Assessment of Surface Runoff Water Quality from Agricultural Croplands in the Odem Ranch Watershed

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Bobby R. Eddleman and Larry Falconer
Texas Agricultural Experiment Station and Texas Agricultural Extension Service

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Coastal Bend Bays & Estuaries Program
1305 N. Shoreline Blvd. Ste 205
Corpus Christi, Texas 78401

The views expressed herein are those of the authors and do not necessarily reflect the views of CBBEP or other organizations that may have provided funding for this project.

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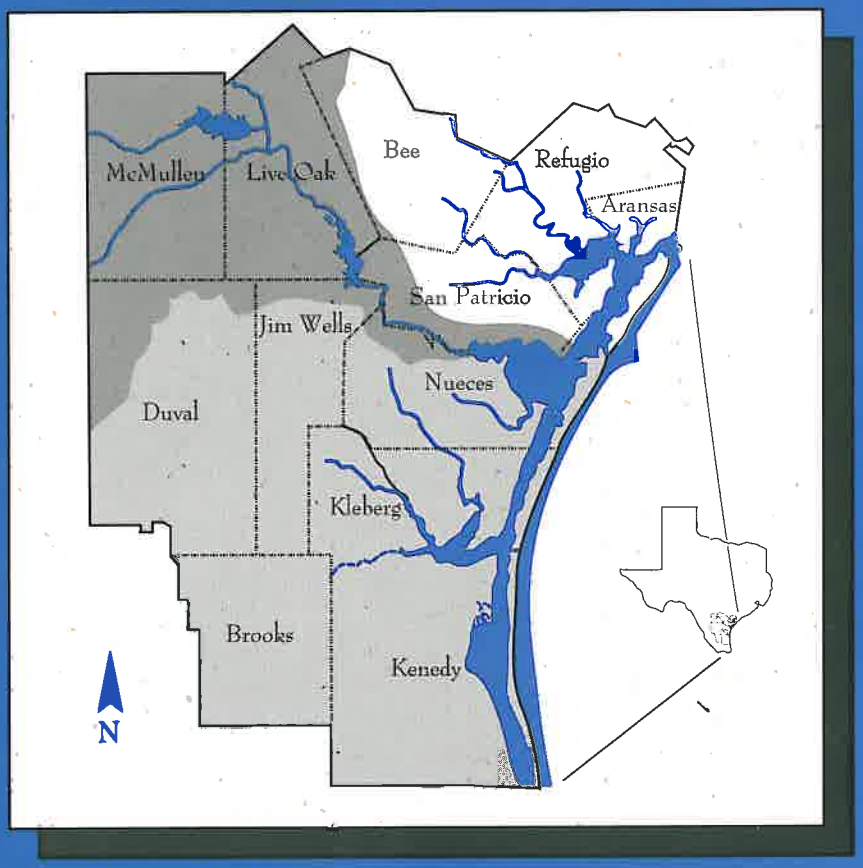

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Special thanks are extended to Darwin Ockerman and Brian Petri of USGS, San Antonio Office, Clint Livingston and Bon Prince of TAES, Corpus Christi Center, and John Barrett, producer in the Odem Ranch Watershed, for their substantial support to this study. Darwin Ockerman and Brian Petri provided valuable project support and technical assistance. Darwin Ockerman untiringly maintained water quality sample data and performed all calculations on rainfall, runoff, rainfall and runoff loads and yields, and associated data. Clint Livingston's service in site and equipment maintenance and along with Bon Prince in sample collection, processing and shipment to the USGS, NWQL was vital to the success of the project. Rick Jahn assisted in collection of information on farmers' use of nutrients and pesticides as well as their crop acreages. Farmers in the watershed who provided information on crop production practices and amounts and timing of nutrient and pesticide applications are acknowledged for their support. Acknowledgment is also extended to USDA, NRCS personnel in Temple and San Patricio County, TSSWCB, EPA, TNRCC, CBBEP, San Patricio County Soil and Water Conservation District, and Behmann Brothers Foundation, who provided funding or in-kind support for the study. Lastly, gratitude is extended to USGS for the valuable oversight, technical assistance, and matching-funds that made this study possible.

Bobby R. Eddleman,
Principal Investigator

Assessment of Surface Runoff Water Quality from Agricultural Croplands in the Odem Ranch Watershed

EXECUTIVE SUMMARY

Project Team:

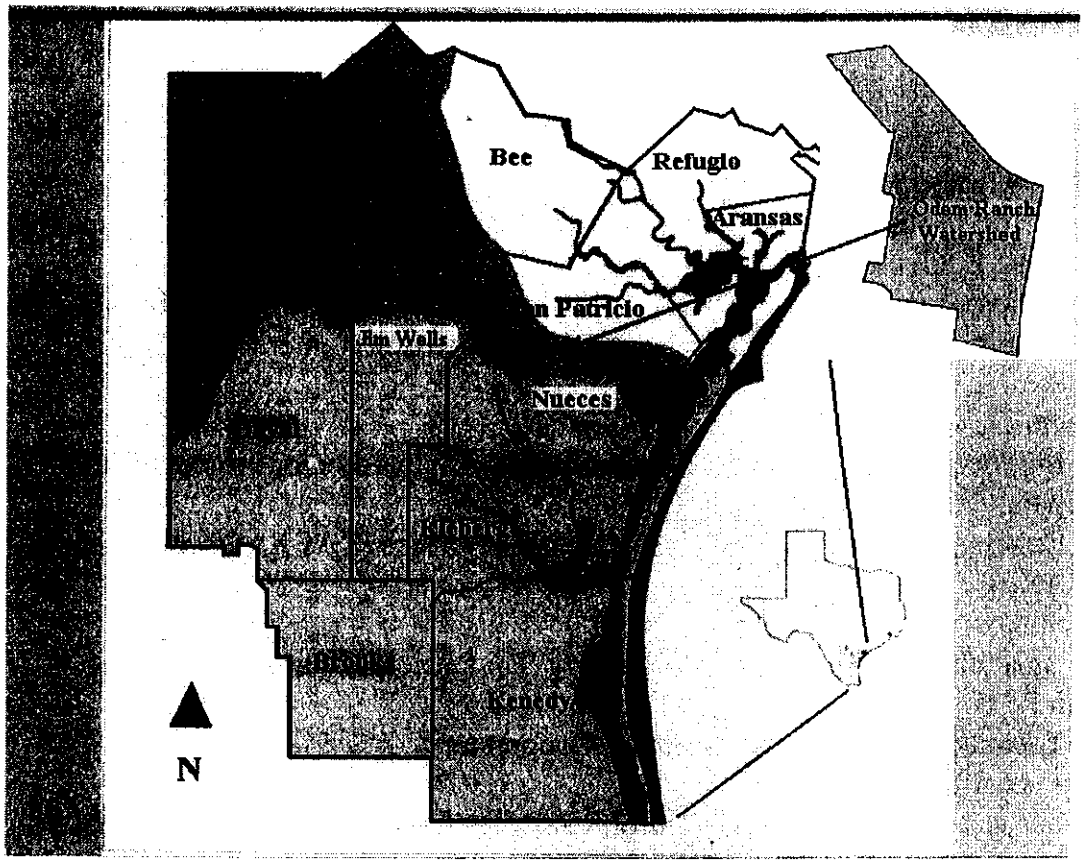
Sandra Alvarado
Formerly Research Specialist, Coastal Bend Bays & Estuaries Program (CBBEP)
Bobby R. Eddleman
Professor and Resident Director, Texas Agricultural Experiment Station (TAES), Corpus Christi Agricultural Research & Extension Center (AREC), Principal Investigator
Darwin Ockerman
Engineer, U.S. Geological Survey (USGS), San Antonio, Project Chief
Larry Falconer
Economist, Texas Agricultural Extension Service (TAEX), Corpus Christi AREC, Cooperator
Rick Jahn
Agricultural Agent, TAEX, Formerly San Patricio County, Cooperator
Brian Petri
Technician, USGS, San Antonio, Cooperator
Leroy Wolff
District Conservationist, Natural Resources Conservation Service (NRCS), Cooperator
John Barrett
Agricultural Producer, San Patricio County, Cooperator
San Patricio County Soil and Water Conservation District, Cooperator

Authors:

Bobby R. Eddleman, Professor and Resident Director, TAES Corpus Christi
Larry Falconer, Economist, TAEX Corpus Christi

The Odem Ranch Watershed encompasses 2,775 acres of cropland located near Edroy, Texas in western San Patricio County within the Nueces River Basin Drainage Area (Figure ES.1). Stormwater runoff exits the watershed at two locations, eventually flows into the Nueces River, then into the Nueces Bay/Corpus Christi Bay System.

Figure ES.1 Coastal Bend Bays & Estuaries Project Area with Odem Ranch Watershed Location



The general objective of this study was to assess water-quality components with respect to nutrients, pesticides, organic materials, and other water-quality constituents from rainfall and storms producing surface water runoff from croplands comprising the Odem Ranch Watershed. The scope of the study included types, concentrations, loads, and yields of nutrients and selected pesticides. Water-quality samples were collected and analyzed for each rainfall and storm event that produced runoff from the watershed. Nutrients and selected pesticides monitored were those commonly used to produce crops in the CBBEP project area. Event mean concentration (EMC) values and nutrient and pesticide loads in runoff were quantified.

Nonpoint Source Event Mean Concentration (EMC) Values

Data collected from seven storm events during 1996, 1997, 1998, and 1999 represent concentrations of nutrients, pesticides, organic matter, and other inorganic chemicals in surface water runoff from agricultural croplands. Table ES.1 provides minimum, median, and maximum EMC values by constituent for three storm events occurring during the crop growing season (June 1996, June 1997 and March 1999), one storm event immediately following crop harvest (August 1996), and three storm events during layby when the ground is relatively bare (one in October 1997 and two in October 1998). All forms of nitrogen and phosphorus, and the most frequently detected pesticides (atrazine, fluometuron, metalochlor, pendimethalin, trifluralin) exhibited higher numerical median concentrations during the preplant and crop growing season (November – June) than in the post-harvest and fall period (August – October). However, only nitrite nitrogen and atrazine exhibited statistically significantly higher seasonal median values for the preplant and crop growing season. Data are insufficient to further catagorize EMC values by seasonal variation.

Sixteen pesticides were detected in runoff with various degrees of frequency during the study. The herbicide atrazine was detected in all runoff samples. Atrazine concentrations in ten samples were below the U.S. Environmental Protection Agency (USEPA) aquatic-life protection criteria of 11 micrograms per liter (ug/L). The maximum EMC value of 4.66 ug/L for atrazine was recorded for the first runoff event (June 1996) and appears to be an outlier value. All other observed concentrations of atrazine in surface water runoff from subsequent storm events did not exceed 1.0 ug/L.

Median EMC values for nutrients in runoff from the watershed are lower than median EMC values reported by Baird et al (1996) for the CBBEP project area. Soils in the watershed are farmed with U.S. Department of Agriculture (USDA), Natural Resources Conservation Service (NRCS) approved conservation and crop management practices. Slopes are relatively flat (less than one degree slope) throughout the watershed. Rainfall

Table ES.1 Summary of EMC Values by Constituent
[Values shown with a < symbol were below detection levels]

Constituent	Unit	EMC for Storm Water Runoff		
		Minimum	Median	Maximum
Organic Chemicals:				
Atrazine	ug/L	0.04	0.10	4.66
Deethyl Atrazine	ug/L	0.03	0.17	1.02
Fluometuron	ug/L	0.04	0.05	1.60
Malathion	ug/L	<0.005	<0.005	0.02
Azinphos-Methyl	ug/L	<0.001	<0.001	0.06
Metalochlor	ug/L	<0.002	0.007	0.01
Pendimethalin	ug/L	<0.004	0.01	0.11
Simazine	ug/L	<0.005	<0.005	0.03
Trifluralin	ug/L	<0.002	0.01	0.17
Diuron	ug/L	<0.02	<0.02	0.11
Carbofuran	ug/L	<0.003	<0.003	0.02
Dicamba	ug/L	<0.035	<0.035	3.60
Diazinon	ug/L	<0.002	<0.002	0.04
Methyl - Parathion	ug/L	<0.006	<0.006	0.02
Inorganic Chemicals:				
Total Nitrogen	mg/L	0.98	2.09	2.74
Nitrate Nitrogen	mg/L	0.04	0.48	1.15
Nitrite Nitrogen	mg/L	<0.01	0.04	0.26
Nitrate + Nitrite Nitrogen	mg/L	0.05	0.56	1.18
Ammonia	mg/L	<0.015	0.05	0.24
Dissolved Ammonia + Organic	mg/L	<0.10	0.41	0.64
Total Ammonia + Organic	mg/L	0.69	1.31	2.10
Total Phosphorus	mg/L	0.27	0.48	0.87
Dissolved Phosphorus	mg/L	<0.05	0.24	0.45
Orthophosphorus	mg/L	<0.01	0.25	0.41
Dissolved Chloride	mg/L	1.1	3.65	8.50
Dissolved Fluoride	mg/L	0.2	0.35	0.80
Dissolved Sulfate	mg/L	0.8	1.3	3.90
Dissolved Iron	ug/L	<3.0	4.5	8.0
Total Dissolved Solids	mg/L	72.0	93.3	151.0
Suspended Solids	mg/L	192.0	366.0	488.0

is generally lower, averaging 32.71 inches annually (1969 – 1998 30-year reporting period), compared to other coastal regions of Texas. Maximum EMC values for runoff from the watershed were less than Texas State Water Quality Standards (TSWQS) for aquatic life and human health protection by the Texas Natural Resources Conservation Commission (TNRCC) for monitoring constituent concentrations in surface waters.

Estimated Constituent Loadings for the Odem Ranch Watershed

Table ES.2 presents annual estimates of constituent loadings from rainfall and from runoff during storm events for the Odem Ranch Watershed. Stormwater runoff volume was combined with EMC values for each storm event to estimate loadings for three groups of constituents: nutrients, other inorganic chemicals, and organic pesticides. Annual loadings are the summation of event loadings for each year.

Total annual runoff from the watershed was 4.5 million cu. ft. (103.5 ac. ft.) in 1996, 13.5 million cu. ft. (309.1 ac. ft.) in 1997, and 31.8 million cu. ft. (730.8 ac. ft.) in 1998. An estimated 0.3 million cu. ft. (6.8 ac. ft.) of runoff occurred during the March 1999 storm event. Runoff during storm events averaged 15 percent of rainfall and ranged from an average of less than 3.0 percent during the crop growing season (March – June) to an average of almost 22.0 percent during harvest and fall (August – October). However, runoff as a proportion of total rainfall falling on the watershed during June 1995 – May 1999 was 4.5 percent. Estimated loadings of nutrients and other inorganic chemicals in runoff are higher in 1997 and 1998 than 1996, depending on annual runoff. In contrast, organic pesticide loads were lower in 1997 and 1998 primarily because the largest runoff events occurred in October when less pesticide residues remained in the fields. Concentrations of nutrients and pesticides in runoff for the March 27-28, 1999 runoff event were not numerically significantly different from concentrations during other periods of the growing season.

Total pesticide residues in runoff were quite small in all years, amounting to less than 1.0 pound annually. Management practices used to produce crops in the watershed apparently are effective in limiting loadings of nutrients and pesticides in stormwater runoff. Rainfall loadings of nitrogen for storm events producing runoff underestimate annual total nitrogen loadings from wet atmospheric deposition. Annual total nitrogen loads from rainfall on the Odem Ranch Watershed were an estimated 5,828 pounds in 1996, 10,712 pounds in 1997, and 8,658 pounds in 1998. Nitrate nitrogen accounted for 37.5 percent, ammonia accounted for 51.6 percent, and organic nitrogen accounted for 10.9 percent of total nitrogen loads in rainfall.

Table ES.2 Annual Constituent Loadings in Rainfall and Runoff

Constituent	Rainfall (lbs.)			Runoff (lbs.)		
	1996	1997	1998	1996	1997	1998
Nutrients:						
Total Nitrogen	5,828	10,712	8,658	449	1,852	2,221
Dissolved Organic Nitrogen	—	—	—	69	433	287
Total Organic Nitrogen	—	—	—	224	1,061	1,932
Nitrate + Nitrite Nitrogen	—	—	—	170	755	289
Nitrate Nitrogen	2,192	4,024	3,297	—	—	—
Ammonia	3,025	5,578	4,468	21	39	80
Total Phosphorus	549	1,021	963	106	409	726
Dissolved Phosphorus	—	—	—	34	231	170
Orthophosphorus	166	261	241	72	201	143
Other Inorganic Chemicals:						
Calcium	—	—	—	4,839	17,543	17,003
Magnesium	—	—	—	360	1,453	1,237
Potassium	—	—	—	1,472	4,411	4,483
Chloride	—	—	—	1,041	5,938	1,700
Organic Pesticides:						
Atrazine	—	—	—	0.505	0.077	0.099
Deethyl Atrazine	—	—	—	0.15	0.095	0.059
Fluometuron	—	—	—	0.248	0	0.022
Malathion	—	—	—	0.002	0	0
Other Pesticides[1]	—	—	—	0.062	0.101	0.070
Total Pesticides	—	—	—	**0.967**	**0.273**	**0.250**

— Data not available

[1] Total for eight other pesticides

During the four-year study, total nitrogen runoff yield from the watershed was 0.54 pound per acre per year, compared to 82 pounds per acre per year applied as fertilizer and 3 pounds per acre per year from rainfall nitrogen. Nearly all fertilizer and rainfall nitrogen was nitrate and ammonia, whereas most runoff nitrogen was particulate organic nitrogen, mostly crop residue. Total nitrogen exiting the watershed in surface water runoff amounted to about 0.6 percent of nitrogen inputs from fertilizer and rainfall. Annual deposition of total nitrogen from rainfall on the watershed actually exceeded loads of total nitrogen in runoff. Total phosphorus runoff yield from the watershed was 0.15 pound per acre per year, compared to 18.5 pounds per acre per year applied to crops as soluble orthophosphate and 0.31 pound per acre per year from rainfall phosphorus.

Compilation of EMC values is an important step in characterizing runoff water quality from agricultural croplands in the CBBEP project area. This data base is applicable primarily to Victoria Clay soils. Soils and topography in the Odem Ranch Watershed and seasonality of storm events make the EMC data base representative of some three-fourths of cropland acreage in the eastern portion of the CBBEP project area.

I. INTRODUCTION

Coastal Bend Bays & Estuaries Program (CBBEP) goals are to protect and improve the environmental and ecological quality of estuarine and living resources of the 12-county CBBEP project area. As a component of developing and implementing a Comprehensive Conservation and Management Plan (CCMP), the CBBEP solicited proposals for Action Plan Demonstration Projects (APDPs) to address nonpoint source pollution concerns relating to agricultural, urban, coastal, or geographically specific environments within the CBBEP project area.

The Texas Agricultural Experiment Station (TAES), in collaboration with the United States Geological Survey (USGS) and the Natural Resources Conservation Service (NRCS) of the United States Department of Agriculture (USDA), initiated a study in 1995 to determine water-quality components of runoff from a small watershed representative of a major portion of cropland soils in the CBBEP project area. The general objective of this study was to assess water-quality components with respect to nutrients, pesticides, organic materials, and other water-quality constituents from rainfall and storms producing surface water runoff from cropland comprising the Odem Ranch Watershed.

Scope of the Study

The scope of the study included identification of types, concentrations, loads, and yields of nutrients and selected pesticides from the Odem Ranch Watershed during stormwater runoff events. The initial phase of the project consisted of installation of fixed-station stream flow gauging and automated water-quality sampling equipment at edge-of-field runoff sites. Descriptions of the watershed, receiving waters and wetlands, environmental conditions, and management practices used to produce crops in the watershed were made. Water-quality samples were collected and analyzed for each rainfall and storm event that produced runoff from the watershed. Rainfall samples were analyzed for total forms of ammonia-plus-organic nitrogen and phosphorus, and dissolved forms of nitrite, nitrate-plus-nitrite, ammonia, ammonia-plus-organic nitrogen, phosphorus and orthophosphorus. Surface runoff water-quality analyses included ammonia, nitrate, nitrite, total nitrogen, total phosphate, orthophosphate, a sample of organochlorine and organophosphorus pesticides, total suspended solids, dissolved solids, and trace elements. Nitrate was the dominant form of nitrogen from fertilizers applied to crops. Pesticides monitored were those commonly used on crops in the CBBEP project area and those pesticides that the USGS National Water Quality Laboratory can currently analyze for presence in water-quality samples. Data were used to quantify nutrient and pesticide loads applied to the

fields and also to relate these loads to concentrations, loadings, and yields in runoff water produced by each storm event.

Runoff and Nonpoint Source (NPS) Pollution from Agriculture

Runoff is a natural hydrologic phenomenon strongly influenced by land use, especially where activities of man have altered land use from natural conditions. Agricultural runoff is related to farming practices, land use, and management factors. Nonpoint source pollution is generated during stormwater runoff events and is often related to agricultural production techniques. Agricultural pollutants include pesticides, sediments, nutrients, and organic materials. NPS loading from agricultural areas tends to be seasonal with higher loading associated with planting and harvesting activities.

Descriptions of Agricultural NPS Runoff Constituents

Water-quality constituents potentially comprising nonpoint source pollution of significance in runoff from this study are described by Baird et al (1996) in the following manner. (*Excerpts taken from Characterization of Nonpoint Sources and Loadings to the Corpus Christi Bay National Estuary Program Study Area, Texas Natural Resources Conservation Commission, January 1996).*

Suspended Solids is the concentration of suspended material in water. Suspended solids interfere with the transmission of light which affects the seabed vegetation and, in turn, the overall health of an estuary system. Suspended solids also provide transport for other pollutants including organics and metals. Suspended solids are often related to the amount of erosion occurring in a watershed.

Dissolved Solids are in theory determined by evaporation of a filtered sample. More commonly, however, dissolved solids are calculated from the dissolved constituents of the sample analysis. In most water, the dissolved solids consist mainly of silica, calcium, magnesium, sodium, potassium, carbonate, bicarbonate, chloride, and sulfate, and trace quantities of other organic and inorganic constituents. Dissolved solids concentrations are often used as an indicator of water quality, since high values of dissolved solids affect taste in drinking water and may limit the use of water for irrigation or certain industrial applications, especially when chloride concentrations are high.

Nitrogen (N) containing compounds that are most important, from a water quality standpoint, are: organic N, ammonia, nitrate, nitrite, urea ($CO(NH_2)_2$), and nitrogen gas (N_2).

Total N(TN) includes all the various forms of organic and inorganic N found in water, except N_2 gas.

Total Kjeldahl N (TKN) refers to an analytical method where ammonia and organic N are combined.

Nitrate (NO_3) is indicative of fertilizer use.

Nitrite (NO_2) and organic species are indicators of pollution by sewage or organic waste.

Ammonia (NH_3) is generally a product of compounds containing organic nitrogen including sewage. Unionized ammonia is toxic to fish and other aquatic animals and consumes oxygen as it is converted to nitrate. At pH below about 9.2, ammonia nitrogen is largely of the form NH_{4+}.

Total Phosphorus (TP) includes dissolved and suspended phosphorus in both organic and inorganic forms. Orthophosphates are associated with fertilizers. Organic phosphates are formed primarily by biological processes. In instances where phosphate is a growth-limiting nutrient, the discharge of phosphates into an estuary or other water body may stimulate excess growth of algae or other organisms in nuisance quantities.

Dissolved Phosphorus includes orthophosphorus, which is available for phytoplankton growth, as well as complex forms of phosphorus.

Fecal Coliform (FC) bacteria are present in the feces of warm blooded animals and are indicators of bacteriological water quality. Coliform concentrations are measured in number of bacterial colonies per 100 ml of sample.

Pesticides are defined in most state and federal laws as any substance used for controlling, preventing, destroying, repelling, or mitigating any pest. The pesticide categories of defoliant, desiccant, fungicide, growth regulator, herbicide, insecticide, and nematicide are of major significance for use on crops in the CBBEP project area and the Odem Ranch Watershed.

Event Mean Concentration

For purposes of this study, water quality is expressed in terms of concentrations of particular constituents. Expressions of concentrations in milligrams per liter

(mg/L) or micrograms per liter (ug/L) are used, with almost equivalent terms of parts per million (ppm) and parts per billion (ppb), respectively. Concentrations of a particular substance in water sufficient to produce detrimental effects for the intended use of the water results in the substance being called a pollutant, and the resulting condition is known as water pollution. Apart from man-made organic chemicals, toxins, or radioactive elements, many substances occur naturally in a wide range of concentrations. Presence of a substance is not necessarily harmful by itself, but rather the relatively high concentration of that substance. Water quality evaluation generally involves comparisons of substance concentrations with water quality standards and criteria.

Constituent load, which is a total amount of a substance in terms of mass, is a measure of water quality. Difficulties are encountered when total load is used to compare constituent loads at different locations and between different storms, because large watersheds will generally yield more mass of a particular constituent than a similar smaller watershed, for similar storm characteristics. An average concentration, or event mean concentration (EMC), obtained by dividing total constituent load by runoff volume during a runoff event, is the appropriate measure for making such comparisons between different locations or between different storms. An EMC can be determined by collecting multiple runoff samples during a storm event while also measuring flow over the course of the event and flow-weighted averaging the measured constituent concentrations. Alternatively, automatic samplers and streamflow gauges are often used to sample runoff at a frequency proportional to the runoff or flow rate so that the samples can be combined to yield a single flow-averaged sample. Constituent concentration of the flow-averaged sample represents an event mean concentration. Automatic samplers and streamflow gauges were used to collect water-quality samples from each sampling site in the Odem Ranch Watershed. EMCs for the constituents in the flow-averaged samples represent the average concentrations and were used in calculating constituent loads.

II. DESCRIPTION OF THE STUDY AREA

The Odem Ranch Watershed is located in western San Patricio County within the Nueces River Basin Drainage Area (Figure II.1). The watershed is comprised of cropland primarily planted to cotton and grain sorghum, with smaller acreage planted to corn each year. Two residences are located within the watershed boundaries. Storm-water runoff exits the watershed at two locations, eventually flows into the Nueces River, then into the Nueces Bay/Corpus Christi Bay system (Figure II.2). Total drainage area of the Odem Ranch Watershed study area is an estimated 2,775 acres.

Climate

Climate of the study area is classified as subtropical (short, mild winters and long, hot and humid summers). Prevailing winds are southeasterly throughout the year. Warm tropical air from the Gulf of Mexico is responsible for the mild winter temperatures and hot, humid summer weather. Rainfall in the Odem Ranch Watershed is around 33 inches per year. Rainfall for the National Oceanic and Atmospheric Administration (NOAA) station located at Corpus Christi International Airport (based on the 30 year average for 1969–1998) is 32.71 inches. The Odem Ranch Watershed is located approximately 18.6 mi. northwest of the NOAA station. Average annual rainfall for each of the 30 years during 1969 to 1998 for the NOAA station is shown in Figure II.3.

An average annual total does not completely describe the nature of rainfall within the watershed. From 1969 to 1998, annual rainfall at the NOAA station varied from 18.63 inches in 1996 to 48.07 inches in 1991. The 30-year average was 32.71 inches with a standard deviation of annual rainfall during this period of about 8.63 inches, indicating that annual rainfall is highly variable from year to year. Also, rainfall is not equally distributed throughout the year. Table II.1 shows average precipitation by month for the NOAA station (1969–1998 avg.).

Table II.1. Average Corpus Christi Monthly Precipitation (NOAA, 1969 to 1998)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
In.	1.71	1.96	0.94	1.72	3.33	3.38	2.39	4.17	5.82	3.73	1.97	1.59

Monthly distribution of rainfall is related to the crop growing season and crop production practices. Most crops are harvested by September 1, and stalks are

Figure II.1 Odem Ranch Watershed Location

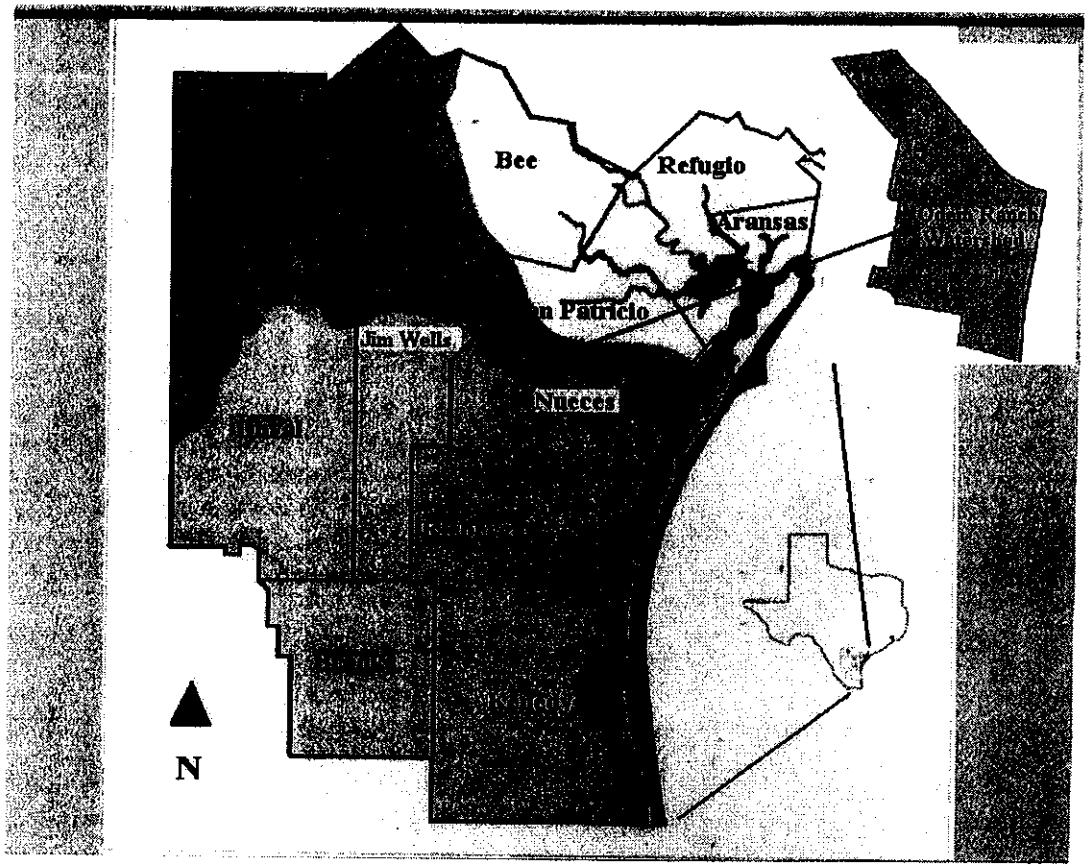


Figure II.2 Odem Ranch Watershed with Sampling Locations

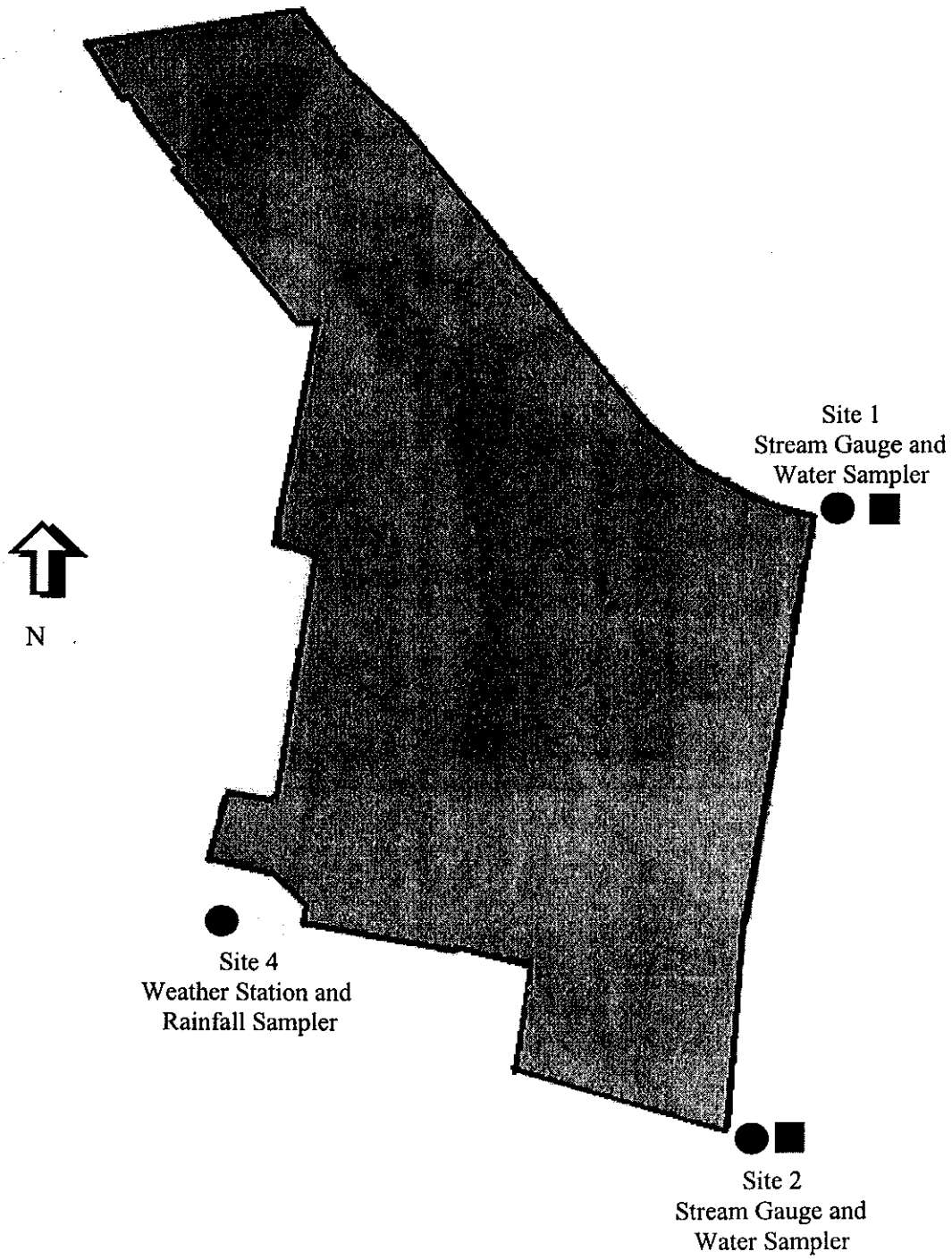
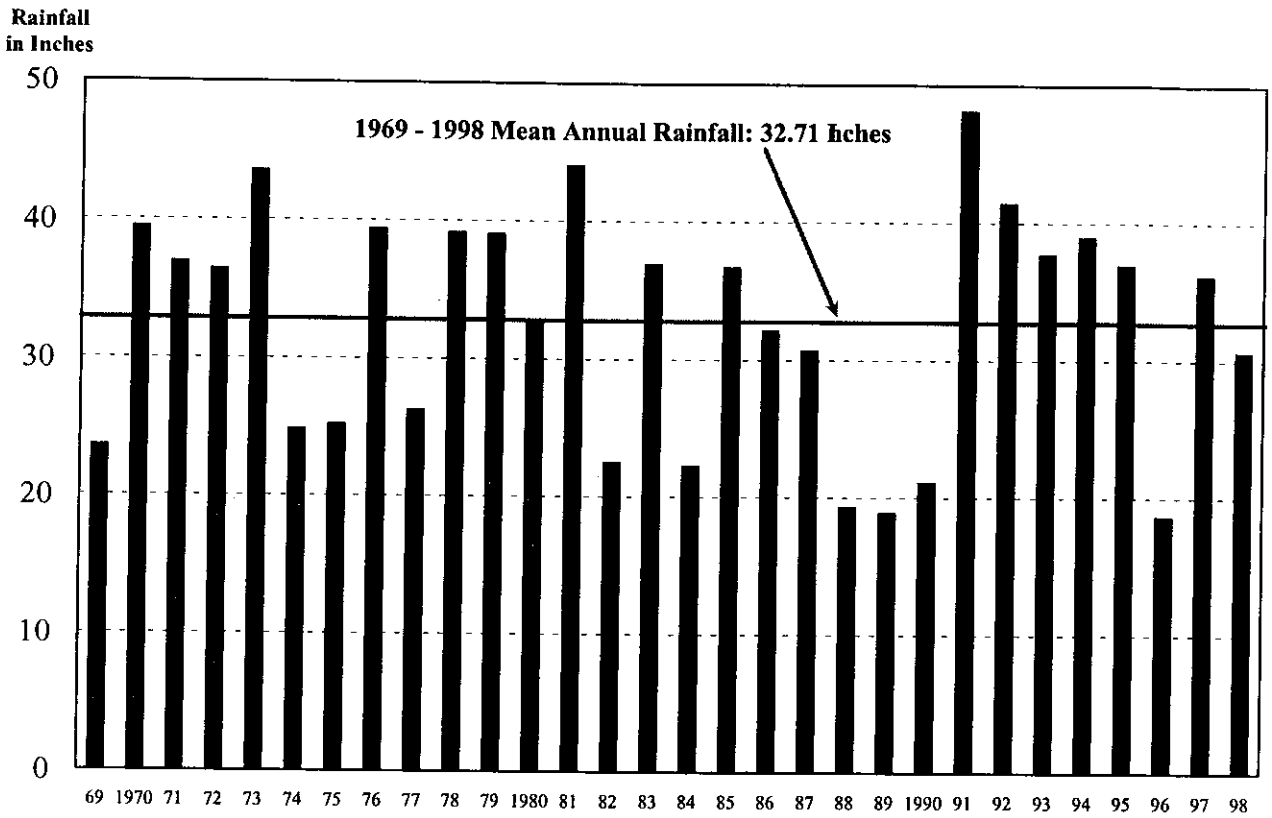


Figure II.3 Annual Rainfall at National Oceanic and Atmospheric Administration (NOAA) Rainfall Station Near Corpus Christi, Texas, 1969 – 1998



shredded and plowed under by early September. Preplant fertilizer and pre-emergence herbicide applications are usually made in November - December with planting commencing in mid-February to early March. September 1 to February 28 is generally considered the preplant period. Crop emergence, plant growth, and fruiting occur during March 1 through June 30, with harvest July 1 through August 31. Lowest rainfall occurs November through April, totaling 9.89 inches, or an average of 1.65 inches per month. Highest rainfall is generally August through October, totaling 13.72 inches, or an average of 4.57 inches per month. Almost 23 inches, or 70 percent of the 1969 - 1998 average annual rainfall occurred during May through October.

