Biological Research Associates
Founded 1974

Horse Creek Stewardship Program

Summary of Historical Information On Water Quantity, Quality and Aquatic Biology

Prepared for:

The Mosaic Company
PO Box 2000
Mulberry, FL 33860-1100

April 2006

Douglas J. Durbin, Ph.D.
Senior Ecologist/Vice President

Kristan M. N. Raymond
Ecologist

TABLE OF CONTENTS

LIST OF APPENDICES

LIST OF FIGURES

LIST OF TABLES

1.0 EXECUTIVE SUMMARY

1.1 INTRODUCTION

The Mosaic Company (Mosaic) and the Peace River Manasota Regional Water Supply Authority (PRMRWSA) executed a settlement agreement to ensure that phosphate mining proposed by Mosaic in eastern Manatee and western Hardee Counties, Florida would not have negative impacts on Horse Creek, a major tributary of the Peace River. A principal component of the agreement was the creation of the Horse Creek Stewardship Program (HCSP).

The overall goals of the HCSP are to ensure that Mosaic's mining activities do not interfere with the ability of the PRMRWSA to withdraw water from the Peace River for potable use nor adversely affect Horse Creek, the Peace River, or Charlotte Harbor. The program, which is funded and managed by Mosaic, has two purposes: 1) in order to detect any adverse conditions or significant trends that may occur as a result of mining, the HCSP provides a protocol for the collection of information on physical, chemical, and biological characteristics of Horse Creek during Mosaic's mining activities in the watershed, and 2) if detrimental changes or trends caused by Mosaic's activities are found, the HCSP provides mechanisms for corrective action.

This program has three basic components: 1) monitoring and reporting on stream quality, 2) investigating adverse conditions or significant trends that are identified through monitoring, and 3) implementing corrective action for adverse changes to Horse Creek caused by Mosaic's mining activities. The HCSP is unique in that it does not rely solely upon the exceedance of a standard or threshold to bring about further investigation and corrective action, where appropriate. The presence of a significant temporal trend alone will be sufficient to initiate such steps. Thus, this program offers additional protection to Horse Creek that is not usually present in most regulatory scenarios.

The HCSP produces a report each year to summarize data collected during the previous year and report on changes or potential effects in the stream indictated through time. This Historical Report is a supplement to the annual reports and is intended to provide background information and conclusions with which modern data can be compared and contrasted. The Historical Report contains a review and summary of all readily available historical water quality, water quantity and biological information for Horse Creek, as well as a compendium of quantitative data on Horse Creek in electronic form.

The Historical Report will help to provide a basis for evaluating HCSP monitoring progress; exceedance of water quality "trigger values" or potential changes in water quality or biological communities can be referenced to historical levels to distinguish between "pre-mining" sporadic events and/or cyclical changes and exceedences or trends that may be somehow linked to mining activities or other recent activities in the basin.

Because preparation of the Historical Report was still in progress when the 2003 Annual Report was prepared, the 2003 Annual Report includes no comparisons with historical data as discussed in the HCSP plan document; however, such analyses will be included as part of the 2004 Annual Report to be prepared in 2005, to the extent such analyses are appropriate and beneficial to the goals of the HCSP.

1.2 PHYSICAL SETTING OF HORSE CREEK BASIN

Horse Creek is located in a generally rural area. Major landuse activities in the basin are primarily agriculturally related, with extractive mining activities occurring in the northern Horse Creek Basin. Agricultural activities include cattle grazing, row crop farming, citrus grove production, sod farming, and conversion of native lands to pasture for both cattle grazing and hay production. Generally, the northern portion of the basin contains more native vegetation, while the southern portion is covered mostly by pasture and row crops.

Mosaic owns 45,000 acres of land in the Horse Creek Basin, of which more than 8,300 acres has been mined through 2003. Phosphate mining by companies now controlled by Mosaic began in the late 1980's in the Horse Creek Basin, when 480 acres were mined in the northern part of the basin. Over time, mining has progressed southward through the Horse Creek Basin to its present location, about 4 km north of SR 64.

1.3 HYDROLOGY

Streamflow in Horse Creek is highly variable over the available period of record (1951-2002). Streamflow and rainfall at both stations follow characteristic seasonal patterns, with maxima in the summer rainy season and minima in the winter dry season. While streamflow at the Horse Creek near Arcadia station shows a slight downward trend from 1950 to 1985, the decline is not significant at the $p = 0.05$ level. However, when streamflow measurements after 1990 are included, the downward trend is far from statistically significant. Streamflow for Horse Creek near Myakka Head does not show a significant trend for any of the time periods tested. Rainfall in the southern Horse Creek Basin from 1907 to 2002 ranged from 30 in/yr to 80 in/yr, averaging 55 in/yr during most years.

As expected, rainfall and stream discharge historically covary in the Horse Creek Basin, but the ration between the two changes over time. From 1950 to 1971, rainfall and discharge have a relatively constant relationship, but after 1971 the slope of the curve decreases, indicating one of three things: 1) discharge has decreased and rainfall is constant, 2) rainfall has increased and discharge is constant, or 3) a combination of 1 and 2. Phosphate mining in the basin could not have caused this decrease in discharge as mining did not begin until the late 1980's, when the discharge/rainfall relationship began to increase. It seems reasonable to assume that the Horse Creek system could see future oscillations in this relationship as a result of both natural and anthropogenic effects.

1.4 SURFACE WATER QUALITY

Many water quality parameters measured in Horse Creek are historically correlated with discharge or rainfall (Tables 36 and 37). Parameters positively correlated with discharge or rainfall, such as turbidity, ammonia, organic, and total nitrogen, color, and iron, had higher concentrations in Horse Creek during the wet season. Negatively correlated parameters, such as pH, dissolved oxygen, phosphorus, nitrogen oxides, chlorophyll a, conductivity, and other dissolved minerals, had higher concentrations in the dry season when temperatures were cooler and groundwater and agricultural runoff contributed more to baseflow. Any analysis of historical or future trends in these data should take this seasonal relationship with flow into account. General observations and trends for the two stations with the largest historical data sets are provided below.

Trends and Exceedances at Horse Creek Near Myakka Head (SR 64):

- Nitrogen concentrations are decreasing.
- Specific conductivity and fluoride concentrations are increasing.
- Most exceedances of water quality standards were isolated instances, with only 1-3 measurements exceeding HCSP trigger values
- Dissolved oxygen and pH fell outside of HCSP trigger values on occasion over the entire period of record, usually seasonally; the HCSP trigger values for these parameters may represent an unrealistic expectation, given historical observations.

Trends and Exceedances at Horse Creek Near Arcadia (SR 72):

- Ammonia and phosphorus are decreasing, but oxidized nitrogen species are increasing.
- Fluoride is decreasing, but conductivity and other dissolved minerals are increasing.
- Dissolved oxygen is increasing.
- Dissolved mineral concentrations (calcium, chloride, fluoride, etc.) and specific conductivity were higher at downstream stations in Horse Creek than upstream.
- Most water quality exceedances were isolated instances, with only 1-3 isolated measurements exceeding HCSP trigger values.
- Dissolved oxygen and pH exceeded HCSP trigger values on occasion over the entire period of record, usually seasonally; the Class III HCSP trigger values for these parameters may represent an unrealistic expectation given historical conditions.
- Orthophosphate and alkalinity exceeded trigger values before 1980, but these exceedances cannot be attributed to phosphate mining in Horse Creek Basin, which did not begin in the basin until the late 1980's
- Calcium and sulfate exceeded HCSP trigger values after 1980, but these exceedances are probably a result of increased groundwater and irrigation contributions to streamflow because of agriculture rather than phosphate mining in Horse Creek Basin
- Dissolved iron at SR 72 always exceeded the lower HCSP trigger value for Class I waters, but not the HCSP trigger value for Class III waters that applies to upstream Horse Creek; the Class I HCSP trigger value may represent an unrealistic expectation for dissolved iron concentrations at SR 72, given historical conditions.

1.5 AQUATIC BIOLOGY

The historic record for macroinvertebrate sampling Horse Creek is limited and intermittent. However, existing studies can be compiled to draw some conclusions about historic conditions. When samples from within each sampling method were compared, more macroinvertebrate taxa and individuals were collected during the dry season (October – April) than during the wet season (May – September). High stream discharge during the wet season may flush invertebrates downstream or allow them to become "diluted" into the flood plain. Therefore, trend analysis of invertebrate richness and diversity must account for seasonal changes before attributing changes in community structure to changes in water quality.

Fish sampling has rarely been conducted in Horse Creek prior to the initiation of the Stewardship Program. In fact, the Stewardship Program will rapidly become the most comprehensive source of fisheries data for Horse Creek. In historical sampling, centrarchids (largemouth bass and pygmy sunfish) comprised a small percentage of individuals captured, but were the highest percentage of the total fish biomass. The relative abundance of fish from the Poeciliidae and Centrarchidae is affected by the hydrological regime, density of macrophytic vegetation, and dominant substrate. In historic sampling, Centrarchids were most abundant in open, flowing regions of Horse Creek, where scoured sand was the dominant substrate. Poeciliids were predominant in low flow, densely vegetated areas where macrophytic vegetation and other structures substrate give shelter.

2.0 INTRODUCTION

As a result of proposed mining operations by The Mosaic Company (Mosaic) in eastern Manatee and western Hardee Counties, Florida, and a series of legal challenges to the permits required for such mining, Mosaic and the Peace River Manasota Regional Water Supply Authority (PRMRWSA) executed a settlement agreement structured to ensure that mining would not have negative impacts on Horse Creek, a major tributary of the Peace River. A principal component of that agreement was the creation of the Horse Creek Stewardship Program (HCSP), which is funded and managed by Mosaic. The program document, as referenced in the settlement agreement, is provided as Appendix A.

There are two purposes for the HCSP. First, it provides a protocol for the collection of information on physical, chemical, and biological characteristics of Horse Creek during Mosaic's mining activities in the watershed in order to detect any adverse conditions or significant trends that may occur as a result of mining. Second, it provides mechanisms for corrective action with regard to detrimental changes or trends caused by Mosaic's activities, if any are found.

The overall goals of the program are to ensure that Mosaic's mining activities do not interfere with the ability of the PRMRWSA to withdraw water from the Peace River for potable use nor adversely affect Horse Creek, the Peace River, or Charlotte Harbor. There are three basic components to the HCSP: 1) monitoring and reporting on stream quality, 2) investigating adverse conditions or significant trends identified through monitoring, and 3) implementing corrective action for adverse stream quality changes attributable to Mosaic's activities. An important aspect of this program is that it will not rely solely upon the exceedance of a standard or threshold to bring about further investigation and, where appropriate, corrective action. The presence of a significant temporal trend alone will be sufficient to initiate such steps. This protection mechanism is not present in the vast majority of regulatory scenarios.

In brief, the HCSP provides for the following data collection:

- Continuous recording (via U.S. Geological Survey (USGS) facilities) of stage and discharge at two locations on the main stem of Horse Creek
- Daily recording of rainfall via Mosaic and USGS rain gauges in the upper Horse Creek basin
- Continuous recording of temperature, dissolved oxygen, conductivity, turbidity and pH at the Horse Creek station nearest to Mosaic's active mining operations
- Monthly water quality monitoring of 21 parameters at four stations on the main stem of Horse Creek
- Sampling of fish, benthic macroinvertebrates and field water quality parameters (temperature, dissolved oxygen, conductivity, turbidity and pH) three times annually at four stations on the main stem of Horse Creek

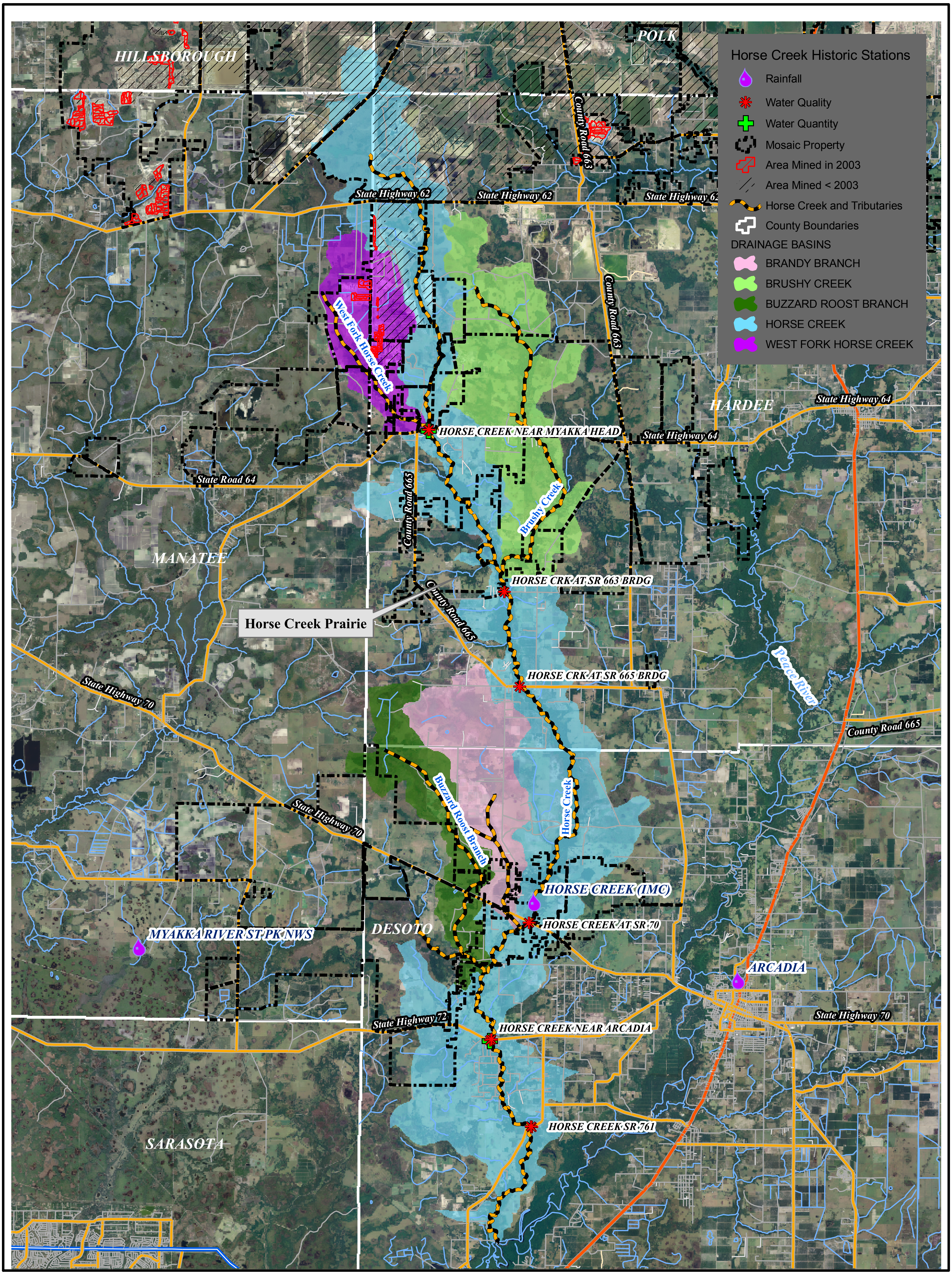
HCSP monitoring began in April 2003. At the time the HCSP was initiated, some 12,000 acres of land in the Upper Horse Creek Basin had been mined, about 10,000 acres of which lies upstream of all HCSP monitoring stations on land controlled by Mosaic, with the remaining mined area on other parties' lands lying upstream of all but the northernmost monitoring location. In 2003, 332 acres were mined in the Horse Creek Basin upstream of the northernmost monitoring location. Water quantity data are collected essentially continuously, water quality data are collected monthly (with some parameters collected continuously at one station), and biological data (fish and benthic macroinvertebrates) are collected three times annually (March or April, July or August, and October or November). Specific months when biological sampling occurs may change from year to year to avoid very low or very high flows which would impede representative sampling.

This historical report is intended to be a supplement to the HCSP Annual Reports, which present the results of monitoring conducted in each year. The Historical Report contains a review and summary of all available historical water quality and biological information for Horse Creek, as well as a compilation of quantitative data on Horse Creek into electronic form. The Historical Report will help to provide a basis for evaluating HCSP monitoring progress; exceedance of water quality trigger values or potential changes in water quality or biological communities can be referenced to historical levels to distinguish between "pre-mining" sporadic events and/or cyclical changes and exceedences or trends that may be somehow linked to mining activities or other recent activities in the basin. Because the Historical Report was still in progress when the 2003 Annual Report was prepared, the 2003 Annual Report includes no comparisons with historical data as discussed in the HCSP plan document; however, such analyses will be included as part of the 2004 Annual Report to be prepared in 2005.

3.0 PHYSICAL SETTING OF HORSE CREEK BASIN

Horse Creek is located in five south Florida counties: Hardee, Desoto, Hillsborough, Polk, and Manatee. The majority of Horse Creek Basin is located in western Hardee and DeSoto Counties. Horse Creek is a major tributary of the Peace River that drains the western part of the Peace River Basin and supplies approximately 15 percent of the surface water runoff to the Peace River (Lewelling 1997).

The Horse Creek Drainage Basin occupies 241 square miles, and the length of the channel is approximately 43 miles (Figure 1). Horse Creek Basin can be described as an elongated basin with a north-to-south drainage that is influenced by the general topography of the area. Six sub-basins and five tributaries make up the Horse Creek Basin. West Fork Horse Creek and Brushy Creek, two northern tributaries in the Polk Uplands, are generally straight-channelized and have relatively rapid flows (Lewelling 1997). The remaining tributaries, in the central to southern Horse Creek Basin, include Buzzard Roost Branch and Brandy Branch. These lower reaches are located in the DeSoto Plains/Gulf Coast Lowlands area and are generally meandering, slower streams. Horse Creek ultimately discharges into the Peace River near Fort Ogden (SWFWMD 2000).



0 3 6 Miles

Imagery: 2004 SWFWMD DOQQs

1 inch equals 3 miles

Preparation Date: 23 May 2005	Revision Date: 21 July 2005	Project Number: 2476-065-b51
Project Manager: KYC	GIS Operator: LBS	GIS QA/QC:
ArcMap Name: horsecreek11x17.mxd	Plot File: historic_aerial.pdf	

Figure 1
Aerial View of Tributaries,
Historical Sampling Locations, and
Mining Ownership of Horse Creek Basin

Biological Research Associates
3910 US Highway 301N
Suite 180
Tampa, Florida 33619
813-664-4500 FAX: 813-664-0440
www.biologicalresearch.com

3.1 PHYSIOGRAPHY

3.1.1 Topography

The topography of the Horse Creek Basin generally follows the north-to-south drainage flows of the creek. Elevation in the basin ranges from 135 ft NGVD in the north to 30 ft NGVD in the south near the confluence of Horse Creek and the Peace River. Horse Creek Basin is located in the mid-peninsular physiographic zone of Florida, in three subdivisions: Polk Uplands, DeSoto Plains, and Gulf Coast Lowlands. The Polk Uplands underlie the northern portion of the Horse Creek Basin, where the elevation generally exceeds 100 feet NGVD. In this location, the channel of Horse Creek is generally steep and slightly incised, with swiftly moving water. The central Horse Creek Basin is located in the DeSoto Plain. Average elevations in this area range from 30 to 100 feet NGVD. Where Horse Creek meets the Peace River, the Gulf Coast Lowlands range in elevation between 30 and 40 feet NGVD. The Horse Creek channel in the Desoto Plain and Gulf Coast Lowlands is slower and more sinuous than the northern channel (SWFWMD 2000, Lewelling 1997).

The northern Horse Creek Basin is located in the Polk Uplands, with Pomona-Floridana-Popash soils characterized by nearly level, poorly drained, and very poorly drained sandy soils. Some soils in this association have dark colored subsoil at a depth of less than 30 inches over loamy material, and some are sandy to a depth of 20 - 40 inches and are loamy below. The extreme northern basin of Horse Creek contains isolated areas of the Arents-Hydraquents-Neilhurst soils group, which have been strip-mined for phosphate (Robbins et al. 1984).

The central and southern Horse Creek Basin is located in the DeSoto Plain, which is a very flat, submarine plain probably formed under Pleistocene Wicomico seas, 70 to 100 ft. above present sea level (Cowherd et al. 1984). The Smyrna-Myakka-Ona and Smyrna-Myakka-Immokalee soil associations characterize this portion of the Horse Creek Basin with flat, poorly drained soils that are sandy throughout (Lewelling, 1997). The soil group Bradenton-Felda-Chobee is also located immediately adjacent to the main channel of Horse Creek, from below State Road 64 to just above the mouth of the creek. These soils are characterized by nearly level, poorly drained and very poorly drained soils that are sandy to a depth of 20 - 40 inches and underlain by loamy material or that are loamy throughout and subject to frequent flooding. The dominant soil groups in the Horse Creek basin are generally poorly drained, reducing the infiltration of rainwater to the water table in the surficial aquifer, thereby limiting the amount of water available to support baseflow (SWFWMD 2000). Over a hundred soil types are present in the Horse Creek Basin (Table 1), so detailed soil maps are too complex to be adequately represented in this report (see example, Figure 2).

Table 1. Soil Type Total Acreage and Percentage in the Horse Creek Basin, from Detailed Soil Survey Maps (USDOA/NCRS 1977-1991).

Soil Codes and Descriptions	Acres	Percent
001 - adamsville fine sand	73.87	0.07
002 - anclote mucky fine sand/depressional	823.01	0.74
002 - zolfo fine sand	1571.62	1.42
003 - basinger fine sand	1906.81	1.72
003 - ft. Green fine sand/2 to 5 percent slopes	101.28	0.09
004 - basinger fine sand/frequently flooded	431.77	0.39
005 - basinger fine sand/depressional	946.94	0.85
005 - basinger/holopaw/and samsula soils/depressional	182.59	0.16
005 - tavares fine sand/0 to 5 percent slopes	233.27	0.21
006 - bradenton fine sand	1134.34	1.02
006 - eaton mucky fine sand/depressional	1.67	0
007 - basinger fine sand	1654.01	1.49
007 - canova/anclote/and okeelanta soils	257.28	0.23
007 - pomona fine sand	204.38	0.18
008 - bradenton loamy fine sand/frequently flooded	694.45	0.63
008 - bradenton-felda-chobee complex/frequently flooded	4295.39	3.87
009 - cassia fine sand	270.57	0.24
009 - popash mucky fine sand/depressional	1463.78	1.32
010 - chobee muck/depressional	146.85	0.13
010 - pomona fine sand	11560.20	10.42
011 - cassia fine sand	568.32	0.51
011 - delray mucky fine sand/depressional	352.32	0.32
011 - felda fine sand	922.54	0.83
012 - cassia fine sand/moderately well drained	205.68	0.19
012 - durbin and wulfert mucks/frequently flooded	3.07	0
012 - felda fine sand/frequently flooded	2304.61	2.08
013 - eaugallie fine sand	2363.14	2.13
013 - floridana mucky fine sand/depressional	1614.74	1.46
014 - farmton fine sand	2424.94	2.19
015 - felda fine sand	1103.33	0.99
015 - immokalee fine sand	3647.87	3.29
016 - delray complex	143.98	0.13
016 - felda fine sand/frequently flooded	239.75	0.22
016 - myakka fine sand	3100.17	2.79
017 - felda fine sand/depressional	213.57	0.19
017 - smyrna and myakka fine sands	59.65	0.05
017 - smyrna sand	11406.74	10.28
018 - cassia fine sand	1160.18	1.05
018 - delray-pomona complex	472.73	0.43
018 - floridana mucky fine sand/depressional	902.34	0.81
019 - duette fine sand/0 to 5 percent slopes	36.58	0.03
019 - floridana mucky fine sand/depressional	56.03	0.05
019 - gator muck/depressional	171.92	0.15
019 - ona fine sand	2276.02	2.05
020 - immokalee fine sand	6580.28	5.93
020 - samsula muck	337.01	0.3
021 - immokalee fine sand	312.54	0.28
021 - malabar fine sand	266.40	0.24
021 - placid fine sand/depressional	1033.53	0.93
022 - felda fine sand	10.99	0.01
022 - malabar fine sand/high	131.47	0.12
022 - pomello fine sand	1690.30	1.52
023 - felda-palmetto complex	170.99	0.15
023 - malabar fine sand/depressional	216.06	0.19

Soil Codes and Descriptions	Acres	Percent
023 - ona fine sand	34.63	0.03
023 - sparr fine sand	45.10	0.04
024 - felda-wabasso association/frequently flooded	193.73	0.17
024 - jonathan sand	607.19	0.55
024 - myakka fine sand	3116.12	2.81
025 - ona fine sand	2135.74	1.93
025 - placid and myakka fine sands/depressional	13.28	0.01
025 - wabasso fine sand	103.48	0.09
026 - electra sand	105.53	0.1
026 - floridana-immokalee-okeelanta association/depressional	1418.81	1.28
026 - pineda fine sand	139.56	0.13
027 - bradenton-felda-chobee association/frequently flooded	2136.53	1.93
027 - malabar fine sand	162.20	0.15
028 - holopaw fine sand	325.44	0.29
028 - pineda fine sand/depressional	16.93	0.02
029 - myakka fine sand	160.36	0.14
029 - pineda-pinellas fine sands	253.25	0.23
030 - hontoon muck	40.47	0.04
030 - myakka fine sand/0 to 2 percent slopes	2933.65	2.64
030 - pomello fine sand	254.20	0.23
031 - pompano fine sand	6.68	0.01
031 - pompano fine sand/frequently flooded	181.82	0.16
032 - felda fine sand/depressional	352.17	0.32
032 - punta fine sand	772.13	0.7
033 - manatee mucky fine sand/depressional	718.60	0.65
034 - samsula muck/depressional	274.18	0.25
034 - wauchula fine sand/0 to 2 percent slopes	488.31	0.44
035 - farmton fine sand	1104.88	1
035 - ona fine sand/ortstein substratum	162.36	0.15
035 - satellite fine sand	115.11	0.1
036 - basinger mucky fine sand/depressional	9.70	0.01
036 - kaliga muck/depressional	2431.59	2.19
036 - smyrna fine sand	9307.74	8.39
037 - basinger fine sand/depressional	189.57	0.17
037 - tavares fine sand/0 to 5 percent slopes	504.32	0.45
038 - palmetto sand	26.58	0.02
038 - st. Lucie fine sand	185.09	0.17
038 - terra ceia muck/depressional	53.59	0.05
039 - arents/very steep	45.80	0.04
039 - bradenton loamy fine sand	571.41	0.52
040 - valkaria fine sand	31.90	0.03
041 - wabasso fine sand	712.48	0.64
042 - pomello fine sand/0 to 2 percent slopes	117.52	0.11
042 - zolfo fine sand	1709.37	1.54
043 - st. Johns fine sand/2 to 5 percent slopes	63.96	0.06
044 - st. Johns-myakka complex	403.36	0.36
051 - wauchula fine sand/o to 2 percent slopes	74.28	0.07
052 - smyrna fine sand	21.60	0.02
052 - waveland fine sand	1417.62	1.28
061 - zolfo fine sand	9.03	0.01
087 - basinger fine sand	0.81	0
099 - water	219.13	0.2

