during runoff events (Buchanan and Somers, 1969). From these relations, continuous runoff was computed for each study subwatershed (Kennedy, 1984).

Water Quality

Water-quality samples were collected for two sources, rainfall and runoff. Rainfall-quality samples were collected to measure nutrient concentrations and compute nutrient deposition to the study subwatersheds. Runoff-quality 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 subwatersheds. Also, runoff-quality samples were collected during runoff events and analyzed for fecal coliform, *E. coli*, and *Enterococci* bacteria.

Rainfall Sampling

Rainfall samples for nutrients and major inorganic ions were collected at the USGS rainfall-quality sampling station (site 2, table 1) by an automatic rainfall sampler. The automatic rainfall sampler is equipped with a polyethylene bucket that is covered to prevent contamination of the bucket and sample when rainfall is not occurring. 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 average constituent concentrations during rainfall events. As soon as possible after rainfall, samples were retrieved from the rainfall sample collector and immediately placed on ice. With the use of a Teflon churn, the composite rainfall sample was then split into various sample containers for overnight shipment to the USGS National Water Quality Laboratory (NWQL), Lakewood, Colo., for analysis. Part of the sample was bottled as unfiltered samples, representing whole-water samples. Analyses of unfiltered samples provided concentrations of total phosphorus and total Kjeldahl nitrogen (ammonia nitrogen plus organic nitrogen). Some samples were filtered through 0.45-micrometer (μm) pore-diameter filters. Analyses of filtered samples provided concentrations of dissolved ammonia as N (nitrogen), nitrite plus nitrate nitrogen, phosphorus, and orthophosphate phosphorus. Major inorganic ion samples also were filtered by using a 0.45-μm pore-diameter filters. Analytical methods are described in Fishman (1993), Fishman and Friedman (1989), Patton and Truitt (2000), and U.S. Environmental Protection Agency (1993).

Runoff Sampling

Automatic water samplers at the runoff-monitoring stations (sites 3, 4, table 1) collected runoff samples for nutrients, major inorganic ions, and pesticides 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 streamflow-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 the volume 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-streamflow hydrograph at West Oso Creek for March 14, 2007, including the subsample-collection timing during the event. As runoff samples were retrieved from the autosampler they were immediately chilled to preserve their composition (Komor and Hansen, 2003). When sample collection was complete, portions of each individual aliquot, based on flow at the time of aliquot collection, were combined in a Teflon churn. Samples were then processed from the churn and bottled as either unfiltered or filtered samples (Wilde and others, 2004) and submitted for laboratory analysis to the NWQL. Similar to rainfall samples, nutrient samples were processed from the churn and bottled as unfiltered and filtered (0.45-μm pore-diameter filters) samples for laboratory analysis. Major inorganic ion samples were filtered through 0.45-μm pore-diameter filters, and pesticide

Figure 3. Streamflow-gaging and water-quality monitoring station 08211525, unnamed Oso Creek tributary at Farm Road 2444 near Corpus Christi, Texas, September 19, 2006.

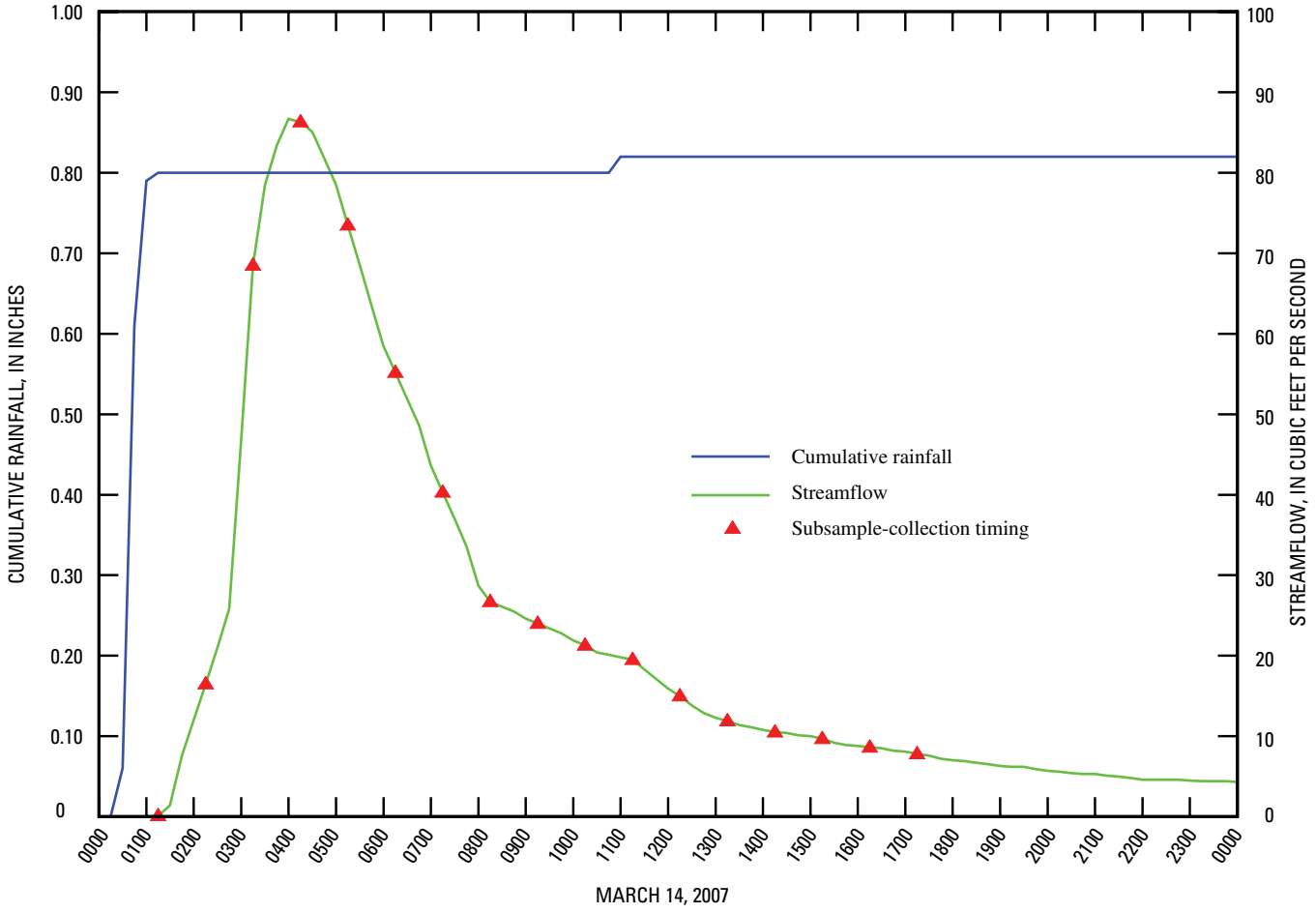

Figure 4. Hydrograph showing cumulative rainfall, streamflow, and subsample-collection timing at station 08211517, West Oso Creek at Merrett Road near Corpus Christi, Texas, during storm runoff, March 14, 2007.

samples were filtered through 0.7-µm pore-diameter filters. Analytical methods are described in Fishman (1993), Fishman and Friedman (1989), Furlong and others (2001), Lindley and others (1996), Madsen and others (2003), Patton and Truitt (2000), Sandstrom and others (2001), U.S. Environmental Protection Agency (1993), and Zaugg and others (1995).

Suspended-sediment samples also were collected during storm-runoff events. Suspended-sediment samples were collected as discrete samples during various streamflow conditions. Samples were collected by the flow-weighted, depth-integrating, equal-width increment (EWI) method (sampler is raised and lowered through the water column at equal intervals across the stream) (U.S. Geological Survey, 2006) with isokinetic samplers US DH-48 and US DH-59 (Federal Interagency Sedimentation Project, 2010). 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 with bridge-suspended equipment during relatively large streamflows. During collection of a suspended-sediment sample at a particular station, samples collected at each vertical section in the stream were combined in a Teflon churn and processed as a composite sample for analysis. The composite sample represents the flow-weighted average suspended-sediment concentration during the period of sample collection. 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 (Guy, 1969). Sand-break analysis gives the percentage of sediment by weight that is finer than 0.062 millimeter (mm). Particle sizes less than 0.062 mm are defined as silt and clay. Particles greater than 0.062 mm are defined as sand.

Discrete bacteria samples were collected during several events at each of the sampling stations. Samples were collected by Texas AgriLife Research personnel and analyzed by the Texas A&M University Environmental Microbiology Laboratory in Corpus Christi. Bacteria samples were collected

Figure 5. Suspended-sediment sample collection at station 08211517, West Oso Creek at Merrett Road near Corpus Christi, Texas, June 2, 2006.

as grab samples from the centroid of flow and analyzed by membrane filtration for fecal coliform (American Public Health Association, 1998), *E. coli* (American Public Health Association, 1998), and *Enterococci* (U.S. Environmental Protection Agency, 2000). The objective for bacteria sampling was a single sample collected as soon as possible after runoff began. Accordingly, samples were collected within several hours of the beginning of runoff and do not necessarily represent average concentrations during the entire runoff event.

Quality Control and Assurance

Quality control (QC) samples, designed to ensure the integrity of water-quality data analyzed in this report, represented more than 10 percent of field samples collected. QC samples consisted of five field blanks that were collected and analyzed to evaluate any contamination, as well as bias and variability of data, which might have resulted from sample collection, processing, transportation, and lab analysis. These samples were collected by passing USGS-certified, highly purified water through the same equipment used to collect and process routine water-quality samples. These blank samples were then collected, processed, and analyzed in the same way as routine environmental samples.

Two field blank samples were collected at the Texas AgriLife Research rainfall-quality site (station 08211511) and analyzed for nutrients and inorganic ions. Two field blank samples were collected at the West Oso Creek subwatershed outlet site (station 08211517). The first of these samples, collected in November 2006, was analyzed for pesticides. The second sample, collected in October 2007, was analyzed for nutrients and inorganic ions. One blank sample was collected at the Oso Creek tributary subwatershed outlet site (station 08211525) in March 2006 and analyzed for nutrients and inorganic ions. Field blank samples were not collected or analyzed for sediment or bacteria samples. QC and assurance methods for sediment and bacteria focused on laboratory analytical procedures.

Most compounds were not detected in the blank samples, but if detected the reported concentrations were less than or near the laboratory reporting level for the compounds (appendix 1). The concentration of the laboratory reporting level is reported with a “less than” (<) remark code (appendix 1) for samples in which the analyte was not detected. Concentrations reported by the NWQL for pesticides are flagged as “estimated” (indicated by an “E” where reported) when they are qualitatively identified as present, but the reported concentrations have a greater uncertainty than usual (Childress and others, 1999). Cases that result in an “estimated” flag include concentrations that are less than the laboratory reporting level but still detectable in the analyst’s judgment. Estimated flags also are associated with any detection of the atrazine degradation compounds 2-chloro-4-isopropylamino-6-amino-s-triazine (CIAT) and 2-chloro-6-ethylamino-4-amino-s-triazine (CEAT). Estimated flags are automatically applied to any CIAT and CEAT detections because of poor performance results during laboratory quality-assurance testing (U.S. Geological Survey, 2010). Estimated concentrations were included in computations of event loads and yields and for statistical analyses. Laboratory reporting levels for some compounds changed during the study. The NWQL updates laboratory reporting levels yearly on the basis of results of internal QC sample analyses.

Reported concentrations for certain nutrient constituents are not analyzed directly but are computed from other constituent concentrations. Computed constituents included dissolved (filtered) and total (unfiltered) nitrogen, dissolved and total organic nitrogen, and dissolved nitrate nitrogen. Laboratory analyses are performed explicitly for ammonia nitrogen, nitrite nitrogen, dissolved nitrite plus nitrate nitrogen, ammonia plus dissolved organic nitrogen, and ammonia plus total organic nitrogen. Dissolved nitrogen is computed as the sum of nitrite plus nitrate nitrogen and ammonia plus dissolved organic nitrogen (filtered); total nitrogen is computed as the sum of nitrite plus nitrate nitrogen and ammonia plus total organic nitrogen (unfiltered). Dissolved organic nitrogen is computed as the difference between ammonia plus dissolved organic nitrogen (filtered) and ammonia nitrogen alone; total organic nitrogen is computed as the difference between ammonia plus total organic nitrogen (unfiltered) and ammonia nitrogen alone. Nitrate nitrogen is computed as the difference between nitrite plus nitrate nitrogen and nitrite nitrogen alone.

QC and assurance procedures applied by the USGS NWQL and sediment laboratories include the determination and tracking of long-term method detection level, internal and external audits, and blind-blank and blind-spike programs that use standard reference materials. Laboratory quality assurance data and methods are documented in U.S. Geological Survey (2007).

Quality assurance procedures applied by the Texas A&M microbiology laboratory for bacteria include field split samples, laboratory duplicates, and method blanks (Texas

Commission on Environmental Quality, 2003). Analytical results of laboratory duplicates and field split replicates are included with primary bacteria sample results.

Water-quality sample data were reviewed by a USGS data manager before data were entered into the USGS National Water Information System (NWIS) (U.S. Geological Survey, 2008). The emphasis of the review was to verify the accuracy and completeness of the laboratory data, to determine whether laboratory QC and assurance data were within acceptable limits, and to determine whether samples were handled appropriately in the field and the laboratory.

Hydrologic Conditions

The 3-water-year study period represents three crop cycles in the study subwatersheds. Water year 2006 was very dry, especially during the planting and preharvest period of February through May. In fact, some producers did not plant or abandoned crops because of lack of rainfall. Water years 2007 and 2008 were relatively typical years in terms of agricultural practices (Dr. Carlos Fernandez, Texas AgriLife Research, written commun., 2008).

Rainfall

Long-term (1960–2008) rainfall from the NWS Corpus Christi International Airport station (site 6, table 1) was compared with rainfall in the subwatersheds during water years 2006–08 (October 2005–September 2008) (table 2). Average annual rainfall in the Corpus Christi area during 1960–2008 was 31.66 in. Area-weighted, average annual rainfall on the two study subwatersheds during water years 2006–08 was 33.26 in. Although rainfall during 2006 was less than normal (29.97 in.), the period of June–August included several major runoff events. Rainfall in water year 2007 was above average (45.03 in.), with especially heavy rainfall during July 2007, about 15 in. Rainfall in water year 2008 was substantially less than average in the West Oso Creek subwatershed (19.61 in.) but only slightly less than average in the Oso Creek tributary subwatershed (29.10 in.).

Mean (1960–2008) monthly rainfall for the NWS Corpus Christi International Airport station and monthly area-weighted rainfall for the West Oso Creek and Oso Creek tributary subwatersheds (combined) for October 2005–September 2006, October 2006–September 2007, and October 2007–September 2008 are shown in figure 6. Although study area rainfall was greater than average during the 3-year study period, monthly rainfall was less than average during 23 of the 36 months.

Runoff

The USGS, in cooperation with the Texas Water Development Board, has operated streamflow-gaging station 08211520 Oso Creek at Corpus Christi, Tex., since 1972 (site 5, fig. 1; table 1). Data from this station were used to estimate long-term annual runoff volumes for comparison with study subwatershed runoff volumes. Land use in the 90.3-mi^2 watershed upstream from the gaging station is largely cropland, similar to that in the study subwatersheds. However, a substantial amount of impervious cover, associated with the town of Robstown, is located upstream from the station. Average streamflow during water years 1973–2008 was 30.6 ft^3/s. Excluding an estimated wastewater treatment discharge of about 3 million gallons per day (Mgal/d) from Robstown, long-term average annual runoff at the Oso Creek at Corpus Christi station was 3.90 in. (table 3). During water years 2006–08, average annual runoff at the Oso Creek at Corpus Christi station was greater than average, 5.82 in. So, it is likely that 2006–08 represents a period of greater than average runoff for the study area subwatersheds.

Runoff during water years 2006–08 corresponded to rainfall patterns, with rainfall and runoff events interspersed between considerable periods of no runoff. Selected rainfall and runoff events (typically rainfall greater than 1.0 in. or runoff greater than 0.001 in., or both) are listed in table 4, including dates, rainfall totals, runoff volumes, and runoff coefficients (ratio of runoff volume, in inches, to rainfall volume, in inches). Most of the minor rainfall and runoff events, for which study subwatersheds had less than 0.01 in. of runoff, are not listed separately but are included in the totals for October 2005–September 2008 listed in table 4. Table 4 also indicates whether runoff water-quality samples were collected during the event. Appendix 2 (West Oso Creek) and appendix 3 (Oso Creek tributary) list water-quality data for all sampled runoff events during water years 2006–08.

Runoff is highly dependent on antecedent conditions. Rainfall of 2 to 3 in. during May 25–29, 2007, resulted in no runoff or only minor runoff at the subwatershed sites. Less rainfall during January 24–February 3, 2007, produced substantially more runoff because of antecedent wet conditions from substantial rainfall in early January.

Most of the runoff from the study subwatersheds occurred in response to a few specific storm periods (events). More than 60 percent of the runoff from each subwatershed occurred during two wet periods: September 18–October 1, 2006, and July 2–August 8, 2007 (table 4). During both periods, multiple rainfall events and prolonged wet-soil conditions contributed to substantial runoff.

The West Oso Creek subwatershed produced more runoff during the study period than the Oso Creek tributary subwatershed, 13.95 in. compared with 9.45 in. (table 4). Runoff response was quicker and peak flows were larger in the West Oso Creek subwatershed than in the Oso Creek tributary subwatershed. Differences in hydrologic response between the subwatersheds might be explained by slightly greater land slopes in the West Oso Creek subwatershed and possible non-contributing areas in the Oso Creek tributary subwatershed. The rainfall/runoff response for each subwatershed during the March 14–18, 2007, event is shown in figure 7.