Severe tropical storms occur about once every 10 years, and less severe storms occur about once every five years. Hurricanes strike the lower Coastal Bend Region chiefly in August and September, though have occurred as early as June and as late as October (Baird et al 1996).

Soils

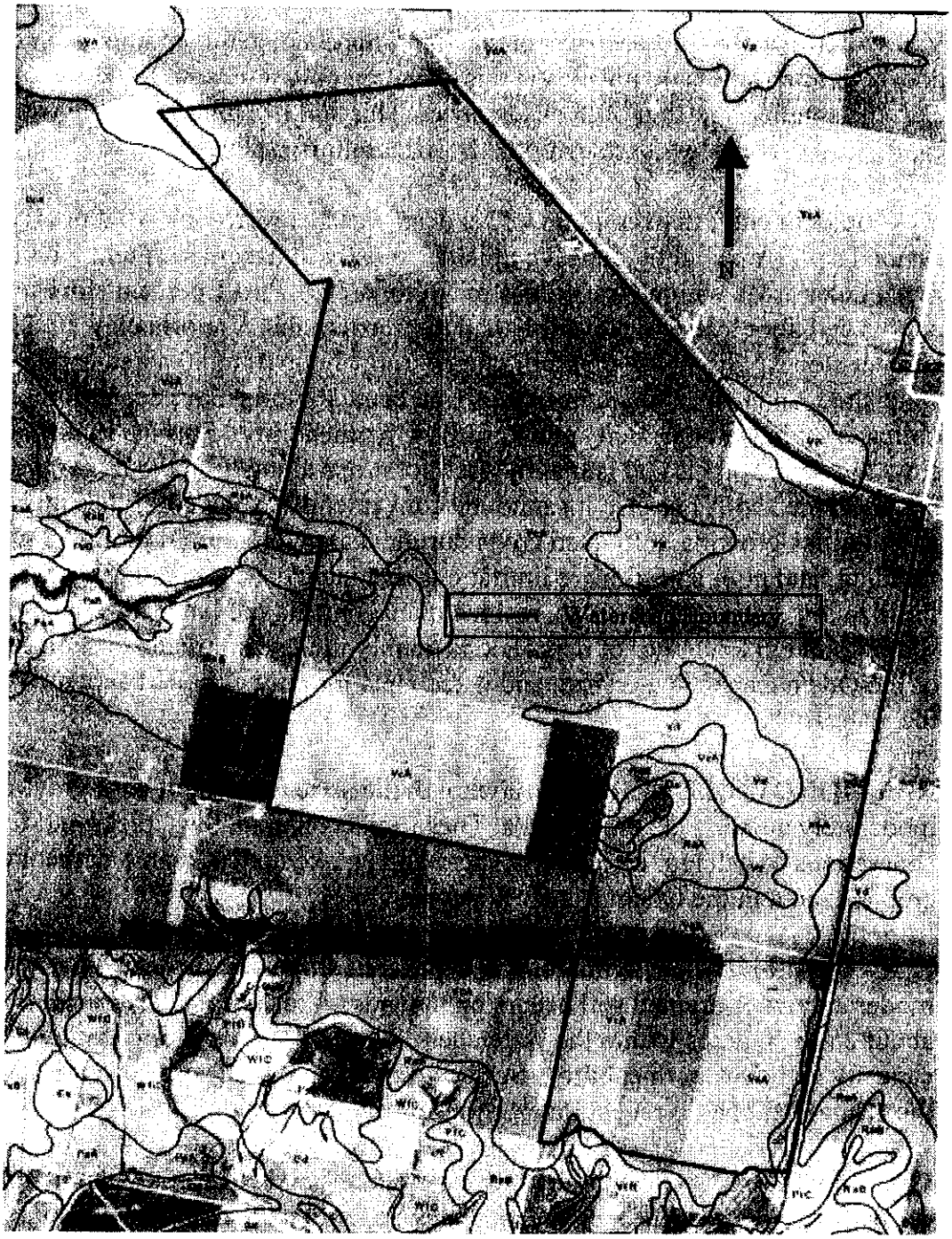
Detailed soil survey information has been published by the USDA, NRCS for San Patricio County. Properties of soils can have significant impact on storm runoff depending on their permeability and erodibility , and the hydrologic cover condition associated with land use or cover crop.

The predominant soil series occurring in the Odem Ranch Watershed is Victoria with small acreages of Raymondville, Orelia, and Edroy series. These soils within the watershed are mapped in Figure II. 4, which also shows the watershed boundary. Victoria soils are generally well suited for field crop and grass production. Grain sorghum, cotton and corn are the most important field crops. A brief description of these soil series is included below. Additional information on these soil series may be found in the published San Patricio and Aransas counties soil survey report (USDA, 1979).

VICTORIA SERIES - Victoria clays are the dominant soils in the watershed and in coastal counties comprising the eastern portion of the CBBEP project area (Figure II. 4). This series consists of dark, calcareous, crumbly soils called blacklands. These soils crack when dry and take in water rapidly. They swell when wet, then take in water slowly.

V_cA - Victoria clay, 0 to 1 percent slopes. This is a deep, nearly level, somewhat poorly drained soil with high available water capacity and very slow permeability.

Figure II.4 Soils Map of the Odem Ranch Watershed
Source: USDA, SCS, Soil Survey of San Patricio and Aransas Counties, Texas



Surface runoff is slow to very slow. These soils are predominant in the Odem Ranch Watershed and account for well over 90 percent of the cropland area.

V_cB - Victoria clay, 1 to 3 percent slopes. This deep, gently sloping, somewhat poorly drained soil is on uplands and is found on only a few cropland acres in the extreme southern portion of the watershed. This soil has high available water capacity and very slow permeability. Surface runoff is slow.

V_d - Victoria clay, depressional. This deep, nearly level, somewhat poorly drained soil is on slightly concave uplands, mostly in irregular, round, oblong, or rectangular areas within larger areas of Victoria clay, 0 to 1 percent slopes. Areas are 0.5 to 1 foot lower in elevation than the surrounding Victoria clay, 0 to 1 percent slopes. Size of these areas ranges from about 10 to 60 acres within the watershed, and slopes range from 0 to 1 percent. Victoria clay, depressional, has high available water capacity and very slow permeability. Surface runoff is very slow to ponded. This soil is mainly used for crops along with the larger areas of better drained soils because it cannot be conveniently excluded. It has high potential for growing cultivated crops during years with normal rainfall. Wetness, flooding, and poor soil tilth are limitations that have been overcome by proper fertilization, high residue crops, residue management, and land smoothing. This soil is found in a number of depressions mainly in the central and eastern portions of the Odem Ranch Watershed, and it accounts for only a limited acreage within the watershed.

RAYMONDVILLE SERIES - Raymondville series consist of dark gray, moderately alkaline clay loam soils. These soils contain a few cracks and fine concretions of calcium carbonate. These soils make up less than 5 percent of the cropland area in the Odem Ranch Watershed.

R_aA - Raymondville clay loam, 0 to 1 percent slopes. This deep, nearly level, moderately well-drained soil occurs on uplands. Areas of this soil range from about 25 to 50 acres within the watershed. This soil has medium available water capacity and slow permeability. Surface runoff is slow. These soils are found in the east central and west central portions of the watershed.

ORELIA SERIES - The Orelia fine sandy loams and Orelia clay loams consist of deep, dark-colored, crusty soils that contain a hardpan and are locally called hardpan soils. The only area of these soils within the watershed is a few acres in the east central portion, intermingled with Victoria Clay, depressional, Raymondville clay loam, 0 to 1 percent slope, and Edroy clay soils (Figure II. 4). Because the subsoil is dense, these soils take in water very slowly.

Os - Orelia fine sandy loan. This is a deep, nearly level, somewhat poorly drained soil on slightly concave uplands. Areas of this soil account for only a few acres in the central portion of the watershed. Slope is from 0 to 1 percent. The soil has medium available water capacity and very slow permeability. Surface runoff is slow.

EDROY SERIES - The Edroy clay series is a deep, poorly drained, nearly level soil. The surface layer is dark gray with medium available water capacity and very slow permeability. It occupies weakly defined and discontinuous water courses.

E_c - Edroy clay. This is a deep, poorly drained, nearly level soil on slightly concave uplands. Limitations of wetness and poor tilth have been overcome by proper fertilization, planting crops that produce a large amount of residue, and land smoothing. This soil comprises very little of the cropland acreage within the watershed, and it is found intermingled with the Raymondville clay loam and Orelia fine sandy loam soils.

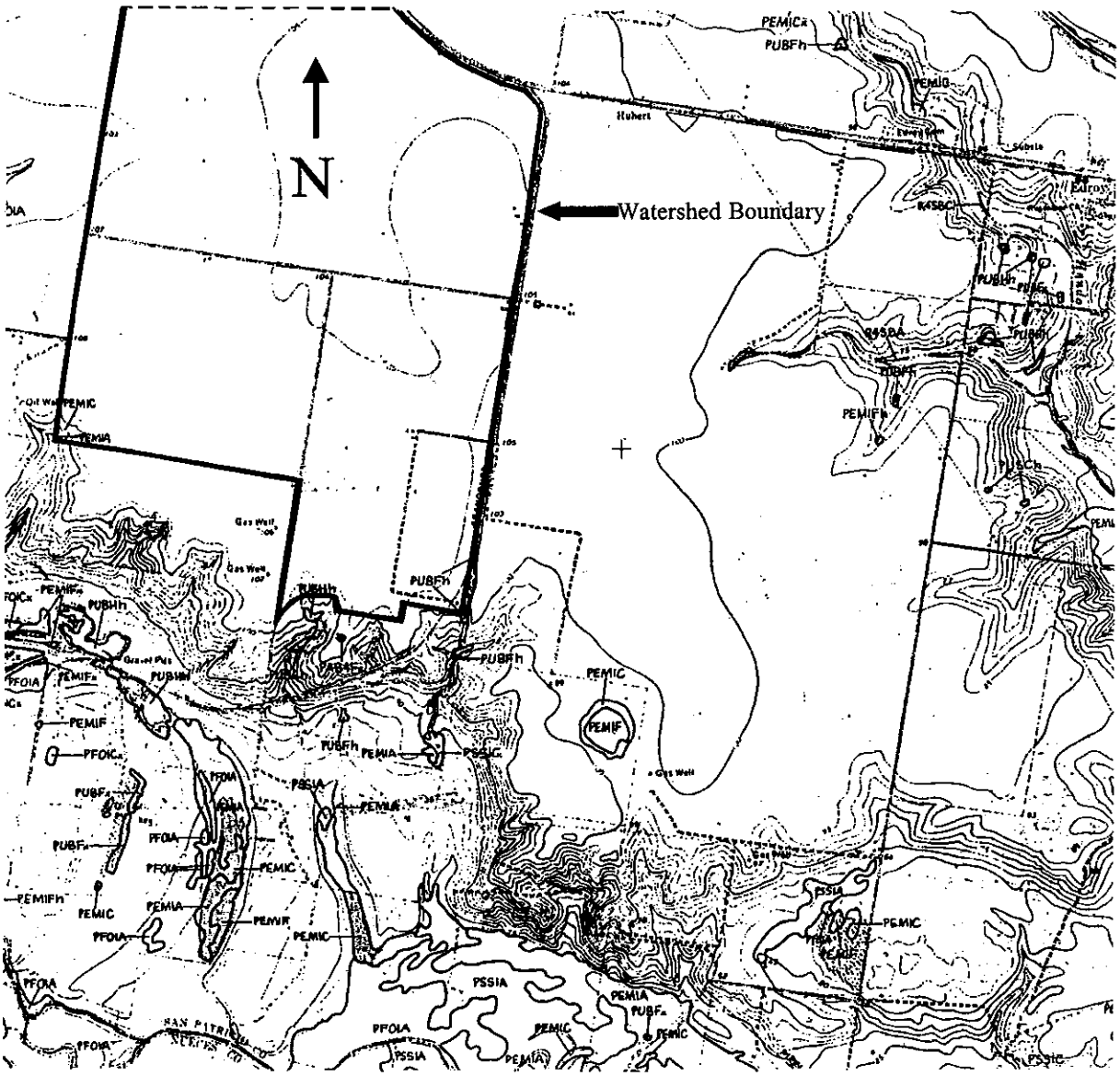
Receiving Waters and Wetlands

Runoff from croplands exits the watershed at the northeast and southeast corners (see Figure II. 2). The northern drainage area is comprised of approximately 1,683 acres with runoff from croplands exiting the fields via culverts and trestles along the Missouri Pacific Railroad. The runoff enters a drainage ditch on the south side of County Road 50 and flows east approximately 1½ mile where it enters into Hondo Creek and eventually flows into the Nueces River (Figure II. 5).

Runoff from the southern drainage area in the watershed is from about 1,092 acres. Runoff flows into a county road drainage ditch along the eastern boundary of the watershed until it reaches an abandoned area containing a constructed drainage canal with two step-down wier impoundments designed to reduce soil erosion and channelization. From the step-downs runoff flows through a weakly defined watercourse into an improved pasture and subsequently a brush covered rangeland area before it enters into the flood plain bordering the Nueces River.

Receiving waters are unclassified freshwater streams that flow into the Nueces River segment below Calallen Dam which is the intake point for the City of Corpus Christi water supply. Beneficial uses of receiving waters include aquatic life habitat, contact or non-contact recreation, aquifer protection, and industrial water supply.

Figure II.5 Wetland Areas in Relation to Drainage Passageways in the Odem Ranch Watershed



Wetlands areas receiving runoff are predominantly classified as Palustrine unconsolidated bottomlands seasonally or semipermanently flooded when storms produce runoff from upland areas (U.S. Dept. of Interior, National Wetlands Inventory, 1992). In the southern drainage channel the two stepdown wier impoundments constructed to reduce soil erosion and channelization of the drainage waterway may retain water for considerable periods following a runoff event.

Wetland areas provide habitat for various species of waterfowl and support plant life which provides habitat for a variety of avian, mammalian, and reptilian wildlife. Wetland habitat consists of open, marshy or swampy, shallow water areas where water-tolerant plants grow. Wildlife attracted to these areas include ducks, geese, and other waterfowl species. Rangeland habitat adjacent to the wetlands consists of areas of herbaceous plants and shrubs and wildlife are attracted to these rangelands. In addition to providing habitat for wildlife, wetland areas also provide grazing for domestic beef cattle during periods when not flooded.

Land Use by Crops

Cropland use is for field crops of cotton, grain sorghum, and corn. Six producers planted a total of 1,616 acres to cotton, 1,178 acres to grain sorghum and 73 acres to corn in 1996 (Table II.2). Cotton acreage was reduced to 1,061 acres in 1997 and 1,103 acres in 1998, while grain sorghum acreage was increased to 1,736 acres in 1997 and 1,313 acres in 1998. Corn acreage was increased to 450 acres in 1998. Farmers in the watershed use a crop rotation between cotton and grain sorghum, and cotton and corn to control pests affecting the crops, primarily soil insects and diseases. Comparison of acreages for crops in Table II.2 indicates that within each farm most acreage was rotated between the 1996, 1997, and 1998 crop years.

Management Practices for Producing Crops

Farmers within the watershed use a set of recommended management practices under NRCS approved conservation systems to produce crops each year. These include tillage and crop rotation practices, variety selections, fertilizer and pesticide rates and application methods, and insect and crop management decision aids. In varying combinations, these management practices are representative of crop management practices used on 70 to 80 percent of croplands within the CBBEP project area.

Tillage and crop rotation practices. These management practices consist of using a cotton stalkpuller to terminate the crop quickly after harvest to reduce

Table II.2 Crops and Acreage by Farm and Rotation, 1996 — 1998

Farm Number	1996		1997		1998	
	Crop	Acres	Crop	Acres	Crop	Acres
253	Cotton	125.8	Sorghum	221.4	Cotton	120.0
	Sorghum	175.6	Cotton	80.0	Sorghum	181.4
271	Cotton	65.0	Corn	69.0	Corn	69.0
	Corn	73.0	Cotton	69.0	Corn	69.0
553	Cotton	36.7	Sorghum	36.7	Cotton	37.0
	Sorghum	36.0	Cotton	36.0	Sorghum	35.7
935	Cotton	60.0	Sorghum	60.0	Cotton	60.0
	Sorghum	60.0	Cotton	60.0	Sorghum	60.0
1172	Cotton	118.0	Sorghum	118.0	Cotton	118.0
	Sorghum	115.5	Cotton	115.5	Sorghum	115.5
2217	Cotton	107.5	Sorghum	107.5	Cotton	107.5
	Sorghum	92.5	Cotton	92.5	Sorghum	92.5
2218	Cotton	144.9	Sorghum	144.9	Cotton	144.9
	Sorghum	608.0	Cotton	608.0	Sorghum	296.0
					Corn	312.0
2231	Cotton	185.0	Sorghum	275.0	Sorghum	275.0
	Sorghum	90.0				
2332	Cotton	257.0	Sorghum	257.0	Sorghum	257.0
2335	Cotton	515.9	Sorghum	515.9	Cotton	515.9
Total All Farms	Cotton	1615.8	Cotton	1061.0	Cotton	1103.3
	Sorghum	1177.6	Sorghum	1736.4	Sorghum	1313.1
	Corn	73.0	Corn	69.0	Corn	450.0
	Total	2866.4	Total	2866.4	Total	2866.4

insect pressure in the following crop year, and to improve water infiltration; use of parabolic shank v-rippers to deep plow the soil for improved water retention and to reduce runoff; flat ground production method, as contrasted to bedding, to reduce water runoff and increase infiltration into the soil; and crop rotations to reduce impacts of soil insects and diseases on crop yields and to reduce the need for soil insecticides, fungicides, and other chemicals.

Resistant varieties/hybrids. These management practices are used to lessen pesticide applications, or at times, raise threshold levels for applications of pesticides. Among the crop variety selections are commercial hybrids of grain sorghum and corn that are resistant to major disease and/or insect pests in this region that affect the plants. During the past three years, cotton varieties have been selected for part of the acreage that are resistant to tobacco budworm *(Helicoverpa zea)* and to herbicides used to control broadleaf weeds and grasses. Early plantings are made of grain sorghum to minimize exposure to midge insects, and of semi-determinate cotton varieties to minimize exposure to boll weevils, late generation pesticide resistant tobacco budworms, and late summer tropical storms and hurricanes.

Fertilizer and pesticide rates and application methods. Fertilizers are required to produce economically acceptable crop yields. Nitrogen and phosphorus are generally applied annually, and some potash and minor elements such as iron, zinc, sulfur, etc. are applied infrequently where indications of soil deficiencies are detected. Fertilizers are applied at recommended rates for crop production based on residual nutrient levels within the plant root zone. Soil fertility tests are taken in the fall each year before application of preplant fertilizers. Fertilizers are applied during low rainfall months (generally November and December) and incorporated into the soil within 12 hours of application to reduce leaching into runoff.

Pesticides used are those with low active ingredient per acre (a.i./ac.) application rates, which degrade rapidly, and are low in toxicity to non-target pests. Pesticides in use within the watershed are herbicides, insecticides, plant growth regulators, and harvest aids (defoliants and desiccants). Crop production chemicals are applied at the low end of the labeled rate after pest populations have reached a university-approved treatment threshold level.

Soil applied insecticides are injected into the soil rather than being banded and left on top of the soil, and are applied at rates equal to the low range of the labeled rate. Pre-emergence herbicides are generally applied with fertilizer applications and immediately incorporated into the soil. Herbicides applied after the crop has

emerged from the soil are banded, to the greatest extent possible, to direct the chemical to problem weeds and to reduce actual poundage of material used to one-third of the low end of the labeled broadcast rate.

Plant growth regulators are used to control height of the crop, to increase fruit setting and retention, and to increase efficacy of insecticides used to control insect pests. Low rates of 1 to 2 oz. of a.i./ac. are used. Chemical harvest aids include defoliants and desiccants. These chemicals are applied at low rates of 1½ oz. a.i./ac.

Insect and crop management decision aids. A set of integrated pest management and integrated crop management (IPM/ICM) practices involving use of chemical pesticides, natural control agents, crop monitoring techniques, bio-assays of moths for pesticide resistance, and other crop growth prediction and monitoring techniques have been developed by TAES scientists and transferred by TAEX specialists to farmers in the lower Coastal Bend Region. These IPM/ICM practices are followed in producing crops in the watershed. Insect pest control practices include use of pheromone traps to capture insect pests in the field and to monitor and predict pest populations and trends. Both beneficial/natural insects that affect problem pests and the microbial/biological *Bacillus therengineis* (Bts) insecticides are used along with chemical pesticides to control crop insect pests. Predictions of moth populations and bio-assays of the *Helicoverpa zea* moth are used to assist in monitoring tobacco budworm populations and to monitor for resistance, and hence selection of pesticides for controlling the pest. Plant mapping techniques to determine stage of crop growth, fruit setting and retention, and fruit development are used to assist in management of cotton crops.

Crop Budgets

Crop budgets are statements of particular production practices and actual or expected outcome in terms of amount of product, gross income, fixed and variable costs, and net returns for each crop. They are particularly useful for describing inputs and operations used to produce each crop, timing of input use, testing economic and financial feasibility of alternative management practices and relating crop production practices to nutrient and pesticide loading on fields.

Crop budgets were used to develop the descriptions of field operations and input use and timing for each crop. Management records kept by cooperating producers in this project were used to record inputs and field operations required to produce each crop and to quantify nutrient and pesticide loadings on fields. Alternative management practices to reduce constituent loads in stormwater runoff were not

considered since EMC values were generally low. Thus detailed financial budgets were not developed for the crops.

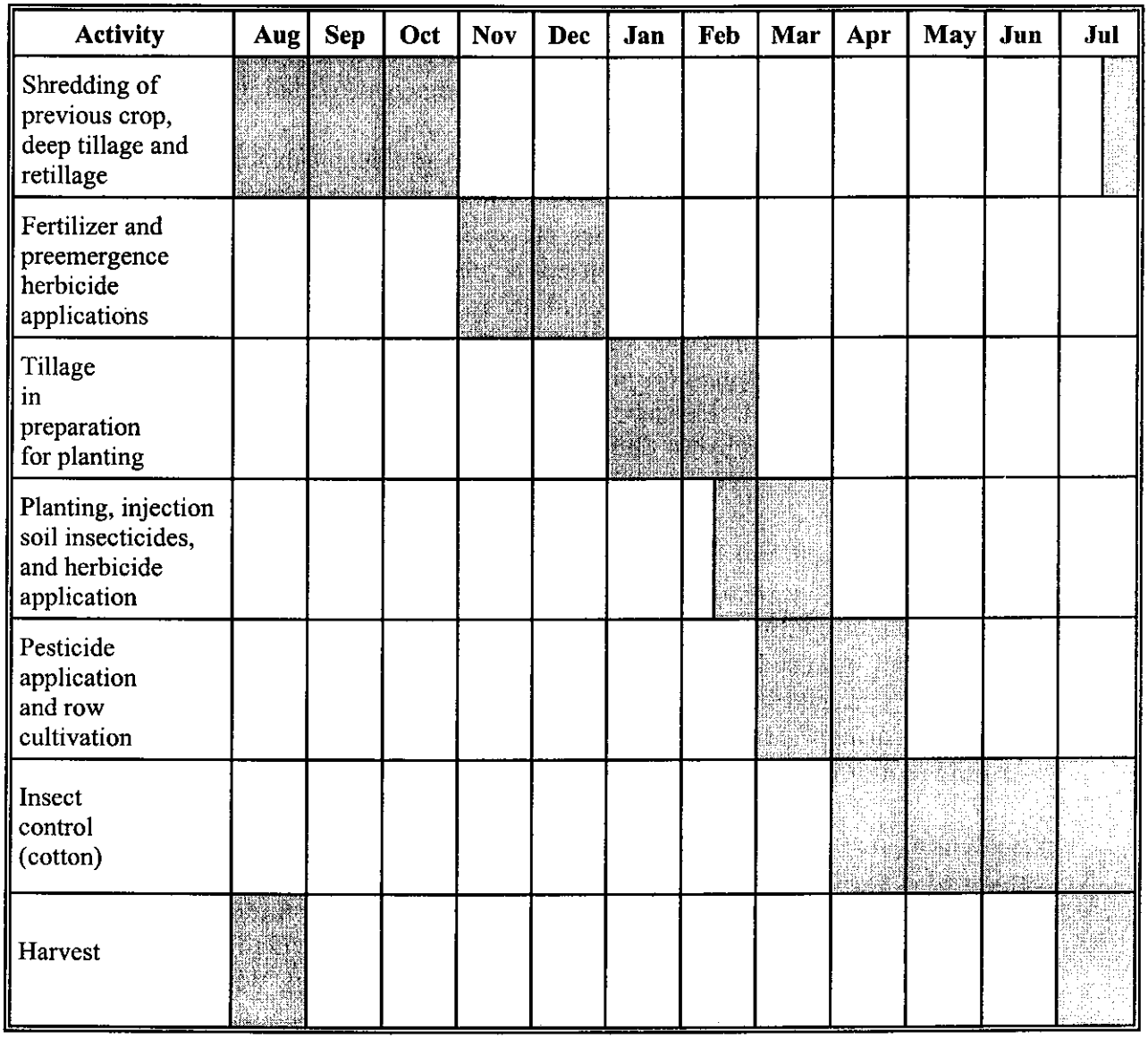
Field operations for crop production. A summary of field operations by time periods and types of activities used to produce crops is provided in Figure II.6.

Shredding of crop residue from the previous crop and deep tillage to plow out stubble and prepare the ground for fall and winter rains are generally performed during mid-July to late-August for each crop. Soil samples are taken in each field at this time and tested for residual nutrient levels remaining in the soils. The soil is retilled during September and October to destroy winter weeds and prepare the seedbed for the succeeding crop. Preplant fertilizer and broadcast pre-emergence herbicides are usually applied during November and December and immediately incorporated into the soil. During January to mid-February, additional tillage operations are performed using field cultivators, tandem disks or listers to rebed prior to planting.

Planting occurs from mid-February through late-March, depending on available soil moisture, soil temperature, and the crop. Corn is generally planted during the last two weeks of February. Early plantings of grain sorghum during late February to early March are used to reduce pressures of the sorghum midge insect on nonresistant commercial hybrid varieties of sorghum. Plantings of cotton usually commence during the second week of March with most producers attempting to complete plantings by the end of the month.

Production practices throughout the growing season after crops have emerged consist of applying pesticides to control problem weeds and insects, and row cultivation to provide soil to plants and destroy weeds in the middles of rows. A layby period from around mid- to late-April to early July occurs for corn and grain sorghum, wherein few, if any, field operations are carried out. This period is one of heavy activity in scouting and controlling insects that attack the cotton plant. Harvest of corn and grain sorghum usually occurs in early- to mid-July and the land is again prepared for next year's crop. Cotton harvest activities are generally under way from mid-July when harvest aids are applied to the crop to mid-August when most of the crop has been harvested and stored in modules or hauled to the gin.

Figure II.6 Typical Timing of Agricultural Activities in Odem Ranch Watershed



III. METHODS AND MEASUREMENTS

Nutrient and Pesticide Loadings on Fields

Records kept by producers for each crop by field were used to calculate total amounts of nutrients and pesticides used in the watershed. Additionally, quantities of malathion insecticide sprayed on cotton fields by the Texas Boll Weevil Eradication Foundation were included in pesticide totals. Total loadings by crop and type of chemical for each year are summarized in Table III.1. Appendix A provides details of synthetic herbicides, insecticides, crop growth and harvest aids, and nutrients applied to crops each year.

Synthetic herbicides, defoliants, desiccants and growth regulators applied to crops varied from about 5,835 lbs. in 1996 and 1998 to 6,352 lbs. of active ingredients in 1997, primarily because of increased acreage of sorghum and a reduction in cotton acreage in 1997. Total synthetic insecticides were some 12,166 lbs. of active ingredients in 1996, only 7,458 lbs. in 1997, and 10,696 lbs. in 1998. Variability in insecticide use was directly related to sprayings for eradication of boll weevils and the proportion of the total acreage planted to cotton. Insecticides were primarily used in cotton insect management. During the three years 1996–1998, total pesticides applied to the crops averaged 5.6 lbs. per acre. An average of 2.1 lbs. per acre was from herbicides, growth regulators and harvest aids while the remaining 3.5 lbs. per acre were insecticides.

Nitrogen use varied from 110.4 tons in 1996 to 124.3 tons in 1997 and 117.7 tons in 1998. Total nitrogen use is directly related to the proportion of total acreage planted to each crop. Total phosphorus used on crops averaged 26.5 tons $\pm$ 1.0 ton each year. Over the three years, producers applied 82 lbs. of nitrogen per acre per year and 18.5 lbs. of phosphorus per acre per year to crops.

Cotton crops accounted for about two-thirds of total herbicide use, 90 percent of total insecticide use and all of the crop growth and harvest aid chemical use in the watershed. In contrast, grain crops of corn and sorghum accounted for 60 percent of total nitrogen use and 45 percent of total phosphorus use during 1996 to 1998.

Runoff Monitoring and Water-Quality Analyses

Sampling procedures. A fixed-station monitoring network was established for collection of runoff water samples. Water sampling at two edge-of-field stations was conducted for each storm event producing runoff. At each station, automatic

Table III.1 Summary of Total Pesticides and Nutrients Applied to Crops, 1996– 1998
[Lbs.a.i. equals pounds of active ingredients]

Item	Unit	Crop			Total
		Corn	Sorghum	Cotton	
1996:					
Planted acreage	**Ac.**	**73.0**	**1177.6**	**1615.8**	**2866.4**
Synthetic herbicides	Lbs.a.i.	34.5	951.3	3279.6	4265.4
Synthetic insecticides	Lbs.a.i.	41.4	646.4	11478.1	12165.9
Harvest aids/growth regulators	Lbs.a.i.	0	0	1560.6	1560.6
Total pesticides	**Lbs.a.i.**	**75.9**	**1386.2**	**16529.8**	**17991.9**
Nitrogen	Lbs. N.	6278.0	106680.0	107824.4	220782.4
Phosphate	Lbs. P.	0	17679.5	33557.0	51236.5
Sulfate	Lbs. S.	0	0	818.4	818.4
1997:					
Planted acreage	**Ac.**	**69.0**	**1736.4**	**1061.0**	**2866.4**
Synthetic herbicides	Lbs.a.i.	62.1	1994.0	2530.5	4586.6
Synthetic insecticides	Lbs.a.i.	41.4	1015.5	6400.8	7457.7
Harvest aids/growth regulators	Lbs.a.i.	0	0	1765.0	1765.0
Total pesticides	**Lbs.a.i.**	**103.5**	**3009.5**	**10696.3**	**13809.3**
Nitrogen	Lbs. N.	5934.0	148282.5	94409.4	248625.9
Phosphate	Lbs. P.	722.7	28154.1	23581.3	52458.1
1998:					
Planted acreage	**Ac.**	**450.0**	**1313.1**	**1103.3**	**2866.4**
Synthetic herbicides	Lbs.a.i.	381.0	1101.5	2699.6	4182.1
Synthetic insecticides	Lbs.a.i.	223.2	694.7	9777.9	10695.8
Harvest aids/growth regulators	Lbs.a.i.	0	0	1660.6	1660.6
Total pesticides	**Lbs.a.i.**	**604.2**	**1796.2**	**14138.1**	**16538.5**
Nitrogen	Lbs. N.	42069.6	106078.2	87180.7	235328.5
Phosphate	Lbs. P.	4713.3	19534.3	31144.5	55392.1

stream gauging instruments were installed to record volume of runoff exiting the croplands at the northeast corner (site 1) and southeast corner (site 2) of the watershed (see Figure II.2). Automatic streamflow gauging was done with the Campbell Scientific Storm Water Discharge Monitoring System (SWD1). The system consisted of a CR10X data logger, battery power supply, double bubbler for stage measurement, water sampler, rain gauge, phone modem, and field equipment enclosure (Figure III.1 and Figure III.2). Gauge height was recorded at sites 1 and 2 using a gas-bubbler and pressure transducer system. Ratings to derive runoff or discharge from gauge height were developed at each site by making independent discharge measurements during runoff events.

Isco 3700 portable automatic stage activated water samplers were installed at both sites to collect edge-of-field runoff samples during storm events (Figure III.3). The streamflow gauging instrumentation was programmed to detect occurrence of runoff and activate the automatic samplers. During runoff, discrete aliquots (sub-samples) were collected by the automatic samplers at a frequency proportional to stream discharge. As flow at a particular site increased, the sampler would collect sub-samples more frequently. Thus, samples were automatically flow-weighted during the collection process. At the end of each storm event, sub-samples from each site were combined into a single discharge-weighted composite sample (one sample from each site). Analysis of composite samples yielded event mean concentrations (EMCs), that represent discharge-weighted average concentrations during the runoff event.