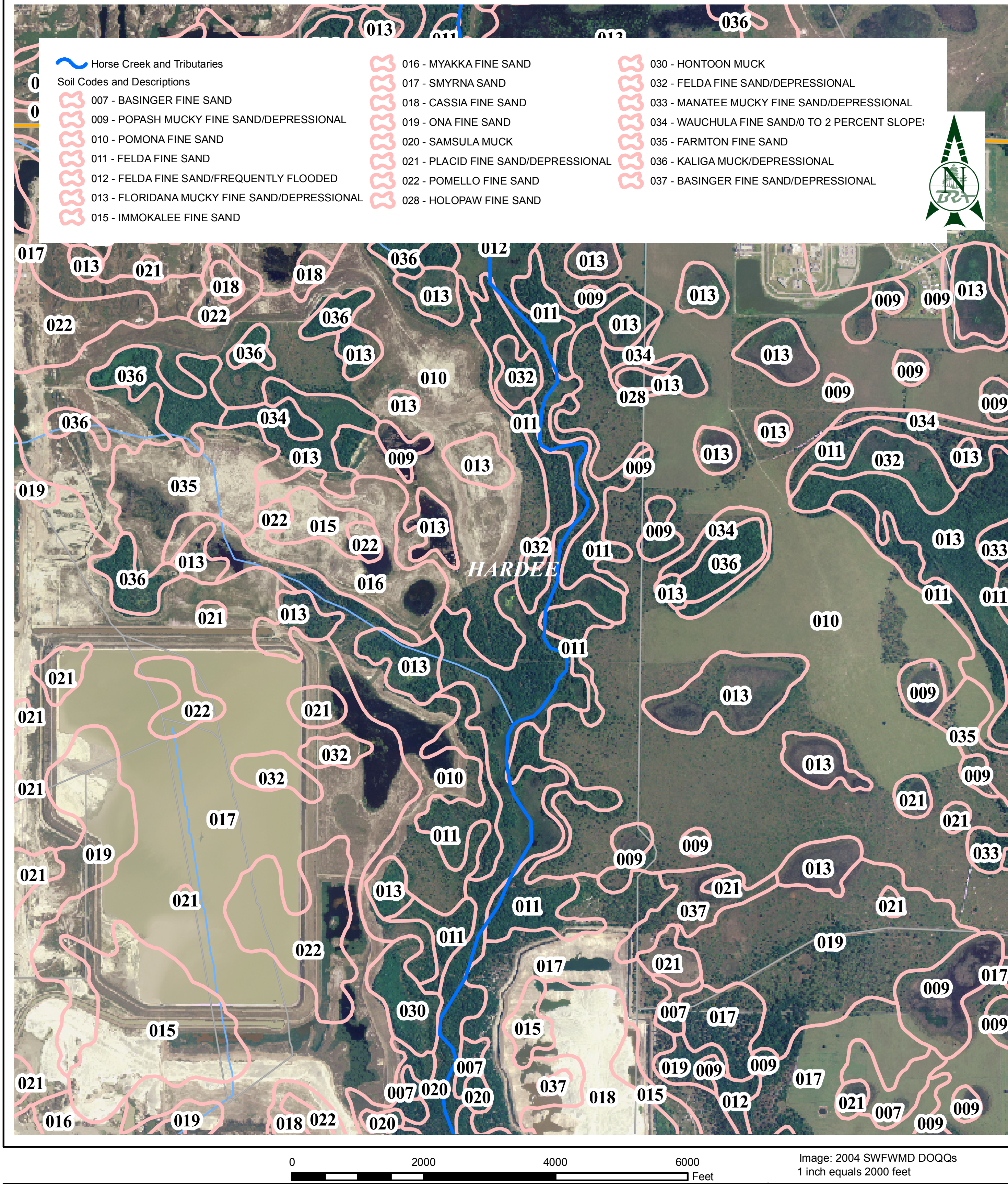


Image: 2004 SWFWMD DOQQs
1 inch equals 2000 feet

Preparation Date: 23 May 2005	Revision Date:	Project Number: 2476-065-b51
Project Manager: DJD	GIS Operator: LBS	GIS QA/ QC:
ArcMap Name: horsecreek_soils.mxd	Plot File: horsecreek_soils.pdf	

Figure 2
Sample of NRCS Soils Map in the Horse Creek Basin

Biological Research Associates
3910 US Highway 301N
Suite 180
Tampa, Florida 33619
813-664-4500 FAX: 813-664-0440
www.biologicalresearch.com

3.1.2 Climate

The climate of Horse Creek Basin is subtropical and humid with an average temperature of about 72 º F (1915-1984). Summer temperatures average 80 ºF, and winter temperatures average 60 ºF (Hammett, 1990). The average daily temperatures in Hardee County, in the northern Horse Creek Basin, range from 52 º F to 91 º F (Robbins et al. 1984). The average daily temperatures in DeSoto County, in the southern Horse Creek Basin, range from 49 ºF to 92 ºF. Average relative humidity in Horse Creek Basin ranges from 57 percent in the mid-afternoon to 87 percent at dawn. The prevailing wind is from the east-northeast, with the highest average wind speed, 7.8 mph, occurring in March (1951-1980) (Cowherd et al. 1984).

The average annual rainfall in the Peace River Basin, which includes Horse Creek, is 52 in (1915-2004) (USGS, 2004c), with more than half of that rainfall falling during localized thundershowers in the wet season (June - September) (Hammett, 1990). Rain during fall, winter, and spring is usually the result of large, broad frontal systems instead of local storms (Hammett, 1990). November is typically the driest month of the year, averaging 1.77 inches over the historic period from 1915 to 2004. The months of April and May are also characteristically dry, averaging 2.56 and 3.95 inches respectively (USGS, 2004c). Dry conditions coincide with high evaporation rates and generally result in the lowest streamflows, lake stages, and ground-water levels of the year (Hammett, 1990). The wettest month of the year is typically June, averaging 8.27 inches (USGS, 2004c). Rainfall is discussed further in relation to basin hydrology in a subsequent section.

3.1.3 Land Use

Horse Creek is located in a generally rural area. Major landuse activities in the basin are primarily agriculturally related, with extractive mining activities occurring in the northern Horse Creek Basin. Agricultural activities include cattle grazing, row crop farming, citrus grove production, sod farming, and conversion of native lands to pasture for both cattle grazing and hay production. Small rural agricultural communities are located in and near the Horse Creek drainage Basin including Fort Green, Ona, and Myakka Head in the northern basin, Limestone, Lily, and Edgeville in the central basin, and Arcadia, Fort Ogden and Nokatee near the southern end of the basin (PBSJ and Dexter Bender 1999). Generally the northern Horse Creek Basin is covered more by natural vegetation, while the southern Basin is covered mostly by pasture and row crops (SWFWMD 2000).

Mosaic owns 45,000 acres of land in the Horse Creek Basin (Figure 1). Over 8300 acres of that land has been mined prior to 2003 (Table 2, Figure 3). Phosphate mining by companies now controlled by Mosaic began in the late 1980's in the Horse Creek Basin, when 480 acres were mined in the northern part of the basin (Figure 4). Over time, mining has progressed southward through the Horse Creek Basin to its present location, about 4 km north of SR 64. Of the 37,000 unmined acres of Mosaic-owned land in Horse Creek Basin, Mosaic plans to mine at least 25 percent, will not disturb 7 percent, and currently has unknown plans for 68 percent. Presumably, at least some of the 68 percent will not be disturbed because of the need to preserve land around Horse Creek. Of the 8,300 acres currently or previously mined by Mosaic in the basin, work has been completed on 1,750 acres in the northernmost part of Horse Creek; of this land, 450 acres has been released and 1,300 acres has had uplands and wetlands established on site (mining lands are “released” when the mining company has successfully completed reclamation/mitigation measures required by the permitting agencies). Extractive land use estimates discussed below (Table 3) may exceed the mining acreage listed in Table 2 for Mosaic-owned properties because of the activities of other phosphate mining companies or differences in how land use was determined by Mosaic and the Southwest Florida Water Management District (SWFWMD).

Table 2. Acres Mined by Mosaic-Controlled Companies in the Horse Creek Basin from the Initiation of Mining in 1988 Until Current Mining Activities Completed During 2003.

Year of Mining	Acres Mined	Cumulative Acres Mined
1988	160.88	160.88
1989	317.34	478.22
1990	78.85	557.08
1991	132.74	689.82
1992	183.40	873.21
1993	500.92	1374.13
1994	727.20	2101.33
1995	430.14	2531.47
1996	606.52	3137.99
1997	763.04	3901.04
1998	946.25	4847.29
1999	1034.99	5882.27
2000	972.00	6854.27
2001	588.11	7442.38
2002	550.99	7993.38
2003	343.16	8336.54

Figure 5 and 6 show 1988 and 1999 land use in Horse Creek Basin, as determined by SWFWMD. In Figure 7, only areas that changed in land use between 1988 and 1999 are shown; these areas are labeled by their 1999 land use category. Land use in the Horse Creek Basin consists mostly of row crops, pasture, and range lands (Table 3). The percentage of land devoted to those land uses has decreased from about 54 percent in 1988 to 50 percent in 1999. Upland forests (15 percent), forested freshwater wetlands (12 percent), and non-forested freshwater wetlands (7 percent) are also prevalent in the Horse Creek Basin, with little change in total cover from 1988 to 1999; upland forests, however, have become more dominated by hardwoods over time. Mining land use in the Horse Creek Basin has changed the most over time. In 1988, 814 acres (0.73 percent) of the Horse Creek Basin was used for extraction, but this increased by 1999 to 7127 acres (6.42 percent). Tree crop land-use ranged from 6 percent in 1988 to 7 percent in 1999. Residential and other uses each made up less than 1 percent of the Horse Creek Basin in 1999.

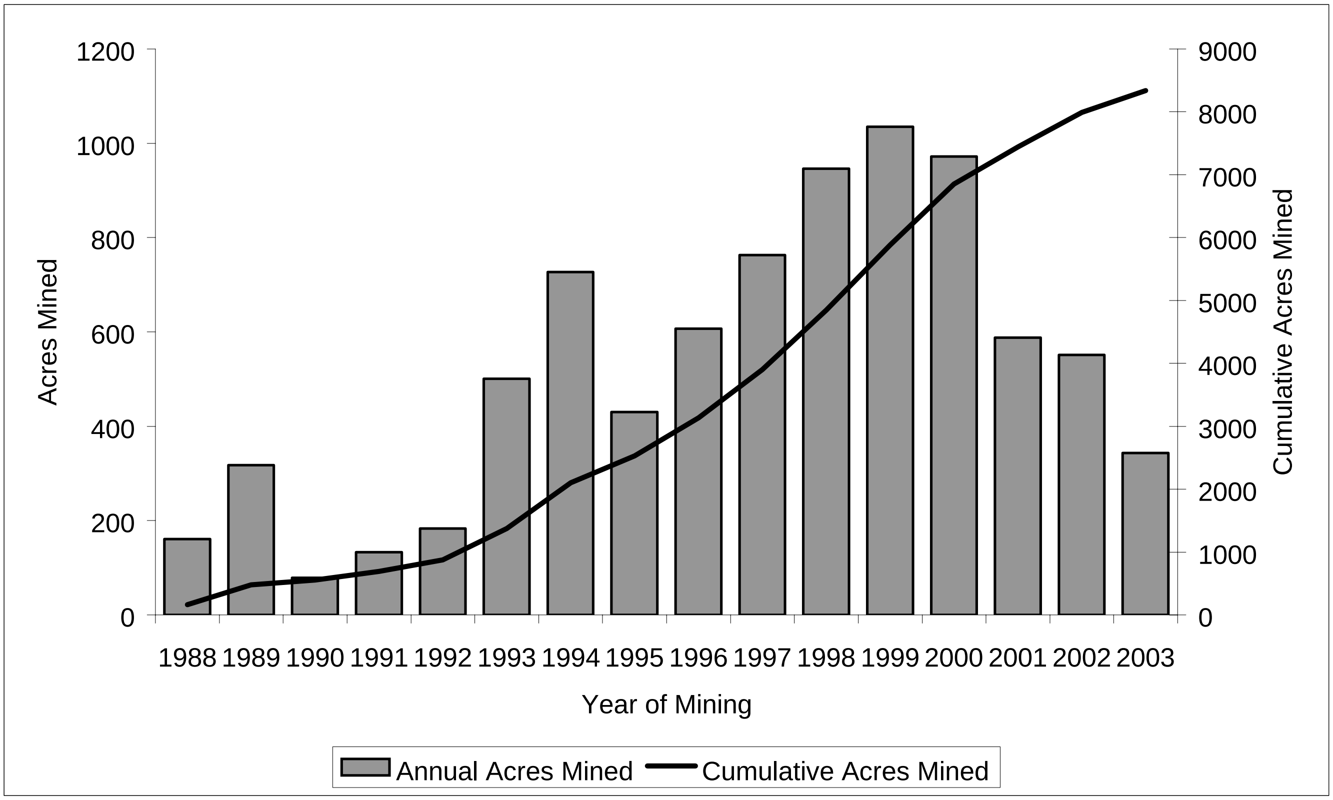


Figure 3. Annual and Cumulative Acres Mined by Mosaic-Controlled Companies in the Horse Creek Basin from the Initiation of Mining in 1988 through 2003.

Acreage and percentage of land use differs between regions of the Horse Creek Basin (Table 4). The Horse Creek Basin was divided into 6 regions for comparison by approximating the drainage area upstream of each historical water quality station. Mining is the primary land use above SR 64 (28 percent), but the percentage of land devoted to mining decreases downstream. Agricultural land use, on the other hand, more than triples in acreage from above SR 663 (HCSW-2, 7535 acres) to above SR 72 (HCSW-4, 44833 acres). Rangeland covers a greater percentage of land in northern (15-19 percent) than southern Horse Creek Basin (13-14 percent). Upland forest and wetland cover substantially increases from above SR 64 (HCSW-1) to above SR 663 (HCSW-2), but the percent forest and wetland cover remains relatively constant between SR 663 and further downstream.

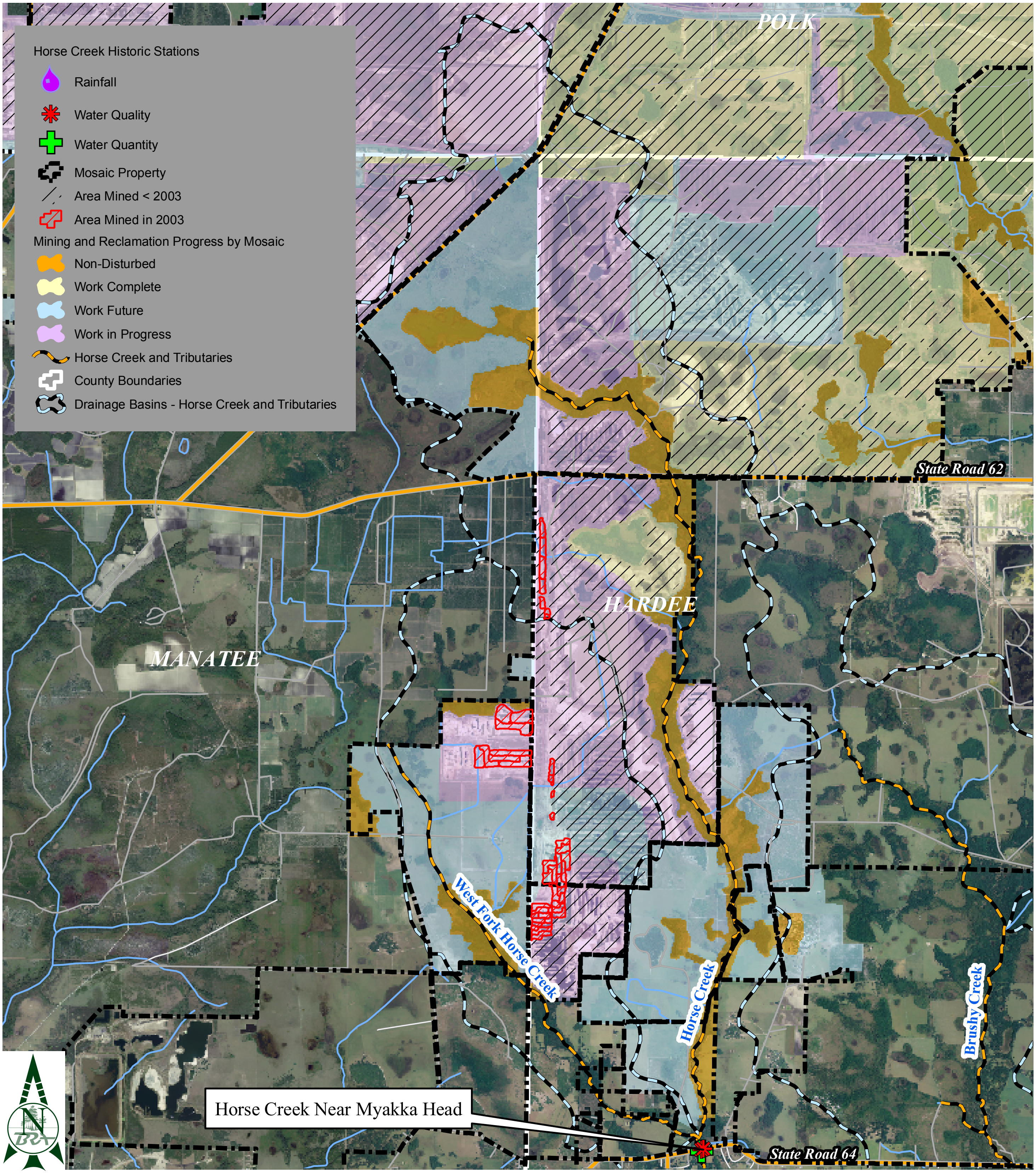
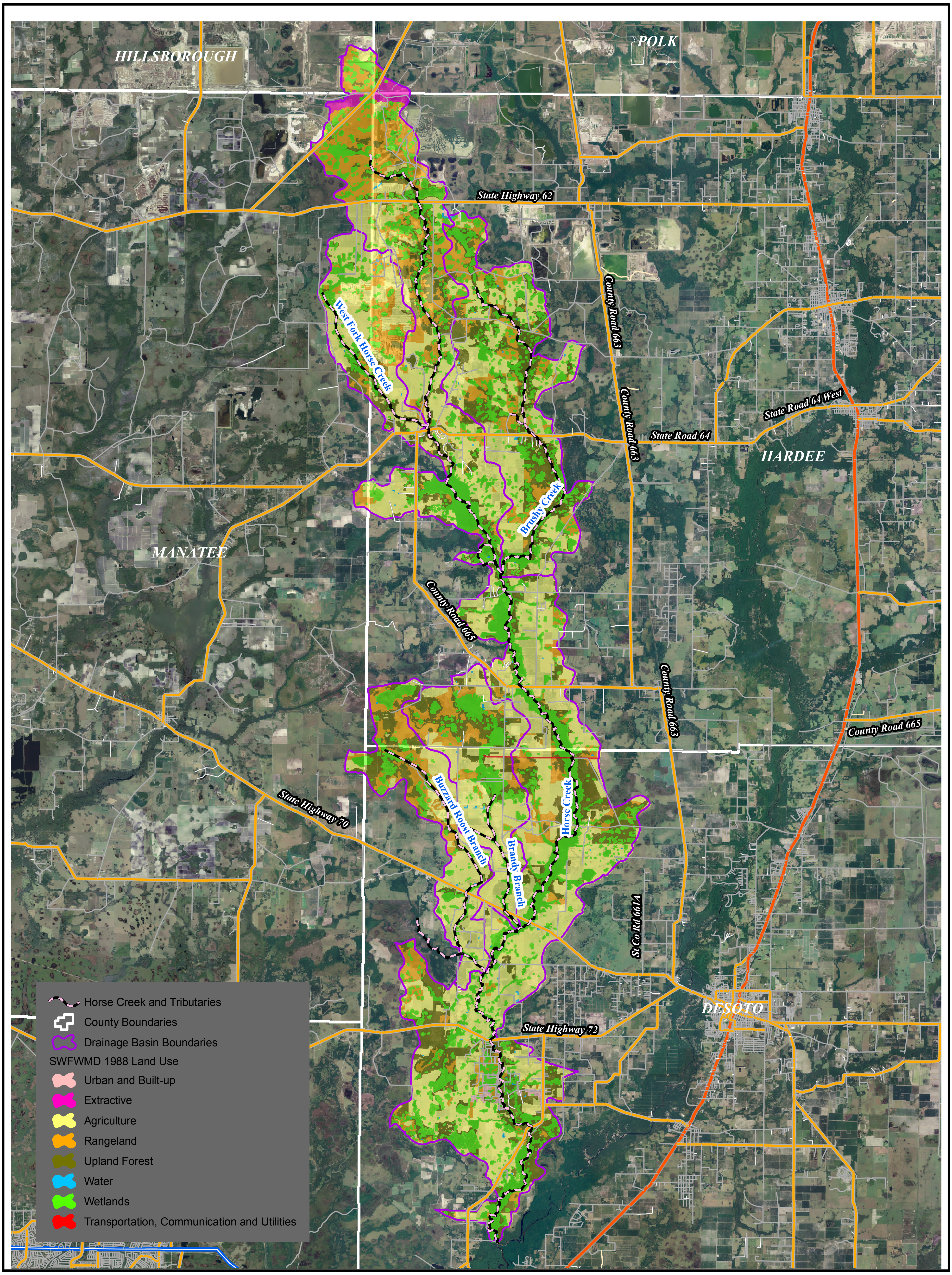


Image: 2004 SWFWMD DOQQs
1 inch equals 1.5 miles

Preparation Date: 20 May 2005	Revision Date: 21 July 2005	Project Number: 2476-065-b51
Project Manager: DJD	GIS Operator: LBS	GIS QA/ QC:
ArcMap Name: horsecreek-mined.mxd	Plot File: horsecreek-mined.pdf	

Figure 4
Mining and Reclamation Area in the Horse Creek Basin

Biological Research Associates
3910 US Highway 301N
Suite 180
Tampa, Florida 33619
813-664-4500 FAX: 813-664-0440
www.biologicalresearch.com



0 3 6 9 Miles

Imagery: 2004 SWFWMD DOQQs

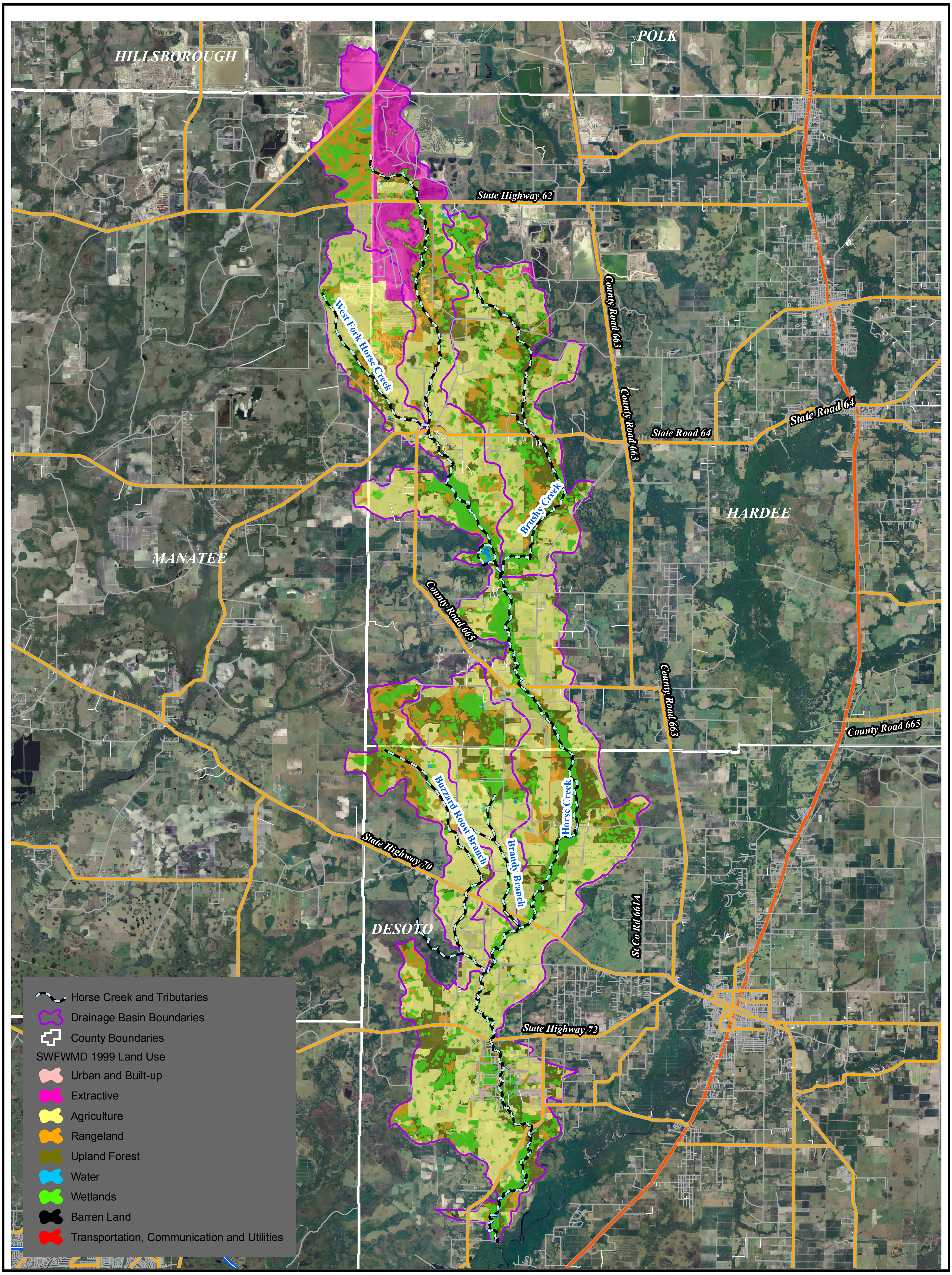
1 inch equals 3 miles

Preparation Date:	Revision Date:	Project Number:
23 May 2005	07 June 2005	2476-065-b51
Project Manager:	GIS Operator:	GIS QA/ QC:
KYC	LBS	
ArcMap Name:	Plot File:	
horsecreek_88lu.mxd	horsecreek_88lu.pdf	

Figure 5

1988 Land Use in the Horse Creek Basin from SWFWMD Land Use Map

Biological Research Associates
3910 US Highway 301N
Suite 180
Tampa, Florida 33619
813-664-4500 FAX: 813-664-0440
www.biologicalresearch.com