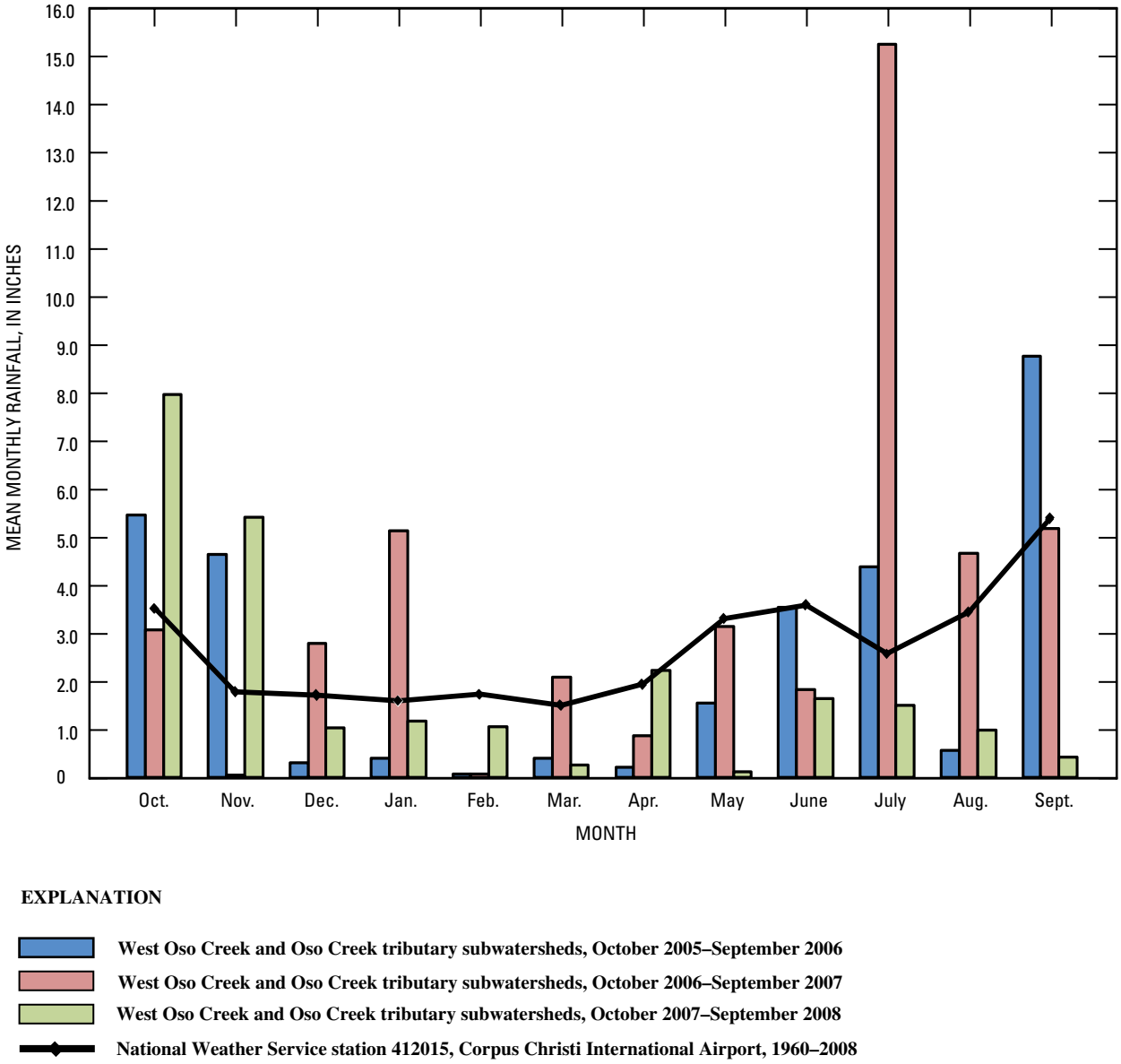

Figure 6. Mean monthly rainfall for National Weather Service station 412015, Corpus Christi International Airport, 1960–2008; and monthly area-weighted rainfall for West Oso Creek and Oso Creek tributary subwatersheds (combined), Nueces County, Texas, water years 2006–08.

Water Quality

Rainfall

Seventeen rainfall samples were collected and analyzed for major inorganic ions and nutrients during the study (table 5). During the October 2005–September 2008 study period, 89.17 in. of rainfall were recorded at the Texas AgriLife Research station (site 1, fig. 1). The 17 rainfall-quality samples represent 31.27 in. of rainfall recorded at the Texas AgriLife Research station or about 35 percent of total rainfall during the study period. Thirteen samples were collected during rainfall for which runoff events were sampled. Five rainfall samples were collected during events for which no runoff occurred. These five samples were collected during rainfall events with about 0.5 in. of rainfall or less. These samples provided only enough sample volume for nutrient analyses.

Summary statistics for selected rainfall nutrient concentrations are listed in table 6. Most of the nitrogen in rainfall is in the form of dissolved ammonia and dissolved nitrate (the nitrite plus nitrate analysis was predominantly nitrate in these samples, and nitrite was rarely detected; therefore, nitrite plus nitrate is referred to as nitrate in this report), which were

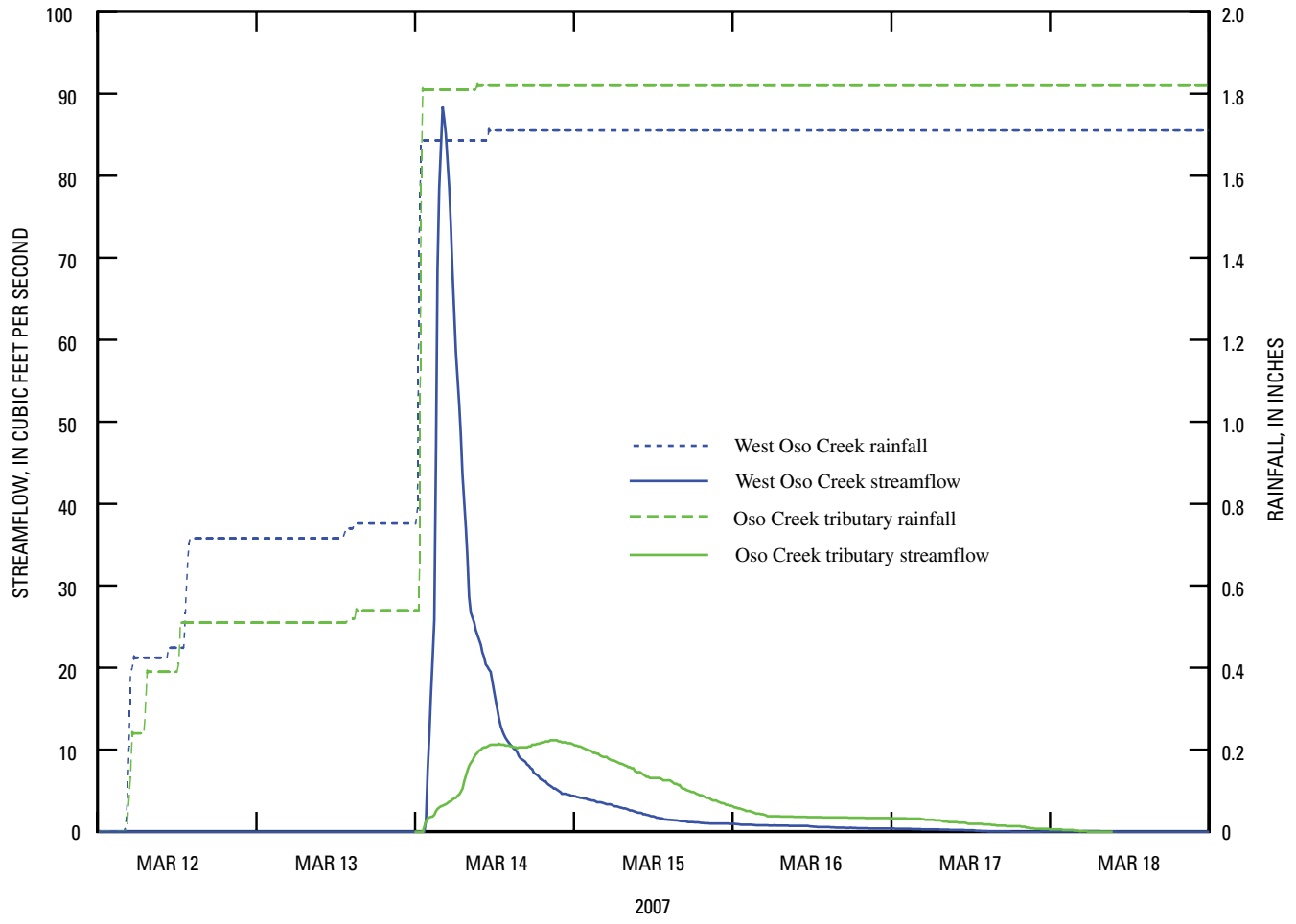

Figure 7. Rainfall/runoff response for West Oso Creek and Oso Creek tributary subwatersheds, Nueces County, Texas, March 12–18, 2007.

detected in all samples. Median concentrations of ammonia and nitrate were 0.17 and 0.12 milligram per liter (mg/L), respectively. Organic forms of nitrogen were detected in all samples at relatively low concentrations; the median concentration of total organic nitrogen was 0.08 mg/L. Nitrite was detected in less than one-half the samples (table 5); the median concentration was less than 0.002 mg/L (table 6). Dissolved and total phosphorus were detected in about one-half of the samples (table 5); the median concentrations were less than 0.006 mg/L and less than 0.007 mg/L, respectively (table 6).

The deposition of rainfall constituents, in pounds 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, daily deposition of a constituent was computed (using total nitrogen for example) as

$$DTN = EMCTN \times R \times cf, \quad (1)$$

where

DTN = daily deposition of total nitrogen, in pounds per acre;
EMCTN = total nitrogen rainfall event-mean concentration, in milligrams per liter;
R = daily rainfall on the study subwatershed, in inches; and
cf = conversion factor of 0.2266.

For unsampled rainfall events, those for which nitrogen concentrations were not available, daily deposition of nitrogen was estimated from a regression equation that relates daily rainfall and daily nitrogen deposition. Least-squares regression was used with the computed event deposition from sampled events to develop the equation relating daily rainfall and daily deposition. Similar to a previous study of rainfall nitrogen deposition in the Coastal Bend area (Ockerman and Livingston, 1999), rainfall and deposition were log-transformed before performing the regression, then retransformed to original units (Helsel and Hirsch, 2002) to improve

Table 2. Estimated annual (water years 2006–08) rainfall for West Oso Creek and Oso Creek tributary subwatersheds, Nueces County, Texas, and long-term average annual (water years 1960–2008) rainfall measured at National Weather Service station 412015, Corpus Christi International Airport.

[--, not available]

Subwatershed	Oct. 2005–Sept. 2006 rainfall (inches)	Oct. 2006–Sept. 2007 rainfall (inches)	Oct. 2007–Sept. 2008 rainfall (inches)	Average annual rainfall, Oct. 2005–Sept. 2008 (inches)	Long-term average annual rainfall, 1960–2008 (inches)
West Oso Creek	27.91	44.87	19.61	30.80	--
Oso Creek tributary	31.97	45.19	29.10	35.65	--
Mean (subwatershed area weighted)	29.97	45.03	24.77	33.26	31.66

Table 3. Annual (water years 2006–08) runoff from West Oso Creek and Oso Creek tributary subwatersheds and long-term average annual (water years 1973–2008) runoff from Oso Creek watershed, Nueces County, Texas.

[--, not applicable]

Subwatershed or station name (number)	Oct. 2005–Sept. 2006 runoff (inches)	Oct. 2006–Sept. 2007 runoff (inches)	Oct. 2007–Sept. 2008 runoff (inches)	Average annual study area runoff (inches)	Water years 1973–2008 average annual runoff (inches)
West Oso Creek (station 08211517)	3.19	8.19	3.14	5.69	--
Oso Creek tributary (station 08211525)	2.60	4.67	2.17	3.64	--
Oso Creek at Corpus Christi, Tex.[1] (station 08211520)	4.37	10.9	2.18	5.82	3.90

[1] Runoff at station 08211520 excludes an estimated annual 3 million gallons per day of wastewater discharge during the study period.

the quality of the regression relation. The resulting regression equation is

$$DTN = 0.09 \times R^{0.360}, \quad (2)$$

where

DTN = daily deposition of total nitrogen, in pounds per acre; and

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

The coefficient of determination (R-squared) for the regression equation was 0.22; the residual standard error was 0.082 pound per acre (lb/acre).

The sampling periods for most rainfall-quality samples collected during the study ranged from 12 to 24 hours and, in most cases, represented the total rainfall for a day. Thus, for purposes of computing deposition of rainfall constituents by using equation 1 and for developing equation 2 relating daily rainfall and daily total nitrogen deposition, the event rainfall for each rainfall sample (table 5) was treated as a daily rainfall total.

Daily total nitrogen deposition for the 17 sampled rainfall events, which was computed by using equation 1 with event (daily) rainfall and total nitrogen sample concentrations (representing EMCs) (total nitrogen unfiltered, table 5), and the corresponding daily total nitrogen deposition, which was estimated by using equation 2, each relative to daily rainfall, are shown in figure 8.

Daily total nitrogen rainfall deposition for each subwatershed was estimated by using equation 2 with daily rainfall for each subwatershed; estimated monthly and annual deposition, computed from summation of daily deposition, are shown in table 7. The average (area-weighted) annual total nitrogen deposition for the subwatersheds over the 3-year study period was 4.47 pounds per acre per year [(lb/acre)/yr].

Rainfall deposition of total phosphorus was much less than that of total nitrogen. The median total phosphorus concentration for the 17 rainfall samples (table 6) was less than

Table 4. Rainfall, runoff, and runoff/rainfall coefficients (ratio of runoff volume to rainfall volume) for selected rainfall and runoff events during water years 2006–08, West Oso Creek and Oso Creek tributary subwatersheds, Nueces County, Texas.

[--, not applicable]

Event date	Subwatershed							
	West Oso Creek				Oso Creek tributary			
	Rainfall (inches)	Runoff (inches)	Runoff/ rainfall coefficient	Runoff water-quality samples collected?	Rainfall (inches)	Runoff (inches)	Runoff/ rainfall coefficient	Runoff water-quality samples collected?
2005								
Oct. 11–13	0.92	0	0	No	7.18	0.14	0.02	No
Nov. 16–17	.49	.01	.02	No	.95	0	0	No
Nov. 26–29	2.62	.24	.09	No	3.80	.04	.01	No
2006								
June 1–4	3.90	.65	.17	Yes	2.50	.08	.03	Yes
July 1–5	2.32	.01	.005	Yes	1.75	.002	.001	Yes
July 6–9	.88	.01	.01	Yes	1.73	.02	.01	Yes
July 26–27	1.34	.02	.01	No	.15	0	0	No
Aug. 19–20	.60	.01	.02	No	0	0	0	No
Sept. 9–17	2.79	.01	0	Yes	2.91	.18	.06	Yes
Sept. 18–23	3.17	.96	.30	Yes	3.58	1.31	.37	Yes
Sept. 24–Oct. 1	2.82	1.29	.46	No	2.04	.85	.42	No
Oct. 22–25	1.36	0	0	No	1.01	.06	.06	No
2007								
Jan. 3–7	1.68	.02	.01	Yes	2.13	.06	.03	Yes
Jan. 24–Feb. 3	2.29	.14	.06	Yes	2.40	.29	.12	Yes
Mar. 14–18	1.71	.12	.07	Yes	1.82	.08	.04	Yes
May 25–29	2.48	0	0	Yes	3.15	.02	.01	No
July 2–10	8.20	2.70	.33	Yes	10.72	3.26	.30	Yes
July 19–24	2.07	1.26	.61	No	1.76	.05	.03	No
July 26–Aug. 8	6.37	2.32	.36	No	2.13	.27	.13	No
Aug. 30–Sept. 2	2.45	0	0	No	1.05	.10	.10	Yes
Sept. 3–13	1.29	.63	.49	No	1.67	.18	.11	No
Sept. 29–Oct. 15	3.34	.32	.10	No	2.43	.46	.12	No
2008								
Mar. 10–19	.75	.03	.04	Yes	1.00	.06	.12	Yes
July 23–Aug. 8	4.51	.22	.05	Yes	6.65	1.62	.12	Yes
Aug. 13–31	3.21	2.81	.88	No	7.21	.12	.12	Yes
Sept. 14–22	.18	0	0	No	.50	.15	.12	No
Sept. 24–30	.14	0	0	No	.84	.03	.03	No
Total—27 events	63.75	13.78	.22	--	73.26	9.43	.13	--
Total—Oct. 2005–Sept. 2008	92.39	13.95	.15	--	106.26	9.45	.09	--

Table 5. Event (daily) rainfall, Texas AgriLife Research at Corpus Christi weather station (WS1); and event concentrations of selected constituents in rainfall samples, Texas AgriLife Research at Corpus Christi rainfall-quality sampling station (08211511), Nueces County, Texas, water years 2006–08.

[fltrd, filtered; mg/L, milligrams per liter; N, nitrogen; unfltrd, unfiltered; --, not analyzed; <, less than; E, estimated; P, phosphorus]

Sample date	Event (daily) 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 + organic nitrogen, water, fltrd (mg/L as N)	Ammonia + organic nitrogen, water, unfltrd (mg/L as N)	Ammonia nitrogen, 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	E.06	.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
Sept. 11, 2006	.46	--	--	--	--	--	--	.13	2.0	.10
Sept. 24, 2006	1.80	.04	.010	.031	.47	.76	.64	.24	.09	.08
Oct. 14, 2006	.14	--	--	--	--	--	--	.75	.75	.71
Jan. 3, 2007	1.49	.09	.035	.024	.34	.47	.59	.17	.17	.13
Jan. 24, 2007	.51	--	--	--	--	--	--	.18	.18	.07
Mar. 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
Mar. 6, 2008	1.24	.68	.192	.091	1.47	2.76	2.18	.34	.35	.30
July 24, 2008	1.77	.29	.100	.109	1.32	2.56	.63	E.10	E.07	.05
Aug. 18, 2008	.26	--	--	--	--	--	--	.40	.34	.32

the minimum laboratory reporting level, 0.008 mg/L. The use of equation 1 with mean annual (October 2005–September 2008) rainfall for the subwatersheds (33.26 in., table 2) and the minimum laboratory reporting level to estimate an upper limit of annual total phosphorus deposition for the study period resulted in an estimate of less than 0.07 (lb/acre)/yr.

Values for estimated monthly and annual total nitrogen deposition for water years 2006–07 were revised and compared with the values published in the previous report on hydrologic conditions and water quality of the study subwatersheds (Ockerman, 2008, table 7). Additional data collected during water year 2008, along with previously collected data, were used to revise the relation between rainfall and nitrogen deposition (equation 2), resulting in revised deposition values for water years 2006–07. Previously published values of average annual total nitrogen deposition for 2006–07 were 5.94 and 5.06 (lb/acre)/yr for the West Oso Creek and Oso Creek tributary subwatersheds, respectively. The revised values of average annual total nitrogen deposition for 2006–07 are 5.52 and 4.52 (lb/acre)/yr for the West Oso Creek and Oso Creek tributary subwatersheds, respectively.

Runoff

During June 2006–September 2008, 24 event-composite runoff (streamflow) samples were collected at the two subwatershed outlet monitoring sites: 12 samples at West Oso Creek (site 3, fig. 1) and 12 samples at Oso Creek tributary (site 4, fig. 1). Samples were analyzed to characterize the quality of storm runoff from the study subwatersheds. Results of analyses of West Oso Creek and Oso Creek tributary samples are shown in appendixes 2 and 3, respectively.

Nutrients and Major Inorganic Ions

Summary statistics for event concentrations of selected nutrient (nitrogen and phosphorus) and major inorganic ions

Table 5. Event (daily) rainfall, Texas AgriLife Research at Corpus Christi weather station (WS1); and event concentrations of selected constituents in rainfall samples, Texas AgriLife Research at Corpus Christi rainfall-quality sampling station (08211511), Nueces County, Texas, water years 2006–08—Continued.