During longer duration volume events, multiple composite samples were collected at each site. After each 24 hours of sampling, sub-samples already collected were composited, processed, and shipped to the USGS, National Water Quality Laboratory (NWQL) for analyses while automatic sampling continued at the site. With this procedure, sub-samples collected during the early phase of a runoff event would not suffer degradation during a runoff event lasting several days. When multiple composite samples were collected and analyzed at a site during a runoff event, EMCs for the entire event were calculated by discharge-weighted averaging of concentrations of the separate composites. Runoff samples were retrieved every 24 hours, placed on ice, transported to the TAES laboratory, and prepared for overnight shipment to the USGS, NWQL for analyses of major ions, nutrients, and dissolved pesticides.

A third water sampler initially was installed approximately 1 mi. downstream from site 2. This site location provided water samples after runoff flowed through a drainage area of natural vegetation, a coastal bermuda pasture, and a brush covered

Figure III.1 SWD1 Monitoring System

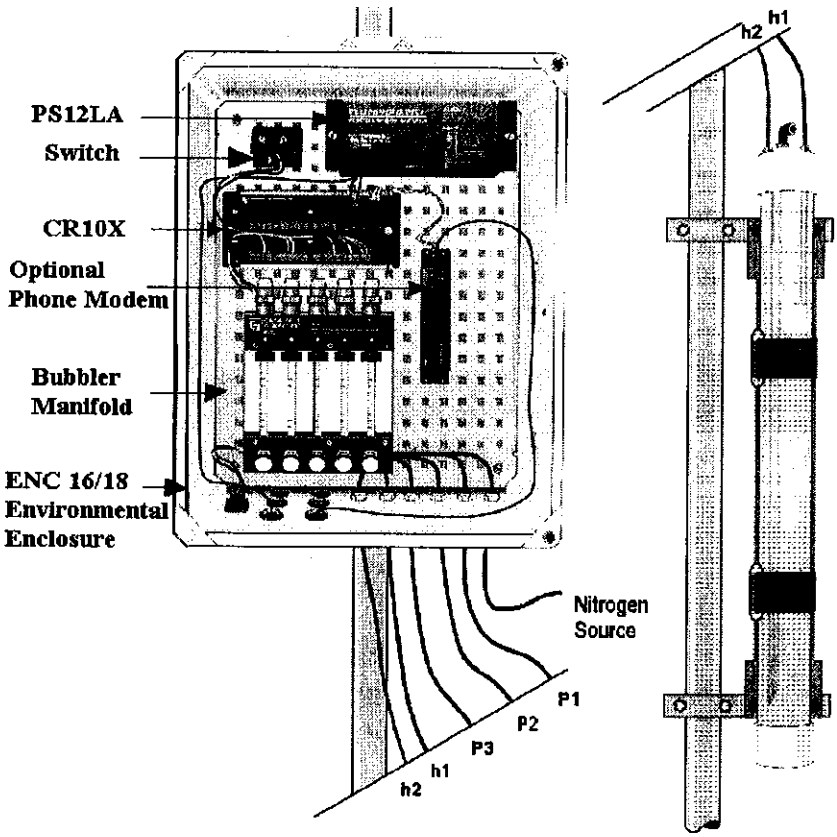


Figure III.2 CR10X Data Logger

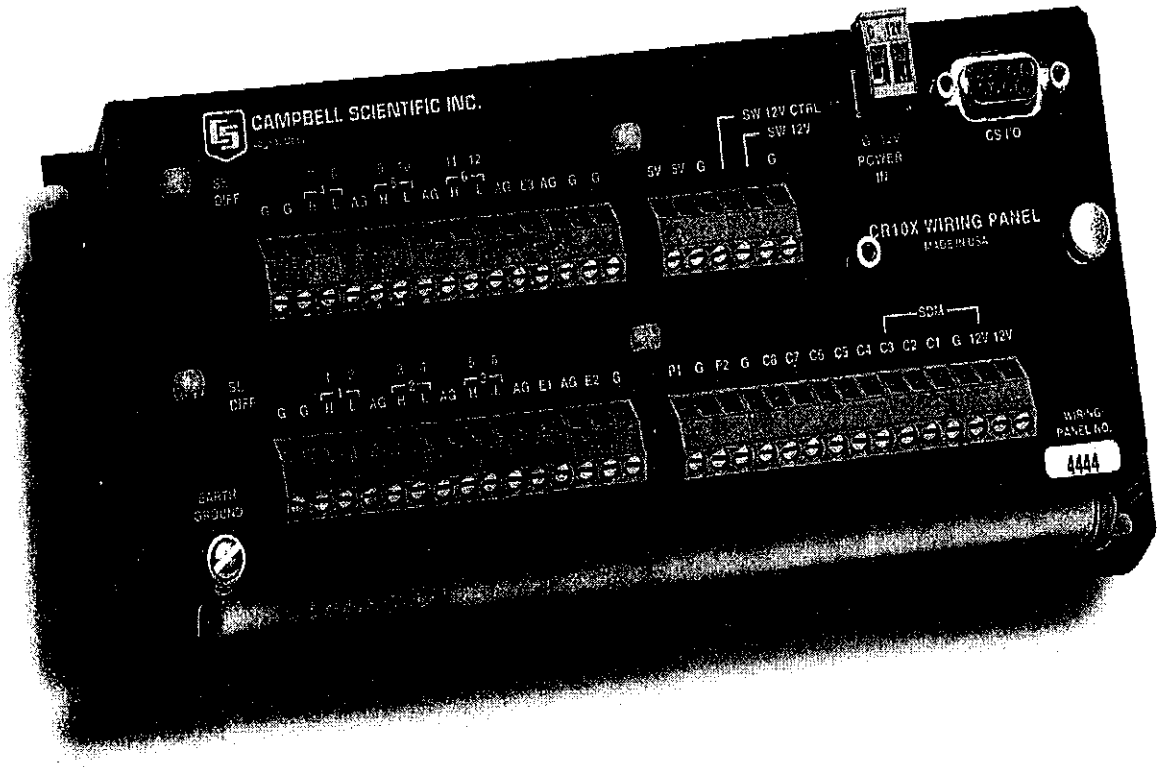
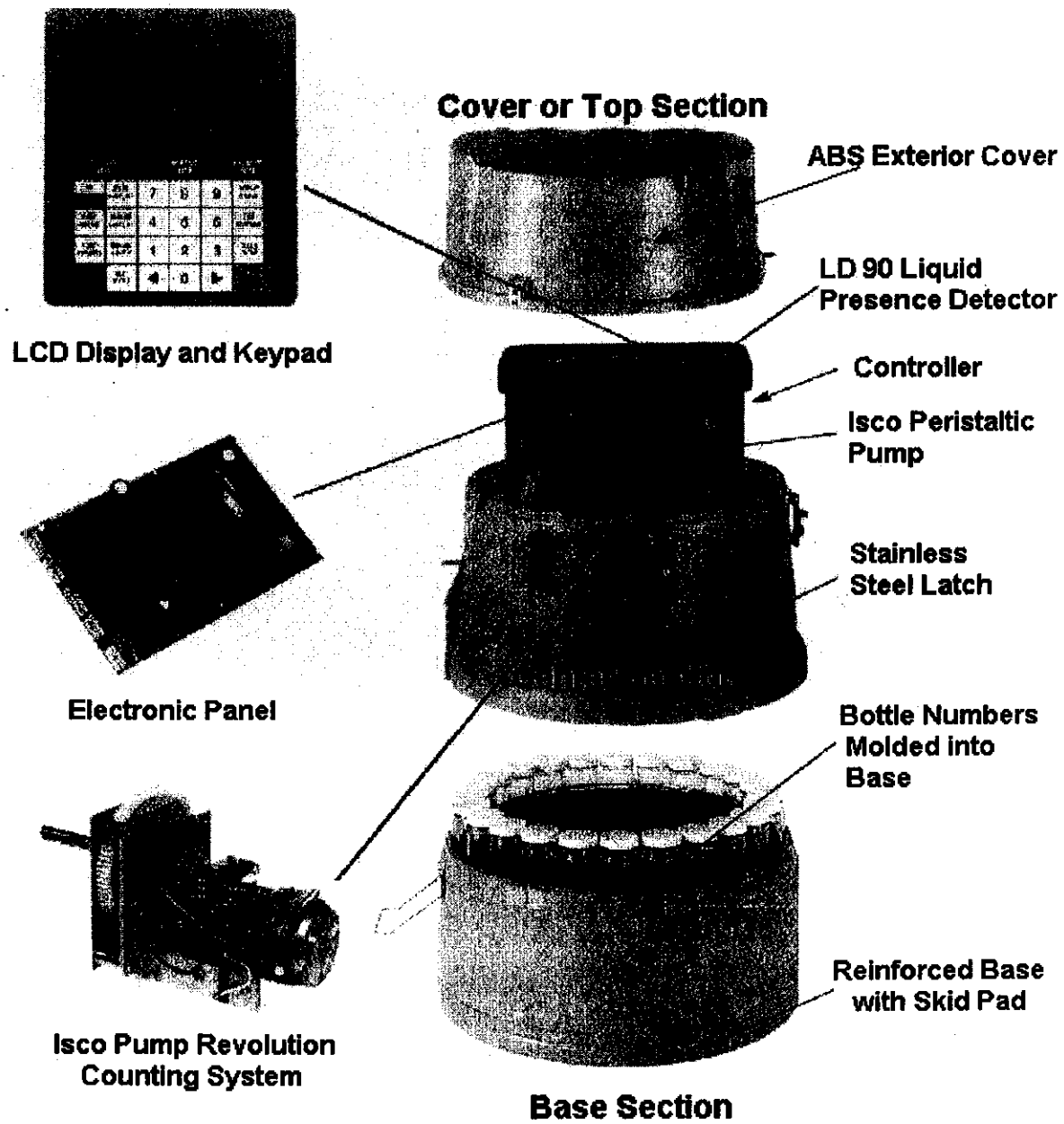


Figure III.3 Disassembled Isco 3700 Portable Water Sampler



rangeland area. It also included drainage from croplands outside the Odem Ranch Watershed. Sampling at this site was discontinued in 1997 due to constraints on budget. The EMCs did not exhibit large numerical differences between site 2 (edge-of-field) and site 3 for nutrients and pesticides detected in the runoff. However, concentrations of ammonia nitrogen, total and dissolved ammonia plus organic nitrogen, total and dissolved phosphorus, and orthophosphorous were numerically larger at site 3 than at site 2 (see Appendix C). Because a much larger drainage area was contributing runoff to site 3, and the contributions were from not only cropland but also rangeland, pastureland and grazing livestock, the EMCs were confounded and not directly comparable to EMCs at site 2.

Rainfall was recorded on an hourly basis with two tipping bucket raingauges at sites 1 and 2 and at the TAES weather station location. Rainfall amounts were stored in datalogger memory over the duration of each rainfall event. The CR10X datalogger totaled cumulative rainfall and streamflow and recorded the time of each observation. The data were retrieved during a site visit or through a phone modem link to a computer at the TAES headquarters building in Corpus Christi and at the USGS office in San Antonio.

Rainfall samples were collected at the TAES weather station location by an automatic precipitation collector. The collector is equipped with polyethylene buckets that are covered when rainfall is not occurring to prevent evaporation and contamination of the collection bucket and sample. When rainfall occurs, a moisture sensor activates a mechanism that uncovers the collection bucket. When rainfall stops, the moisture sensor activates the mechanism to cover the sample container. About 0.2 inches of rain was required to provide enough sample volume to perform an analysis. Rainfall samples were collected as single event-composite samples after rainfall events and therefore represent event-mean concentrations (EMCs). Samples were retrieved immediately following a rainfall event, chilled, and shipped overnight to the USGS, NWQL for analysis. Rainfall samples were analyzed for the following forms of nitrogen: nitrite plus nitrate, ammonia, dissolved organic nitrogen, and total organic nitrogen. Total nitrogen concentrations were calculated for each sample as the sum of nitrite, nitrate, ammonia, and total organic nitrogen. Samples also were analyzed for total phosphorus, dissolved phosphorus, and dissolved orthophosphate.

Parameters monitored and the method detection limit for rainfall and runoff and each parameter are presented in Table III.2. Pesticides listed were applied to crops in the watershed. Other pesticides applied to crops but not included in batch screenings of 88 pesticides in water samples by the USGS, NWQL may be found

Table III.2 Parameters Monitored for Rainfall and Surface Water Runoff

Parameter	Method Detection Limit	Parameter	Method Detection Limit
Rainfall & Runoff:	**mg/L**	**Runoff Water:**	**ug/L**
Ammonia	0.015	2,4-D	0.035
Nitrate	0.01	Aldicarb	0.016
Nitrite	0.01	Atrazine	0.005
Nitrite + Nitrate, Total	0.01	Azinphos-Methyl	0.001
Organic Nitrogen, Total	0.1	Carbofuran	0.003
Organic Nitrogen, Dis.	0.1	Chlorpyrifos	0.004
Phosphorus, Total	0.05	Diazinon	0.002
Phosphorus, Dis.	0.05	Dicamba	0.035
Phosphorus, Ortho	0.01	Diuron	0.02
		Esfenvalerate	0.019
Runoff Water:	**mg/L**	Fluometuron	0.035
Calcium, Dis.	0.1	Glyphosate	5.000
Magnesium, Dis.	0.1	Malathion	0.005
Sodium, Dis.	0.1	Methyl Parathion	0.006
Potassium, Dis.	0.1	Metalochlor	0.002
Chloride, Dis.	0.1	Oxamyl	0.018
Sulfate, Dis.	0.1	Pendimethalin	0.004
Fluoride, Dis.	0.1	Phorate	0.002
Silica, Dis.	0.1	Propazine	0.050
Boron, Dis.	0.6	Simazine	0.005
Iron, Dis.	0.03	Terbufos	0.013
Dissolved Solids	0.1	Trifluralin	0.002
Suspended Solids, Total	0.1		

in Appendix A tables for each year. A complete listing of all pesticides included in batch screening by the USGS, NWQL may be found in Appendix C. Pesticides listed in Table III.2 account for 100 percent of total quantities (in lbs. of active ingredients) of herbicides, and 80-90 percent of total quantities of synthetic insecticides applied to crops each year.

Field Sampling and Laboratory Analysis Quality Assurance

Automatic streamflow gauges were equipped with hardline telephones and pagers that signaled when stormwater runoff activated automatic water samplers. TAES and USGS field personnel were immediately dispatched to sampling sites to collect water-quality samples. Samples were collected and placed on ice during and immediately following each storm event that produced runoff from the watershed. All rainfall and runoff water samples were transported to the TAES laboratory within 6 hours of collection where they were composited into a single sample, subsampled, and filtered or left unfiltered, treated with appropriate preservatives (Table III.3), chilled to 4°C, packaged in ice in high-impact resistant plastic ice chests, and shipped overnight to the USGS, NWQL. Chain-of-custody records, sample labels, transfer of custody, and documentation of sample identification were maintained. Recommended procedures for decontamination of sampling equipment and laboratory equipment for sample preparation were followed.

Quality control for sampling activities used standard documented procedures for all field sampling activities. Field sampling equipment was calibrated according to EPA-approved and USGS-established procedures and calibration was documented by USGS personnel for each stormwater runoff event. Field equipment blanks were obtained twice annually, prepared, and sent to the USGS, NWQL for analyses. Each sampling site was visited by TAES field personnel once every two weeks to check battery charge levels, tubing connections, and pump operations for automatic water samplers, rainfall sampler, and streamflow gauges.

Quality control procedures for the USGS, NWQL as documented in Jones (1987) were followed for all laboratory analyses. These standard USGS procedures were used for all analytical methods and for all detection limits. Analysis methods codes, reporting levels, sample volumes, preservation, and bottle requirements for both rainfall and runoff samples submitted to the NWQL are listed in Table III.3. Detection limits were provided in Table III.2. Maximum holding times from time of sampling that the NWQL required to be met for constituents were as follows:

Acidity	14 days
Alkalinity	14 days
Ammonia-Nitrogen	28 days
Nitrate-Nitrogen	48 hours
Nitrogen, Total Kjeldahl	28 days
Nitrogen, Total Organic	28 days
Nitrite-Nitrogen	48 hours
Ortho Phosphate	48 hours
Total Phosphate/Phosphorus	28 days
Sulfur/Sulfate	28 days
Soluble Boron	28 days
Soluble Iron	28 days
Total Suspended Solids	7 days
Organochlorine Pesticides — Extraction	2 days after receipt, 7 days total
— Chromatography	45 days
Organophosphorus Pesticides — Extraction	2 days after receipt, 7 days total
— Chromatography	45 days

Table III.3 Sample Containers, Volumes and Method References

S. No.	Parameter	Preservative	Container Type *	Volume Required (ml)	EPA Method Reference
1	Ammonia-Nitrogen	4°C	P,G	400	350.3
2	Nitrate-Nitrogen	4°C	P,G	100	353.3
3	Nitrogen, Total Kjeldahl	4°C, H_2SO_4 to pH<2	P,G	500	351.4
4	Nitrogen, Total Organic	4°C	P,G	500	351.4/350.2
5	Nitrite-Nitrogen	4°C	P,G	100	354.1
6	Ortho Phosphate	4°C	P,G	250	365.3
7	Total Phosphate/Phosphorus	4°C, H_2SO_4 to PH<2	P,G	250	365.3
8	Sulfur/Sulfate	4°C<	P,G	500	375.3
9	Soluble Boron	Filter & HNO_3 to pH<2	P,G	100	200.7
10	Soluble Iron	Filter & HNO_3 to pH<2	P,G	100	236.1
11	Total Suspended Solids	4°C	P,G	100	160.2
12	Organochlorine Pesticides	4°C	G-TLC	2,000	8080
13	Organophosphorus Pesticides	4°C	G-TLC	2,000	8041
14	Acidity	4°C	P,G	100	305.1
15	Alkalinity	4°C	P,G	100	310.1

* G: Glass
P,G: Plastic or Glass
G-TLC: Glass with Teflon Lined Caps

Source: Quality Control Manual of the U.S. Geological Survey's National Water Quality Laboratory, U.S. Geological Survey Open-File Report 87-457.

IV. RESULTS

Hydrologic Conditions

Rainfall. Long-term rainfall data from the NOAA station at Corpus Christi, Texas (Figure II.3) were compared with rainfall in the Odem Ranch Watershed during 1996 to 1998. The 30-year (1969–1998) mean rainfall is 32.71 inches with a minimum of 18.63 inches in 1996 and a maximum of 48.07 inches in 1991. From June 1995 through May 1999, 109.37 inches of rain fell on the watershed. Rainfall was annually distributed as shown in Table IV.1.

Table IV.1 Annual and Mean Annual Rainfall for Odem Ranch Watershed (1996–1998) Compared with NOAA, Corpus Christi, Texas, Rainfall (1969–1998) [in inches]

Odem Ranch Watershed				Corpus Christi NOAA Station Mean Annual Rainfall 1969 – 1998
Annual Rainfall			Mean Annual Rainfall 1996-1998	
1996	1997	1998		
18.79	33.83	31.74	28.12	32.71

Annual rainfall in the watershed during 1996 was only 0.16 inches above the minimum annual rainfall recorded during 1969–1998 at the Corpus Christi NOAA station (18.63 inches in 1996). Rainfall in the watershed in 1997 was slightly above (1.12 inches) Corpus Christi average rainfall for 1969–1998 because of heavy June and October rains. However, the watershed received only 2.91 inches of rain during the months of July through September, 9.47 inches less than the Corpus Christi station average (30-year 1969–1998 reporting period). In 1998, rainfall in the watershed was slightly less (0.97 inches) than average 1969–1998 Corpus Christi station rainfall even though heavy rains occurred in August and October.

Average monthly rainfall (Corpus Christi 1969-1998) is shown in Figure IV.1. Greatest rainfall tends to occur in a bimodal pattern with May–June and August–October generally receiving the highest rainfall. Heavy rainfall during August–October is often associated with tropical disturbances originating from the Gulf of Mexico.

Figure IV.2 shows monthly deviation of Odem Ranch Watershed rain, during June 1995–May 1999, from the 1969–1998 Corpus Christi NOAA station average.

Figure IV.1 Mean Monthly Rainfall at National Oceanic and Atmospheric Administration (NOAA) Rainfall Station Near Corpus Christi, Texas, 1969 – 1998

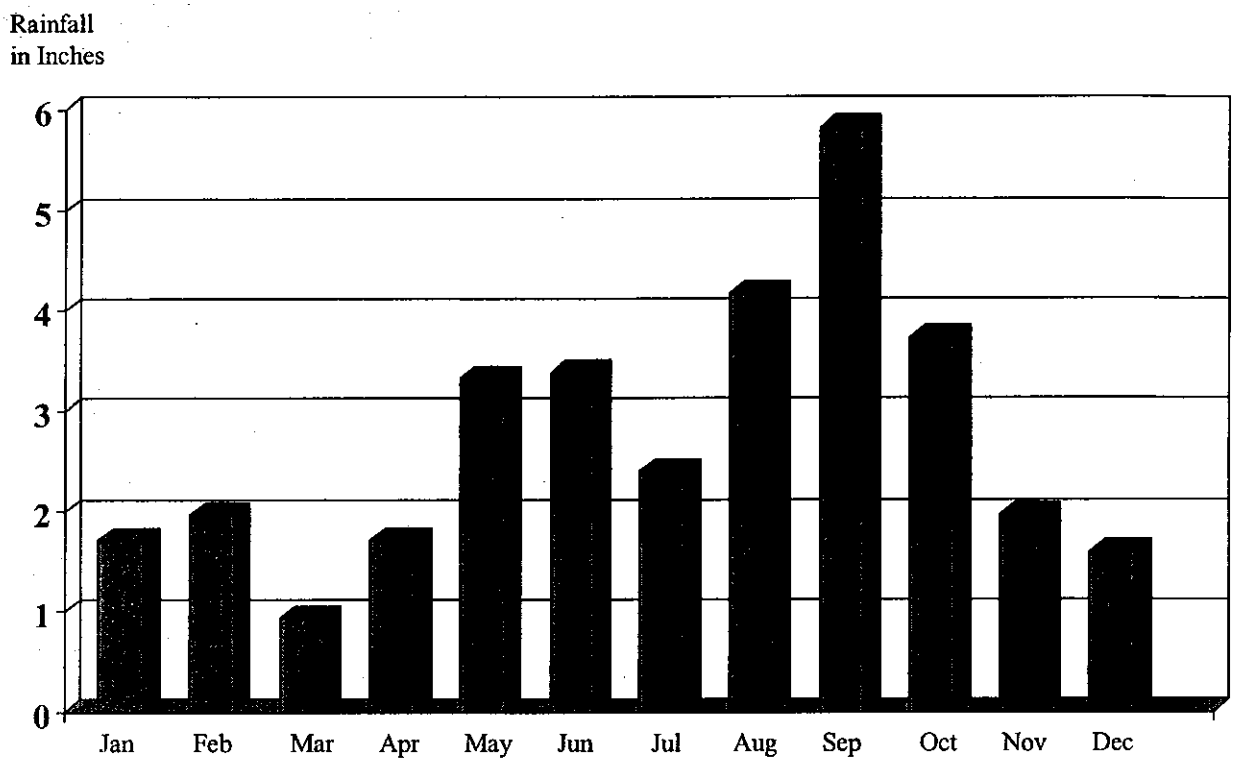
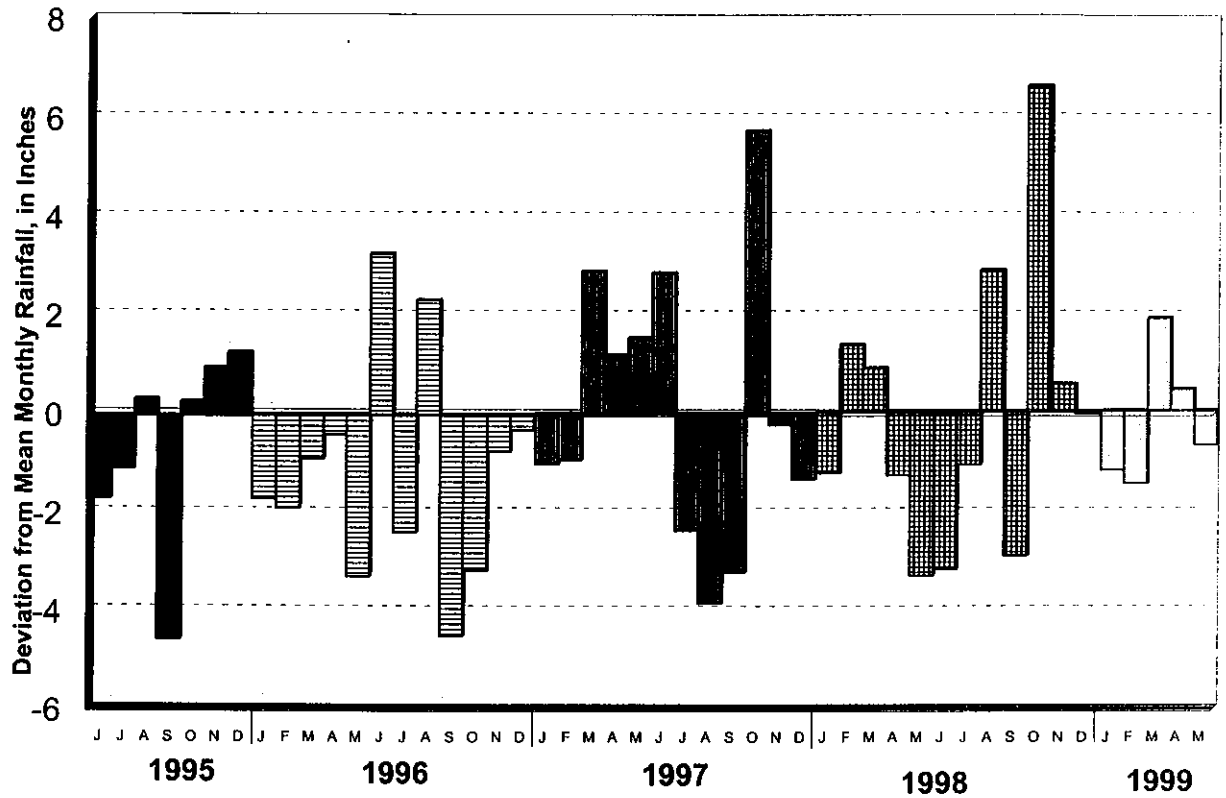


Figure IV.2 Monthly Deviation of Odem Ranch Watershed Rainfall From 1969–1998 Mean Monthly Rainfall at NOAA Corpus Christi Station



During four years spanning June 1995 to May 1999, rainfall in 30 of the 48 months was below the monthly average. Even in 1997 when the watershed received above average rainfall, precipitation in seven of the months was below average. This pattern of periods of below average rainfall punctuated by extreme rainfall events is typical of historical patterns (Ward, 1997).

Runoff. Runoff from the watershed during the study period generally reflected the rainfall pattern, with runoff events interspersed between long periods when no runoff occurred. Figure IV.3 shows cumulative rainfall and runoff during the study period. A total of 109.37 inches of rain falling on the watershed during June 1995–May 1999 resulted in 4.97 inches (1,150 acre-ft) of runoff. The runoff coefficient for the entire study period was 0.045. Annual coefficients were 0.024 in 1996, 0.039 in 1997, and 0.10 in 1998.

Data from five rainfall events producing runoff during June 1996 through October 1998 were used to estimate the relation between rainfall and runoff in the watershed. Samples collected at sites 1 and 2 represent 28.07 inches of rain and 981 acre-ft (or 85 percent) of total runoff during the study period. Figure IV.4 shows the relation between storm event rainfall and runoff along with the predictive equation. The March 1999 runoff event occurred after removal of the automatic stream flow gauging and water sampling equipment from the watershed. The predictive equation for the graph was used to estimate runoff volume from the watershed for this event.

During the study, 14 separate runoff events (seven rainfall events resulting in runoff at both sampling sites) occurred. Appendix B, Table 1 shows the dates of runoff event rainfall on the watershed, rainfall amount, runoff volume at each sampling station, total runoff exiting the watershed, and runoff coefficient (ratio of runoff volume to rainfall volume) for individual events. Runoff coefficients ranged from 0.013 to 0.391 (event of October 17–26, 1998).

Runoff also depends on antecedent rainfall and rainfall intensity. Generally at least 2.5 inches of rainfall on the watershed were required to generate runoff at gauging and sampling stations. An event rainfall of 2.70 inches (August 7, 1998) did not result in runoff since rainfall had not occurred for the previous 34 days. In contrast, 2.65 inches that fell on the watershed October 6, 1998 was followed 11 days later by 6.29 inches of rain on October 17–19, 1998 that resulted in almost half of the total runoff during the four-year period, June 1995–May 1999.

Occurrence of runoff during the study period was mainly due to relatively extreme storm events (greater than 5 inches of rainfall). Table IV.2 shows percentage of runoff that occurred during specified amounts of event rainfall.

Figure IV.3 Odem Ranch Watershed Monthly Cumulative Rainfall and Runoff June 1995–May 1999

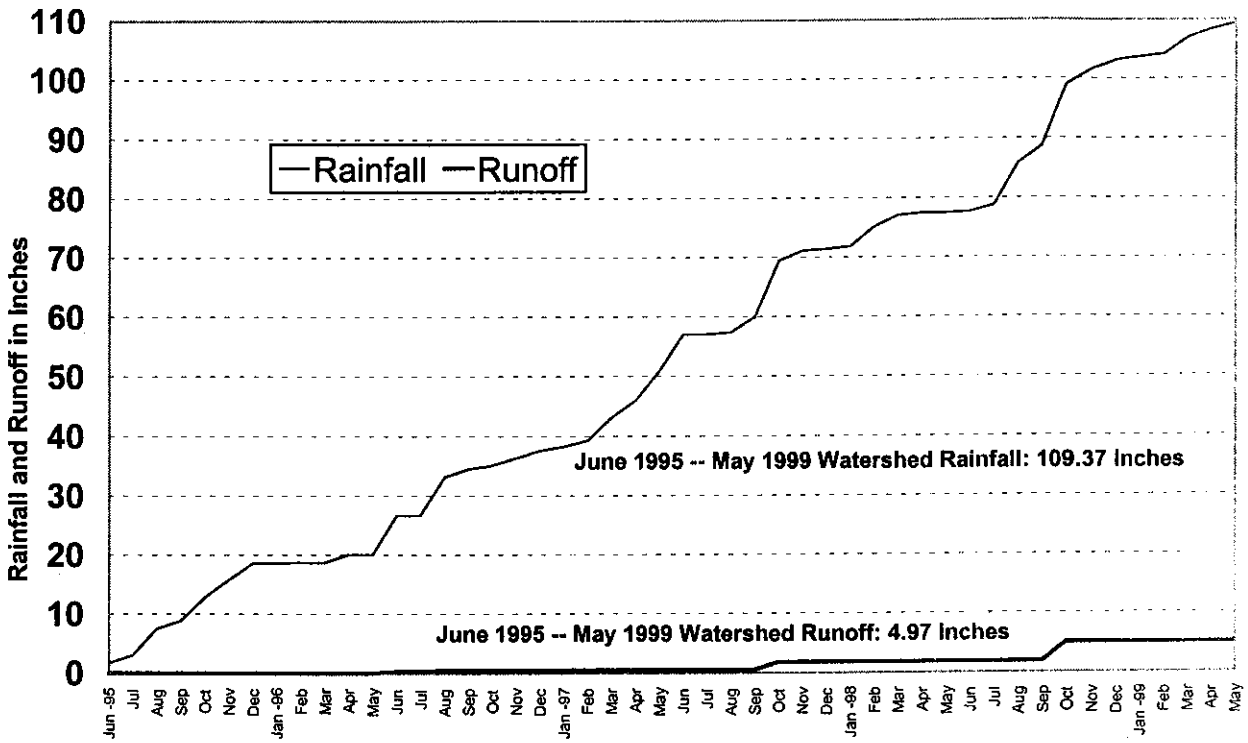


Figure IV.4 Relation Between Rainfall and Runoff for the Odem Ranch Watershed, June 1996–December 1997

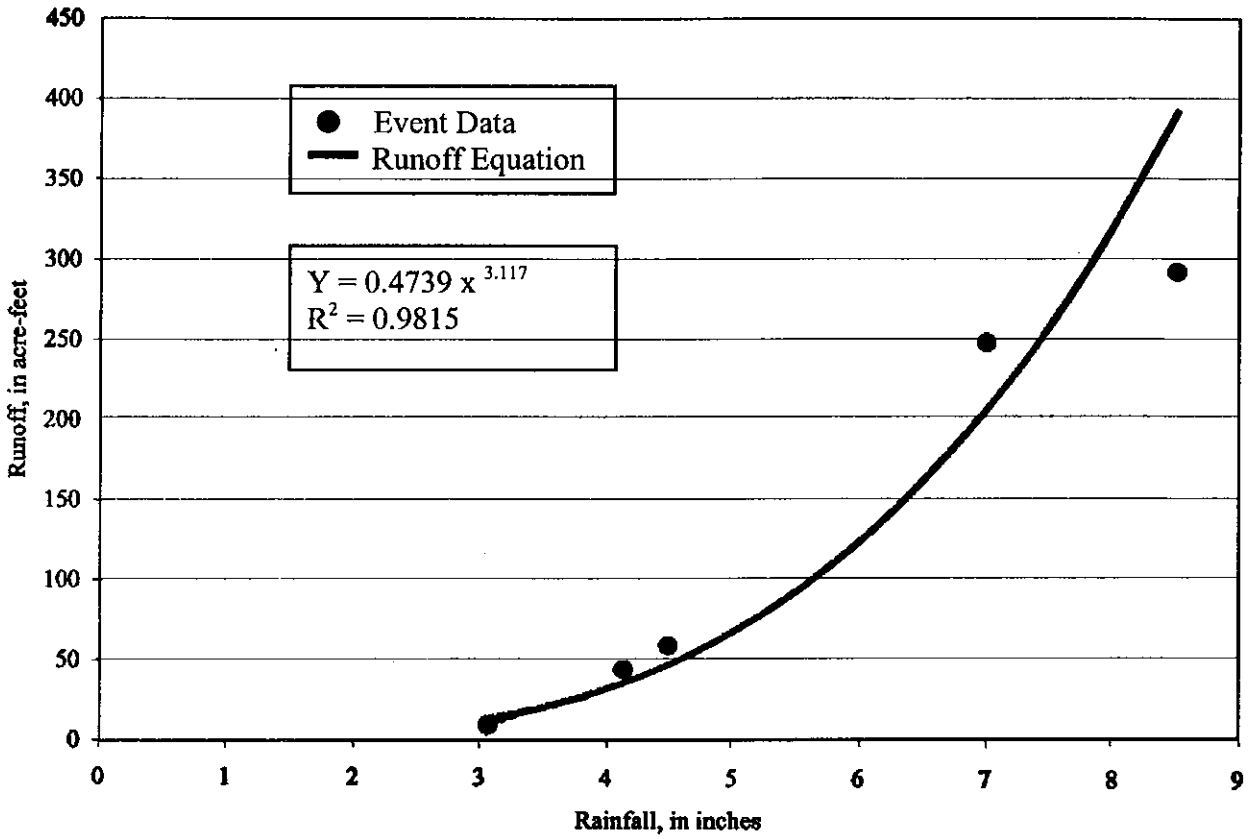


Table IV.2 Distribution of 14 Runoff Events by Rainfall Amount, 1996–1999.