0 3 6 Miles

Imagery: 2004 SWFWMD DOQQs

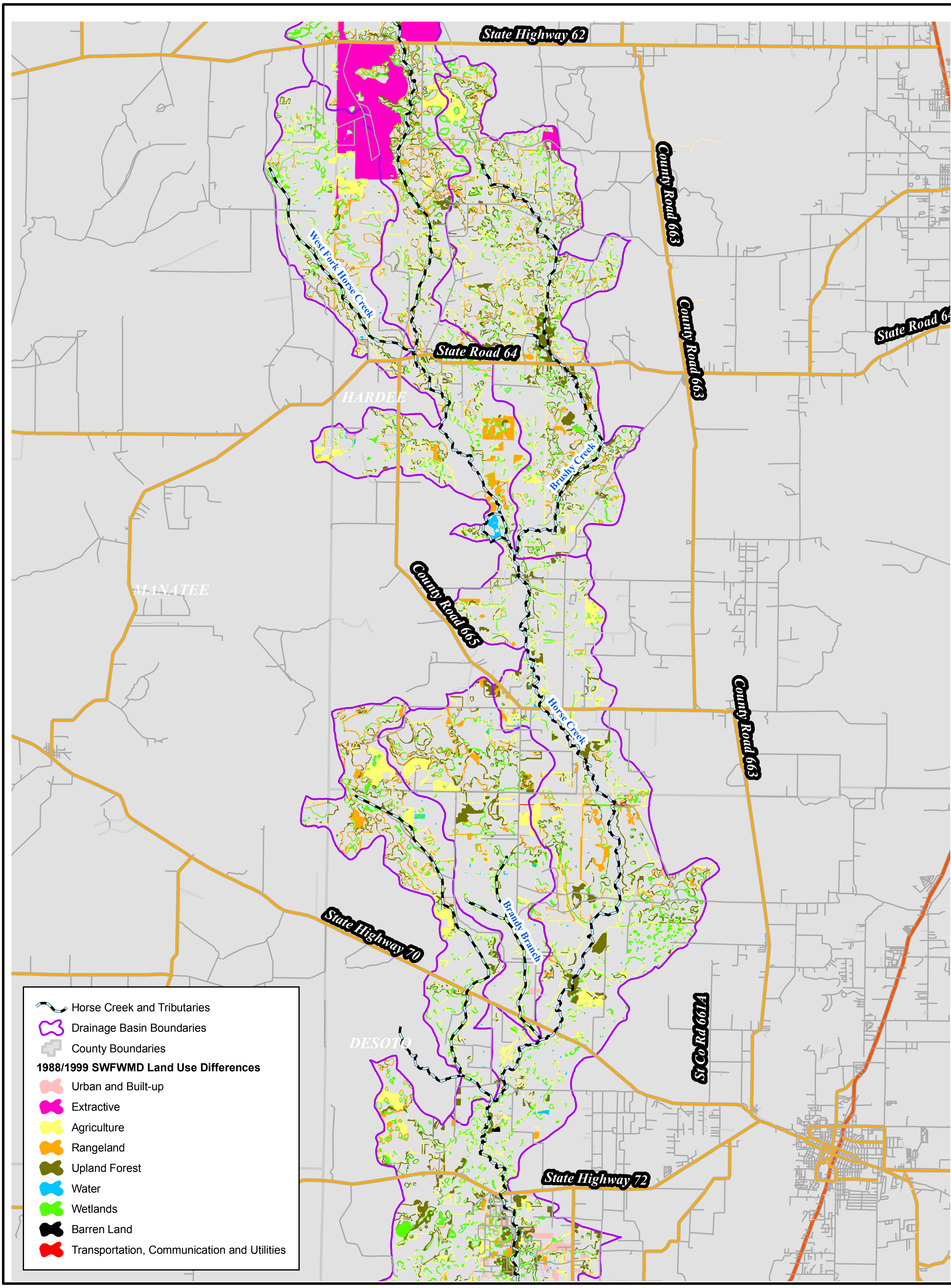
1 inch equals 3 miles

Preparation Date: 23 May 2005	Revision Date: 07 June 2005	Project Number: 2476-065-b51
Project Manager: KYC	GIS Operator: LBS	GIS QA/ QC:
ArcMap Name: horsecreek_99lu.mxd	Plot File: horsecreek_99lu.pdf	

Figure 6

1999 Land Use in the Horse Creek Basin from 1999 SWFWMD Land Use Map

Biological Research Associates
3910 US Highway 301N
Suite 180
Tampa, Florida 33619
813-664-4500 FAX: 813-664-0440
www.biologicalresearch.com



0 3 6 Miles

Imagery: 2004 SWFWMD DOQQs

1 inch equals 2.21 miles

Preparation Date:	Revision Date:	Project Number:
23 May 2005	07 June 2005	2476-065-b51
Project Manager:	GIS Operator:	GIS QA/ QC:
KYC	LBS	
ArcMap Name:	Plot File:	
horsecreek_lu_diff.mxd	horsecreek_lu_diff.pdf	

Figure 7
Changes in Land Use in the
Horse Creek Basin from 1988 to 1999
Represented by 1999 SWFWMD Land Use

Biological Research Associates
3910 US Highway 301N
Suite 180
Tampa, Florida 33619
813-664-4500 FAX: 813-664-0440
www.biologicalresearch.com

Table 3. SWFWMD Land Use (Level II FLUCCS) in the Horse Creek Basin, Including Tributary Subbasins, from 1988 to 1999.

	FLUCCS	1988		1999		1988 to 1999 change	
SWFWMD Land Use Category	**Level II**	**Acres**	**Percent**	**Acres**	**Percent**	**Acres**	**Percent**
Cropland and Pastureland	21	42746	38.51	41424	37.32	-1322	-1.19
Shrub and Rangeland	32	17219	15.51	13805	12.44	-3414	-3.07
Wetland Hardwood Forests	61	11881	10.70	11138	10.03	-743	-0.67
Upland Coniferous Forest	41	9792	8.82	9101	8.20	-691	-0.62
Tree Crops	22	7168	6.46	8224	7.41	1056	0.95
Upland Hardwood Forests	43	6988	6.30	7812	7.04	824	0.74
Vegetated Non-forested Wetlands	64	7685	6.92	7720	6.96	35	0.04
Extractive	16	814	0.73	7127	6.42	6313	5.69
Wetland Coniferous Forests	62	1234	1.11	1219	1.10	-15	-0.01
Herbaceous (Dry Prairie)	31	1977	1.78	805	0.72	-1172	-1.06
Other Open Lands	26	1206	1.09	673	0.61	-533	-0.48
Residential, Low Density	11	543	0.49	632	0.57	89	0.08
Upland Hardwood Forests	42	378	0.34	361	0.33	-17	-0.01
Wetland Forested Mixed	63	347	0.31	302	0.27	-45	-0.04
Reservoirs	53	86	0.08	159	0.14	73	0.06
Streams and Waterways	51	36	0.03	77	0.07	41	0.04
Tree Plantations	44		0.00	68	0.06	68	0.06
Lakes	52	14	0.01	64	0.06	50	0.05
Feeding Operations	23	54	0.05	60	0.05	6	0
Institutional	17	50	0.05	60	0.05	10	0
Disturbed Land	74		0.00	32	0.03	32	0.03
Nurseries and Vineyards	24	681	0.61	32	0.03	-649	-0.58
Utilities	83	60	0.05	31	0.03	-29	-0.02
Recreational	18		0.00	24	0.02	24	0.02
Commercial and Services	14		0.00	21	0.02	21	0.02
Mixed Rangeland	33	35	0.03	15	0.01	-20	-0.02
Sand Other than Beaches	72		0.00	8	0.01	8	0.01

**** Level II FLUCCS is the second level of SWFWMD's land use categorization scheme that provides a lower resolution categorization of land use than Level I and is usually used for large areas.***

Table 4. SWFWMD 1999 Land Use (Level II FLUCCS) for Segments of Horse Creek and Tributary Subbasins Above Historic and HCSP Sampling Stations.

	Level II FLUCCS	**Above SR 64**		**Above SR 663**		**Above SR 665**		**Above SR 70**		**Above SR 72**		**Above SR 761**	
		Acres	**%**	**Acres**	**%**	**Acres**	**%**	**Acres**	**%**	**Acres**	**%**	**Acres**	**%**
Urban and Built-up	**10**	**7060**	**28.38**	**7211**	**14.02**	**7211**	**12.75**	**7232**	**8.91**	**7232**	**7.47**	**7857**	**7.37**
Extractive	16	7032	28.27	7127	13.85	7127	12.60	7127	8.78	7127	7.37	7127	6.68
Agriculture	**20**	**7535**	**30.29**	**19328**	**37.57**	**22706**	**40.15**	**35607**	**43.89**	**44833**	**46.34**	**48768**	**45.74**
Cropland And Pastureland	21	6379	25.64	16690	32.44	18770	33.19	29046	35.80	36807	38.04	39944	37.46
Tree Crops	22	1157	4.65	2587	5.03	3738	6.61	6131	7.56	7354	7.60	8074	7.57
Rangeland	**30**	**4727**	**19.00**	**8498**	**16.52**	**8652**	**15.30**	**11443**	**14.10**	**13581**	**14.04**	**14354**	**13.46**
Upland Forests	**40**	**2202**	**8.85**	**7557**	**14.69**	**8016**	**14.18**	**12025**	**14.82**	**13871**	**14.34**	**16481**	**15.46**
Water	**50**	**57**	**0.23**	**134**	**0.26**	**151**	**0.27**	**200**	**0.25**	**228**	**0.24**	**248**	**0.23**
Wetlands	**60**	**3295**	**13.24**	**8715**	**16.94**	**9810**	**17.35**	**14598**	**17.99**	**16969**	**17.54**	**18879**	**17.71**
Disturbed Land	**70**									**9**	**0.01**	**9**	**0.01**
Utilities	**80**							**31**	**0.04**	**31**	**0.03**	**31**	**0.03**

**** Level II FLUCCS is the second level of SWFWMD's land use categorization scheme that provides a lower resolution categorization of land use than Level I and is usually used for large areas.***

4.0 HYDROLOGY

Streamflow, stream stage, stream velocity, and rainfall data for each station were obtained from USGS and NOAA gages from several sources over the period from 1951 to 2002. Box and whisker plots have been used for exploratory data analysis (see Appendix B). To determine relationships between streamflow and rainfall, Pearson's product-moment or Spearman's rho correlation coefficients (Zar 1999) were calculated between discharge and rainfall at Horse Creek near SR 64. Correlation coefficients (r) range between 0 (no correlation) and 1 (completely correlated); we considered correlations to be statistically significant if p values were less than 0.05, but relationships were only considered to be "strong" if $r > 0.60$. Discharge duration curves were used to evaluate high and low flow levels throughout the period of record. A double mass curve was used to show the relationship between rainfall and streamflow changes.

Because of inconsistent sampling frequency in some source data, parametric methods for time-series analysis were not appropriate for the streamflow data set. Therefore, Mann-Kendall Tau (Zar 1999), a nonparametric correlation by ranks, was used to determine if observed changes in annual mean streamflow over time were significant at SR 64 and SR 72. The Mann-Kendall Tau test ranks a chronologically ordered list of annual mean streamflow values and tests the number of times the latter rank is higher/lower than the previous rank. The p value of this test gives the probability that the observed trend in ranks could be due to random chance. Values of p below the 0.05 level (or in some cases, the 0.10 level) were considered to indicate a significant upward or downward trend in streamflow.

4.1 GROUNDWATER

Horse Creek is a perennial stream and a major contributor to surface drainage in Hardee and DeSoto Counties. Ground water in these areas is obtained from the surficial aquifer, the intermediate aquifer, and the Floridan Aquifer systems. Both the intermediate and Floridan aquifers are under confined conditions and may contribute to the artesian flow in portions of the Horse Creek drainage area (Cowherd et al. 1984).

The unconfined surficial aquifer in the Horse Creek basin is permeable and contiguous with the land surface. Soils in the aquifer are fine to medium sand, becoming increasingly clayey and phosphatic with depth. Aquifer permeability is influenced by variable sediment grain size, which affects aquifer transmittance (Lewelling, 1997).

The intermediate aquifer lies between the upper surficial aquifer and the underlying Floridan aquifer system. The intermediate aquifer system consists of three hydrogeologic units: 1) confining unit that separates the intermediate system from the surficial aquifer, 2) a system of water bearing units composed of carbonate rocks, sand, and beds of sand and clay, and 3) a lower confining unit that separates the intermediate and Upper Floridan aquifers. The intermediate aquifer is recharged by leakage from the surficial aquifer, sinkholes, and abandoned mine pits that breach the confining units (Lewelling, 1997).

The Floridan aquifer is separated into Upper and Lower aquifers by a middle confining unit. The confining unit and Lower aquifer usually contain saltwater, and the Upper Floridan consists of limestone from the Oligocene and Eocene age. According to Lewelling (1997), virtually all municipalities, industrial, and agricultural systems in the Horse Creek basin draw from the Upper Floridan aquifer.

The groundwater discharge from the surficial aquifer contributes to most of the baseflow of the Horse Creek basin. However, in the southern Horse Creek Basin, where the head of the intermediate aquifer system is higher than the water level in the surficial aquifer, ground water moves upwards from the intermediate aquifer in to the surficial aquifer and then discharges into the creek. Water from the intermediate aquifer often has higher concentrations of dissolved minerals than runoff or water from the surficial aquifer (SWFWMD 2000).

The direction of the ground water flow is generally east to west following the direction of the slope of the land surface. The transmissivity values for the surficial aquifer in the Horse Creek basin range from 3,000 gpd/ft to 40,000 gpd/ft. For the intermediate aquifer, the lateral flow is generally west-southwest, with transmissivity values of 3,000 to 52,400 gpd/ft. The general direction of ground water flow in the Upper Floridan aquifer is west to southwest. Although transmissivity values are highly variable they typically range from 528,000 gpd/ft to 1,300,000 gpd/ft (SWFWMD 2000).

Ground water from the surficial and intermediate aquifers is suitable for potable use. However, only the northern portion of the Floridan aquifer in the Horse Creek basin is potable. Recharge to the surficial aquifer is high, but the recharge potential to the intermediate and Floridan aquifers is low because of artesian conditions and thick confinement (SWFWMD 2000).

The Horse Creek basin has limited potential for ground-water supply development. The basin is located within the Southern Water Use Caution Area, which will probably restrict future groundwater supply development. New ground-water withdrawals, combined with existing permitted quantities, may reduce stream flow and increase ground-water salinity along coastal Manatee and Sarasota Counties. Ground-water withdrawals in the basin area in 2000 totaled approximately 2 mgd actual usage of the 22 mgd permitted. Most water in the area is used for agriculture, and other minor uses include industrial, commercial, mining, and dewatering (SWFWMD 2000).

4.2 STREAMFLOW

Historic stream discharge and velocity data for the Horse Creek Basin was obtained from the USGS online database for two stations: Horse Creek Near Myakka Head (2297155) and Horse Creek Near Arcadia (2297310). These stations correspond to the Horse Creek Stewardship Program's stations HCSW-1 and HCSW-4, respectively (Table 5). Stream discharge and stream velocity is available for the Myakka station from 1977 to 2002 and the Arcadia station from 1951 to 2002.

Table 5. Data Sources and Period of Record for Stage Height, Stream Discharge, and Stream Velocity USGS Data in the Horse Creek Basin. Stations are Listed from North to South (Figure 1).

Agency	Station Name	Station Number	Data Type	Period of Record	HCSP synonym	Alternate Station Name
USGS	Horse Creek Near Myakka Head	2297155	Stage, discharge, velocity	1977-2002	HCSW-1	Horse Creek at SR 64 BRDG
USGS	Horse Creek Near Arcadia	2297310	Stage, discharge, velocity	1951-2002	HCSW-4	Horse Creek at SR 72 Br

Streamflow in Horse Creek is highly variable over the historical period 1951-2002 (USGS, 2004a). Data was collected from the USGS gauging stations on Horse Creek near Myakka Head (SR 64) and Arcadia, FL (SR 72). Streamflow at both stations follows characteristic seasonal patterns (Figure 8). Maximum discharges normally occur in September, near the end of the summer rainy season, and streamflow is lowest in April and May at the end of the typical dry season (Hammett, 1990).

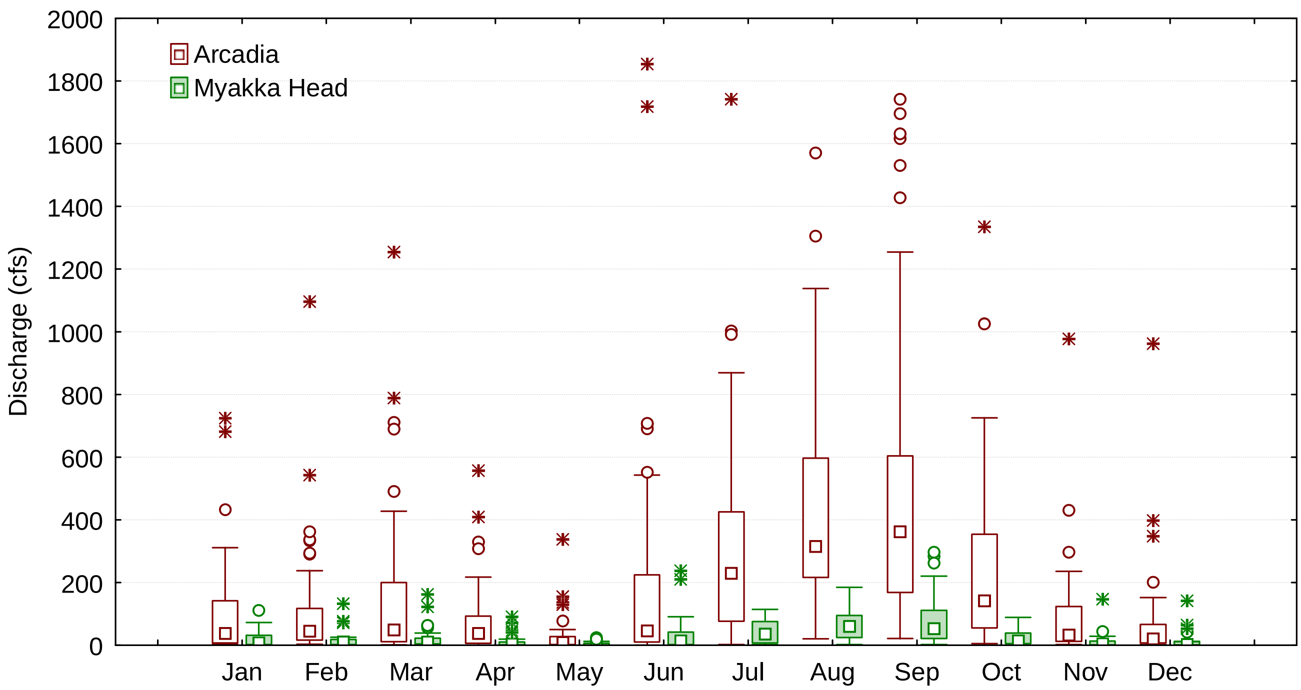


Figure 8. Median Box-and-Whisker Plot of Monthly Stream Flow at USGS Stations Horse Creek Near Myakka Head (297155) and Horse Creek Near Arcadia (2297310) over the historical period of record (Table 5). **See explanation of Box-and-Whisker Plots in Appendix B.*

Annual streamflow varies cyclically from year to year for both Myakka Head and Arcadia stations (Figures 9 and 10). Mean annual streamflow at the Myakka Head station typically ranged from 0 to 50 cfs and average daily streamflow ranged from 0 to 1,380 cfs from 1977-2002 (Hammett, 1990). At the USGS station near Arcadia, mean annual streamflow ranged to 500 cfs. Daily peak discharges were variable, ranging from numerous periods of no flow to a high of 11,700 cfs on August 1, 1960

(SWFWMD, 2000). Streamflow at the Arcadia station is much greater than at the Myakka Head station because Arcadia is downstream in Horse Creek Basin.

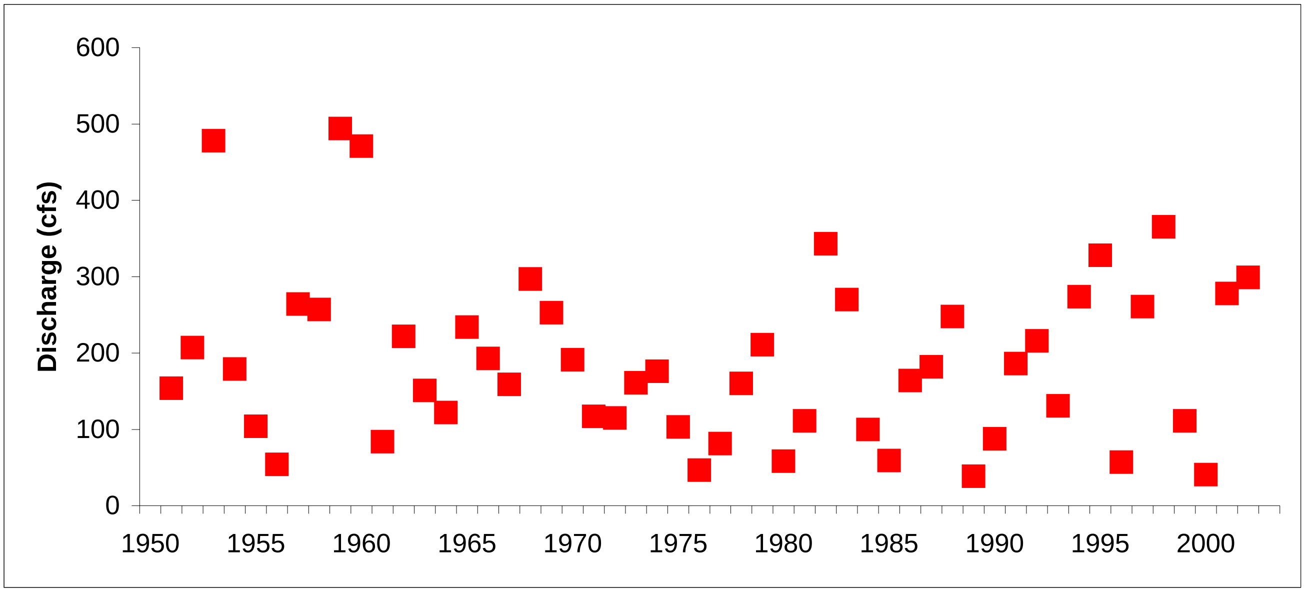


Figure 9. Mean Annual Stream Flow at USGS Station Horse Creek Horse Creek Near Arcadia (2297310).

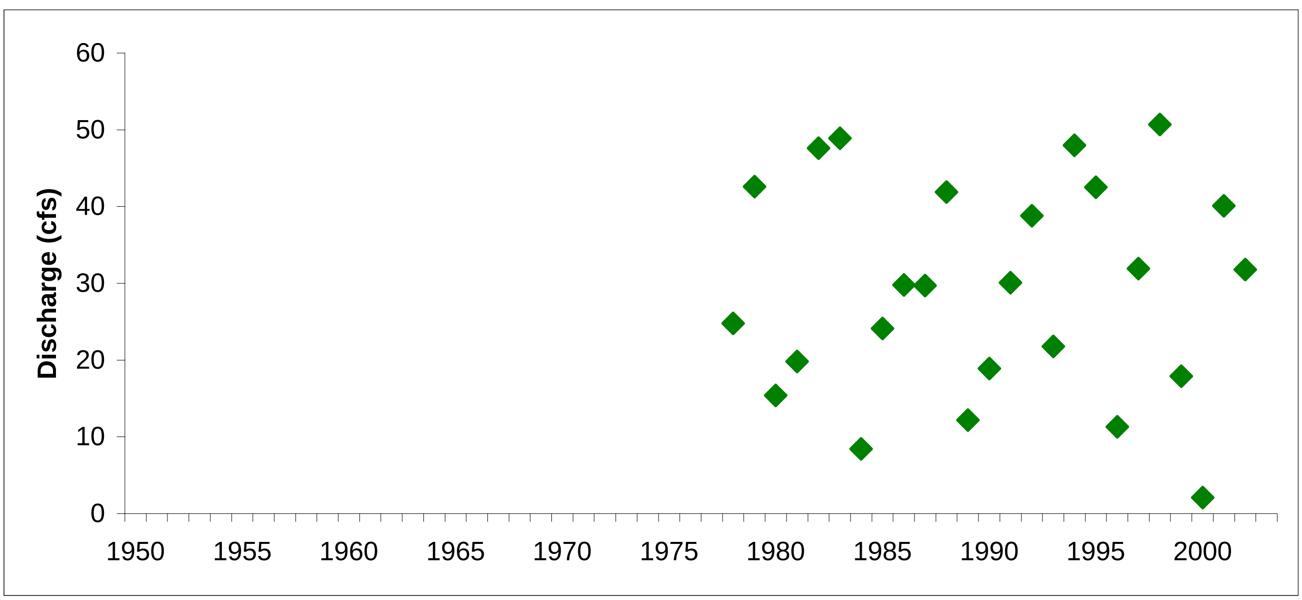


Figure 10. Mean Annual Stream Flow at USGS Station Horse Creek Near Myakka Head (297155) (data collection began in 1977).

Hammett (1990) and Coastal Environmental (1996) both found statistically significant declines in streamflow in the northern sections of the Peace River basin from 1950 to 1985. While streamflow at the Horse Creek near Arcadia station does show a slight downward trend in streamflow from 1950 to 1985 (Hammett 1990) and from 1950 to 1990, the decline is not significant at the $p = 0.05$ level, but approaches significance at the $p = 0.10$ level. (Table 6). However, when streamflow measurements after 1990 are included, the downward trend is far from statistically significant. Streamflow for Horse Creek near Myakka Head does not show a significant trend for any of the time periods tested (Table 6). Declining rainfall in the 1960s and 1970s may have played a role in the observed declines in streamflow in the Peace River Basin (Hammett 1990, Stoker et al., 1989, Coastal Environmental 1996, Palmer and Bone 1977). Drawdown of the potentiometric surface of the Floridan Aquifer in the Upper Peace River watershed by groundwater pumping may be a major contributor to reduced streamflow and well depth in the region (Hammett 1990). Although the surface of the aquifer has not returned to pre-development levels, groundwater levels may have recovered in much of the watershed because of reduced groundwater use by the phosphate industry (SWFWMD, 2001).

Table 6. Mann-Kendall Tau Non-Parametric Trend Test for Annual Streamflow at USGS Stations Horse Creek Near Myakka Head (297155) and Horse Creek Near Arcadia (2297310) during the selected time intervals.

	Horse Creek Near Myakka Head (from 1977)		Horse Creek Near Arcadia (from 1950)	
Time interval	Kendall Tau	p	Kendall Tau	p
To 1985	0.22	0.40	-0.18	0.13
To 1990	0.05	0.78	-0.18	0.10
To 1995	0.23	0.17	-0.06	0.58
To 2000	0.06	0.69	-0.08	0.42
To 2002	0.10	0.49	-0.02	0.87

Discharge duration curves (Figures 11 and 12) show the percent of time stream discharge levels were maintained over the period of record at Horse Creek near Arcadia and Horse Creek near Myakka Head. During 10 percent of the period of record (P_{10}), stream discharge was at least 71 cfs near Myakka and some seven times higher at 520 cfs near Arcadia (Tables 7 and 8). The P_{25}, P_{50}, and P_{75} discharge values were also about seven times greater at Horse Creek near Arcadia than at the upstream Myakka Head station. Extremely low flows, as indicated by the P_{90} values, are markedly lower at Myakka Head than at Arcadia (see Table 6). Dicharge duration was similar over several time periods for both Horse Creek near Myakka Head (Table 7) and near Arcadia (Table 8).