Sample date	Event (daily) rainfall (inches)	Nitrite + nitrate nitrogen, water, fltrd (mg/L as N)	Nitrite nitrogen, water, fltrd (mg/L as N)	Organic nitrogen, water, fltrd (mg/L as N)[1]	Organic nitrogen, water, unfltrd (mg/L as N)[1]	Total nitrogen, water, fltrd (mg/L as N)[1]	Total nitrogen, water, unfltrd (mg/L as N)[1]	Phospho-rus, water, fltrd (mg/L as P)	Phospho-rus, water, unfltrd (mg/L as P)	Ortho-phosphate phosphorus, 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	E.09	<.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
Sept. 11, 2006	.46	.091	<.002	.03	1.9	.22	2.1	<.004	<.004	<.006
Sept. 24, 2006	1.80	.078	<.002	.16	--	.32	E.17	<.004	<.004	<.006
Oct. 14, 2006	.14	.250	.004	.01	.04	.96	1.0	.018	.028	.013
Jan. 3, 2007	1.49	.064	.002	.03	.04	.22	.24	.005	<.008	.003
Jan. 24, 2007	.51	.066	.002	.05	.10	.19	.24	<.006	<.008	<.006
Mar. 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	E.13	<.006	.004	<.006
Mar. 6, 2008	1.24	.132	E.002	.11	.12	.47	.48	.008	.009	E.003
July 24, 2008	1.77	E.013	<.002	E.07	E.03	E.11	E.08	E.004	E.005	E.004
Aug. 18, 2008	.26	.134	<.002	.15	.09	.53	.47	E.005	E.007	E.005

[1] Concentration of constituent not analyzed directly but computed from other analyzed constituents.

(calcium, potassium, chloride, and sulfate) for each subwatershed are shown in table 8. Nutrient concentrations in runoff were greater at the West Oso Creek site than at the Oso Creek tributary site. Major inorganic ion concentrations were greater at the Oso Creek tributary site than at the West Oso Creek site.

The results of Wilcoxon rank-sum tests (Helsel and Hirsch, 2002), done to indicate whether event-median concentrations of respective constituents at the two subwatershed sites are significantly different at the .05 level, are listed in table 9. The tests indicate that event-median concentrations of selected forms of nitrogen are significantly greater at the West Oso Creek subwatershed. Event-median concentrations of major inorganic ions in runoff were all significantly greater at the Oso Creek tributary subwatershed. There was no significant difference in the total phosphorus median concentrations between the two subwatersheds; however, dissolved orthophosphate concentrations were greater in the Oso Creek tributary subwatershed.

The load of a constituent in runoff (streamflow) is the mass of a given constituent transported past a site on a stream during a specified period (Huber, 1993, p. 14.2). Daily nutrient loads were computed for the study subwatershed outlet sites 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 computed as

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

where

L = constituent load, in pounds per day;
EMC = event-mean concentration during runoff event, in milligrams per liter or micrograms per liter;
R = runoff, in acre-feet per day; and
cf = conversion factor, 2.719 for concentrations in milligrams per liter or 2.719×10^{-3} for concentrations in micrograms per liter.

Table 6. Summary statistics for event rainfall, Texas AgriLife Research at Corpus Christi weather station (WS1); and event concentrations of selected nutrients in rainfall samples, Texas AgriLife Research at Corpus Christi rainfall-quality sampling station (08211511), Nueces County, Texas, water years 2006–08.

[in., inches; mg/L, milligrams per liter; --, not applicable; <, less than]

Constituent	Number of samples	Mean	Median	Minimum	Maximum
Rainfall (in.)	17	1.84	1.30	0.14	9.30
Ammonia + organic nitrogen, dissolved (mg/L)	17	.42	.24	.08	2.30
Ammonia + organic nitrogen, total (mg/L)	17	.40	.20	.06	2.00
Ammonia nitrogen, dissolved (mg/L)	17	.26	.17	.04	.82
Nitrite + nitrate nitrogen, dissolved (mg/L)	17	.17	.12	.013	.378
Nitrite nitrogen, dissolved (mg/L)	17	--	<.002	<.002	.004
Nitrate nitrogen, dissolved (mg/L)[1]	17	.17	.12	.013	.78
Organic nitrogen, total (mg/L)[2]	17	.20	.08	.02	1.9
Nitrogen, total (mg/L)[3]	17	.56	.33	.17	2.10
Phosphorus, dissolved (mg/L)	17	<.006	<.006	<.004	.021
Phosphorus, total (mg/L)	17	--	<.007	<.004	.043
Orthophosphate phosphorus, dissolved (mg/L)	17	<.006	<.006	<.006	.013

[1] Computed as difference between nitrite plus nitrate nitrogen and nitrite nitrogen.

[2] Computed as difference between ammonia plus total organic nitrogen (unfiltered) and ammonia nitrogen.

[3] Computed as sum of nitrite plus nitrate nitrogen and ammonia plus total organic nitrogen (unfiltered).

Event-median concentrations of selected nutrients in samples at each site (table 9) were used to estimate runoff loads for unsampled events at each site. During water years 2006–08, sampled runoff events represent about 35 percent of total runoff from the West Oso Creek subwatershed. About 65 percent of the runoff was unsampled. Sampled and unsampled runoff percentages from the Oso Creek tributary subwatershed were about 76 percent and 24 percent, respectively. The percentage of total runoff sampled in the West Oso Creek subwatershed was less than that sampled in the Oso Creek tributary subwatershed because three of the four runoff events with the greatest runoff volume in West Oso Creek were not sampled. The three runoff events with the greatest runoff volume in Oso Creek tributary were sampled.

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.

Estimated monthly and annual loads of selected nutrients in runoff from each of the study subwatersheds are listed in table 10, and the corresponding annual runoff yields are listed in table 11. Monthly and annual nutrient loads were highly variable, depending on storm runoff. Large storm events contributed most of the runoff constituent loads. As a result of large storms in July 2007, about 39 percent of the total nitrogen runoff load and 44 percent of the total phosphorus runoff load for the entire study period for both subwatersheds occurred in this 1-month period.

Nitrogen yields from the West Oso Creek subwatershed were greater than yields from the Oso Creek tributary subwatershed for two reasons: (1) West Oso Creek subwatershed runoff was greater, and (2) nitrogen concentrations generally were greater for the West Oso Creek subwatershed. Average total nitrogen yield from the West Oso Creek subwatershed was 2.62 (lb/acre)/yr for the 3-year study period. Average total nitrogen yield from the Oso Creek tributary subwatershed for the 3-year period was less than one-half that for the West Oso Creek subwatershed, 0.839 (lb/acre)/yr.

Average total phosphorus yield from the West Oso Creek subwatershed was greater than that from the Oso Creek tributary subwatershed. Although the median runoff concentrations for total phosphorus were about the same for each subwatershed, greater runoff at West Oso Creek resulted in greater runoff yields. The average annual total phosphorus yields for West Oso Creek and Oso Creek tributary were 0.644 and 0.419 (lb/acre)/yr, respectively (table 11).

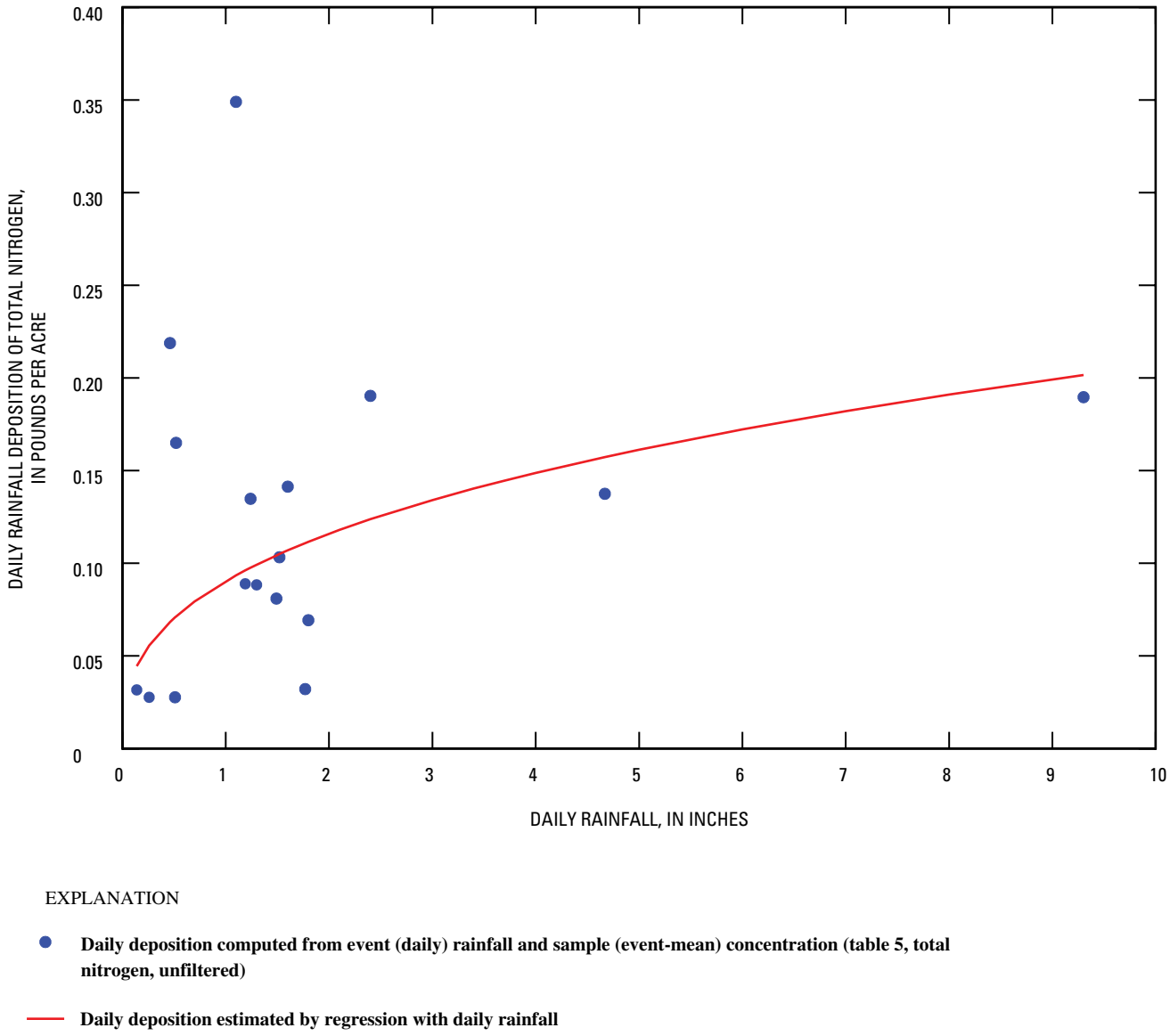

Figure 8. Daily deposition of total nitrogen computed from event (daily) rainfall and sample concentrations and estimated by regression with daily rainfall, each relative to daily rainfall, for sampled rainfall events, Oso Creek watershed, Nueces County, Texas, water years 2006–08.

Estimated runoff loads and yields of nitrogen and phosphorus for water years 2006–07 were revised from estimates published in the previous report on the study subwatersheds (Ockerman, 2008). Runoff-quality data collected since the previous report, along with previous data, were used to estimate median concentrations that were then used to compute runoff loads during unsampled events. This resulted in revisions to 2006–07 load and yield estimates. The previously published 2006–07 average annual runoff yield (weighted average of both study subwatersheds) for total nitrogen was 1.78 (lb/acre)/yr. The revised estimate of average annual runoff yield for 2006–07 is 1.91 (lb/acre)/yr.

Information on fertilizer nutrient application in study subwatershed croplands for 2006–08 was compiled by Texas AgriLife Research (Dr. Bobby Eddleman, Texas AgriLife Research, written commun., 2007) and the Natural Resources Conservation Service (John Freeman, U.S. Department of Agriculture, Natural Resources Conservation Service, Nueces County, Tex., written commun., 2009). Annual runoff yields of total nitrogen and total phosphorus were compared to nutrient inputs from fertilizer applications and rainfall deposition (table 12).

Nitrogen input from fertilizer is much larger than nitrogen that either enters the study area subwatersheds through rainfall deposition or exits the subwatersheds in runoff. Average (area-weighted for both subwatersheds) annual application of fertilizer-based nitrogen was 64.2 (lb/acre)/yr, compared to 4.47 (lb/acre)/yr from rainfall deposition

Table 7. Estimated monthly and annual total nitrogen rainfall deposition on West Oso Creek and Oso Creek tributary subwatersheds, Nueces County, Texas, water years 2006–08.

[In pounds per acre]

Year	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Annual
West Oso Creek subwatershed													
2006	0.48	0.37	0.12	0.23	0.15	0.19	0.14	0.47	0.39	0.73	0.27	1.03	4.57
2007	.38	.05	.52	.68	.13	.20	.44	.53	.52	1.39	.95	.68	6.47
2008	.26	.25	.20	.54	.16	.23	.31	.23	.12	.60	.67	.19	3.76
Oso Creek tributary subwatershed													
2006	.59	.43	.18	.17	0	.09	0	.31	.26	.42	.08	.94	3.48
2007	.62	0	.51	.72	.07	.24	.29	.33	.41	1.06	.76	.56	5.56
2008	.20	.27	.06	.38	.05	.18	.14	.21	.13	.60	.55	.13	3.03

Table 8. Summary statistics for event concentrations of selected nutrients and major inorganic ions in runoff samples, West Oso Creek (station 08211517) and Oso Creek tributary (station 08211525) subwatersheds, Nueces County, Texas, water years 2006–08.

[mg/L, milligrams per liter; --, not available; <, less than laboratory reporting level]

Constituent	Number of samples	Mean	Median	Minimum	Maximum
West Oso Creek subwatershed					
Ammonia nitrogen, dissolved (mg/L)	12	--	0.040	<0.02	0.228
Nitrite + nitrate nitrogen, dissolved (mg/L)	12	1.00	.61	.22	3.26
Ammonia + organic nitrogen, total (mg/L)	12	2.50	2.20	.75	7.0
Organic nitrogen, total (mg/L)[1]	12	2.40	2.07	.74	6.6
Nitrogen, total (mg/L)[2]	12	3.50	3.18	.97	9.0
Phosphorus, total (mg/L)	12	.71	.62	.29	1.5
Calcium, dissolved (mg/L)	11	14.2	14.4	8.9	18.4
Potassium, dissolved (mg/L)	11	4.86	4.07	3.24	9.73
Chloride, dissolved (mg/L)	11	2.33	1.61	.97	6.03
Sulfate, dissolved (mg/L)	11	1.99	1.60	.90	3.90
Oso Creek tributary subwatershed					
Ammonia nitrogen, dissolved (mg/L)	12	--	.021	<.020	.172
Nitrite + nitrate nitrogen, dissolved (mg/L)	12	--	.20	<.04	1.37
Ammonia + organic nitrogen, total (mg/L)	12	1.28	1.04	.79	2.5
Organic nitrogen, total (mg/L)[1]	12	1.26	1.03	.78	2.3
Nitrogen, total (mg/L)[2]	12	1.68	1.26	.84	3.57
Phosphorus, total (mg/L)	12	.66	.61	.41	1.02
Calcium, dissolved (mg/L)	11	18.7	18.9	10.3	28.5
Potassium, dissolved (mg/L)	11	8.58	8.31	4.82	16.9
Chloride, dissolved (mg/L)	11	11.9	11.0	1.97	23.8
Sulfate, dissolved (mg/L)	11	6.98	6.23	1.30	17.4

[1] Computed as difference between ammonia plus total organic nitrogen (unfiltered) and ammonia nitrogen.

[2] Computed as sum of nitrite plus nitrate nitrogen and ammonia plus organic nitrogen, total.

Table 9. Event-median concentrations of selected nutrients and major inorganic ions in runoff samples, West Oso Creek (station 08211517) and Oso Creek tributary (station 08211525) subwatersheds, Nueces County, Texas, water years 2006–08; and results of Wilcoxon rank-sum tests to indicate whether event-median concentrations for the two subwatersheds are significantly different.

[mg/L, milligrams per liter]

Constituent	Subwatershed event-median concentration (mg/L)		*p*-value	Concentrations significantly different at .05 level?
	West Oso Creek	Oso Creek tributary		
Ammonia nitrogen, dissolved	0.040	0.021	.03	Yes
Nitrite + nitrate nitrogen, dissolved	.61	.20	.02	Yes
Ammonia + organic nitrogen, total	2.20	1.04	.01	Yes
Organic nitrogen, total[1]	2.07	1.03	.01	Yes
Nitrogen, total[2]	3.18	1.26	.01	Yes
Phosphorus, total	.62	.61	.34	No
Orthophosphate phosphorus, dissolved	.284	.418	.0068	Yes
Calcium, dissolved	14.4	18.9	.02	Yes
Potassium, dissolved	4.07	8.31	.0009	Yes
Chloride, dissolved	1.61	11.0	.0001	Yes
Sulfate, dissolved	1.60	6.23	.001	Yes

[1] Computed as difference between ammonia plus total organic nitrogen (unfiltered) and ammonia nitrogen.

[2] Computed as sum of nitrite plus nitrate nitrogen and ammonia plus total organic nitrogen (unfiltered).

and 1.72 (lb/acre)/yr 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 exceed rainfall nitrogen deposition. The average annual runoff yield of total nitrogen represents about 2.5 percent of nitrogen applied as fertilizer and nitrogen entering the subwatersheds through rainfall deposition. Also, nearly all of the nitrogen applied as fertilizer and entering the subwatersheds through rainfall deposition is in the form of ammonia and nitrate. Nitrogen exiting the study subwatersheds in runoff is mostly organic nitrogen (table 11).

As with nitrogen, fertilizer inputs of phosphorus are much greater than phosphorus runoff yields. Average annual fertilizer input of phosphorus was 13.2 (lb/acre)/yr (table 12). Average runoff of total phosphorus was 0.530 (lb/acre)/yr, or about 4.0 percent of the phosphorus applied as fertilizer. Average phosphorus input from rainfall was relatively small, estimated to be less than 0.07 (lb/acre)/yr. Fertilizer is applied as soluble orthophosphate. Most of the runoff phosphorus also was in the form of orthophosphate (table 11).

Suspended Sediment

Results of analyses for 26 samples of suspended sediment in runoff are listed in table 13. Twelve samples were collected at West Oso Creek (station 08211517), and 14 samples were collected at Oso Creek tributary (station 08211525). The samples were analyzed for concentration and for percentage silt and clay, by weight (particle size less than 0.062 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 streamflow and other factors, including soil erodibility, rainfall intensity and duration, and crop growth stage and tillage practices (U.S. Department of Agriculture, Agricultural Research Service, 2006). Generally, suspended-sediment concentrations, loads, and yields were larger for the West Oso Creek subwatershed than for the Oso Creek tributary subwatershed. Considering all samples from both sites, the percentage of silt and clay was 96 or greater for 23 of the 26 samples.

For each subwatershed (sites 3, 4, fig. 1), a regression equation was developed relating suspended-sediment load ([instantaneous] tons per day) to streamflow (cubic feet per second). The regression relations for each site are shown in figure 9. The equations and R-squared and residual standard error values are listed in table 14.

