EIGHTEENTH ANNUAL REPORT OF THE CONTINUING SURFACE WATER QUALITY MONITORING PROGRAM FOR CATFISH, NORTH AND SOUTH CREEKS ON THE PALMER RANCH SARASOTA COUNTY, FLORIDA JANUARY - DECEMBER, 2002

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SARASOTA COUNTY, FLORIDA

1.0 INTRODUCTION

A master development plan for the Palmer Ranch is being implemented pursuant to the terms and conditions of the **Amended and Restated Master Development Order** (Amended MDO, Resolution No. 91-170) for the Palmer Ranch Development of Regional Impact (DRI) which was adopted on July 12, 1991, by the Board of County Commissioners of Sarasota County. The amended and original MDO's call for planning and developing the 5,119-acre Palmer Ranch DRI in incremental developments. Construction of the first incremental development (Prestancia) was initiated in 1986. The Palmer Ranch is located in west-central Sarasota County as shown in **Figure 1.1**.

Pursuant to the conditions of the original MDO, a "Continuing Surface Water Quality Monitoring Program" was required to be performed before and during construction, except during the period in which a "Pollutant Loading Monitoring Program" was to be performed as specified in the Agreement of Understanding between Sarasota County and Palmer Venture established during August 1987.

The original monitoring program, which was initiated in May 1984 by GeoScience, Inc., employed a bimonthly sampling frequency as required for the first year of monitoring. Subsequently, the scope of the monitoring program for the following two-year period was revised during an agency review meeting in June 1985. This meeting involved the developer's representative, Mr. T. W. Goodell, and Mr. Russ Klier of Sarasota County Pollution Control Division (personal communication with Mr. T. W. Goodell). The revised work scope entailed a 13-station network with a quarterly sampling frequency for the parameters monitored during the first year, except trace elements and organochlorine pesticides that would receive annual audits (refer to July 24, 1986 correspondence of Mr. T. W. Goodell to Mr. Russ Klier).

Palmer Ranch Holdings, Ltd. (*f.k.a.* Palmer Venture and Palmer Ranch Development, Ltd.) contracted Vanasse Hangen Brustlin, Inc. (*f.k.a.* CCI Environmental Services, Inc. and Conservation Consultants, Inc.) to implement the "Continuing Surface Water Quality Monitoring Program" during the second year of the monitoring program. Vanasse Hangen Brustlin, Inc. (VHB) began monitoring on September 16, 1985, pursuant to the instructions provided by Palmer Ranch Holdings, Ltd. Except for an annual sampling event conducted in September 1988, the "Continuing Surface Water Quality Monitoring Program" was suspended in June 1988, due to the initiation of the "Pollutant Loading Monitoring Program". The Stormwater Pollutant Loading Monitoring Program was performed between June 1988 and December 1989 and a report submitted to Sarasota County on May 29, 1992. Subsequent to an agreement between the Sarasota County Pollution Control Division and Palmer Ranch Holdings, Ltd., the "Continuing Surface Water Quality Monitoring Program" was resumed in December 1989 with a single annual sampling event conducted during the fifth monitoring year. After resumption of monitoring in December 1989, the surface water quality monitoring was performed quarterly at all stations until December 10, 1991.

With adoption of **Exhibit "E" to the Amended and Restated Master Development Order for the Palmer Ranch Development of Regional Impact** (**Appendix A**), a revised water quality monitoring program was implemented in 1992. This revised monitoring program consisted of quarterly water quality measurements and grab sample collection in Catfish Creek, North Creek and South Creek at a total of 10 monitoring stations. In accordance with Exhibit "E", monitoring in the South Creek Basin was suspended until one month before any development activity occurring in the basin. Upon intent to reinitiate monitoring of the South Creek Basin, Sarasota County Pollution Control Division was notified of dates of sampling and stations to be sampled. Monitoring of the South Creek Basin was reinitiated with the first quarterly sampling occurring on January 13, 1994. As specified in Exhibit "E", this pre-development monitoring event included water quality grab sampling and *in situ* measurements at four (4) monitoring stations along South Creek. Following this initial monitoring event, all subsequent monitoring shall be performed quarterly during the development phase. During development, all stations located downstream of an area under development shall be monitored. Additionally, one sampling site located upstream of a development area shall also be monitored to determine baseline water quality conditions. Once an area is substantially developed as agreed to by the Sarasota County Pollution Control Division and Palmer Ranch Development, Ltd., a modification of the monitoring program shall be subject to discussion for change in water quality monitoring frequency from quarterly to semi-annually or to be discontinued.

Under the amended and approved monitoring plan as stated in Exhibit "E", monitoring of Catfish Creek and North Creek is to continue quarterly for a maximum of two years or until substantial development occurs. On April 29, 1994, Mr. Kent Kimes of the Sarasota County Pollution Control Division approved a reduction in sampling frequency for the Catfish Creek and North Creek monitoring stations from quarterly to semi-annually.

The water quality conditions recorded during sampling events conducted during the period from January through December 2002 in the Catfish Creek, North Creek and South Creek basins are reported herein. This report includes a discussion of the results with respect to applicable water quality criteria, observed spatial and temporal trends, and comparisons with results obtained during previous monitoring events.

2.0 GENERAL ENVIRONMENTAL SETTING

2.1 Climate

Prevailing climatic conditions in west central Florida are subtropical, characterized by abundant rainfall and moderate temperatures. Average monthly temperatures derived from two separate 30-year periods of record are provided in **Table 2.1** below:

TABLE 2.1. AVERAGE MONTHLY AIR TEMPERATURES (NATIONAL WEATHER SERVICE, TAMPA, FLORIDA)

Month	Air Temperature			
	1941-1970A		1931-1960[b]	
	°C	°F	°C	°F
January	16.4	61.6	16.9	62.4
February	17.2	62.9	17.7	63.8
March	19.4	66.9	19.4	67.0
April	22.3	72.1	22.1	71.8
May	24.8	76.7	24.9	76.8
June	26.8	80.3	26.9	80.4
July	27.6	81.6	27.6	81.6
August	27.7	81.9	27.8	82.0
September	26.9	80.5	27.0	80.6
October	23.9	75.0	23.9	75.1
November	19.8	67.7	19.9	67.9
December	17.1	62.8	17.4	63.4
Annual Average	22.5	72.5	22.6	72.7

[a]Thompson, 1976
[b]Bradley, 1974

Based on a 30-year period of record, rainfall in Bradenton, Florida (NOAA, 1977) averages 56 inches per year. The minimum annual rainfall recorded during the 30-year period was 29 inches while the maximum was 93 inches. Historical rainfall trends for this area show that a wet season occurs during the period of June through September followed by a dry season during the period of October through January. On the average 62 percent (35 inches) of the annual rainfall occurs during the summer with only 13 percent (7 inches) during the fall. The dry season is followed by a short wet period during February and March and subsequently a short dry period during April and May.

2.2 Soils

Soils in the area of the Palmer Ranch are generally sandy except in areas of low relief and poor drainage where peaty mucks are common (Florida Division of State Planning, 1975). Upland soils found throughout the Palmer Ranch are predominately of the Myakka-Immokalee-Basinger Association. This soil association is defined as nearly level with poorly drained sandy soils (Florida Division of State Planning, 1975).

Along the well-incised banks of several drainage ditches traversing the Palmer Ranch (*e.g.,* lower reach of Catfish Creek), it is evident that a natural marine deposit exists a few feet below the ground surface. This marine deposit contains a thin layer of shells and shell fragments. **Figure 2.1** and **Table 2.2** provide the locations and descriptions of the soil associations that occur in the area of the Palmer Ranch.

2.3 Land Use and Vegetation

Historically, the primary land use within the Palmer Ranch has been cattle ranching. However, changes in land uses on the Palmer Ranch have included the following: construction of surface water management systems; construction of roads, golf courses, homes, wastewater treatment facilities and associated domestic wastewater spray effluent fields, and land disposal of sludge. During the second monitoring year (April 1985 - March 1986), the land application of sludge wastes on the Palmer Ranch was discontinued and construction of the Central County Utilities Regional Treatment Plant and an adjacent golf course was completed. Subsequently, construction of a residential development was initiated during the third monitoring year.

Land uses located upstream of the ranch include golf courses, roads and highways, residential developments, a mobile home park, commercial businesses, a dairy farm that was changed to a sod farm (effective August 1, 1987), light industry, and a metal salvage operation.

The primary vegetation associations found on the undeveloped areas of the ranch include pine flatwoods, improved and semi-improved pastures, wet prairies, marshes and sloughs, swamps, and mesic hammocks.

TABLE 2.2. DESCRIPTIONS OF SOIL ASSOCIATIONS

Area Definition	Map Unit No.	Soil Association Description
Areas dominated by moderately well to poorly drained soils not subject to flooding.	4	Tavares-Myakka association: Nearly level to gently sloping, moderately well-drained soils sandy throughout and poorly drained sandy soils with weakly cemented sub-soils.
	5	Pomello-St. Lucie association: Nearly level to sloping, moderately well drained, sandy soils with weakly cemented sandy subsoil and excessively drained soils sandy throughout.
	7	Myakka-Pomello-Bassinger association: Nearly level, poorly and moderately well drained, sandy soils with weakly cemented sandy subsoil and poorly drained sandy soils throughout.
	8	Myakka-Immokalee-Bassinger association: Nearly level, poorly drained, sandy soils with weakly cemented sandy subsoil and poorly drained sandy soils throughout.
	26	Immokalee-Pomello association: Nearly level to gently sloping, poorly and moderately well drained, sandy soils with weakly cemented sandy subsoil.
	30	Wabasso-Bradenton-Myakka association: Nearly level, poorly drained, sandy soils with a weakly cemented sandy subsoil layer underlain by loamy subsoil; poorly drained soils with thin, sandy layers over loamy subsoil and poorly drained soils with weakly cemented sand subsoil.
Areas dominated by moderately well to poorly drained soils not subject to flooding.	35	Pomello-Paola-St. Lucie association: Nearly level to sloping, moderately well drained sandy soils with weakly cemented sandy not subject to flooding (continued) subsoil and excessively drained soils, sandy throughout.
	36	Immokalee-Myakka-Pompano association: Nearly level, poorly drained, sandy soils with weakly cemented sandy subsoil and poorly drained soils, sandy throughout.

TABLE 2.2. (CONTINUED)

Area Definition	Map Unit No.	Soil Association Description
	37	Adamsville-Pompano association: Nearly level, somewhat poorly and poorly drained, soils, sandy throughout.
	38	Scranton, var.-Ona-Placid association: Nearly level, somewhat poorly drained, dark surface soils, sandy throughout; poorly drained soils with thin, sandy layers over weakly cemented sandy subsoil and very poorly drained soils, sandy throughout.
Areas dominated by poorly and very poorly drained soils subject to flooding.	28	Pompano-Charlotte-Delray association: Nearly level, poorly drained soils, sandy throughout, and very poorly drained soils with thick sandy layers over loamy sub-soil.
	31	Placid-Bassinger association: Nearly level, very poorly and poorly drained soils, sandy throughout.
	32	Delray-Manatee-Pompano association: Nearly level, very poorly drained soils with thick, sandy layers over loamy subsoil; very poorly drained sandy soils, with loamy subsoil and poorly drained soils, sandy throughout.
Areas dominated by poorly and very poorly drained soils subject to flooding (continued)	33	Fresh Water Swamp and Marsh association: Nearly level, very poorly drained soils subject to prolonged flooding.
	34	Tidal Marsh and Swamp-Coastal Beach Ridges/Dune association: Nearly level, very poorly drained soils subject to frequent tidal flooding, high-lying coastal dune-like ridges and deep, droughty sands.
	39	Terra Ceia association: Nearly level, very poorly drained, well-decomposed, organic soils 40-91 cm (16-36 inches) thick over loamy material.

2.4 Drainage

The Palmer Ranch DRI is divided into six primary drainage basins that ultimately discharge into Little Sarasota Bay and Drymond Bay. Two basins, the Catfish Creek/Trunk Ditch Basin and the South Creek Basin, drain most of the North Tract. Approximately 2,590 acres of the Catfish Creek-Trunk Ditch Basin, that has a total drainage area of 3,700 acres, and approximately 1,770 acres of the South Creek Basin, that has a total drainage area of approximately 12,000 acres, are located on the North Tract. Four minor basins also drain portions of the property. These include Matheny Creek Basin (40 acres), Elligraw Bayou Basin (180 acres), North Creek Basin (460 acres), and Clower Creek Basin (80 acres). A general description of the major streams in these basins is provided in the following sections.

2.4.1 *Catfish Creek*

Catfish Creek within the limits of the Palmer Ranch DRI was a man-made ditch/channel system that flowed southwest to the southern boundary of the property, intersecting Trunk Ditch, a straight man-made canal, at five locations. The upper portion of Catfish Creek receives off-site drainage from commercial and industrial areas near Clark Road. Many of these commercial and industrial areas lack stormwater management systems. The lower portion of the Catfish Creek drainage system receives stormwater runoff from various stormwater management systems located throughout the Palmer Ranch residential development.

Immediately downstream of the Palmer Ranch, the Catfish Creek drainage system receives drainage and at times "overflow" from the wastewater treatment ponds associated with a mobile home park. Farther downstream, drainage from residential areas and runoff from U.S. Highway 41 enter the creek. Beyond U.S. Highway 41, Catfish Creek is affected by tidal changes from Little Sarasota Bay.

2.4.2 *Trunk Ditch*

Trunk Ditch was originally constructed to improve drainage. Initially, it extended from the northern boundary of the Palmer Ranch property to North Creek and resulted in scouring velocities during major storm events. These high velocities resulted in out-of-bank flooding and sediment transport. During early 1986, a segment of Trunk Ditch was reconstructed in association with the Development of Prestancia. This reconstruction resulted in an improved channel and the placement of two water level control weirs. Because of these two weirs, lentic conditions occur during the dry season. Vegetation in Trunk Ditch is dominated by hydrilla, water-weed, and other aquatic weeds. As mentioned earlier, Catfish Creek intersects Trunk Ditch at five locations.