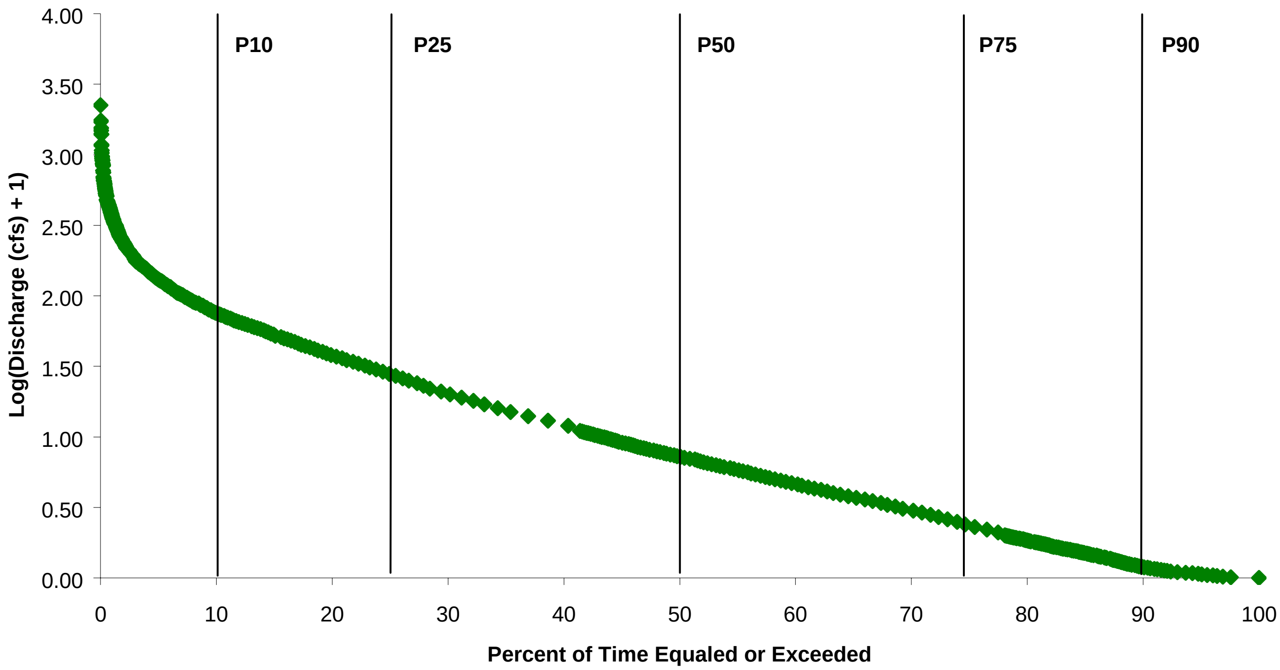


Figure 11. Horse Creek Near Myakka Head Historical Discharge Duration Curve, 1977 - 2002

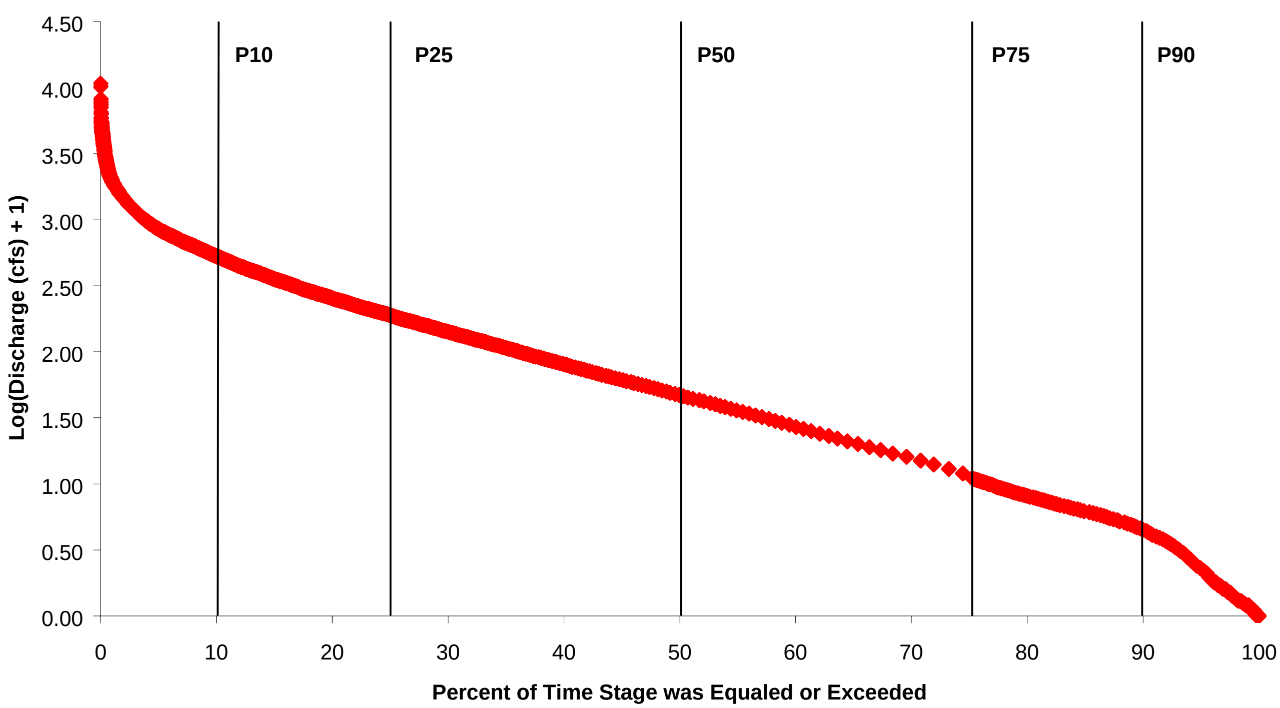


Figure 12. Horse Creek Near Arcadia Historical Discharge Duration Curve, 1950 – 2002

Table 7. Summary Of Discharge Duration Curves For Streamflow At Horse Creek Near Myakka Head For Various Time Periods.

Percent of time discharge was equaled or exceeded	Horse Creek Near Myakka Head				
	1977-1985	1977-1990	1977-1995	1977-2000	1977-2002
P_{10}	73.0	70.0	75.0	69.0	71.0
P_{25}	24.0	24.0	28.0	25.0	28.0
P_{50}	5.9	5.9	6.7	6.0	6.0
P_{75}	1.0	1.2	1.7	1.4	1.3
P_{90}	0.2	0.3	0.4	0.2	0.2

Table 8. Summary Of Discharge Duration Curves For Streamflow At Horse Creek Near Arcadia For Various Time Periods.

Percent of time discharge was equaled or exceeded	Horse Creek Near Arcadia				
	1950-1985	1950-1900	1950-1995	1950-2000	1950-2002
P_{10}	512.0	494.0	510.0	500.0	520.0
P_{25}	192.0	184.0	187.0	181	185
P_{50}	45.0	45.0	47.0	45.0	45.0
P_{75}	8.5	9.3	10.0	9.8	9.9
P_{90}	2.7	2.9	3.3	3.4	3.4

4.3 RAINFALL, RUNOFF, AND EVAPOTRANSPIRATION

Out of the approximately 55 inches of rain per year that the Horse Creek basin receives, only around one inch per year (2 percent) infiltrates and recharges the aquifer. Approximately 39 in/yr (71 percent) of the water is lost to the atmosphere due to evapotranspiration, and 27 percent (15 in/yr) flows into the streams as surface water runoff (SWFWMD, 2000). The Horse Creek station near Myakka Head had an average annual runoff of 10.14 in/yr from 1977 to 1990, and the Horse Creek station near Arcadia, FL, had an average annual runoff of 12.15 in/yr from 1950-1990 (Hammett 1990).

Average monthly and annual rainfall data from NOAA and SWFWMD rain gauges was obtained from the SWFWMD online database for three rainfall gauges near Horse Creek: Myakka River St Pk NWS (336), west of Horse Creek; Horse Creek (IMC) (494) at SR 70 on Horse Creek; and Arcadia (148), east of Horse Creek. The period of record for rainfall stations 336 and 148 overlapped completely with the period of stream discharge data, but rainfall has only been collected since 2000 at the Horse Creek (IMC) station (Table 9). For each rainfall gage, years or months with more than five days of missing data were omitted from further analysis.

Table 9. Data Sources and Period of Record for Rainfall Data from NOAA and SWFWMD in the Horse Creek Basin. Stations are Also Depicted on Figure 1.

Agency	Station Name	Station Number	Data Type	Period of Record	HCSP synonym	Alternate Station Name
SWFWMD	Horse Creek (IMC)	494	Rainfall	2000-2002	HCSW-3	Horse Creek at SR 70
NOAA	Arcadia	148	Rainfall	1907-2002		
NOAA	Myakka River St Pk NWS	336	Rainfall	1943-2002		

Rainfall in the southern Horse Creek Basin from 1907 to 2002 ranged from 30 in/yr to 80 in/yr, averaging 55 in/yr during most years (Figure 13). The southern Horse Creek Basin experienced a few very dry years at around 30 in/yr (1907, 1932, 1955, 1956, 1961, 1989) and several very wet years (1947, 1957, 1959, 1982, 1983, 1995, 1997, 1998, 2002, & 2003), according to at least one gauge. Rainfall in the basin has a distinct seasonal pattern (Figure 14). Median monthly rainfall from June to September, the wet season, may be up to twice the amount of monthly rainfall from October to May, the dry season.

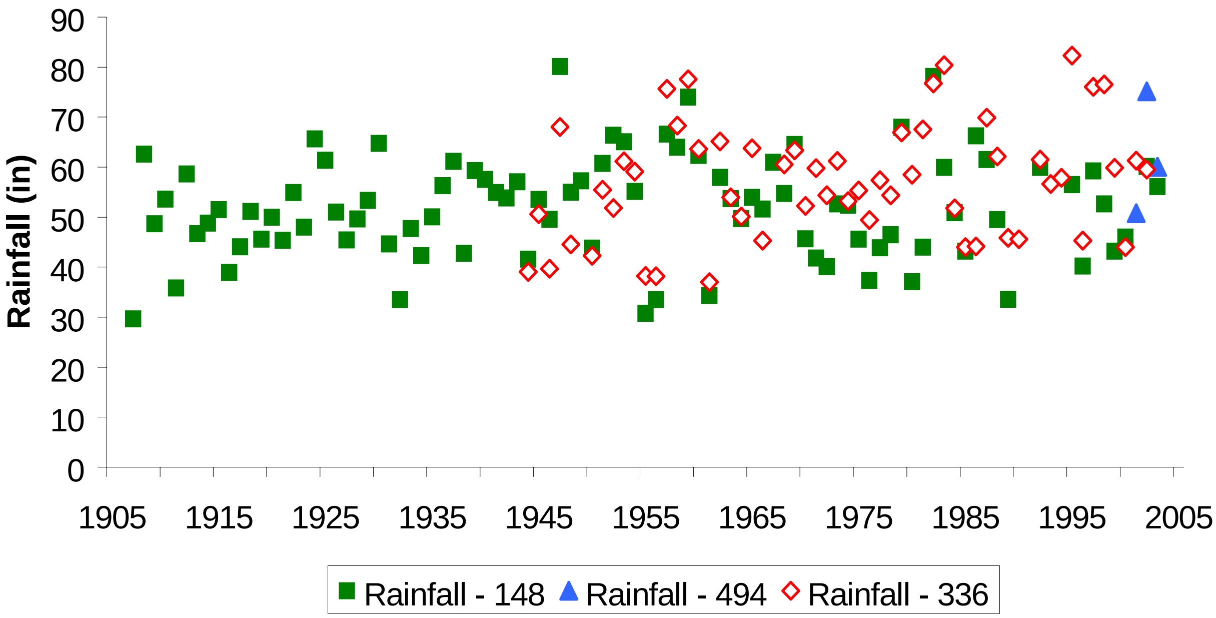


Figure 13. Total Annual Rainfall (1907-2002) at NOAA and SWFWMD Rain Gauges Near Myakka River State Park (Station 336), Arcadia (Station 148), and Horse Creek (IMC) (Station 494). (Points omitted if more than 5 days of missing data in one year (Site 148: 1990, 1991, 1993, 1994, 2001; Site 336: 1949, 1967, 1991, 2003; and Site 494: 2000.))

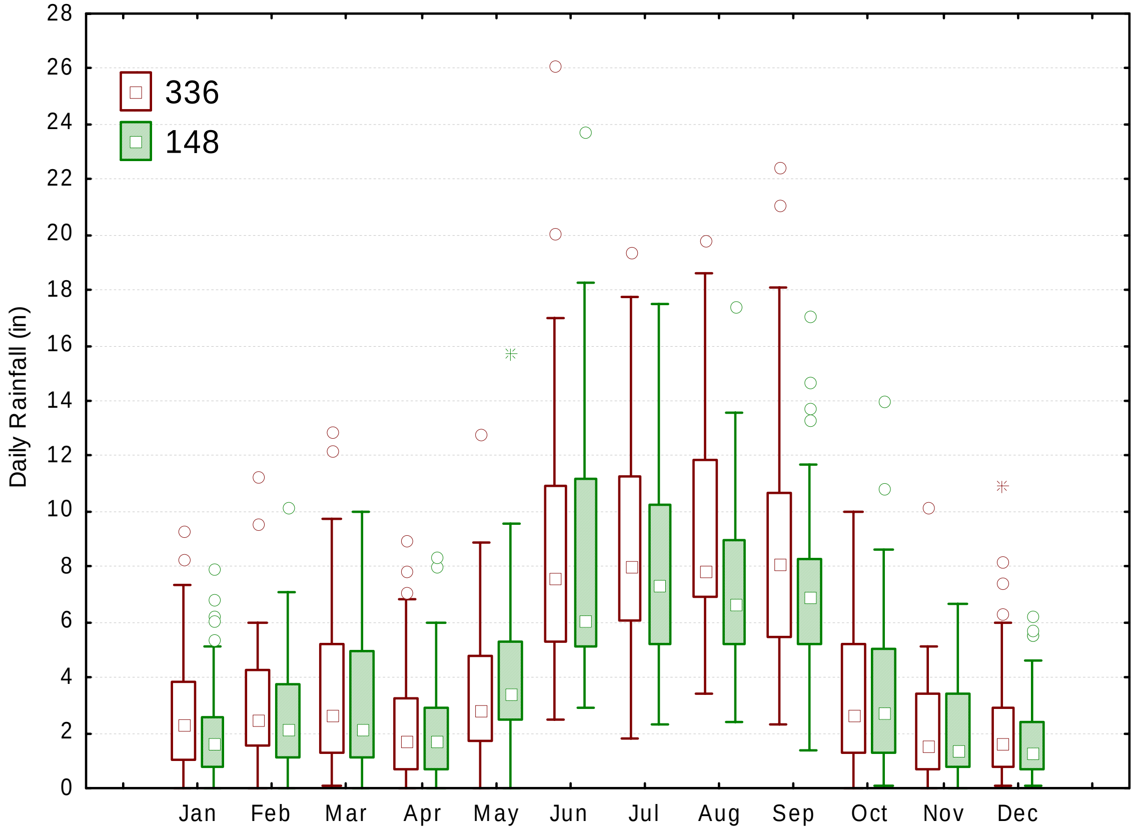


Figure 14. Median Box-and-Whisker Plot of Total Monthly Rainfall (1950-2002) at NOAA Rain Gauges Near Myakka River State Park (Station 336) and Arcadia (Station 148).).

As expected, rainfall and stream discharge historically covary in the Horse Creek Basin (Figure 15). Average annual stream discharge at Arcadia and Myakka Head is positively correlated with average annual rainfall at three rainfall gauges in the Horse Creek Basin (Table 10). The correlation between discharge and rainfall is stronger at the Arcadia station than the Myakka Head station because of the relative proximity of the rain gauges (Figure 1). Mean monthly rainfall and stream discharge were also significantly positively correlated at all stations, including the Horse Creek (IMC) rainfall station (Table 11). Correlations between rainfall and discharge at both stations are approximately constant over time (Tables 10 and 11).

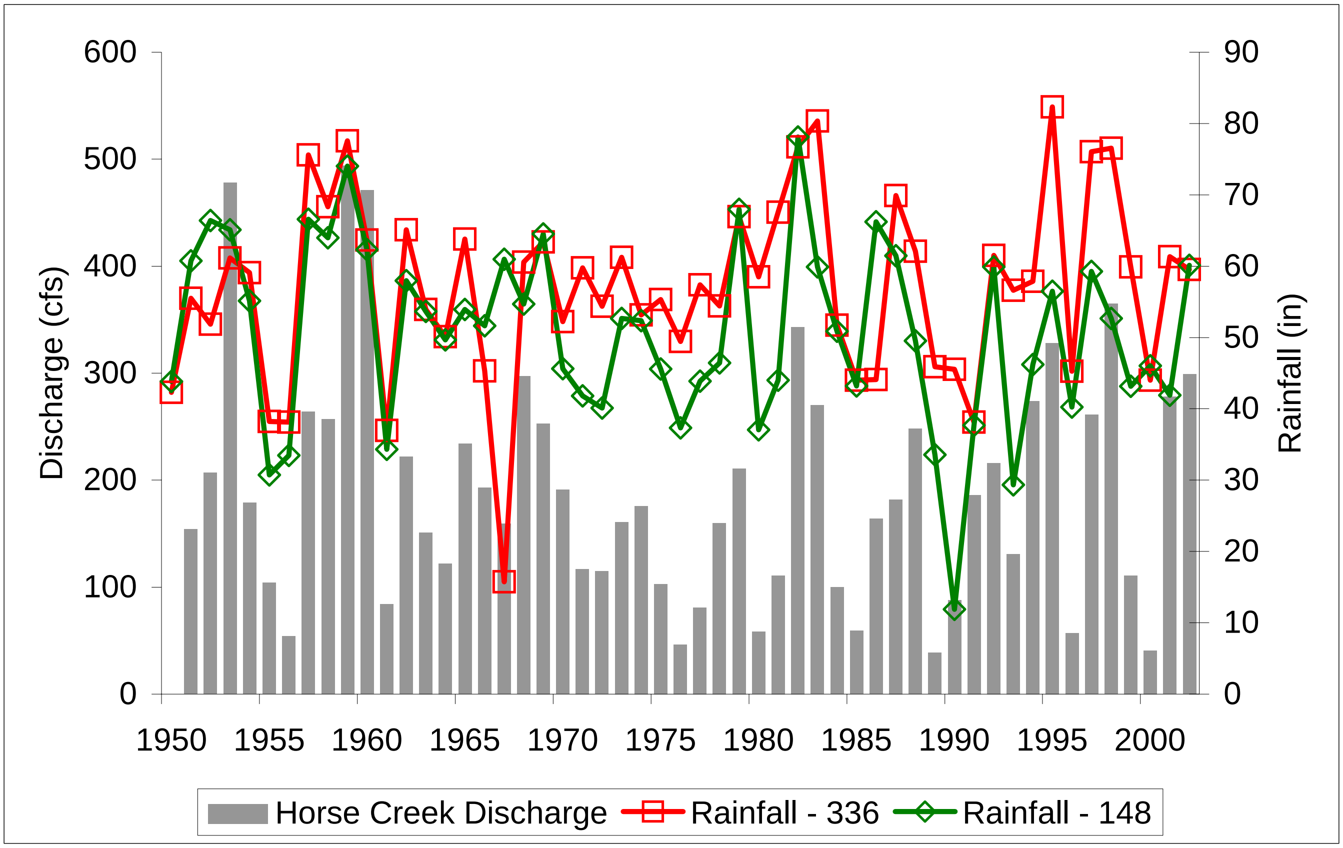


Figure 15. Mean Annual Streamflow USGS Station Horse Creek Near Arcadia (2297310) and NOAA Total Annual Rainfall at Near Myakka River State Park (336) and Arcadia (148).). (Rainfall omitted if more than 5 days of missing data in one year (Site 148: 1990, 1991, 1993, 1994, 2001; Site 336: 1949, 1967, 1991, 2003; and Site 494: 2000.))

Table 10. Pearson's Product Moment Correlation Coefficients (r) for Average Annual Stream Discharge and Rainfall in the Horse Creek Basin.

	Arcadia Discharge (from 1950)			Myakka Head Discharge (from 1977)		
NOAA Rainfall Station	Myakka St Pk - 336	Arcadia -148	Average of 148 and 336	Myakka St Pk - 336	Arcadia -148	Average of 148 and 336
To 1985	0.6759**	0.8389**	0.8070**	0.5822*	0.6640*	0.6895**
To 1990	0.6729**	0.8312**	0.8148**	0.4981*	0.6616**	0.6755**
To 1995	0.6836**	0.8283**	0.7966**	0.5171**	0.6751**	0.6254**
To 2000	0.7170**	0.8023**	0.8098**	0.6237**	0.5802**	0.6618**
To 2002	0.7138**	0.8047**	0.8148**	0.6199**	0.5864**	0.6698**

* $p < 0.10$, ** $p < 0.05$, and the Shapiro-Wilk test for normality gave $p > 0.05$ for all variables.

Table 11. Spearman's Rho Nonparametric Correlation Coefficients (r_s) for Average Monthly Stream Discharge and Rainfall in the Horse Creek Basin.

	Arcadia Discharge (from 1950)			**Myakka Head Discharge (from 1977)**		
NOAA Rainfall Station	Myakka St Pk - 336	Arcadia -148	Average of 148 and 336	Myakka St Pk - 336	Arcadia -148	Average of 148 and 336
To 1985	0.6049	0.5799	0.6179	0.6001	0.5391	0.5962
To 1990	0.5987	0.5746	0.6133	0.6120	0.5543	0.6137
To 1995	0.6112	0.5901	0.6277	0.6251	0.5883	0.6302
To 2000	0.6093	0.5838	0.6258	0.6081	0.5634	0.6144
To 2002	0.6070	0.5886	0.6251	0.6139	0.5787	0.6213

* All coefficients were significant at the $p < 0.001$ level, and the Shapiro-Wilk test for normality gave $p < 0.05$ for all variables.

A double-mass curve was created (after Hammett 1990) to compare the ratio of precipitation to discharge over time at the stations Horse Creek near Arcadia (Figure 16). Straight lines indicate a constant ratio of rainfall to discharge; any change in the ratio will be reflected by a change in the slope of the line. The double-mass curve in Figure 14 was divided into subsections that represent changes in slope. Points included in each sub-section of the double-mass curve were selected in a manner that maximized the regression coefficient of each subsection; each subsection was chosen to contain at least 10 years of data to avoid short-term fluctuations in rainfall.

From 1950 to 1971, rainfall and discharge have a relatively constant relationship ($r^2 = 0.995$, slope = 1.50). After 1971, however, the slope of the curve decreases ($r^2 = 0.995$, slope = 0.986), indicating one of three things: 1) discharge has decreased and rainfall is constant, 2) rainfall has increased and discharge is constant, or 3) a combination of 1 and 2 (Meyer 2002). From Figure 16, discharge appears to have decreased from 1971 - 1989, while rainfall during that time period remained similar to that of previous years. The decrease in discharge, if not explained by rainfall, may indicate an increase in impervious surfaces (Meyer 2002), groundwater pumpage (Hammett 1990), or wetland disconnection in the Horse Creek Basin (Meyer 2002). It is impossible, however, that phosphate mining in the basin caused this decrease in discharge as mining did not begin until the late 1980's, when the discharge/rainfall relationship began to increase. After 1989, the ratio between rainfall and discharge changes again ($r^2 = 0.994$, slope = 1.39); the slope increase indicates an increase in discharge relative to rainfall (Figure 16). Increases in the discharge-rainfall relationship after 1989 appear to have returned the overall pattern to roughly the same condition observed before 1971. It seems reasonable to assume that the Horse Creek system could see future oscillations in this relationship as a result of both natural and anthropogenic effects.

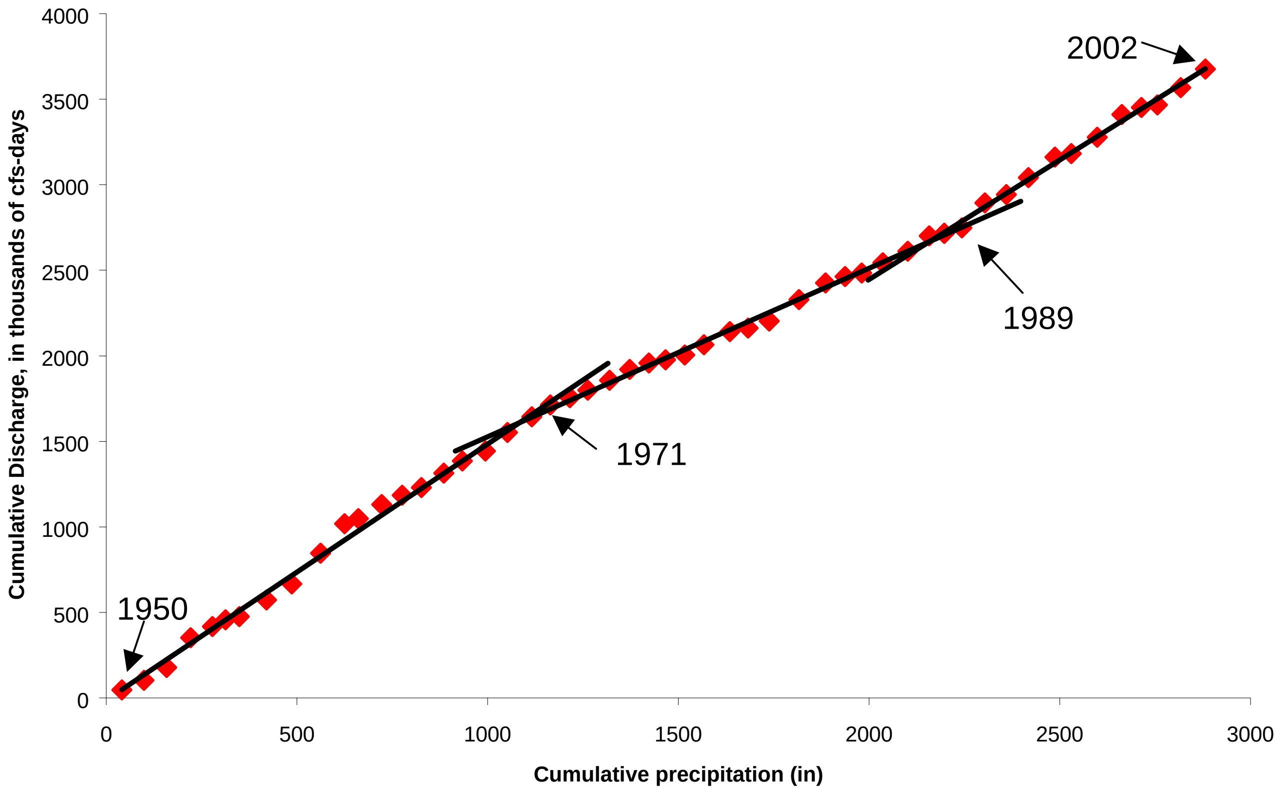


Figure 16. Accumulated Annual Mean Discharge (USGS, Horse Creek Near Arcadia) as a Function of Precipitation (Average of Three SWFWMD Rain Gauges).