From these equations, instantaneous sediment loads were computed for each subwatershed outlet site and aggregated to obtain monthly and annual loads (table 15). As with runoff and nutrient loads, suspended-sediment loads were highly variable by month. More than 75 percent of the entire sediment load from the study subwatersheds occurred during the 3 months of September 2006, July 2007, and August 2008.

Table 10. Estimated monthly and annual runoff loads of selected nutrients from West Oso Creek (station 08211517) and Oso Creek tributary (station 08211525) subwatersheds, Nueces County, Texas, water years 2006–08.

[In pounds]

Nutrient	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Annual
West Oso Creek subwatershed													
Water year 2006													
Ammonia nitrogen, dissolved	0	11.4	0	0	0	0	0	0	13	1.1	0.5	105	131
Nitrite + nitrate nitrogen, dissolved	0	175	0	0	0	0	0	0	190	14	5.2	1,350	1,730
Organic nitrogen, total	0	601	0	0	0	0	0	0	910	65	17	4,760	6,350
Nitrogen, total	0	910	0	0	0	0	0	0	1,140	84	26	5,030	7,190
Phosphorus, total	0	177	0	0	0	0	0	0	356	20	5.3	1,580	2,140
Orthophosphate phosphorus, dissolved	0	81	0	0	0	0	0	0	127	7.5	2.5	703	884
Water year 2007													
Ammonia nitrogen, dissolved	.1	0	0	11	0	27	0	.4	0	189	6.8	41	275
Nitrite + nitrate nitrogen, dissolved	1.1	0	0	583	.4	105	0	2.2	0	2,550	138	620	4,000
Organic nitrogen, total	3.9	0	0	251	.1	566	0	7.4	0	11,000	467	2,135	14,400
Nitrogen, total	5.8	0	0	851	.5	688	0	10	0	16,400	718	3,230	21,900
Phosphorus, total	1.1	0	0	102	.1	205	0	2.9	0	4,460	140	630	5,540
Orthophosphate phosphorus, dissolved	.5	0	0	48	0	48	0	1.0	0	2,650	63	285	3,100
Water year 2008													
Ammonia nitrogen, dissolved	3.4	0	0	0	0	15	0	0	0	8.8	131	0	158
Nitrite + nitrate nitrogen, dissolved	52	0	0	0	0	75	0	0	0	89	2,000	.2	2,220
Organic nitrogen, total	180	0	0	0	0	243	0	0	0	531	6,770	.8	7,720
Nitrogen, total	273	0	0	0	0	332	0	0	0	405	10,400	1.2	11,400
Phosphorus, total	53	0	0	0	0	11	0	0	0	147	2,030	.2	2,240
Orthophosphate phosphorus, dissolved	24	0	0	0	0	11	0	0	0	87	916	.1	1,040

Annual and average annual suspended-sediment yields for the subwatersheds (table 16) were computed from the loads and watershed drainage areas. Suspended-sediment yields from the West Oso Creek subwatershed were more than three times greater than those from the Oso Creek tributary subwatershed. The average suspended-sediment yield from the West Oso Creek subwatershed was 522 (lb/acre)/yr. The average suspended-sediment yield from the Oso Creek tributary subwatershed was 139 (lb/acre)/yr. One reason the West Oso Creek sediment yield is greater is that the subwatershed produced more runoff than the Oso Creek tributary subwatershed. Also, because runoff response is more rapid for the West Oso Creek subwatershed than for the Oso Creek tributary subwatershed, larger peak flows can generate higher stream velocities and, potentially, greater sediment concentrations and loads. The West Oso Creek monitoring station is located at 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 from the monitoring site is not a well-defined channel, but a watercourse that flows through (over) cultivated cropland. In contrast, the Oso Creek tributary upstream from the monitoring site on that stream is surrounded by a buffer area of grassland along the sides of the channel.

Table 10. Estimated monthly and annual runoff loads of selected nutrients from West Oso Creek (station 08211517) and Oso Creek tributary (station 08211525) subwatersheds, Nueces County, Texas, water years 2006–07—Continued.

Nutrient	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Annual
Oso Creek tributary subwatershed													
Water year 2006													
Ammonia nitrogen, dissolved	3.3	1.0	0	0	0	0	0	0	2.3	0.3	0	63	70
Nitrite + nitrate nitrogen, dissolved	33	9.9	0	0	0	0	0	0	24	1.3	0	559	627
Organic nitrogen, total	168	51	0	0	0	0	0	0	135	25	0	2,530	2,910
Nitrogen, total	206	62	0	0	0	0	0	0	162	26	0	3,520	3,980
Phosphorus, total	100	30	0	0	0	0	0	0	88	17	0	1,450	1,680
Orthophosphate phosphorus, dissolved	69	21	0	0	0	0	0	0	57	12	0	877	1,040
Water year 2007													
Ammonia nitrogen, dissolved	1.9	0	0	9.0	.3	16	0	.6	0	74	3.3	12	117
Nitrite + nitrate nitrogen, dissolved	18	0	0	311	6.2	95	0	14.8	0	662	28	107	1,240
Organic nitrogen, total	90	0	0	426	7.4	228	0	26	0	4,070	165	590	5,600
Nitrogen, total	110	0	0	749	13.7	333	0	23.1	0	4,660	190	714	6,790
Phosphorus, total	53	0	0	190	3.3	93	0	18	0	2,780	80	343	3,560
Orthophosphate phosphorus, dissolved	37	0	0	118	2.2	35	0	6.5	0	2,330	58	237	2,820
Water year 2008													
Ammonia nitrogen, dissolved	4.5	0	0	0	0	13	0	0	0	38	3.6	4.6	64
Nitrite + nitrate nitrogen, dissolved	45	0	0	1.1	0	101	0	0	0	96	30	43	316
Organic nitrogen, total	232	0	0	.6	0	147	0	.1	0	1,830	165	221	2,600
Nitrogen, total	284	0	0	.7	0	258	0	.1	0	1,600	146	271	2,560
Phosphorus, total	138	0	0	.3	0	75	0	0	0	975	93	131	1,410
Orthophosphate phosphorus, dissolved	95	0	0	.2	0	41	0	0	0	776	82	90	1,080

Estimated runoff loads of suspended sediment for water years 2006–07 were revised from estimates published in the previous report on the study subwatersheds (Ockerman, 2008). Additional suspended-sediment data collected since the previous report were used to revise the relations used to estimate suspended-sediment loads (fig. 9). The 2006–07 average annual runoff yield for suspended sediment in the West Oso Creek subwatershed was revised to 608 (lb/acre)/yr, compared with the previous estimate of 582 (lb/acre)/yr. The 2006–07 average annual runoff yield for suspended sediment in the Oso Creek tributary subwatershed was revised to 159 (lb/acre)/yr, compared with the previous estimate of 257 (lb/acre)/yr.

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 subwatersheds, and some pesticides used in the subwatersheds were not included in the 88 requested analyses because some analyses were not available through the NWQL. Also, a complete list of pesticides applied by agricultural users in the subwatersheds was not available at the beginning of the study. Texas AgriLife Research (Dr. Bobby Eddleman, Texas AgriLife Research, written commun., 2007), with assistance from the Natural Resources Conservation Service

Table 11. Estimated annual and average annual runoff yields of selected nutrients from West Oso Creek (station 08211517) and Oso Creek tributary (station 08211525) subwatersheds, Nueces County, Texas, water years 2006–08.

[In pounds per acre per year]

Nutrient	Water year 2006	Water year 2007	Water year 2008	Water years 2006–08 average
West Oso Creek subwatershed (5,145 acres)				
Ammonia nitrogen, dissolved	0.026	0.053	0.031	0.037
Nitrite + nitrate nitrogen, dissolved	.336	.778	.432	.515
Organic nitrogen, total	1.23	2.80	1.50	1.84
Nitrogen, total	1.39	4.26	2.22	2.62
Phosphorus, total	.416	1.08	.435	.644
Orthophosphate phosphorus, dissolved	.172	.602	.202	.325
Oso Creek tributary subwatershed (5,287 acres)				
Ammonia nitrogen, dissolved	.013	.022	.012	.016
Nitrite + nitrate nitrogen, dissolved	.119	.235	.060	.138
Organic nitrogen, total	.550	1.06	.492	.701
Nitrogen, total	.753	1.28	.484	.839
Phosphorus, total	.318	.673	.267	.419
Orthophosphate phosphorus, dissolved	.197	.533	.204	.311

(John Freeman, U.S. Department of Agriculture, Natural Resources Conservation Service, Nueces County, Tex., written commun., 2009), compiled information on pesticide application rates for the study subwatersheds during 2005–08. The pesticides that were reported as applied in the study subwatersheds during 2005–08 are listed in table 17. Table 17 also indicates applied pesticides that were not included in the laboratory analyses of runoff samples.

Pesticides detected in runoff samples and concentration summary statistics are listed in table 18. Pesticide analytical results for all samples are listed in appendixes 2 and 3. Laboratory analyses indicated detection of 32 pesticide compounds (24 herbicides and 8 insecticides) in 24 runoff samples collected from the two subwatershed outlet sites combined. At the West Oso Creek site, 23 pesticides were detected (19 herbicides and 4 insecticides) and at the Oso Creek tributary site, 24 pesticides were detected (18 herbicides and 6 insecticides). Of the 32 pesticides detected during the study, 14 were detected only once, either at the West Oso Creek site or the Oso Creek tributary site. All of these 14 single detections were at low concentrations (near the minimum laboratory reporting level). Two herbicides were detected in all samples from both sites: atrazine and atrazine degradation byproduct CIAT. Also, glyphosate and glyphosate degradation byproduct aminomethylphosphonic acid (AMPA) were detected in all samples collected during water years 2006–07. Glyphosate and AMPA were not included in the sample analysis for samples collected during water year 2008. Herbicides 2,4-D and pendimethalin were detected in more than 50 percent of all samples at both sites.

Pesticide runoff loads and yields were computed by using equations 3 and 4, respectively, for atrazine, glyphosate, and pendimethalin. For sampled events, sample concentrations were used to estimate runoff loads. For unsampled runoff, seasonal event-median concentrations (table 19) were used to estimate runoff loads. The preharvest season comprises January–June; the harvest/postharvest season comprises July–September. No samples were collected from October through December. Monthly and annual estimates of selected pesticide runoff loads are listed in table 20.

Annual and average annual application rates and runoff yields for selected pesticides are listed in table 21. Similar to results for nutrients and suspended sediment, runoff yields of the herbicides atrazine, glyphosate, and pendimethalin were greater for the West Oso Creek subwatershed than for the Oso Creek tributary subwatershed. Of all pesticides detected in runoff, the highest runoff yields were for glyphosate, 0.012 (lb/acre)/yr for the West Oso Creek subwatershed and 0.001 (lb/acre)/yr for the Oso Creek tributary subwatershed. Average annual runoff yields of atrazine were 0.002 and 0.0003 (lb/acre)/yr, respectively, from the West Oso Creek and Oso Creek tributary subwatersheds. Comparison of applications and runoff yields indicates that, for water years 2006–08, about 0.9 percent of glyphosate applied to the West Oso Creek

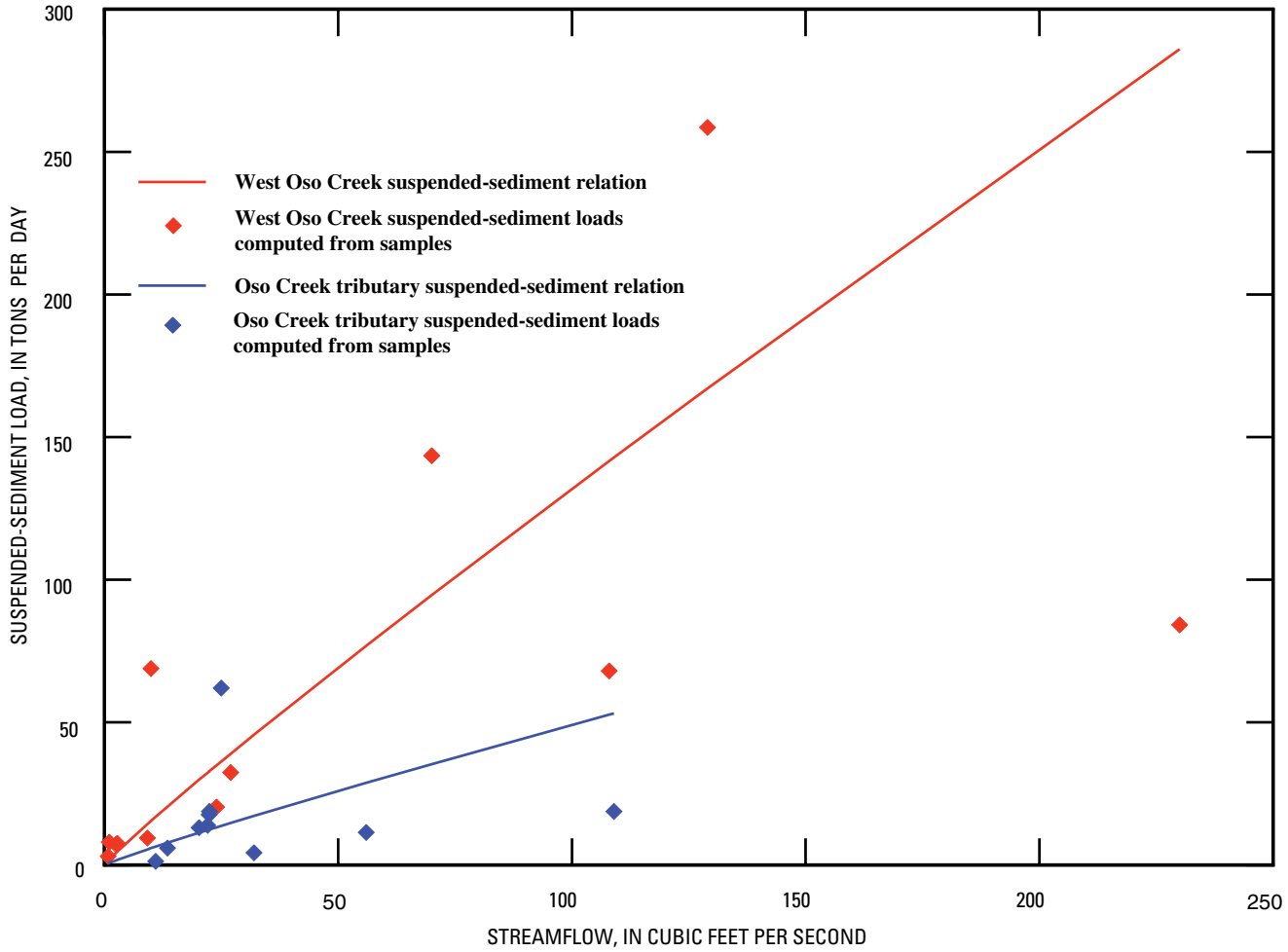

Figure 9. Relations between suspended-sediment load and streamflow for West Oso Creek (station 08211517) and Oso Creek tributary (station 082115725) subwatersheds, Nueces County, Texas, water years 2006–08.

subwatershed croplands was detected in runoff. For the Oso Creek tributary subwatershed, about 0.08 percent of applied glyphosate was detected in runoff. The percentages of applied atrazine in runoff were about 0.4 and 0.05, respectively, in the West Oso Creek and Oso Creek tributary subwatersheds. Applied pendimethalin in runoff was estimated to be 0.08 and 0.008 percent, respectively, in the West Oso Creek and Oso Creek tributary subwatersheds.

Estimated runoff loads and yields of selected pesticides for water years 2006–07 were revised from estimates published in the previous report on the study subwatersheds (Ockerman, 2008). Runoff-quality data collected since the previous report, along with previous data, were used to estimate median concentrations that were then used to compute runoff loads during unsampled events. This resulted in revisions to 2006–07 load and yield estimates. The 2006–07 average annual runoff yield for atrazine was unchanged for the West Oso Creek subwatershed. The 2006–07 average annual runoff yield for atrazine for the Oso Creek tributary subwatershed was revised to 0.00023 (lb/acre)/yr, compared with a previous estimate of 0.00012 (lb/acre)/yr. No additional sample data were collected for glyphosate since the previous study, so runoff load and yield estimates for glyphosate did not change from the previous report.

Bacteria

Seventeen bacteria samples were collected during the study, 10 from the West Oso Creek subwatershed outlet site and 7 from the Oso Creek tributary subwatershed outlet site (table 22). Summary statistics of bacteria sample analysis results are shown in table 23. Table 23 also shows 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 densities were greater at the West Oso Creek subwatershed than at the Oso Creek tributary subwatershed. Bacteria loads and yields were not estimated because bacteria samples were collected near the beginning of runoff events, and concentrations

Table 12. Fertilizer applications, rainfall deposition, and runoff yields of total nitrogen and total phosphorus for West Oso Creek and Oso Creek tributary subwatersheds, Nueces County, Texas, water years 2006–08.

[lb/acre, pounds per acre; (lb/acre)/yr, pounds per acre per year; <, less than]

Subwatershed and period	Fertilizer application	Rainfall deposition	Runoff yield
Total nitrogen			
West Oso Creek			
Water year 2006, lb/acre	71.3	4.57	1.39
Water year 2007, lb/acre	65.6	6.47	4.26
Water year 2008, lb/acre	59.6	3.76	2.22
2006–08 average, (lb/acre)/yr	65.5	4.93	2.62
Oso Creek tributary			
Water year 2006, lb/acre	68.7	3.48	.753
Water year 2007, lb/acre	62.9	5.56	1.28
Water year 2008, lb/acre	57.5	3.03	.484
2006–08 average, (lb/acre)/yr	63.0	4.02	.839
Area-weighted average, both subwatersheds, 2006–08, (lb/acre)/yr	64.2	4.47	1.72
Total phosphorus			
West Oso Creek			
Water year 2006, lb/acre	15.4	<.06	.416
Water year 2007, lb/acre	14.3	<.09	1.08
Water year 2008, lb/acre	11.1	<.04	.435
2006–08 average, (lb/acre)/yr	13.6	<.07	.644
Oso Creek tributary			
Water year 2006, lb/acre	14.6	<.06	.318
Water year 2007, lb/acre	12.9	<.09	.673
Water year 2008, lb/acre	10.8	<.06	.267
2006–08 average, (lb/acre)/yr	12.8	<.07	.419
Area-weighted average, both subwatersheds, 2006–08, (lb/acre)/yr	13.2	<.07	.530

might not be representative of bacteria conditions throughout the runoff events. Most sample bacteria densities exceeded TSWQS (table 23). The TSWQS listed in table 23 apply to Oso Bay and Oso Creek and are not technically applicable to the study subwatersheds. Also, because runoff and associated bacteria densities represent relatively brief and infrequent conditions, the resulting effect on downstream receiving waters (Oso Bay and Oso Creek) is not known. However, the relatively large bacteria densities (compared to TSWQS) indicate that runoff from these subwatersheds has the potential to contribute bacteria to Oso Bay and Oso Creek.