Event Rainfall (Inches)	0 to 3	3 to 4	4 to 5	5 to 6	> than 6
Number of Events	5	1	2	1	5
Runoff (acre-ft.)	174.18	7.90	45.07	316.65	606.43
Proportion of Total Watershed Runoff	0.152	0.007	0.039	0.275	0.527

During the study period, three storm events with greater than 5 inches of rainfall contributed 80 percent of total runoff. In June 1995 – May 1996, no daily rain greater than 2.7 inches occurred. As a result of dry antecedent conditions no runoff occurred. In June 1996 – June 1997, in spite of 37 inches of rain falling on the watershed, only 10 percent of total runoff for the four-year period occurred. Runoff during October 10–16, 1997, October 6–10, 1998, and October 17–26, 1998 resulted in about 89 percent of total runoff. It should be noted that during June 1995–May 1999 no runoff events occurred during any September, which historically is the month with highest average rainfall.

Slightly more runoff from the watershed exited through site 1 than site 2. Total runoff from the watershed during June 1995 – May, 1999 was 1,150 acre-ft. Fifty eight percent of total runoff (669 acre-ft) exited the watershed through site 1.

Water Quality

Rainfall and runoff quality were investigated by measurement of event-mean concentrations, computation of constituent deposition, loads, and yields, and determination of average watershed constituent concentrations. Quantities of plant nutrients and chemicals applied to crops as fertilizer and pesticides were compared with amounts of chemicals present in rainfall and runoff.

Rainfall. Nineteen rainfall samples were collected and analyzed during the study. Results of the analyses are shown in Appendix B, Table 2 for the period May 1, 1996 through December 31, 1997. Rainfall samples were collected during seven rain events that produced runoff as well as 12 other selected rainfall events that did not produce runoff. During the June 1995–May 1999 study period, 109.37 inches of rainfall were recorded falling on the watershed. The nineteen samples represent 23.44 inches of rainfall, or about 21.4 percent of the total rainfall (recorded at the sampling sites) during the four-year study period.

Event Mean Concentrations in Rainfall. Descriptive statistics were computed for selected nutrient concentrations in rainfall and are shown in Table IV.3.

Table IV.3 Summary Statistics for Selected Nutrient Concentrations in Rainfall [all concentrations in milligrams per liter; N, nitrogen; P, phosphorus; – Not determined; < value below detection level]

Constituent	Number of Samples	Mean	Median	Minimum	Maximum
Nitrogen, total (as N)	19	0.46	0.44	0.10	1.47
Ammonia nitrogen (as N)	19	0.22	0.18	0.02	0.75
Nitrate nitrogen (as N)	19	0.18	0.15	0.02	0.67
Nitrite nitrogen (as N)	19	–	0.001	<0.001	.01
Organic nitrogen, total (as N)	19	0.07	0.05	0.00	0.50
Phosphorus, total (as P)	19	0.01	0.005	0.001	0.06
Phosphorus, dissolved (as P)	19	–	0.004	<0.001	0.02
Orthophosphorus, dissolved (as P)	19	–	0.002	<0.001	0.02

Most nitrogen in rainfall occurs as dissolved ammonia (NH_4) and dissolved nitrate (NO_3) which were detected in all rainfall samples. Median ammonia and nitrate concentrations were 0.18 mg/L and 0.15 mg/L as nitrogen, respectively. Nitrite (NO_2) and dissolved and total forms of organic nitrogen also were detected in most rainfall samples. Nitrite concentrations were less than the NWQL reporting limit (0.001 mg/L) in 10 samples and the median concentration was 0.001 mg/L. Median total organic nitrogen concentration was 0.05 mg/L.

Total phosphorus was detected in all samples and the median concentration was 0.005 mg/L. Most phosphorus was dissolved phosphorus with median concentration of 0.004 mg/L. Orthophosphate was detected above minimum reporting limit (0.001 mg/L) in 9 of 19 samples. Maximum concentration was 0.02 mg/L.

Rainfall Deposition. Deposition of rainfall constituents is the product of event constituent concentration and rainfall volume and was measured in pounds per acre. Daily rainfall deposition on the watershed was computed for total nitrogen, nitrate, ammonia, total phosphorus, and orthophosphorus. During rainfall events when rainfall samples were collected and analyzed for constituent EMCs, daily deposition was computed as:

$$D = EMC \times R \times Cf,$$

where D = daily deposition in pounds per acre, EMC = constituent rainfall concentration in milligrams per liter, R = daily rainfall in inches, and Cf =

conversion factor of 0.2266. Daily rainfall used to estimate deposition was computed from a Theissan-weighted average (Wanielista, 1990, p.51) of rain from three rain gauges in the watershed (the TAES weather station location and tipping bucket rain gauges at sites 1 and 2).

For unsampled events without rainfall constituent concentration data, daily depositions of ammonia, nitrate, and total nitrogen were estimated by regression equations relating daily rainfall to daily constituent deposition (Table IV.4). The regression equations were developed from a larger data base that included data from this study and rainfall nitrogen data collected from another study underway in northern Kleberg County within the CBBEP project area (Ockerman and Livingston, 1999).

Table IV.4 Prediction Equations for Estimating Rainfall Event Loads [R is event rainfall]

Constituent	Load Equation (pounds per acre)
Total Nitrogen (as N)	$1.08 \times 10^{-1.12} \times R^{0.456}$
Ammonia Nitrogen (as N)	$1.16 \times 10^{-1.47} \times R^{0.372}$
Nitrate Nitrogen (as N)	$1.16 \times 10^{-1.60} \times R^{0.433}$

Daily rainfall deposition of total phosphorus and orthophosphorus for unsampled events was computed from median constituent concentrations from Table IV.3. Daily values for nitrogen and phosphorus rainfall deposition were aggregated to obtain monthly and annual nitrogen and phosphorus rainfall deposition in pounds per acre from the watershed. These constituent loads are summarized in Table IV.5 and Appendix B, Table 3. Appendix B also contains detailed daily, monthly and annual data for rainfall and total nitrogen, nitrate nitrogen, ammonia nitrogen, total phosphorus, and ortho-phosphate loads in rainfall for 1996, 1997, 1998, and January – June 21, 1999.

Applying deposition rates from Table IV.5, 25,197 pounds of total nitrogen were deposited from rainfall on the 2,775-acre watershed during 1996-1998 with an additional 2,165 pounds deposited from rain during January – May, 1999. Slightly more than 89 percent of total nitrogen deposition occurred as ammonia and nitrate.

Table IV.5 Annual Nitrogen and Phosphorus Rainfall Deposition, 1996–1998 [in pounds per acre]

Constituent	1996	1997	1998
Total Nitrogen (as N)	2.10	3.86	3.12
Ammonia Nitrogen (as N)	1.09	2.01	1.61
Nitrate Nitrogen (as N)	0.79	1.45	1.17
Total Phosphorus (as P)	0.20	0.37	0.35
Orthophosphorus (as P)	0.06	0.09	0.09

Compared to total nitrogen, total phosphorus deposition from rainfall was small with 2,553 pounds of total phosphorus deposited in rainfall on the watershed during 1996-1998. During this period 666 pounds of orthophosphorus was deposited in rainfall on the watershed.

Runoff. A total of 10 runoff-event samples were collected and analyzed from June 1996 to March 1999 at the two edge-of-field gauging and sampling stations and used to characterize quality of stormwater runoff from the watershed. Runoff event-mean concentrations for each station and event are presented in Appendix C, along with results of runoff water quality sample analyses.

Event Mean Concentrations for Major Ions and Nutrients in Runoff. Differences in major ion and nutrient concentrations between sites 2 and 3 could not be statistically tested because of insufficient number of observations. Site 3 was downstream from site 2 after runoff from the watershed's croplands flowed through an area of natural vegetation, a coastal bermuda pasture, and a brush covered area. EMC values for the two data sets and comparable runoff events are provided in Table IV.6.

The EMCs did not appear to exhibit large numerical differences for the major ions. However, concentrations were numerically larger at site 2 (edge-of-field) than site 3 (downstream) for all the ions listed in Table IV.6, except for dissolved potassium, possibly reflecting the influence of grazing livestock on potassium concentrations at site 3. Concentrations of ammonia nitrogen, ammonia plus organic nitrogen, total and dissolved phosphorus, and orthophosphorus were numerically larger at site 3 (downstream) than site 2 (edge-of-field). Site 3

Table IV.6 EMC Values for Constituents in Comparable Runoff Events at Site 2 and Site 3 [in milligrams per liter; – not determined]

Constituent	June 1996		October 1997	
	Site 2	Site 3	Site 2	Site 3
Calcium, dissolved	15.0	5.4	21.5	14.0
Potassium, dissolved	3.6	4.9	4.7	5.2
Magnesium, dissolved	0.94	0.7	1.5	1.3
Chloride, dissolved	1.4	1.1	5.2	3.0
Sulfate, dissolved	0.9	0.6	2.9	1.6
Ammonium, dissolved	0.08	0.11	0.04	0.14
Nitrate + Nitrite Nitrogen	0.37	0.23	0.47	0.26
Ammonia + Organic Nitrogen, total	–	–	1.30	1.70
Nitrogen, total	–	0.23	1.77	1.96
Phosphorus, total	0.27	0.53	0.45	0.62
Phosphorus, dissolved	–	–	0.21	0.38
Orthophosphorus, dissolved	0.22	0.36	0.18	0.35

represented runoff from a much larger drainage area that included croplands outside the Odem Ranch Watershed, pasture land, rangeland and grazing livestock. These land uses probably account for the larger numerical values for the nitrogen and phosphorus concentrations at site 3.

Concentrations of major ion and nutrient constituents were analyzed by computing summary statistics of the data to characterize cropland runoff-event concentrations. Data from sites 1 and 2 were combined and summary statistics were generated (Table IV.7). EMCs for nutrients and selected pesticides for each sampling event are presented in Appendix C. For comparative purposes, TNRCC Texas Surface Water Quality Standards (TSWQS) for aquatic life protection and human health protection, and TNRCC-TSWQS for the Nueces River below Lake Corpus Christi from Calallen Dam 1.7 kilometers upstream of US77/IH37 in Nueces/San Patricio County to Wesley E. Seale Dam in Jim Wells/San Patricio County are also included in Table IV.7.

Table IV.7 Statistical Summary of Selected Major Ion and Nutrient Concentrations in Runoff
[TNRCC, Texas Natural Resources Conservation Commission; TSWQS, Texas Surface Water Quality Standards; mg/L, milligrams per liter; <, less than]

Constituent	Number of Samples	Mean	Median	Maximum	Minimum	TNRCC-TSWQS Aquatic Life Protection (mg/L)	TNRCC - TSWQS Human Health Protection (mg/L)	TNRCC–TSWQS Site Specific Criteria* (mg/L)
Calcium, dissolved (mg/L)	8	17.4	17.3	21.8	11.0			
Magnesium, dissolved (mg/L)	8	1.33	1.30	1.90	0.79			
Potassium, dissolved (mg/L)	8	4.86	4.80	9.30	2.90			
Sulfate, dissolved (mg/L)	8	1.85	1.30	3.90	0.80			250.0
Chloride, dissolved (mg/L)	8	4.15	3.65	8.50	1.10			250.0
Nitrogen, total (mg/L as N)	8	1.94	2.09	2.74	0.98			
Ammonia plus organic N, total (mg/L as N)	8	1.32	1.31	2.10	0.69			
Ammonia nitrogen, dissolved (mg/L as N)	10	0.08	0.05	0.24	<0.015			
Nitrite plus nitrate, dissolved (mg/L as N)	10	0.63	0.56	1.18	0.05		10.0	
Phosphorus, total (mg/L as N)	10	0.51	0.48	0.87	0.27		100.0	
Phosphorus, orthophosphate (mg/L as N)	10	0.24	0.25	0.41	<0.01			
Phosphorus, dissolved (mg/L as N)	8	0.26	0.24	0.45	<0.05			
Total suspended solids (mg/L)	8	350.0	366.0	488.0	192.0			
Total dissolved solids (mg/L)	7	102.0	93.0	151.0	72.0			500.0

* TNRCC–SWQS site specific criteria for Segment 2102, Nueces River below Lake Corpus Christi

TNRCC, TSWQS (TNRCC, 1999) divide major river basins, bays, and estuaries into defined segments. Segment-specific standards identify appropriate uses for specific water bodies (aquatic life, contact or noncontact recreation, drinking water, etc.) and list upper and lower limits for common indicators of water quality (dissolved oxygen, temperature, pH, dissolved minerals, fecal coliform bacteria). Other standards such as toxic criteria to protect aquatic life and human health are applied statewide. TNRCC has not developed any segment specific standards for any of the creeks or drainage waterways monitored in the Odem Ranch watershed. None of the major ion or nutrient concentrations in runoff from the watershed exceeded any TNRCC–TSWQS criteria listed in Table IV.7.

Concentrations of nutrients in runoff were examined for seasonal differences due to timing of field applications and stormwater runoff events. Median concentrations during the preplant and crop growing season (November – June), post-harvest period (August – October) and overall sampling period are shown in Table IV.8.

Table IV.8 Seasonal Median Concentrations of Nutrients in Runoff
[all concentrations in milligrams per liter]

Constituent	Preplant and Crop Season (Nov.–June)	Post-Harvest (Aug.–Oct.)	Overall Sampling Period
Nitrogen, total (as N)	2.45	1.38	2.09
Ammonia Nitrogen, dissolved (as N)	0.11	0.04	0.05
Nitrite Nitrogen, dissolved (as N)	0.12	0.02	0.04
Nitrate + Nitrite Nitrogen, dissolved (as N)	0.80	0.47	0.56
Ammonia + Organic Nitrogen, dissolved (as N)	0.42	0.40	0.41
Ammonia + Organic Nitrogen, total (as N)	1.65	0.93	1.31
Phosphorus, total (as P)	0.61	0.45	0.48
Phosphorus, dissolved (as P)	0.26	0.21	0.24
Orthophosphorus, dissolved (as P)	0.25	0.18	0.25

Median concentrations of all forms of nitrogen and phosphorus are numerically larger for the preplant and crop growing period than the post-harvest period. However, only nitrite nitrogen exhibited significantly higher seasonally median

value for the preplant and crop growing period at the 5 percent probability level based on the Mann-Whitney rank-sum test (Snedecor and Cochran, p. 130) for comparison of medians of groups differentiated by one explanatory variable (in this case, season) to determine whether all groups have the same median value.

Event Mean Concentrations for Pesticides. The first step in analyzing pesticide concentrations in runoff was to identify compounds used to produce crops in the watershed. Table IV.9 identifies pesticides used during 1996–1998 and pesticides that were included in analyses of runoff water samples.

The second step in analyses of pesticide data was to identify pesticides detected in runoff. Event water samples were analyzed for a suite of 88 pesticides, some of which were not used in the watershed. Also, some pesticides used in the watershed were not included in the suite of chemicals included in the USGS, NWQL sample analyses (Table IV. 9).

A measure of pesticide occurrence in runoff is the frequency of detection among all the samples. Figure IV.5 is a bar graph showing percent of samples in which pesticides were detected.

Sixteen pesticides (10 herbicides and six insecticides) were detected with varying degrees of frequency in the runoff samples. The herbicide atrazine was detected in all samples. By-products deethyl atrazine and deisopropylatrazine were detected in 90 percent and 60 percent of samples, respectively. Other herbicides detected in 50 percent or more of samples were metolachlor, trifluralin, fluometuron, and pendimethalin. Insecticides detected in samples were malathion, azinphos-methyl, diazinon, methyl parathion, aldicarb, and carbofuran. These compounds were not found in more than a fourth of all samples.

A statistical summary of concentrations for detected pesticides is provided in Table IV. 10. Atrazine concentrations did not exceed TNRCC aquatic life protection maximum contaminant level (MCL) of 11 ug/L. Median EMC values for all pesticides were less than TNRCC Texas State Water Quality Standards for aquatic life and human health protection. Certain pesticide concentrations exhibited seasonal differences due to timing of field applications and storm-water runoff events. Median concentrations in runoff during the preplant and crop growing season (November – June), post-harvest period (August - October), and overall sampling period for most frequently detected pesticides are reported in Table IV. 11.

Table IV.9 Pesticides Used in the Odem Ranch Watershed, 1996 – 1998
[x indicates pesticide used during the crop year]

Pesticide	1996	1997	1998	Included in Sample Analysis
Herbicides:				
Atrazine	X	X	X	Yes
Fluometuron	X	X	X	Yes
Diuron	X	X		Yes
Propazine	X			Yes
Pendimethalin	X	X	X	Yes
Glyphosate	X	X	X	Yes
Trifluralin	X	X	X	Yes
Insecticides:				
Esfenvalerate	X	X	X	Yes
Cyfluthrin	X			No
Dicrotophos	X	X	X	No
Tebufenozide	X			No
Terbufos	X	X	X	Yes
Dimethoate	X	X	X	No
Diflubenzuron	X	X	X	No
Carbofuran	X			Yes
Zeta-cypermethrin	X	X	X	No
Malathion	X	X	X	Yes
Azinphos-methyl	X	X	X	Yes
Methyl Parathion	X	X		Yes
Acephate	X	X	X	No
Imidacloprid	X	X	X	No
Aldicarb	X	X	X	Yes
Endosulfan	X	X		No
Oxamyl	X	X	X	Yes
Bt. Microbial Insecticides:				
DiPel	X			No
Defoliants, Desiccants, Growth Regulators:				
Paraquat	X			No
Tribufos	X	X	X	No
Thidiazuron	X	X	X	No
Ethephon	X	X	X	No
Gibberellic Acid	X			No

Figure IV.5 Frequency of Pesticide Detection in Runoff Samples, 1996–1999

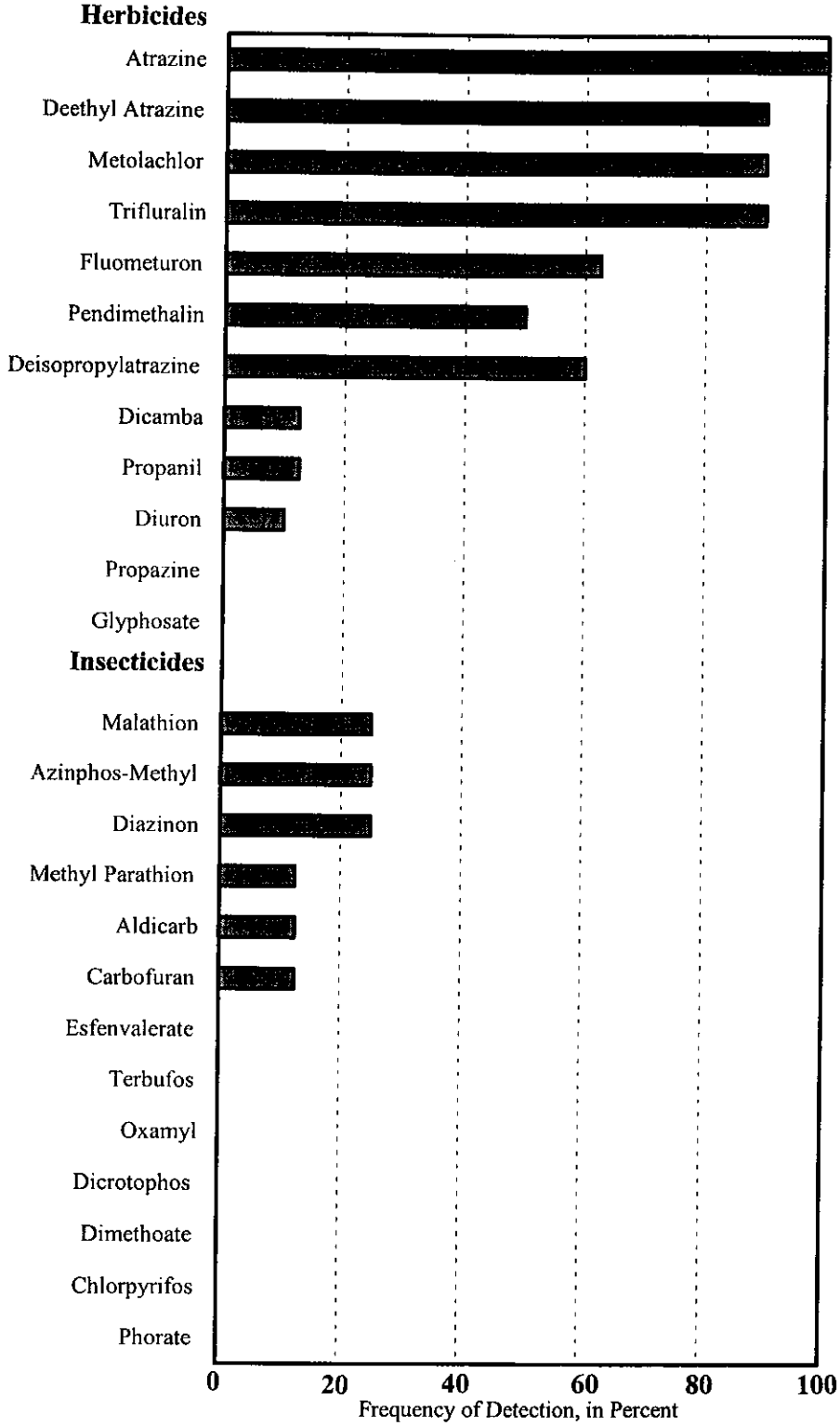


Table IV. 10 Summary Statistics of Selected Pesticide Concentrations
[all concentrations in micrograms per liter; <, less than; – , not determined]

Constituent	Number of Samples	Number of Detections	Mean	Medium	Maximum	Minimum	TNRCC-TSWQS Aquatic Life Protection (ug/L)	TNRCC - TSWQS Human Health Protection (ug/L)
Herbicides								
Atrazine, dissolved	10	10	0.70	0.10	4.66	0.04	11	
Atrazine-Deethyl, dissolved	10	9	–	0.17	1.02	0.03		
Metolachlor, dissolved	10	9	–	0.007	0.01	<0.002		
Trifluralin, dissolved	10	9	–	0.01	0.17	<0.002		
Fluometuron, dissolved	8	6	–	0.05	1.60	0.04		
Pendimethalin, dissolved	10	5	–	0.01	0.11	<0.004		
Deisopropylatrazine,	5	1	–	0.05	0.05	<0.035		
Dicamba, dissolved	8	1	–	<0.035	3.60	<0.035		
Propanil, dissolved	8	1	–	<0.004	0.006	<0.004		
Diuron, dissolved	10	1	–	<0.02	0.11	<0.02	70[1]	
Insecticides								
Malathion, dissolved	8	2	–	<0.005	0.02	<0.005	0.01[2]	
Azinphos-methyl, dissolved	8	2	–	<0.001	0.06	<0.001		
Diazinon, dissolved	8	2	–	<0.002	0.04	<0.002		
Methyl Parathion, dissolved	8	1	–	<0.006	0.02	<0.006		
Aldicarb, dissolved	8	1	–	<0.016	0.05	<0.016		
Carbofuran, dissolved	8	1	–	<0.003	0.02	<0.003		

[1] Aquatic Life Protection - Fresh Water Chronic Criteria
[2] Aquatic Life Protection - Marine Chronic Criteria

Table IV. 11 Seasonal Median Concentrations of Selected Pesticides in Runoff
[all concentrations in micrograms per liter; <, less than]

Constituent	Preplant and Crop Season (Nov.– June)	Post-harvest (Aug.– Oct.)	Overall Sampling Period
Atrazine, dissolved	0.58	0.05	0.10
Deethyl Atrazine, dissolved	0.17	0.13	0.17
Metolachlor, dissolved	0.008	0.005	0.007
Trifluralin, dissolved	0.04	0.007	0.01
Fluometuron, dissolved	0.82	0.04	0.05
Pendimethalin, dissolved	0.06	<0.004	0.012

All pesticides listed in Table IV. 11 that had larger numerical median concentrations in runoff during the crop growing season than the post-harvest period were herbicides. However, only atrazine exhibited statistically significantly higher seasonal median values for the preplant and crop growing season.

Constituent Loads and Yields. Constituent load in runoff is the mass of a given constituent transported past a site during a specified time. Daily nutrient and pesticide loads were calculated at each site from runoff and concentration data. Runoff events when water quality samples were collected and EMCs determined were used to calculate daily load for a constituent, Ln, at a particular site n as:

$$Ln = EMC \times V \times Cf,$$

where Ln = constituent load in pounds per day at site n,
EMC = event mean concentration during the event in milligrams per liter or micrograms per liter,
V = daily runoff in acre-ft,
Cf = conversion factor 2.719 for concentrations in milligrams per liter, or 0.00272 for concentrations in micrograms per liter.

Median EMC values were used with the above equation to estimate daily loads for unsampled runoff events. Runoff loads from the watershed are the sum of loads from site 1 and site 2. Daily loads were aggregated to report monthly and annual loads.

Constituent yield is a measure of the load producing character of a watershed, and is computed by dividing load by area in the watershed.

$$Y = L/A$$

where Y = constituent yield in pounds per acre per month, or per year,
L = constituent load exiting the watershed in pounds per month, or per year,
A = contributing area of the watershed in acres.

Nutrient Loads and Yields. Median EMCs (from Table IV. 7) were used to estimate nutrient concentrations and calculate daily loads. Unsampled events at site 2 on June 22, 1997 and October 17–26, 1998 and both sites 1 and 2 on October 6 – 10, 1998 accounted for about 37 percent (422 acre-ft of a total of 1,150 acre-ft) of runoff exiting the watershed during the study period. Monthly and annual loads of selected nutrients are provided in Appendix C. Table 1. Corresponding annual yields are shown in Table IV. 12.

Table IV. 12 Annual and Average Annual Runoff Nutrient Yields, 1996 – 1998 [all yields are in pounds per acre per year]

Constituent	1996	1997	1998	1996-1998 Average
Nitrogen, total	0.162	0.667	0.800	0.54
Ammonia plus organic N, total	0.088	0.396	0.725	0.403
Ammonia nitrogen, dissolved	0.007	0.014	0.029	0.017
Nitrite plus nitrate nitrogen, dissolved	0.061	0.272	0.104	0.146
Phosphorus, total	0.038	0.147	0.261	0.149
Ortho-Phosphate, dissolved	0.026	0.072	0.051	0.050

Annual nutrient runoff loads and yields were variable, corresponding to differences in volume of annual runoff, and depending highly on occurrence of relatively large events. Total nitrogen load exiting the watershed in 1996 was 449 pounds compared with 1,852 pounds in 1997 and 2,221 pounds in 1998. Total nitrogen load averaged 1,507 pounds annually over the 1996–1998 period. Annual total phosphorus loads in runoff were 106 pounds in 1996, 409 pounds in 1997 and 726 pounds in 1998. Average annual load was 414 pounds over the 1996–1998 period.

Total nitrogen yield was 0.162 pound per acre per year in 1996, 0.667 pound per acre in 1997, and 0.8 pound per acre in 1998. The 1996-1998 average was 0.54 pound per acre per year. Total phosphorus yield was 0.038 pound per acre in 1996, 0.147 pound per acre in 1997, and 0.261 pound per acre in 1998. The 1996-1998 average was 0.149 pound per acre per year. The increase in total nitrogen and total phosphorus yield from 1996 to 1997 and from 1997 to 1998 was directly related to the annual increase in volume of runoff from the watershed. Annual runoff increased from 103 acre-ft in 1996 to 309 acre-ft in 1997 to 731 acre-ft in 1998. Increase in annual runoff was not due to any changes in crop management practices; rather it was a function of the volume and intensity of rainfall from storm events and antecedent soil moisture conditions. The two highest rainfall storm events occurred in October 1997 and October 1998.

Runoff nutrient yields for the watershed were compared to inputs from fertilizer applications and rainfall deposition as shown in Table IV. 13.

Table IV. 13 Nitrogen and Phosphorus Fertilizer Applications, Rainfall Deposition, and Runoff Yields [total nitrogen, as N, and total phosphorus, as P, pounds per acre per year].

Year or Period	Nitrogen Fertilizer Applications	Rainfall Nitrogen	Nitrogen in Runoff	Phosphorus Fertilizer Applications	Rainfall Phosphorus	Phosphorus in Runoff
1996	77.02	2.10	0.16	17.87	0.20	0.04
1997	86.74	3.86	0.67	18.30	0.37	0.15
1998	82.10	3.12	0.80	19.32	0.35	0.26
Average, 1996-1998	81.95	3.03	0.54	18.50	0.31	0.15

Nitrogen as fertilizer applications far exceeds all other inputs or outputs of nitrogen from croplands in the watershed. Average annual fertilizer applications were 81.95 pounds per acre over the 1996-1998 period compared to 3.03 pounds per acre from rainfall deposition and 0.54 pound per acre in runoff. Fertilizer applications are computed as the total mass (pounds of active ingredients) divided by total acreage in the watershed, including crop acreages, roads, turnrows, field roads, drainage ways, etc., which do not receive any fertilizer applications.

Croplands in the watershed actually function as a net nitrogen sink as annual rainfall nitrogen deposition exceeds nitrogen runoff yields exiting croplands by a factor of 5.6. Most rain falling on the watershed does not runoff.

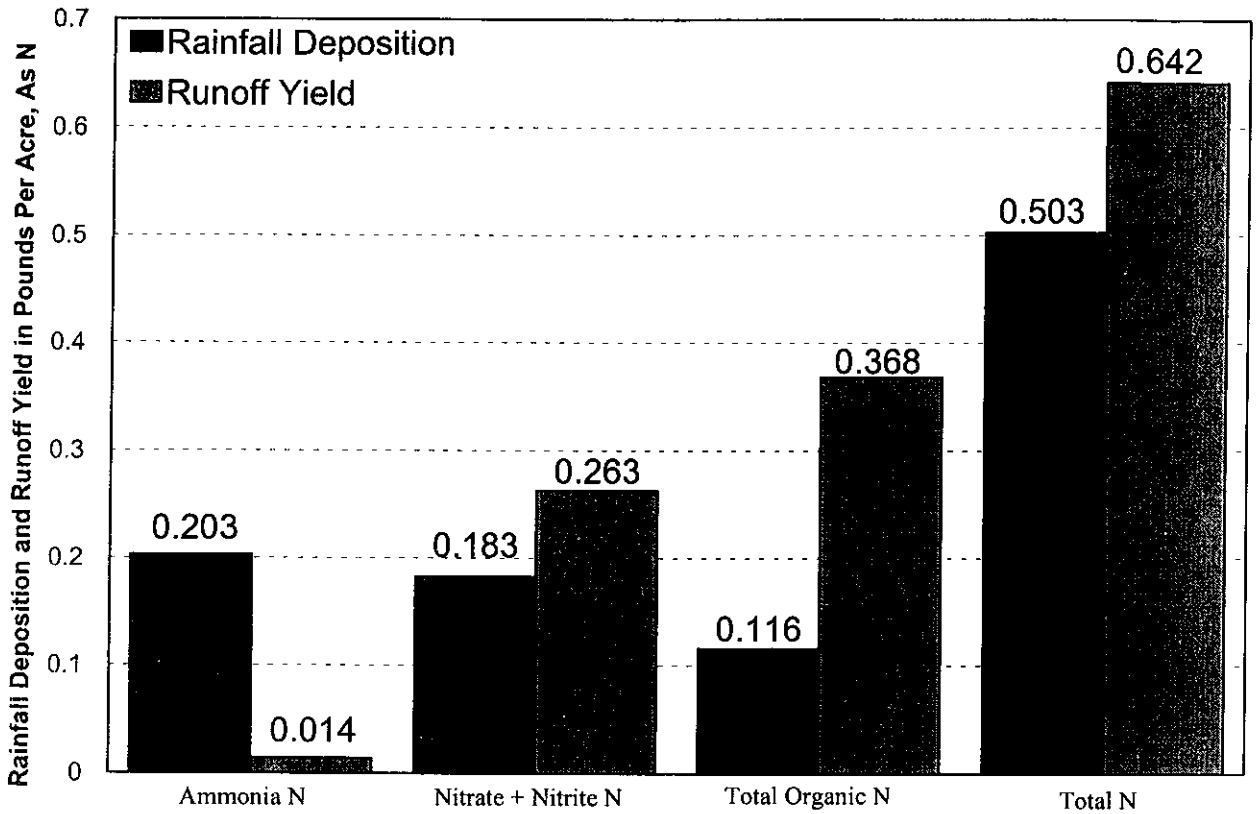
Nitrogen in runoff represent 0.6 percent of nitrogen applied to crops as fertilizer and rainfall nitrogen. Forms of nitrogen entering the watershed differ from forms of nitrogen exiting it in runoff. Nitrogen applied as fertilizer is in the form of ammonia and nitrate. Rainfall nitrogen also consists primarily of ammonia and nitrate (Table IV. 5). However, runoff nitrogen is primarily (about 71 percent) organic nitrogen (Table IV. 12), and organic nitrogen is mostly in particulate form (crop residue), rather than dissolved organic nitrogen.

Application of phosphorus as fertilizer greatly exceeds rainfall phosphorus deposition or runoff phosphorus. Average annual phosphorus applications as fertilizer were 18.5 pounds per acre as phosphorus. Phosphorus is applied as soluble ortho-phosphate. Total phosphorus yields in runoff from the watershed average 0.15 pound per acre per year, with about one-third (0.05 pound per acre per year) as ortho-phosphate. Most phosphorus in runoff was in particulate form associated with crop residue and soil particles from soils that are naturally high in phosphorus content. Phosphorus deposition from rainfall averaged 0.31 pound per acre per year. As with total nitrogen, croplands in the watershed serve as a phosphorus sink whereby rainfall phosphorus exceeds runoff phosphorus by a factor of 2.1.

In addition to annual comparisons of sources of nitrogen and phosphorus, comparisons were made for an individual event (October 1997) that exhibited the highest rainfall (8.45 inches) and relatively large runoff (296 acre-ft.). Pounds per acre of various components of nitrogen in rainfall and runoff yields for the watershed are shown in Figure IV. 6. Total nitrogen deposited by rainfall amounted to 0.503 pound per acre (as N) compared to 0.642 pound per acre of total nitrogen in runoff. As with annual values, most of rainfall nitrogen was ammonia and nitrate while most of runoff nitrogen was particulate organic nitrogen and nitrate. Rainfall ammonia nitrogen was substantially greater than runoff ammonia yield, indicating that some of the rainfall ammonia probably is transformed to other forms of nitrogen, e.g., nitrate, during the soil holding and subsequent runoff process.

Runoff yield of total phosphorus was 0.141 pound per acre during the October 10 – 16, 1997 event, including 0.068 pound per acre of dissolved ortho-phosphate (as

Figure IV.6 Nitrogen Rainfall Deposition and Runoff Yields During October 10–16, 1997 [<, less than]



P). Rainfall deposition of phosphorus was only 0.01 pound per acre, including 0.006 pound per acre of ortho-phosphate. The ratio of ortho-phosphate to total phosphorus in runoff during this event was 0.6, about double the 0.33 ratio observed over the 1996-1998 period.

Pesticide Loads and Yields. Runoff loads for pesticides were computed similarly to nutrient loads. Loads during unsampled events were computed using median concentrations of Table IV. 10. Monthly and annual loads for atrazine plus deethyl atrazine, fluometuron, and a grouping of other pesticides in runoff that occurred in minute amounts are presented in Appendix C, Table 2. Annual runoff yields and average annual runoff yield for pesticides over the 1996-1998 period are presented in Table IV. 14. Yield in runoff of all pesticides was an estimated 0.00017 pound per acre per year over the 1996-1998 period.

Table IV. 14 Annual and Average Annual Runoff Yield for Selected Pesticides, 1996-1998 [yield in pounds per acre per year]

Pesticide	1996	1997	1998	1996-1998 Average
Atrazine plus deethyl atrazine, dissolved	0.000228	0.000060	0.000055	0.000114
Fluometuron, dissolved	0.000086	0	0.000008	0.000031
Others - total dissolved [1]	0.000022	0.000035	0.000024	0.000027
Total Pesticides	0.000336	0.000095	0.000087	0.000172

[1] Other pesticides consisted primarily of malathion, metolachlor, trifluralin, and pendimethalin.