4.4 STREAM VELOCITY

Mean daily stream velocity for Horse Creek at the Arcadia and Myakka Head stations ranged from 0 ft/s to about 2.5 ft/s. Mean annual stream velocity was slightly higher at the Arcadia station (0.98 ft/s) than at Myakka Head (0.8 ft/s), but the range was similar at both stations. Stream velocity shows a weak seasonal trend, with slightly lower velocity at the end of the dry season, and higher velocity at the end of the wet season (Figure 17). Inasmuch as stream velocity is primarily a function of topographic relief and in-stream morphometry, there is little reason to expect this parameter to change as a result of human activities in the basin. Stream velocity was included in this report to complete a comprehensive view of the hydrology of Horse Creek, but there is little reason to expect changes in stream velocity to be an indicator of potential mining impacts.

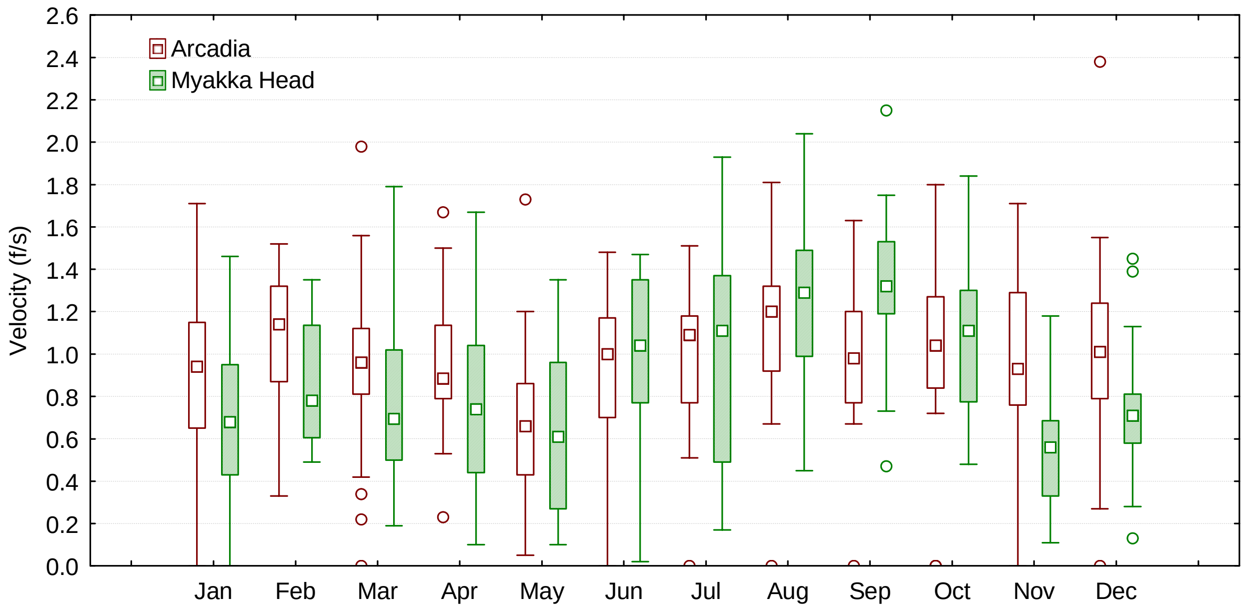


Figure 17. Median Box-and-Whisker Plot of Monthly Stream Velocity at USGS Station Horse Creek Near Arcadia (2297310) (1950-1990) and Horse Creek Near Myakka Head (2297155) (1977-2002).

5.0 SURFACE WATER QUALITY

5.1 DATA SOURCES

Water quality data were obtained from four sources [USGS, Florida Department of Environmental Protection (FDEP), SWFWMD, and Environmental Quality Laboratories (EQL)] for six sites along Horse Creek. From north to south, these sites are Horse Creek near Myakka Head (SR 64), at SR 663 BRDG, at SR 665 BRDG, at SR 70, near Arcadia (SR 72), and at SR 761 (Table 12). Four of these sites correspond to those monitored by the Horse Creek Stewardship Program (SR 64, SR 663, SR 70, and SR 72). Very little data is available for the SR 663, SR 665, and SR 70 stations for most water quality parameters. An electronic database of the historical water quality data is available on the attached CD-ROM. For use in this report, we have chosen a less stringent acceptance criterion to choose data for analysis than some other entity might. We recognize that there may be several drawbacks to using all of the data that we obtained. For instance, data on parameters collected over a more than 30-yr period may not be consistent over time if collection and laboratory methods have not remained consistent. However, we have chosen to include all available data in this analysis, other than those extremes that are obviously false (e.g. 400000 mg/L when all other values are less than 400 mg/L).

The SWFWMD dataset provides the most recent, consistent data (monthly for 1997-2000), while the USGS dataset has the longest period of record (from the 1960's), but with lower sampling frequency. The FDEP dataset is less consistent than the SWFWMD dataset and does not extend back as far as the USGS dataset, but represents more stations (including stations HCSW-2 (SR 663) and HCSW-3 (SR 665) of the HCSP) and covers much of the gap in time between the other datasets. The FDEP records from the STORET database may include data that were collected for purposes other than ambient condition monitoring (e.g., investigation of potential contamination, etc.), potentially biasing the results. For future comparisons between current and historical water quality in HCSP Annual Reports, we recommend that all three of these major data sources be used.

The EQL data is only available for one station on Horse Creek (SR 761), which is not part of the HCSP monitoring area. While the EQL dataset has value for evaluating the lower reach of Horse Creek, it is not considered in detail here because there are no comparative data being collected through the HCSP. In the event the HCSP monitoring shows effects in the lower basin, the EQL data can always be used in the future as a supplemental source for comparison.

Small amounts of additional water quality data from Development of Regional Impact (DRI) applications and Environmental Impact Statements (EIS) in the Horse Creek Basin have been collected by private companies in the past. These datasets are quite limited in their period of record and thus would add little to the information collected by SWFWMD, FDEP and USGS. Some of the DRI/EIS data are included in the FDEP STORET data summarized herein (Rutter et al. 1985), but some of the data are privately held and are, therefore, not readily available for this analysis (ESE 1986).

Data for each station were combined from several sources over the period from 1972 to 2002. The parameters used in the analysis include most of those being monitored by the Horse Creek Stewardship Program. Consistent data for most water quality parameters are not available over the entire 30-yr period, making trend analysis difficult. Box and whisker plots, therefore, have been used for exploratory data analysis (Appendix B for explanation). Plots for two Horse Creek Stewardship Program stations with the best period of record (Horse Creek near Myakka Head (SR 64) and near Arcadia (SR 72)) are included in the main text; plots for other stations are located in Appendix B. To determine relationships between water quality parameters and streamflow, Pearson's product moment correlation coefficients (Zar 1999) were calculated between pairs of water quality parameters and between water quality and discharge and rainfall at Horse Creek stations near SR 64 and SR 72. Correlation coefficients (r) range between 0 (no correlation) and 1 (completely correlated); we considered correlations to be statistically significant if p values were less than 0.05, but relationships were only considered to be "strong" if $r > 0.60$ or greater.

Because of inconsistent sampling frequency and the combination of data sources, parametric methods for time-series analysis were not appropriate for this data set. Therefore, Seasonal Kendall Tau (Schertz et al. 1991), a nonparametric correlation by ranks, was used to determine if observed changes in parameters over time were significant at SR 64 and SR 72. The program ESTREND, provided by the USGS, was used to estimate long-term trends in water quality at those two stations (Schertz et al. 1991). ESTREND uses the Seasonal Kendall Tau test, a nonparametric trend test, to determine water quality trends after correcting for seasonality by only comparing values between similar seasons over time (Schertz et al. 1991). The Seasonal Kendall Tau test selects one value for each season (the most central with respect to sampling time) and makes all pair-wise comparisons between time-ordered seasonal values; a statistic is computed by comparing the number of times a later value is larger than an earlier value in the data set, and vice-versa (Schertz et al. 1991).

Exploratory data analysis (box-plots and time-series graphs) was used to select the number and duration of seasons for each water quality parameter; the seasons were chosen based on logical temporal differences in water quality parameters caused by streamflow and other sources, usually corresponding to the wet (May-September) and dry seasons (October-April). After seasons were chosen, ESTREND then indicated whether portions of the data set (first fifth, last fifth, middle three fifths) contained sufficient data for each season to make pair-wise comparisons without bias toward more densely sampled portions of the period of record. Trend analyses were only conducted on parameters that contained enough data for over 50 percent of the possible seasonal pair-wise comparisons. Usually, the data set contained sufficient data to select only two seasons (May-Sept and Oct-April), although in some cases one or three seasons was selected (Tables 38 and 39). Some water quality parameters were adjusted for correlations with streamflow when seasonality corrections did not eliminate the correlation.

The magnitude of the Seasonal Kendall Tau, its significance (p), its slope (Sen slope estimator), and the direction of significant trends (at $p < 0.05$) are reported in Tables 38 and 39 for each water quality parameter tested for Horse Creek. The trend (Sen) slope is the median slope of all pairwise comparisons and the direction of this slope (positive or negative) is more resistant to minimum detection limits, reporting limits, and missing data than the magnitude of the slope. The slope is a measure of the monotonic trend, which is an apprimoximation of the actual temporal variation than may change differently (by steps, reversals, etc.). Parameters or stations with significant gaps in data or with less than five years or less than ten observations (ESTREND minimum requirements) in the dataset were eliminated from trend analyses. Outliers were removed from the datasets prior to trend analysis. Minimum detection limits were not specifically accounted for in trend analysis because of the various methodologies used by the source agencies; however, non-parametric methods that rank values, such as the Seasonal Kendall Tau, are more robust than parametric methods against bias that values below the minimum detection limit can create. Long-term trend analysis with the Seasonal Kendall Tau test may have some limitations when used on multiple- source, inconsistent datasets, but we expect that the test is robust enough to identify significant trends and their direction when used on datasets that meet the program ESTREND's requirements.

Table 12. Sources, Period of Record, and Parameters for Water Quality Data in the Horse Creek Basin. Stations are Listed from North to South. Stations Depicted in Figure 1.

Agency	Station Name	Station No.	Data Type	Period of Record	HCSP	Alternate Name
USGS	Horse Creek Near Myakka Head	2297155	DO, pH, conductivity, temp	1978-1999	HCSW-1	Horse Creek at SR 64 Bridge
			NH4, sulfate, Fl, OP, color, Cl, Ca, TKN, NOx, TP	1992-1999		
			TN, Alkalinity, Fe	1982 (once)		
SWFWMD	Horse Creek Near Myakka Head	27291408 2012401	pH, conductivity, turbidity, DO, NH4, Chlorophyll a, OP, color, NOx, TP, temp	1997-2002	HCSW-1	Horse Creek at SR 64 Bridge
			Sulfate, Fl, Cl, Ca	2000-2002		
			TN	1997-2002 (spotty)		
FDEP	Horse Crk at SR 64 Brdg	25020428	pH, DO, color, temp	1972-1990	HCSW-1	Horse Creek Near Myakka Head
			Conductivity, turbidity, NH4, sulfate, Fl, OP, Cl, TKN, NOx, TP	1972-1990 (spotty)		
			Ca, Alkalinity, Iron	(few)		
FDEP	Horse Crk at SR 663 Brdg	25020430	pH, DO, color, temp	1972-1990	HCSW-2	
			Conductivity, turbidity, NH4, sulfate, Fl, Cl, TKN, NOx, TP	1972-1990 (spotty)		
			OP, chlorophyll a	(few)		
FDEP	Horse Crk at SR 665 Brdg	25020427	pH, DO, color, temp	1972-1991		
			Conductivity, turbidity, NH4, sulfate, Fl, Cl, TKN, NOx, TP	1972-1991 (spotty)		
			OP, chlorophyll a, alkalinity, Fe	(few)		
FDEP	Horse Creek at SR 70	25020423	pH, DO, color, temp	1972-1991	HCSW-3	Horse Creek (IMC)
			Conductivity, turbidity, OP , sulfate, Fl, Cl, TKN, NOx,	1972-1991 (spotty)		
			NH4, chlorophyll a, Fe	(few)		
USGS	Horse Creek Near Arcadia	2297310	pH, conductivity, temp	1962-1999	HCSW-4	Horse Creek at SR 72 Bridge
			DO	1968-1999		
			Sulfate, Fl, color, Cl, Ca, Fe, turbidity	1962-1999 (spotty)		
			Alkalinity	1962-1970		
			TKN, NOx, TP, NH4	1979-1999		
SWFWMD	Horse Creek Near Arcadia	27115808 1591801	pH, conductivity, turbidity, DO, NH4, chlorophyll a, OP, color, NOx, TP, temp	1997-2002	HCSW-4	Horse Creek at SR 72 Bridge
			Sulfate, Fl, Cl, Ca	2000-2002		
			Alkalinity, TN	1997-2002 (spotty)		
FDEP	Horse Cr SR 72 Br	25020111	pH, conductivity, turbidity, DO, color, temp	1972-2001	HCSW-4	Horse Creek Near Arcadia
			NH4, sulfate, Fl, OP, Cl, Ca, alkalinity, iron, TKN, NOx, TP	1972-2001 (spotty)		
EQL	Horse Creek SR 761	21	pH, conductivity, turbidity, DO, temp	1975-1990		
			Sulfate, Fl, chlorophyll a, color, Cl, Ca, alkalinity, NOx, TP	1976-1990		
			NH4, TKN	1977-1990		
			Fe	1982-1990		
FDEP	Horse Creek SR 761	25020420	pH, conductivity, turbidity, DO, sulfate, Fl, Cl, TKN, NOx, TP, temp	1972-2002 (spotty)		
			NH4, chlorophyll a	(few)		

5.2 TURBIDITY

Turbidity was collected in nephlometric turbidity units (NTU) at stations near SR 64, SR 72, and SR 761. Only a few extreme values of turbidity at SR 761 and SR 64 exceeded the HCSP trigger value of 29 NTU from 1972 - 2002. Median turbidity values were usually less than 4 NTU. Overall, turbidity was much higher at station SR 761 than the other stations; station SR 761 is the closest station to the swifter Peace River. Trend analysis was not conducted for turbidity because of large gaps in data sets for the Horse Creek station near Arcadia (SR 72) and at the Myakka Head station. One outlier at Horse Creek near Myakka Head was removed for graphing (52 NTU on 2 June 2003).

Additional turbidity measurements were collected over time in Horse Creek, but in units that are not directly convertible into NTU, the units used for the Horse Creek Stewardship Program's water quality monitoring plan. These turbidity measurements in formazine nephelometric units (FNU) and Jackson candle units (JCU) are available in an electronic database on the attached CD-ROM. At the Horse Creek near Myakka Head station, turbidity was measured in JCU biannually from 1972-1976 and in FNU bimonthly from 1979-1984 and quarterly from 1989 – 1990. At the Horse Creek at Arcadia station, turbidity was measured in JCU bimonthly from 1970-1981 and in FNU monthly from 1979-1998.

Table 13. Turbidity Period of Record and Sampling Frequency of Each Data Source for Horse Creek at Myakka Head and Horse Creek at Arcadia.

Station	Time period	Measurement Frequency	Source Agency
Horse Creek at Myakka Head	1982	Once	USGS
	1997-2003	Monthly	SWFWMD
Horse Creek at Arcadia	1979-1983	Bimonthly	USGS
	1999-2001	Annual-biannual	FDEP
	1997-2003	Monthly	SWFWMD

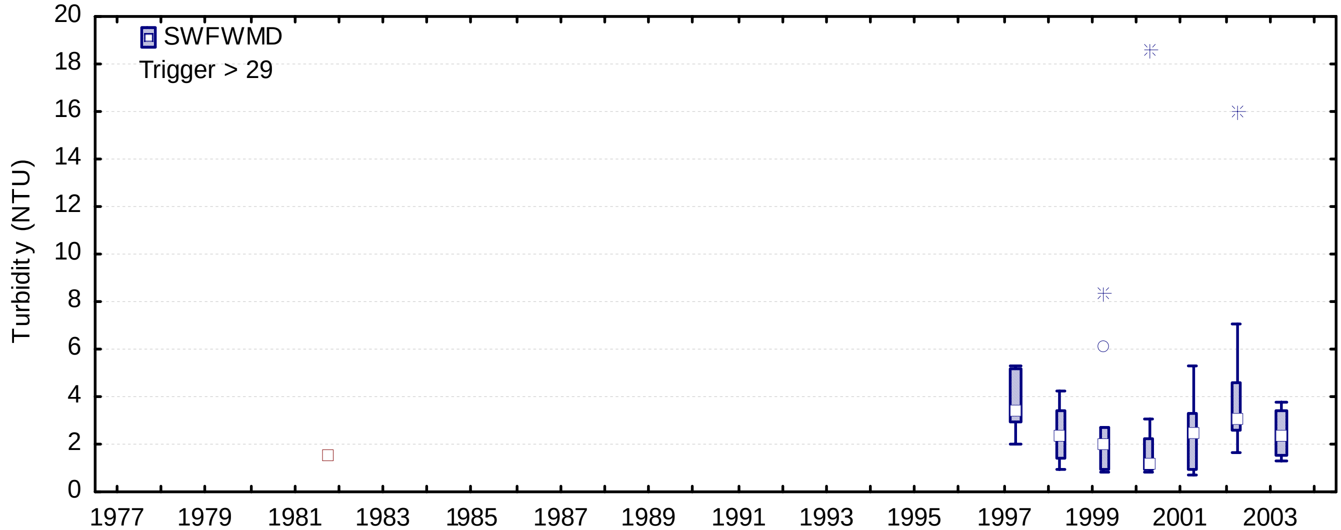


Figure 18. Annual Median Boxplots of Turbidity Levels Collected by USGS, FDEP, and SWFWMD in Horse Creek at Myakka Head - SR 64 from 1962 to 2003.

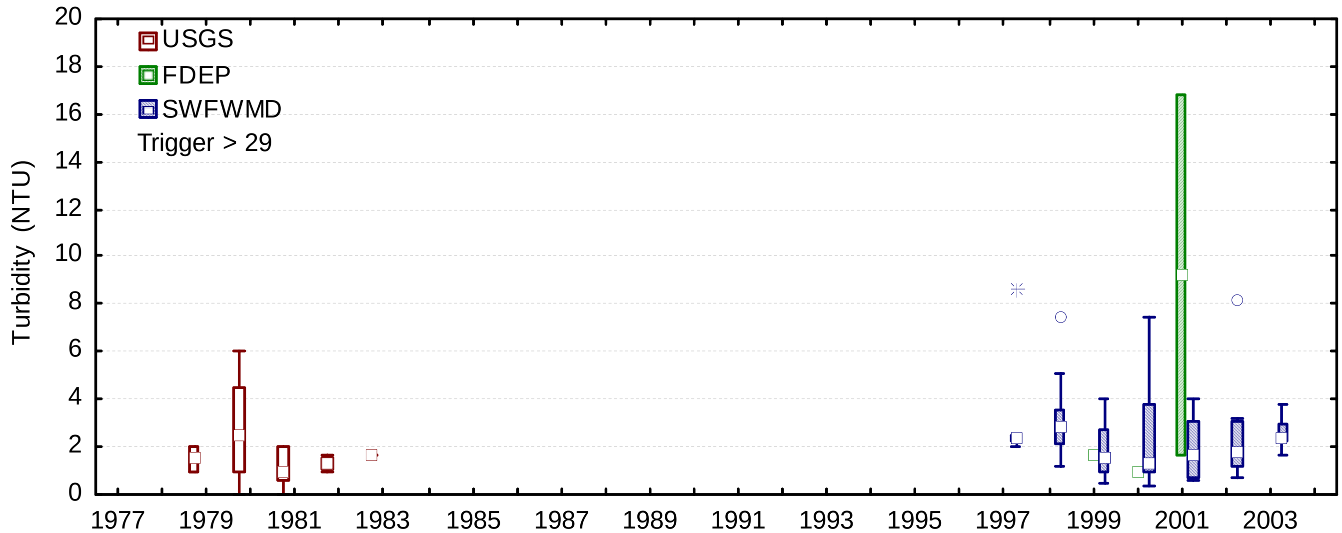


Figure 19. Annual Median Boxplots of Turbidity Levels Collected by USGS, FDEP, and SWFWMD in Horse Creek at Arcadia - SR 72 from 1962 to 2003.

5.3 pH

Although a few outliers lay beyond the HCSP trigger values, pH in Horse Creek Basin has historically fallen between 6.0 and 8.5 SU (Figures 20 and 21). At the stations on the northern and southern ends of Horse Creek (SR 64, SR 72, and SR 761), annual median pH is around 7.0. At the SR 663 and SR 665 stations that are immediately downstream of Horse Creek Prairie (Figure 24), however, pH is usually below 7.0 because of the influence of tannic acids from the swamp (Appendix B). Levels of pH decreased to near the lower HCSP trigger value (6.0) from July to October at SR 64 and SR 72, probably because of acidic runoff from decomposing vegetation (Figures 22 and 23). Seasonal Kendall Tau analyses showed no evidence of long-term trends in pH levels from stations near Myakka Head or Arcadia (Tables 38 and 39). In a Mann-Kendall trend analysis of annual pH data from 1970 – 1998, however, the Charlotte Harbor Environmental Center (CHEC 2001) found a significant decreasing trend in pH for Horse Creek. Color and pH were significantly, but weakly, negatively correlated at Horse Creek near Myakka Head, but not near Arcadia (Table 14). Low pH is associated with wetland discharge into Horse Creek, which may also increase the color of the stream with an influx of tannins.

Table 14. Pearson's Product Moment Correlation of pH and Color at Myakka Head and Arcadia Stations. (Only Correlations Significant at $p < 0.05$ Level are Listed.)

		Myakka Head
		Color
pH	r	-0.36
	N	101

Table 15. pH Period of Record and Sampling Frequency of Each Data Source for Horse Creek at Myakka Head and Horse Creek at Arcadia.

Station	Time period	Measurement Frequency	Agency
Horse Creek at Myakka Head	1972-1977, 1984, 1989, 1990	Annual-quarterly	FDEP
	1979-1983	Monthly	FDEP
	1977-1978	Annual-quarterly	USGS
	1979-1983, 1992-1999	Bimonthly	USGS
	1997-2003	Monthly	SWFWMD
Horse Creek at Arcadia	1962-1969	Annual-quarterly	USGS
	1970-1999	Bimonthly	USGS
	1972-1973, 1998-2001	Annual-biannual	FDEP
	1974-1997	Monthly-bimonthly	FDEP
	1997-2003	Monthly	SWFWMD

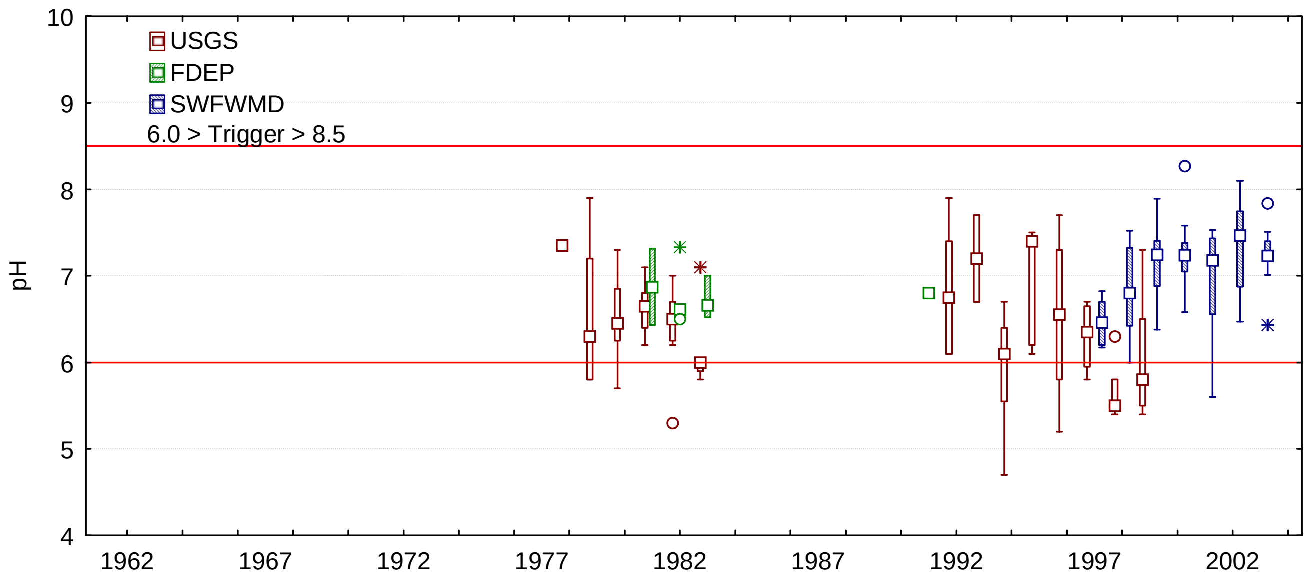


Figure 20. Annual Median Boxplots of pH Levels Collected by USGS, FDEP, and SWFWMD in Horse Creek at Myakka Head - SR 64 from 1962 to 2003.

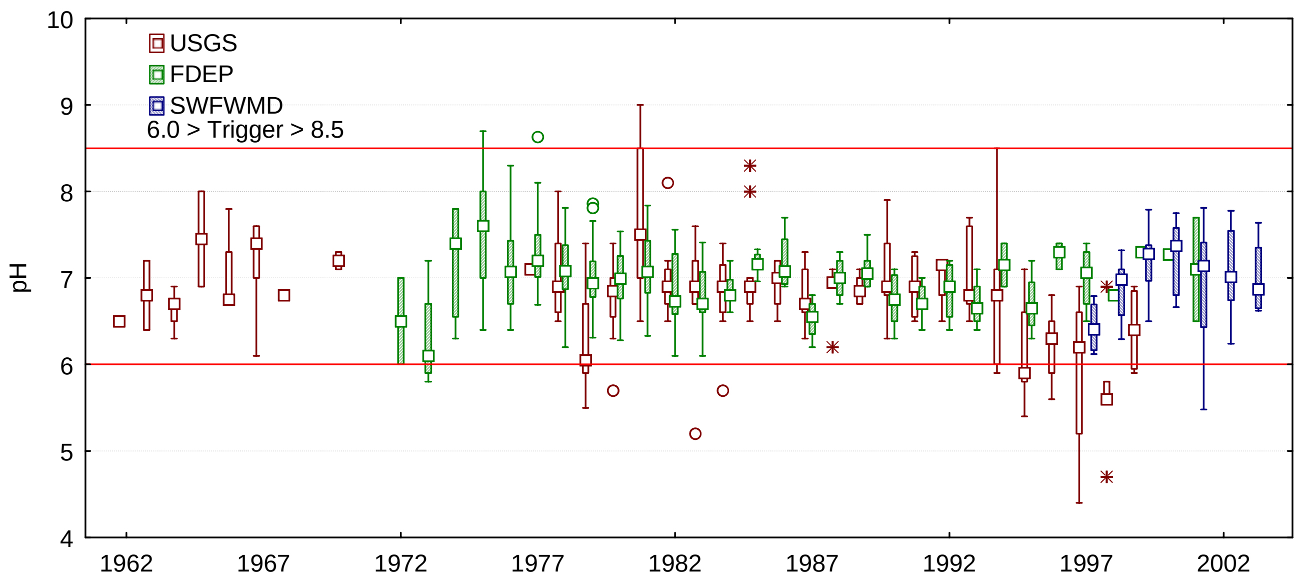


Figure 21. Annual Median Boxplots of pH Levels Collected by USGS, FDEP, and SWFWMD in Horse Creek at Arcadia - SR 72 from 1962 to 2003.