Runoff entering the upper reaches of Trunk Ditch originates along Clark Road, including the adjacent commercial and industrial areas. Downstream, runoff enters Trunk Ditch from Prestancia's golf course and residential development, the Country Club of Sarasota and associated residential area, as well as pine flatwoods, improved pastures, and wetlands of the Palmer Ranch. Subsequently, three (3) additional weirs were added in the reconstructed portion of the Trunk Ditch during 1988 to 1991. Also, a drainage-basin divide between Catfish Creek and North Creek was created at that time with the construction of Central Sarasota Parkway.

2.4.3 *North Creek*

North Creek is connected to Trunk Ditch by a dredged tributary located near the southern boundary of the North Tract. The banks of this tributary are vegetated with grasses and trees resulting in a partially overhanging canopy. Most of the drainage into this dredged tributary originates from residential development, roadways, a marsh/slough system, and an off-site metal salvage operation. Downstream of the North Tract, Trunk Ditch enters the main channel of North Creek, which subsequently flows into Little Sarasota Bay. Residential areas, U. S. Highway 41, and pine flatwoods drain into the downstream reach of North Creek.

2.4.4 *South Creek*

South Creek within the Palmer Ranch is largely a shallow ditch system constructed through historic, broad sloughs or interconnecting previously isolated marshes. The banks of South Creek are vegetated with grasses and occasional pines, while its channel is generally void of aquatic vegetation. Upstream of the Palmer Ranch, South Creek receives drainage in its western tributary from a golf course and a mobile home park. At its eastern boundary, it receives drainage from agricultural and recreational land uses, as well as Interstate I-75. Before mid-1987, much of the area upstream of I-75 was used as a dairy farm.

Within the Palmer Ranch, South Creek receives drainage primarily from improved pastures, pine flatwoods and the newly constructed residential developments. Downstream of the Ranch, South

Creek flows through Oscar Scherer State Park and subsequently into the tidal waters of Drymond Bay.

2.4.5 *Elligraw Bayou*

Elligraw Bayou is a channelized stream that flows southwesterly to Little Sarasota Bay. The banks of Elligraw Bayou are sloped and vegetated with grasses and trees. On the Ranch, Elligraw Bayou receives drainage from Increment II development areas and Prestancia (Increment I). Downstream of the Palmer Ranch, Elligraw Bayou flows through Ballantrae and several other residential areas before entering Little Sarasota Bay.

2.4.6 *Matheny Creek*

Matheny Creek is a channelized stream that originates in the marshes and sloughs northwest of the Palmer Ranch. It flows southwest and eventually discharges into Little Sarasota Bay. The banks of Matheny Creek are steep and vegetated with grasses and some trees. Drainage enters Matheny Creek from residential developments, commercial and industrial areas, and golf courses.

2.4.7 *Clower Creek*

Clower Creek forms the south border of the 70-acre Sarasota Square Mall. A 1.6 acre wet prairie located east of the mall on the Palmer Ranch most likely represents the headwaters of Clower Creek during the wet season. Drainage conveyed by Clower Creek flows westerly for 1,350 feet, and subsequently, through an underground pipeline along the north and west borders of a trailer park adjacent to the Sarasota Square Mall. After flowing underground for about 650 feet, drainage enters the mall's stormwater management system. Subsequently, discharge from the mall's stormwater management system drains through swales into culverts and underneath U.S. 41 to Little Sarasota Bay.

2.5 Water Quality Classification

The segments of the streams traversing the North Tract of the Palmer Ranch are non-tidal freshwater systems designated by the State as Class III waters pursuant to Subsection 62-302.400(1) of the Florida Administrative Code (FAC). Downstream, these streams flow into an estuarine system (Little Sarasota and Drymond Bays) which is classified as an Outstanding Florida Waters (OFW). In addition, the segment of South Creek that flows through Oscar Scherer State Park is classified as an OFW. State and Sarasota County water quality standards applicable to the "Continuing Water Quality Monitoring Program" (*i.e.*, those applicable to Class III, predominantly fresh surface waters) are listed in **Table 2.3**.

TABLE 2.3. APPLICABLE STATE AND COUNTY WATER QUALITY CRITERIA FOR CLASS III, PREDOMINATELY FRESH WATERS

Parameter	Water Quality Standard[a]
Arsenic	Not >50 µg/L
Biochemical Oxygen Demand	Not to be increased in a manner that would depress Dissolved Oxygen levels below criteria.
Fecal Coliform Bacteria	Not >800/100 mL
Total Coliform Bacteria	Not >2,400/100 mL
Specific Conductance	Shall not be increased more than 50% above background or to 1,275 µmhos/cm, whichever is greater, in predominantly fresh waters.
Copper	Not >12.8 µg/L at a Total Hardness of 110 mg/L
Dissolved Oxygen	Not <5 mg/L
Lead	Not >3.6 µg/L at a Total Hardness of 110 mg/L
Nutrients	Concentrations in a body of water shall not be altered in such a manner as to cause an imbalance in natural populations of aquatic flora or fauna.
Ammonia Nitrogen (ionic plus non-ionic)	See Nutrients
Nitrite Nitrogen	See Nutrients
Nitrate Nitrogen	See Nutrients
Total Nitrogen	See Nutrients
Organic Nitrogen	See Nutrients
Oil and Greases	Not >5 mg/L
Orthophosphate	See Nutrients
Total Phosphorus	See Nutrients

TABLE 2.3. (CONTINUED)

Parameter	Water Quality Standard[a]
pH	6.0 - 8.5
Total Suspended Solids	-----
Turbidity	Not >29 NTU above background
Zinc	Not >115 µg/L at a Total Hardness of 110 mg/L

[a]State surface water quality criteria as listed in Chapter 62-302, Florida Administrative Code, and Sarasota County Ordinance No. 98-066.

3.0 FIELD AND LABORATORY PROCEDURES

3.1 Station Locations and General Descriptions

The "Continuing Surface Water Quality Monitoring Program" employs a network of 10 sampling stations located at various sites along South Creek, Catfish Creek, North Creek, and Trunk Ditch (**Figure 3.1**). A general description of the characteristics of the 10 sampling stations is provided in **Table 3.1.**

In Catfish Creek, inflow into the Palmer Ranch was monitored at Station CC-1 while outflow was monitored at Station CC-5. Station CC-1 receives drainage from Clark Road, McIntosh Road, and various commercial/industrial developments. Two tributaries of Catfish Creek were also monitored near their confluences with Trunk Ditch (Stations CC-2 and CC-3). These two stations represent stream segments that receive drainage from Prestancia and backwater effects of Trunk Ditch.

Trunk Ditch was monitored within its realigned segment within the Catfish Creek-Trunk Ditch Drainage Basin at Station CC-4. This site lays adjacent to and receives drainage from both the Country Club of Sarasota and Prestancia and sources farther upstream, as well as pine flatwoods, improved pastures, and wetlands of the Palmer Ranch. Farther to the South, Trunk Ditch was monitored at a location within the North Creek Basin, *i.e.*, Station NC-6. South Creek was monitored at four (4) locations. These include one point of outflow (SC-2) and one point of inflow (SC-3), as well as in the interior of the North Tract at Stations SC-4 and SC-1. Station SC-3 is upstream of any development underway presently in the South Creek Basin. During some previous monitoring years, only Stations SC-1, SC-2, and SC-4 were monitored because no construction extended beyond Station SC-4. Sampling at Station SC-3 was reinitiated in October 1996 when construction activity moved upstream of Station SC-4.

3.2 Parameters and Sampling Frequency

Semi-annual sampling of Catfish and North Creeks was performed during March and September 2002, and quarterly sampling was performed during January, April, July, and October 2002 in South Creek. The analysis of the annual parameters was performed for samples collected during the wet season events (i.e. September and October 2002). The dates and times of all sample

TABLE 3.1. GENERAL DESCRIPTIVE CHARACTERISTICS OF SURFACE WATER QUALITY SAMPLING STATIONS

Station	General Location	Water Depth[a] (ft)	Channel Width (ft)	Habitat
CC-1	Catfish Creek Site Entry	1.0-1.6	10	75-100% Canopy of *Salix*, Rooted Emergents, Incised Banks.
CC-2	Catfish Creek Upstream of Trunk Ditch	0.0-0.45	12	Aquatic Vegetation, Shallow Sloped Banks.
CC-3	Catfish Creek Upstream of Trunk Ditch	0.3-0.6	6	Aquatic Vegetation, Incised Banks.
CC-4[b]	Trunk Ditch Downstream of Catfish Creek Confluence	0.6-2.2	50	Sodded Banks, Rooted Emergents.
CC-5	Catfish Creek Outfall from Site	0.3-0.8	50	Shading in by Oaks, Willows, and Wax Myrtle, Sodded Banks.
NC-6	Trunk Ditch Downstream of Catfish Creek	1.7-2.7	12	Aquatic Vegetation.
SC-1	South Creek Mid-property	0.6-0.7	12	Sand covered with Organic Matter.
SC-2	South Creek at Site Exit	0.5-1.2	17	Rooted Emergents, Floating Aquatics, Palm Trees Shade Channel in A.M.
SC-3	South Creek Outfall from Large Wetland	0.0-0.7	10	Shallow banks, Aquatic Vegetation.
SC-4	South Creek near Honore Avenue	0.7-1.2	8	Rooted Emergents Cover 33% of Channel, Canopy of Pine.

[a]Range in Depth recorded during monitoring period of April, 1987 - March, 1988.
[b]Depths reported are depths at sampling location - total depth at site averages 8.0 feet.

collections are provided in **Table 3.2a**. Weather conditions at the time of monitoring are provided in **Table 3.2b**.

Surface water quality monitoring from January through December 2002 was performed by (1) the use of field instrumentation and *in situ* measurements; and (2) the collection of grab samples for subsequent laboratory analyses. A digital readout YSI/Endeco multi-parameter water quality meter was used for *in situ* measurements of dissolved oxygen, pH, specific conductance, and water temperature. Prior to deployment in the field, all instrumentation was calibrated according to the manufacturer's recommended procedures. All *in situ* measurements were taken at approximate

TABLE 3.2a DATE AND TIME OF SAMPLING FOR THE EIGHTEENTH ANNUAL MONITORING PERIOD OF JANUARY THROUGH DECEMBER, 2002

West Side

Event No.	Date of Sampling	Monitoring Stations					
		CC-1	CC-2	CC-3	CC-4	CC-5	NC-6
1	March 25, 2002	1215	1518	1258	1312	1352	1450
2	September 25, 2002	1105	1130	1155	1205	1220	1255

East Side

Event No.	Date of Sampling	Monitoring Stations			
		SC-1	SC-2	SC-3	SC-4
1	January 25, 2002	1510	1457	1423	1532
2	April 5, 2002	1356	1420	N/A	1445
3	July 31, 2002	1515	1531	1352	1602
4	October 3, 2002	1402	1335	1250	1445

N/A – Station not Sampled (Dry)

TABLE 3.2b WEATHER CONDITIONS OBSERVED DURING SAMPLING FOR THE EIGHTEENTH ANNUAL MONITORING PERIOD OF JANUARY THROUGH DECEMBER, 2002

Date	Air Temperature (F)	Cloud Cover (%)	Speed	Wind Direction	Rain
January 25, 2002					No
March 25, 2002	80-85	75	5-10	SE	No
April 5, 2002	82-84	1	5-10	W	No
July 31, 2002	91	10	0-5	SW	No
September 25, 2002	85	75-80	10-15	SE	No
October 3, 2002	91	20	0-5	SW	No

midstream and mid-depth at each station. Grab samples were collected at each station during the six monitoring events, preserved, and analyzed in the laboratory within the recommended hold times for the following parameters:

- Ammonia Nitrogen
- Nitrate Nitrogen
- Nitrite Nitrogen
- Organic Nitrogen[1]
- Total Nitrogen
- Orthophosphate
- Total Phosphorus
- Oil and Grease
- Total Suspended Solids
- Turbidity
- Biochemical Oxygen Demand
- Fecal Coliform Bacteria
- Total Coliform Bacteria

Additional surface water grab samples were collected at each of the ten monitoring stations during the September or October 2002 monitoring events for the laboratory analysis of the following parameters:

- Arsenic
- Lead
- Copper
- Zinc

All sampling was performed in accordance with the Florida Department of Environmental Protection standard operating procedures ID #E84017. Laboratory analyses were performed in accordance with the procedures described in the 18th edition of *Standard Methods for the Examination of Water and Wastewater* (APHA, 1992), *Methods for Chemical Analysis of Water and Wastes* (USEPA, 1983) or other FDEP/USEPA approved methodology. The methods used in the collection, preservation, handling, storage, and analysis of all surface water samples are provided by parameter in **Table 3.3**.

Laboratory analyses were performed by Benchmark EnviroAnalytical's laboratory which is certified by Florida Department of Health and Rehabilitative Services for the analyses of environmental and drinking water samples.

Two additional parameters, stream flow and stream depth, were monitored at each sampling point concurrently with water quality monitoring as an aid in evaluating the water quality data although not formally part of the "Continuing Surface Water Quality Monitoring Program." Water velocity was determined using a Marsh-McBirney model 201D flow meter. Stream flows were subsequently

[1]Organic Nitrogen = Total Kjeldahl Nitrogen - Ammoniacal Nitrogen.