Yield of dissolved atrazine plus deethyl atrazine in runoff was calculated and compared to pounds per acre applied to crops in the watershed (Table IV. 15).

An average of 1,438 pounds of atrazine, or 0.501 pound per acre per year was applied during 1996-1998. Atrazine applications ranged from 0.27 pound per acre in 1996 when planted sorghum acreage was 1,178 acres to 0.717 pound per acre in 1997 when planted sorghum acreage was 1,736 acres. During 1996-1998, 0.985

Table IV. 15 Application and Runoff Yield of Atrazine
[in pounds per acre per year]

Year or Period	Application to Crops	Runoff Yield
1996	0.270	0.000228
1997	0.717	0.000060
1998	0.517	0.000055
1996-1998 Average	0.501	0.000114

pound of atrazine plus deethyl atrazine exited the watershed, or about 0.000114 pound per acre per year. Only about 0.02 percent average annual washoff (loss of pesticide in runoff) occurred. Most atrazine runoff occurred in June 1996, resulting in a higher 1996 annual atrazine washoff of about 0.08 percent.

Suspended and Dissolved Solids Loads and Yields. Runoff loads for suspended and dissolved solids were computed by

$$L_S = R \times EMC_S \times 2.719,$$

where L_S = suspended or dissolved solids load in pounds,
R = event runoff in acre-ft.,
EMC_S = suspended or dissolved solids event-mean concentration in milligrams per liter, and
2.719 = conversion factor for concentrations in milligrams per liter.

Event loads were computed for each event using gauged runoff volumes and EMCs from water samples collected during the runoff event. For ungauged events, the median value of suspended and dissolved solids concentrations at sites 1 and 2 were used with gauged runoff volume to estimate solids concentration at each site.

The estimated relationship between event runoff and suspended solids concentration at site 1 and site 2 respectively, were

$L_{S1} = -0.3678R_1 + 437.12, \quad R^2 = 0.3254$
$L_{S2} = 0.0155\ R_2 + 273.35, \quad R^2 = 0.0001$

Neither regression was statistically significant at the 10 percent probability level. Both the mean and median suspended and dissolved solids concentrations were higher at site 1 than site 2, particularly for suspended solids. The step-down weir control structure at site 2 pools water behind the dam and retards runoff from site 2, possibly allowing some settling of suspended material.

Solids loads from each site were summed to compute total solids loads from the 2,775-acre watershed. Annual solids loads and yields (loads per acre) for the watershed are provided in Table IV.16.

Table IV.16 Suspended and Dissolved Solids Loads and Yields, 1996–1998
[loads in pounds per year, yields in pounds per acre per year]

Year	Suspended Solids Load	Suspended Solids Yield	Dissolved Solids Load	Dissolved Solids Yield
1996	108000	38.9	24550	8.8
1997	232050	83.6	117230	42.2
1998	505640	182.2	150980	54.4
1996-1998 Average	281897	101.6	97587	35.2

Total suspended solids averaged 281,897 pounds annually during 1996-1998, or 102 pounds per acre per year. About 63.5 percent of total runoff over the study period occurred in 1998. Consequently, 60 percent of total suspended solids load and 52 percent of total dissolved solids loads in runoff were experienced in 1998. Yield of suspended solids ranged from 39 pounds per acre in 1996 to 182 pounds per acre in 1998, or an annual average over the study period of 102 pounds per acre. The annual yield of dissolved solids over the 1996–1998 period was 35 pounds per acre.

Runoff-Weighted Average Concentrations. Load of a constituent exiting the watershed divided by watershed runoff gives a measure of runoff-weighted average concentration of the constituent. This measure of constituent concentration takes into account runoff at each site, appropriately averaging concentrations according to site runoff. Runoff-weighted concentrations may be thought of as a way to express total watershed load in terms of a concentration

value. Runoff-weighted average concentration can be determined for a single event or for a longer time period, such as month or year. Also, for annual or longer periods, concentration data from larger runoff events will have more influence on the result than concentration data from smaller runoff events. For example, runoff generally was much greater at site 1 than site 2. Therefore, event mean concentrations at site 1 will be weighted more heavily in calculating average concentrations in runoff exiting the watershed. Further, runoff during the post-harvest period (August–October) far exceeded runoff during the preplant and crop growing season (November–June). Concentration data from larger runoff events in August and October will have more influence on the results than data from smaller runoff events in calculating annual or longer period runoff-weighted concentrations.

Watershed runoff-weighted nutrient concentrations were calculated by month, year, and for the 1996-1998 study period. Results are presented in Appendix C, Table 3. Monthly runoff-weighted concentrations generally correspond to concentrations associated with single events, and principally runoff and concentrations at site 1. Annual and overall 1996-1998 period concentrations provide longer-term measures of runoff quality (Table IV. 17).

Table IV. 17 Watershed Runoff-Weighted Average Concentrations for Selected Constituents, 1996–1998 [units are milligrams per liter for nutrients and total suspended and dissolved solids and micrograms per liter for pesticides]

Constituent	Concentration
Nitrogen, total	1.069
Ammonia plus Organic N, total	1.149
Ammonia Nitrogen, dissolved	0.044
Nitrite plus Nitrate Nitrogen, dissolved	0.393
Phosphorus, total	0.417
Orthophosphorus, dissolved	0.159
Atrazine plus Deethyl Atrazine	0.470
Total suspended solids	317.0
Total dissolved solids	110.0

Overall runoff-weighted concentration for total nitrogen at 1.069 mg/L is lower than both the mean (1.94 mg/L) and median (2.09 mg/L) of the EMCs presented in Table IV. 7. The large runoff event on October 17–26, 1998, accounting for half of total runoff during 1996-1998 with a lower EMC value of 0.08 mg/L, greatly influences the overall runoff-weighted concentration. Similarly, the other forms of nitrogen as well as total phosphorus and ortho-phosphorus shown in Table IV. 17, exhibited overall runoff-weighted concentrations lower than the mean and median values given in Table IV. 7. Runoff-weighted concentration of suspended solids also are less than the mean and median values for the separate events, whereas the weighted concentration of dissolved solids exceeds both the mean and median values.

Runoff weighted concentration for atrazine plus deethyl atrazine was calculated by month and year (Appendix C, Table 3). Atrazine was the most frequently detected pesticide in runoff during the study. The relatively large value for atrazine concentration in runoff for the June 1996 event resulted in an annual 1996 runoff-weighted concentration value of 2.335 ug/L for atrazine plus deethyl atrazine. However, since the greatest volume of runoff occurred in 1997 (309 acre-ft) and 1998 (731 acre-ft) the overall runoff-weighted concentration was 0.47 ug/L, which was less than the mean EMC (0.7 ug/L) for atrazine but somewhat larger than the median EMC (0.27 ug/L) for atrazine plus deethyl atrazine shown in Table IV. 10.

Most atrazine runoff occurred during the preplant and crop growing season (November–June). However, less than 1.0 pound total atrazine exited the watershed in runoff during the June 1996 through March 1999 storm events.

V. SUMMARY AND CONCLUSIONS

From June 1, 1995 to May 31, 1999, rainfall and runoff were monitored at two sites in a 2,775 acre cropland watershed in western San Patricio County within the Nueces River Basin Drainage Area. Nineteen rainfall samples along with 16 rainfall samples from a second site located in northern Kleberg County were collected during May 1996 to December 1997 and analyzed for nitrogen and phosphorus. Ten event-average runoff samples were collected during June 1996 to March 1999 and analyzed for major ions, nutrients, and pesticides. Results of rainfall, runoff and water-quality analyses are summarized below.

Hydrologic Conditions

Rainfall in the CBBEP project area can be characterized by long periods of below average rainfall punctuated by extreme rainfall events, with heaviest rainfall occurring during May–June and August–September. Rainfall in the Odem Ranch Watershed during June 1995 – May 1999 was typical of the pattern. During the 1996–1998 period, rainfall in the watershed was 4.59 inches below long-term (1969–1998) annual average at the NOAA station near Corpus Christi, TX, particularly during 1996 (18.79 inches of rain). However, extreme rainfall events in October 1997 and October 1998 resulted in above average rainfall in 1997 and near-average rainfall in 1998.

Most rain events did not result in runoff from the watershed. Climate, soil characteristics, and tillage practices typically result in runoff occurrence only after heavy rain of 2.5 inches or more, depending on antecedent soil moisture conditions. Occurrence of relatively extreme rainfall events was the primary factor influencing amount and timing of runoff and associated constituent loads. During 1996, rainfall was well below (13.92 inches) normal, but two extreme storm events in June (6.12 inches of rainfall) and August (4.16 inches of rainfall) produced only 103.5 acre-ft of runoff (about 9 percent of total runoff during June 1996 through March 1999). During 1997, rainfall of 8.45 inches on October 10–16 resulted in 25.7 percent of total runoff over the study period. Similarly, in 1998, 2.56 inches of rainfall during October 6–10 and 6.29 inches of rainfall on October 17–26, produced 63.5 percent of total runoff during the June 1996 to March 1999 period. Overall, four rain events with rainfall in excess of 4 inches and accounting for only about 23 percent of total rainfall on the watershed during June 1995 through May 1999 produced 84 percent of total runoff.

Annual runoff coefficients (runoff, in inches divided by rainfall, in inches) for the

watershed were 0.024 in 1996, 0.039 in 1997, and 0.10 in 1998. The overall runoff coefficient during June 1995 to May, 1999 was 0.045. Lowest runoff coefficient was 0.013 for the storm event of March 28, 1999, and highest runoff coefficient was 0.391 for the storm event of October 17–26, 1998.

Water Quality

Nitrogen in rainfall occurs primarily as dissolved ammonia and dissolved nitrate which were detected in all rainfall samples. Rainfall deposited an annual average of 3.03 pounds of total nitrogen per acre compared to 81.95 pounds of nitrogen per acre applied to crops as fertilizer, or about 3.5 percent of nitrogen input to cropland in the watershed.

Total phosphorus deposited on the watershed in rainfall amounted to 0.31 pound per acre per year compared to 18.5 pounds per acre per year applied as fertilizer.

Annual yield of total nitrogen in runoff exiting the watershed ranged from 0.16 pound per acre in 1996 to 0.80 pound per acre in 1998, with an average 0.54 pound per acre per year over the 1996–1998 period. Whereas most nitrogen applied to croplands in rainfall or fertilizer is ammonia and nitrate, most nitrogen in runoff is particulate organic nitrogen. Major source of organic nitrogen is crop residue. Total nitrogen in runoff is only 0.6 percent of combined fertilizer and rainfall nitrogen applied to the watershed during 1996–1998.

Annual yield of total phosphorus in runoff ranged from 0.04 pound per acre in 1996 to 0.26 pound per acre in 1998 with an average 0.15 pound per acre per year during 1996–1998. Fertilizer phosphorus is applied as soluble ortho-phosphate. However, most phosphorus in runoff is particulate total phosphorus associated with crop debris and soil particles. Total phosphorus in runoff amounted to about 0.8 percent of combined rainfall and fertilizer phosphorus applied to the watershed during 1996–1998.

Atrazine and its metabolite, deethyl atrazine, were detected in all runoff samples collected during the study. Other frequently detected pesticides were metolachlor and trifluralin (detected in 90 percent of runoff samples), fluometuron (62.5 percent), pendimethalin (50 percent), malathion, azinphos-methyl, and diazinon (25 percent). Concentrations of detected pesticides were numerically higher in the preplant and crop growing season (November–June) than the post-harvest period (August–October). However, only atrazine exhibited a statistically higher seasonal median value for the preplant and crop growing season. Atrazine concentration in

ten samples did not exceed the 11 ug/L criterion established by USEPA for aquatic-life protection. The maximum EMC value was 4.66 ug/L. All other observed concentrations of atrazine in runoff were less than 1.0 ug/L.

Atrazine and fluometuron contributed to greatest loads of pesticides in runoff. Because of higher concentrations in spring, June runoff events exhibited greater potential to deliver higher pesticide loads than fall events. For example, during the June 1996 runoff event, 0.63 pound of atrazine plus deethyl atrazine and 0.21 pound of fluometuron exited the watershed in runoff compared to 0.16 pound atrazine and 0.02 pound fluometuron in runoff for an even larger event in October 1998. Runoff yield of atrazine-plus deethyl atrazine was only 0.02 percent of atrazine applied to croplands in the watershed during 1996–1998.

Runoff-weighted average concentrations for the watershed were calculated for selected nutrients and pesticides by dividing total constituent loads by watershed runoff. Calculations were performed monthly, annually, and for the 1996–1998 study period. Runoff-weighted average concentrations assigns more weight to sample concentrations at sites or during events with greater runoff. Runoff-weighted average concentrations perhaps better characterize water quality from runoff than mean or median concentration values for all samples. Overall, runoff-weighted concentrations for total nitrogen and total phosphorus for 1996–1998 were 1.069 mg/L and 0.417 mg/L, respectively. Runoff-weighted concentrations for all forms of nitrogen as well as total phosphorus and ortho-phosphorus were lower than mean and median values of the EMCs. Runoff-weighted atrazine concentration for 1996–1998 was 0.47 ug/L which was less than the mean EMC value of 0.7 ug/L, but greater than the median EMC value of 0.27 ug/L. However, less than 1.0 pound total atrazine exited the 2,775-acre watershed in runoff over the sampling period, June 1996 through March 1999.

Conclusions

Conclusions from the results of the study are as follows:

- Soils, topography, and management practices of the Odem Ranch Watershed are representative of 70–80 percent of cropland acreage in the CBBEP project area and suggest that data collected during 1996–1999 are representative of surface-water quality from croplands in the eastern portion of the CBBEP project area.

- Loads and yields of nutrients and pesticides in runoff are minute in relation to nutrients and pesticides applied to croplands.

- Both nitrogen and phosphorus in runoff are comprised primarily of particulate organic nitrogen and particulate phosphorus, whereas nitrogen and phosphorus applied to crops are ammonia and nitrate nitrogen and soluble ortho-phosphate.

- Croplands serve as a sink for both nitrogen and phosphorus deposition in rainfall. Over 5 times more nitrogen in the form of ammonia and nitrate was deposited annually in rainfall than exited the watershed primarily as particulate organic nitrogen and nitrate in runoff from storm events. Twice as much phosphorus was deposited annually in rainfall on the watershed than exited the watershed in runoff.

- EMC maximum value for atrazine was less than maximum contaminant level (MCL) of 11 ug/L used as the standard for aquatic life protection by USEPA. Maximum EMC values for all nutrients, pesticides, and major inorganic ions in runoff were less than TNRCC Texas State Water Quality Standards (TSWQS) for aquatic life and human health protection.

- Median, mean and runoff-weighted EMC values for all forms of nitrogen and phosphorus as well as for selected pesticides in runoff were substantially less than median values reported for Oso Creek and other areas along the upper Texas Gulf Coast.

- Management practices used to produce crops in the watershed are effective in limiting loads and yields of nutrients and pesticides in runoff.

- Seasonality of crop production, timing of applications of nutrients and pesticides to croplands, and seasonality of stormwater runoff did not impose seasonal differences in nutrient and pesticide loads and yields in runoff from the watershed.

- Changes in tillage practices, crop rotations, row spacings, plant populations, and amount of crop residue left on the soil have different implications for water quality in runoff since loads and yields of particulate organic nitrogen and particulate phosphorus may vary with cultural practices.

- Results from this study and a companion study for southern Nueces and northern Kleberg counties within the CBBEP project area indicate that crop agriculture poses little risk to the coastal environment in this area of the state and nation.

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VII. APPENDICES

Appendix A

Total Product Used by Crop in the Odem Ranch Watershed

Appendix A. Table 1 Total Product Used by Crop in the Odem Ranch Watershed, 1996

Item	Crop			Total	Units	Lbs. of Active Ingredient
	Corn	Sorghum	Cotton			
Planted Acres	73.0	1,177.6	1,615.8	2,866.4		
Synthetic herbicides:(common name)						
Atrazine 4L (Atrazine)	34.5	739.8	0	774.3	Lbs.	774.3
Cotoran 4L (Fluometuron)	0	0	550.1	550.1	Lbs.	550.1
Direx (Diuron)	0	0	34.5	34.5	Lbs.	34.5
Diuron (Diuron)	0	0	385.5	385.5	Lbs.	385.5
Milo Pro 4L (Propazine)	0	211.5	0	211.5	Lbs.	211.5
Prowl (Pendimethalin)	0	0	304.9	304.9	Pts.	125.8
Roundup (Glyphosate)	0	0	10,337.0	10,337.0	Ozs.	323.0
Super-T (Trifluralin)	0	0	75.9	75.9	Lbs.	75.9
Treflan (Trifluralin)	0	0	1,784.8	1,784.8	Lbs.	1,784.8
Subtotal						**4,265.4**
Synthetic Insecticides: (common name)						
Asana (Esfenvalerate)	0	0	36.2	36.2	Gals.	23.9
Baythroid (Cyfluthrin)	0	0	15.6	15.6	Pts.	3.9
Bidrin (Dicrotophos)	0	0	55.5	55.5	Qts.	111.0
Confirm (Tebufenozide)	0	0	128.5	128.5	Pts.	32.1
Counter 15G (Terbufos)	276.0	1,822.0	0	2,098.0	Lbs.	314.7
Dimethoate 4E (Dimethoate)	0	746.2	125.0	871.2	Pts.	435.6
Dimilin (Diflubenzuron)	0	0	2,570.0	2,570.0	Ozs.	80.3
Furadan (Carbofuran)	0	0	128.5	128.5	Pts.	64.2
Fury (Zeta-cypermethrin)	0	0	822.4	822.4	Gals.	1,233.6
Fyfanon (Malathion)	0	0	108,014.0	108,014.0	Ozs.	8,354.2
Guthion 2L (Azinphos-methyl)	0	0	3,138.0	3,138.0	Pts.	784.5
Methyl #4 (Methyl Parathion)	0	0	128.5	128.5	Ozs.	4.0
Orthene 90s (Acephate)	0	0	34.5	34.5	Ozs.	1.9
Provado (Imidacloprid)	0	0	86.2	86.2	Ozs.	1.1

Appendix A. Table 1 (Continued)

Item	Crop			Total	Units	Lbs. of Active Ingredient
	Corn	Sorghum	Cotton			
Temik (Aldicarb)	0	0	2,192.1	2,192.1	Lbs.	328.8
Thiodan (Endosulfan)	0	0	12,799.3	12,799.3	Ozs.	300.0
Vydate (Oxamyl)	0	0	195.1	195.1	Pts.	92.1
Subtotal						**12,165.9**
Bt Microbial Insecticides (common name)						
DiPel (Bacillus thuringiensis va. Kurstaki)	0	0	7,265.4	7,265.4	Ozs.	8
Subtotal						**8**
Defoliants, Desiccants, Growth Regulators: (common name)						
Cyclone (Paraquat)	0	0	12,772.0	12,772.0	Ozs.	199.6
Def 6 (Tribufos)	0	0	251.2	251.2	Pts.	188.4
Dropp (Thidiazuron)	0	0	823.1	823.1	Lbs.	823.1
Folex (Tribufos)	0	0	439.5	439.5	Pts.	329.6
Ginstar (Thidiazuron + diuron)	0	0	654.2	654.2	Ozs.	7.7
Prep (Ethephon)	0	0	257.0	257.0	Ozs.	12.1
PGR-IV (Gibberellic acid)	0	0	290.0	290.0	Ozs.	0.1
Latron CS-7 (Spray adjuvant)	0	0	5.1	5.1	Pts.	0
Subtotal						**1,560.6**
TOTAL SYNTHETIC PESTICIDES						**17,991.9**
Nutrients:						
Nitrogen	6,278.0	106,680.0	105,953.8	218,911.8	Lbs.	218,911.8
Phosphate	0	40,510.8	76,892.4	117,403.2	Lbs.	51,236.5
Ammonium Sulfate - Nitrogen	0	0	5,845.6	5,845.6	Gals.	1,870.6
Ammonium Sulfate - Sulfate	0	0	5,845.6	5,845.6	Gals.	818.4

Appendix A. Table 2 Total Product Used by Crop in the Odem Ranch Watershed, 1997

Item	Crop			Total	Units	Lbs. of Active Ingredient
	Corn	Sorghum	Cotton			
Planted Acres	69.0	1,736.4	1,061.0	2,866.4		
Synthetic herbicides:(common name)						
Atrazine 4L (Atrazine)	62.1	1,994.0	0	2,056.1	Lbs.	2,056.1
Cotoran 4L (Fluometuron)	0	0	676.3	676.3	Lbs.	676.3
Direx (Diuron)	0	0	86.3	86.3	Lbs.	86.3
Prowl (Pendimethalin)	0	0	34.5	34.5	Pts.	34.5
Roundup (Glyphosate)	0	0	6,366.0	6,366.0	Ozs.	198.9
Treflan (Trifluralin)	0	0	1,534.5	1,534.5	Lbs.	1,534.5
Subtotal						**4,586.6**
Synthetic Insecticides: (common name)						
Asana (Esfenvalerate)	0	0	36.8	36.8	Gals.	24.3
Bidrin (Dicrotophos)	0	0	31.8	31.8	Qts.	63.6
Counter 15G (Terbufos)	276.0	3,102.3	0	3,378.3	Lbs.	506.7
Dimethoate 4E (Dimethoate)	0	1,100.3	0	1,100.3	Pts.	550.2
Dimilin (Diflubenzuron)	0	0	3,057.0	3,057.0	Ozs.	95.5
Fury (Zeta-cypermethrin)	0	0	381.4	381.4	Gals.	572.1
Fyfanon (Malathion)	0	0	54,822.0	54,822.0	Ozs.	4,192.8
Guthion 2L (Azinphos-methyl)	0	0	4,244.0	4,244.0	Pts.	1,061.0
Methyl #4 (Methyl Parathion)	0	0	1,104.0	1,104.0	Ozs.	34.5
Orthene 90s (Acephate)	0	0	4,244.0	4,244.0	Ozs.	238.7
Provado (Imidacloprid)	0	0	103.8	103.8	Ozs.	1.3

Appendix A. Table 2 (continued)

Item	Crop			Total	Units	Lbs. of Active Ingredient
	Corn	Sorghum	Cotton			
Temik (Aldicarb)	0	0	634.5	634.5	Lbs.	95.2
Thiodan (Endosulfan)	0	0	738.3	738.3	Ozs.	1.7
Vydate (Oxamyl)	0	0	42.6	42.6	Pts.	20.1
Subtotal						**7,457.7**
Defoliants, Desiccants, Growth Regulators: (common name)						
Def 6 (Tribufos)	0	0	780.5	780.5	Pts.	585.4
Dropp (Thidiazuron)	0	0	1,061.0	1,061.0	Lbs.	1,061.0
Folex (Tribufos)	0	0	105.8	105.8	Pts.	79.4
Ginstar (Thidiazuron + diuron)	0	0	2,192.4	2,192.4	Ozs.	25.8
Prep (Ethephon)	0	0	69.0	69.0	Ozs.	3.3
Subtotal						**1,765.0**
TOTAL SYNTHETIC PESTICIDES						**13,809.3**
Nutrients:						
Nitrogen	5,934.0	148,282.5	94,409.4	248,625.9	Lbs.	248,625.9
Phosphate	1,656.0	64,512.2	54,034.2	120,202.4	Lbs.	52,458.1

Appendix A. Table 3 Total Product Used by Crop in the Odem Ranch Watershed, 1998

Item	Crop			Total	Units	Lbs. of Active Ingredient
	Corn	Sorghum	Cotton			
Planted Acres	450.0	1,313.1	1,103.3	286.4		
Synthetic herbicides:(common name)						
Atrazine 4L (Atrazine)	381.0	1,101.5	0	1,482.5	Lbs.	1,482.5
Cotoran 4L (Fluometuron)	0	0	670.1	670.1	Lbs.	670.1
Prowl (Pendimethalin)	0	0	270.4	270.4	Pts.	111.5
Roundup (Glyphosate)	0	0	10,337.8	10,337.8	Ozs.	323.0
Treflan (Trifluralin)	0	0	1,595.0	1,595.0	Lbs.	1,595.0
Subtotal						**4,182.1**
Synthetic Insecticides: (common name)						
Asana (Esfenvalerate)	0	0	13.3	13.3	Gals.	8.8
Bidrin (Dicrotophos)	0	0	27.6	27.6	Qts.	55.2
Counter 15G (Terbufos)	1,488.0	2,731.8	0	4,219.8	Lbs.	633.0
Dimethoate 4E (Dimethoate)	0	569.9	120.0	689.9	Pts.	345.0
Dimilin (Diflubenzuron)	0	0	2,421.8	2,421.8	Ozs.	75.7
Fury (Zeta-cypermethrin)	0	0	307.2	307.2	Gals.	460.8
Fyfanon (Malathion)	0	0	103,471.2	103,471.2	Ozs.	8,002.9
Guthion 2L (Azinphos-methyl)	0	0	2,758.3	2,758.3	Pts.	689.6
Orthene 90s (Acephate)	0	0	1,117.2	1,117.2	Ozs.	62.8
Provado (Imidacloprid)	0	0	240.0	240.0	Ozs.	3.0

Appendix A. Table 3 (continued)

Item	Crop			Total	Units	Lbs. of Active Ingredient
	Corn	Sorghum	Cotton			
Temik (Aldicarb)	0	0	2,192.7	2,192.7	Lbs.	328.9
Vydate (Oxamyl)	0	0	63.9	63.9	Pts.	63.9
Subtotal						**10,695.8**
Defoliants, Desiccants, Growth Regulators: (common name)						
Def 6 (Tribufos)	0	0	372.4	372.4	Pts.	186.2
Dropp (Thidiazuron)	0	0	1,110.3	1,110.3	Lbs.	1,110.3
Folex (Tribufos)	0	0	365.4	365.4	Pts.	274.1
Prep (Ethephon)	0	0	1,920.0	1,920.0	Ozs.	90.0
Subtotal						**1,660.6**
TOTAL SYNTHETIC PESTICIDES						**16,538.5**
Nutrients:						
Nitrogen	42,069.6	106,078.2	87,180.7	235,328.5	Lbs.	235,328.5
Phosphate	10,800.0	44,760.8	71,364.6	126,925.4	Lbs.	55,392.1

Appendix B

Rainfall and Runoff Data From the Odem Ranch Watershed

Appendix B. Table 1 Date, Event Rainfall, Runoff Volumes, and Runoff Coefficients for Runoff Events
[total watershed runoff is the sum of runoff from sites 1 and 2]

Event Date	Watershed Rainfall (inches)	Runoff, Site 1 (acre-feet)	Runoff, Site 2 (acre-feet)	Runoff, total watershed (acre-feet)	Runoff Coefficient
6/25-26/96	6.12	36.81	21.62	58.43	0.041
8/24-25/96	4.16	29.36	15.71	45.07	0.047
6/22/97	3.05	5.08	7.90	12.98	0.018
10/10-16/97	8.45	180.90	115.20	296.10	0.151
10/6-10/98	2.56	96.20	66.10	162.30	0.274
10/17-26/98	6.29	316.65	251.90	568.55	0.391
3/28/99	2.35	4.10	2.70	6.80	0.013
Total of 7 Events	**32.98**	**669.10**	**481.13**	**1,150.23**	**0.151**

Appendix B. Table 2 Rainfall Sampling Analysis Results from NWQL

[$CaCO_3$, calcium carbonate; N, nitrogen; mg/L, milligrams per liter, –, no data; <, less than laboratory reporting limit]

Site	Date	Rainfall inches	pH standard units	Alkalinity mg/L as $CaCO_3$	Nitrate NO_3 mg/L as N	Nitrate NO_2 mg/L as N	Ammonia NH_4 mg/L as N	Ammonia plus Organic N, tot. mg/L as N	Ammonia plus Organic N, diss mg/L as N	Total N mg/L
1	6/1/96	0.70	–	–	0.17	<0.01	0.30	0.37	0.31	0.54
1	6/23/96	1.13	–	–	0.14	<0.01	0.21	0.20	0.33	0.35
1	6/24/96	0.44	–	–	0.19	<0.01	0.39	0.42	0.39	0.59
1	6/25/96	4.05	–	–	0.07	<0.01	0.07	0.07	0.09	0.14
1	8/8/96	1.08	5.7	2.8	0.15	<0.001	0.129	0.0	0.01	0.28
1	8/9/96	0.31	–	–	0.22	<0.001	0.21	0.30	0.30	0.52
1	8/21/96	1.12	5.4	–	0.11	0.002	0.171	0.17	0.20	0.28
1	8/24/96	1.21	5.5	–	0.07	<0.001	0.085	0.14	0.05	0.21
1	9/10/96	0.50	–	–	0.32	0.003	0.038	0.50	0.40	0.82
1	9/20/96	0.56	–	–	0.21	<0.001	0.233	0.30	0.30	0.51
1	11/24/96	0.79	–	–	0.04	<0.001	0.158	0.20	0.20	0.24
1	12/15/96	0.68	–	–	0.22	<0.001	0.301	0.80	0.80	0.94
1	2/12/97	0.21	–	–	0.67	<0.001	0.746	0.80	0.80	1.47
1	3/11/97	0.41	6.0	2.8	0.10	<0.01	0.18	0.30	0.20	0.44
1	5/9/97	1.31	–	–	0.22	<0.001	0.227	0.16	0.19	0.44
1	6/22/97	4.48	–	–	0.10	0.001	0.10	0.04	0.02	0.20
1	9/21/97	0.78	–	–	0.17	0.005	0.172	0.29	0.20	0.47
1	10/6/97	0.25	–	–	0.14	<0.001	0.09	0.14	0.16	0.28
1	10/11/97	3.43	–	–	0.02	<0.001	0.016	0.08	0.04	0.10

Appendix B. Table 3 Monthly and Annual Nitrogen and Phosphorus Rainfall Deposition, in Pounds Per Acre, 1996-1998
[N, nitrogen; P, phosphorus; –, data not available]

Ammonia—NH_4 (as N)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1996	0.01	0.00	0.06	0.06	0.01	0.22	0.00	0.35	0.13	0.06	0.10	0.09	1.09
1997	0.10	0.19	0.22	0.23	0.29	0.24	0.01	0.03	0.17	0.31	0.17	0.05	2.01
1998	0.07	0.19	0.15	0.05	0.00	0.03	0.04	0.26	0.20	0.27	0.19	0.15	1.61
1999	0.07	0.07	0.13	0.07	0.10	–	–	–	–	–	–	–	–

Nitrate—NO_3 (as N)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1996	0.00	0.00	0.04	0.04	0.01	0.16	0.00	0.26	0.09	0.05	0.07	0.06	0.79
1997	0.07	0.13	0.16	0.17	0.21	0.18	0.00	0.02	0.12	0.23	0.12	0.04	1.45
1998	0.05	0.14	0.11	0.04	0.00	0.02	0.03	0.19	0.14	0.20	0.13	0.11	1.17
1999	0.05	0.05	0.10	0.05	0.07	–	–	–	–	–	–	–	–

Total Nitrogen (as N)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1996	0.01	0.00	0.11	0.10	0.02	0.46	0.00	0.70	0.24	0.12	0.18	1.17	2.10
1997	0.18	0.32	0.42	0.44	0.57	0.49	0.01	0.06	0.33	0.65	0.30	0.09	3.86
1998	0.13	0.37	0.28	0.09	0.00	0.05	0.09	0.54	0.37	0.58	0.35	0.27	3.12
1999	0.11	0.11	0.26	0.13	0.17	–	–	–	–	–	–	–	–

Total Phosphorus (as P)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1996	0.00	0.00	0.004	0.003	0.00	0.072	0.00	0.070	0.014	0.006	0.013	0.014	0.198
1997	0.007	0.011	0.014	0.031	0.053	0.068	0.000	0.003	0.028	0.103	0.019	0.003	0.368
1998	0.005	0.036	0.020	0.005	0.000	0.002	0.012	0.076	0.032	0.112	0.028	0.018	0.347
1999	0.006	0.005	0.031	0.015	0.011	–	–	–	–	–	–	–	–

Orthophosphorus (as P)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1996	0.000	0.000	0.001	0.001	0.000	0.018	0.000	0.018	0.004	0.002	0.003	0.014	0.060
1997	0.002	0.003	0.010	0.008	0.013	0.017	0.000	0.001	0.007	0.026	0.005	0.003	0.094
1998	0.001	0.009	0.005	0.001	0.000	0.001	0.003	0.019	0.008	0.028	0.007	0.005	0.087
1999	0.001	0.001	0.008	0.004	0.003	–	–	–	–	–	–	–	–

Appendix B. Rainfall and Runoff Volumes by Site
(see following tables)

Rainfall and Runoff Volumes for Odem Ranch Site 1 - June, 1996 Event

Drainage Area: 1683 acres

Date	Rainfall (inches)	Rainfall Volume (acre-ft)	Rainfall Volume (cu. ft.)	Runoff Volume (acre-ft)	Runoff Volume (cu. ft.)
23-Jun	1.13	158	6903497.7	--	--
24-Jun	0.44	62	2688087.6	--	--
25-30-Jun	4.55	638	27797269	36.81	1603444
Total	6.12	858	37388855	36.81	1603444

Runoff Coefficient:

Based upon 6/25-30, 4.55" rain only:	**0.058**
Including antecedent rain:	**0.043**

Rainfall and Runoff Volumes for Odem Ranch Site 2 - June, 1996 Event

Drainage Area: 1092 acres

Date	Rainfall (inches)	Rainfall Volume (acre-ft)	Rainfall Volume (cu. ft.)	Runoff Volume (acre-ft)	Runoff Volume (cu. ft.)
23-Jun	1.13	103	4479274.8	--	--
24-Jun	0.44	40	1744142.4	--	--
25-30-Jun	4.55	414	18036018	21.62	941767
Total	6.12	557	24259435	21.62	941767

Runoff Coefficient:

Based upon 6/25-30, 4.55" rain only:	**0.052**
Including antecedent rain:	**0.039**

Rainfall and Runoff Volumes for Odem Ranch Site 1 - August, 1996 Event

Drainage Area: 1683 acres

Date	Rainfall (inches)	Rainfall Volume (acre-ft)	Rainfall Volume (cu. ft.)	Runoff Volume (acre-ft)	Runoff Volume (cu. ft.)
21-Aug	1.12	157	6842404.8	--	--
22-Aug	1.06	149	6475847.4	--	--
23-Aug	0.54	76	3299016.6	--	--
24-Aug	1.4	196	8553006	20.24	881654
25-27 Aug	0.04	6	244372	9.12	397267
Total	4.16	583	25414646	29.36	1278922

Runoff Coefficient:

Based upon 8/24-27, 1.44" rain only:	**0.145**
Including antecedent rain:	**0.037**

Rainfall and Runoff Volumes for Odem Ranch Site 2 - August, 1996 Event

Drainage Area: 1092 acres

Date	Rainfall (inches)	Rainfall Volume (acre-ft)	Rainfall Volume (cu. ft.)	Runoff Volume (acre-ft)	Runoff Volume (cu. ft.)
21-Aug	1.12	102	4439635.2	--	--
22-Aug	1.06	96	4201797.6	--	--
23-Aug	0.54	49	2140538.4	--	--
24-Aug	1.4	127	5549544	11.76	512266
25-27 Aug	0.04	4	158558	3.95	172062
Total	4.16	379	16490074	15.71	684328

Runoff Coefficient:

Based upon 8/24-27, 1.44" rain only:	**0.120**
Including antecedent rain:	**0.041**

Rainfall and Runoff Volumes for Odem Ranch Site 1 - June, 1997 Event

Drainage Area: 1683 acres

Date	Rainfall (inches)	Rainfall Volume (acre-ft)	Rainfall Volume (cu. ft.)	Runoff Volume (acre-ft)
21-Jun	2.0	280	12218580	0.2
22-Jun	0.7	98	4276503	4.88
Total	2.7	379	16495083	5.08