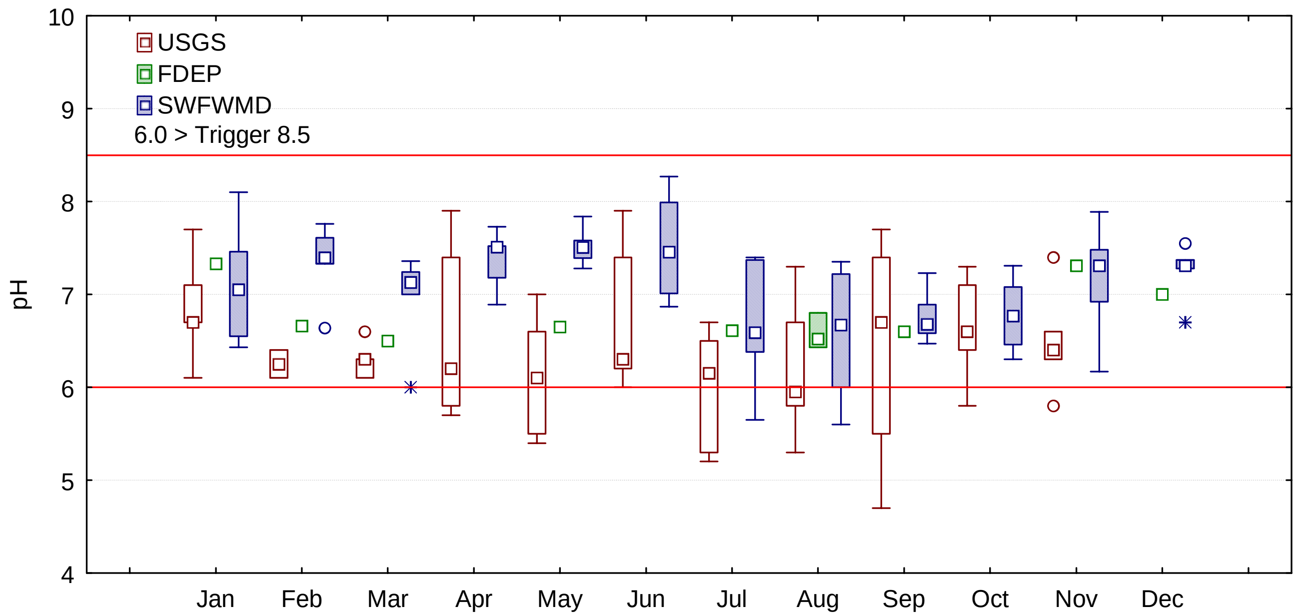


Figure 22. Monthly Median Boxplots of pH Levels Collected by USGS, FDEP, and SWFWMD in Horse Creek at Myakka Head - SR 64 from 1962 to 2003.

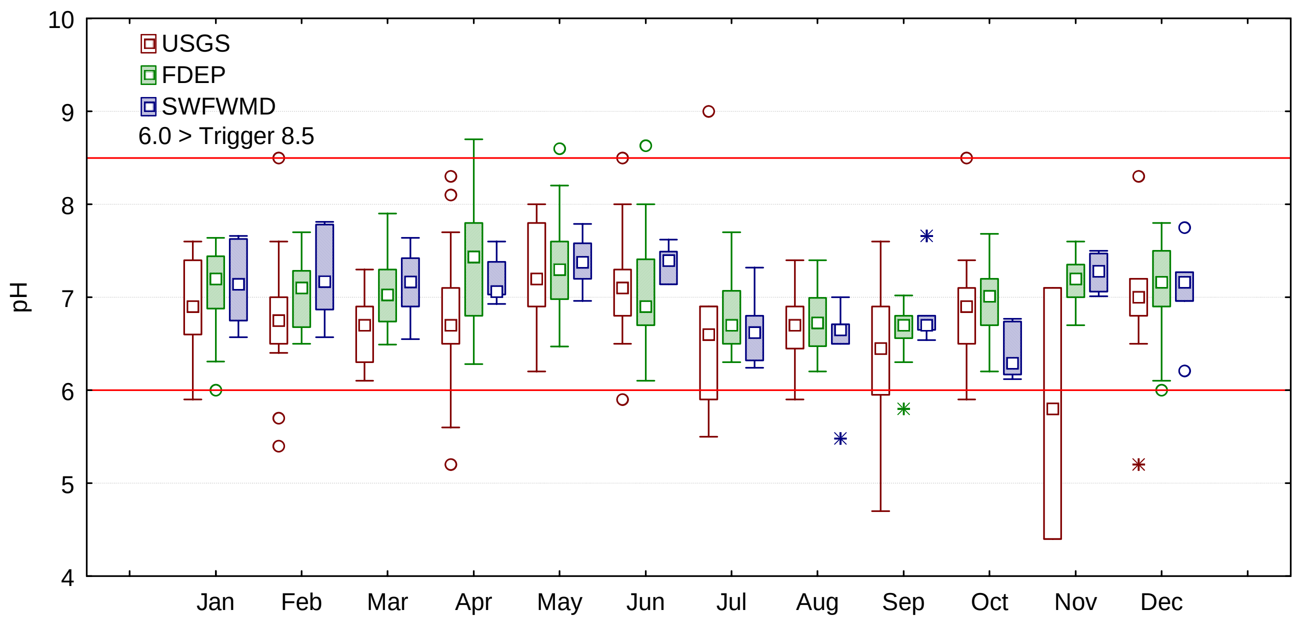
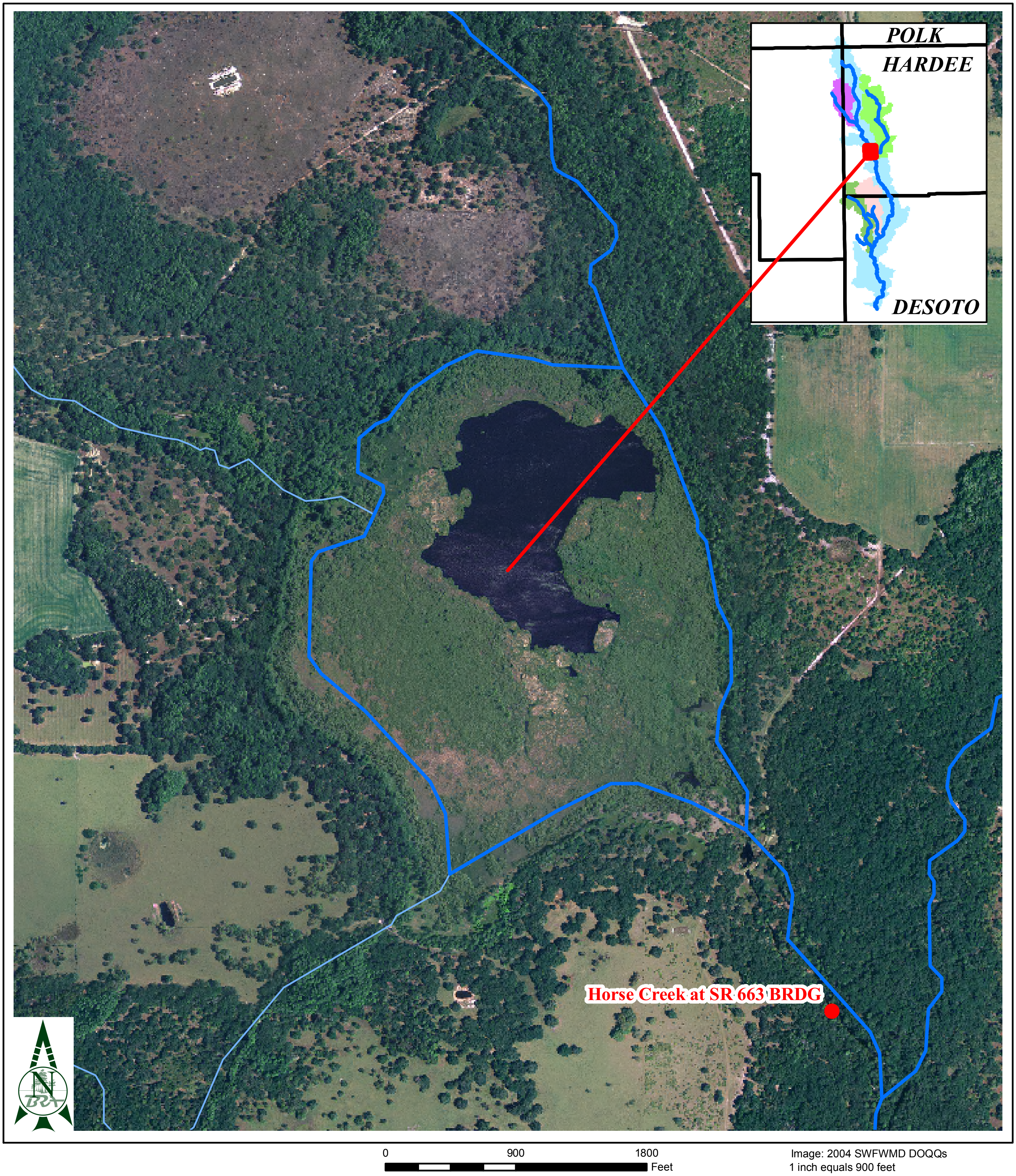


Figure 23. Monthly Median Boxplots of pH Levels Collected by USGS, FDEP, and SWFWMD in Horse Creek at Arcadia - SR 72 from 1962 to 2003.



Preparation Date: 20 May 2005	Revision Date: 21 July 2005	Project Number: 2476-065-b51
Project Manager: DJD	GIS Operator: LBS	GIS QA/ QC:
ArcMap Name: horsecreek-prairie.mxd	Plot File: horsecreek_prairie.pdf	

Figure 24
2004 Aerial Photography of Horse Creek Prairie, a 160-acre swamp lying 1.5 km upstream of SR 663 (HCSW-2) on Horse Creek

Biological Research Associates
3910 US Highway 301N
Suite 180
Tampa, Florida 33619
813-664-4500 FAX: 813-664-0440
www.biologicalresearch.com

5.4 DISSOLVED OXYGEN

Dissolved oxygen levels show an interesting pattern across the six sites. During the 30-year period of interest, stations at SR 64, SR 70, and SR 72 (corresponding to HCSW-1, 3, and 4 of the HCSP) very seldom had dissolved oxygen concentrations of less than 5 mg/L, the HCSP trigger value for the HCSP. Stations at SR 663 and SR 665, which are nearest to HCSW-2 of HCSP, have much lower dissolved oxygen concentrations than the other stations. At SR 663, dissolved oxygen is always less than the HCSP trigger value, ranging from 0.5 to 5.0 mg/L. At SR 665 dissolved oxygen was measured at slightly higher concentrations, ranging from 3.0 – 8.0 mg/L. Both stations are directly downstream of Horse Creek Prairie (Figure 24), a hypoxic swamp. Some measurements of dissolved oxygen at SR 761 were also below the HCSP trigger value, but the annual median concentration was always above 5.0 mg/L. One outlier at Horse Creek at Arcadia was removed for graphing (17.2 mg/L, 4 March 1980).

Dissolved oxygen concentrations showed a seasonal trend, with concentrations lowered to near the HCSP trigger value (5 mg/L) during the wet season, when higher temperatures lower the capacity of the stream to hold oxygen (Figures 27 and 28). Dissolved oxygen at SR 72 showed a trend of increasing concentration over time (Seasonal Kendall Tau slope = 0.04 mg/L/yr), but levels at SR 64 showed no long-term trend (Tables 38 and 39). The increasing trend in dissolved oxygen at SR 72 is consistent with an annual Mann-Kendall trend analysis of 1970-1998 data (CHEC 2001), but that study also found a decrease in dissolved oxygen at SR 64. The difference between the results of BRA and CHEC (2001) trend tests may be because of the difference in the period of record (BRA went to 2003) or the statistical methods (BRA used Seasonal Kendall Tau, not Mann-Kendall Tau using annual means). Dissolved oxygen was significantly positively correlated with pH and negatively correlated with water temperature at both SR 72 and SR 64 (Table 16).

Table 16. Pearson's Product Moment Correlation of Dissolved Oxygen with pH and Water Temperature at Myakka Head and Arcadia Stations. (Only Correlations Significant at $p < 0.05$ Level are Listed.)

		Myakka Head		Arcadia	
		pH	Temperature	pH	Temperature
Dissolved Oxygen	r	0.27	-0.49	0.49	-0.31
	N	159	162	491	538

Table 17. Dissolved Oxygen Period of Record and Sampling Frequency of Each Data Source for Horse Creek at Myakka Head and Horse Creek at Arcadia.

Station	Time period	Measurement Frequency	Agency
Horse Creek at Myakka Head	1972-1977, 1989-1990	Annual-quarterly	FDEP
	1979-1984	Monthly-bimonthly	FDEP
	1977-1978	Annual-quarterly	USGS
	1979-1983, 1992-1999	Bimonthly	USGS
	1997-2003	Monthly	SWFWMD
Horse Creek at Arcadia	1962-1969	Annual-quarterly	USGS
	1970-1999	Bimonthly	USGS
	1972-1997	Monthly-bimonthly	FDEP
	1998-2001	Annual	FDEP
	1997-2003	Monthly	SWFWMD

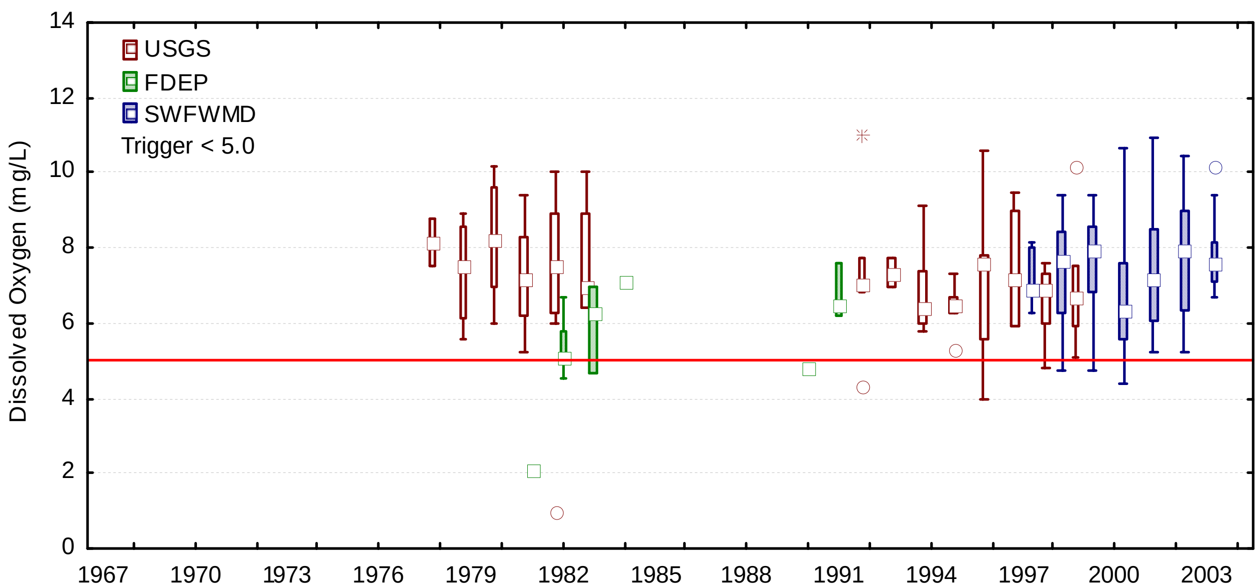


Figure 25. Annual Median Boxplots of Dissolved Oxygen Concentrations Collected by USGS, FDEP, and SWFWMD in Horse Creek at Myakka Head - SR 64 from 1962 to 2003.

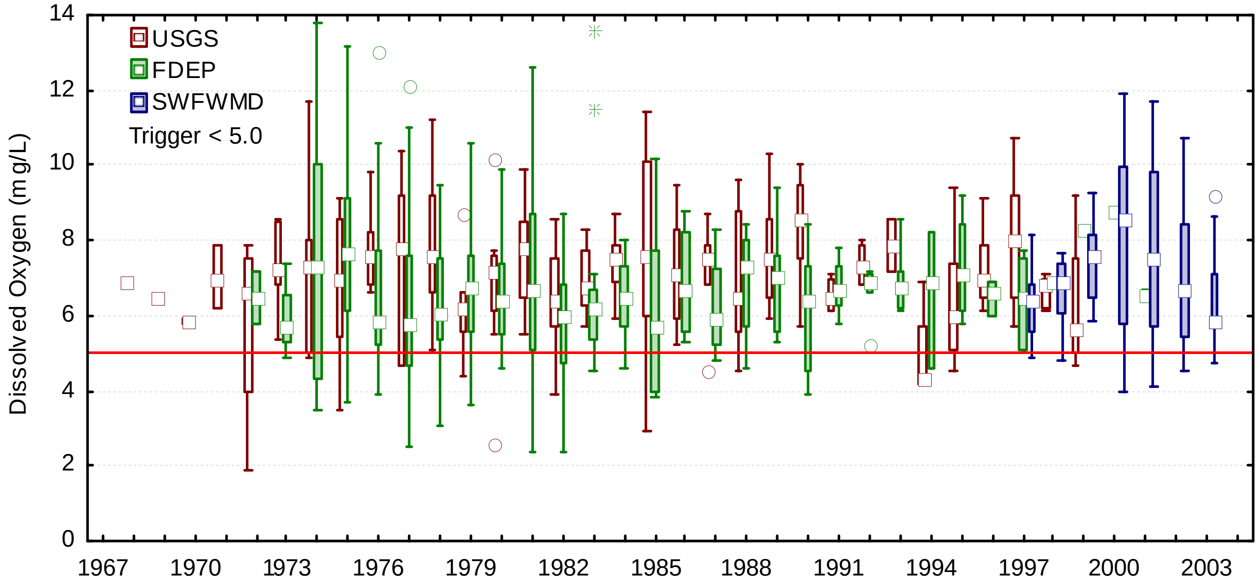


Figure 26. Annual Median Boxplots of Dissolved Oxygen Concentrations Collected by USGS, FDEP, and SWFWMD in Horse Creek at Arcadia - SR 72 from 1962 to 2003.

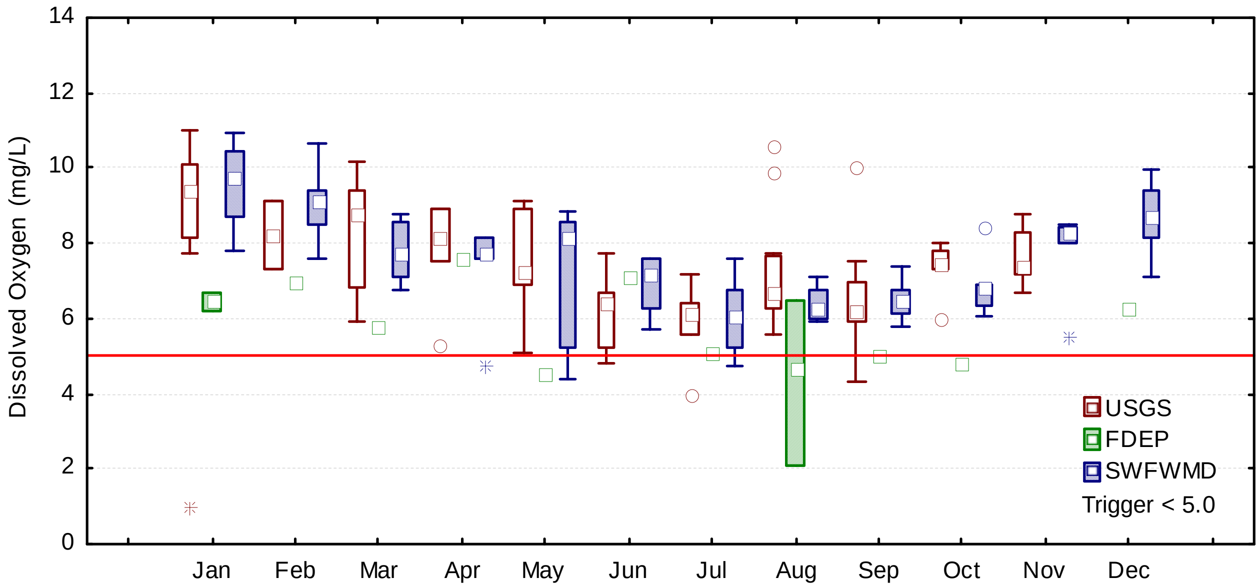


Figure 27. Monthly Median Boxplots of Dissolved Oxygen Concentrations Collected by USGS, FDEP, and SWFWMD in Horse Creek at Myakka Head - SR 64 from 1962 to 2003.

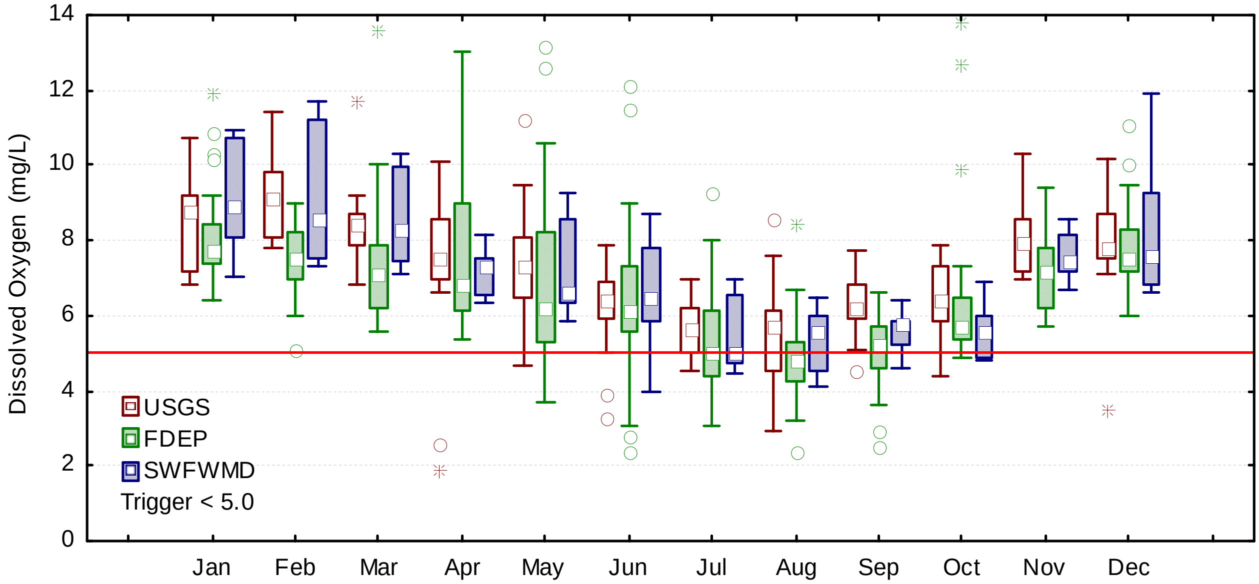


Figure 28. Monthly Median Boxplots of Dissolved Oxygen Concentrations Collected by USGS, FDEP, and SWFWMD in Horse Creek at Arcadia - SR 72 from 1962 to 2003.

5.5 NITROGEN

5.5.1 Nitrate plus Nitrite

Nitrate plus nitrite concentrations were almost always below 3.0 mg/L, the HCSP trigger value for total nitrogen in the Horse Creek Basin (Figures 29 and 30). The two southernmost stations had the highest concentrations of nitrogen oxides, most likely from rangeland runoff from pasture in central and southern Horse Creek Basin (SWFWMD 2000, Lewelling 1997). The northern Horse Creek Basin is covered with more natural vegetation than rangeland. A Seasonal Kendall's Tau test showed that nitrogen oxide concentrations in the basin are rising over time at the downstream SR 72 station by 0.011 mg/L/yr, but are decreasing at the upstream SR 64 station by 0.005 mg/L/yr (Tables 38 and 39). The upward trend at the SR 72 station was consistent with trend analyses performed by several researchers (CHEC 2001, Wade et al. 2003, Coastal Environmental 1996, PBSJ and Bexter Dender 1999). Six outliers were removed for graphing, including one outlier from Horse Creek near Myakka Head (4.9 mg/L) and five from Horse Creek at Arcadia (2.7 – 4.0 mg/L)

Sludge application has been suggested as a possible cause for increased oxidized nitrogen concentrations downstream in Horse Creek. There is little evidence, however, that sludge application has been widespread in the Horse Creek Basin. Like most rural inland areas, the small amount of sludge generated within the basin (from private septic tanks) would have traditionally been informally disposed of in the same area. There has been no known large-scale importation and spreading of sludge from outside the basin in the past. Within the last two decades, there was some limited spreading in the upper part of the basin (principally in the West Fork of Horse Creek). There is no recognized active sludge spreading in the Horse Creek Basin on lands that drain to the Stewardship Program sampling sites at this time.

Table 18. Nitrate plus Nitrite Period of Record and Sampling Frequency of Each Data Source for orse Creek at Myakka Head and Horse Creek at Arcadia.

Station	Time period	Measurement Frequency	Agency
Horse Creek at Myakka Head	1972-1977, 1983-1984, 1989-1990	Annual-quarterly	FDEP
	1979-1982	Monthly-bimonthly	FDEP
	1992-1993	Annual-quarterly	USGS
	1994-1999	Bimonthly	USGS
	1997-2003	Monthly	SWFWMD
Horse Creek at Arcadia	1979-1999	Bimonthly	USGS
	1974-1993	Monthly-bimonthly	FDEP
	1994-2001	Annual-quarterly	FDEP
	1997-2003	Monthly	SWFWMD

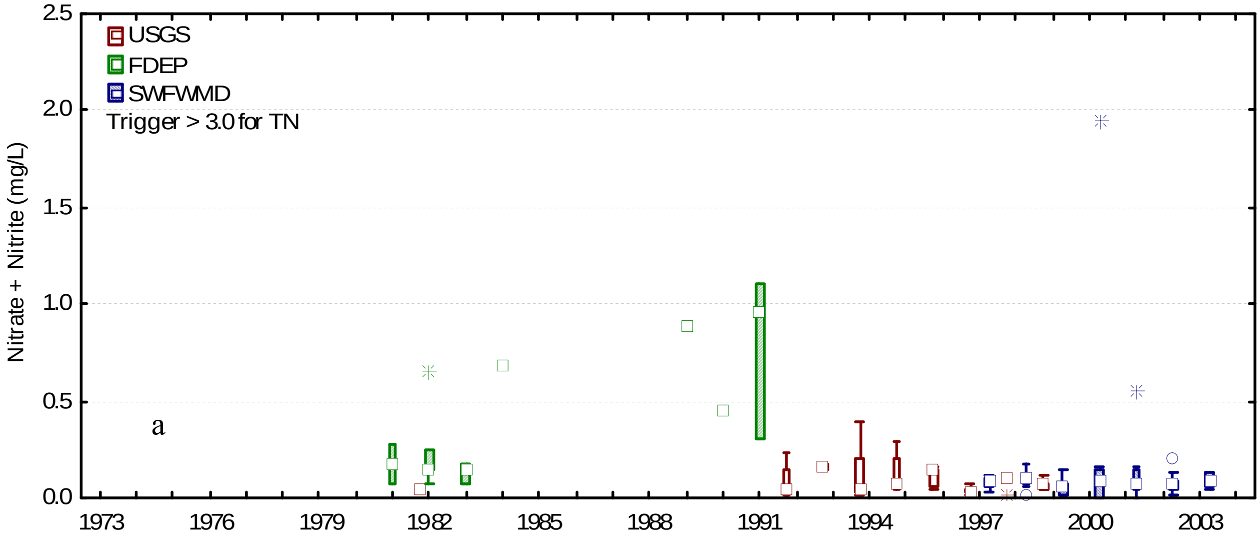


Figure 29. Annual Median Boxplots of Nitrate + Nitrite Concentrations Collected by USGS, FDEP, and SWFWMD in Horse Creek at Myakka Head - SR 64 from 1962-2003.