TABLE 3.3. COLLECTION AND ANALYTICAL METHODS USED DURING THE CONTINUING SURFACE WATER QUALITY MONITORING PROGRAM

Parameter	Sample Type	Field Handling	Hold Time	Laboratory Handling	Analytical Method	Method Reference
Total Arsenic	Grab	HNO_3 to pH <2, Stored on Ice	6 Months	Stored at Room Temperature	Digestion, Atomic Absorption - Furnace Technique	EPA 206.2
Fecal Coliform Bacteria	Grab	Stored on Ice	30 Hours	Immediate Analysis	Multiple Tube Fermentation	APHA 9222 D
Total Coliform Bacteria	Grab	Stored on Ice	30 Hours	Immediate Analysis	Multiple Tube Fermentation	APHA 9222 B
Biochemical Oxygen Demand (BOD-5 Day)	Grab	Stored on Ice	48 Hours	Immediate Analysis	Membrane Electrode	APHA 5210 B
Conductivity	*In situ*	----	----	----	Hydrolab - Wheatstone Bridge	APHA 2510 B
Total Copper	Grab	HNO_3 to pH <2, Stored on Ice	6 Months	Stored at Room Temperature	Digestion, Atomic Absorption	EPA 220.2
Total Lead	Grab	HNO_3 to pH <2, Stored on Ice	6 Months	Stored at Room Temperature	Digestion, Atomic Absorption	EPA 239.1
Ammonia Nitrogen	Grab	H_2SO_4 to pH <2, Stored on Ice	28 Days	Stored at 4 °C	Automated Phenate	EPA 350.2
Nitrate + Nitrite Nitrogen	Grab	H_2SO_4 to pH <2,	28 Days	Stored at 4 °C Stored on Ice	Automated Cadmium Reduction	EPA 353.2
Nitrite Nitrogen	Grab	Stored on Ice	48 Hours	Stored at 4 °C	Automated Autoanalyzer	APHA 4500NO2B
Nitrate Nitrogen	Grab	----	----	----	Calculation	EPA 353.2
Total Kjeldahl Nitrogen	Grab	H_2SO_4 to pH <2, Stored on Ice	28 Days	Stored at 4 °C	Automated Block Digestion, Autoanalyzer	EPA 351.2

TABLE 3.3. (CONTINUED)

Parameter	Sample Type	Field Handling	Hold Time	Laboratory Handling	Analytical Method	Method Reference
Total Nitrogen	Grab	----	----	----	Calculation	EPA 351.2
Oil and Grease	Grab	H_2SO_4 to pH <2,	28 Days	Stored at 4 °C Stored on Ice	Gravimetric	EPA 1664
Dissolved Oxygen	*In situ*	----	----	----	Hydrolab - Membrane Electrode	APHA 4500 G
pH	*In situ*	----	----	----	Hydrolab - Electrometric	APHA 4500-H^+
Orthophosphate	Grab	Stored on Ice	48 Hours	Immediate Analysis	Automated, Ascorbic Acid	EPA 365.3
Total Phosphorus	Grab	H_2SO_4 to pH <2, Stored on Ice	28 Days	Stored at 4 °C	Automated Block Digestion, Autoanalyzer	EPA 365.3
Total Suspended Solids (TSS)	Grab	Stored on Ice	7 Days	Stored at 4 °C	Glass Fiber Filtration, Dried at 105 °C	EPA 160.2
Temperature	*In situ*	----	----	----	Hydrolab - Thermistor	APHA 2550 B
Turbidity	Grab	Stored on Ice	48 Hours	Stored at 4 °C	Nephelometric	EPA 180.1
Total Zinc	Grab	HNO_3 to pH <2, Stored on Ice	6 Months	Stored at Room Temperature	Digestion, Atomic Absorption	EPA 289.1
Flow/Direction	*In situ*	----	----	----	Marsh-McBirney Flow Meter –Electromagnetic Sensor	Manufacturer's Specifications

APHA - American Public Health Association, American Water Works Association and Water Pollution Control Federation, 1992. *Standard Methods for the Examination of Water and Wastewater*, 18th Edition. American Public Health Association.

EPA - U.S. Environmental Protection Agency, 1983. *Methods for Chemical Analysis of Water and Wastes*, EPA - 600/4-79-020, National Environmental Research Center, Cincinnati, Ohio.

determined in accordance with the USGS two-point (*i.e.*, area/velocity) method (USGS, 1982). Stream depth was measured with a weighted fiberglass tape at each point of water quality sampling.

4.0 RESULTS AND DISCUSSION

During the eighteenth year of the "Continuing Surface Water Quality Monitoring Program" (*i.e.*, January through December 2002) six surface water quality monitoring events were conducted by VHB. Sampling of Catfish and North Creeks was conducted on March 25 and September 25, 2002 and sampling of South Creek was conducted on January 25, April 5, July 31 and October 3, 2002. All monitoring was conducted in compliance with the conditions of the Amended and Restated Master Development Order for the Palmer Ranch Development of Regional Impact (**Appendix A**).

Individual results for the six events performed during the 2002 monitoring year for the "Continuing Surface Water Quality Monitoring Program" are tabulated by parameter in **Appendix B**. For each parameter, statistics (*i.e.*, mean, range, standard deviation, and number of observations) are calculated across sampling events and sampling locations. Also, applicable water quality criteria are footnoted below each table.

Copies of the data tables for the samples collected during the 2002 monitoring year are provided in **Appendix C**. Comparison of the data with previous results and general conclusions are included with the discussion for each parameter or group of related parameters.

4.1 Rainfall and Hydrology

4.1.1 *Rainfall*

The annual rainfall amount recorded at Oscar Scherer State Park, located to the south of the Palmer Ranch, during the eighteenth year of the "Continuing Surface Water Quality Monitoring Program" is slightly lower than the historic average annual rainfall of approximately 54.8 inches (based on a 30-year period of record, NOAA, 1982). Approximately 49.61 inches of precipitation were recorded during the October 2001 to September 2002 (**Table 4.1**) time period at Oscar Scherer State Park in comparison to a range of 24 to 74 inches recorded during the period of record. On Palmer Ranch, 38 to 65 inches were recorded during previous monitoring years (CCI, 1988a, 1988b, 1991, 1992a, 1993, 1994, 1995, 1996, 1997, 1998 and 1999, and VHB, 1999, 2000 and 2001).

Figure 4.1 provides a comparison of the monthly distribution of rainfall measured in Oscar Scherer State Park from October 2001 through October 2002 with the average monthly distribution of historic rainfall for the 23-year period of record. Rainfall recorded during the 2002 monitoring year

TABLE 4.1. RAINFALL RECORDED AT OSCAR SCHERER STATE PARK DURING THE PERIOD OF OCTOBER 2001 THROUGH OCTOBER 2002

Date	Monthly Rainfall (Inches)	Seasonal Rainfall (Inches)	Pre-Event Rainfall (Inches)		
			2 Day	2 WEEK	2 Month
October 2001	0.82				
November 2001	0.00				
December 2001	1.06				
Fall (Dry Season)		**1.88**			
January 2002	2.85		0.00	1.60	3.91
February 2002	3.40				
March 2002	0.71		0.00	0.00	4.11
WINTER		**6.96**			
April 2002	1.10		0.01	0.01	4.21
May 2002	4.96				
June 2002	7.95				
SPRING		**14.01**			
July 2002	7.27		0.12	2.32	15.19
August 2002	15.10				
September 2002	4.39		0.04	2.24	20.49
Summer (Wet Season)		**26.76**			
October 2002	0.49		0.24	2.07	19.33
Yearly Total (10/01 – 9/02)		**49.61**			

[a]**Seasonal Rainfall (inches):**

Primary Wet Season (June - September):	34.71
Primary Dry Season (October 2001 - January 2002):	4.73
Secondary Wet Season (February - March):	4.11
Secondary Dry Season (April - May):	6.06

exhibited the typical seasonal trend for this region of Florida. The cumulative amount of precipitation for the primary wet season (*i.e.*, June - September) was 34.71 inches, which is 7.99 inches above the period of record average. Recorded rainfall amounts during the primary wet season compensated for below average rainfall during the winter and spring and consequently contributed to an annual rainfall just below the historic levels (**Figure 4.1**). During the thirteen month monitoring year, below-normal rainfall was observed during eight months of the year (*i.e.* October, November, December 2001, and January, March, April, September and October, 2002), whereas above-normal rainfall occurred during February, May, June, July and August, 2002 (**Figure 4.1**). The highest monthly rainfall totals during 2002 were observed in June and August when 7.95 and 15.10 inches of precipitation were recorded, respectively. Historically, 6.63 and 6.92 inches of rainfall occur during June and August, respectively.

As provided in **Table 4.1**, the seasonal amounts of rainfall recorded at Oscar Scherer State Park during the fall and winter quarters totaled 1.88 and 6.96 inches, respectively. Rainfall amounts recorded during the spring and summer quarters were 14.01 and 26.76 inches, respectively. In the four-month period from June through September, when the primary wet season normally occurs, 34.71 inches (or 70 percent of the total annual rainfall) was recorded at Oscar Scherer State Park. The total rainfall recorded during the primary wet season for 2002 was considerably lower than the previous year of 43.22 inches.

Antecedent rainfall accumulations during 2-day, 2-week and 2-month periods before each monitoring event are also presented in **Table 4.1**. As evident in this table, the April, July, September and October monitoring events had rain recorded during the 2-day antecedent period prior to monitoring. The July and September monitoring events had the highest rainfall recorded during the 2-week antecedent period, with 2.32 and 2.24 inches, respectively. The 2002 wet season sampling events (*i.e.*, September and October) exhibited similar rainfall amounts during the 2-month antecedent period (20.49 and 19.33 inches, respectively). The January, March and April sampling events had the lowest two-month antecedent period rainfall amounts.

4.1.2 *Stream Stage*

Water depths measured at each station during the sampling events performed during 2002 are tabulated in **Appendix Tables B-1** and **C-1** for the west and east side, respectively.

West Side

Stream stages on the west side of the ranch during 2002 averaged 1.5 feet and ranged from 0.1 to 4.6 feet. Overall, stream stages measured during 2002 are higher than those measured during 1997 and 1998, but are comparable to those measured during the 2001 monitoring year. During 2001, stream stages for the Catfish Creek and North Creek monitoring stations averaged 1.3 feet with a range of 0.0 to 3.1 feet (VHB, 2001) compared with an average of 1.5 feet recorded during the 2002 monitoring year.

The deepest waters of the streams traversing the west side of the Palmer Ranch are located in Trunk Ditch. Here, depths of approximately 8 feet can be found near the center of its reconstructed segment that runs adjacent to the Country Club of Sarasota and Prestancia. Station CC-4 is located on the reconstructed segment of Trunk Ditch and exhibited an average depth of 2.9 feet.

The lowest stream levels in Catfish Creek were observed during the September 2002 monitoring event. Average stream stages for Stations CC-2 and NC-6 were both below 1.0 foot during the year (Appendix Table B-1). These stations also exhibited the lowest average stream stages recorded in the 2001 monitoring year. Station CC-2 has exhibited dry conditions (*i.e.*, stream stage of 0.0 feet) for one of the sampling events (March) during the 1996, 1997, 1998, 1999, 2000 and 2001 monitoring years.

East Side

Rainfall recorded during the 2002 monitoring year was substantially below normal during the beginning of the year. As a result, stream stages measured in South Creek are lower than those observed for previous monitoring years. During the 2002 monitoring year, stream stages at the four monitoring stations in South Creek averaged 0.8 feet with a range from 0.0 to 1.8 feet (**Appendix Table C-1**) compared to an average stream stage of 1.3 feet determined during 2001. Average stream stages recorded from 1985 through 2001 ranged from 0.4 to 2.5 feet (CCI, 1986, 1988a, 1988b, 1990, 1991, 1992a, 1995, 1996, 1997, 1998, 1999 and VHB, 1999, 2000 and 2001).

Spatially, Station SC-4 exhibited the greatest water depths during the 2002 monitoring year. The shallowest stream stages were exhibited by Stations SC-2 and SC-3, which averaged 0.6 feet deep for all sampling events. Station SC-3 is located at the upper reach of the South Creek basin, while

SC-2 is in the lower reach. Seasonally, the highest average water levels at the four South Creek monitoring stations were recorded during the July and October 2002 monitoring events, which followed 15.19 and 19.33 inches of rainfall during a 2-month period preceding the sampling event, respectively. The lowest water level (0.0 feet or dry) was determined for the April sampling event at Station SC-3. This water level trend is similar to the seasonal trends reported during previous monitoring years (CCI, 1986, 1988a, 1988b, 1990, 1991, 1992a, 1995, 1996, 1997, 1998, 1999 and VHB, 1999, 2000 and 2001), except for 1998, which reflects the *El Nino* climatic event.

4.1.3 *Stream Flow*

West Side

As evident in **Appendix Table B-2**, stream flows measured during the 2002 monitoring year for all six monitoring stations in Catfish and North Creeks ranged from 0.0 to 1714.4 gallons per minute (GPM) and averaged 464.4 GPM. During the eighteenth year of monitoring, stream flows in the Catfish Creek/Trunk Ditch Basin ranged from 0.0 to 718.1 GPM in its upper reaches (CC-1 and CC-2) and there was no flow exhibited in its mid-reach (CC-3 and CC-4). Stream flows recorded for the six monitoring stations during the 2002 monitoring year are illustrated in **Figure 4.2**.

Seasonally, the highest steam flows during 2002 occurred during the September monitoring event with stream flows in Catfish Creek/Trunk Ditch averaging 492.3 GPM. Higher stream flows measured in September coincide with the high 2-month antecedent rainfall amount (**Table 4.1**). The higher rainfall amounts reported for this period resulted in an elevated groundwater table and a higher percentage of runoff, both of which increased stream flow. Spatially, low flow conditions were observed in the Catfish Creek/Trunk Ditch Basin at Stations CC-2, CC-3 and CC-4. During 2002, there was no discernable flow at Stations CC-3 and CC-4. However, Station CC-2 has typically exhibited the lowest flow conditions during the previous monitoring years. The highest stream flows were determined for Station CC-5 with an average of 1510.7 GPM and a range of 1306.9 to 1714.4 GPM.