Table 13. Results of analyses for samples of suspended sediment in runoff from West Oso Creek (station 08211517) and Oso Creek tributary (station 08211525) subwatersheds, Nueces County, Texas, water years 2006–08.

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

Sample collection date	Collection time	Discharge (ft^3/s)	Concentration (mg/L)	Percentage silt and clay, by weight
West Oso Creek subwatershed				
June 1, 2006	1400	129	745	96
	1140	27	447	99
	1600	24	315	97
July 3, 2006	1717	.81	1,400	99
Jan. 4, 2007	1145	2.8	1,005	100
	1530	2.5	1,070	100
Jan. 25, 2007	0900	9.2	383	97
Mar. 14, 2007	1430	10	2,560	99
July 2, 2007	1845	108	234	72
July 3, 2007	0945	230	136	73
Mar. 11, 2008	0445	1.1	2,720	99
July 24, 2008	1300	70	762	99
Oso Creek tributary subwatershed				
June 1, 2006	1710	25	923	97
Sept. 15, 2006	1400	22.4	293	99
	1505	22.5	311	99
	1730	22.1	234	99
	1930	20.3	239	96
Sept. 16, 2006	0730	13.5	163	96
Jan. 4, 2007	1415	8.1	484	97
Jan. 25, 2007	0700	24.8	200	100
Mar. 14, 2007	1700	10	1,504	98
July 3, 2007	1930	32	50	99
July 4, 2007	0830	56	76	100
Aug. 30, 2007	0800	11	44	99
Mar. 11, 2008	1400	3.8	882	99
July 24, 2008	1700	109	64	87

Table 14. Regression equations relating suspended-sediment load to streamflow for West Oso Creek (station 08211517) and Oso Creek tributary (station 08211525) subwatersheds, Nueces County, Texas, water years 2006–08.

[L, load in tons per day; Q, streamflow in cubic feet per second]

Subwatershed	Equation	Coefficient of determination (R-squared)	Residual standard error (tons per day)
West Oso Creek	$L = 1.82 \times Q^{0.93}$	0.80	71
Oso Creek tributary	$L = 0.71 \times Q^{0.92}$	.64	20

Table 15. Estimated monthly and annual runoff suspended-sediment loads, West Oso Creek (station 08211517) and Oso Creek tributary (station 08211525) subwatersheds, Nueces County, Texas, water years 2006–08.

[In tons]

Water year	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Annual
West Oso Creek subwatershed													
2006	0	74	0	0	0	0	0	0	187	9.2	1.3	627	898
2007	.6	0	0	54	.04	36	0	1.0	0	1,827	63	253	2,230
2008	25	0	0	0	0	10	0	0	0	66	798	0	899
Oso Creek tributary subwatershed													
2006	16	5.8	0	0	0	0	0	0	10	2.7	0	266	300
2007	10	0	0	45	1.0	11	0	2.4	0	399	14	60	542
2008	26	0	0	0	0	9	0	0	0	178	21	23	257

Table 16. Annual and average annual runoff yields of suspended sediment, West Oso Creek (station 08211517) and Oso Creek tributary (station 08211525) subwatersheds, Nueces County, Texas, water years 2006–08.

[In pounds per acre per year]

Subwatershed	Water year 2006	Water year 2007	Water year 2008	Water years 2006–08 average
West Oso Creek	349	867	350	522
Oso Creek tributary	113	205	97	139

Table 17. Pesticides used in West Oso Creek and Oso Creek tributary subwatersheds, Nueces County, Texas, water years 2006–08.

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

Herbicides	Insecticides	Defoliants, desicants, growth regulators
2,4-D	*Acephate	*Ethephon
Atrazine	*Acetamiprid	*Mepiquat chloride
Glyphosate	*Cyfluthrin	*Mepiquat pentaborate
Glufosinate-ammonium	*Deltamethrin	*Thidiazuron
*Prosulfuron	Dicrotophos	*Thidiazuron + diuron
Pendimethalin	Imidacloprid	*Paraquat chloride
Prometryn	Malathion	
Trifluralin	Myclobutanil[1]	
	Propoxur[2]	
	*Thiamethoxam	
	Zeta-cypermethrin	

[1] Fungicide used primarily for residential applications.

[2] Insecticide used primarily for residential applications.

Table 18. Summary statistics of concentrations of selected pesticides in runoff samples from West Oso Creek (station 08211517) and Oso Creek tributary (station 08211525) subwatersheds, Nueces County, Texas, water years 2006–08.

[µg/L, micrograms per liter; --, not computed; <, less than]

Pesticide	Number of samples	Number of detections	Mean (µg/L)	Median (µg/L)	Minimum (µg/L)	Maximum (µg/L)
West Oso Creek subwatershed						
Herbicides						
2,4-D	12	8	--	0.09	<0.02	6.24
2-Chloro-4-isopropylamino-6-amino-s-triazine (CIAT)	12	12	0.07	.05	.015	.18
2-Chloro-6-ethylamino-4-amino-s-triazine (CEAT)	12	2	<.08	<.08	<.08	<.08
2-Hydroxy-4-isopropylamino-6-ethylamino-s-triazine (OIET)	12	11	.17	.11	<.04	.529
Acifluorfen	12	1	<.06	<.06	<.028	<.06
Aldicarb sulfoxide	12	1	<.04	<.04	<.04	<.04
Aminomethylphosphonic acid (AMPA)	10	10	5.44	3.60	1.13	13.2
Atrazine	12	12	.98	.120	.02	8.90
Benfluralin	12	1	<.01	<.01	<.01	<.01
Dimethyl tetrachloroterephthalate (DCPA)	12	2	<.003	<.003	<.003	.004
Diuron	12	2	<.04	<.04	<.01	.08
Dinoseb	12	1	<.04	<.04	<.04	<.04
Glufosinate	10	2	--	<.14	<.14	.58
Glyphosate	10	10	17.6	8.51	1.81	53.5
Metolachlor	12	4	--	<.006	<.010	.228
Metribuzin	12	1	<.028	<.028	<.028	<.028
Pendimethalin	12	9	--	.33	<.020	13.7
Simazine	12	4	--	<.006	<.005	.022
Trifluralin	12	4	--	<.009	<.009	.05
Insecticides						
Dicrotophos	12	1	<.08	<.08	<.08	<.08
Imidacloprid	12	1	--	<.060	<.020	.086
Myclobutanil	12	1	--	<.0334	<.033	<.033
Propoxur	12	1	--	<.004	<.004	<.005

Table 18. Summary statistics of concentrations of selected pesticides in runoff samples from West Oso Creek (station 08211517) and Oso Creek tributary (station 08211525) subwatersheds, Nueces County, Texas, water years 2006–08—Continued.

Pesticide	Number of samples	Number of detections	Mean (µg/L)	Median (µg/L)	Minimum (µg/L)	Maximum (µg/L)
Oso Creek tributary subwatershed						
Herbicides						
2,4-D	12	8	--	<0.05	<0.02	1.23
2-Chloro-4-isopropylamino-6-amino-s-triazine (CIAT)	12	12	0.107	.062	.009	.562
2-Chloro-6-ethylamino-4-amino-s-triazine (CEAT)	12	3	--	<.08	<.08	.11
2-Hydroxy-4-isopropylamino-6-ethylamino-s-triazine (OIET)	12	12	.257	.200	.021	.902
3,4 Dichloroaniline	12	1	--	<.004	<.004	.006
Aminomethylphosphonic acid (AMPA)	8	8	.90	.60	.35	1.94
Atrazine	12	12	1.94	.254	.012	10.5
Bromacil	12	1	--	<.04	<.02	.05
Carbaryl	12	4	<.02	<.02	<.02	<.02
Dimethyl tetrachloroterephthalate (DCPA)	12	1	<.003	<.003	<.003	.004
Dicamba	12	1	--	<.04	<.04	.97
Diuron	12	3	--	<.04	<.02	.10
Glyphosate	8	8	2.56	1.08	.59	10.6
Metolachlor	12	3	--	<.010	<.006	.008
Pendimethalin	12	8	--	.040	<.012	.144
Simazine	12	5	--	<.006	<.005	.064
Terbuthylazine	12	1	--	<.01	<.01	.02
Trifluralin	12	4	--	<.009	<.009	.054
Insecticides						
Azinphos-methyl	9	1	<.05	<.05	<.05	<.08
Dicrotophos	12	1	<.08	<.08	<.08	<.08
Malathion	12	2	--	<.016	<.016	2.64
Fipronil sulfide	12	1	--	<.013	<.013	<.013
Malaoxon	12	1	--	<.039	<.039	.049
Myclobutanil	12	2	--	<.033	<.010	<.033

Table 19. Event-median concentrations of selected pesticides in runoff samples from West Oso Creek (station 08211517) and Oso Creek tributary (station 08211525) subwatersheds, Nueces County, Texas, by season (preharvest or harvest/postharvest), water years 2006–08, used to estimate runoff loads for unsampled events.

[In micrograms per liter]

Pesticide	Season median concentration		Median concentration, all samples
	Preharvest (Jan.–June)	Harvest/postharvest (July–Sept.)	
West Oso Creek subwatershed			
Atrazine	0.198	0.097	0.120
Glyphosate	5.10	12.6	8.51
Pendimethalin	1.28	.210	.334
Oso Creek tributary subwatershed			
Atrazine	1.88	.194	.254
Glyphosate	1.34	1.08	1.08
Pendimethalin	.091	.020	.040

Table 20. Estimated monthly and annual runoff loads of selected pesticides from West Oso Creek (station 08211517) and Oso Creek tributary (station 08211525) subwatersheds, Nueces County, Texas, water years 2006–08.

[In pounds]

Pesticide	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Annual
West Oso Creek subwatershed													
Water year 2006													
Atrazine	0	0.028	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	.581	.104	21.5	27.2
Pendimethalin	0	.06	0	0	0	0	0	0	.015	.043	.002	.728	.85
Water year 2007													
Atrazine	.0002	0	0	.010	0	.034	0	.0004	0	28.4	.023	.102	28.6
Glyphosate	.023	0	0	.448	0	.703	0	.153	0	92.5	2.85	12.8	109
Pendimethalin	.0004	0	0	.483	0	.003	0	.007	0	1.20	.05	.21	1.95
Water year 2008													
Atrazine	.008	0	0	0	0	.035	0	0	0	.023	.317	0	.38
Glyphosate	1.08	0	0	0	0	.466	0	0	0	3.18	41.2	0	45.9
Pendimethalin	.018	0	0	0	0	.015	0	0	0	.064	.70	0	.78
Oso Creek tributary subwatershed													
Water year 2006													
Atrazine	.032	.010	0	0	0	0	0	0	.170	.007	0	.086	.30
Glyphosate	.176	.053	0	0	0	0	0	0	.055	.014	0	2.34	2.64
Pendimethalin	.003	.001	0	0	0	0	0	0	.002	.001	0	.134	.14
Water year 2007													
Atrazine	.017	0	0	.009	0	.897	0	.004	0	.82	.091	.170	2.01
Glyphosate	.096	0	0	.335	.005	.364	0	.024	0	8.24	.234	.677	10.0
Pendimethalin	.002	0	0	.056	.001	.013	0	0	0	.085	.063	.071	.290
Water year 2008													
Atrazine	.044	0	0	0	0	.774	0	0	0	.69	.06	.10	1.67
Glyphosate	.242	0	0	0	0	.099	0	0	0	2.06	.24	.23	2.88
Pendimethalin	.005	0	0	0	0	.005	0	0	0	.04	.06	.004	.11

Table 21. Estimated annual and average annual application rates and runoff yields of selected pesticides from West Oso Creek and Oso Creek tributary subwatersheds, Nueces County, Texas, water years 2006–08.

[In pounds per acre per year]

Pesticide	Water year 2006		Water year 2007		Water year 2008		Water years 2006–08 average	
	Application	Runoff yield	Application	Runoff yield	Application	Runoff yield	Application	Runoff yield
West Oso Creek subwatershed (5,145 acres)								
Atrazine	0.54	0.0002	0.58	0.006	0.52	0.00007	0.55	0.002
Glyphosate	1.40	.005	1.85	.021	.86	.009	1.37	.012
Pendimethalin	.39	.0002	.36	.0004	.37	.0002	.37	.0003
Oso Creek tributary subwatershed (5,287 acres)								
Atrazine	.54	.00006	.67	.0004	.49	.0003	.57	.0003
Glyphosate	1.42	.0005	1.65	.002	.72	.0005	1.26	.001
Pendimethalin	.38	.00003	.27	.00005	.50	.00002	.38	.00003
Area-weighted average, both subwatersheds, 2006–08								
Atrazine							.56	.001
Glyphosate							1.31	.006
Pendimethalin							.38	.0002

Table 22. Bacteria densities in runoff samples from West Oso Creek (station 08211517) and Oso Creek tributary (station 08211525) subwatersheds, Nueces County, Texas, water years 2006–08.

[CFU/100 mL, colony forming units per 100 milliliters; *E. coli*, *Escherichia coli*; --, not analyzed for]

Sample collection date	Collection time	Fecal coliform (CFU/100 mL)	*E. coli* (CFU/100 mL)	*Enterococci* (CFU/100 mL)
West Oso Creek subwatershed				
July 7, 2006				
(primary sample)	1015	320	46	59,000
(lab duplicate)	1015	--	--	107,000
(average concentration)	1015	320	46	83,000
July 27, 2006				
(primary sample)	0935	31,000	4,700	127,000
(field split sample)	0935	42,000	9,000	154,000
(lab duplicate of primary sample)	0935	--	--	145,000
(average concentration)	0935	36,500	6,850	142,000
Sept. 18, 2006				
(primary sample)	0918	60,000	84,000	96,000
(field split sample)	0918	46,000	100,000	88,000
(average concentration)	0918	53,000	92,000	92,000
Jan. 4, 2007				
(primary sample)	1154	6,000	7,600	21,000
(lab duplicate)	1154	14,000	--	--
(average concentration)	1154	10,000	7,600	21,000
Jan. 25, 2007				
(primary sample)	0900	44,000	39,000	64,000
(lab duplicate)	0900	45,000	--	--
(average concentration)	0900	44,500	39,000	64,000

Table 22. Bacteria densities in runoff samples from West Oso Creek (station 08211517) and Oso Creek tributary (station 08211525) subwatersheds, Nueces County, Texas, water years 2006–08—Continued.

Sample collection date	Collection time	Fecal coliform (CFU/100 mL)	*E. coli* (CFU/100 mL)	*Enterococci* (CFU/100 mL)
West Oso Creek subwatershed—Continued				
May 25, 2007				
(primary sample)	1512	304	391	5,200
(lab duplicate)	1512	761	--	--
(average concentration)	1512	532	391	5,200
July 7, 2007				
(primary sample)	1150	--	15,600	45,000
(field split sample)	1150	--	5,800	83,000
(lab duplicate of primary sample)	1150	--	7,200	49,000
(average concentration)	1150	--	9,530	59,000
Aug. 30, 2007				
(primary sample)	1540	82,000	12,500	145,000
(field split sample)	1540	69,000	69,000	143,000
(lab duplicate of primary sample)	1540	--	30,000	--
(average concentration)	1540	75,500	37,200	144,000
July 24, 2008				
(primary sample)	1015	10,200	1,550	127,000
(field split sample)	1015	9,800	1,125	197,000
(average concentration)	1015	10,000	1,338	162,000
Aug. 18, 2008				
(primary sample)	0935	<63	250	11,600
(field split sample)	0935	<63	125	11,500
(average concentration)	0935	<63	188	11,600
Oso Creek tributary subwatershed				
July 7, 2006				
(primary sample)	1110	145	80	4,800
(field split sample)	1110	253	77	5,200
(lab duplicate)	1110	--	53	--
(lab duplicate of primary sample)	1110	83	--	--
(average concentration)	1110	160	70	5,000
Sept. 15, 2006				
(primary sample)	1000	3,600	16,000	25,000
(field split sample)	1000	8,000	21,000	28,000
(lab duplicate of primary sample)	1000	--	--	25,000
(average concentration)	1000	5,800	18,500	26,000
Jan. 4, 2007				
(primary sample)	1217	4,300	5,300	31,000
(field split sample)	1217	2,780	3,000	39,000
(average concentration)	1217	3,540	4,150	35,000
Jan. 25, 2007				
(primary sample)	0920	14,900	4,100	22,000
July 2, 2007				
(primary sample)	1150	--	5,000	75,000
July 24, 2008 (primary sample)	1100	1,600	933	71,000
(field split sample)	1100	--	--	83,000
(average concentration)	1100	1,600	933	77,000
Aug. 18, 2008				
(primary sample)	1015	<63	188	10,800
(field split sample)	1015	<63	313	5,800
(average concentration)	1015	<63	250	8,300

Table 23. Summary statistics of bacteria densities in runoff samples from West Oso Creek (station 08211517) and Oso Creek tributary (station 08211525) subwatersheds, Nueces County, Texas, water years 2006–08; and Texas surface-water-quality standards for bacteria in Oso Bay and Oso Creek, Texas Commission on Environmental Quality segments 2485 and 2485A, respectively.

[CFU/100 mL, colony forming units per 100 milliliters; TSWQS, Texas surface-water-quality standard; <, less than; *E. coli*, *Escherichia coli*]

Bacteria	Number of samples	Mean (CFU/100 mL)	Median (CFU/100 mL)	Minimum (CFU/100 mL)	Maximum (CFU/100 mL)	TSWQS[1] (CFU/100 mL) for receiving waters of Oso Bay and Oso Creek
West Oso Creek subwatershed						
Fecal coliform	9	25,600	10,000	<63	75,500	[2]200/400
E. coli	10	19,400	7,220	46	92,000	[3]126/394
Enterococci	10	78,400	73,500	5,200	162,000	[4]35/89
Oso Creek tributary subwatershed						
Fecal coliform	6	4,340	2,570	<63	14,900	[2]200/400
E. coli	7	4,720	4,100	70	18,500	[3]126/394
Enterococci	7	35,500	26,000	5,000	77,000	[4]35/89

[1] Texas Commission on Environmental Quality (2006).

[2] Geometric mean of fecal coliform should not exceed 200 CFU/100 mL; single samples should not exceed 400 CFU/100 mL (freshwater, contact recreation criteria).

[3] Geometric mean of *E. coli* should not exceed 126 CFU/100 mL; single samples should not exceed 394 CFU/100 mL (freshwater, contact recreation criteria).

[4] Geometric mean of *Enterococci* should not exceed 35 CFU/100 mL; single samples should not exceed 89 CFU/100 mL (saltwater, contact recreation criteria).

Summary

During water years 2006–08 (October 2005–September 2008), the U.S. Geological Survey (USGS), in cooperation with the Texas State Soil and Water Conservation Board, Coastal Bend Bays and Estuaries Program (CBBEP), and Texas AgriLife Research and Extension Center at Corpus Christi, studied hydrologic conditions and water quality of rainfall and storm runoff of two primarily agricultural subwatersheds of the Oso Creek watershed in Nueces County, Texas. One area, the upper West Oso Creek subwatershed, is about 5,145 acres. The other area, a subwatershed drained by an unnamed tributary to Oso Creek (hereinafter, Oso Creek tributary), is about 5,287 acres.