Runoff Coefficient: 0.013

Rainfall and Runoff Volumes for Odem Ranch Site 2 - June, 1997 Event

Drainage Area: 1092 acres

Date	Rainfall (inches)	Rainfall Volume (acre-ft)	Rainfall Volume (cu. ft.)	Runoff Volume (acre-ft)
21-Jun	2.4	218	9513504	0.0
22-Jun	1.19	108	4717112.4	7.9
Total	3.59	327	14230616	7.9

Runoff Coefficient: 0.024

Rainfall and Runoff Volumes for Odem Ranch Site 1 - October, 1997 Event

Drainage Area: 1683 acres

Date	Rainfall (inches)	Rainfall Volume (acre-ft)	Rainfall Volume (cu. ft.)	Runoff Volume (acre-ft)
6-Oct	0.55	77	3360109.5	
7-Oct	0.01	1	61092.9	
8-Oct	0.31	43	1893879.9	0
9-Oct	0.86	121	5253989.4	0
10-Oct	2.39	335	14601203.1	0.1
11-Oct	2.92	410	17839126.8	29
12-Oct	0.00	0	0	39
13-Oct	1.85	259	11302186.5	60.3
14-Oct	0.00	0	0	42
15-Oct	0.00	0	0	8.6
16-Oct	0.00	0	0	1.9
Total	8.89	1247	54311588.1	180.9

Runoff Coefficient: 0.145

Rainfall and Runoff Volumes for Odem Ranch Site 2 - October, 1997 Event

Drainage Area: 1092 acres

Date	Rainfall (inches)	Rainfall Volume (acre-ft)	Rainfall Volume (cu. ft.)	Runoff Volume (acre-ft)
6-Oct	0.60	55	2378376	0
7-Oct	0.01	1	39639.6	0
8-Oct	0.33	30	1308106.8	0
9-Oct	0.46	42	1823421.6	0
10-Oct	2.20	200	8720712	0
11-Oct	2.62	238	10385575.2	11.9
12-Oct	0.02	2	79279.2	13.7
13-Oct	1.54	140	6104498.4	32.4
14-Oct	0.00	0	0	24.8
15-Oct	0.00	0	0	13
16-Oct	0.00	0	0	8.4
17-Oct	0.00	0	0	7
18-Oct	0.00	0	0	4
Total	7.78	708	30839608.8	115.2

Runoff Coefficient: 0.163

Rainfall and Runoff Volumes for Odem Ranch Site 1 - October 6-10, 1998 Event

Drainage Area: 1683 acres

Date	Rainfall (inches)	Rainfall Volume (acre-ft)	Rainfall Volume (cu. ft.)	Runoff Volume (acre-ft)
6-Oct	2.5	351	15273225	28.8
7-Oct	0	0	0	37.9
8-Oct	0	0	0	20.8
9-Oct	0	0	0	7.6
10-Oct	0	0	0	1.10
Total	2.5	351	15273225	96.2

Runoff Coefficient: 0.274

Rainfall and Runoff Volumes for Odem Ranch Site 2 - October 6-10, 1998 Event
(Estimated from runoff coefficient at site 1)

Drainage Area: 1092 acres

Date	Rainfall (inches)	Rainfall Volume (acre-ft)	Rainfall Volume (cu. ft.)	Est Runoff Volume (acre-ft)
6-Oct	2.65	241	10504494	
Total	2.65	241	10504494	66.1

Runoff Coefficient: 0.274
Runoff coefficient from site 1 used to calculate runoff volume for site 2

Total Runoff volume for site 1 + site 2 : 162.3 **acre-feet**

Rainfall and Runoff Volumes for Odem Ranch Site 1 - October 17-26, 1998 Event

Drainage Area: 1683 acres

Date	Rainfall (inches)	Rainfall Volume (acre-ft)	Rainfall Volume (cu. ft.)	Runoff Volume (acre-ft)
17-Oct	0.2	28	1221858	0
18-Oct	4.52	634	27613991	52.05
19-Oct	0.89	125	5437268.1	98.15
20-Oct	0.00	0	0	78.93
21-Oct	0.00	0	0	52.00
22-Oct	0.00	0	0	25.65
23-Oct	0.00	0	0	8.49
24-Oct	0.00	0	0	1.22
25-Oct	0.07	10	427650	0.12
26-Oct	0.10	14	610929	0.04
Total	5.78	811	35311696	316.65

Runoff Coefficient: 0.391

Rainfall and Runoff Volumes for Odem Ranch Site 2 - October 17-26, 1998 Event
(Estimated from runoff coefficient at site 1)

Drainage Area: 1092 acres

Date	Rainfall (inches)	Rainfall Volume (acre-ft)	Rainfall Volume (cu. ft.)	Runoff Volume (acre-ft)
17-Oct	0.53	48	2100898.8	0
18-Oct	4.97	452	19700881	0
19-Oct	1.58	144	6263056.8	0
20-Oct	0.00	0	0	0
21-Oct	0.00	0	0	0
22-Oct	0.00	0	0	0
23-Oct	0.00	0	0	0
24-Oct	0.00	0	0	0
25-Oct	0.00	0	0	0
26-Oct	0.00	0	0	0
Total	7.08	644	28064837	251.9

Runoff Coefficient: 0.391
Runoff coefficient from site 1 used to calculate runoff volume for site 2

Total Runoff volume for site 1 + site 2 : 568.5 **acre-feet**

Appendix B. Daily and Monthly Rainfall and Rainfall Nutrient Loads
(see following tables)

Edroy Weather Station
Daily Rainfall - 1996

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
1	0.00	0.00	0.03	0.00	0.00	0.70	0.00	0.00	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.41	0.00	0.00
5	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.00
6	0.01	0.00	0.00	0.15	0.04	0.00	0.00	0.00	0.08	0.00	0.00	0.00
7	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.08	0.00	0.01	0.00
8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.08	0.00	0.00	0.00	0.00
9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.31	0.03	0.00	0.00	0.00
10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.50	0.00	0.00	0.00
11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.00
14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.41	0.00	0.02	0.00	0.00
15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.19	0.00	0.00	0.24	0.89
16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.00
17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.01	0.00	0.00	0.00
20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.56	0.00	0.00	0.00
21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.12	0.00	0.00	0.00	0.00
22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.06	0.00	0.09	0.00	0.00
23	0.00	0.00	0.23	0.01	0.00	1.13	0.00	0.54	0.00	0.00	0.00	0.00
24	0.00	0.00	0.10	0.00	0.00	0.44	0.00	1.40	0.00	0.00	0.80	0.00
25	0.00	0.00	0.00	0.00	0.00	4.05	0.00	0.04	0.00	0.00	0.00	0.00
26	0.00	0.00	0.00	0.00	0.00	0.06	0.00	0.12	0.00	0.00	0.00	0.14
27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.00	0.00	0.00	0.00
28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.00
29	0.00	0.00	0.00	0.01	0.00	0.14	0.00	0.03	0.00	0.00	0.04	0.00
30	0.00	--	0.00	0.02	0.00	0.11	0.00	0.00	0.00	0.00	0.00	0.01
31	0.00	--	0.00	0.00	0.00	--	0.00	0.07	--	0.00	--	0.24
TOTALS	0.01	0.00	0.41	0.24	0.04	6.63	0.00	6.48	1.33	0.56	1.23	1.28

1996 TOTAL **18.21**

Edroy Weather Station - 1996
Rainfall Total Nitrogen Loads (lbs as N / acre)

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
1	0.00	0.00	0.01	0.00	0.00	0.07	0.00	0.00	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.00
5	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00
6	0.01	0.00	0.00	0.03	0.02	0.00	0.00	0.00	0.02	0.00	0.00	0.00
7	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.02	0.00	0.01	0.00
8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.00	0.00	0.00	0.00
9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.01	0.00	0.00	0.00
10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.00	0.00	0.00
11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00
14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.01	0.00	0.00
15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.04	0.08
16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00
17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.01	0.00	0.00	0.00
20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.00	0.00	0.00
21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.00	0.00	0.00	0.00
22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.00	0.03	0.00	0.00
23	0.00	0.00	0.04	0.01	0.00	0.09	0.00	0.06	0.00	0.00	0.00	0.00
24	0.00	0.00	0.03	0.00	0.00	0.06	0.00	0.10	0.00	0.00	0.08	0.00
25	0.00	0.00	0.00	0.00	0.00	0.17	0.00	0.02	0.00	0.00	0.00	0.00
26	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.03	0.00	0.00	0.00	0.03
27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00
28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00
29	0.00	0.00	0.00	0.01	0.00	0.03	0.00	0.01	0.00	0.00	0.02	0.00
30	0.00	--	0.00	0.01	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.01
31	0.00	--	0.00	0.00	0.00	--	0.00	0.02	--	0.00	--	0.04
TOTALS	0.01	0.00	0.10	0.09	0.02	0.47	0.00	0.69	0.23	0.11	0.18	0.16
1996 TOTAL		**2.05**										

Edroy Weather Station - 1996
Rainfall Nitrate Loads (lbs as N / acre)

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
1	0.00	0.00	0.01	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00
5	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00
6	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.01	0.00	0.00	0.00
7	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00
8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00
9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.01	0.00	0.00	0.00
10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00
11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00
14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.01	0.00	0.00
15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.02	0.03
16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00
17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00
20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00
21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00
22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.01	0.00	0.00
23	0.00	0.00	0.02	0.00	0.00	0.03	0.00	0.02	0.00	0.00	0.00	0.00
24	0.00	0.00	0.01	0.00	0.00	0.02	0.00	0.03	0.00	0.00	0.03	0.00
25	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.01	0.00	0.00	0.00	0.00
26	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.00	0.00	0.00	0.01
27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00
28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00
29	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.00	0.00	0.01	0.00
30	0.00	--	0.00	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00
31	0.00	--	0.00	0.00	0.00	--	0.00	0.01	--	0.00	--	0.02
TOTALS	0.00	0.00	0.04	0.04	0.01	0.16	0.00	0.26	0.09	0.05	0.07	0.06

1996 TOTAL **0.79**

Edroy Weather Station - 1996
Rainfall Ammonia Loads (lbs as N / acre)

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
1	0.00	0.00	0.01	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.00
6	0.01	0.00	0.00	0.02	0.01	0.00	0.00	0.00	0.00	0.01	0.00	0.00
7	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00
8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.01	0.00
9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00
10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.01	0.00	0.00	0.00
11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.00
12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00
15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.01	0.00	0.00
16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.02	0.04
17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00
18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.00
21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.00
22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00
23	0.00	0.00	0.02	0.01	0.00	0.04	0.00	0.04	0.00	0.02	0.00	0.00
24	0.00	0.00	0.02	0.00	0.00	0.03	0.00	0.03	0.00	0.00	0.00	0.00
25	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.04	0.00	0.00	0.04	0.00
26	0.00	0.00	0.00	0.00	0.00	0.07	0.00	0.01	0.00	0.00	0.00	0.00
27	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.02	0.00	0.00	0.00	0.02
28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00
29	0.00	0.00	0.00	0.01	0.00	0.02	0.00	0.00	0.00	0.00	0.02	0.00
30	0.00	--	0.00	0.01	0.00	0.02	0.00	0.01	0.00	0.00	0.01	0.00
31	0.00	--	0.00	0.00	0.00	--	0.00	0.00	0.00	0.00	0.00	0.01
TOTALS	0.01	0.00	0.06	0.06	0.01	0.22	0.00	0.35	0.13	0.06	0.10	0.09

1996 TOTAL **1.09**

Edroy Weather Station - 1996
Rainfall Total Phosphorus Loads (lbs as P / acre)

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
1	0.000	0.000	0.000	0.000	0.000	0.008	0.000	0.000	0.000	0.000	0.000	0.000
2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
3	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
4	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.004	0.000	0.000
5	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
6	0.000	0.000	0.000	0.002	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000
7	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000
8	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.012	0.000	0.000	0.000	0.000
9	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.003	0.000	0.000	0.000	0.000
10	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.005	0.000	0.000	0.000
11	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
12	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
13	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
14	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.004	0.000	0.000	0.000	0.000
15	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.000	0.000	0.003	0.010
16	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
17	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
18	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
19	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
20	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.006	0.000	0.000	0.000
21	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.012	0.000	0.000	0.000	0.000
22	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.012	0.000	0.001	0.000	0.000
23	0.000	0.000	0.003	0.000	0.000	0.012	0.000	0.006	0.000	0.000	0.000	0.000
24	0.000	0.000	0.001	0.000	0.000	0.005	0.000	0.015	0.000	0.000	0.009	0.000
25	0.000	0.000	0.000	0.000	0.000	0.044	0.000	0.000	0.000	0.000	0.000	0.000
26	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.001	0.000	0.000	0.000	0.002
27	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000
28	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.000
29	0.000	0.000	0.000	0.000	0.000	0.002	0.000	0.000	0.000	0.000	0.000	0.000
30	0.000	--	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000
31	0.000	--	0.000	0.000	0.000	--	0.000	0.001	--	0.000	--	0.003
TOTALS	0.000	0.000	0.004	0.003	0.000	0.072	0.000	0.070	0.014	0.006	0.013	0.014

1996 TOTAL **0.198**

Edroy Weather Station - 1996
Rainfall Ortho-Phosphate Loads (lbs as P / acre)

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
1	0.000	0.000	0.000	0.000	0.000	0.002	0.000	0.000	0.000	0.000	0.000	0.000
2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
3	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
4	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000
5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
6	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
7	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
8	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.003	0.000	0.000	0.000	0.000
9	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000
10	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000
11	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
12	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
13	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
14	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000
15	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.001	0.010
16	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
17	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
18	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
19	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
20	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.000	0.000	0.000
21	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.003	0.000	0.000	0.000	0.000
22	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.003	0.000	0.000	0.000	0.000
23	0.000	0.000	0.001	0.000	0.000	0.003	0.000	0.001	0.000	0.000	0.000	0.000
24	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.004	0.000	0.000	0.002	0.000
25	0.000	0.000	0.000	0.000	0.000	0.011	0.000	0.000	0.000	0.000	0.000	0.000
26	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002
27	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
28	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
29	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
30	0.000	--	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
31	0.000	--	0.000	0.000	0.000	--	0.000	0.000	--	0.000	--	0.003
TOTALS	0.000	0.000	0.001	0.001	0.000	0.018	0.000	0.018	0.004	0.002	0.003	0.014

1996 TOTAL **0.060**

Edroy Weather Station
Daily Rainfall - 1997

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
1	0.05	0.00	0.00	0.30	0.00	0.00	0.00	0.30	0.00	0.00	0.01	0.00
2	0.01	0.00	0.00	0.64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	0.00	0.01	0.00	0.90	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	0.00	0.01	0.00	0.22	0.00	0.00	0.00	0.00	0.37	0.00	0.00	0.00
5	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00
6	0.00	0.06	0.00	0.00	0.00	0.50	0.00	0.00	0.00	0.55	0.27	0.00
7	0.05	0.09	0.00	0.03	0.00	0.02	0.00	0.00	0.00	0.01	0.00	0.07
8	0.12	0.00	0.00	0.22	0.00	0.00	0.00	0.00	0.00	0.46	0.00	0.00
9	0.00	0.08	0.00	0.00	1.34	0.03	0.00	0.00	0.00	0.82	0.00	0.00
10	0.00	0.07	0.00	0.01	0.13	0.00	0.00	0.00	0.00	2.69	0.02	0.00
11	0.00	0.05	2.20	0.00	0.00	0.00	0.00	0.00	0.00	2.55	0.90	0.00
12	0.00	0.17	0.03	0.00	0.18	0.00	0.00	0.00	0.00	0.06	0.11	0.00
13	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	2.24	0.16	0.00
14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	0.00	0.00	0.00	0.00	0.61	0.03	0.00	0.00	0.00	0.00	0.09	0.00
16	0.00	0.00	0.36	0.00	0.54	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	0.00	0.00	0.20	0.00	0.82	1.07	0.00	0.00	0.00	0.00	0.03	0.00
18	0.00	0.00	0.62	0.36	0.00	0.00	0.00	0.00	0.10	0.00	0.14	0.00
19	0.23	0.06	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00
20	0.19	0.19	0.00	0.02	0.61	0.00	0.00	0.00	0.26	0.00	0.00	0.06
21	0.03	0.00	0.00	0.00	0.00	2.80	0.00	0.00	0.93	0.00	0.00	0.11
22	0.00	0.00	0.00	0.00	0.47	1.68	0.00	0.00	0.30	0.00	0.00	0.00
23	0.00	0.03	0.01	0.00	0.05	0.02	0.00	0.00	0.62	0.00	0.00	0.00
24	0.00	0.14	0.00	0.00	0.01	0.01	0.00	0.01	0.01	0.00	0.00	0.00
25	0.00	0.05	0.29	0.06	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00
26	0.00	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
27	0.00	0.00	0.00	0.12	0.08	0.00	0.00	0.00	0.00	0.01	0.00	0.00
28	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.05	0.01	0.00
29	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
30	0.00	--	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31	0.00	--	0.04	--	0.00	--	0.00	0.00	--	0.01	--	0.00
TOTALS	0.68	1.02	3.81	2.89	4.86	6.22	0.01	0.31	2.59	9.45	1.74	0.25

1997 TOTAL **33.83**

Edroy Weather Station - 1997
Rainfall Total Nitrogen Loads (lbs as N / acre)

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
1	0.019	0.000	0.000	0.047	0.000	0.000	0.000	0.047	0.000	0.000	0.009	0.000
2	0.009	0.000	0.000	0.068	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
3	0.000	0.009	0.000	0.081	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
4	0.000	0.009	0.000	0.040	0.000	0.000	0.000	0.000	0.052	0.000	0.000	0.000
5	0.000	0.000	0.000	0.000	0.000	0.000	0.009	0.000	0.000	0.000	0.000	0.000
6	0.000	0.021	0.000	0.000	0.000	0.060	0.000	0.000	0.000	0.063	0.044	0.000
7	0.019	0.026	0.000	0.015	0.000	0.012	0.000	0.000	0.000	0.009	0.000	0.023
8	0.030	0.000	0.000	0.040	0.000	0.000	0.000	0.000	0.000	0.058	0.000	0.000
9	0.000	0.024	0.000	0.000	0.098	0.015	0.000	0.000	0.000	0.077	0.000	0.000
10	0.000	0.023	0.000	0.009	0.031	0.000	0.000	0.000	0.000	0.139	0.012	0.000
11	0.000	0.019	0.126	0.000	0.000	0.000	0.000	0.000	0.000	0.136	0.081	0.000
12	0.000	0.035	0.015	0.000	0.036	0.000	0.000	0.000	0.000	0.021	0.028	0.000
13	0.000	0.000	0.009	0.000	0.000	0.000	0.000	0.000	0.000	0.127	0.034	0.000
14	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
15	0.000	0.000	0.000	0.000	0.066	0.015	0.000	0.000	0.000	0.000	0.026	0.000
16	0.000	0.000	0.051	0.000	0.063	0.000	0.000	0.000	0.000	0.000	0.000	0.000
17	0.000	0.000	0.038	0.000	0.077	0.088	0.000	0.000	0.000	0.000	0.015	0.000
18	0.000	0.000	0.067	0.051	0.000	0.000	0.000	0.000	0.027	0.000	0.032	0.000
19	0.041	0.021	0.000	0.000	0.000	0.017	0.000	0.000	0.000	0.000	0.000	0.000
20	0.037	0.037	0.000	0.012	0.066	0.000	0.000	0.000	0.043	0.000	0.000	0.021
21	0.015	0.000	0.000	0.000	0.000	0.142	0.000	0.000	0.082	0.000	0.000	0.028
22	0.000	0.000	0.000	0.000	0.058	0.110	0.000	0.000	0.047	0.000	0.000	0.000
23	0.000	0.015	0.009	0.000	0.019	0.012	0.000	0.000	0.067	0.000	0.000	0.000
24	0.000	0.032	0.000	0.000	0.009	0.009	0.000	0.009	0.009	0.000	0.000	0.000
25	0.000	0.019	0.046	0.021	0.000	0.012	0.000	0.000	0.000	0.000	0.000	0.000
26	0.000	0.009	0.009	0.009	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.009
27	0.000	0.000	0.000	0.030	0.024	0.000	0.000	0.000	0.000	0.009	0.000	0.000
28	0.000	0.000	0.000	0.000	0.012	0.000	0.000	0.000	0.000	0.019	0.009	0.000
29	0.000	--	0.009	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
30	0.000	--	0.015	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
31	0.000	--	0.017	--	0.000	--	0.000	0.000	--	0.009	--	0.000
TOTALS	0.17	0.30	0.41	0.42	0.56	0.49	0.01	0.06	0.33	0.67	0.29	0.08

1997 TOTAL **3.77**

Edroy Weather Station - 1997
Rainfall Nitrate Loads (lbs as N / acre)

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
1	0.009	0.000	0.000	0.018	0.000	0.000	0.000	0.018	0.000	0.000	0.005	0.000
2	0.005	0.000	0.000	0.024	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
3	0.000	0.005	0.000	0.028	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
4	0.000	0.005	0.000	0.016	0.000	0.000	0.000	0.000	0.020	0.000	0.000	0.000
5	0.000	0.000	0.000	0.000	0.000	0.000	0.005	0.000	0.000	0.000	0.000	0.000
6	0.000	0.009	0.000	0.000	0.000	0.022	0.000	0.000	0.000	0.023	0.017	0.000
7	0.009	0.011	0.000	0.007	0.000	0.006	0.000	0.000	0.000	0.005	0.000	0.010
8	0.012	0.000	0.000	0.016	0.000	0.000	0.000	0.000	0.000	0.021	0.000	0.000
9	0.000	0.011	0.000	0.000	0.033	0.007	0.000	0.000	0.000	0.027	0.000	0.000
10	0.000	0.010	0.000	0.005	0.013	0.000	0.000	0.000	0.000	0.043	0.006	0.000
11	0.000	0.009	0.040	0.000	0.000	0.000	0.000	0.000	0.000	0.042	0.028	0.000
12	0.000	0.014	0.007	0.000	0.015	0.000	0.000	0.000	0.000	0.009	0.012	0.000
13	0.000	0.000	0.005	0.000	0.000	0.000	0.000	0.000	0.000	0.040	0.014	0.000
14	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
15	0.000	0.000	0.000	0.000	0.024	0.007	0.000	0.000	0.000	0.000	0.011	0.000
16	0.000	0.000	0.019	0.000	0.023	0.000	0.000	0.000	0.000	0.000	0.000	0.000
17	0.000	0.000	0.015	0.000	0.027	0.030	0.000	0.000	0.000	0.000	0.007	0.000
18	0.000	0.000	0.024	0.019	0.000	0.000	0.000	0.000	0.012	0.000	0.013	0.000
19	0.016	0.009	0.000	0.000	0.000	0.008	0.000	0.000	0.000	0.000	0.000	0.000
20	0.015	0.015	0.000	0.006	0.024	0.000	0.000	0.000	0.017	0.000	0.000	0.009
21	0.007	0.000	0.000	0.000	0.000	0.044	0.000	0.000	0.028	0.000	0.000	0.012
22	0.000	0.000	0.000	0.000	0.021	0.036	0.000	0.000	0.018	0.000	0.000	0.000
23	0.000	0.007	0.005	0.000	0.009	0.006	0.000	0.000	0.024	0.000	0.000	0.000
24	0.000	0.013	0.000	0.000	0.005	0.005	0.000	0.005	0.005	0.000	0.000	0.000
25	0.000	0.009	0.018	0.009	0.000	0.006	0.000	0.000	0.000	0.000	0.000	0.000
26	0.000	0.005	0.005	0.005	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.005
27	0.000	0.000	0.000	0.012	0.011	0.000	0.000	0.000	0.000	0.005	0.000	0.000
28	0.000	0.000	0.000	0.000	0.006	0.000	0.000	0.000	0.000	0.009	0.005	0.000
29	0.000	0.000	0.005	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
30	0.000	--	0.007	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
31	0.000	--	0.008	--	0.000	--	0.000	0.000	--	0.005	--	0.000
TOTALS	0.07	0.13	0.16	0.17	0.21	0.18	0.00	0.02	0.12	0.23	0.12	0.04

1997 TOTAL **1.45**

Edroy Weather Station - 1997
Rainfall Ammonia Loads (lbs as N / acre)

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
1	0.013	0.000	0.000	0.025	0.000	0.000	0.000	0.025	0.000	0.000	0.007	0.000
2	0.007	0.000	0.000	0.033	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
3	0.000	0.007	0.000	0.038	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
4	0.000	0.007	0.000	0.022	0.000	0.000	0.000	0.000	0.027	0.000	0.000	0.000
5	0.000	0.000	0.000	0.000	0.000	0.000	0.007	0.000	0.000	0.000	0.000	0.000
6	0.000	0.014	0.000	0.000	0.000	0.030	0.000	0.000	0.000	0.031	0.024	0.000
7	0.013	0.016	0.000	0.011	0.000	0.009	0.000	0.000	0.000	0.007	0.000	0.015
8	0.018	0.000	0.000	0.022	0.000	0.000	0.000	0.000	0.000	0.029	0.000	0.000
9	0.000	0.015	0.000	0.000	0.043	0.011	0.000	0.000	0.000	0.036	0.000	0.000
10	0.000	0.015	0.000	0.007	0.018	0.000	0.000	0.000	0.000	0.056	0.009	0.000
11	0.000	0.013	0.052	0.000	0.000	0.000	0.000	0.000	0.000	0.055	0.038	0.000
12	0.000	0.020	0.011	0.000	0.021	0.000	0.000	0.000	0.000	0.014	0.017	0.000
13	0.000	0.000	0.007	0.000	0.000	0.000	0.000	0.000	0.000	0.053	0.020	0.000
14	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
15	0.000	0.000	0.000	0.000	0.032	0.011	0.000	0.000	0.000	0.000	0.016	0.000
16	0.000	0.000	0.027	0.000	0.031	0.000	0.000	0.000	0.000	0.000	0.000	0.000
17	0.000	0.000	0.021	0.000	0.036	0.040	0.000	0.000	0.000	0.000	0.011	0.000
18	0.000	0.000	0.033	0.027	0.000	0.000	0.000	0.000	0.017	0.000	0.019	0.000
19	0.023	0.014	0.000	0.000	0.000	0.012	0.000	0.000	0.000	0.000	0.000	0.000
20	0.021	0.021	0.000	0.009	0.032	0.000	0.000	0.000	0.024	0.000	0.000	0.014
21	0.011	0.000	0.000	0.000	0.000	0.057	0.000	0.000	0.038	0.000	0.000	0.017
22	0.000	0.000	0.000	0.000	0.029	0.047	0.000	0.000	0.025	0.000	0.000	0.000
23	0.000	0.011	0.007	0.000	0.013	0.009	0.000	0.000	0.033	0.000	0.000	0.000
24	0.000	0.019	0.000	0.000	0.007	0.007	0.000	0.007	0.007	0.000	0.000	0.000
25	0.000	0.013	0.025	0.014	0.000	0.009	0.000	0.000	0.000	0.000	0.000	0.000
26	0.000	0.007	0.007	0.007	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.007
27	0.000	0.000	0.000	0.018	0.015	0.000	0.000	0.000	0.000	0.007	0.000	0.000
28	0.000	0.000	0.000	0.000	0.009	0.000	0.000	0.000	0.000	0.013	0.007	0.000
29	0.000	0.000	0.007	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
30	0.000	--	0.011	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
31	0.000	--	0.012	--	0.000	--	0.000	0.000	--	0.007	--	0.000
TOTALS	0.10	0.19	0.22	0.23	0.29	0.24	0.01	0.03	0.17	0.31	0.17	0.05

1997 TOTAL **2.01**

Edroy Weather Station - 1997
Rainfall Total Phosphorus Loads (lbs as P / acre)

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
1	0.001	0.000	0.000	0.003	0.000	0.000	0.000	0.003	0.000	0.000	0.000	0.000
2	0.000	0.000	0.000	0.007	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
3	0.000	0.000	0.000	0.010	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
4	0.000	0.000	0.000	0.002	0.000	0.000	0.000	0.000	0.004	0.000	0.000	0.000
5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
6	0.000	0.001	0.000	0.000	0.000	0.005	0.000	0.000	0.000	0.006	0.003	0.000
7	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001
8	0.001	0.000	0.000	0.002	0.000	0.000	0.000	0.000	0.000	0.005	0.000	0.000
9	0.000	0.001	0.000	0.000	0.015	0.000	0.000	0.000	0.000	0.009	0.000	0.000
10	0.000	0.001	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.029	0.000	0.000
11	0.000	0.001	0.024	0.000	0.000	0.000	0.000	0.000	0.000	0.028	0.010	0.000
12	0.000	0.002	0.000	0.000	0.002	0.000	0.000	0.000	0.000	0.001	0.001	0.000
13	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.024	0.002	0.000
14	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
15	0.000	0.000	0.000	0.000	0.007	0.000	0.000	0.000	0.000	0.000	0.001	0.000
16	0.000	0.000	0.004	0.000	0.006	0.000	0.000	0.000	0.000	0.000	0.000	0.000
17	0.000	0.000	0.002	0.000	0.009	0.012	0.000	0.000	0.000	0.000	0.000	0.000
18	0.000	0.000	0.007	0.004	0.000	0.000	0.000	0.000	0.001	0.000	0.002	0.000
19	0.003	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
20	0.002	0.002	0.000	0.000	0.007	0.000	0.000	0.000	0.003	0.000	0.000	0.001
21	0.000	0.000	0.000	0.000	0.000	0.030	0.000	0.000	0.010	0.000	0.000	0.001
22	0.000	0.000	0.000	0.000	0.005	0.018	0.000	0.000	0.003	0.000	0.000	0.000
23	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.007	0.000	0.000	0.000
24	0.000	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
25	0.000	0.001	0.003	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
26	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
27	0.000	0.000	0.000	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000
28	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000
29	0.000	--	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
30	0.000	--	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
31	0.000	--	0.000	--	0.000	--	0.000	0.000	--	0.000	--	0.000
TOTALS	0.007	0.011	0.041	0.031	0.053	0.068	0.000	0.003	0.028	0.103	0.019	0.003
1997 TOTAL		**0.368**										

Edroy Weather Station - 1997
Rainfall Ortho-Phosphate Loads (lbs as P / acre)

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
1	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000
2	0.000	0.000	0.000	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
3	0.000	0.000	0.000	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
4	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000
5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
6	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.001	0.001	0.000
7	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001
8	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000
9	0.000	0.000	0.000	0.000	0.004	0.000	0.000	0.000	0.000	0.002	0.000	0.000
10	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.007	0.000	0.000
11	0.000	0.000	0.006	0.000	0.000	0.000	0.000	0.000	0.000	0.007	0.002	0.000
12	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
13	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.006	0.000	0.000
14	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
15	0.000	0.000	0.000	0.000	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000
16	0.000	0.000	0.001	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000
17	0.000	0.000	0.001	0.000	0.002	0.003	0.000	0.000	0.000	0.000	0.000	0.000
18	0.000	0.000	0.002	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
19	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
20	0.001	0.001	0.000	0.000	0.002	0.000	0.000	0.000	0.001	0.000	0.000	0.001
21	0.000	0.000	0.000	0.000	0.000	0.008	0.000	0.000	0.003	0.000	0.000	0.001
22	0.000	0.000	0.000	0.000	0.001	0.005	0.000	0.000	0.001	0.000	0.000	0.000
23	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.000	0.000	0.000
24	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
25	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
26	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
27	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
28	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
29	0.000	--	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
30	0.000	--	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
31	0.000	--	0.000	--	0.000	--	0.000	0.000	--	0.000	--	0.000
TOTALS	0.002	0.003	0.010	0.008	0.013	0.017	0.000	0.001	0.007	0.026	0.005	0.003

1997 TOTAL **0.094**

Edroy Weather Station
Daily Rainfall - 1998

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
1	0.0	0.47	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.07	0.03
2	0.21	0.0	0.01	0.0	0.0	0.0	0.0	0.0	0.0	0.24	0.0	0.01
3	0.0	0.0	0.0	0.0	0.0	0.0	1.14	0.0	0.0	0.0	0.0	0.0
4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.30	0.0
6	0.06	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.65	0.22	0.0
7	0.0	0.0	0.01	0.0	0.0	0.0	0.0	2.70	0.0	0.0	0.30	0.93
8	0.0	0.0	0.07	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.11	0.0	0.0	0.04
10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.59	0.0	0.0	0.20
11	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.39	0.0	0.0	0.35
12	0.0	0.23	0.14	0.0	0.0	0.0	0.0	0.0	0.23	0.0	0.17	0.0
13	0.08	0.01	0.82	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.07	0.0
14	0.0	1.63	0.11	0.0	0.0	0.0	0.0	1.99	0.0	0.0	1.37	0.0
15	0.0	0.0	0.08	0.0	0.0	0.15	0.0	0.0	0.03	0.0	0.0	0.0
16	0.0	0.03	0.58	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
17	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.52	0.08	0.53	0.0	0.0
18	0.0	0.0	0.0	0.32	0.0	0.0	0.0	0.0	0.0	4.97	0.0	0.0
19	0.0	0.59	0.01	0.01	0.0	0.0	0.0	0.09	0.0	1.60	0.0	0.01
20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.52	0.0	0.0	0.01	0.0
21	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.93	0.0	0.0	0.0	0.0
22	0.10	0.32	0.0	0.0	0.0	0.0	0.0	0.14	0.05	0.0	0.0	0.11
23	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.14	0.40	0.0	0.0	0.01
24	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.01
25	0.0	0.01	0.0	0.0	0.0	0.0	0.0	0.0	0.01	0.27	0.0	0.0
26	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.04	0.01	0.0
27	0.0	0.03	0.0	0.11	0.0	0.0	0.0	0.0	0.01	0.03	0.01	0.0
28	0.0	0.0	0.0	0.0	0.0	0.04	0.0	0.0	0.0	0.0	0.0	0.0
29	0.0	--	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
30	0.0	--	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
31	0.01	--	0.0	--	0.0	--	0.0	0.0	--	0.0	--	0.0
TOTALS	0.46	3.32	1.83	0.44	0.00	0.19	1.14	7.03	2.90	10.33	2.53	1.70

1998 TOTAL **31.87**

Edroy Weather Station - 1998
Rainfall Total Nitrogen Loads (lbs as N / acre)

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
1	0.000	0.058	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.023	0.015
2	0.039	0.000	0.009	0.000	0.000	0.000	0.000	0.000	0.000	0.042	0.000	0.009
3	0.000	0.000	0.000	0.000	0.000	0.000	0.091	0.000	0.000	0.000	0.000	0.000
4	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.047	0.000
6	0.021	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.138	0.040	0.000
7	0.000	0.000	0.009	0.000	0.000	0.000	0.000	0.140	0.000	0.000	0.047	0.082
8	0.000	0.000	0.023	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
9	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.028	0.000	0.000	0.017
10	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.065	0.000	0.000	0.038
11	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.100	0.000	0.000	0.050
12	0.000	0.041	0.032	0.000	0.000	0.000	0.000	0.000	0.041	0.000	0.035	0.000
13	0.024	0.009	0.077	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.023	0.000
14	0.000	0.108	0.028	0.000	0.000	0.000	0.000	0.120	0.000	0.000	0.099	0.000
15	0.000	0.000	0.024	0.000	0.000	0.033	0.000	0.000	0.015	0.000	0.000	0.000
16	0.000	0.015	0.065	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
17	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.061	0.024	0.062	0.000	0.000
18	0.000	0.000	0.000	0.048	0.000	0.000	0.000	0.000	0.000	0.189	0.000	0.000
19	0.000	0.065	0.009	0.009	0.000	0.000	0.000	0.026	0.000	0.107	0.000	0.009
20	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.061	0.000	0.000	0.009	0.000
21	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.082	0.000	0.000	0.000	0.000
22	0.027	0.048	0.000	0.000	0.000	0.000	0.000	0.032	0.019	0.000	0.000	0.028
23	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.032	0.054	0.000	0.000	0.009
24	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.009
25	0.000	0.009	0.000	0.000	0.000	0.000	0.000	0.000	0.009	0.044	0.000	0.000
26	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.017	0.009	0.000
27	0.000	0.015	0.000	0.028	0.000	0.000	0.000	0.000	0.009	0.015	0.009	0.000
28	0.000	0.000	0.000	0.000	0.000	0.017	0.000	0.000	0.000	0.000	0.000	0.000
29	0.000	--	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
30	0.000	--	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
31	0.009	--	0.000	--	0.000	--	0.000	0.000	--	0.000	--	0.000
TOTALS	0.12	0.37	0.27	0.08	0.00	0.05	0.09	0.55	0.36	0.61	0.34	0.26