During the 2002 monitoring year, positive stream flows (*i.e.*, measurable flows) were recorded for 7 of the 12 measurements (*i.e.*, 58 percent) taken. The percentage of positive flows measured during 2002 is lower than most of those reported for previous monitoring years (CCI, 1986, 1988a, 1988b, 1990, 1991, 1992a, 1993, 1994, 1997, 1998, 1999 and VHB, 1999, 2000 and 2001). A higher incident of positive flows (*i.e.*, 100 percent) was observed during the 1995 monitoring year and is directly attributed to the wetter conditions reported with the annual rainfall being 28 inches higher than the 23-year average. The historic high percentage of positive flows in these two basins can be attributed to improved basin geometry and hydraulic residence time in the watershed resulting in a more efficient drainage system. However, the lack of substantial rainfall witnessed during most of 2002 has negatively affected the current stream flow percentage on both Catfish and North Creeks.

East Side

As evident in **Appendix Table C-2**, positive stream flows (*i.e.*, measurable flows) were recorded for 5 of 16 measurements (*i.e.*, 31 percent) taken during the 2002 monitoring year in the South Creek Basin. The percentage of positive flows measured during 2002 is lower than the 56 to 100 percent positive flow measurements observed during the 1991 through 1999 and 2001 monitoring years (CCI, 1992a, 1995, 1996, 1997, 1998, 1999 and VHB, 1999 and 2001). During 2002, stream flow in South Creek averaged 409.7 gallons per minute (gpm) and ranged from 0.0 to 1698.7 gpm. Stream flows measured during 2002 are presented in **Figure 4-3**. As a result of the below average rainfall amounts recorded during most of 2002, the mean stream flows were much lower than those recorded during the previous monitoring years (CCI, 1986, 1988a, 1988b, 1990, 1991, 1992a, 1995, 1996, 1997, 1998, and VHB, 1999, 2000 and 2001).

Seasonally, stream flows followed the same general trends described for stream stage with the highest flows being observed during the October 2002 monitoring event when stream flows averaged 678.2 GPM (**Appendix Table C-2**). The higher stream flows measured in October 2002 probably resulted from saturated soil conditions caused by the only substantial rainfall amounts that occurred during the late summer of 2002. Saturated soil conditions can result in an elevated groundwater table and a higher percentage of surface runoff, and therefore, increased stream flow.

Spatially, stream flows followed expected trends with flows generally increasing in a downstream direction. Stream flows in the upper reaches (*i.e.*, Stations SC-3 and SC-4) exhibited no flow conditions, while the lower reach (SC-1 and SC-2) ranged from 0 to 1698.7 GPM.

4.2 Physical Water Quality Parameters

4.2.1 *Water Temperature*

Appendix Tables B-3 and **C-3** present the surface water temperature measurements acquired during the 2002 monitoring year for Catfish Creek/Trunk Ditch and South Creek, respectively.

West Side

Results indicate that the water temperature of the streams of the west side of the Palmer Ranch averaged 26.6°C and ranged from 22.7 to 30.1°C during the two monitoring events. This range is similar to those recorded during previous years of monitoring (Palmer Venture, 1986; and CCI, 1986, 1988a, 1988b, 1991, 1992a, 1993, 1994, 1995, 1996, 1997, 1998, 1999 and VHB, 1999, 2000 and 2001).

As expected, the lowest water temperatures were recorded in the streams of the west side during the March 2002 event with the highest water temperatures recorded during the September monitoring event. Water temperatures averaged 28.5°C during the September 2002 event, while an average temperature of 24.8°C was observed during the March event. Average temperatures for Catfish Creek and North Creek for each event are very similar with differences among stations generally being less than 2 °C.

East Side

Results indicate that the water temperature in South Creek on the Palmer Ranch averaged 27.3 °C and ranged from 20.9 to 33.4°C during the four monitoring events **(Appendix Table C-3)**. This range is similar to those recorded during previous years of monitoring (Palmer Venture, 1986; and CCI, 1986, 1988a, 1988b, 1991, 1992a, 1995, 1996, 1997, 1998, and VHB, 1999,2000 and 2001).

As expected, the lowest water temperatures averaging 22.7 °C were recorded in the streams of the east side during the winter quarterly event (*i.e.*, January 2002), with higher water temperatures recorded during July and October monitoring events. The highest water temperatures, averaging 31.5 °C, were recorded during the July 2002 (*i.e.*, summer) monitoring event. Water temperatures recorded for the April event averaged 27.2 °C. Average water temperatures determined for each station in the South Creek basin exhibited temperature differences among stations of approximately 3 °C, or less.

An evaluation of diurnal variations in water temperature in the Catfish Creek and South Creek Basins was performed during the 1985 dry season and the 1986 wet season. Results of the diurnal evaluation showed increases in water temperature to maximum levels by mid-afternoon followed by declines during the evening to minimal levels by early morning. The results of the diurnal study are provided in the report prepared by CCI (CCI, 1987).

4.2.2 *Specific Conductance*

West Side

As evidenced in **Appendix Table B-4**, Catfish Creek and North Creek exhibited an average specific conductance of 1,070 micromhos per centimeter (µmhos/cm) with a range from 590 to 1,349 µmhos/cm during 2002. In previous studies, Catfish Creek and North Creek exhibited specific conductance ranges of 366 to 1,625 µmhos/cm (CCI, 1991, 1992a, 1993, 1994, 1995, 1996, 1997, 1998 and VHB, 1999, 2000 and 2001). A greater range of conductivity levels (567 to 1,625 µmhos/cm) was reported for the sixth monitoring year and probably resulted from the relatively low amount of rainfall that occurred during 1990.

In a comparison of both streams monitored during 2002 within the west side of Palmer Ranch, the annual mean conductivities for North Creek and Catfish Creek Basins were 1,218 and 1,040 µmhos/cm, respectively. Spatially, the highest conductivity levels in the Catfish Creek Basin were determined in the mid reaches of the basin with lower conductivities in the upper portions of the basin. Specific conductivities in the mid reaches of Catfish Creek averaged 1,066 µmhos/cm compared with an average of 1,037 µmhos/cm observed for the upper-reach.

East Side

South Creek exhibited a range in specific conductance of 373 to 1,275 µmhos/cm (**Appendix Table C-4**) during 2002 compared with conductivity levels ranging from 289 to 1,497 µmhos/cm during the fourth through the sixteenth monitoring years (CCI, 1988b, 1991, 1992a, 1995, 1996, 1997, 1998, 1999 and VHB, 1999, 2000 and 2001). Above normal rainfall in 1995 resulted in the lowest specific conductance levels ranging from 289 to 1,100 µmhos/cm. The highest values were observed during the sixth and sixteenth monitoring years and resulted from the relatively low amount of rainfall that occurred during 1990 and 2000. Seasonally, the lowest conductivities recorded during 2002 occurred during the October monitoring event when conductivities averaged 724 µmhos/cm. As described above, these lower conductivities can be correlated to high precipitation during the summer wet season and are most likely resulted from cumulative effects of increased surface runoff of low conductivity storm water during a period of high rainfall (refer to **Table 4.1**). Specific conductivity levels at the remaining sampled stations averaged 1,162, 1,207, and 891 µmhos/cm during the January, April and July sampling events, respectively.

Average conductivities measured in the South Creek Basin for the upper and lower reaches were 907 and 1,047 µmhos/cm, respectively. A slight trend for higher conductivity values in the upper reach of South Creek was indicated in the 1999 annual report (VHB, 1999). However, much like the 2000 and 2001 results, the 2002 data indicates a slightly higher conductivity in the lower reach and these results are similar to those observed during the previous years of monitoring (CCI 1988a, 1988b, 1991, 1992a, 1995, 1996, 1997, 1998 and VHB, 1999, 2000 and 2001). During these years, no apparent spatial trends in conductivity were evident within the South Creek Basin of the Palmer Ranch. The higher conductivity in the lower reach could reflect the effects of dewatering for construction.

The State specific conductance criterion applicable to the streams of the Palmer Ranch allows an increase of not more than 50 percent above background levels or to a level of 1,275 µmhos/cm whichever is greater. Two of the 12 conductivity measurements made during the 2002 monitoring year on the east side exceeded the 1,275 µmhos/cm (1,282 and 1,349 µmhos/cm at Stations CC-4 and NC-6, respectively). None of the South Creek basin conductivity measurements exceeded this criterion.

4.2.3 *Total Suspended Solids*

During the eighteenth year of monitoring, Catfish Creek and North Creek in the Palmer Ranch exhibited a range of total suspended solids (TSS) from 1.8 to 75.2 mg/L with an annual average of approximately 12.6 mg/L (**Appendix Table B-5**). Total suspended solid levels observed during 2002 were generally higher than those recorded during other previous monitoring years (Palmer Venture, 1986; CCI, 1986, 1987, 1988a, 1988b, 1991, 1992a, 1993, 1994, 1996, 1997, 1998, 1999 and VHB, 1999, 2000 and 2001).

The highest TSS levels during 2002 were recorded in the upper-reach of Catfish Creek (*i.e.*, CC-2). The lowest TSS levels were recorded in North Creek (*i.e.*, NC-6). The highest average TSS level (*i.e.*, 18.0 mg/L) was recorded for the March sampling event. The higher TSS values reported for the March sampling event are probably due to higher rainfall recorded at the secondary wet season (February – March), after a period of lower rainfall, and the subsequent increase in surface water runoff, which carries particles into the creek. The high concentrations of TSS recorded during 2002 monitoring year may be attributed to below average rainfall observed throughout most of the year. Overall, the observed TSS range of approximately 1.8 to 75.2 is significantly higher then the 2001 monitoring data (2.0 to 38.6). This broad range is primarily due to the high value reported for Station CC-2 (75.2 mg/L) during the March 2002 monitoring event.

East Side

During the 2002 monitoring year, stations along South Creek on the Palmer Ranch exhibited a range of total suspended solids (TSS) from 2.4 to 53.5 mg/L, with an annual average of 13.6 mg/L (**Appendix Table C-5**). Overall, the TSS levels observed are comparable to those recorded during previous monitoring years (Palmer Venture, 1986; CCI, 1986, 1987, 1988a, 1988b, 1991, 1992a, 1995, 1996, 1997, 1998 and VHB, 1999, 2000 and 2001), and exhibit a slightly higher average than those observed last year.

The highest TSS levels of 53.5 and 43.2 mg/L were recorded in the upper reach of the creek at Stations SC-3 and SC-4, respectively, during the October 2002 monitoring event. The elevated TSS level probably resulted from higher organic matter content (*i.e.*, aquatic plants) because of low water levels at these sites and/or from upstream construction within the basin. The lowest yearly average TSS levels were recorded at Station SC-1 and SC-2 (*i.e.*, lower reach) during 2002. Overall, the lowest average TSS concentration was observed during the July event.

4.2.4 *Turbidity*

West Side

During the 2002 monitoring year, turbidity levels measured in Catfish Creek and North Creek ranged from 1.9 to 37.0 NTU and averaged 8.4 NTU (**Appendix Table B-6**). In comparison, a turbidity range of 0.3 to 36 NTU was exhibited during the previous ten years of monitoring (CCI, 1988a, 1988b, 1991, 1992a, 1993, 1994, 1995b, 1996, 1997, 1998 and VHB, 1999, 2000 and 2001).

The highest mean turbidity level (*i.e.*, 11.4 NTU) occurred March 2002 while the lowest mean level (*i.e.*, 5.4 NTU) was determined for the September event (**Appendix Table B-6**). This seasonal variation typically results from differences in rainfall amounts and the subsequent changes in storm water inputs to the surface waters.

East Side

During the eighteenth year of the monitoring program, turbidity levels measured in South Creek ranged from 1.0 to 39.0 NTU with an overall average of 8.4 NTU (**Appendix Table C-6**). The turbidity levels measured in 2002 were higher than those observed in 1998, 1999, 2000 and 2001. The lowest turbidity levels were measured during the 1995 and 1997 monitoring years. Turbidity levels ranged from 1.7 to 11.8 NTU, and from 1.0 to 5.3 NTU during 1995 and 1997, respectively (CCI, 1996 and 1998).

Seasonally, the highest mean turbidity level (*i.e.*, 20.5 NTU) occurred during the October sampling event while the lowest turbidity level (*i.e.*, 3.5 NTU) was determined for the January event (**Appendix Table C-6**).

The General Water Quality Criteria for all surface waters (FAC Chapter 62-302) specifies that turbidity shall not exceed 29 NTU above natural background. Based on turbidity measurements taken during previous years of monitoring, natural background turbidity levels are expected to be less than 25 NTU (mean plus one standard deviation), although higher background turbidities might occur because of natural processes, *e.g.*, organic decay and import of particulate matter via stormwater runoff. Therefore, only turbidity measurements collected during the October 2002 monitoring year at stations SC-3 and SC-4 were out of compliance with the applicable water quality criteria.

4.3 Oxygen Demand and Related Parameters

4.3.1 *Biochemical Oxygen Demand*

Biochemical oxygen demand can be defined as "*the amount of oxygen required by bacteria while stabilizing organic matter under aerobic conditions* "(Sawyer and McCarthy, 1978).

West Side

The decomposable organic matter present in Catfish Creek is mostly attributed to decaying vegetation and hydrocarbon inputs (*i.e.*, automobile emission, oil leakage, *etc.*). As presented in **Appendix Table B-7**, the 5-day biochemical oxygen demand (BOD_5) recorded in the two streams of the west side averaged 3.2 mg/L and ranged from <2.0 to 9.2 mg/L during the 2002 monitoring year.