Rainfall and runoff (streamflow) were continuously monitored at USGS stations at the outlets of the study subwatersheds during the 3-year study. Seventeen rainfall samples were collected and analyzed for nutrients and major inorganic ions. Twenty-four composite runoff samples were collected and analyzed for nutrients, major inorganic ions, and pesticides. Twenty-six discrete suspended-sediment samples were collected and analyzed, and 17 bacteria samples were collected and analyzed for fecal coliform, *Escherichia coli* (*E. coli*), and *Enterococcus*. These rainfall, streamflow, and water-quality data were used to estimate loads of selected constituents entering the study subwatersheds in rainfall and exiting the subwatersheds in runoff. Data on applications of fertilizers to croplands in the study subwatersheds were compiled and compared with quantities of nutrients in rainfall deposition and runoff yields, and data on applications of pesticides were compiled and compared with quantities of pesticides in runoff yields.

For the study period, total rainfall was greater than average, although annual rainfall was less than average in each of water years 2006 and 2008, and monthly rainfall was less than average during 23 of the 36 months. Runoff in the subwatersheds during water years 2006–08 corresponded to rainfall patterns, with periods of runoff interspersed between considerable periods of no runoff. Most of the runoff from the two subwatersheds occurred in response to a few temporally isolated storm periods. More than 60 percent of the runoff from each subwatershed 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. The West Oso Creek subwatershed produced more runoff during the study period than the Oso Creek tributary subwatershed, 13.95 in. compared with 9.45 in. Runoff response was quicker and peak flows were larger in the West Oso Creek subwatershed than in the Oso Creek tributary subwatershed.

Most of the nitrogen in rainfall was in the form of dissolved ammonia and dissolved nitrate, which were detected in all samples. Median concentrations of ammonia and nitrate were 0.17 and 0.12 mg/L, respectively. Organic forms of nitrogen were detected in all samples at relatively low concentrations; the median value of total organic nitrogen was 0.08 mg/L. Nitrite was detected in less than one-half of the samples at low concentrations; the median concentration was less than 0.002 mg/L. Total phosphorus was detected in about one-half of the samples at relatively low concentrations; the median concentration was less than 0.007 mg/L.

Based on rainfall volumes in the study subwatersheds and sample concentrations, daily total nitrogen and total phosphorus deposition were computed for each subwatershed. The average (area-weighted) annual total nitrogen deposition for both subwatersheds over the 3-year study period was 4.47 (lb/acre)/yr, compared with less than 0.07 (lb/acre)/yr for total phosphorus.

Statistical tests (Wilcoxon rank-sum tests) indicate significant differences in median values of event-mean runoff concentrations between the two subwatersheds. Nitrogen concentrations in runoff were greater at the West Oso Creek site than at the Oso Creek tributary site. Major inorganic ion concentrations were greater at the Oso Creek tributary site than at the West Oso Creek site. There was no significant difference in total phosphorus concentrations between the subwatersheds.

Runoff loads and yields were computed for selected nutrients. Total nitrogen runoff yield for the 3-year study period averaged 2.62 (lb/acre)/yr from the West Oso Creek subwatershed and 0.839 (lb/acre)/yr from the Oso Creek tributary subwatershed. Total phosphorus yields from the West Oso Creek and Oso Creek tributary subwatersheds for the 3-year period were 0.644 and 0.419 (lb/acre)/yr, respectively. Runoff yields of nitrogen and phosphorus were relatively small compared to inputs of nitrogen in fertilizer and rainfall deposition. Average annual runoff yield of total nitrogen (subwatersheds combined) represents about 2.5 percent of nitrogen applied as fertilizer and nitrogen entering the subwatersheds through rainfall deposition. Average annual runoff yield of total phosphorus (subwatersheds combined) represents about 4.0 percent of the phosphorus in applied fertilizer and rainfall deposition.

Suspended-sediment yields from the West Oso Creek subwatershed were more than three times those from the Oso Creek tributary subwatershed. The average suspended-sediment yield from the West Oso Creek subwatershed was 522 (lb/acre)/yr. The average suspended-sediment yield from the Oso Creek tributary subwatershed was 139 (lb/acre)/yr.

Thirty-two pesticide compounds (24 herbicides and 8 insecticides) were detected in runoff samples collected from the two subwatersheds. At the West Oso Creek subwatershed, 23 pesticides were detected (19 herbicides and 4 insecticides). At the Oso Creek tributary subwatershed, 24 pesticides were detected (18 herbicides and 6 insecticides). Of the 32 pesticides detected during the study, 14 of the pesticides were detected in only one sample (at either one or the other subwatershed site). All of these 14 detections were at low concentrations (near the minimum laboratory reporting level). Two herbicides were detected in all samples: atrazine and atrazine degradation byproduct 2-chloro-4-isopropylamino-6-amino-s-triazine (CIAT). Glyphosate and glyphosate byproduct aminomethylphosphonic acid (AMPA) were detected in all samples collected during water years 2006–07. However, these compounds were not included in the analyses of samples collected during water year 2008. Herbicides 2,4-D and pendimethalin were detected in more than 50 percent of the samples.

Runoff yields of the herbicides glyphosate, atrazine, and pendimethalin were greater for the West Oso Creek subwatershed than for the Oso Creek tributary subwatershed. Of all pesticides detected in runoff, the highest runoff yields were for glyphosate: 0.012 (lb/acre)/yr for the West Oso Creek subwatershed and 0.001 (lb/acre)/yr for the Oso Creek tributary subwatershed. Comparison of applications and runoff yields indicates that, for water years 2006–08, about 0.9 percent of glyphosate applied to the West Oso Creek subwatershed croplands was detected in runoff. For the Oso Creek tributary subwatershed, about 0.08 percent of applied glyphosate was detected in runoff.

At both subwatershed outlet sites, most sample concentrations of fecal coliform, *E. coli*, and *Enterococci* were greater than Texas surface-water-quality standards for those bacteria established for the receiving waters of Oso Creek and Oso Bay. Because runoff and associated bacteria densities represent relatively brief and infrequent conditions, the resulting effect on Oso Bay and Oso Creek is not known. However, the relatively large bacteria densities (compared to Texas surface-water-quality standards) indicate that runoff from the study subwatersheds is a potential source of bacteria for Oso Bay and Oso Creek.

Estimates of rainfall nitrogen deposition and runoff loads and yields of nutrients, suspended sediment, and pesticides for 2006–07 from the previous report of the study subwatersheds were revised, based on the collection and analysis of additional data during the 2008 water year. The new data were used to revise the relations used to estimate deposition and loads during unsampled events, resulting in revised estimates of deposition, loads, and yields.

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Appendixes 1–3

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Appendix 1. Quality control and assurance data for rainfall samples collected at Texas AgriLife Research at Corpus Christi (station 08211511); and for runoff samples collected at West Oso Creek (station 08211517) and Oso Creek tributary (station 08211525), Nueces County, Texas, water years 2006–08.

[unfltrd, unfiltered; µS/cm, microsiemens per centimeter at 25 degrees Celsius; fltrd, filtered; mg/L, milligrams per liter; E, estimated, <, less than; --, not analyzed; N, nitrogen; P, phosphorus; µg/L, micrograms per liter; CIAT, 2-chloro-4-isopropylamino-6-amino-s-triazine; CEAT, 2-chloro-6-ethylamino-4-amino-s-triazine; OIET, 2-hydroxy-4-isopropylamino-6-ethylamino-s-triazine; DCPA, dimethyl tetrachloroterephthalate; MCPA, 4-chloro-2-methylphenoxy acetic acid; MCPB, 4-(2-methyl-4-chlorophenoxy)butyric acid]

Date	Sample type	pH, water, unfltrd, lab (standard units)	Specific conductance, unfltrd, lab (µS/cm)	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)
Station 08211511—Texas AgriLife Research at Corpus Christi, Tex.								
Mar. 28, 2006	Blank	8.5	3	0.11	E0.005	E0.005	0.26	<0.01
Oct. 25, 2007	Blank	6.1	5	<.04	<.02	.006	<.12	<.01
Station 08211517—West Oso Creek at Merrett Road near Corpus Christi, Tex.								
Nov. 20, 2006	Blank	--	--	--	--	--	--	--
Oct. 25, 2007	Blank	5.8	5	<.04	<.02	.007	<.12	<.01
Station 08211525—Unnamed Oso Creek tributary at Farm Road 2444 near Corpus Christi, Tex.								
Mar. 28, 2006	Blank	9.5	14	<.04	.02	.03	<.12	<.01

Date	Sample type	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, unfltrd (mg/L as N)	Ammonia, water, fltrd (mg/L as N)	Nitrite + nitrate, water, fltrd (mg/L as N)
Station 08211511—Texas AgriLife Research at Corpus Christi, Tex.								
Mar. 28, 2006	Blank	0.03	--	<0.01	<0.10	<0.10	<0.01	<0.016
Oct. 25, 2007	Blank	<.01	<0.02	<.01	E.08	<.02	<.02	<.016
Station 08211517—West Oso Creek at Merrett Road near Corpus Christi, Tex.								
Nov. 20, 2006	Blank	--	--	--	--	--	--	--
Oct. 25, 2007	Blank	<.01	<.02	<.01	--	--	<.02	<.016
Station 08211525—Unnamed Oso Creek tributary at Farm Road 2444 near Corpus Christi, Tex.								
Mar. 28, 2006	Blank	.03	.03	<.01	--	--	<.01	<.016

Date	Sample type	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)	Ortho-phosphate, water, fltrd (mg/L as P)	Phosphorus, water, unfltrd (mg/L as P)
Station 08211511—Texas AgriLife Research at Corpus Christi, Tex.								
Mar. 28, 2006	Blank	<0.002	--	--	--	--	<0.006	<0.004
Oct. 25, 2007	Blank	<.002	--	--	--	--	<.006	<.008
Station 08211517—West Oso Creek at Merrett Road near Corpus Christi, Tex.								
Nov. 20, 2006	Blank	--	--	--	--	--	--	--
Oct. 25, 2007	Blank	<.002	--	--	--	--	<.006	--
Station 08211525—Unnamed Oso Creek tributary at Farm Road 2444 near Corpus Christi, Tex.								
Mar. 28, 2006	Blank	E.001	--	--	--	--	<.006	--

Appendix 1. Quality control and assurance data for rainfall samples collected at Texas AgriLife Research at Corpus Christi (station 08211511); and for runoff samples collected at West Oso Creek (station 08211517) and Oso Creek tributary (station 08211525), Nueces County, Texas, water years 2006–08—Continued.

Date	Sample type	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)	2-Chloro-2,6-diethyl acetanilide, water, fltrd (µg/L)	CIAT, water, fltrd (µg/L)
Station 08211511—Texas AgriLife Research at Corpus Christi, Tex.								
Mar. 28, 2006	--	--	--	--	--	--	--	--
Oct. 25, 2007	--	--	--	--	--	--	--	--
Station 08211517—West Oso Creek at Merrett Road near Corpus Christi, Tex.								
Nov. 20, 2006	Blank	<0.09	<0.19	<0.04	<0.02	<0.006	<0.006	<0.014
Oct. 25, 2007	--	--	--	--	--	--	--	--
Station 08211525—Unnamed Oso Creek tributary at Farm Road 2444 near Corpus Christi, Tex.								
Mar. 28, 2006	--	--	--	--	--	--	--	--

Date	Sample type	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-2-methyl phenol, water, fltrd (µg/L)	Acetochlor, water, fltrd (µg/L)
Station 08211511—Texas AgriLife Research at Corpus Christi, Tex.								
Mar. 28, 2006	--	--	--	--	--	--	--	--
Oct. 25, 2007	--	--	--	--	--	--	--	--
Station 08211517—West Oso Creek at Merrett Road near Corpus Christi, Tex.								
Nov. 20, 2006	Blank	<0.08	<0.010	<0.08	<0.004	<0.008	<0.005	<0.006
Oct. 25, 2007	--	--	--	--	--	--	--	--
Station 08211525—Unnamed Oso Creek tributary at Farm Road 2444 near Corpus Christi, Tex.								
Mar. 28, 2006	--	--	--	--	--	--	--	--

Date	Sample type	Acifluorfen, water, fltrd (µg/L)	Alachlor, water, fltrd (µg/L)	Aldicarb sulfone, water, fltrd (µg/L)	Aldicarb sulfoxide, water, fltrd (µg/L)	Aldicarb, water, fltrd (µg/L)	Atrazine, water, fltrd (µg/L)	Azinphos-methyl oxon, water, fltrd (µg/L)
Station 08211511—Texas AgriLife Research at Corpus Christi, Tex.								
Mar. 28, 2006	--	--	--	--	--	--	--	--
Oct. 25, 2007	--	--	--	--	--	--	--	--
Station 08211517—West Oso Creek at Merrett Road near Corpus Christi, Tex.								
Nov. 20, 2006	Blank	<0.06	<0.005	<0.08	<0.04	<0.04	<0.007	<0.04
Oct. 25, 2007	--	--	--	--	--	--	--	--
Station 08211525—Unnamed Oso Creek tributary at Farm Road 2444 near Corpus Christi, Tex.								
Mar. 28, 2006	--	--	--	--	--	--	--	--

Appendix 1. Quality control and assurance data for rainfall samples collected at Texas AgriLife Research at Corpus Christi (station 08211511); and for runoff samples collected at West Oso Creek (station 08211517) and Oso Creek tributary (station 08211525), Nueces County, Texas, water years 2006–08—Continued.

Date	Sample type	Azinphos-methyl, water, fltrd (µg/L)	Bendiocarb, water, fltrd (µg/L)	Benfluralin, water, fltrd (µg/L)	Benomyl, water, fltrd (µg/L)	Bensulfuron methyl, water, fltrd (µg/L)	Bentazon, water, fltrd (µg/L)	Bromacil, water, fltrd (µg/L)
Station 08211511—Texas AgriLife Research at Corpus Christi, Tex.								
Mar. 28, 2006	--	--	--	--	--	--	--	--
Oct. 25, 2007	--	--	--	--	--	--	--	--
Station 08211517—West Oso Creek at Merrett Road near Corpus Christi, Tex.								
Nov. 20, 2006	Blank	<0.08	<0.04	<0.01	<0.02	<0.06	<0.02	<0.04
Oct. 25, 2007	--	--	--	--	--	--	--	--
Station 08211525—Unnamed Oso Creek tributary at Farm Road 2444 near Corpus Christi, Tex.								
Mar. 28, 2006	--	--	--	--	--	--	--	--

Date	Sample type	Bromoxynil, water, fltrd (µg/L)	Carbaryl, water, fltrd (µg/L)	Carbofuran, water, fltrd (µg/L)	Chloramben methyl ester, water, fltrd (µg/L)	Chlorimuron, water, fltrd (µg/L)	Chlorodiamino-s-triazine, water, fltrd (µg/L)	Chlorpyrifos oxon, water, fltrd (µg/L)
Station 08211511—Texas AgriLife Research at Corpus Christi, Tex.								
Mar. 28, 2006	--	--	--	--	--	--	--	--
Oct. 25, 2007	--	--	--	--	--	--	--	--
Station 08211517—West Oso Creek at Merrett Road near Corpus Christi, Tex.								
Nov. 20, 2006	Blank	<0.12	<0.02	<0.06	<0.10	<0.08	<0.12	<0.06
Oct. 25, 2007	--	--	--	--	--	--	--	--
Station 08211525—Unnamed Oso Creek tributary at Farm Road 2444 near Corpus Christi, Tex.								
Mar. 28, 2006	--	--	--	--	--	--	--	--

Date	Sample type	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)	Cypermethrin, water, fltrd (µg/L)	Dacthal mono-acid, water, fltrd (µg/L)
Station 08211511—Texas AgriLife Research at Corpus Christi, Tex.								
Mar. 28, 2006	--	--	--	--	--	--	--	--
Oct. 25, 2007	--	--	--	--	--	--	--	--
Station 08211517—West Oso Creek at Merrett Road near Corpus Christi, Tex.								
Nov. 20, 2006	Blank	<0.005	<0.01	<0.06	<.06	<0.053	<0.046	<0.02
Oct. 25, 2007	--	--	--	--	--	--	--	--
Station 08211525—Unnamed Oso Creek tributary at Farm Road 2444 near Corpus Christi, Tex.								
Mar. 28, 2006	--	--	--	--	--	--	--	--

Appendix 1. Quality control and assurance data for rainfall samples collected at Texas AgriLife Research at Corpus Christi (station 08211511); and for runoff samples collected at West Oso Creek (station 08211517) and Oso Creek tributary (station 08211525), Nueces County, Texas, water years 2006–08—Continued.

Date	Sample type	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)
Station 08211511—Texas AgriLife Research at Corpus Christi, Tex.								
Mar. 28, 2006	--	--	--	--	--	--	--	--
Oct. 25, 2007	--	--	--	--	--	--	--	--
Station 08211517—West Oso Creek at Merrett Road near Corpus Christi, Tex.								
Nov. 11, 2006	Blank	<0.003	<0.012	<0.005	<0.08	<0.04	<0.08	<0.009
Oct. 25, 2007	--	--	--	--	--	--	--	--
Station 08211525—Unnamed Oso Creek tributary at Farm Road 2444 near Corpus Christi, Tex.								
Mar. 28, 2006	--	--	--	--	--	--	--	--

Date	Sample type	Dimethoate, water, fltrd (µg/L)	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)
Station 08211511—Texas AgriLife Research at Corpus Christi, Tex.								
Mar. 28, 2006	--	--	--	--	--	--	--	--
Oct. 25, 2007	--	--	--	--	--	--	--	--
Station 08211517—West Oso Creek at Merrett Road near Corpus Christi, Tex.								
Nov. 11, 2006	Blank	<0.006	<0.04	<0.04	<0.04	<0.021	<0.016	<0.053
Oct. 25, 2007	--	--	--	--	--	--	--	--
Station 08211525—Unnamed Oso Creek tributary at Farm Road 2444 near Corpus Christi, Tex.								
Mar. 28, 2006	--	--	--	--	--	--	--	--

Date	Sample type	Fenamiphos sulfoxide, water, fltrd (µg/L)	Fenamiphos, water, fltrd (µg/L)	Fenuron, water, fltrd (µg/L)	Desulfinyl-fipronil amide, water, fltrd (µg/L)	Fipronil sulfide, water, fltrd (µg/L)	Fipronil sulfone, water, fltrd (µg/L)	Fipronil, water, fltrd (µg/L)
Station 08211511—Texas AgriLife Research at Corpus Christi, Tex.								
Mar. 28, 2006	--	--	--	--	--	--	--	--
Oct. 25, 2007	--	--	--	--	--	--	--	--
Station 08211517—West Oso Creek at Merrett Road near Corpus Christi, Tex.								
Nov. 11, 2006	Blank	<0.04	<0.03	<0.04	<0.029	<0.013	<0.024	<0.016
Oct. 25, 2007	--	--	--	--	--	--	--	--
Station 08211525—Unnamed Oso Creek tributary at Farm Road 2444 near Corpus Christi, Tex.								
Mar. 28, 2006	--	--	--	--	--	--	--	--

Appendix 1. Quality control and assurance data for rainfall samples collected at Texas AgriLife Research at Corpus Christi (station 08211511); and for runoff samples collected at West Oso Creek (station 08211517) and Oso Creek tributary (station 08211525), Nueces County, Texas, water years 2006–08—Continued.