1998 TOTAL **3.12**

Edroy Weather Station - 1998
Rainfall Nitrate Loads (lbs as N / acre)

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
1	0.000	0.021	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.010	0.007
2	0.016	0.000	0.005	0.000	0.000	0.000	0.000	0.000	0.000	0.016	0.000	0.005
3	0.000	0.000	0.000	0.000	0.000	0.000	0.031	0.000	0.000	0.000	0.000	0.000
4	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.018	0.000
6	0.009	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.043	0.016	0.000
7	0.000	0.000	0.005	0.000	0.000	0.000	0.000	0.043	0.000	0.000	0.018	0.028
8	0.000	0.000	0.010	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
9	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.012	0.000	0.000	0.008
10	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.024	0.000	0.000	0.015
11	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.033	0.000	0.000	0.019
12	0.000	0.016	0.013	0.000	0.000	0.000	0.000	0.000	0.016	0.000	0.014	0.000
13	0.011	0.005	0.027	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.010	0.000
14	0.000	0.035	0.012	0.000	0.000	0.000	0.000	0.038	0.000	0.000	0.033	0.000
15	0.000	0.000	0.011	0.000	0.000	0.014	0.000	0.000	0.007	0.000	0.000	0.000
16	0.000	0.007	0.023	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
17	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.022	0.011	0.023	0.000	0.000
18	0.000	0.000	0.000	0.018	0.000	0.000	0.000	0.000	0.000	0.055	0.000	0.000
19	0.000	0.024	0.005	0.005	0.000	0.000	0.000	0.011	0.000	0.035	0.000	0.005
20	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.022	0.000	0.000	0.005	0.000
21	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.028	0.000	0.000	0.000	0.000
22	0.012	0.018	0.000	0.000	0.000	0.000	0.000	0.013	0.009	0.000	0.000	0.012
23	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.013	0.020	0.000	0.000	0.005
24	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.005
25	0.000	0.005	0.000	0.000	0.000	0.000	0.000	0.000	0.005	0.017	0.000	0.000
26	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.008	0.005	0.000
27	0.000	0.007	0.000	0.012	0.000	0.000	0.000	0.000	0.005	0.007	0.005	0.000
28	0.000	0.000	0.000	0.000	0.000	0.008	0.000	0.000	0.000	0.000	0.000	0.000
29	0.000	--	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
30	0.000	--	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
31	0.005	--	0.000	--	0.000	--	0.000	0.000	--	0.000	--	0.000
TOTALS	0.05	0.14	0.11	0.04	0.00	0.02	0.03	0.19	0.14	0.20	0.13	0.11
1998 TOTAL		**1.17**										

Edroy Weather Station - 1998
Rainfall Ammonia Loads (lbs as N / acre)

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
1	0.000	0.029	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.015	0.011
2	0.022	0.000	0.007	0.000	0.000	0.000	0.000	0.000	0.000	0.023	0.000	0.007
3	0.000	0.000	0.000	0.000	0.000	0.000	0.041	0.000	0.000	0.000	0.000	0.000
4	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.025	0.000
6	0.014	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.056	0.022	0.000
7	0.000	0.000	0.007	0.000	0.000	0.000	0.000	0.056	0.000	0.000	0.025	0.038
8	0.000	0.000	0.015	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
9	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.017	0.000	0.000	0.012
10	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.032	0.000	0.000	0.021
11	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.044	0.000	0.000	0.026
12	0.000	0.023	0.019	0.000	0.000	0.000	0.000	0.000	0.023	0.000	0.020	0.000
13	0.015	0.007	0.036	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.015	0.000
14	0.000	0.047	0.017	0.000	0.000	0.000	0.000	0.050	0.000	0.000	0.044	0.000
15	0.000	0.000	0.015	0.000	0.000	0.019	0.000	0.000	0.011	0.000	0.000	0.000
16	0.000	0.011	0.032	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
17	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.031	0.015	0.031	0.000	0.000
18	0.000	0.000	0.000	0.026	0.000	0.000	0.000	0.000	0.000	0.071	0.000	0.000
19	0.000	0.032	0.007	0.007	0.000	0.000	0.000	0.016	0.000	0.046	0.000	0.007
20	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.031	0.000	0.000	0.007	0.000
21	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.038	0.000	0.000	0.000	0.000
22	0.017	0.026	0.000	0.000	0.000	0.000	0.000	0.019	0.013	0.000	0.000	0.017
23	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.019	0.028	0.000	0.000	0.007
24	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.007
25	0.000	0.007	0.000	0.000	0.000	0.000	0.000	0.000	0.007	0.024	0.000	0.000
26	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.012	0.007	0.000
27	0.000	0.011	0.000	0.017	0.000	0.000	0.000	0.000	0.007	0.011	0.007	0.000
28	0.000	0.000	0.000	0.000	0.000	0.012	0.000	0.000	0.000	0.000	0.000	0.000
29	0.000	--	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
30	0.000	--	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
31	0.007	--	0.000	--	0.000	--	0.000	0.000	--	0.000	--	0.000
TOTALS	0.07	0.19	0.15	0.05	0.00	0.03	0.04	0.26	0.20	0.27	0.19	0.15
1998 TOTAL		**1.61**										

Edroy Weather Station - 1998
Rainfall Total Phosphorus Loads (lbs as P / acre)

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
1	0.000	0.005	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000
2	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.003	0.000	0.000
3	0.000	0.000	0.000	0.000	0.000	0.000	0.012	0.000	0.000	0.000	0.000	0.000
4	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.003	0.000
6	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.029	0.002	0.000
7	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.029	0.000	0.000	0.003	0.010
8	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
9	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000
10	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.006	0.000	0.000	0.002
11	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.015	0.000	0.000	0.004
12	0.000	0.003	0.002	0.000	0.000	0.000	0.000	0.000	0.003	0.000	0.002	0.000
13	0.001	0.000	0.009	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000
14	0.000	0.018	0.001	0.000	0.000	0.000	0.000	0.022	0.000	0.000	0.015	0.000
15	0.000	0.000	0.001	0.000	0.000	0.002	0.000	0.000	0.000	0.000	0.000	0.000
16	0.000	0.000	0.006	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
17	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.006	0.001	0.006	0.000	0.000
18	0.000	0.000	0.000	0.003	0.000	0.000	0.000	0.000	0.000	0.054	0.000	0.000
19	0.000	0.006	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.017	0.000	0.000
20	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.006	0.000	0.000	0.000	0.000
21	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.010	0.000	0.000	0.000	0.000
22	0.001	0.003	0.000	0.000	0.000	0.000	0.000	0.002	0.001	0.000	0.000	0.001
23	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.004	0.000	0.000	0.000
24	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
25	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.003	0.000	0.000
26	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
27	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
28	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
29	0.000	--	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
30	0.000	--	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
31	0.000	--	0.000	--	0.000	--	0.000	0.000	--	0.000	--	0.000
TOTALS	0.005	0.036	0.020	0.005	0.000	0.002	0.012	0.076	0.032	0.112	0.028	0.018

1998 TOTAL **0.347**

Edroy Weather Station - 1998
Rainfall Ortho-Phosphorus Loads (lbs as P / acre)

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
1	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000
3	0.000	0.000	0.000	0.000	0.000	0.000	0.003	0.000	0.000	0.000	0.000	0.000
4	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000
6	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.007	0.001	0.000
7	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.007	0.000	0.000	0.001	0.003
8	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
9	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
10	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.000	0.000	0.001
11	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.004	0.000	0.000	0.001
12	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000
13	0.000	0.000	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
14	0.000	0.004	0.000	0.000	0.000	0.000	0.000	0.005	0.000	0.000	0.004	0.000
15	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
16	0.000	0.000	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
17	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.001	0.000	0.000
18	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.014	0.000	0.000
19	0.000	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.004	0.000	0.000
20	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000
21	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.003	0.000	0.000	0.000	0.000
22	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
23	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000
24	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
25	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000
26	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
27	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
28	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
29	0.000	--	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
30	0.000	--	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
31	0.000	--	0.000	--	0.000	--	0.000	0.000	--	0.000	--	0.000
TOTALS	0.001	0.009	0.005	0.001	0.000	0.001	0.003	0.019	0.008	0.028	0.007	0.005

1998 TOTAL **0.087**

Edroy Weather Station
Daily Rainfall - 1999

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
1	0.02	0.00	0.00	0.00	0.00	0.00						
2	0.41	0.00	0.00	0.01	0.00	0.00						
3	0.00	0.00	0.00	0.00	0.00	0.00						
4	0.00	0.00	0.00	0.02	0.00	0.00						
5	0.00	0.00	0.00	0.00	0.00	0.00						
6	0.00	0.00	0.00	0.00	0.00	0.00						
7	0.00	0.00	0.02	0.00	0.00	0.00						
8	0.00	0.00	0.00	0.00	0.00	0.00						
9	0.00	0.00	0.00	0.00	0.00	0.00						
10	0.00	0.00	0.00	0.00	0.06	0.00						
11	0.00	0.20	0.00	0.00	0.00	0.00						
12	0.00	0.00	0.00	0.00	0.22	0.00						
13	0.05	0.00	0.02	0.00	0.00	0.08						
14	0.01	0.00	0.00	0.00	0.00	0.63						
15	0.00	0.00	0.00	0.00	0.00	0.38						
16	0.00	0.06	0.00	0.00	0.00	0.03						
17	0.00	0.20	0.00	0.00	0.00	0.00						
18	0.00	0.00	0.02	0.00	0.65	0.00						
19	0.01	0.00	0.28	0.00	0.00	1.23						
20	0.00	0.00	0.00	0.00	0.00	0.48						
21	0.00	0.00	0.00	0.00	0.00	0.16						
22	0.00	0.00	0.00	0.00	0.00							
23	0.00	0.00	0.00	0.00	0.00							
24	0.00	0.01	0.00	0.00	0.00							
25	0.00	0.00	0.13	0.00	0.00							
26	0.00	0.01	0.00	1.34	0.06							
27	0.00	0.00	0.04	0.01	0.03							
28	0.00	0.00	2.31	0.00	0.00							
29	0.01	--	0.00	0.00	0.01							
30	0.00	--	0.00	0.00	0.00							
31	0.00	--	0.00	--	0.00							
TOTALS	0.51	0.48	2.82	1.38	1.03	2.99						

1999 TOTAL **9.21**

Edroy Weather Station - 1999
Rainfall Total Nitrogen Loads (lbs as N / acre)

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
1	0.012	0.000	0.000	0.000	0.000	0.000						
2	0.054	0.000	0.000	0.009	0.000	0.000						
3	0.000	0.000	0.000	0.000	0.000	0.000						
4	0.000	0.000	0.000	0.012	0.000	0.000						
5	0.000	0.000	0.000	0.000	0.000	0.000						
6	0.000	0.000	0.000	0.000	0.000	0.000						
7	0.000	0.000	0.012	0.000	0.000	0.000						
8	0.000	0.000	0.000	0.000	0.000	0.000						
9	0.000	0.000	0.000	0.000	0.000	0.000						
10	0.000	0.000	0.000	0.000	0.021	0.000						
11	0.000	0.038	0.000	0.000	0.000	0.000						
12	0.000	0.000	0.000	0.000	0.040	0.000						
13	0.019	0.000	0.012	0.000	0.000	0.024						
14	0.009	0.000	0.000	0.000	0.000	0.067						
15	0.000	0.000	0.000	0.000	0.000	0.052						
16	0.000	0.021	0.000	0.000	0.000	0.015						
17	0.000	0.038	0.000	0.000	0.000	0.000						
18	0.000	0.000	0.012	0.000	0.069	0.000						
19	0.009	0.000	0.045	0.000	0.000	0.094						
20	0.000	0.000	0.000	0.000	0.000	0.059						
21	0.000	0.000	0.000	0.000	0.000	0.034						
22	0.000	0.000	0.000	0.000	0.000							
23	0.000	0.000	0.000	0.000	0.000							
24	0.000	0.009	0.000	0.000	0.000							
25	0.000	0.000	0.031	0.000	0.000							
26	0.000	0.009	0.000	0.098	0.021							
27	0.000	0.000	0.017	0.009	0.015							
28	0.000	0.000	0.129	0.000	0.000							
29	0.009	--	0.000	0.000	0.009							
30	0.000	--	0.000	0.000	0.000							
31	0.000	--	0.000	--	0.000							
TOTALS	0.11	0.11	0.26	0.13	0.17	0.35						

1999 TOTAL **1.13**

Edroy Weather Station - 1999
Rainfall Nitrate Loads (lbs as N / acre)

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
1	0.006	0.000	0.000	0.000	0.000	0.000						
2	0.020	0.000	0.000	0.005	0.000	0.000						
3	0.000	0.000	0.000	0.000	0.000	0.000						
4	0.000	0.000	0.000	0.006	0.000	0.000						
5	0.000	0.000	0.000	0.000	0.000	0.000						
6	0.000	0.000	0.000	0.000	0.000	0.000						
7	0.000	0.000	0.006	0.000	0.000	0.000						
8	0.000	0.000	0.000	0.000	0.000	0.000						
9	0.000	0.000	0.000	0.000	0.000	0.000						
10	0.000	0.000	0.000	0.000	0.009	0.000						
11	0.000	0.015	0.000	0.000	0.000	0.000						
12	0.000	0.000	0.000	0.000	0.016	0.000						
13	0.009	0.000	0.006	0.000	0.000	0.011						
14	0.005	0.000	0.000	0.000	0.000	0.024						
15	0.000	0.000	0.000	0.000	0.000	0.020						
16	0.000	0.009	0.000	0.000	0.000	0.007						
17	0.000	0.015	0.000	0.000	0.000	0.000						
18	0.000	0.000	0.006	0.000	0.024	0.000						
19	0.005	0.000	0.017	0.000	0.000	0.031						
20	0.000	0.000	0.000	0.000	0.000	0.022						
21	0.000	0.000	0.000	0.000	0.000	0.014						
22	0.000	0.000	0.000	0.000	0.000							
23	0.000	0.000	0.000	0.000	0.000							
24	0.000	0.005	0.000	0.000	0.000							
25	0.000	0.000	0.013	0.000	0.000							
26	0.000	0.005	0.000	0.033	0.009							
27	0.000	0.000	0.008	0.005	0.007							
28	0.000	0.000	0.040	0.000	0.000							
29	0.005	--	0.000	0.000	0.005							
30	0.000	--	0.000	0.000	0.000							
31	0.000	--	0.000	--	0.000							
TOTALS	0.05	0.05	0.10	0.05	0.07	0.13						

1999 TOTAL **0.44**

Edroy Weather Station - 1999
Rainfall Ammonia Loads (lbs as N / acre)

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
1	0.009	0.000	0.000	0.000	0.000	0.000						
2	0.028	0.000	0.000	0.007	0.000	0.000						
3	0.000	0.000	0.000	0.000	0.000	0.000						
4	0.000	0.000	0.000	0.009	0.000	0.000						
5	0.000	0.000	0.000	0.000	0.000	0.000						
6	0.000	0.000	0.000	0.000	0.000	0.000						
7	0.000	0.000	0.009	0.000	0.000	0.000						
8	0.000	0.000	0.000	0.000	0.000	0.000						
9	0.000	0.000	0.000	0.000	0.000	0.000						
10	0.000	0.000	0.000	0.000	0.014	0.000						
11	0.000	0.021	0.000	0.000	0.000	0.000						
12	0.000	0.000	0.000	0.000	0.022	0.000						
13	0.013	0.000	0.009	0.000	0.000	0.015						
14	0.007	0.000	0.000	0.000	0.000	0.033						
15	0.000	0.000	0.000	0.000	0.000	0.027						
16	0.000	0.014	0.000	0.000	0.000	0.011						
17	0.000	0.021	0.000	0.000	0.000	0.000						
18	0.000	0.000	0.009	0.000	0.033	0.000						
19	0.007	0.000	0.024	0.000	0.000	0.042						
20	0.000	0.000	0.000	0.000	0.000	0.030						
21	0.000	0.000	0.000	0.000	0.000	0.020						
22	0.000	0.000	0.000	0.000	0.000							
23	0.000	0.000	0.000	0.000	0.000							
24	0.000	0.007	0.000	0.000	0.000							
25	0.000	0.000	0.018	0.000	0.000							
26	0.000	0.007	0.000	0.043	0.014							
27	0.000	0.000	0.012	0.007	0.011							
28	0.000	0.000	0.053	0.000	0.000							
29	0.007	--	0.000	0.000	0.007							
30	0.000	--	0.000	0.000	0.000							
31	0.000	--	0.000	--	0.000							
TOTALS	0.07	0.07	0.13	0.07	0.10	0.18						

1999 TOTAL **0.62**

Edroy Weather Station - 1999
Rainfall Total Phosphorus Loads (lbs as P / acre)

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
1	0.000	0.000	0.000	0.000	0.000	0.000						
2	0.004	0.000	0.000	0.000	0.000	0.000						
3	0.000	0.000	0.000	0.000	0.000	0.000						
4	0.000	0.000	0.000	0.000	0.000	0.000						
5	0.000	0.000	0.000	0.000	0.000	0.000						
6	0.000	0.000	0.000	0.000	0.000	0.000						
7	0.000	0.000	0.000	0.000	0.000	0.000						
8	0.000	0.000	0.000	0.000	0.000	0.000						
9	0.000	0.000	0.000	0.000	0.000	0.000						
10	0.000	0.000	0.000	0.000	0.001	0.000						
11	0.000	0.002	0.000	0.000	0.000	0.000						
12	0.000	0.000	0.000	0.000	0.002	0.000						
13	0.001	0.000	0.000	0.000	0.000	0.001						
14	0.000	0.000	0.000	0.000	0.000	0.007						
15	0.000	0.000	0.000	0.000	0.000	0.004						
16	0.000	0.001	0.000	0.000	0.000	0.000						
17	0.000	0.002	0.000	0.000	0.000	0.000						
18	0.000	0.000	0.000	0.000	0.007	0.000						
19	0.000	0.000	0.003	0.000	0.000	0.013						
20	0.000	0.000	0.000	0.000	0.000	0.005						
21	0.000	0.000	0.000	0.000	0.000	0.002						
22	0.000	0.000	0.000	0.000	0.000	0.000						
23	0.000	0.000	0.000	0.000	0.000	0.000						
24	0.000	0.000	0.000	0.000	0.000	0.000						
25	0.000	0.000	0.001	0.000	0.000	0.000						
26	0.000	0.000	0.000	0.015	0.001	0.000						
27	0.000	0.000	0.000	0.000	0.000	0.000						
28	0.000	0.000	0.025	0.000	0.000	0.000						
29	0.000	--	0.000	0.000	0.000	0.000						
30	0.000	--	0.000	0.000	0.000	0.000						
31	0.000	--	0.000	--	0.000	--						
TOTALS	0.006	0.005	0.031	0.015	0.011	0.033						

1999 TOTAL **0.100**

Edroy Weather Station - 1999
Rainfall Ortho-Phosphorus Loads (lbs as P / acre)

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
1	0.000	0.000	0.000	0.000	0.000	0.000						
2	0.001	0.000	0.000	0.000	0.000	0.000						
3	0.000	0.000	0.000	0.000	0.000	0.000						
4	0.000	0.000	0.000	0.000	0.000	0.000						
5	0.000	0.000	0.000	0.000	0.000	0.000						
6	0.000	0.000	0.000	0.000	0.000	0.000						
7	0.000	0.000	0.000	0.000	0.000	0.000						
8	0.000	0.000	0.000	0.000	0.000	0.000						
9	0.000	0.000	0.000	0.000	0.000	0.000						
10	0.000	0.000	0.000	0.000	0.000	0.000						
11	0.000	0.001	0.000	0.000	0.000	0.000						
12	0.000	0.000	0.000	0.000	0.001	0.000						
13	0.000	0.000	0.000	0.000	0.000	0.000						
14	0.000	0.000	0.000	0.000	0.000	0.002						
15	0.000	0.000	0.000	0.000	0.000	0.001						
16	0.000	0.000	0.000	0.000	0.000	0.000						
17	0.000	0.001	0.000	0.000	0.000	0.000						
18	0.000	0.000	0.000	0.000	0.002	0.000						
19	0.000	0.000	0.001	0.000	0.000	0.003						
20	0.000	0.000	0.000	0.000	0.000	0.001						
21	0.000	0.000	0.000	0.000	0.000	0.000						
22	0.000	0.000	0.000	0.000	0.000							
23	0.000	0.000	0.000	0.000	0.000							
24	0.000	0.000	0.000	0.000	0.000							
25	0.000	0.000	0.000	0.000	0.000							
26	0.000	0.000	0.000	0.004	0.000							
27	0.000	0.000	0.000	0.000	0.000							
28	0.000	0.000	0.006	0.000	0.000							
29	0.000	--	0.000	0.000	0.000							
30	0.000	--	0.000	0.000	0.000							
31	0.000	--	0.000	--	0.000							
TOTALS	0.001	0.001	0.008	0.004	0.003	0.008						

1999 TOTAL **0.025**

Appendix C

Water Quality Characteristics of Runoff

Appendix C. Table 1. Monthly and Annual Runoff Loads of Selected Nutrients, 1996-1999
[loads in pounds; N, nitrogen]

1996

Constituent	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Nitrogen, total	0	0	0	0	0	291	0	162	0	0	0	0	449
Ammonia plus organic N, total	0	0	0	0	0	143	0	102	0	0	0	0	245
Ammonia nitrogen, dissolved	0	0	0	0	0	16	0	5	0	0	0	0	21
Nitrite plus nitrate N, dissolved	0	0	0	0	0	114	0	56	0	0	0	0	170
Total phosphorus	0	0	0	0	0	54	0	52	0	0	0	0	106
Orthophosphorus, dissolved	0	0	0	0	0	33	0	39	0	0	0	0	72

1997

Constituent	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Nitrogen, total	0	0	0	0	0	68	0	0	0	1,784	0	0	1,852
Ammonia plus organic N, total	0	0	0	0	0	42	0	0	0	1,058	0	0	1,700
Ammonia nitrogen, dissolved	0	0	0	0	0	1	0	0	0	38	0	0	39
Nitrite plus nitrate N, dissolved	0	0	0	0	0	28	0	0	0	727	0	0	755
Total phosphorus	0	0	0	0	0	17	0	0	0	392	0	0	409
Orthophosphorus, dissolved	0	0	0	0	0	12	0	0	0	184	0	0	201

1998

Constituent	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Nitrogen, total	0	0	0	0	0	0	0	0	0	2,221	0	0	2,221
Ammonia plus organic N, total	0	0	0	0	0	0	0	0	0	2,021	0	0	2,021
Ammonia nitrogen, dissolved	0	0	0	0	0	0	0	0	0	80	0	0	80
Nitrite plus nitrate N, dissolved	0	0	0	0	0	0	0	0	0	289	0	0	289
Total phosphorus	0	0	0	0	0	0	0	0	0	726	0	0	726
Orthophosphorus, dissolved	0	0	0	0	0	0	0	0	0	143	0	0	143

1999

Constituent	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Nitrogen, total	0	0	47	0	0								
Ammonia plus organic N, total	0	0	35	0	0								
Ammonia nitrogen, dissolved	0	0	4	0	0								
Nitrite plus nitrate N, dissolved	0	0	14	0	0								
Total phosphorus	0	0	14	0	0								
Orthophosphorus, dissolved	0	0	5	0	0								

Appendix C. Table 2 Monthly and Annual Runoff Loads of Selected Pesticides, 1996 – 1999
[all loads in pounds]

1996

Pesticide	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Atrazine plus deethyl atrazine, dissolved	0	0	0	0	0	0.63	0	0.025	0	0	0	0	0.655
Fluometuron, dissolved	0	0	0	0	0	0.21	0	0.038	0	0	0	0	0.248
Others - Total, dissolved [1]	0	0	0	0	0	0.053	0	0.011	0	0	0	0	0.064

1997

Pesticide	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Atrazine plus deethyl atrazine, dissolved	0	0	0	0	0	0.005	0	0	0	0.167	0	0	0.172
Fluometuron, dissolved	0	0	0	0	0	0	0	0	0	0	0	0	0
Others - Total, dissolved [1]	0	0	0	0	0	0.051	0	0	0	0.05	0	0	0.101

1998

Pesticide	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Atrazine plus deethyl atrazine, dissolved	0	0	0	0	0	0	0	0	0	0.158	0	0	0.158
Fluometuron, dissolved	0	0	0	0	0	0	0	0	0	0.022	0	0	0.022
Others - Total, dissolved [1]	0	0	0	0	0	0	0	0	0	0.070	0	0	0.070

1999

Pesticide	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Atrazine plus deethyl atrazine, dissolved	0	0	0.013	0	0								
Fluometuron, dissolved	0	0	0	0	0								
Others - Total, dissolved [1]	0	0	0	0	0								

[1] Other pesticides consisted primarily of malathion, metolachlor, trifluralin, and pendimethalin in minute quantities.

Appendix C. Table 3. Watershed Runoff-Weighted Concentrations for Selected Nutrients and Pesticides, 1996 – 1999
[units are milligrams per liter for nutrients and micrograms per liter for atrazine]

1996

Constituent	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Nitrogen, total	0	0	0	0	0	1.13	0	1.29	0	0	0	0	1.20
Ammonia plus organic N, total	0	0	0	0	0	0.41	0	0.83	0	0	0	0	0.593
Ammonia nitrogen, dissolved	0	0	0	0	0	0.10	0	0.04	0	0	0	0	0.074
Nitrite plus nitrate nitrogen,	0	0	0	0	0	0.72	0	0.46	0	0	0	0	0.606
Phosphorus, total	0	0	0	0	0	0.34	0	0.42	0	0	0	0	0.375
Ortho-Phosphate, dissolved	0	0	0	0	0	0.25	0	0.32	0	0	0	0	0.28
Atrazine + deethyl atrazine	0	0	0	0	0	3.972	0	0.213	0	0	0	0	2.335

1997

Constituent	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Nitrogen, total	0	0	0	0	0	2.41	0	0	0	0.84	0	0	0.906
Ammonia plus organic N, total	0	0	0	0	0	1.43	0	0	0	1.31	0	0	1.315
Ammonia nitrogen, dissolved	0	0	0	0	0	0.015	0	0	0	0.046	0	0	0.045
Nitrite plus nitrate N, dissolved	0	0	0	0	0	0.98	0	0	0	0.904	0	0	0.907
Phosphorus, total	0	0	0	0	0	0.61	0	0	0	0.548	0	0	0.551
Ortho-Phosphate, dissolved	0	0	0	0	0	0.41	0	0	0	0.32	0	0	0.324
Atrazine + deethyl atrazine	0	0	0	0	0	0.24	0	0	0	0.207	0	0	0.208

1998

Constituent	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Nitrogen, total	0	0	0	0	0	0	0	0	0	1.12	0	0	1.12
Ammonia plus organic N, total	0	0	0	0	0	0	0	0	0	1.157	0	0	0.157
Ammonia nitrogen, dissolved	0	0	0	0	0	0	0	0	0	0.04	0	0	0.04
Nitrite plus nitrate nitrogen,	0	0	0	0	0	0	0	0	0	0.145	0	0	0.145
Phosphorus, total	0	0	0	0	0	0	0	0	0	0.366	0	0	0.366
Ortho-Phosphate, dissolved	0	0	0	0	0	0	0	0	0	0.072	0	0	0.072
Atrazine + deethyl atrazine	0	0	0	0	0	0	0	0	0	0.317	0	0	0.317

Summary of Rainfall and Runoff Loads (see following tables)

Summary of Rainfall and Runoff Loads for Odem Ranch Cropland Watershed - June, 1996 Event

Constituent	Runoff Loads Site 1 (lbs)	Runoff Loads Site 2 (lbs)	Units	Runoff Loads Total (lbs)	Rainfall Loads Total (lbs)
Total Nitrogen	183	108		291	1039
Diss. Org N	19	13		32	130
Total Org N	80	47		127	--
Nitrate +Nitrite	92	22		114	384
Ammonia	11	5		16	523
Total Phos.	38	16		54	35.0
Diss. Phos.	--	--		--	5.3
Ortho Phos.	20	13		33	3.5
Calcium	1401	882		2283	--
Magnesium	110	55		165	--
Potassium	300	212		512	--
Chloride	130	82		212	--
Boron	7.5	3.4		10.9	--
Iron	0.5	0.5		1	--
Atrazine	0.47	0.03		0.5	--
Deethyl Atrazine	0.1	0.03		0.13	--
Fluometeron	0.16	0.05		0.21	--
Others-total	0.034	0.019		0.053	--
Total Pesticides	0.763	0.128		0.891	--

Rainfall Volume = 1415 acre-ft
Runoff Volume = 58.4 acre-ft

Summary of Rainfall and Runoff Loads for Odem Ranch Cropland Watershed - August, 1996

Constituent	Runoff Loads Site 1 (lbs)	Runoff Loads Site 2 (lbs)	Runoff Loads Total (lbs)	Rainfall Loads Total (lbs)
Total Nitrogen	110	48	158	654
Diss. Org N	28	9	37	79
Total Org N	68	29	97	--
Nitrate +Nitrite	38	18	56	236
Ammonia	4	0.6	4.6	340
Total Phos.	40	12	52	5.0
Diss. Phos.	28	6	34	3.5
Ortho Phos.	32	7	39	3.0
Calcium	1740	816	2556	--
Magnesium	144	51	195	--
Potassium	742	218	960	--
Chloride	671	158	829	--
Boron	6	2.4	8.4	--
Iron	0.3	0.1	0.4	--
Atrazine	0.003	0.002	0.005	--
Deethyl Atrazine	0.013	0.007	0.02	--
Fluometeron	0.035	0.003	0.038	--
Malathion	0.001	0.001	0.002	--
Others-total	0.003	0.006	0.009	--
Total Pesticides	0.056	0.019	0.075	--

Rainfall Volume = 962 acre-ft
Runoff Volume = 45.1 acre-ft

Summary of Rainfall and Runoff Loads for Odem Ranch Cropland Watershed - June, 1997 Event

Constituent	Runoff Site 1 (lbs)	Runoff Loads Site 2 (lbs)*	Runoff Loads Total (lbs)	Rainfall Total (lbs)
Total Nitrogen	33	35	68	441
Diss. Org N	6	7	13	12
Total Org N	20	21	41	40
Nitrate +Nitrite	14	14	28	384
Ammonia	0.2	0.3	0.5	523
Total Phos.	8	9	17	35.0
Diss. Phos.	6	7	--	5.3
Ortho Phos.	6	6	12	3.5
Calcium	214	--	--	--
Magnesium	19	--	--	--
Potassium	111	--	--	--
Chloride	50	--	--	--
Boron	1.2	--	--	--
Iron	0.07	--	--	--
Atrazine	0.001	0.001	0.002	--
Desethyl Atrazine	0.002	0.001	0.003	--
Fluometeron	--	--	--	--
Others-total	0.05	0.001	0.051	--
Total Pesticides	0.060	0.003	0.06	--

Rainfall Volume = 705 acre-ft
Runoff Volume = 12.98 acre-ft

* Concentrations from site 2 were estimated from site 1 results and previous sampled Site 2 events to

Summary of Rainfall and Runoff Loads for Odem Ranch Cropland Watershed - October, 1997 Event

Constituent	Runoff Site 1 (lbs)	Runoff Site 2 (lbs)	Runoff Loads Total (lbs)	Rainfall Loads Total (lbs)
Total Nitrogen	1230	554	1784	1395
Diss. Org N	285	135	420	--
Total Org N	625	395	1020	--
Nitrate +Nitrite	580	147	727	509
Ammonia	25	13	38	563
Total Phos.	251	141	392	28
Diss. Phos.	152	66	218	16
Ortho Phos.	133	56	189	16
Calcium	10329	6578	16907	--
Magnesium	935	470	1405	--
Potassium	2656	1472	4128	--
Chloride	4181	1629	5810	--
Boron	74	35	109	--
Iron	2	--	--	--
Atrazine	0.059	0.016	0.075	--
Desethyl Atrazine	0.064	0.028	0.092	--
Fluometeron	--	--	--	--
Others-total	0.03	0.02	0.05	--
Total Pesticides	0.17	0.064	0.24	--

Rainfall Volume = 1955
Runoff Volume = 296 acre-ft

Summary of Rainfall and Runoff Loads for Odem Ranch Watershed - October 6-10, 1998 Event
(Median Concentrations from 8 runoff events at sites 1 and 2 used to estimate loads)
(Regression equations used to estimate rainfall nitrogen loads)
(Median Total Phosphorus rainfall concentration used to estimate rainfall load)

Constituent	Rainfall Concentration	Runoff Concentration	Units	Rainfall Load	Runoff Load
				(lbs)	(lbs)
Total Nitrogen	0.046	1.60	mg/L	349	706
Diss. Org N	--	0.30	mg/L	--	132
Total Org N	--	1.12	mg/L	--	494
Nitrate + Nitrite	0.02	0.48	mg/L	121	212
Ammonia	0.02	0.04	mg/L	155	18
Total Phos.	0.004	0.42	mg/L	6	185
Diss. Phos.	–	0.21	mg/L	--	93
Ortho Phos.	--	0.29	mg/L	--	128
Atrazine	--	0.05	ug/L	--	0.022
Deethyl Atrazine	--	0.03	ug/L	--	0.013
Fluometeron	–	0.05	ug/L	--	0.022

Rainfall Volume = 592 acre-ft
Runoff Volume = 162.3 acre-ft

Summary of Rainfall and Runoff Loads for Odem Ranch Watershed - October 17-26, 1998 Event

(Concentrations from site 1 composite sample used to estimate loads for entire watershed)

Constituent	Rainfall Concentration	Runoff Concentration	Units	Rainfall Load (lbs)	Runoff Load (lbs)
Total Nitrogen 1	0.43	0.98	mg/L	1701	1515
Diss. Org N	0.16	<0.10	mg/L	633	< 155
Total Org N	<0.1	0.93	mg/L	396	1438
Nitrate + Nitrite	0.25	0.05	mg/L	989	77
Ammonia	0.009	0.04	mg/L	36	62
Total Phos.	0.002	0.35	mg/L	8	541
Diss. Phos.	0.121	<0.05	mg/L	479	< 77
Ortho Phos.	0.109	<0.01	mg/L	431	< 15
Calcium	--	11	mg/L	--	17003
Magnesium	--	0.8	mg/L	--	1237
Potassium	--	2.9	mg/L	--	4483
Chloride	--	1.1	mg/L	--	1700
Boron	--	43	ug/L	--	66467
Iron	--	5.5	ug/L	--	8502
Atrazine	--	0.05	ug/L	--	0.077
Deethyl Atrazine	--	0.03	ug/L	--	0.046
Deisopropyl Atrazine	--	--	ug/L		--
Fluometeron	--	<0.52	ug/L	--	--
Malathion	--	<0.005	ug/L	--	--
Others-total	--	0.016 2	ug/L	--	0.070
Total Pesticides					0.19