Seasonally, the highest BOD_5 levels were recorded for the March event. Generally, September corresponds to the end of the summer-wet season when storm water runoff is high which typically results in more organic material being transported to the surface waters.

Biochemical oxygen demand levels in Catfish Creek averaged 3.7 mg/L with a range of <2.0 to 9.2 mg/L. Spatially, lower mean BOD_5 levels were observed among the upper reach stations in the basin (**Appendix Table B-7**). A similarly low mean BOD_5 level of <2.0 mg/L was observed for the North Creek sampling station.

The BOD_5 levels measured during the 2002 monitoring year are slightly higher than those reported in the 1995, 1996, 1997, 1999, 2000 and 2001 monitoring years.

East Side

The decomposable organic matter present in South Creek is mostly attributed to decaying vegetation with a minor contribution hydrocarbon input (*i.e.*, automobile emission, oil leakage, *etc.*) resulting from runoff from Interstate-75. As presented in **Appendix Table C-7**, the 5-day biochemical oxygen demand (BOD_5) recorded in the South Creek Basin during the 2002 monitoring year averaged 2.6 mg/L and ranged from <2.0 to 5.4 mg/L. Seasonally, the highest mean BOD_5 levels were determined during the January 2002 sampling event. Spatially, the highest BOD_5 levels were measured in samples collected in the upper reach of South Creek (*i.e.*, Stations SC-3 and SC-4). Overall, the lowest BOD_5 levels were observed within the lower reach (*i.e.*, Stations SC-1 and SC-2).

According to Hynes (1966), a BOD_5 of 3 mg/L suggests "fairly clean" water while a BOD_5 of 5 mg/L suggests "doubtful" quality water. In addition, a BOD_5 screening level of greater than 3.3 mg/L has been established for Florida waters to indicate potential water quality problems (FDER, 1990). Based on BOD_5 measurements made in North Creek and Catfish Creek during the 2002 monitoring year, the surface water of the west side generally exhibited clean conditions where six of the eleven measurements were found below the 3.3 mg/L screening level. South Creek also exhibited clean conditions with 63% of the measurements performed in 2002 being under the 3.3 mg/L screening level.

The General Criteria for BOD_5 in all surface waters as designated by FAC Chapter 62-302, "Rules and Regulations of the Department of Environmental Protection," as well as Sarasota County Ordinance No. 98-066, as amended, specifies that BOD_5 shall not be increased to levels that would result in violations of dissolved oxygen. Eleven of the twenty-seven BOD_5 concentrations measured in Catfish Creek, North Creek and South Creek during 2002 exceeded the 3.3 mg/L screening level that the FDER (1990) considers to suggest potential water quality problems. Also during the eighteenth year of monitoring, only two (2) of the 27 BOD_5 measurements collected from the east side or west side exceeded the 5 mg/L level which Hynes (1966) considered "doubtful" or between "fairly clean" and "bad" water quality.

4.3.2 *Dissolved Oxygen*

<u>West Side</u>

Appendix Table B-8 provides the results of dissolved oxygen measurements acquired during the eighteenth year of monitoring. Overall, dissolved oxygen was found to average 8.5 mg/L, with a range of 2.4 to 11.9 mg/L.

Seasonally, the highest average dissolved oxygen levels were observed for the March monitoring event with concentrations averaging 9.2 mg/L. Typically, higher dissolved oxygen levels are associated with the lower water temperatures observed during the March event. In contrast, dissolved oxygen concentrations for the September monitoring event averaged 7.7 mg/L in conjunction with the higher average water temperatures. The 2002 monitoring year seasonal trends are similar to those observed for dissolved oxygen during previous monitoring years (CCI, 1988a, 1988b, 1991, 1992a, 1993, 1994, 1995b, 1996, 1997, 1998 and VHB 2001), which reflect the changes in the solubility of dissolved oxygen throughout the water column with changes in water temperature. Spatially, average dissolved oxygen concentrations were generally higher for stations within the Catfish Creek Basin with lower concentrations recorded for Station NC-6 in the North Creek Basin.

The dissolved oxygen concentrations obtained during the 2002 monitoring year for Catfish and North Creeks are generally comparable to those measured during the previous monitoring years (CCI, 1988a, 1988b, 1991, 1992a, 1993, 1994, 1995b, 1996, 1997, 1998 and VHB, 1999, 2000 and 2001) but slightly higher than the concentrations determined during the initial two years of the monitoring program (Palmer Venture, 1986; and CCI, 1986). During the third through seventeenth monitoring years, dissolved oxygen was found to average from 4.5 to 6.3 mg/L (CCI, 1988a, 1988b, 1991, 1992a, 1993, 1994, 1995b, 1996, 1997, 1998, 1999 and VHB, 1999, 2000 and 2001).

Dissolved oxygen concentrations in the two streams of the west side sometimes occurred at levels below the 5.0 mg/L criteria specified by FAC Chapter 62-302 for predominantly freshwater. However, none of the 12 dissolved oxygen measurements made during 2002 were below the 5.0 mg/L state criteria.

East Side

Appendix Table C-8 provides the results of dissolved oxygen measurements acquired during the 2002 monitoring year in South Creek. Overall, dissolved oxygen was found to average 4.6 mg/L and range from 1.2 to 8.0 mg/L. The highest dissolved oxygen concentration (7.4 mg/L) was recorded at Station SC-4 during the January event. The lowest average dissolved oxygen level (*i.e.*, 1.2 mg/L) was recorded in the upper-reach of South Creek (at Station SC- 3).

Seasonally, the highest average dissolved oxygen levels were observed for both the January and April 2002 monitoring event with the lowest levels occurring during the October event. This is similar to the previous monitoring years (CCI, 1988a, 1988b, 1991, 1992a, 1993, 1996, 1997 and VHB, 1999, 2000 and 2001), and reflects the changes in the solubility of dissolved oxygen in the water column with changes in water temperature. During 2002, the average dissolved oxygen levels followed seasonal trends and were lower during the warmer events. During the eighteenth monitoring year, dissolved oxygen concentrations in South Creek occurred at levels below the 5.0

mg/L criteria specified by FAC Chapter 62-302 for predominantly freshwater approximately 60% of the time. Of the fifteen dissolved oxygen measurements made during the 2002 monitoring year, nine measurements were below the 5.0 mg/L state criteria.

An evaluation of diurnal variations in dissolved oxygen in Catfish Creek and South Creek was performed during the dry season of 1985 and the wet season of 1986. The results of the diurnal evaluation showed typical increases in dissolved oxygen during the day to maximum levels by mid-afternoon and declines during the night to minimal levels by midmorning, as well as diurnal trends characteristic of the stream community. A summary of the results of the diurnal study is provided in the report prepared by CCI (1987).

4.3.3 *Water pH*

West Side

Results of pH monitoring in Catfish Creek and North Creek during 2002 are provided in **Appendix Table B-9**. During the 2002 monitoring year, pH levels in these two streams of the Palmer Ranch ranged from 6.7 to 7.7. Similar pH ranges were observed during the first through seventeenth monitoring years (Palmer Venture, 1986; and CCI, 1986, 1988a, 1988b, 1991, 1992a, 1993, 1994, 1995b, 1996, 1997, 1998, 1999 and VHB, 1999, 2000 and 2001).

During 2002, the lowest pH levels were observed at CC-1 and NC-6 with pH levels averaging 7.0 and 6.9, respectively. The highest pH levels were recorded at Stations CC-3 and CC-5, which both exhibited average pH levels of 7.6. These minimal differences are attributed primarily to spatial variations in community metabolisms.

East Side

Results of pH monitoring in South Creek during 2002 are given in **Appendix Table C-9**. During the 2002 monitoring year, surface water quality stations along South Creek exhibited pH levels ranging from 6.0 to 7.4. The range of pH observed during the 2002 monitoring year was similar to that observed during previous years of monitoring (Palmer Venture, 1986; and CCI, 1986, 1988a, 1988b, 1991, 1992a, 1995, 1996, 1997, 1998, 1999 and VHB, 1999, 2000 and 2001).

Seasonally, slightly higher pH levels were recorded for the April sampling event. These higher pH levels are probably associated with the less input of low pH stormwater runoff and greater accumulation of algae and plants due to lower stream flows resulting in a greater level of photosynthetic activity. Spatially, the lowest pH levels were observed at SC-3 with pH levels averaging 6.5 units. The highest pH levels were recorded at Station SC-1 and SC-2 with an average of 7.0. These slight differences in pH distributions in South Creek are primarily attributed to spatial variations in community metabolisms.

Differences or changes in pH are indicative of the effects of net community metabolisms on the level of carbon dioxide and pH. During periods of net community respiration, carbon dioxide (CO_2) is produced faster than it is assimilated. When CO_2 is dissolved in water, carbonic acid (H_2CO_3) is formed in the following reaction:

$$H_2O + CO_{2(g)} \rightleftharpoons H_2CO_{3(aq)} \rightleftharpoons H^+ + HCO_3^-$$

As a result of CO_2 production during respiration, water pH is depressed due to the release of hydrogen ions (H^+) as H_2CO_3 dissociates. In contrast, carbon dioxide is consumed faster than it is produced during periods of net community photosynthesis (primary production). Thus, the reaction will shift toward the left, thereby removing CO_2 and increasing pH.

Therefore, pH typically exhibits a diel trend of increases during the day and decreases during the night. The amplitude of the cycle normally depends on the rate of production and consumption and to a lesser extent on the buffering capacity, *i.e.*, alkalinity, of the water and atmospheric exchange of carbon dioxide.

In a diurnal evaluation of Catfish Creek and South Creek, which was conducted during the dry season of 1985 and the wet season of 1986, CCI (1987) reported changes in pH characteristic of the different biological communities. During the day, Catfish Creek and South Creek exhibited changes in pH ranging up to a 1 to 2 unit increase with maximum diurnal changes observed in the lower reach of Catfish Creek (*i.e.*, CC-5) where the greatest metabolic rates were encountered.

As specified in the General Criteria for all surface waters (FAC Chapter 62-302) and in Sarasota County Ordinance No. 98-066, as amended, the allowable variation in pH is 1.0 units above or below the normal pH if the pH is not lowered or elevated outside the range of 6.0 to 8.5. Additionally, if natural background is less than 6.0, the pH shall not vary below the natural backgrounds or vary more than one unit above natural background. Similarly, if natural background is above 8.5, pH shall not vary above natural background or vary more than one unit below background. During the eighteenth year of monitoring, all pH measurements in Catfish Creek, North Creek and South Creek were within the allowable range of 6.0 to 8.5.

4.4 Macronutrients

4.4.1 *Total Nitrogen*

West Side

Appendix Table B-10 provides the results of total nitrogen measurements acquired during the 2002 monitoring year for Catfish Creek and North Creek. Overall, total nitrogen levels in Catfish Creek and North Creek ranged from 0.87 to 2.42 mg/L and averaged 1.32 mg/L during the 2002 monitoring year. Similar average total nitrogen concentrations of 1.37, 1.32 and 1.26 mg/L were observed during the eighth, ninth and fourteenth years of monitoring (CCI, 1992, 1993 and 1998).

Figure 4.4 provides the mean total nitrogen concentrations observed for the streams traversing the west side of the Palmer Ranch during the Second through Eighteenth monitoring years. Also included in **Figure 4.4** is the average total nitrogen concentration measured in Catfish Creek during the "Stormwater Pollutant Loading Monitoring Program" performed at the Palmer Ranch (CCI, 1992b). The mean concentrations for each component of total nitrogen (*i.e.*, ammonia, nitrate + nitrite, and organic nitrogen) are also depicted in **Figure 4.4** in order to compare the relative importance of each nitrogen fraction. The average total nitrogen concentrations for the six monitoring stations in these two streams of the west side of the Palmer Ranch increased in 2002. Of forms of nitrogen that are readily assimilated by algae and plants (*i.e.*, nitrate + nitrite, ammonia), both ammonia and nitrate + nitrite nitrogen slightly increased this year.

Seasonally, total nitrogen concentrations in September were generally higher than those observed during the March semi-annual monitoring event at all stations. During 2001, the upper and lower reaches of Catfish Creek exhibited similar average total nitrogen levels, while the mid reach average was lower in 2002. In Catfish Creek, the highest average total nitrogen concentration of 2.42 mg/L was observed at Station CC-2. The lowest average total nitrogen concentration in Catfish Creek was 0.87 mg/L, and was recorded at Station CC-1. The average total nitrogen levels determined in North Creek were above the average level reported for the stations located in Catfish Creek.

As has been reported for all previous monitoring years, the largest fraction of total nitrogen observed during 2002 is organic nitrogen. During the eighteenth monitoring year, organic nitrogen represented approximately 89.4 percent of total nitrogen and averaged 1.18 mg/L. The second most abundant form of nitrogen was nitrate nitrogen, which represented approximately 9.1 percent of the total nitrogen with an average concentration of 0.12 mg/L. Ammoniacal (*i.e.*, ionized plus unionized ammonia) nitrogen represented approximately 1.5 percent of the total nitrogen with an average level of 0.02 mg/L. As expected, the smallest fraction of total nitrogen was found to be nitrite with an average concentration of 0.01 mg/L that represented 0.8 percent of the total nitrogen concentration.