Date	Sample type	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)	Hexazinone, water, fltrd (µg/L)	Imazaquin, water, fltrd (µg/L)
Station 08211511—Texas AgriLife Research at Corpus Christi, Tex.								
Mar. 28, 2006	--	--	--	--	--	--	--	--
Oct. 25, 2007	--	--	--	--	--	--	--	--
Station 08211517—West Oso Creek at Merrett Road near Corpus Christi, Tex.								
Nov. 11, 2006	Blank	<0.06	<0.04	<0.006	<0.14	<0.15	<0.026	<0.04
Oct. 25, 2007	--	--	--	--	--	--	--	--
Station 08211525—Unnamed Oso Creek tributary at Farm Road 2444 near Corpus Christi, Tex.								
Mar. 28, 2006	--	--	--	--	--	--	--	--

Date	Sample type	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)
Station 08211511—Texas AgriLife Research at Corpus Christi, Tex.								
Mar. 28, 2006	--	--	--	--	--	--	--	--
Oct. 25, 2007	--	--	--	--	--	--	--	--
Station 08211517—West Oso Creek at Merrett Road near Corpus Christi, Tex.								
Nov. 11, 2006	Blank	<0.04	<0.06	<0.026	<0.011	<0.04	<0.039	<0.016
Oct. 25, 2007	--	--	--	--	--	--	--	--
Station 08211525—Unnamed Oso Creek tributary at Farm Road 2444 near Corpus Christi, Tex.								
Mar. 28, 2006	--	--	--	--	--	--	--	--

Date	Sample type	MCPA, water, fltrd (µg/L)	MCPB, water, fltrd (µg/L)	Metalaxyl, water, fltrd (µg/L)	Methidathion, water, fltrd (µg/L)	Methiocarb, water, fltrd (µg/L)	Methomyl, water, fltrd (µg/L)	Methyl paraoxon, water, fltrd (µg/L)
Station 08211511—Texas AgriLife Research at Corpus Christi, Tex.								
Mar. 28, 2006	--	--	--	--	--	--	--	--
Oct. 25, 2007	--	--	--	--	--	--	--	--
Station 08211517—West Oso Creek at Merrett Road near Corpus Christi, Tex.								
Nov. 11, 2006	Blank	<0.06	<0.2	<0.04	<0.007	<0.04	<0.06	<0.02
Oct. 25, 2007	--	--	--	--	--	--	--	--
Station 08211525—Unnamed Oso Creek tributary at Farm Road 2444 near Corpus Christi, Tex.								
Mar. 28, 2006	--	--	--	--	--	--	--	--

Appendix 1. Quality control and assurance data for rainfall samples collected at Texas AgriLife Research at Corpus Christi (station 08211511); and for runoff samples collected at West Oso Creek (station 08211517) and Oso Creek tributary (station 08211525), Nueces County, Texas, water years 2006–08—Continued.

Date	Sample type	Methyl parathion, water, fltrd (µg/L)	Metolachlor, water, fltrd (µg/L)	Metribuzin, water, fltrd (µg/L)	Metsulfuron, water, fltrd (µg/L)	Myclobutanil, water, fltrd (µg/L)	N-(4-Chloro-phenyl)-N'-methylurea (µg/L)	Neburon, water, fltrd (µg/L)
Station 08211511—Texas AgriLife Research at Corpus Christi, Tex.								
Mar. 28, 2006	--	--	--	--	--	--	--	--
Oct. 25, 2007	--	--	--	--	--	--	--	--
Station 08211517—West Oso Creek at Merrett Road near Corpus Christi, Tex.								
Nov. 11, 2006	Blank	<0.008	<0.010	<0.012	<0.14	<0.033	<0.06	<0.02
Oct. 25, 2007	--	--	--	--	--	--	--	--
Station 08211525—Unnamed Oso Creek tributary at Farm Road 2444 near Corpus Christi, Tex.								
Mar. 28, 2006	--	--	--	--	--	--	--	--

Date	Sample type	Nicosul-furon, water, fltrd (µg/L)	Norflurazon, water, fltrd (µg/L)	Oryzalin, water, fltrd (µg/L)	Oxamyl, water, fltrd (µg/L)	Pendi-methalin, water, fltrd (µg/L)	Phorate oxon, water, fltrd (µg/L)	Phorate, water, fltrd (µg/L))
Station 08211511—Texas AgriLife Research at Corpus Christi, Tex.								
Mar. 28, 2006	--	--	--	--	--	--	--	--
Oct. 25, 2007	--	--	--	--	--	--	--	--
Station 08211517—West Oso Creek at Merrett Road near Corpus Christi, Tex.								
Nov. 11, 2006	Blank	<0.10	<0.04	<0.04	<0.04	<0.02	<0.03	<0.02
Oct. 25, 2007	--	--	--	--	--	--	--	--
Station 08211525—Unnamed Oso Creek tributary at Farm Road 2444 near Corpus Christi, Tex.								
Mar. 28, 2006	--	--	--	--	--	--	--	--

Date	Sample type	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)	Propyz-amide, water, fltrd (µg/L)	Propham, water, fltrd (µg/L)
Station 08211511—Texas AgriLife Research at Corpus Christi, Tex.								
Mar. 28, 2006	--	--	--	--	--	--	--	--
Oct. 25, 2007	--	--	--	--	--	--	--	--
Station 08211517—West Oso Creek at Merrett Road near Corpus Christi, Tex.								
Nov. 11, 2006	Blank	<0.051	<0.008	<0.12	<0.01	<0.006	<0.004	<0.06
Oct. 25, 2007	--	--	--	--	--	--	--	--
Station 08211525—Unnamed Oso Creek tributary at Farm Road 2444 near Corpus Christi, Tex.								
Mar. 28, 2006	--	--	--	--	--	--	--	--

Appendix 1. Quality control and assurance data for rainfall samples collected at Texas AgriLife Research at Corpus Christi (station 08211511); and for runoff samples collected at West Oso Creek (station 08211517) and Oso Creek tributary (station 08211525), Nueces County, Texas, water years 2006–08—Continued.

Date	Sample type	Propiconazole, water, fltrd (µg/L)	Propoxur, water, fltrd (µg/L)	Siduron, water, fltrd (µg/L)	Simazine, water, fltrd (µg/L)	Sulfometuron, water, fltrd (µg/L)	Tebuthiuron, water, fltrd (µg/L)	Terbacil, water, fltrd (µg/L)
Station 08211511—Texas AgriLife Research at Corpus Christi, Tex.								
Mar. 28, 2006	--	--	--	--	--	--	--	--
Oct. 25, 2007	--	--	--	--	--	--	--	--
Station 08211517—West Oso Creek at Merrett Road near Corpus Christi, Tex.								
Nov. 11, 2006	Blank	<0.06	<0.04	<0.04	<0.006	<0.06	<0.02	<0.04
Oct. 25, 2007	--	--	--	--	--	--	--	--
Station 08211525—Unnamed Oso Creek tributary at Farm Road 2444 near Corpus Christi, Tex.								
Mar. 28, 2006	--	--	--	--	--	--	--	--

Date	Sample type	Terbufos oxon sulfone, water, fltrd (µg/L)	Terbufos, water, fltrd (µg/L)	Terbuthylazine, water, fltrd (µg/L)	Tribuphos, water, fltrd (µg/L)	Triclopyr, water, fltrd (µg/L)	Trifluralin, water, fltrd (µg/L)	Dichlorvos, water, fltrd (µg/L)
Station 08211511—Texas AgriLife Research at Corpus Christi, Tex.								
Mar. 28, 2006	--	--	--	--	--	--	--	--
Oct. 25, 2007	--	--	--	--	--	--	--	--
Station 08211517—West Oso Creek at Merrett Road near Corpus Christi, Tex.								
Nov. 11, 2006	Blank	<0.045	<0.012	<0.009	<0.035	<0.04	<0.009	<0.013
Oct. 25, 2007	--	--	--	--	--	--	--	--
Station 08211525—Unnamed Oso Creek tributary at Farm Road 2444 near Corpus Christi, Tex.								
Mar. 28, 2006	--	--	--	--	--	--	--	--

Appendix 2. Water-quality data for runoff samples collected at West Oso Creek (station 08211517), Nueces County, Texas, water years 2006–08.

[unfltrd, unfiltered; µS/cm, microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter; $CaCO_3$, calcium carbonate; fltrd, filtered; --, not analyzed; N, nitrogen; <, less than; P, phosphorus; µg/L, micrograms per liter; CIAT, 2-chloro-4-isopropylamino-6-amino-s-triazine; E, estimated; CEAT, 2-Chloro-6-ethylamino-4-amino-s-triazine; OIET, 2-hydroxy-4-isopropylamino-6-ethylamino-s-triazine; DCPA, Dimethyl tetrachloroterephthalate; MCPA, 4-chloro-2-methylphenoxy acetic acid; MCPB, 4-(2-methyl-4-chlorophenoxy)butyric acid]

Date	pH, water, unfltrd, field (standard units)	pH, water, unfltrd, lab (standard units)	Specific conductance, unfltrd, lab (µS/cm)	Specific conductance, unfltrd, field (µS/cm)	Hardness, water (mg/L as $CaCO_3$)	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
Sept. 9–10, 2006	7.4	8.3	124	122	38	13.5	.958	3.24
Sept. 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
July 2–3, 2007	6.7	7.3	86	77	26	8.91	1.20	6.74
Mar. 10–11, 2008	--	8.3	139	127	41	14.4	1.17	3.73
July 24, 2008	7.6	6.8	133	129	43	15.1	1.32	9.73

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, unfltrd (mg/L as N)	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	0.017
July 1–2, 2006	7.38	1.58	.4	15.4	2.2	.49	2.1	.027
July 6, 2006	5.82	1.61	.3	13.6	1.6	.75	2.4	.032
Sept. 9–10, 2006	6.65	1.54	.5	11.2	1.5	2.7	3.3	.121
Sept. 18–19, 2006	4.23	2.72	.2	10.9	1.3	.47	1.4	.039
Jan. 3–5, 2007	6.33	2.24	.27	8.4	2.64	.56	2.3	.228
Jan. 24–25, 2007	7.80	3.11	.20	8.1	3.65	.47	1.3	.041
Mar. 14–15, 2007	--	--	--	--	--	.65	4.3	.200
May 25, 2007	2.87	.97	.19	8.2	1.39	.55	2.8	.148
July 2–3, 2007	1.81	1.52	.13	8.6	.93	.46	.75	<.020
Mar. 10–11, 2008	7.58	3.16	.40	9.8	3.90	1.1	7.0	.398
July 24, 2008	3.43	6.03	.15	13.4	1.86	.59	1.2	<.020

Appendix 2. Water-quality data for runoff samples collected at West Oso Creek (station 08211517), Nueces County, Texas, water years 2006–08—Continued.

Date	Nitrate, water, fltrd (mg/L as N)[1]	Nitrite + nitrate, water, fltrd (mg/L as N)	Nitrite, water, fltrd (mg/L as N)	Organic nitrogen, water, fltrd (mg/L as N)[1]	Organic nitrogen, water, unfltrd (mg/L as N)[1]	Total nitrogen, water, fltrd (mg/L as N)[1]	Total nitrogen, water, unfltrd (mg/L as N)[1]	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	0.167
July 1–2, 2006	.44	.49	.049	.47	2.1	.98	2.6	.216
July 6, 2006	.36	.38	.026	.72	2.3	1.1	2.8	.264
Sept. 9–10, 2006	.65	.71	.058	2.6	3.2	3.4	4.0	.159
Sept. 18–19, 2006	.49	.51	.017	.43	1.4	.97	1.9	.251
Jan. 3–5, 2007	2.01	2.19	.178	.33	2.1	2.7	4.5	.310
Jan. 24–25, 2007	3.13	3.26	.123	.43	1.3	3.7	4.6	.252
Mar. 14–15, 2007	.72	.78	.057	.45	4.2	1.4	5.1	.350
May 25, 2007	.73	.77	.042	.40	2.6	1.3	3.5	.342
July 2–3, 2007	.21	.22	.008	.44	.73	.68	.98	.463
Mar. 10–11, 2008	1.95	2.04	.089	.70	6.6	3.1	9.0	.303
July 24, 2008	.33	.34	.009	--	--	.94	1.6	.332

[1] Concentration of constituent not analyzed directly but computed from other analyzed constituents.

Date	Phosphorus, water, fltrd (mg/L as P)	Phosphorus, water, unfltrd (mg/L as P)	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)	2-Chloro-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	<.02	<.006	<.006	E.048
July 6, 2006	.28	.66	<.09	<.190	E3.35	<.02	<.006	<.006	E.030
Sept. 9–10, 2006	.27	.75	<.09	<.190	<.04	<.02	<.006	<.006	E.109
Sept. 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
July 2–3, 2007	.49	.59	<.09	<.200	<.04	<.02	<.006	<.006	E.179
Mar. 10–11, 2008	.33	.29	<.04	<.040	.28	<.02	<.006	<.010	E.138
July 24, 2008	.365	.57	<.04	<.040	<.02	<.02	<.006	<.010	E.149

Appendix 2. Water-quality data for runoff samples collected at West Oso Creek (station 08211517), Nueces County, Texas, water years 2006–08—Continued.

Date	CEAT, water, fltrd (µg/L)	2-Ethyl-6-methyl-aniline water, fltrd (µg/L)	OIET, water, fltrd (µg/L)	3,4-Di-chloro-aniline water, fltrd (µg/L)	3-Hydroxy carbofuran, water, fltrd (µg/L)	4-Chloro-2-methyl 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	E0.008	<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
Sept. 9–10, 2006	E.04	<.010	E.302	<.004	<.008	<.005	<.006	<.028	<.005
Sept. 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
July 2–3, 2007	E.07	<.010	.529	<.004	<.020	<.005	<.006	<.006	<.005
Mar. 10–11, 2008	<.08	<.010	<.040	<.006	<.040	<.005	<.006	<.040	<.006
July 24, 2008	<.08	<.010	.247	<.006	<.040	<.005	<.006	<.040	<.006

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)	Bendio-carb, water, fltrd (µg/L)	Benfluralin, water, fltrd (µg/L)
June 1–2, 2006	<0.02	E0.006	<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
Sept. 9–10, 2006	<.02	<.100	<.15	10.3	.192	<.04	<.050	<.08	<.010
Sept. 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
July 2–3, 2007	<.08	<.040	<.04	8.20	8.90	<.04	<.080	<.04	<.010
Mar. 10–11, 2008	<.08	<.060	<.12	--	E.939	<.04	<.120	<.04	<.010
July 24, 2008	<.08	<.060	<.12	--	.091	<.06	<.120	<.04	<.010

Appendix 2. Water-quality data for runoff samples collected at West Oso Creek (station 08211517), Nueces County, Texas, water years 2006–08—Continued.

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
Sept. 9–10, 2006	<.022	<.02	<.02	<.02	<.04	<.02	<.016	<.02
Sept. 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
July 2–3, 2007	<.020	<.06	<.02	<.04	<.12	<.02	<.060	<.10
Mar. 10–11, 2008	<.040	<.06	<.04	<.02	<.12	<.04	<.020	<.10
July 24, 2008	<.040	<.06	<.04	<.02	<.12	<.04	<.020	<.10

Date	Chlorimuron, water, fltrd (µg/L)	Chlorodiamino-s-triazine, water, fltrd (µg/L)	Chlorpyrifos 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)	Cypermethrin, 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
Sept. 9–10, 2006	<.032	<.04	<.06	<.005	<.006	<.07	<.01	<.053	<.046
Sept. 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
July 2–3, 2007	<.080	<.12	<.06	<.005	<.010	<.06	<.06	<.053	<.046
Mar. 10–11, 2008	<.080	--	<.06	<.005	<.010	<.06	<.02	<.016	<.014
July 24, 2008	<.080	--	<.06	<.005	<.010	<.06	<.02	<.016	<.014

Appendix 2. Water-quality data for runoff samples collected at West Oso Creek (station 08211517), Nueces County, Texas, water years 2006–08—Continued.

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)	Dichlor-prop, water, fltrd (µg/L)	Dicroto-phos, water, fltrd (µg/L)	Dieldrin, water, fltrd (µg/L)	Dimetho-ate, 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
Sept. 9–10, 2006	<.03	<.003	<.012	<.005	<.04	<.03	<.08	<.009	<.006
Sept. 18–19, 2006	<.03	E.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
July 2–3, 2007	<.02	<.003	<.012	<.005	<.08	<.04	E.04	<.009	<.006
Mar. 10–11, 2008	<.02	<.003	<.012	<.005	<.04	<.02	<.08	<.009	<.006
July 24, 2008	<.02	<.003	<.012	<.005	<.04	<.02	<.08	<.009	<.006

Date	Dinoseb, water, fltrd (µg/L)	Diphena-mid, water, fltrd (µg/L)	Diuron, water, fltrd (µg/L)	Ethion monoxon, water, fltrd (µg/L)	Ethion, water, fltrd (µg/L)	Fenami-phos sulfone, water, fltrd (µg/L)	Fenami-phos sulfoxide, water, fltrd (µg/L)	Fenami-phos, water, fltrd (µg/L)	Fenuron, water, fltrd (µg/L)
June 1–2, 2006	<0.04	<0.01	<0.01	<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	.03	<.02	<.016	<.053	<.04	<.03	<.10
Sept. 9–10, 2006	<.04	<.01	<.02	<.02	<.016	<.053	<.04	<.03	<.10
Sept. 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
July 2–3, 2007	<.04	<.04	<.04	<.02	<.016	<.053	<.04	<.03	<.04
Mar. 10–11, 2008	<.04	<.04	.08	<.02	<.016	<.053	<.20	<.03	<.04
July 24, 2008	<.04	<.04	<.04	<.02	<.016	<.053	<.20	<.03	<.04

Appendix 2. Water-quality data for runoff samples collected at West Oso Creek (station 08211517), Nueces County, Texas, water years 2006–08—Continued.