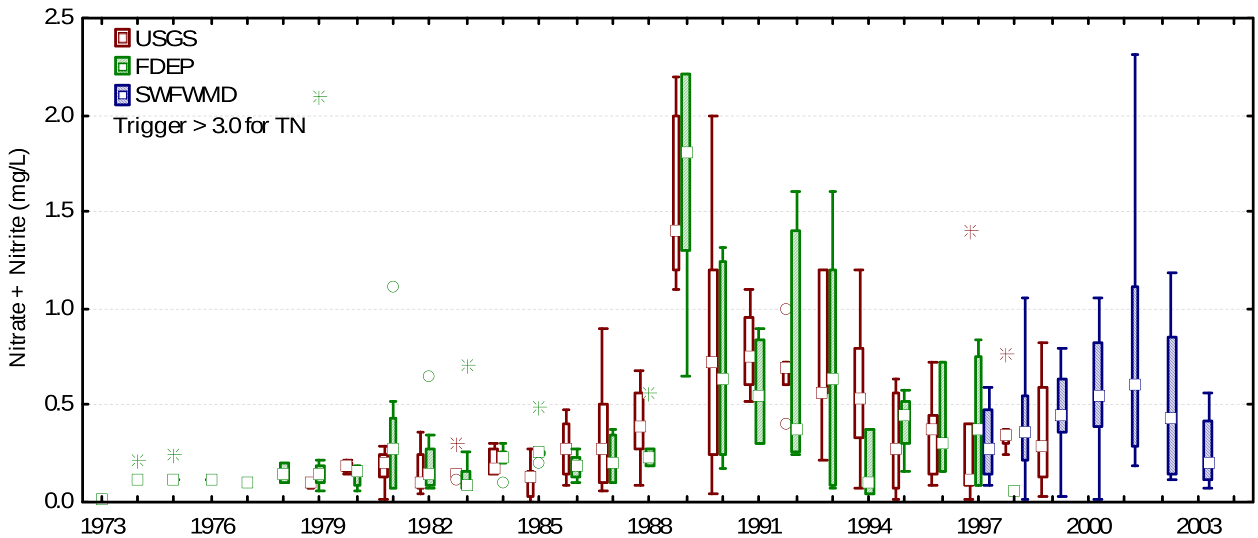


Figure 30. Annual Median Boxplots of Nitrate + Nitrite Concentrations Collected by USGS, FDEP, and SWFWMD in Horse Creek at (Arcadia - SR 72 from 1962-2003.

5.5.2 Total Kjedahl Nitrogen and Total Nitrogen

Total nitrogen is an important parameter of interest for the Horse Creek Stewardship Program, but very little data is available for the six Horse Creek sites. Total Kjedahl Nitrogen (TKN), usually the major component of total nitrogen, can be used as a substitute. Total Kjedahl Nitrogen was below the HCSP total nitrogen trigger value of 3.0 mg/L at all sites, except for a few extreme values at the two southernmost sites, SR 72 (Figure 32) and SR 761. Annual median TKN was between 0.5 and 1.5 mg/L at all stations, with no clear trends. Concentrations of TKN have decreased at the SR 64 station over time (Seasonal Kendall Tau slope = -0.036 mg/L/yr), but have no trend at the downstream SR 72 station (Tables 38 and 39). Another study also found that TKN had no trend at Horse Creek near SR 72 (CHEC 2001).

SWFWMD (2000) found that total nitrogen was usually highest at downstream stations, probably because of agricultural and rangeland runoff in central and southern Horse Creek Basin. Seasonal Kendall Tau trend analysis was not performed on total nitrogen because of insufficient data, but other studies using alternate methods requiring less data have found that total nitrogen is increasing at Horse Creek near SR 72 (CHEC 2001, annual Mann-Kendall Tau; SWFWMD 2001, simple regression on annual values). Total nitrogen (Figures 33 and 34) was significantly, but weakly, positively correlated with ammonia (SR 64 and SR 72) and nitrogen oxide (SR 72), and was strongly correlated with TKN (SR 72) (Table 19).

Table 19. Pearson's Product Moment Correlation of Total Nitrogen with Other Nitrogen Species at Myakka Head and Arcadia Stations. (Only Correlations Significant at $p < 0.05$ Level are Listed.)

		Myakka Head	**Arcadia**		
		Ammonia	**Ammonia**	**TKN**	**Nitrate + Nitrite**
Total Nitrogen	r	0.46	0.34	0.97	0.37
	N	37	56	22	56

Table 20. Total Kjedahl Nitrogen Period of Record and Sampling Frequency of Each Data Source for Horse Creek at Myakka Head and Horse Creek at Arcadia.

Station	**Time period**	**Measurement Frequency**	**Agency**
Horse Creek at Myakka Head	1976-1977, 1979, 1981-1984, 1989-1990	Annual-quarterly	FDEP
	1992-1999	Bimonthly	USGS
Horse Creek at Arcadia	1978-1995	Monthly-bimonthly	FDEP
	1996-2001	Annual-quarterly	FDEP
	1979-1999	Bimonthly	USGS

Table 21. Total Nitrogen Period of Record and Sampling Frequency of Each Data Source for Horse Creek at Myakka Head and Horse Creek at Arcadia.

Station	Time period	Measurement Frequency	Agency
Horse Creek at Myakka Head	1998-2003	Monthly	SWFWMD
Horse Creek at Arcadia	1979-1983, 1986, 1993	Annual-quarterly	USGS
	1998-2003	Monthly	SWFWMD

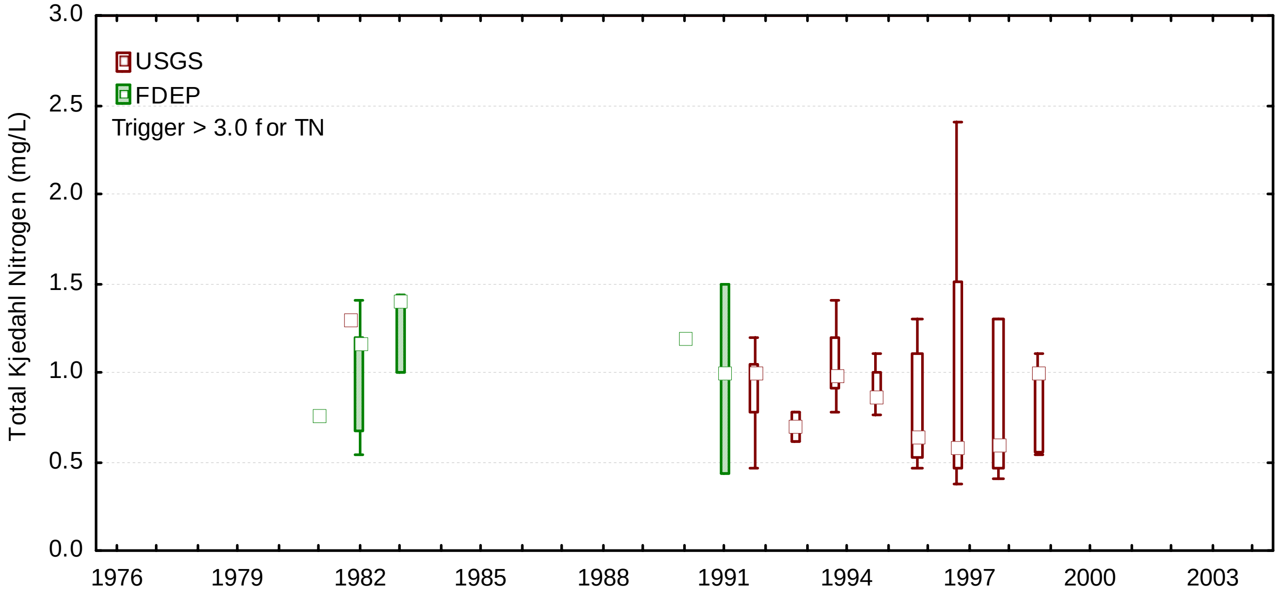


Figure 31. Annual Median Boxplots of Total Kjedahl Nitrogen Concentrations Collected by USGS, FDEP, and SWFWMD in Horse Creek at Myakka Head - SR from 1962 to 2003.

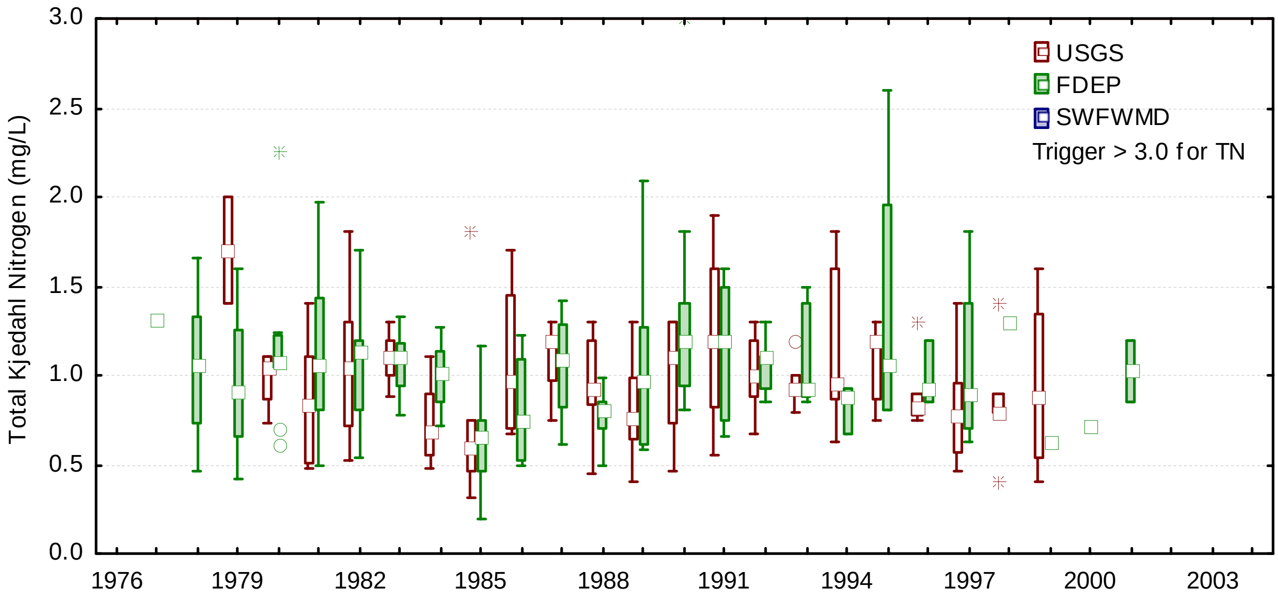


Figure 32. Annual Median Boxplots of Total Kjedahl Nitrogen Concentrations Collected by USGS, FDEP, and SWFWMD in Horse Creek at Arcadia - SR 72 from 1962 to 2003.

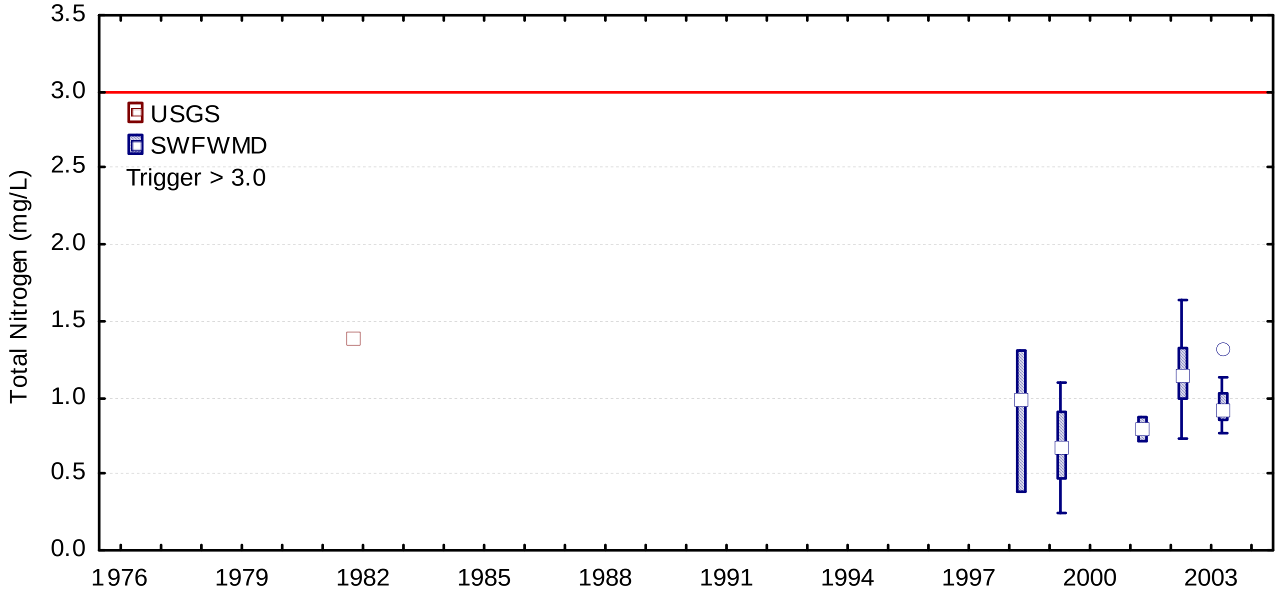


Figure 33. Annual Median Boxplots of Total Nitrogen Concentrations Collected by USGS, FDEP, and SWFWMD in Horse Creek at Myakka Head - SR 64 from 1962 to 2003.

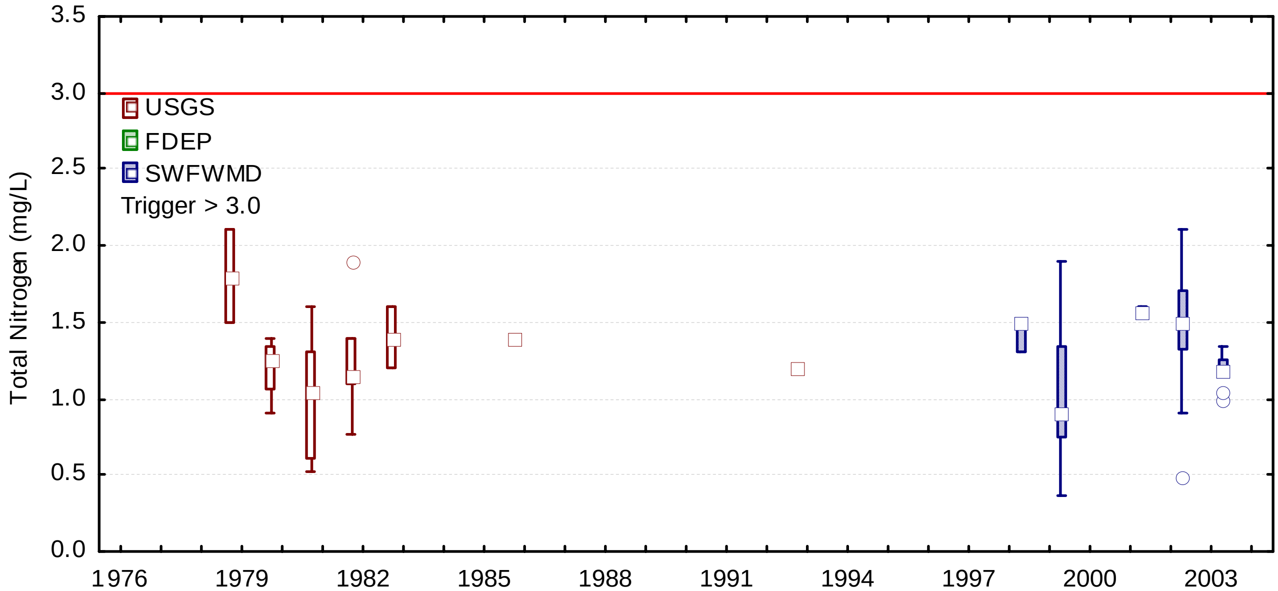


Figure 34. Annual Median Boxplots of Total Nitrogen Concentrations Collected by USGS, FDEP, and SWFWMD in Horse Creek at Arcadia - SR 72 from 1962 to 2003.

5.5.3 Ammonia

Some ammonia measurements have been taken at each of the 6 Horse Creek stations, but only SR 64, SR 72, and SR 761 had more than ten years of data collected. During most years, observations of ammonia were below the HCSP trigger value of 0.3 mg/L; some outliers were present, however, especially at SR 761 (Appendix B). A single ammonia measurement of greater than 2.0 mg/L at SR 72 was assumed to be erroneous and was not used in trend analysis. Annual median ammonia was less than 2.0 mg/L at all stations. Ammonia levels have decreased at the SR 72 station over time (Seasonal Kendall Tau slope = -0.001 mg/L/yr), consistent with the findings of Wade et al. (2003), but have no trend at SR 64 (Tables 38 and 39). Four outliers were removed for graphing, including two outliers from Horse Creek near Myakka Head (0.847 and 2.93 mg/L) and two from Horse Creek at Arcadia (3.2 and 10.0 mg/L)

Table 22. Ammonia Period of Record and Sampling Frequency of Each Data Source for Horse Creek at Myakka Head and Horse Creek at Arcadia.

Station	Time period	Measurement Frequency	Agency
Horse Creek at Myakka Head	1972, 1974-1977, 1979	Annual-quarterly	FDEP
	1982, 1993	Annual-quarterly	USGS
	1992, 1994-1999	Bimonthly	USGS
	1997-2003	Monthly	SWFWMD
Horse Creek at Arcadia	1971, 1979-1980, 1998-1999	Annual-quarterly	USGS
	1981-1997	Bimonthly	USGS
	1974-1979, 1981-1983, 1993	Monthly-bimonthly	FDEP
	1973, 1980, 1992, 1994-2001	Annual-quarterly	FDEP
	1997-2003	Monthly	SWFWMD

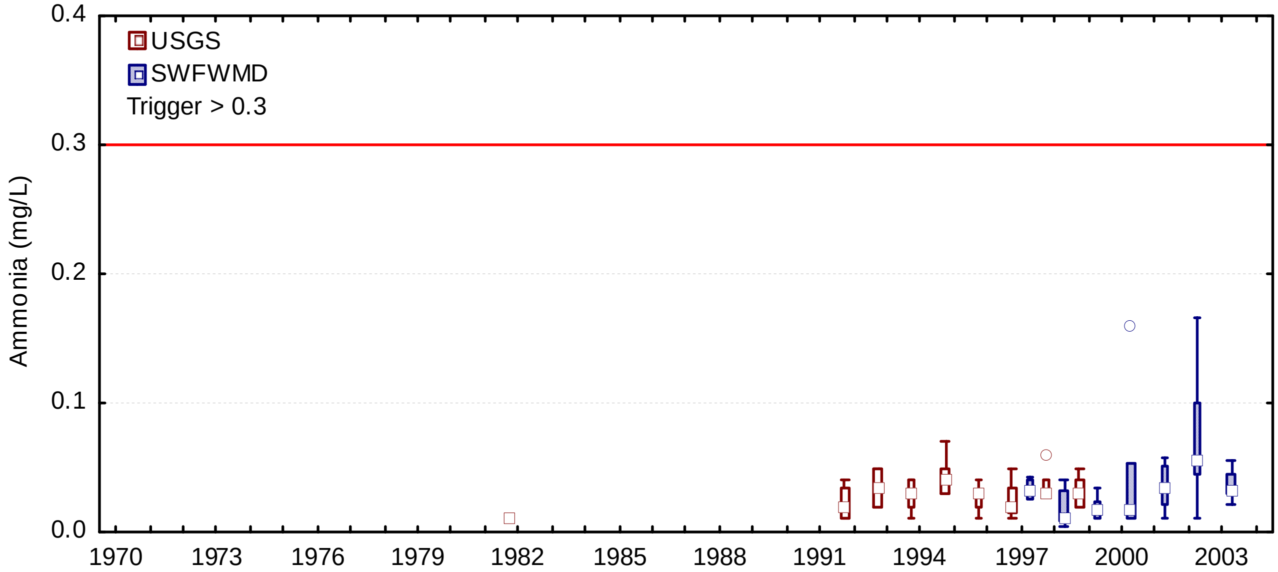


Figure 35. Annual Median Boxplots of Ammonia Concentrations Collected by USGS, FDEP, and SWFWMD in Horse Creek at Myakka Head - SR 64 from 1962 to 2003.

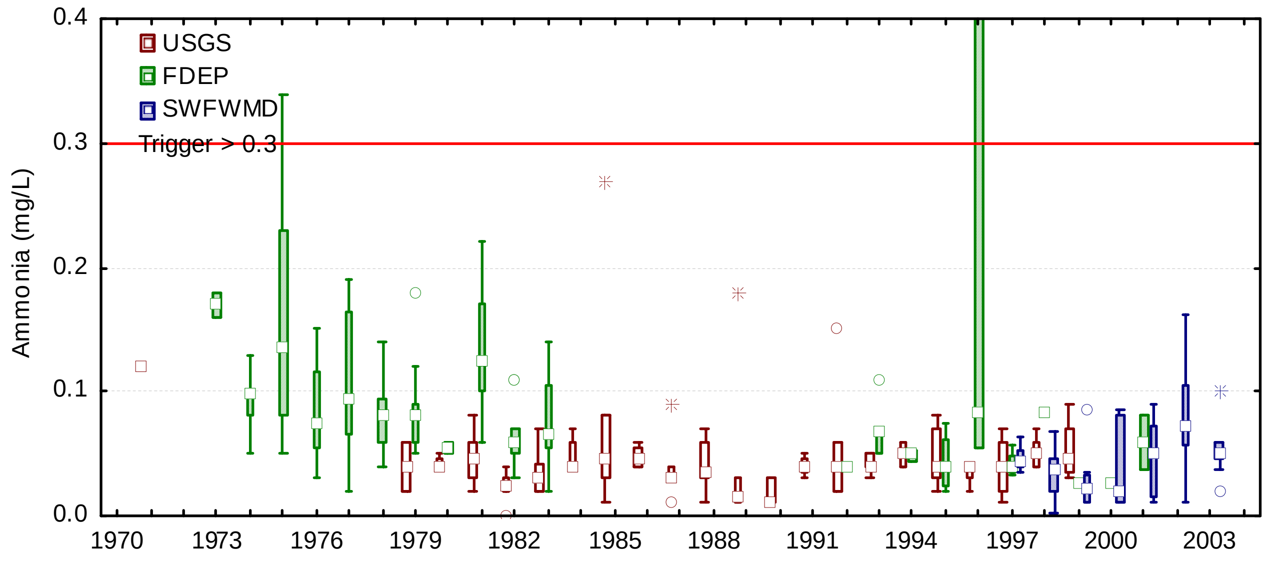


Figure 36. Annual Median Boxplots of Ammonia Concentrations Collected by USGS, FDEP, and SWFWMD in Horse Creek at Arcadia - SR 72 from 1962 to 2003.

5.6 PHOSPHOROUS

5.6.1 Orthophospate

Median orthophosphate concentrations were less than 1 mg/L at all stations in Horse Creek after phosphate mining began in the Horse Creek Basin (late 1980's). At a downstream Horse Creek stations, SR 72, orthophosphate concentrations from 1960-1980 ranged from 0.5 to 6.0 mg/L (Figure 38). Average annual orthophosphate concentrations have decreased in southern Horse Creek over the past 30 years.

A Seasonal Kendall's Tau test showed orthophosphate levels decreasing at the SR 72 (Arcadia) by 0.016 mg/L per year on the average (Table 39), which is consistent with other trend analyses (CHEC 2001, PBSJ and Dexter Bender 1999). Orthophosphate concentrations at northern SR 64 station showed no significant trend (Table 38). Only a few observations (at SR 72) exceeded the HCSP trigger value of 2.5 mg/L of orthophosphate. Higher levels of orthophosphate and a declining trend at SR 72 may be artifacts of the longer period of record available at that site (1962-2003), and not a result of phosphate mining practices in the Horse Creek Basin. Orthophosphate concentrations were strongly correlated with total phosphorus concentrations at SR 64 and SR 72, and weakly correlated with chlorophyll a at SR 64 (Table 23). Chlorophyll a was not correlated with any other nutrients (nitrogen or phosphorus). One outlier was removed for graphing from Horse Creek at Arcadia (5.8 mg/L, 14 September 1965).

Table 23. Pearson's Product Moment Correlations of Orthophosphate with Chlorophyll a and Total Phosphorus at Myakka Head and Arcadia Stations. (Only Correlations Significant at $p < 0.05$ Level are Listed.)

		Myakka Head		Arcadia
		Chlorophyll a	Total Phosphorus	Total Phosphorus
Orthophosphate	r	0.33	0.90	0.66
	N	73	116	123

Table 24. Orthophosphate Period of Record and Sampling Frequency of Each Data Source for Horse Creek at Myakka Head and Horse Creek at Arcadia.