Similarly, CCI (1986, 1988a, 1988b, 1991, 1992a, 1993, 1994, 1995b, 1996, 1997, 1998 and VHB, 1999, 2000 and 2001) reported generally comparable breakdowns of total nitrogen in Catfish Creek and North Creek during previous years of monitoring. The largest fraction of total nitrogen observed during the previous years of monitoring also occurred as organic nitrogen. Organic nitrogen represented from 76 to 91 percent of the total nitrogen content and averaged from 0.58 to 1.67 mg/L during these periods. The second most abundant form of nitrogen has generally been ammoniacal nitrogen that represented from 4 to 10 percent of the total, with concentrations averaging 0.04 to 0.22 mg/L over the same period. However, in the fourth, twelfth and fourteenth and current year (eighteenth event), nitrate nitrogen represented a higher percent of the total nitrogen. Nitrate represented approximately 4 to 15 percent of the total nitrogen content with average nitrate levels ranging from 0.04 to 0.21 mg/L during the previous years of monitoring. As during the 2002 monitoring year, the smallest fraction of total nitrogen during previous years of monitoring was nitrite, which represented 0.8 percent of the total nitrogen present. During most years of monitoring, the percentage of total nitrogen represented by nitrite was less than 1.

East Side

Total nitrogen measurements acquired during the 2002 monitoring year in South Creek are provided in **Appendix Table C-10**. During the four 2002 sampling events, total nitrogen concentrations in South Creek averaged 1.37 mg/L and ranged from 0.92 to 2.62 mg/L. Spatially, the highest average total nitrogen concentration of 1.82 mg/L was observed at Station SC-4. Station SC-1 exhibited the lowest average total nitrogen concentration at 1.11 mg/L during the 2002 monitoring year. Seasonally, the highest mean total nitrogen concentration (1.68 mg/L) was observed for the October monitoring event.

Overall, total nitrogen concentrations measured during 2002 were only higher than those determined during the ninth, eleventh, twelfth and sixteenth years when total nitrogen averaged 1.17, 1.06, 1.05 and 1.32 mg/L, respectively.

Figure 4.5 provides the mean total nitrogen concentrations observed for South Creek during the second, third, fourth, fifth, sixth, seventh, tenth, eleventh, twelfth, thirteenth, fourteenth, fifteenth, sixteenth, seventeenth and eighteenth monitoring years. Also included in **Figure 4.5** is the average total nitrogen concentration measured in South Creek during the "Stormwater Pollutant Loading Monitoring Program" performed at the Palmer Ranch (CCI, 1992b). In addition, mean concentrations for each component of total nitrogen (*i.e.*, ammonia, nitrate + nitrite, and organic nitrogen) are also depicted in **Figure 4.5** in order to compare the relative importance of each nitrogen fraction. Prior to 1998, average total nitrogen concentrations in South Creek had generally decreased. The average total nitrogen concentration measured during the 2002 monitoring year is below the average recorded during the 18 years of monitoring. The most pronounced decrease in nitrogen content occurred after the third monitoring year (*i.e.*, 1987) (**Figure 4.5**). At that time, an area located upstream of the eastern branch of South Creek on the Palmer Ranch property was used as a dairy farm (August 1987). Before the deactivation of the dairy farm, ammoniacal nitrogen comprised from 11 to 25 percent of the total nitrogen. After the deactivation of the dairy farm, 4 to 6 percent of the total nitrogen content of South Creek was in the form of ammonia. Not only have total nitrogen levels decreased, the forms of nitrogen that are readily assimilated by algae and plants (*i.e.*, nitrate + nitrite and ammonia) have also declined. The largest fraction of total nitrogen observed during the entire monitoring program is organic nitrogen. During the eighteenth monitoring year, organic nitrogen represented approximately 94.2 percent of total nitrogen and averaged 1.29 mg/L. The second most abundant form of nitrogen during 2002 was ammoniac nitrogen (*i.e.*, ionized and un-ionized ammonia), which represented approximately 2.9 percent of the total nitrogen with an average concentration of 0.04 mg/L. Nitrate nitrogen also represented approximately 2.9 percent of the total nitrogen. As expected, the smallest fraction of total nitrogen was found to be nitrite with the concentration in the majority of samples collected during 2002 being at or below the 0.01-mg/L analytical detection limit. Therefore, nitrite represented approximately 0.7 percent of the total nitrogen concentration.

As stated previously, different breakdowns of total nitrogen were reported for South Creek during previous monitoring years (CCI, 1986, 1988a, 1988b, 1991 and 1992a). The largest fraction of total nitrogen observed during the previous years of monitoring also occurred in the form of organic nitrogen. Prior to 1988, organic nitrogen represented from 71 to 84 percent of the total nitrogen content and averaged from 1.08 to 2.18 mg/L. After the fourth monitoring year, organic nitrogen comprised ≥88 percent of the total nitrogen measured in South Creek. Similarly, the second most abundant form of nitrogen prior to 1988 was ammoniacal nitrogen that represented from 11 to 24 percent of the total nitrogen content with average levels of 0.15 to 0.59 mg/L. Ammoniacal nitrogen also represented the second most abundant form of nitrogen after 1988. However, generally only 4 to 5 percent of the nitrogen was present in the ammonia fraction. Nitrate and nitrite represented approximately from 2 to 7 percent of the total nitrogen content with an average nitrate concentration ranging from 0.02 to 0.10 mg/L during the previous years of monitoring. As during the 2002 monitoring year, the smallest fraction of total nitrogen during previous years of monitoring was nitrite, which represented less than 1 percent of the total nitrogen present during all years.

As specified in FAC Chapter 62-302, nutrients, including total nitrogen, shall not be elevated to levels causing an imbalance in the natural flora and fauna, a condition characteristic of eutrophic or nutrient-rich streams. In this respect, there were some implications in the data acquired during the second, third, and fourth monitoring years that linked the observed total nitrogen levels to eutrophic conditions even though there appeared to be a general trend of decreasing nitrogen levels as previously discussed (CCI, 1986, 1988a, 1988b, 1991, 1992a, 1993, 1994, 1995b, 1996, 1997 and 1998). Total nitrogen results obtained during the 2002 were below the average measured during the eighteen years of the monitoring program and only one (1) of the 12 total nitrogen samples collected on the west side of the Palmer Ranch exhibited concentrations above the 2.0 mg/L screening level (considered by the FDEP (FDER, 1990) to be characteristic of eutrophic conditions). In addition, two (2) of the fifteen total nitrogen samples collected on the east side of the Palmer

Ranch exceeded the screening level of 2.0 mg/L considered to be characteristic of eutrophic conditions.

4.4.2 *Nitrite*

West Side

Nitrite levels observed in Catfish Creek and North Creek during the eighteenth year of monitoring are provided in **Appendix Table B-11**. As expected, nitrite concentrations throughout these two streams traversing the west side were much lower than for other forms of nitrogen, and too low to be a significant nutrient source. Four of the 12 samples collected during the 2002 monitoring year contained nitrite concentrations above the 0.01 mg/L analytical detection limit. During the previous monitoring years, nitrite concentrations measured in Catfish Creek and North Creek averaged <0.01 to 0.03 mg/L and had a range from <0.01 to 0.20 mg/L (CCI, 1987, 1988a, 1988b, 1991, 1992a, 1993, 1994, 1995b, 1997, 1998 and VHB, 1999, 2000 and 2001).

East Side

Nitrite levels observed in South Creek during the eighteenth year of monitoring are also provided in **Appendix Table C-11**. Nitrite concentrations throughout South Creek were much lower than the other forms of nitrogen, and too low to be a significant nutrient source. Six of the fifteen samples collected during the 2002 monitoring year contained nitrite concentrations above the analytical detection limit. During the previous monitoring years, nitrite concentrations measured in South Creek averaged <0.01 to 0.02 mg/L and had a range from <0.01 to 0.13 mg/L (CCI, 1986, 1987, 1988a, 1988b, 1991, 1992a, 1995, 1996, 1997, 1998 and VHB, 1999, 2000 and 2001).

As a nutrient, nitrite is covered by the general water quality standard (FAC Chapter 62-302). However, due to the observed low concentrations, nitrite was generally of little importance as a nutrient in the streams of the Palmer Ranch. For all practical purposes, nitrite is considered to meet desired standards.

4.4.3 *Nitrate*

West Side

As shown in the results provided in **Appendix Table B-12**, nitrate levels observed for Catfish Creek and North Creek in the Palmer Ranch during 2002 exhibited a yearly average of 0.12 mg/L with a range of <0.01 to 0.58 mg/L. Similar nitrate concentrations were reported for the eighth, ninth, twelfth and seventeenth monitoring years. During these years average nitrate concentrations ranged from 0.10 to 0.13 mg/L (CCI, 1992, 1993, 1996 and VHB, 2001).

Nitrate levels were slightly higher during the March monitoring event averaging 0.14 mg/L in Catfish and North Creeks compared to an average of 0.10 mg/L determined for the September sampling. The higher average nitrate level recorded during the March monitoring event resulted from elevated nitrate concentrations at Stations NC-6 and CC-1 whose nitrate concentrations were 0.58 and 0.22 mg/L, respectively. Nitrate concentrations of 0.58 and 0.26 mg/L were recorded at Station NC-6 during the March and September monitoring events, respectively, with the concentration at the other monitoring stations being at lower levels (**Appendix Table B-12**). Spatially, the highest average nitrate concentration of 0.42 mg/L was observed at Station NC-6. Due to the very low levels of nitrate generally found during 2002 no other spatial trends could be discerned.

East Side

As shown in the results provided in **Appendix Table C-12**, nitrate levels observed for South Creek the Palmer Ranch during 2002 exhibited a yearly average of 0.04 mg/L with a range of <0.01 to 0.15 mg/L. The 2002 nitrate concentrations are comparable to those determined during the eleventh, thirteenth and fourteenth monitoring years when nitrate exhibited yearly averages of 0.04 mg/L (CCI, 1995, 1997 and 1998).

Seasonally, the highest nitrate levels for the four monitoring sites during 2002 were observed during the January and October sampling events. Slightly higher nitrate levels commonly occur in October when higher rainfall amounts result in an increase of stormwater runoff, which occurs during the summer. Nitrate concentrations observed during the July event at all four monitoring sites in the South Creek basin were below the detection limits. These low concentrations of nitrate probably are a result of low inputs of nutrients in the form of stormwater runoff as well as higher nutrient uptake by aquatic vegetation.

Spatially, the highest average nitrate concentration of 0.05 mg/L was recorded for the lower reach (Station SC-1) of the creek (**Appendix Table C-12**).

As a nutrient, nitrate is designated as a parameter covered by the general water quality criteria (FAC Chapter 62-302), and is an important limiting nutrient in the streams of the Palmer Ranch. Therefore, increases in nitrate availability from anthropogenic sources would accelerate production rates of aquatic plants resulting in an imbalance in the flora and fauna that would be considered a violation of the nutrient standard. The nitrate concentrations determined during the 2002 monitoring year were similar to those recorded during the previous years of monitoring and are not thought to represent an important source of nitrogen in the streams of the Palmer Ranch. Therefore, nitrate is considered to meet desired criteria.

4.4.4 *Ammoniacal Nitrogen*

West Side

Appendix Table B-13 provides the results of ammoniacal nitrogen measurements (ionized plus un-ionized ammonia) recorded during the eighteenth year of monitoring on the west side of Palmer Ranch. As described previously, ammoniacal nitrogen represented approximately 1.5 percent of the total nitrogen measured during the 2002 monitoring year. Overall, ammoniacal nitrogen exhibited an average of 0.02 mg/L with a range from <0.01 to 0.03 mg/L. Ammonia concentrations measured during 2002 were within the range determined for the previous years of monitoring (Palmer Venture, 1986; and CCI, 1986, 1988a, 1991, 1992a, 1993, 1994, 1995b, 1996, 1997, 1998 and VHB, 1999, 2000 and 2001).

Seasonally, ammoniacal nitrogen concentrations in Catfish Creek and North Creek averaged 0.03 and <0.01 mg/L during the March and September sampling events, respectively. Spatially, identical average ammoniacal nitrogen concentrations occurred within all stations of Catfish Creek and North Creek with the ammonia concentrations averaging 0.02 mg/L.

East Side

Appendix Table C-13 provides the results of ammoniacal nitrogen measurements (ionized plus un-ionized ammonia) recorded during the eighteenth year of monitoring at South Creek. As described previously, ammoniacal nitrogen represented 2.9 percent of the total nitrogen measured during the 2002 monitoring year. Overall, ammoniacal nitrogen exhibited an average of 0.04 mg/L with a range from <0.01 to 0.08 mg/L. Similar ammoniacal nitrogen concentrations were observed during 1986, 1987, 1991, 1996, 1997, and 2000. During these years, ammoniacal nitrogen levels averaged from 0.04 to 0.06 mg/L (Palmer Venture, 1986; CCI, 1987, 1991, 1996, 1997 and VHB, 2000). During the previous years of monitoring (and CCI, 1988a, and 1988b), ammonia concentrations were higher than those measured during the 1996, 1997, 1998, 1999, 2000, 2001 and 2002 monitoring years. These higher levels can be attributed to runoff originating from a dairy farm upstream of the Palmer Ranch property.

The highest ammoniacal nitrogen concentrations in South Creek were recorded during the January 2002 sampling event averaging 0.07 mg/L. These higher ammoniacal nitrogen concentrations are believed to be associated with the decay of vegetation in the creek. Additional ammoniacal nitrogen input is also associated with stormwater runoff entering the creek, which occurs during prolonged and/or heavy amounts of precipitation.

Although ammoniacal nitrogen is a nutrient and therefore has the potential to influence the growth of the primary producers (plants) and their balance with the consumers (bacteria and animals), FAC Chapter 62-302 does not provide a quantitative nutrient standard for ammoniacal nitrogen. Even though ammoniacal nitrogen is a potentially important nutrient to the primary producers in the streams of the Palmer Ranch, results obtained during the monitoring program suggest that nitrate might be the preferred nitrogen source. This indication is based on trends observed during previous monitoring years as related to normal plant production and decay (CCI, 1996). Other freshwater studies (Wetzel, 1975) have also concluded that aquatic vegetation, including algae, prefer nitrate to ammonia. Although it might be less preferred than nitrate, increases in ammonia have the ability to accelerate plant production, and, in turn, influence the balance between the flora and fauna of the streams traversing the Palmer Ranch. Concentrations of ammoniacal nitrogen determined during the 2002 monitoring year were generally similar to those recorded during the previous years of monitoring. These levels are not thought to represent an important source of nitrogen in the streams of the Palmer Ranch. Therefore, ammonia is considered to meet desired criteria. Since the un-ionized fraction of ammoniacal nitrogen was not evaluated independently, comparisons to County and State criteria for un-ionized ammonia were not made.