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)	Flumet-sulam, water, fltrd (µg/L)	Fluo-meturon, water, fltrd (µg/L)	Fonofos, water, fltrd (µg/L)	Glufos-inate, 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	E0.120	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
Sept. 9–10, 2006	<.029	<.013	<.024	<.016	<.04	<.02	<.005	<.140	30.3
Sept. 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
July 2–3, 2007	<.029	<.016	<.024	<.016	<.06	<.04	<.006	<.140	E12.6
Mar. 10–11, 2008	<.029	<.013	<.024	<.020	<.06	<.04	<.010	--	--
July 24, 2008	<.029	<.013	<.024	<.020	<.06	<.04	<.010	--	--

Date	Hexazi-none, 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 1–2, 2006	<.026	<.04	<.04	<.020	<.026	<.011	<.01	<.039	<.027
July 6, 2006	<.026	<.04	<.04	<.020	<.026	<.011	<.01	<.039	<.027
Sept. 9–10, 2006	<.026	<.04	<.04	<.020	<.026	<.011	<.01	<.039	<.027
Sept. 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
July 2–3, 2007	<.026	<.04	<.04	<.060	<.026	<.011	<.04	<.039	<.016
Mar. 10–11, 2008	<.008	<.04	<.04	<.060	<.01	<.006	<.02	<.020	<.016
July 24, 2008	<.008	<.04	<.04	<.060	<.01	<.006	<.02	<.020	<.016

Appendix 2. Water-quality data for runoff samples collected at West Oso Creek (station 08211517), Nueces County, Texas, water years 2006–08—Continued.

Date	MCPA, water, fltrd (µg/L)	MCPB, water, fltrd (µg/L)	Metalaxyl, water, fltrd (µg/L)	Methida-thion, water, fltrd (µg/L)	Methio-carb, water, fltrd (µg/L)	Methomyl, water, fltrd (µg/L)	Methyl paraoxon, water, fltrd (µg/L)	Methyl parathion, water, fltrd (µg/L)	Metola-chlor, 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
Sept. 9–10, 2006	<.07	<.10	<.007	<.009	<.034	<.070	<.02	<.015	<.006
Sept. 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
July 2–3, 2007	<.06	<.20	<.007	<.009	<.040	<.060	<.02	<.008	E.008
Mar. 10–11, 2008	<.06	<.06	<.02	<.004	<.040	<.120	<.01	<.008	E.012
July 24, 2008	<.06	<.06	<.02	<.004	<.040	<.120	<.01	<.008	<.025

Date	Metribuzin, water, fltrd (µg/L)	Metsulfu-ron, water, fltrd (µg/L)	Myclobu-tanil, water, fltrd (µg/L)	N-(4-Chloro-phenyl)-N′-methylurea (µg/L)	Neburon, water, fltrd (µg/L)	Nicosul-furon, water, fltrd (µg/L)	Norflura-zon, 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
Sept. 9–10, 2006	<.028	<.07	<.033	<.04	<.01	<.04	<.02	<.02	<.05
Sept. 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
July 2–3, 2007	<.012	<.14	<.033	<.06	<.02	<.10	<.04	<.04	<.04
Mar. 10–11, 2008	E.022	<.14	<.010	<.12	<.02	<.10	<.02	<.04	<.12
July 24, 2008	<.012	<.14	<.010	<.12	<.02	<.10	<.02	<.04	<.12

Appendix 2. Water-quality data for runoff samples collected at West Oso Creek (station 08211517), Nueces County, Texas, water years 2006–08—Continued.

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
Sept. 9–10, 2006	13.7	<.03	<.055	<.05	<.008	<.03	<.01	<.006	<.004
Sept. 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
July 2–3, 2007	.100	<.03	<.020	<.05	<.008	<.12	<.01	<.006	<.004
Mar. 10–11, 2008	E.417	<.03	<.040	<.05	<.008	<.12	<.01	<.006	<.004
July 24, 2008	.252	<.03	<.040	<.06	<.008	<.12	<.01	<.006	<.004

Date	Propham, water, fltrd (µg/L)	Propiconazole, water, fltrd (µg/L)	Propoxur, water, fltrd (µg/L)	Siduron, water, fltrd (µg/L)	Simazine, water, fltrd (µg/L)	Sulfometuron, 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	E0.005	<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
Sept. 9–10, 2006	<.030	<.01	<.008	<.02	<.010	<.090	<.02	<.026	<.04
Sept. 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
July 2–3, 2007	<.060	<.06	<.040	<.04	.022	<.060	<.02	<.040	<.04
Mar. 10–11, 2008	<.040	<.04	<.040	<.02	E.017	<.060	<.02	<.040	<.04
July 24, 2008	<.040	<.04	<.040	<.02	<.006	<.060	<.02	<.040	<.04

Appendix 2. Water-quality data for runoff samples collected at West Oso Creek (station 08211517), Nueces County, Texas, water years 2006–08—Continued.

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
Sept. 9–10, 2006	<.02	<.01	<.035	<.03	<.012	<.01
Sept. 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
July 2–3, 2007	<.01	<.01	<.035	<.04	<.009	<.01
Mar. 10–11, 2008	<.02	<.01	<.035	<.04	E.019	<.01
July 24, 2008	<.02	<.01	<.035	<.04	<.009	<.01

Appendix 3. Water-quality data for runoff samples collected at Oso Creek tributary (station 08211525), Nueces County, Texas, water years 2006–08.

[unfltrd, unfiltered; µS/cm, microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter; $CaCO_3$, calcium carbonate; fltrd, filtered; --, not analyzed; N, nitrogen; E, estimated; <, less than; P, phosphorus; µg/L, micrograms per liter; CIAT, 2-chloro-4-isopropylamino-6-amino-s-triazine; CEAT, 2-Chloro-6-ethylamino-4-amino-s-triazine; OIET, 2-hydroxy-4-isopropylamino-6-ethylamino-s-triazine; DCPA, dimethyl tetrachloroterephthalate; MCPA, 4-chloro-2-methylphenoxy acetic acid; MCPB, 4-(2-methyl-4-chlorophenoxy)butyric acid]

Date	pH, water, unfltrd, field (standard units)	pH, water, unfltrd, lab (standard units)	Specific conductance, unfltrd, lab (µS/cm)	Specific conductance, unfltrd, field (µS/cm)	Hardness, water (mg/L as $CaCO_3$)	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
Sept. 9–15, 2006	6.7	7.6	153	154	55	18.9	1.85	7.67
Sept. 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
Mar. 11, 2008	--	7.9	270	248	83	28.5	2.95	10.7
July 24, 2008	--	7.0	115	--	32	10.3	1.56	9.53
Aug. 18, 2008	7.5	7.5	246	243	82	27.6	3.12	16.9

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, unfltrd (mg/L as N	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	0.026
July 6–7, 2006	9.16	6.58	.20	22.8	4.88	.55	1.2	.012
Sept. 9–15, 2006	6.15	3.20	.15	19.9	2.13	1.2	.92	.028
Sept. 18–19, 2006	3.46	1.97	.13	11.0	1.30	.66	.89	.021
Jan. 3–4, 2007	14.7	19.5	.12	11.0	12.8	.43	1.4	.024
Jan. 24–25, 2007	15.7	17.2	.14	12.4	11.0	.48	.99	.021
Mar. 14–15, 2007	--	--	--	--	--	1.1	2.5	.171
July 3–4, 2007	9.75	11.0	.10	16.0	6.23	.64	.97	E.013
Aug. 30–31, 2007	13.1	21.6	E.10	18.3	7.63	.71	1.1	<.020
Mar. 11, 2008	15.6	23.8	.23	12.2	17.4	.90	2.2	.172
July 24, 2008	4.26	7.92	E.06	12.4	2.65	.58	.79	<.020
Aug. 18, 2008	8.42	11.7	.15	29.2	6.46	1.0	.91	<.020

Appendix 3. Water-quality data for runoff samples collected at Oso Creek tributary (station 08211525), Nueces County, Texas, water years 2006–08—Continued.

Date	Nitrate, water, fltrd (mg/L as N)[1]	Nitrite + nitrate, water, fltrd (mg/L as N)	Nitrite, water, fltrd (mg/L as N)	Organic nitrogen, water, fltrd (mg/L as N)[1]	Organic nitrogen, water, unfltrd (mg/L as N)[1]	Total nitrogen, water, fltrd (mg/L as N)[1]	Total nitrogen, water, unfltrd (mg/L as N)[1]	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	0.663
July 6–7, 2006	--	<.06	.002	.54	1.1	--	--	.525
Sept. 9–15, 2006	.18	.20	.016	1.2	.89	1.4	1.1	.429
Sept. 18–19, 2006	.19	.20	.005	.63	.87	.85	1.1	.229
Jan. 3–4, 2007	.49	.50	.015	.40	1.3	.93	1.9	.331
Jan. 24–25, 2007	.80	.81	.014	.46	.97	1.3	1.8	.276
Mar. 14–15, 2007	.86	1.0	.144	.92	2.4	2.1	3.5	.366
July 3–4, 2007	.12	.13	.008	.40	.96	.77	1.1	.557
Aug. 30–31, 2007	.16	.17	.009	.70	1.1	.88	1.2	.311
Mar. 11, 2008	1.31	1.37	.177	.72	2.0	2.3	3.5	.550
July 24, 2008	.05	.05	.012	--	--	.63	.84	.406
Aug. 18, 2008	--	<.04	.011	--	--	--	--	.494

[1] Concentration of constituent not analyzed directly but computed from other analyzed constituents.

Date	Phosphorus, water, fltrd (mg/L as P)	Phosphorus, water, unfltrd (mg/L as P)	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)	2-Chloro-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
Sept. 9–15, 2006	.53	.61	<.09	<.190	E.03	<.02	<.006	<.006	E.029
Sept. 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
Mar. 11, 2008	.61	1.02	<.04	<.040	.14	<.02	<.006	<.010	E.562
July 24, 2008	.44	.51	<.04	<.040	<.02	<.02	<.006	<.010	E.118
Aug. 18, 2008	.51	.55	<.04	<.040	.49	<.02	<.006	<.010	E.074

Appendix 3. Water-quality data for runoff samples collected at Oso Creek tributary (station 08211525), Nueces County, Texas, water years 2006–08—Continued.

Date	CEAT, water, fltrd (µg/L)	2-Ethyl-6-methyl-aniline, water, fltrd (µg/L)	OIET, water, fltrd (µg/L)	3,4-Di-chloro-aniline, water, fltrd (µg/L)	3-Hydroxy carbofuran, water, fltrd (µg/L)	4-Chloro-2-methyl 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	<0.028	<0.005
July 6–7, 2006	E.07	<.010	.517	<.004	<.008	<.005	<.006	<.028	<.005
Sept. 9–15, 2006	<.08	<.010	.272	<.004	<.008	<.005	<.006	<.028	<.005
Sept. 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
Mar. 11, 2008	.08	<.010	.346	<.006	<.040	<.005	<.006	<.040	<.006
July 24, 2008	<.08	<.010	.135	<.006	<.040	<.005	<.006	<.040	<.006
Aug. 18, 2008	<.08	<.010	.266	E.006	<.040	<.005	<.006	<.040	<.006

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)	Bendio-carb, 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
Sept. 9–15, 2006	<.02	<.100	<.15	.350	.042	<.04	<.050	<.08	<.010
Sept. 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
Mar. 11, 2008	<.08	<.060	<.12	--	10.5	<.04	<.120	<.04	<.010
July 24, 2008	<.08	<.060	<.12	--	.363	<.06	<.120	<.04	<.010
Aug. 18, 2008	<.08	<.060	<.12	--	.464	<.04	<.120	<.04	<.010

Appendix 3. Water-quality data for runoff samples collected at Oso Creek tributary (station 08211525), Nueces County, Texas, water years 2006–08—Continued.

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
Sept. 9–15, 2006	<.022	<.02	<.02	<.02	<.04	<.02	<.016	<.02
Sept. 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
Mar. 11, 2008	<.040	<.06	<.04	<.02	<.12	E.010	<.020	<.10
July 24, 2008	<.040	<.06	<.04	<.02	<.12	E.016	<.020	<.10
Aug. 18, 2008	<.040	<.06	<.04	<.02	<.12	E.060	<.020	<.10

Date	Chlorimuron, water, fltrd (µg/L)	Chloro-di-amino-s-triazine, water, fltrd (µg/L)	Chlorpyrifos-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)	Cypermethrin, 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
Sept. 9–15, 2006	<.032	<.04	<.06	<.005	<.006	<.07	<.01	<.053	<.046
Sept. 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
Mar. 11, 2008	<.080	--	<.06	<.005	<.010	<.06	<.02	<.016	<.014
July 24, 2008	<.080	--	<.06	<.005	<.010	<.06	<.02	<.016	<.014
Aug. 18, 2008	<.080	--	<.06	<.005	<.010	<.06	<.02	<.016	<.014

Appendix 3. Water-quality data for runoff samples collected at Oso Creek tributary (station 08211525), Nueces County, Texas, water years 2006–08—Continued.

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)	Dichlor-prop, water, fltrd (µg/L)	Dicroto-phos, 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
Sept. 9–15, 2006	<.03	<.003	<.012	<.005	<.04	<.03	<.08	<.009	<.006
Sept. 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
Mar. 11, 2008	<.02	<.003	<.012	<.005	<.04	<.02	<.08	<.009	<.006
July 24, 2008	<.02	<.003	<.012	<.005	<.04	<.02	<.08	<.009	<.006
Aug. 18, 2008	<.02	<.003	<.012	<.005	<.04	<.02	<.08	<.009	<.006

Date	Dinoseb, water, fltrd (µg/L)	Diphena-mid, water, fltrd (µg/L)	Diuron, water, fltrd (µg/L)	Ethion monoxon, water, fltrd (µg/L)	Ethion, water, fltrd (µg/L)	Fenami-phos sulfone, water, fltrd (µg/L)	Fenami-phos sulfoxide, water, fltrd (µg/L)	Fenami-phos, 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
Sept. 9–15, 2006	<.04	<.01	<.02	<.02	<.016	<.053	<.04	<.03	<.10
Sept. 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
Mar. 11, 2008	<.04	<.04	.10	<.02	<.006	<.053	<.20	<.03	<.04
July 24, 2008	<.04	<.04	<.04	<.02	<.006	<.053	<.20	<.03	<.04
Aug. 18, 2008	<.04	<.04	<.04	<.02	<.006	<.053	<.20	<.03	<.04

Appendix 3. Water-quality data for runoff samples collected at Oso Creek tributary (station 08211525), Nueces County, Texas, water years 2006–08—Continued.

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)	Flumet-sulam, 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
Sept. 9–15, 2006	<.029	<.013	<.024	<.016	<.04	<.02	<.005	<.140	1.51
Sept. 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	--	--
Mar. 11, 2008	<.029	<.013	<.024	<.020	<.06	<.04	<.010	--	--
July 24, 2008	<.029	<.013	<.024	<.020	<.06	<.04	<.010	--	--
Aug. 18, 2008	<.029	<.013	<.024	<.020	<.06	<.04	<.010	--	--

Date	Hexazi-none, 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
Sept. 9–15, 2006	<.026	<.04	<.04	<.020	<.026	<.011	<.01	<.039	<.027
Sept. 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
Mar. 11, 2008	<.008	<.04	<.04	<.060	<.01	<.006	<.02	<.020	<.016
July 24, 2008	<.008	<.04	<.04	<.060	<.01	<.006	<.02	<.020	<.016
Aug. 18, 2008	<.008	<.04	<.04	<.060	<.01	<.006	<.02	<.020	<.016

Appendix 3. Water-quality data for runoff samples collected at Oso Creek tributary (station 08211525), Nueces County, Texas, water years 2006–08—Continued.

Date	MCPA, water, fltrd (µg/L)	MCPB, water, fltrd (µg/L)	Metalaxyl, water, fltrd (µg/L)	Methida-thion, water, fltrd (µg/L)	Methio-carb, water, fltrd (µg/L)	Methomyl, water, fltrd (µg/L)	Methyl paraoxon, water, fltrd (µg/L)	Methyl parathion, water, fltrd (µg/L)	Metola-chlor, 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.006
Sept. 9–15, 2006	<.07	<.10	<.007	<.009	<.034	<.070	<.02	<.015	<.006
Sept. 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
Mar. 11, 2008	<.06	<.06	E.014	<.004	<.040	<.120	<.01	<.008	<.010
July 24, 2008	<.06	<.06	<.007	<.004	<.040	<.120	<.01	<.008	<.011
Aug. 18, 2008	<.06	<.06	<.020	<.004	<.040	<.120	<.01	<.008	<.010

Date	Metribuzin, water, fltrd (µg/L)	Metsulfu-ron, water, fltrd (µg/L)	Myclobu-tanil, water, fltrd (µg/L)	N-(4-Chloro-phenyl)-N′-methyl-urea (µg/L)	Neburon, water, fltrd (µg/L)	Nicosul-furon, water, fltrd (µg/L)	Norflura-zon, 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
Sept. 9–15, 2006	<.028	<.07	E.010	<.04	<.01	<.04	<.02	<.02	<.05
Sept. 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
Mar. 11, 2008	.021	<.14	<.010	<.12	<.02	<.10	<.02	<.04	<.12
July 24, 2008	<.012	<.14	<.010	<.12	<.02	<.10	<.02	<.04	<.12
Aug. 18, 2008	<.012	<.14	<.010	<.12	<.02	<.10	<.02	<.04	<.12

Appendix 3. Water-quality data for runoff samples collected at Oso Creek tributary (station 08211525), Nueces County, Texas, water years 2006–08—Continued.

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
Sept. 9–15, 2006	.131	<.03	<.055	<.05	<.008	<.03	<.01	<.006	<.004
Sept. 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
Mar. 11, 2008	.071	<.03	<.040	<.05	<.008	<.12	<.01	<.006	<.004
July 24, 2008	.019	<.03	<.040	<.06	<.008	<.12	<.01	<.006	<.004
Aug. 18, 2008	<.012	<.03	<.040	<.05	<.008	<.12	<.01	<.006	<.004

Date	Propham, water, fltrd (µg/L)	Propiconazole, water, fltrd (µg/L)	Propoxur, water, fltrd (µg/L)	Siduron, water, fltrd (µg/L)	Simazine, water, fltrd (µg/L)	Sulfometruron, 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
Sept. 9–15, 2006	<.030	<.01	<.008	<.02	<.005	<.090	<.02	<.026	<.04
Sept. 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
Mar. 11, 2008	<.040	<.04	<.040	<.02	E.022	<.060	<.02	<.040	<.04
July 24, 2008	<.040	<.04	<.040	<.02	<.006	<.060	<.02	<.040	<.04
Aug. 18, 2008	<.040	<.04	<.040	<.02	<.006	<.060	<.02	<.040	<.04

Appendix 3. Water-quality data for runoff samples collected at Oso Creek tributary (station 08211525), Nueces County, Texas, water years 2006–08—Continued.

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
Sept. 9–15, 2006	<.02	<.01	<.035	<.03	<.009	<.01
Sept. 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	.02	<.035	<.04	.054	<.01
July 3–4, 2007	<.01	<.01	<.035	<.04	<.009	<.01
Aug. 30–31, 2007	<.01	<.01	<.035	<.04	<.009	<.01
Mar. 11, 2008	<.02	<.01	<.035	<.08	.026	<.01
July 24, 2008	<.02	<.01	<.035	<.08	<.009	<.01
Aug. 18, 2008	<.02	<.01	<.035	<.08	<.009	<.01

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