Rainfall Volume = 1455 acre-ft
Runoff Volume = 568.5 acre-ft

1 Total Nitrogen = Ammonia + Total Organic N + Nitrate+Nitrite.

2 Average concentration of 3 detected pesticides

Summary of Rainfall and Runoff Loads for Odem Ranch Cropland Watershed - March, 1999 Event

Constituent	Runoff Loads Site 1 (lbs)	Runoff Loads Site 2 (lbs)	Units	Runoff Loads Total (lbs)	Runoff Loads Total (lbs)
Total Nitrogen	27	20		47	405
Diss. Org N	3.0	1.7		4.7	--
Total Org N	17	14		31	--
Nitrate +Nitrite	8.9	4.7		13.6	133
Ammonia	1.7	1.8		3.5	180
Total Phos.	7.5	6.4		13.9	69
Diss. Phos.	3.0	1.9		4.9	--
Ortho Phos.	2.7	1.8		4.5	17
Calcium	--	--		--	--
Magnesium	--	--		--	--
Potassium	--	--		--	--
Chloride	--	--		--	--
Boron	--	--		--	--
Iron	--	--		--	--
Atrazine	0.01	0.003		0.013	--
Deethyl Atrazine	--	--		--	--
Fluometeron	--	--		--	--
Others-total	--	--		--	--
Total Pesticides	--	--		--	--

Rainfall Volume = 543 acre-ft
Runoff Volume = 6.8 acre-ft

Results of Runoff Water Quality Sample Analyses (see following tables)

Odem Ranch Site 1 - Runoff Sample Analyses

Parameter	Units	6/25-26/96 Event Mean	8/24-25/96 Composite1	8/24-25/96 Composite2	8/24-25/96 Event Mean	6/22/1997 Event Mean	10/10-16/97 Event Mean	10/19/1998 Event Mean	3/28/1999 Event Mean
Nitrogen, Ammonia	mg/L as N	0.11	0.03	0.06	0.05	0.015	0.05	0.04	0.15
Nitrogen, Nitrite	mg/L as N	0.26	0.02	0.03	0.03	0.047	0.03	<0.01	0.13
Nitrogen, Nitrite+Nitrate	mg/L as N	0.92	0.6	0.43	0.48	0.98	1.18	0.05	0.80
Nitrogen, Amm+Org, Dis.	mg/L as N	0.3	0.2	0.5	0.4	0.47	0.64	<0.10	0.42
Nitrogen, Amm+Org, Tot.	mg/L as N	--	1.1	0.8	0.9	1.43	1.32	0.93	1.65
Phosphorus, Total	mg/L as P	0.38	0.51	0.49	0.50	0.61	0.51	0.35	0.67
Phosphorus, Diss.	mg/L as P	--	0.22	0.4	0.35	0.45	0.31	<0.05	0.27
Phosphorus, Ortho	mg/L as P	0.2	0.27	0.46	0.40	0.41	0.27	<0.01	0.24
Calcium, Dis.	mg/L as Ca	14	9.7	27	21.8	15.5	20.9	11	--
Magnesium, Dis.	mg/L as Mg	1.1	0.82	2.2	1.79	1.4	1.9	0.79	--
Sodium, Dis.	mg/L as Na	5.7	3.5	8.1	6.7	8.0	22.6	4.9	--
Potassium, Dis.	mg/L as K	3	3.1	12	9.3	4.9	5.4	2.9	--
Chloride, Dis.	mg/L as Cl	1.3	2.2	11	8.4	3.6	8.5	1.1	--
Sulfate, Dis.	mg/L as SO4	1	1.5	1.1	1.2	2.7	3.9	0.8	--
Fluoride, Dis.	mg/L as F	0.5	0.2	0.3	0.3	0.4	0.8	0.2	--
Silica, Dis.	mg/L as SiO2	9.6	7.0	18	14.7	10.8	19.5	7.8	--
Boron, Dis.	ug/L as B	75	32	100	80	90	151	43	--
Iron, Dis.	ug/L as Fe	5	5.0	3.0	3.6	5.2	4	5.5	--
Dissolved Solids	mg/L	72	59	138	114	87	151	--	--
Suspended Solids	mg/L	488	1090	66	373	468	275	372	--
Specific Conductance	uS/cm	119	98	227	188	138	236	94	--
Alkalinity	mg/L as CaCO3	52	46	92	78	56	102	48	--
pH	std units	7.8	8.0	7.4	7.6	7.6	8.0	8.1	--
Pesticides	**Units**								
2,4DB	ug/L	<0.035	<0.035	<0.035	<0.035	<0.035	<0.035	<0.24	--
2,4-D	ug/L	<0.035	<0.035	<0.035	<0.035	<0.035	<0.035	<0.15	--
2,4,5-T	ug/L	<0.035	<0.035	<0.035	<0.035	<0.035	<0.035	<0.035	--
3Hydroxycarbofuran	ug/L	<0.014	<0.014	<0.014	<0.014	<0.014	<0.014	<0.014	--
Acetochlor	ug/L	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.05
Amiben	ug/L	<0.011	<0.011	<0.011	<0.011	<0.011	<0.011	--	--
Aldicarb	ug/L	<0.016	<0.016	<0.016	<0.016	<0.016	<0.016	<0.55	--
Aldicarb Sulfone	ug/L	<0.016	<0.016	<0.016	<0.016	<0.016	<0.016	<0.10	--
Aldicarb Sulfoxide	ug/L	<0.021	<0.021	<0.021	<0.021	<0.021	<0.021	<0.021	--
Acifluorfen	ug/L	<0.035	<0.035	<0.035	<0.035	<0.035	<0.035	<0.13	--
Atrazine	ug/L	4.66	0.02	0.05	0.04	0.07	0.12	0.05	0.91
Deethyl Atrazine	ug/L	1.02	0.04	0.23	0.17	0.17	0.13	0.03	<0.05
Alachlor	ug/L	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.05
Azinphos-Methyl	ug/L	0.06	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	--
Bentazon	ug/L	<0.014	<0.014	<0.014	<0.014	<0.014	<0.014	<0.014	--
Bromacil	ug/L	<0.035	<0.035	<0.035	<0.035	<0.035	<0.035	<0.035	<0.05
Benfluralin	ug/L	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	--
Bromoxynil	ug/L	<0.035	<0.035	<0.035	<0.035	<0.035	<0.035	<0.035	--
Butylate	ug/L	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.05
Carbaryl	ug/L	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.008	--
Carbofuran	ug/L	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	0.02	--
Chloramben	ug/L	<0.011	<0.011	<0.011	<0.011	<0.011	<0.011	<0.42	--
Chlorpyrifos	ug/L	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	--
Cyanazine	ug/L	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.2
Clopyralid	ug/L	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.23	--
Chlorothalonil	ug/L	<0.035	<0.035	<0.035	<0.035	<0.035	<0.035	<0.48	--
Dacthal Mono-Acid	ug/L	<0.017	<0.017	<0.017	<0.017	<0.017	<0.017	<0.017	--
Dicamba	ug/L	<0.035	<0.035	<0.035	<0.035	3.6	<0.035	<0.035	--
2,6Diethylaniline	ug/L	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	--
Diuron	ug/L	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	--
Dinoseb	ug/L	<0.035	<0.035	<0.035	<0.035	<0.035	<0.035	<0.035	--
Dichlorprop	ug/L	<0.032	<0.032	<0.032	<0.032	<0.032	<0.032	<0.032	--
Dichlobenil	ug/L	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<1.20	--
DCPA	ug/L	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	--
DDE	ug/L	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	--
Diazinon	ug/L	<0.002	<0.002	<0.002	<0.002	<0.002	0.045	0.009	--

Odem Ranch Site 1 - Runoff Sample Analyses

Parameter	Units	6/25-26/96 Event Mean	8/24-25/96 Composite1	8/24-25/96 Composite2	8/24-25/96 Event Mean	6/22/1997 Event Mean	10/10-16/97 Event Mean	10/19/1998 Event Mean	3/28/1999 Event Mean
Dieldrin	ug/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	--
Disulfoton	ug/L	<0.017	<0.017	<0.017	<0.017	<0.017	<0.017	<0.017	--
DNOC	ug/L	<0.035	<0.035	<0.035	<0.035	<0.035	<0.035	<0.42	--
EPTC	ug/L	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	--
Esfenvalerate	ug/L	<0.019	<0.019	<0.019	<0.019	<0.019	<0.019	--	--
Ethalfluralin	ug/L	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	--
Ethoprop	ug/L	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	--
Fluometuron	ug/L	1.6	1.4	<0.035	0.44	<0.035	<0.035	<0.52	--
Fenuron	ug/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.013	--
Fonofos	ug/L	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	--
HCH Alpha	ug/L	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	--
Lindane	ug/L	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	--
Linuron	ug/L	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	--
MCPA	ug/L	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.17	--
MCP	ug/L	<0.035	<0.035	<0.035	<0.035	<0.035	<0.035	<0.14	--
Methiocarb	ug/L	<0.026	<0.026	<0.026	<0.026	<0.026	<0.026	<0.026	--
Methomyl	ug/L	<0.017	<0.017	<0.017	<0.017	<0.017	<0.017	<0.017	--
Methyl Parathion	ug/L	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	0.02	--
Metolachlor	ug/L	0.013	0.007	0.012	0.011	0.004	0.005	<0.002	0.007
Metribuzin	ug/L	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.05
Molinate	ug/L	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	--
Napropamide	ug/L	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	--
Norflurazon	ug/L	<0.024	<0.024	<0.024	<0.024	<0.024	<0.024	<0.024	--
Neburon	ug/L	<0.015	<0.015	<0.015	<0.015	<0.015	<0.015	<0.40	--
1-Naphthol	ug/L	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	--	--
Oryzalin	ug/L	<0.019	<0.019	<0.019	<0.019	<0.019	<0.019	<0.31	--
Oxamyl	ug/L	<0.018	<0.018	<0.018	<0.018	<0.018	<0.018	<0.018	--
Ocresol	ug/L	<0.035	<0.035	<0.035	<0.035	<0.035	<0.035	--	--
Parathion	ug/L	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	--
Pebulate	ug/L	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	--
Pendimethalin	ug/L	0.064	0.048	<0.004	0.017	<0.004	<0.004	<0.004	--
Permethrin	ug/L	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	--
Phorate	ug/L	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	--
Picloram	ug/L	<0.035	<0.035	<0.035	<0.035	<0.035	<0.035	<0.05	--
Prometon	ug/L	<0.018	<0.018	<0.018	<0.018	<0.018	<0.018	<0.018	<0.05
Pronamide	ug/L	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	--
Propanil	ug/L	<0.004	<0.004	0.007	0.006	<0.004	<0.004	<0.004	--
Propachlor	ug/L	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.05
Propargite	ug/L	<0.013	<0.013	<0.013	<0.013	<0.013	<0.013	<0.013	--
Propoxur	ug/L	<0.035	<0.035	<0.035	<0.035	<0.035	<0.035	<0.035	--
Propham	ug/L	<0.035	<0.035	<0.035	<0.035	<0.035	<0.035	<0.035	--
Silvex	ug/L	<0.021	<0.021	<0.021	<0.021	<0.021	<0.021	<0.021	--
Simazine	ug/L	0.03	<0.005	<0.005	<0.005	<0.005	0.003	<0.005	<0.05
Thiobencarb	ug/L	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	--
Tebuthiuron	ug/L	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.01	--
Terbacil	ug/L	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.05
Terbufos	ug/L	<0.013	<0.013	<0.013	<0.013	<0.013	<0.013	<0.013	--
Triallate	ug/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	--
Trifluralin	ug/L	0.173	0.014	0.005	0.006	0.01	0.007	<0.002	0.04
Triclopyr	ug/L	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.25	--
Glyphosate	ug/L	<5	<5	<5	<5	<10	<5	<5	<5
Ametryn	ug/L	--	--	--	--	0.06	<0.05	--	<0.05
Butachlor	ug/L	--	--	--	--	0.06	<0.05	--	<0.05
Carboxin	ug/L	--	--	--	--	0.04	<0.05	--	<0.05
Cycloate	ug/L	--	--	--	--	<0.05	<0.05	--	<0.05
Deisopropylatrazine	ug/L	--	--	--	--	0.10	0.04	--	<0.05
Diphenamid	ug/L	--	--	--	--	0.04	<0.05	--	<0.05
Hexazinone	ug/L	--	--	--	--	<0.05	<0.05	--	0.01
Propazine	ug/L	--	--	--	--	<0.05	<0.05	--	<0.05
Simetryn	ug/L	--	--	--	--	0.08	<0.05	--	<0.05
Vernolate	ug/L	--	--	--	--	<0.05	<0.05	--	<0.05

Odem Ranch Site 2 - Runoff Sample Analyses

Parameter	Units	6/25-26/96 Event Mean	8/24-25/96 Composite1	8/24-25/96 Composite2	8/24-25/96 Event Mean	10/11-18/97 Event Mean	3/28/1999 Event Mean
Nitrogen, Ammonia	mg/L as N	0.08	<0.015	<0.015	<0.015	0.04	0.24
Nitrogen, Nitrite	mg/L as N	0.11	<0.01	0.01	0.01	0.02	0.12
Nitrogen, Nitrite+Nitrate	mg/L as N	0.37	0.33	0.44	0.43	0.47	0.64
Nitrogen, Amm+Org, Dis.	mg/L as N	0.3	0.3	0.2	0.21	0.47	0.47
Nitrogen, Amm+Org, Tot.	mg/L as N	--	1.5	0.6	0.69	1.3	2.10
Phosphorus, Total	mg/L as P	0.27	0.49	0.26	0.28	0.45	0.87
Phosphorus, Diss.	mg/L as P	--	0.17	0.15	0.15	0.21	0.26
Phosphorus, Ortho, Dis.	mg/L as P	0.22	0.18	0.17	0.17	0.18	0.25
Calcium, Dis.	mg/L as Ca	15	20	19	19.1	21.5	--
Magnesium, Dis.	mg/L as Mg	0.94	1.3	1.2	1.2	1.5	--
Sodium, Dis.	mg/L as Na	4.6	6.8	5.9	6.0	14.8	--
Potassium, Dis.	mg/L as K	3.6	4.7	5.1	5.1	4.7	--
Chloride, Dis.	mg/L as Cl	1.4	3.2	3.8	3.7	5.2	--
Sulfate, Dis.	mg/L as SO4	0.9	2.3	1.3	1.4	2.9	--
Fluoride, Dis.	mg/L as F	0.3	0.2	0.2	0.2	0.6	--
Silica, Dis.	mg/L as SiO2	10	14	13	13.1	18.6	--
Boron, Dis.	ug/L as B	56.8	72.5	53.7	55.6	112	--
Iron, Dis.	ug/L as Fe	8	5.0	3	3.2	<3	--
Dissolved Solids	mg/L	72	105	92	93.3	127	--
Suspended Solids	mg/L	360	880	116	192	270	--
Specific Conductance	uS/cm	118	170	149	151	196	--
Alkalinity	mg/L as CaCO3	54	84	66	68	90	--
pH	std units	7.6	7.0	7.3	7.3	8.0	--
Pesticides							
2,4DB	ug/L	<0.035	<0.035	<0.035	<0.035	<0.035	--
2,4-D	ug/L	<0.035	<0.035	<0.035	<0.035	<0.035	--
2,4,5-T	ug/L	<0.035	<0.035	<0.035	<0.035	<0.035	--
3Hydroxycarbofuran	ug/L	<0.014	<0.014	<0.014	<0.014	<0.014	--
Acetochlor	ug/L	<0.002	<0.002	<0.002	<0.002	<0.002	<0.05
Amiben	ug/L	<0.011	<0.011	<0.011	<0.011	<0.011	--
Aldicarb	ug/L	<0.016	<0.016	<0.016	<0.016	<0.016	--
Aldicarb Sulfone	ug/L	<0.016	<0.016	<0.016	<0.016	<0.016	--
Aldicarb Sulfoxide	ug/L	<0.021	<0.021	<0.021	<0.021	<0.021	--
Acifluorfen	ug/L	<0.035	<0.035	<0.035	<0.035	<0.035	--
Atrazine	ug/L	0.58	0.077	0.044	0.047	0.050	0.43
Deethyl Atrazine	ug/L	0.45	0.086	0.184	0.174	0.090	<0.05
Alachlor	ug/L	<0.002	<0.002	<0.002	<0.002	<0.002	<0.05
Azinphos-Methyl	ug/L	0.05	<0.001	<0.001	<0.001	<0.001	--
Bentazon	ug/L	<0.014	<0.014	<0.014	<0.014	<0.014	--
Bromacil	ug/L	<0.035	<0.035	<0.035	<0.035	<0.035	<0.05
Benfluralin	ug/L	<0.002	<0.002	<0.002	<0.002	<0.002	--
Bromoxynil	ug/L	<0.035	<0.035	<0.035	<0.035	<0.035	--
Butylate	ug/L	<0.002	<0.002	<0.002	<0.002	<0.002	<0.05
Carbofuran	ug/L	<0.028	<0.028	<0.028	<0.028	<0.028	--
Carbaryl	ug/L	<0.003	<0.003	<0.003	<0.003	0.007	--
Carbofuran	ug/L	<0.003	<0.003	<0.003	<0.003	<0.003	--
Chloramben	ug/L	<0.011	<0.011	<0.011	<0.011	<0.011	--
Chlorpyrifos	ug/L	<0.004	<0.004	<0.004	<0.004	<0.004	–

Odem Ranch Site 2 - Runoff Sample Analyses

Parameter	Units	6/25-26/96 Event Mean	8/24-25/96 Composite1	8/24-25/96 Composite2	8/24-25/96 Event Mean	10/11-18/97 Event Mean	3/28/1999 Event Mean
Cyanazine	ug/L	<0.004	<0.004	<0.004	<0.004	<0.004	<0.2
Clopyralid	ug/L	<0.05	<0.05	<0.05	<0.05	<0.05	--
Chlorothalonil	ug/L	<0.035	<0.035	<0.035	<0.035	<0.035	--
Dacthal Mono-Acid	ug/L	<0.017	<0.017	<0.017	<0.017	<0.017	--
Dicamba	ug/L	<0.035	<0.035	<0.035	<0.035	<0.035	--
2,6 Diethylaniline	ug/L	<0.003	<0.003	<0.003	<0.003	<0.003	--
Diuron	ug/L	<0.02	0.06	0.12	0.11	<0.02	--
Dinoseb	ug/L	<0.035	<0.035	<0.035	<0.035	<0.035	--
Dichlorpro	ug/L	<0.032	<0.032	<0.032	<0.032	<0.032	--
Dichlobenil	ug/L	<0.02	<0.02	<0.02	<0.02	<0.02	--
DCPA	ug/L	<0.002	<0.002	<0.002	<0.002	<0.002	--
DDE	ug/L	<0.006	<0.006	<0.006	<0.006	<0.006	--
Diazinon	ug/L	<0.002	<0.002	<0.002	<0.002	<0.002	--
Dieldrin	ug/L	<0.001	<0.001	<0.001	<0.001	<0.001	--
Disulfoton	ug/L	<0.017	<0.017	<0.017	<0.017	<0.017	--
DNOC	ug/L	<0.035	<0.035	<0.035	<0.035	<0.035	--
EPTC	ug/L	<0.002	<0.002	<0.002	<0.002	<0.002	--
Esfenvalerate	ug/L	<0.019	<0.019	<0.019	<0.019	<0.019	--
Ethalfluralin	ug/L	<0.004	<0.004	<0.004	<0.004	<0.004	--
Ethoprop	ug/L	<0.003	<0.003	<0.003	<0.003	<0.003	--
Fluometuron	ug/L	0.82	0.27	<0.035	0.06	<0.035	--
Fenuron	ug/L	<0.01	<0.01	<0.01	<0.01	<0.01	--
Fonofox	ug/L	<0.003	<0.003	<0.003	<0.003	<0.003	--
HCH Alpha	ug/L	<0.002	<0.002	<0.002	<0.002	<0.002	--
Lindane	ug/L	<0.004	<0.004	<0.004	<0.004	<0.004	--
Linuron	ug/L	<0.002	<0.002	<0.002	<0.002	<0.002	--
MCPA	ug/L	<0.05	<0.05	<0.05	<0.05	<0.05	--
MCP	ug/L	<0.035	<0.035	<0.035	<0.035	<0.035	--
Malathion	ug/L	<0.005	0.038	0.02	0.023	<0.005	--
Methyl Parathion	ug/L	<0.006	<0.006	<0.006	<0.006	<0.006	--
Metolachlor	ug/L	0.008	0.004	0.006	0.006	0.004	0.009
Metribuzin	ug/L	<0.004	<0.004	<0.004	<0.004	<0.004	<0.05
Molinate	ug/L	<0.004	0.003	0.005	0.004	0.005	--
Methomyl	ug/L	<.017	<.017	<.017	<.017	<.017	--
Methiocarb	ug/L	<0.026	<0.026	<0.026	<0.026	<0.026	--
Napropamide	ug/L	<0.003	<0.003	<0.003	<0.003	<0.003	--
Norflurazon	ug/L	<0.024	<0.024	<0.024	<0.024	<0.024	--
Neburon	ug/L	<0.015	<0.015	<0.015	<0.015	<0.015	--
1-Naphthol	ug/L	<0.007	<0.007	<0.007	<0.007	<0.007	--
Oryzalin	ug/L	<0.019	<0.019	<0.019	<0.019	<0.019	--
Oxamyl	ug/L	<0.018	<0.018	<0.018	<0.018	<0.018	--
Ocresol	ug/L	<0.035	<0.035	<0.035	<0.035	<0.035	--
Parathion	ug/L	<0.004	<0.004	<0.004	<0.004	<0.004	--
Pebulate	ug/L	<0.004	<0.004	<0.004	<0.004	<0.004	--
Pendimethalin	ug/L	0.109	0.011	0.017	0.017	<0.004	--
Permethrin	ug/L	<0.005	<0.005	<0.005	<0.005	<0.005	--
Phorate	ug/L	<0.002	<0.002	<0.002	<0.002	<0.002	--
Prometon	ug/L	<0.018	<0.018	<0.018	<0.018	<0.018	<0.05
Pronamide	ug/L	<0.003	<0.003	<0.003	<0.003	<0.003	--
Propanil	ug/L	<0.004	<0.004	<0.004	<0.004	<0.004	--

Odem Ranch Site 2 - Runoff Sample Analyses

Parameter	Units	6/25-26/96 Event Mean	8/24-25/96 Composite1	8/24-25/96 Composite2	8/24-25/96 Event Mean	10/11-18/97 Event Mean	3/28/1999 Event Mean
Propachlor	ug/L	<0.007	<0.007	<0.007	<0.007	<0.007	<0.05
Propargite	ug/L	<.013	<0.013	<0.013	<0.013	<0.013	--
Propoxur	ug/L	<0.035	<0.035	<0.035	<0.035	<0.035	--
Propham	ug/L	<0.035	<0.035	<0.035	<0.035	<0.035	--
Picloram	ug/L	<0.035	<0.035	<0.035	<0.035	<0.035	--
Silvex	ug/L	<0.021	<0.021	<0.021	<0.021	<0.021	--
Simazine	ug/L	0.005	<0.005	<0.005	<0.005	<0.005	<0.05
Thiobencarb	ug/L	<0.002	<0.002	<0.002	<0.002	<0.002	--
Tebuthiuron	ug/L	<0.010	<0.010	<0.010	<0.010	<0.010	--
Terbacil	ug/L	<0.007	<0.007	<0.007	<0.007	<0.007	<0.05
Terbufos	ug/L	<0.013	<0.013	<0.013	<0.013	<0.013	--
Triallate	ug/L	<0.001	<0.001	<0.001	<0.001	<0.001	--
Trifluralin	ug/L	0.154	0.014	0.011	0.011	0.008	0.02
Triclopyr	ug/L	<0.05	<0.05	<0.05	<0.05	<0.05	--
Glyphosate	ug/L	<5	<5	<5	<5	<5	<5
Ametryn	ug/L	--	--	--	--	<0.05	<0.05
Butachlor	ug/L	--	--	--	--	<0.05	<0.05
Carboxin	ug/L	--	--	--	--	<0.05	<0.05
Cycloate	ug/L	--	--	--	--	<0.05	<0.05
Deisopropylatrazine	ug/L	--	--	--	--	0.035	<0.05
Diphenamid	ug/L	--	--	--	--	<0.05	<0.05
Hexazinone	ug/L	--	--	--	--	<0.05	0.02
Propazine	ug/L	--	--	--	--	<0.05	<0.05
Simetryn	ug/L	--	--	--	--	<0.05	<0.05
Vernolate	ug/L	--	--	--	--	<0.05	<0.05

Odem Ranch Site 3 - Runoff Sample Analyses

Parameter	Units	6/25-26/96 Event Mean	6/22/1997 Event Mean	10/13/1997 Event Mean
Nitrogen, Ammonia	mg/L as N	0.11	0.30	0.14
Nitrogen, Nitrite	mg/L as N	0.02	0.02	0.01
Nitrogen, Nitrite+Nitrate	mg/L as N	0.23	0.21	0.26
Nitrogen, Amm+Org, Dis.	mg/L as N	0.4	0.58	0.6
Nitrogen, Amm+Org, Tot.	mg/L as N	--	1.59	1.7
Phosphorus, Total	mg/L as P	0.53	0.47	0.62
Phosphorus, Diss.	mg/L as P	--	0.30	0.38
Phosphorus, Ortho	mg/L as P	0.36	0.29	0.35
Calcium, Dis.	mg/L as Ca	5.4	10.3	14
Magnesium, Dis.	mg/L as Mg	0.7	0.9	1.3
Sodium, Dis.	mg/L as Na	0.9	1.7	7.5
Potassium, Dis.	mg/L as K	4.9	5.6	5.2
Chloride, Dis.	mg/L as Cl	1.1	1.9	3.0
Sulfate, Dis.	mg/L as SO4	0.6	1.5	1.6
Fluoride, Dis.	mg/L as F	0.06	<0.1	0.3
Silica, Dis.	mg/L as SiO2	3.1	7.0	13
Boron, Dis.	ug/L as B	28	34	70
Iron, Dis.	ug/L as Fe	15.7	15.8	5.3
Dissolved Solids	mg/L	30	53	95
Suspended Solids	mg/L	324	177	355
Specific Conductance	uS/cm	56.3	90	140
Alkalinity	mg/L as CaCO3	21.5	37	77
pH	std units	7.0	7.6	8.0
Pesticides	**Units**			
2,4DB	ug/L	<0.035	<0.035	<0.035
2,4-D	ug/L	<0.035	<0.035	<0.035
2,4,5-T	ug/L	<0.035	<0.035	<0.035
3Hydroxycarbofuran	ug/L	<0.014	<0.014	<0.014
Acetochlor	ug/L	<0.002	<0.002	<0.002
Amiben	ug/L	<0.011	<0.011	<0.011
Aldicarb	ug/L	<0.016	<0.016	<0.016
Aldicarb Sulfone	ug/L	<0.016	<0.016	<0.016
Aldicarb Sulfoxide	ug/L	<0.021	<0.021	<0.021
Acifluorfen	ug/L	<0.035	<0.035	<0.035
Atrazine	ug/L	0.17	0.09	0.03
Deethyl Atrazine	ug/L	0.02	0.06	0.04
Alachlor	ug/L	<0.002	<0.002	<0.002
Azinphos-Methyl	ug/L	0.16	0.08	<0.001
Bentazon	ug/L	<0.014	<0.014	<0.014
Bromacil	ug/L	<0.035	<0.035	<0.035
Benfluralin	ug/L	<0.002	<0.002	<0.002
Bromoxynil	ug/L	<0.035	<0.035	<0.035
Butylate	ug/L	<0.002	<0.002	<0.002
Carbofuran	ug/L	<0.028	<0.028	<0.028
Carbaryl	ug/L	0.02	<0.003	<0.003
Carbofuran	ug/L	<0.003	<0.003	<0.003
Chloramben	ug/L	<0.011	<0.011	<0.011

Odem Ranch Site 3 - Runoff Sample Analyses

Parameter	Units	6/25-26/96 Event Mean	6/22/1997 Event Mean	10/13/1997 Event Mean
Chlorpyrifos	ug/L	<0.004	<0.004	<0.004
Cyanazine	ug/L	<0.004	<0.004	<0.004
Clopyralid	ug/L	<0.05	<0.05	<0.05
Chlorothalonil	ug/L	<0.035	<0.035	<0.035
Dacthal Mono-Acid	ug/L	<0.017	<0.017	<0.017
Dicamba	ug/L	<0.035	<0.035	<0.035
2,6Diethylaniline	ug/L	<0.003	<0.003	<0.003
Diuron	ug/L	<0.02	<0.02	<0.02
Dinoseb	ug/L	<0.035	<0.035	<0.035
Dichlorpro	ug/L	<0.032	<0.032	<0.032
Dichlobenil	ug/L	<0.02	<0.02	<0.02
DCPA	ug/L	<0.002	<0.002	<0.002
DDE	ug/L	<0.006	<0.006	<0.006
Diazinon	ug/L	<0.002	<0.002	<0.002
Dieldrin	ug/L	<0.001	<0.001	<0.001
Disulfoton	ug/L	<0.017	<0.017	<0.017
DNOC	ug/L	<0.035	<0.035	<0.035
EPTC	ug/L	<0.002	<0.002	<0.002
Esfenvalerate	ug/L	<0.019	<0.019	<0.019
Ethalfluralin	ug/L	<0.004	<0.004	<0.004
Ethoprop	ug/L	<0.003	<0.003	<0.003
Fluometuron	ug/L	<0.035	<0.035	<0.035
Fenuron	ug/L	<0.01	<0.01	<0.01
Fonofos	ug/L	0.003	<0.003	<0.003
HCH Alpha	ug/L	<0.002	<0.002	<0.002
Lindane	ug/L	<0.004	<0.004	<0.004
Linuron	ug/L	<0.002	<0.002	<0.002
MCPA	ug/L	<0.05	<0.05	<0.05
MCP	ug/L	<0.035	<0.035	<0.035
Malathion	ug/L	<0.005	<0.005	<0.005
Methyl Parathion	ug/L	<0.006	<0.006	<0.006
Metolachlor	ug/L	0.003	<0.002	<0.002
Metribuzin	ug/L	<0.004	<0.004	<0.004
Molinate	ug/L	0.004	<0.004	0.007
Methomyl	ug/L	<.017	<.017	<.017
Methiocarb	ug/L	<0.026	<0.026	<0.026
Napropamide	ug/L	<0.003	<0.003	<0.003
Norflurazon	ug/L	<0.024	<0.024	<0.024
Neburon	ug/L	<0.015	<0.015	<0.015
1-Naphthol	ug/L	<0.007	<0.007	<0.007
Oryzalin	ug/L	<0.019	<0.019	<0.019
Oxamyl	ug/L	<0.018	<0.018	<0.018
Ocresol	ug/L	<0.035	<0.035	<0.035
Parathion	ug/L	<0.004	<0.004	<0.004
Pebulate	ug/L	<0.004	<0.004	<0.004
Pendimethalin	ug/L	<0.004	<0.004	<0.004
Permethrin	ug/L	<0.005	<0.005	<0.005
Phorate	ug/L	<0.002	<0.002	<0.002
Prometon	ug/L	<0.018	<0.018	<0.018

Odem Ranch Site 3 - Runoff Sample Analyses

Parameter	Units	6/25-26/96 Event Mean	6/22/1997 Event Mean	10/13/1997 Event Mean
Pronamide	ug/L	<0.003	<0.003	<0.003
Propanil	ug/L	<0.004	<0.004	<0.004
Propachlor	ug/L	<0.007	<0.007	<0.007
Propargite	ug/L	<.013	<.013	<.013
Propoxur	ug/L	<0.035	<0.035	<0.035
Propham	ug/L	<0.035	<0.035	<0.035
Picloram	ug/L	<0.035	<0.035	<0.035
Silvex	ug/L	<0.021	<0.021	<0.021
Simazine	ug/L	<0.005	<0.005	<0.005
Thiobencarb	ug/L	<0.002	<0.002	<0.002
Tebuthiuron	ug/L	<0.010	<0.010	<0.010
Terbacil	ug/L	<0.007	<0.007	<0.007
Terbufos	ug/L	<0.013	<0.013	<0.013
Triallate	ug/L	<0.001	<0.001	<0.001
Trifluralin	ug/L	0.009	0.01	0.008
Triclopyr	ug/L	<0.05	<0.05	<0.05
Glyphosate	ug/L	<5.0	<5.0	<5.0
Ametryn	ug/L	--	<0.05	--
Butachlor	ug/L	--	<0.05	--
Carboxin	ug/L	--	<0.05	--
Cycloate	ug/L	--	<0.05	--
Deisopropylatrazine	ug/L	--	0.04	--
Diphenamid	ug/L	--	<0.05	--
Hexazinone	ug/L	--	<0.05	--
Propazine	ug/L	--	<0.05	--
Simetryn	ug/L	--	<0.05	--
Vernolate	ug/L	--	<0.05	--

Summary of EMCs for Nutrients and Selected Pesticides (see following table)

Summary of EMC Values for Odem Ranch Sites 1 and 2

Site/Station Date		1 June, 96	1 August, 96	1 June, 97	1 Oct, 97	1 Oct, 98	1 March, 99	2 June, 96	2 August, 96	2 Oct, 97	2 March, 99	Median
Nitrogen, Total	mg/L as N	--	1.38	2.41	2.50	0.98	2.45	--	1.12	1.77	2.74	2.09
Nitrogen, Ammonia	mg/L as N	0.11	0.05	0.015	0.05	0.04	0.15	0.08	0.015	0.04	0.24	0.05
Nitrogen, Nitrite	mg/L as N	0.26	0.03	0.047	0.03	0.01	0.13	0.11	0.01	0.02	0.12	0.04
Nitrogen, Nitrite+Nitrate	mg/L as N	0.92	0.48	0.98	1.18	0.05	0.80	0.37	0.43	0.47	0.64	0.56
Nitrogen, Amm+Org, Dis.	mg/L as N	0.30	0.40	0.47	0.64	0.1	0.42	0.30	0.21	0.47	0.47	0.41
Nitrogen, Amm+Org, Tot.	mg/L as N	--	0.90	1.43	1.32	0.93	1.65	--	0.69	1.3	2.10	1.31
Phosphorus, Total	mg/L as P	0.38	0.50	0.61	0.61	0.35	0.67	0.27	0.28	0.45	0.87	0.48
Phosphorus, Diss.	mg/L as P	0.20	0.35	0.45	0.45	0.05	0.27	0.22	0.15	0.21	0.26	0.24
Phosphorus, Ortho	mg/L as P	--	0.40	0.41	0.41	0.01	0.24	--	0.17	0.18	0.25	0.25
Atrazine	µy/Λ	4.7	0.04	0.07	0.12	0.05	0.91	0.58	0.05	0.05	0.43	0.10
Deethyl Atrazine	µy/Λ	1	0.17	0.17	0.13	0.03	<0.05	0.45	0.17	0.09	<0.05	0.17
Fluometuron	µy/Λ	1.6	0.44	0.04	0.04	0.04	--	0.82	0.06	0.04	--	0.05
Metalochlor	µy/Λ	0.01	0.01	0.004	0.005	0.002	0.007	0.008	0.006	0.004	0.01	0.007
Pendimethalin	µy/Λ	0.06	0.02	0.004	0.004	0.004	--	0.11	0.02	0.004	--	0.012
Trifluralin	µy/Λ	0.17	0.006	0.01	0.007	0.002	0.04	0.15	0.01	0.008	0.02	0.01