4.4.5 *Organic Nitrogen*

West Side

Organic nitrogen[2] concentrations determined in Catfish Creek and North Creek within the Palmer Ranch during the 2002 monitoring year are provided in **Appendix Table B-14**. Overall, an average organic nitrogen concentration of 1.18 mg/L was measured in these streams on the west side during the 2002 monitoring year with a range from 0.62 to 2.40 mg/L. Similar average organic nitrogen concentrations were observed during the third, and eighth monitoring years (CCI, 1987 and 1992) with concentrations of 1.23 and 1.17, respectively. Lower organic nitrogen concentrations were reported for the 1994, 1995 and 1997 monitoring years. Organic nitrogen concentrations for these three years averaged 0.86, 0.58 and 0.82 mg/L, respectfully (CCI, 1994, 1995b and 1997). A stabilizing or gradual improvement in water quality with respect to nitrogen is documented over the past ten years. Also, channel maintenance in Trunk Ditch during the fourth monitoring year, as well as the aquatic community changes resulting from the "reconstruction" of a segment of the Catfish Creek/Trunk Ditch Basin during the second year, may have contributed to the stabilizing/declining trend in organic nitrogen.

The concentration of organic nitrogen followed the expected seasonal trends as observed during previous monitoring years when organic nitrogen levels increased from the spring through the summer. As during most of the monitoring years, higher organic nitrogen concentrations were recorded during the September 2002 monitoring event as compared to the March sampling event. Organic nitrogen levels in Catfish and North Creeks averaged 1.02 and 1.35 mg/L during the March and September 2002 monitoring events, respectively.

Typically, peaks in organic nitrogen during September are apparently associated with peaks in the standing crop of aquatic vegetation and storm water loadings, since this month represents the primary wet season. During the fall and winter, the standing crop of vegetation declines in association with low production rates and the decay of plant material. In past monitoring years, organic nitrogen concentrations have exhibited a concomitant decline as the plant material was depleted by the microbial heterotrophs during this period. Additionally, storm water loading rates

[2]Organic Nitrogen = Total Kjeldahl Nitrogen - Ammoniacal Nitrogen.

most likely declined in association with minimal runoff during the relatively drier months of October through May.

East Side

Organic nitrogen concentrations determined in South Creek within the Palmer Ranch during the 2002 monitoring year are provided in **Appendix Table C-14**. An average organic nitrogen concentration of 1.29 mg/L was measured in South Creek during the eighteenth year of monitoring with a range from 0.88 to 2.57 mg/L. The average organic nitrogen level during the 2002 monitoring year was lower than that was observed during the last monitoring year, yet is comparable to the data recorded in 1995 where organic nitrogen level was 1.26.

Seasonally, organic nitrogen concentrations were highest during the April and October events with organic nitrogen concentrations averaging 1.60 and 1.56 mg/L, respectively. Lower organic nitrogen levels were observed in the January and July events with average concentrations 1.13 and 0.95 mg/L, respectively (**Appendix Table C-14**). The lower organic nitrogen concentration probably resulted from greater flushing of the creek by increases in rainfall and subsequent stormwater runoff causing less accumulation of decaying vegetation.

4.4.6 *Total Phosphorus*

West Side

During the 2002 monitoring year, total phosphorus in the Catfish Creek/Trunk Ditch basin of the Palmer Ranch averaged 0.15 mg/L and a range of 0.04 to 0.38 mg/L (**Appendix Table B-15**). The highest total phosphorus level, 0.38 mg/L, was recorded at Stations CC-2 during the September monitoring event. The lowest mean total phosphorus concentrations were observed at Stations CC-3 and NC-6 (**Appendix Table B-15**).

Similar total phosphorus distributions were observed during the 1989, 1990, 1991, 1995, 1996, 1998, 2000 and 2001 monitoring years, with concentrations averaging 0.12, 0.12, 0.15, 0.18, 0.17, 0.12, 0.15 and 0.15 mg/L, respectively (CCI, 1990, 1991, 1992, 1996, 1997 and VHB 2000 and 2001). During the 1992 monitoring year, higher total phosphorus concentrations were observed with an average concentration of 0.38 mg/L and a range of 0.06 to 2.22 mg/L (CCI, 1993). **Figure 4.6** provides the average phosphorus levels recorded for the second through the eighteenth years of monitoring. For comparison, the fractionation of orthophosphate and organic phosphorus levels is also provided in **Figure 4.6**. Average phosphorus concentrations in the Catfish Creek/Trunk Ditch and North Creek Basins declined during the third, fourth, fifth, sixth, seventh, ninth, eleventh, twelfth, fourteenth and sixteenth years of monitoring, as illustrated in **Figure 4.6**. However, average phosphorus levels recorded for the eighth year of monitoring were higher than recorded for previous years. This observed increase in phosphorus was attributed to a high rainfall amount of 41.59 inches recorded during the primary wet season. Additionally, the average phosphorus level increased slightly during the thirteenth and fifteenth monitoring years. These increases are primarily due to an increase in organic phosphorus which may have resulted from the drier conditions experienced during much of the year and the subsequent die-off and decay of vegetation. The total phosphorous levels observed during the eighteenth year of monitoring were below the average recorded to date.

East Side

During the 2002 monitoring year, total phosphorus in South Creek averaged 0.20 mg/L with a range of 0.05 to 0.37 mg/L (**Appendix Table C-15**). Total phosphorus concentrations during 1997, 1998, 1999 and 2000 were similar, averaging 0.23, 0.19, 0.24 and 0.25 mg/L, respectively (CCI, 1997, 1998 and VHB, 1999 and 2000). The highest total phosphorus levels were reported for the second monitoring year with concentrations averaging 1.63 mg/L (CCI, 1986). The source of this phosphorus in the South Creek basin of Palmer Ranch during the second year of monitoring was attributed to runoff originating from the dairy farm draining into the eastern tributary of the creek. A pronounced decrease in total phosphorus concentration was observed after the deactivation of the dairy farm located upstream of the Palmer Ranch property.

Generally, average phosphorus concentrations in the South Creek basin have declined during the third through the eighteenth years of monitoring, as illustrated in **Figure 4.7**. However, total phosphorus concentrations increased slightly during the eleventh year of monitoring. This increase was attributed to higher nutrient input to South Creek in the form of runoff resulting from higher than normal rainfall recorded for the 1995 monitoring year. For comparison, the fractionation of orthophosphate and organic phosphorus levels is also provided in **Figure 4.7**. In general, orthophosphate comprised 50 percent of the total phosphorus content in South Creek.

As a nutrient, phosphorus is required by algae and other plants for the primary production of organic matter and, therefore, as specified in FAC Chapter 62-302, shall not be elevated to levels that will cause an imbalance in the natural flora and fauna. The results of the 2002 monitoring year indicate that none of the 12 samples collected on the west side of Palmer Ranch exhibited a total phosphorus concentration that exceeded the FDEP screening level of 0.46 mg/L (FDER, 1990). In addition, none of the fifteen total phosphorus concentrations measured in South Creek exceeded the FDEP screening level. The majority of the total phosphorus concentrations measured in Catfish Creek, North Creek and South Creek were above the 0.09 mg/L level determined to be the median concentration for Florida streams (FDER, 1990).

Similar phosphorus concentrations are normally found in west central Florida because of the widespread deposits of naturally occurring phosphate (Sheldon, 1982). Interestingly, well driller's logs show that phosphates exist in shallow deposits on the Palmer Ranch (Patton and Associates, 1984). In the past years, a relatively high correlation was found between the total phosphorus concentrations and turbidity levels which suggests the controlling role of naturally occurring phosphate deposits on the phosphorus concentrations in the streams of the Palmer Ranch. In addition, Palmer Venture (1986) noted that the phosphate levels in the streams of the Palmer Ranch were significantly influenced by groundwater during periods when stream flow was augmented by groundwater exfiltration (*i.e.*, low flow conditions). Consequently, phosphates originating from these naturally occurring deposits within, or upstream of, the Palmer Ranch should not be considered violations even though they exhibit the potential for contributing to high rates of primary production and a concomitant imbalance in the flora and fauna.

4.4.7 *Orthophosphate*

West Side

Orthophosphate concentrations determined in the streams traversing the west side of Palmer Ranch during the 2002 monitoring year are provided in **Appendix Table B-16**. Overall, the Catfish Creek/Trunk Ditch and North Creek basins of the Palmer Ranch exhibited an average orthophosphate concentration of 0.06 mg/L with a range from <0.01 to 0.20 mg/L. As expected, orthophosphate concentrations during 2002 exhibited spatial and seasonal trends similar to those observed for total phosphorus.

Similar orthophosphate concentrations were reported during the 1987, 1990, 1991, 1998 and 2000 monitoring years (CCI, 1988, 1991, 1992 and 1999 and VHB, 2001). Orthophosphate concentrations measured during these monitoring years averaged from 0.06 to 0.09 mg/L. The 2002 average orthophosphate level was tied for the lowest average recorded for the Catfish Creek/Trunk Ditch and North Creek basins to date. The highest averages occurred during the fourth and eighth monitoring years, where orthophosphate concentrations averaged 0.21 and 0.29 mg/L, respectively.

Although the phosphorus concentrations have varied considerably over the last seven years, the percentage of total phosphorus consisting of orthophosphate has remained relatively constant averaging 40 percent for the past two years. In general, orthophosphate represented approximately 50 to 88 percent of the total phosphorus recorded for previous ten years of monitoring.

Seasonally, higher orthophosphate concentrations were observed during the September monitoring event. Generally, the higher orthophosphate concentrations are observed during the September event and reflect the high rainfall experienced prior monitoring. This temporal increase in orthophosphate concentrations recorded at the end of the primary wet season is attributed to increased runoff during the primary wet season.

East Side

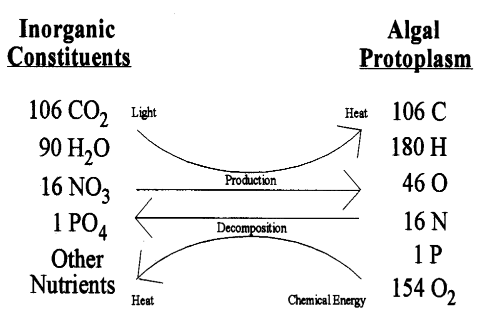
Orthophosphate concentrations determined in South Creek traversing the Palmer Ranch during the 2002 monitoring year are provided in **Appendix Table C-16**. Overall, the South Creek basin of the Palmer Ranch exhibited an average orthophosphate concentration of 0.10 mg/L during the eighteenth year of monitoring with a range from 0.01 to 0.28 mg/L. The highest orthophosphate concentrations observed during the 2002 monitoring year occurred in July 2002. Historically, the average orthophosphate concentration observed during the 2002 monitoring year was the lowest to date. Significantly higher orthophosphate concentrations were reported for the second through fourth monitoring years. During these monitoring periods, orthophosphate concentrations averaged from 0.53 to 1.37 mg/L (CCI, 1987, 1988a, and 1988b). These higher orthophosphate levels reported for previous monitoring years were attributed to runoff that originated from a deactivated dairy farm that discharged into the eastern tributary of South Creek.

The percentage of total phosphorus consisting of orthophosphate has remained relatively constant in South Creek, ranging from 71 to 95 percent, except for 1997 when it represented 55 percent. In 2002, orthophosphate represented approximately 50 percent of the total phosphorus. The lower percentage of orthophosphate determined in 1997 and 2002 may be associated with the overall lower phosphorus levels observed and the relatively dry antecedent conditions for most sampling events. The drier conditions would result in less orthophosphate being transported to the surface waters. Therefore, a greater percentage of the orthophosphate in the creek would be organic phosphorus resulting from decaying vegetation.

As a nutrient, orthophosphate is designated by FAC Chapter 62-302 as a general water quality parameter. This criterion specifies that the discharge of nutrients, such as orthophosphate, shall be limited to prevent an imbalance in the natural populations of aquatic flora and fauna. Although the observed levels are occasionally above the threshold considered to indicate eutrophic conditions as defined by FDEP (FDER, 1983), orthophosphate has been found to occur naturally on the Palmer Ranch. Consequently, other factors, such as nitrogen availability, are probably more growth limiting than orthophosphate. Therefore, the phosphate levels found during the 2002 monitoring year are not likely to have caused an imbalance in the aquatic flora and fauna.

4.4.8 *Nutrient Ratios*

Nitrate and phosphate are required by aquatic plants in proportions of approximately 6.8:1 on a weight basis (or 16:1 N:P on a molar basis) (Odum, 1959 and GESAMP, 1987). Nitrogen and phosphorus are assimilated in this proportion by the primary producers (rooted aquatic plants and algae) and converted into protoplasm during the process of photosynthesis. Conversely, the (unresistant or digestible) organic forms of nitrogen and phosphate are oxidized back into their biogenic salts during the process of aerobic respiration, *e.g.*, organic decomposition, heterotrophic activity. This relationship can be illustrated as:



The primary forms of these biogenic salts are nitrate and orthophosphate. However, nitrate may be substituted by some plants for other forms of nitrogen, such as ammonia. Also of importance, orthophosphate may be accumulated and stored as polyphosphates by some algae, thereby alleviating a potential future phosphate limiting condition.

Importantly, other limiting factors such as low light and low dissolved oxygen could play as important, if not more important, roles in limiting the rate of primary production and decomposition in the streams of the Palmer Ranch, respectively. For example, if the availability of inorganic nitrogen is high and the N_i:P_i ratio is low, *e.g.*, 2:1, it would indicate that some factor other than inorganic nitrogen is the real limiting factor. Even so, determinations and the use of nutrient ratios in light of other important and potentially limiting factors are helpful in evaluating the results of long-term monitoring programs when nutrient loading and its consequences are major concerns, such as for the "Continuing Surface Water Quality Monitoring Program."

Total nitrogen to total phosphorus ratios (N_t:P_t) are provided in **Appendix Tables B-17 and C-17** with ratios of inorganic nitrogen (ammonia, nitrite, and nitrate) to orthophosphate (N_i:P_i) being given in **Appendix Tables B-18 and C-18**. The most meaningful ratio in assessing nutrient limiting conditions is based on the inorganic forms (biogenic salts as previously discussed) since these constituents are immediately available to the primary producers whereas even the unresistant organic forms must be chemically transformed into the inorganic forms prior to photosynthesis.

West Side

The N_i:P_i ratios determined from March 2002 nutrient data are found to average approximately 4.73:1. A slightly higher average ratio was observed for the September event (i.e., 5.09:1) primarily because of large ratios observed at Stations CC-4 and NC-6. Generally, a low N_i:P_i ratio would be indicative of conditions in which fixed inorganic nitrogen would limit plant growth before orthophosphate. Nutrient data collected at Stations CC-4 and NC-6 during the September monitoring event yielded a N_i:P_i ratio 8.40:1 and 13.95:1, respectively. This high ratio suggests that surface waters at this station may be limiting with respect to phosphorus. Further, this ratio indicates that additional input of nitrogen to Stations CC-4 and NC-6 may be associated with increased decomposition of organic matter in conjunction with decreased gross primary productivity.

The $N_t:P_t$ ratios determined from 2002 nutrient data in the Catfish and North Creeks exhibited an overall average of 13.74:1 (**Appendix Table B-17**). Because this ratio is higher than 6.8:1, it would be indicative of a system out of balance with respect to nitrogen and phosphorus. Since the $N_t:P_t$ ratio is higher than 6.8:1(algal protoplasm, by weight) it indicates a condition in which phosphorus would limit plant growth before nitrogen. However, it is important to note that this average $N_t:P_t$ ratio is skewed with respect to the March 2002 monitoring event. During this event, the $N_t:P_t$ ratio calculated for Stations CC-2, CC-3 and NC-6 were, 15.55:1, 17.50:1 and 36.50:1, respectively, suggesting that there may be additional nitrogen input in the vicinity of Stations CC-2, CC-3 and NC-6 (Meybeck, 1982).

Overall, the generally low $N_i:P_i$ ratios calculated from the 2002 data are attributed to the naturally high levels of orthophosphate, while total nitrogen is comprised of approximately 13 percent inorganic nitrogen. The higher $N_t:P_t$ ratios determined during the 2002 monitoring events are indicative of the abundance of aquatic vegetation in the creeks and the high percentage of organic nutrients present.

East Side

The $N_i:P_i$ ratios determined during 2002 for South Creek are generally low and found to average approximately 2.99:1. This is indicative of conditions in which fixed inorganic nitrogen would limit plant growth before orthophosphate (**Appendix Table C-18**). Conversely, the $N_t:P_t$ ratios for South Creek were found to average 9.54:1 indicating a different balance with respect to nitrogen and phosphorus (**Appendix Table C-17**). In a nutrient-balanced system, neither nitrogen nor phosphorus limit plant growth because both are present in the proper proportions for plant growth. The lower $N_i:P_i$ ratios calculated from the 2002 data are attributed to the naturally high levels of orthophosphate, as well as the high percentage of total phosphorus represented by orthophosphate (50 percent of total phosphorus) while approximately 4 percent of the total nitrogen is comprised of inorganic nitrogen.

During the eighteenth year of monitoring, the $N_i:P_i$ ratios in South Creek were generally indicative of excess phosphorus with respect to nitrogen (*i.e.*, nitrogen limited system). Only during January did N_i:P_i ratios exhibit high averages (9.44:1). The N_i:P_i ratios averaged approximately 1.10:1, 0.29:1, and 0.66:1 during the April, July and October events, respectively.

4.5 Oils and Greases

<u>West Side</u>

As provided in **Appendix Table B-19**, the concentration of oil and grease in the streams on the west side of the Palmer Ranch averaged 1.9 mg/L during the 2002 monitoring year. Additionally, all oil and grease measurements made during 2002 were below the State and County standard of 5.0 mg/L specified in FAC Chapter 62-302. The concentrations of oils and greases reported in the streams of the west side during the previous years of the monitoring program (Palmer Venture, 1986; and CCI, 1986, 1988a, 1988b, 1991, 1992a, 1993, 1994, 1995b, 1996, 1997, 1998 and VHB, 1999, 2000 and 2001), ranged from less than 0.1 mg/L to 17 mg/L. Most of the historic observations (264 of 271) were found to be less than the maximum allowable State criteria of 5.0 mg/L.

<u>East Side</u>

Six of the fifteen oil and grease concentrations determined for water samples collected in the South Creek during the 2002 monitoring year were below analytical detection limits (**Appendix Table C-19**). Overall, oil and grease content in South Creek averaged 2.7 mg/L and ranged from <1.4 to 12.3 mg/L. Fourteen of the fifteen measurements made during 2002 were below the State standard of 5.0 mg/L specified in FAC Chapter 62-302. The concentrations of oils and greases reported in South Creek during the previous years of the monitoring program ranged from <0.2 mg/L to 11 mg/L. Ninety-nine (99) percent of the observations (*i.e.*, 182 of 184) in the Palmer Ranch portion of South Creek were found to be lower than the maximum allowable State criteria of 5 mg/L.

4.6 Bacteriological Parameters

4.6.1 *Total Coliform*

<u>West Side</u>

As indicated in **Appendix Table B-20**, the streams traversing the west side were found to exhibit concentrations of total coliform bacteria ranging from 100 to 8,400 colonies/100 mL with an average of 1,393 colonies/100 mL. Of the 12 samples collected during the 2002 monitoring year, only two (2) exceeded the State and County water quality standards which allow up to 2,400 colonies/100 mL. The highest bacteria concentrations were observed in the upper reach of the Catfish Creek/Trunk Ditch basin. During the second, third, fourth, sixth, seventh and fourteenth monitoring years (CCI, 1986, 1988a, 1988b, 1991, 1992a and 1999), the total coliform concentrations in the Catfish Creek/Trunk Ditch basin were also found to commonly exceed the State and County standards with 67, 52, 53, 43, 78, 32 and 55 percent of the results being higher than the 2,400 colonies/100 mL criteria, respectively.

During previous years of monitoring, the highest number of total coliform bacteria colonies have generally been observed after periods of rainfall, typically during the primary wet season. The results, however, for the 2002 monitoring year were different. The mean total coliform level recorded for the March monitoring event in Catfish and North Creeks was 2,333-colonies/100 mL compared to an average of 452-colonies/100 mL for the September event. More common seasonal trends with respect to coliform bacteria levels are typically associated with rainfall.

East Side

As indicated in **Appendix Table C-20**, South Creek was found to exhibit total coliform bacteria concentrations ranging from 80 to 1,350 colonies/100 mL and averaging 534 colonies/100 mL. None of the 15 total coliform bacteria levels measured during 2002 exceeded the State water quality criteria, which allows up to 2,400 colonies/100 mL.

The highest total coliform bacteria levels observed during 2002 occurred during stagnant water conditions in April (average of 1,070 colonies/mL) with the second highest levels during October with bacteria levels averaging 560 colonies/100 mL.

Spatially, the highest average bacteria concentration (*i.e.*, 670 colonies/100 mL) was observed at Station SC-2 of the South Creek Basin. The cattle and wild animals using the area around Station SC-2 are likely to represent the most significant source of bacteria in the area.

As noted in previous years (CCI, 1988a, 1988b, 1991, 1992a, 1995, 1996, 1997, 1998 and VHB, 1999, 2000 and 2002), data show that several sources of coliform bacteria exist on and upstream of the Palmer Ranch. A primary source is expected to be the naturally occurring coliform bacteria of the soils and vegetation on and upstream of the ranch. During periods of land clearing coupled with significant runoff, this source is expected to be exacerbated. Such a condition probably occurred during the second and third monitoring years in the Catfish Creek/Trunk Ditch basin as the construction of Prestancia was initiated. Another source of coliform bacteria is represented by the warm-blooded animals inhabiting the watershed, including dogs, cats, cattle, birds, feral hogs, deer, and rodents.

4.6.2 *Fecal Coliform*

West Side

During the 2002 monitoring year, the streams on the west side of the Palmer Ranch exhibited fecal coliform densities ranged from <100 to 1,200 colonies/100 mL and averaged 289 colonies/100 mL (**Appendix Table B-21**). Only one of the twelve samples (8 percent) collected during 2002 contained fecal coliform bacteria densities exceeding the 800 colonies/100 mL maximum allowed by State and County water quality criteria for Class III surface waters. The 2002 results reported this year are the lowest to date. Previous monitoring years exhibited 18 to 73 percent of the samples collected exceeding the 800 colonies/100 mL standard.

Spatially, the highest number of fecal coliform colonies during the 2002 monitoring year occurred in the upper reach of the Catfish Creek/Trunk Ditch basin at Station CC-1. This indicates that the fecal coliform bacteria are primarily associated with runoff draining into the Catfish Creek/Trunk Ditch basin from off-site. As described for total coliform bacteria, higher fecal coliform levels have typically been observed in Catfish and North Creeks during the September monitoring event (*i.e.*, end of the summer wet season). However, during the 2002 monitoring year, the highest mean fecal coliform level of 300 colonies/100 mL was observed during the March monitoring event compared with an average of 278 colonies/100 mL determined for the September sampling. During the March sampling event, a large concentration (1,200 colonies/mL) observed at Stations CC-1 was primarily responsible for the high seasonal average. The high fecal coliform bacteria levels observed in the upper reach of Catfish Creek within the Palmer Ranch indicate significant sources of fecal coliform bacteria originating upstream the ranch.

East Side

During the eighteenth year of monitoring, the South Creek basin of the Palmer Ranch exhibited fecal coliform densities that ranged from 30 to 490 colonies/100 mL and averaged 151 colonies/100 mL (**Appendix Table C-21**). Of the fifteen samples collected during 2002, none exceeded the Class III State and County Standard of 800 colonies/100 mL. This is below, but comparable to the low range of 15 to 29 percent, which was recorded during the third, fourth, sixth, seventh and fourteenth monitoring years.

Spatially, Station SC-3 had the highest average concentration of fecal coliform colonies during the 2002 monitoring year. The higher bacteria levels in this portion of the creek probably reflect the greater number of warm-blooded animals in the stream communities associated with the upstream areas of the creek. Primary sources of fecal coliform bacteria are considered to be dogs, cats, birds, cattle, and other warm-blooded wild animals inhabiting the basin.

4.7 Trace Elements

<u>West Side</u>

During 2002, samples were collected for the analyses of trace elements (*i.e.*, arsenic, copper, lead, and zinc) during the September monitoring event. The results of these analyses are provided in **Appendix Table B-22** along with the applicable State and County Standards for each element.

Arsenic concentrations during the 2002 monitoring year ranged from 2.0 to 7.4 µg/L and averaged 4.7 µg/L (**Appendix Table B-22**). The concentrations of copper ranged from 2.3 to 47.2 µg/L and averaged 12.7 µg/L. Total lead concentrations measured in the streams on the west side of the Palmer Ranch during 2002 averaged <1.0 µg/L. The concentration of zinc determined for the six monitoring stations during 2002 averaged 4.7 µg/L.

<u>East Side</u>

During the 2002 monitoring event, samples were collected in South Creek for the analyses of trace elements (*i.e.*, arsenic, copper, lead, and zinc) during the October event. The results of these analyses are provided in **Appendix Table C-22** along with the applicable State Standards for each element.

Arsenic concentrations during the 2002 monitoring year ranged from 2.6 to 4.2 µg/L and averaged 3.3 µg/L (**Appendix Table C-22**). Concentrations of total copper in the South Creek basin during the 2002 monitoring period averaged 1.0 µg/L and ranged from <1.0 to 1.6 µg/L. All total lead concentrations measured on the east side of the Palmer Ranch during 2002 were less than 1.0 µg/L

(**Appendix Table C-22**). The concentration determined for zinc samples collected in South Creek during 2002 averaged 16, with a range of 10 to 25 µg/L.

All arsenic concentrations measured during the 2002 monitoring year on Palmer Ranch were below the State standard of 50 µg/L[3]. Possible sources of arsenic include naturally occurring minerals and the use of arsenic-based pesticides on and upstream of the Palmer Ranch. Only one of the copper concentrations on the ranch exceeded the State and County standard of 12.8 µg/L[4]. Possible sources of copper in the surface waters of the Palmer Ranch include the use of copper containing herbicides, fertilizers, algicides, and pesticides. All of the measured lead concentrations in streams on Palmer Ranch were in compliance with the State and County standard of 3.6 µg/L[5]. Possible anthropogenic sources of lead in the surface waters of the Palmer Ranch included automobile emissions, roads and parking areas, and runoff from light industrial land uses located upstream of the Palmer Ranch property. All zinc concentrations determined during the 2002 monitoring events were within the State and County standard of 115 µg/L based upon a hardness of 110 mg/L. Possible sources of zinc include the use of zinc containing fertilizers and runoff from roads on and upstream of the Palmer Ranch.

[3]Based on a total hardness of 110 mg/L

[4]*Ibid*.

[5]*Ibid*.

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