Station	Time period	Measurement Frequency	Agency
Horse Creek at Myakka Head	1972-1976	Annual-quarterly	FDEP
	1982, 1993, 1996-1997	Annual-quarterly	USGS
	1992, 1994-1995, 1998-1999	Bimonthly	USGS
	1997-2003	Monthly	SWFWMD
Horse Creek at Arcadia	1962-1967, 1970-1971	Annual-quarterly	USGS
	1974-1980, 1982-1983	Monthly-bimonthly	FDEP
	1972-1973, 1981, 1995, 2001	Annual-quarterly	FDEP
	1997-2003	Monthly	SWFWMD

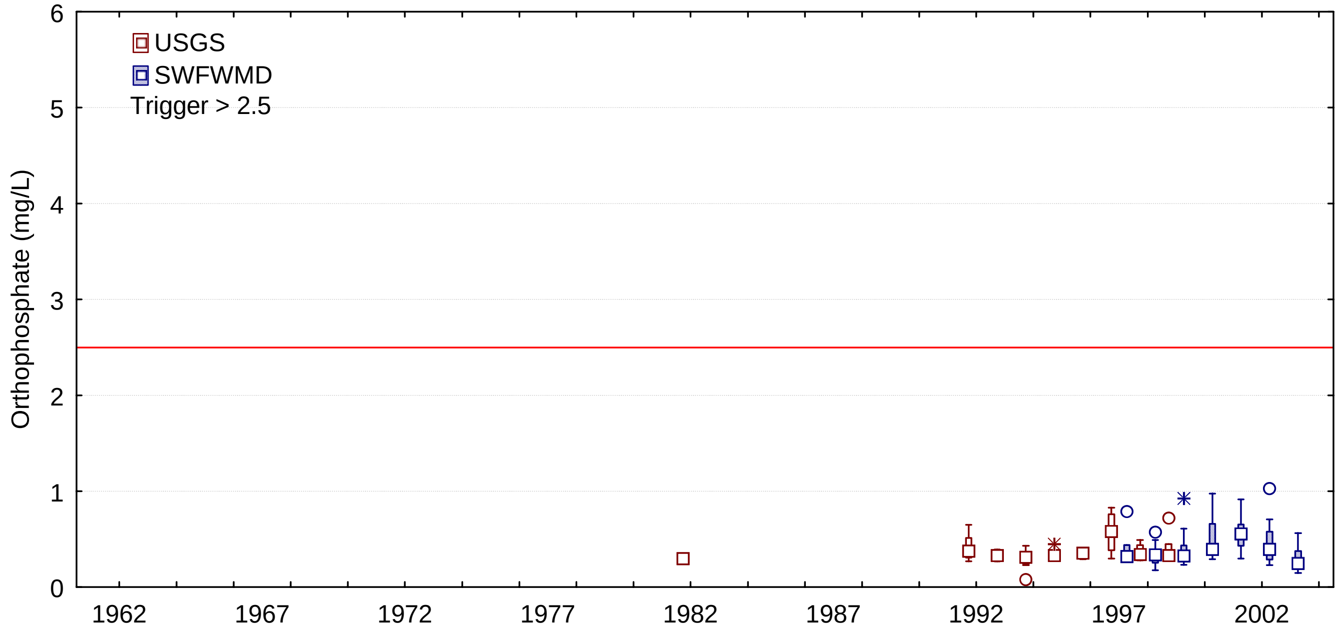


Figure 37. Annual Median Boxplots of Orthophosphate Concentrations Collected by USGS, FDEP, and SWFWMD in Horse Creek at Myakka Head - SR 64 from 1962 to 2003.

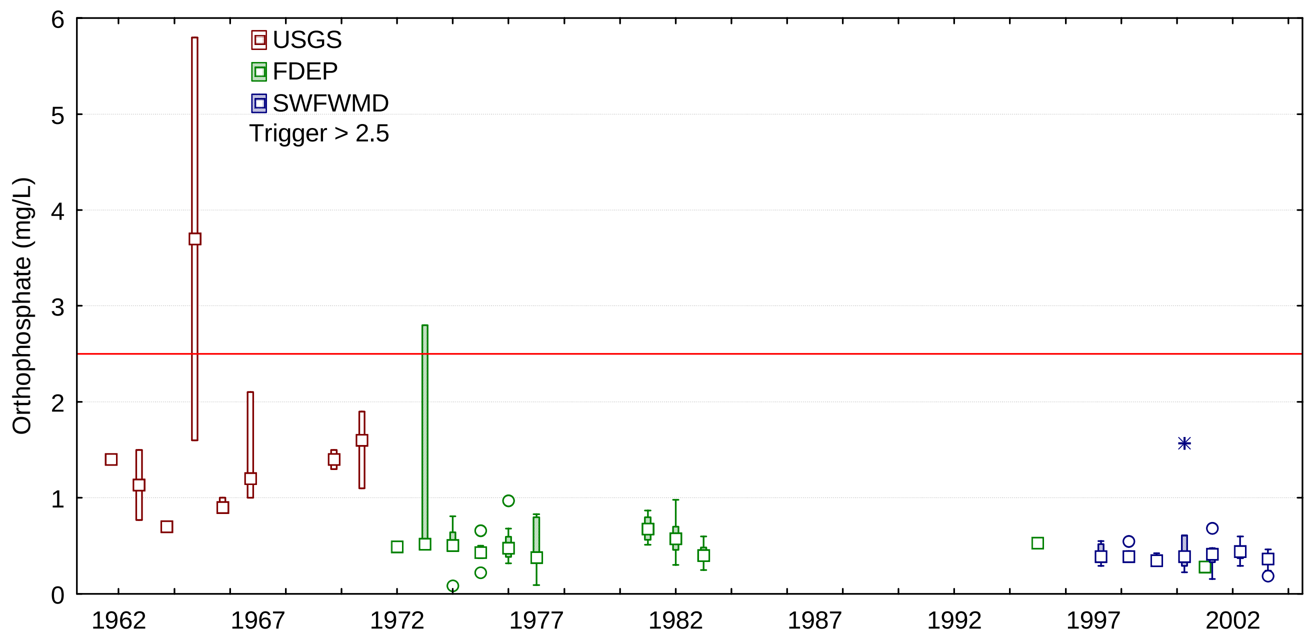


Figure 38. Annual Median Boxplots of Orthophosphate Concentrations Collected by USGS, FDEP, and SWFWMD in Horse Creek at Arcadia - SR 72 from 1962 to 2003.

5.6.2 Total Phosphorus

Median phosphorus concentrations ranged from 0.3 to 1.0 mg/L throughout most of the Horse Creek Basin. Phosphorus concentrations have decreased in Horse Creek from 1972 to 2002 (Figures 39 and 40). Phosphorus at the southern SR 72 station has significantly decreased from 1971 – 2003 (Seasonal Kendall's Tau slope = -0.005 mg/L/yr, Table 39), consistent with the findings of other trend studies (CHEC 2001, Wade et al. 2003, SWFWMD 2001, PBSJ and Dexter Bender 1999). Phosphorus levels at the SR 64 station, nearest to mining activities, showed no trend (Table 38), possibly because the available period of record was shorter (1981-2003). Phosphorus concentrations in Horse Creek are lower than in the northern Peace River (Bone Valley), but still higher than typical Florida stream background levels (SWFWMD 2000). Phosphorus concentrations do not usually exceed the HCSP trigger concentration of 2.5 mg/L, except at the station nearest to the Peace River, SR 761 during the years prior to phosphate mining in Horse Creek Basin.

Table 25. Total Phosphate Period of Record and Sampling Frequency of Each Data Source for Horse Creek at Myakka Head and Horse Creek at Arcadia.

Station	Time period	Measurement Frequency	Agency
Horse Creek at Myakka Head	1973-1977, 1979, 1981-1984, 1989-1990	Annual-quarterly	FDEP
	1982, 1993	Annual-quarterly	USGS
	1992, 1994-1999	Bimonthly	USGS
	1997-2003	Monthly	SWFWMD
Horse Creek at Arcadia	1971-1974,1979-1980	Annual-quarterly	USGS
	1981-1999	Bimonthly	USGS
	1975-1986, 1988-1995	Monthly-bimonthly	FDEP
	1972-1974, 1987, 1989, 1996-2001	Annual-quarterly	FDEP
	1997-2003	Monthly	SWFWMD

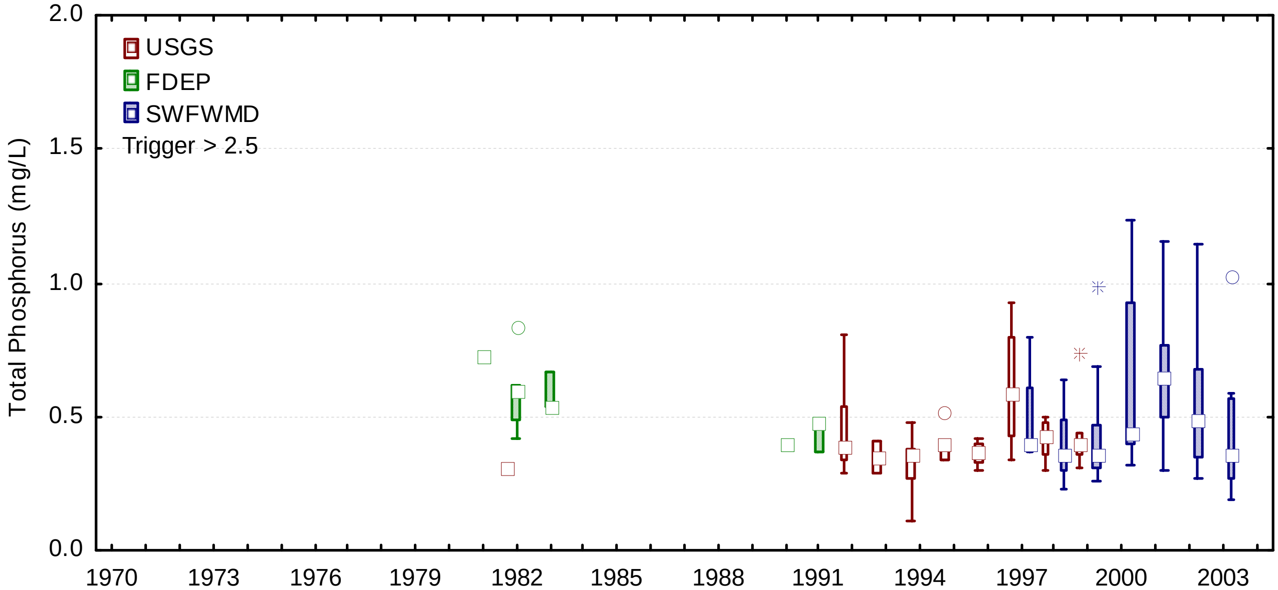


Figure 39. Annual Median Boxplots of Total Phosphorus Concentrations Collected by USGS, FDEP, and SWFWMD in Horse Creek at Myakka Head - SR 64 from 1962 to 2003.

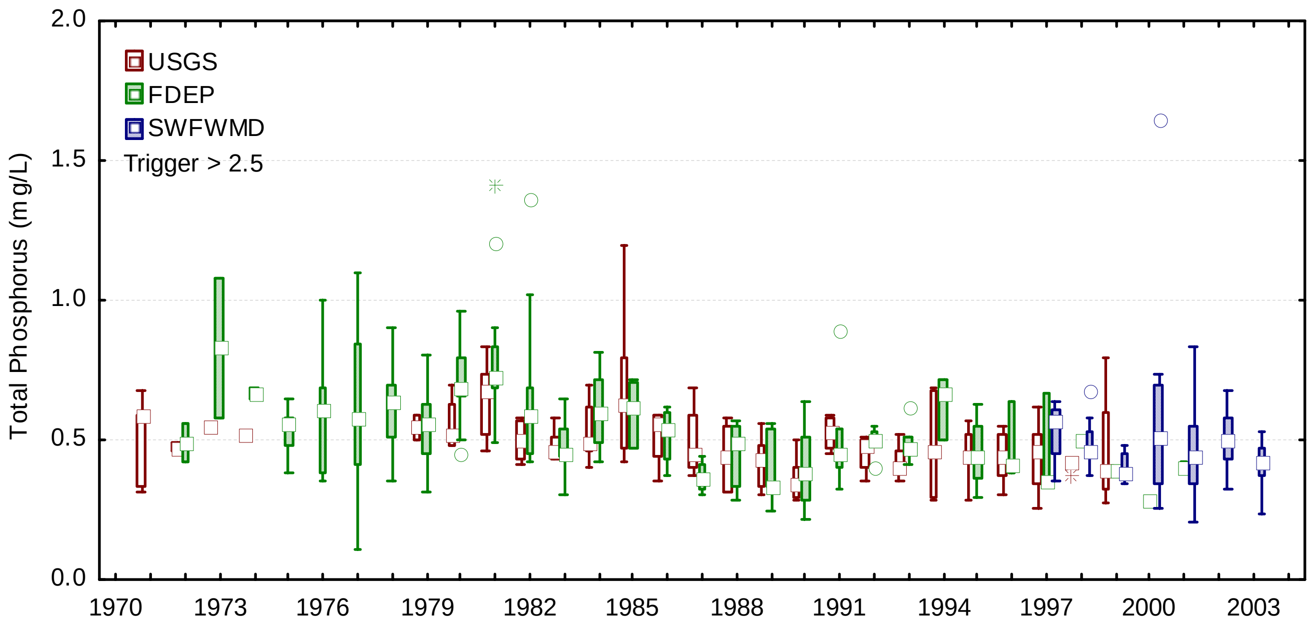


Figure 40. Annual Median Boxplots of Total Phosphorus Concentrations Collected by USGS, FDEP, and SWFWMD in Horse Creek at Arcadia - SR 72 from 1962 to 2003.

5.7 COLOR

True color measurements are available for all six stations, with color only at SR 761 dropping below the HCSP trigger value of 25 cu (cobalt units) (Appendix B). Annual median color ranged from 50 – 350 cu at SR 64, 200 - 350 cu at SR 663, 50 – 250 cu at SR 665 and SR 70, and 50 – 500 at SR 72 and SR 761. Elevated median color at northern stations may be related to the influence of tannins from natural vegetation land cover and Horse Creek Prairie; southern Horse Creek is diluted with groundwater (SWFWMD 2000). True color usually increased by 100 cu during the wet season (July – October) and was often very close to the HCSP trigger value of 25 cu during the dry season (Figures 43 and 44). Wet season runoff over organic material and dry season groundwater dilution probably contribute to this seasonal color trend. Color showed no significant long-term trends at stations near SR 64 or SR 72 (Tables 38 and 39), consistent with other trend studies (CHEC 2001, PBSJ and Dexter Bender 1999). Two outliers were removed for graphing from Horse Creek at Arcadia (880 and 720 CU).

Table 26. Color Period of Record and Sampling Frequency of Each Data Source for Horse Creek at Myakka Head and Horse Creek at Arcadia.

Station	Time period	Measurement Frequency	Agency
Horse Creek at Myakka Head	1972-1976, 1989-1990	Annual-quarterly	FDEP
	1979-1984	Bimonthly	FDEP
	1979, 1982, 1992-1996, 1998-1999	Annual-quarterly	USGS
	1997-2003	Monthly	SWFWMD
Horse Creek at Arcadia	1962-1968, 1970 , 1978-1999	Annual-quarterly	USGS
	1974-1997	Monthly-bimonthly	FDEP
	1972-1973, 1998-2001	Annual-quarterly	FDEP
	1997-2003	Monthly	SWFWMD

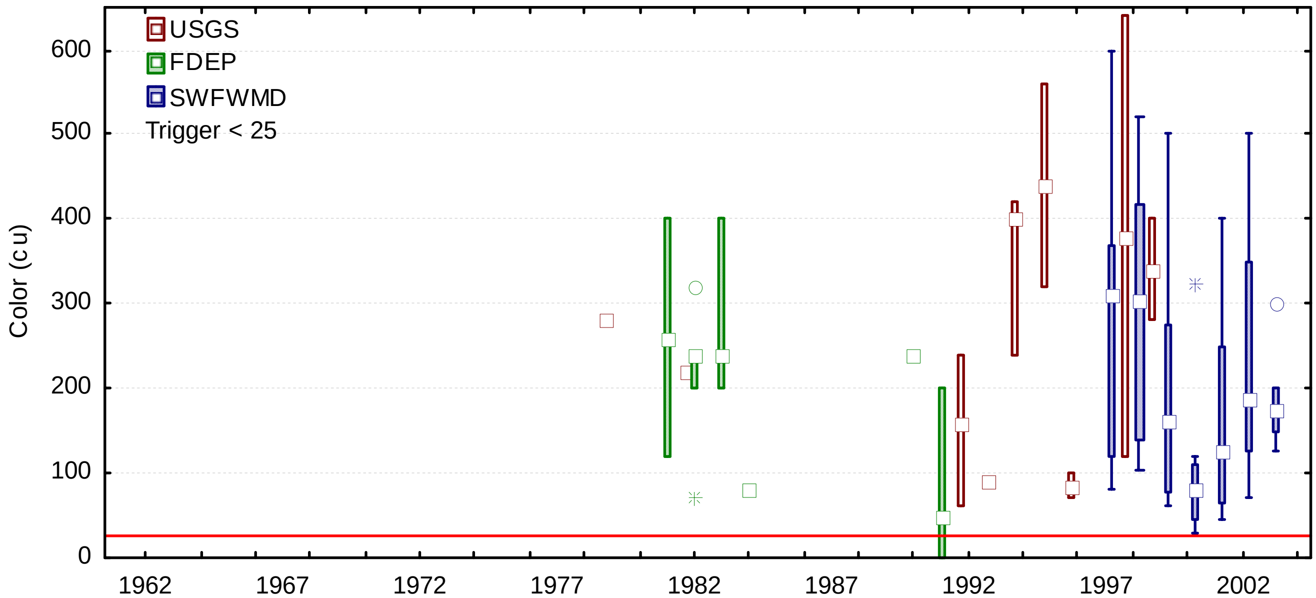


Figure 41. Annual Median Boxplots of Color Levels Collected by USGS, FDEP, and SWFWMD in Horse Creek at Myakka Head - SR 64 from 1962 to 2003.

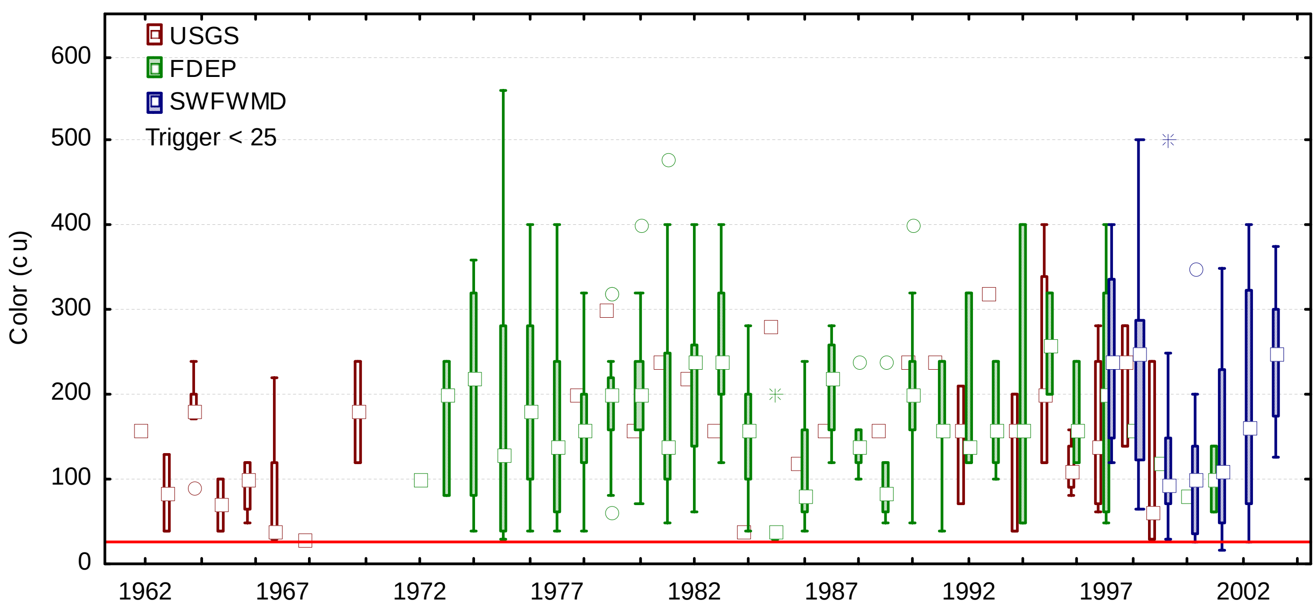


Figure 42. Annual Median Boxplots of Color Levels Collected by USGS, FDEP, and SWFWMD in Horse Creek at ((b) Arcadia - SR 72 from 1962 to 2003.

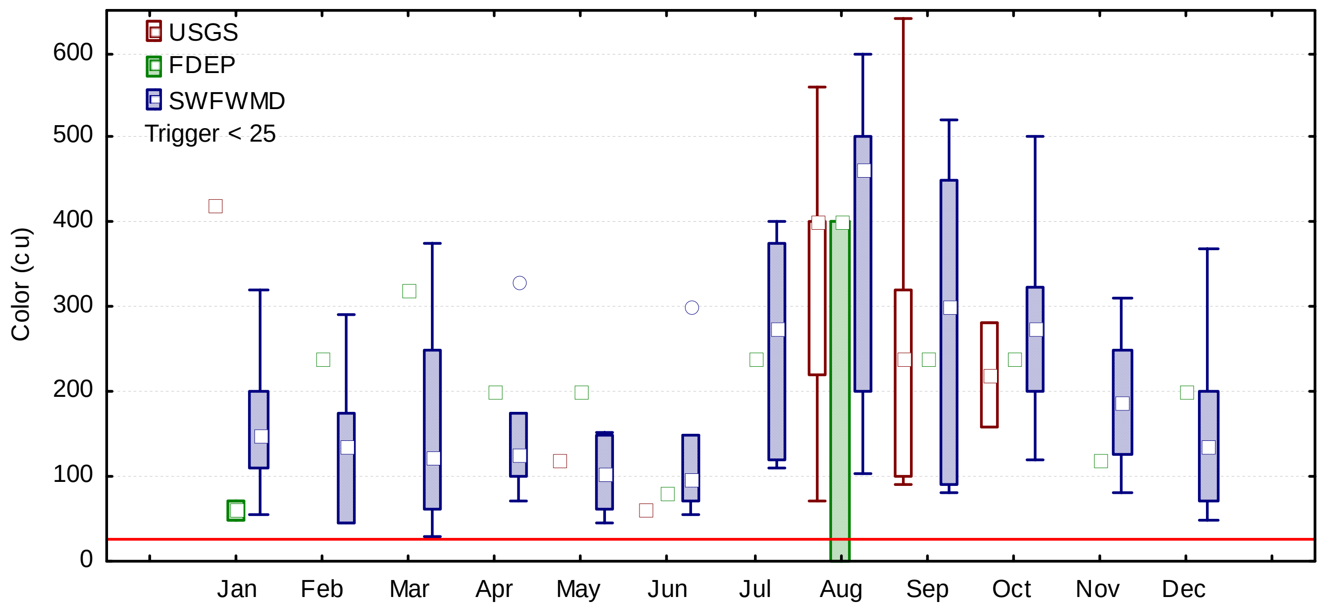


Figure 43. Monthly Median Boxplots of Color Levels Collected by USGS, FDEP, and SWFWMD in Horse Creek at Myakka Head - SR 64 from 1962 to 2003.

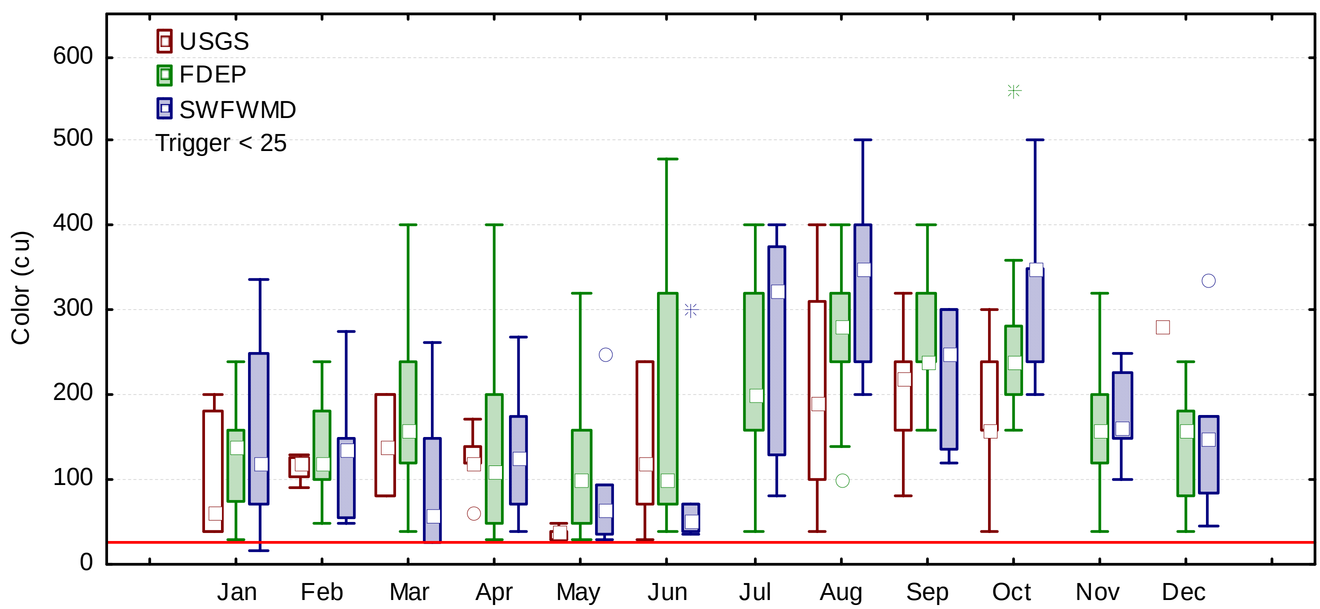


Figure 44. Monthly Median Boxplots of Color Levels Collected by USGS, FDEP, and SWFWMD in Horse Creek at Arcadia - SR 72 from 1962 to 2003.

5.8 CHLOROPHYLL A

Chlorophyll *a* was measured only a few times at most of the sites (Figures 45 and 46). At stations near SR 64 and SR 72, chlorophyll a concentrations in recent years only exceeded the HCSP trigger value of 15 ug/L once (the other measurement greater than 150 ug/ml at SR 64 was assumed to be erroneous). Chlorophyll *a* concentrations at the SR 761 station, however, were consistently higher than other stations and often above the HCSP trigger value. Environmental Science and Engineering, Inc. (1982) found that from 1978-1979, chlorophyll *a* concentrations ranged from 0.2 – 17.5 ug/L in Horse Creek and 0.2 – 19.4 ug/L in Horse Creek tributaries, Brandy Branch and Buzzard Roost Branch. The dataset for chlorophyll *a* showed was insufficient to test for long-term trends using the Seasonal Kendall Tau test. A previous trend analysis of historical data from 1975 – 1996 (by EQL) found that chlorophyll a concentrations were increasing in Horse Creek at SR 70 (PBSJ and Dexter Bender 1999). The difference in results of the BRA and PBSJ and Dexter Bender (1999) trend analysis is probably because of differences in statistical methods (Seasonal Kendall Tau versus annual Mann-Kendall Tau), stations (SR 64 and 72 versus SR 70), and sources (FDEP/SWFWMD versus EQL). Two outliers were removed for graphing, including one outlier from Horse Creek near Myakka Head (129 ug/L, 10 May 2000) and one from Horse Creek at Arcadia (31.5 ug/L, 7 July 1998). Chlorophyll a was weakly correlated with orthophosphate concentrations at SR 64 (Table 23), but chlorophyll a was not correlated with any other nutrients (nitrogen or phosphorus).

Table 27. Chlorophyll a Period of Record and Sampling Frequency of Each Data Source for Horse Creek at Myakka Head and Horse Creek at Arcadia.

Station	Time period	Measurement Frequency	Agency
Horse Creek at Myakka Head	1989	Annual	FDEP
	1997-2003	Monthly	SWFWMD
Horse Creek at Arcadia	1976, 2001	Annual-quarterly	FDEP
	1997-2003	Monthly	SWFWMD

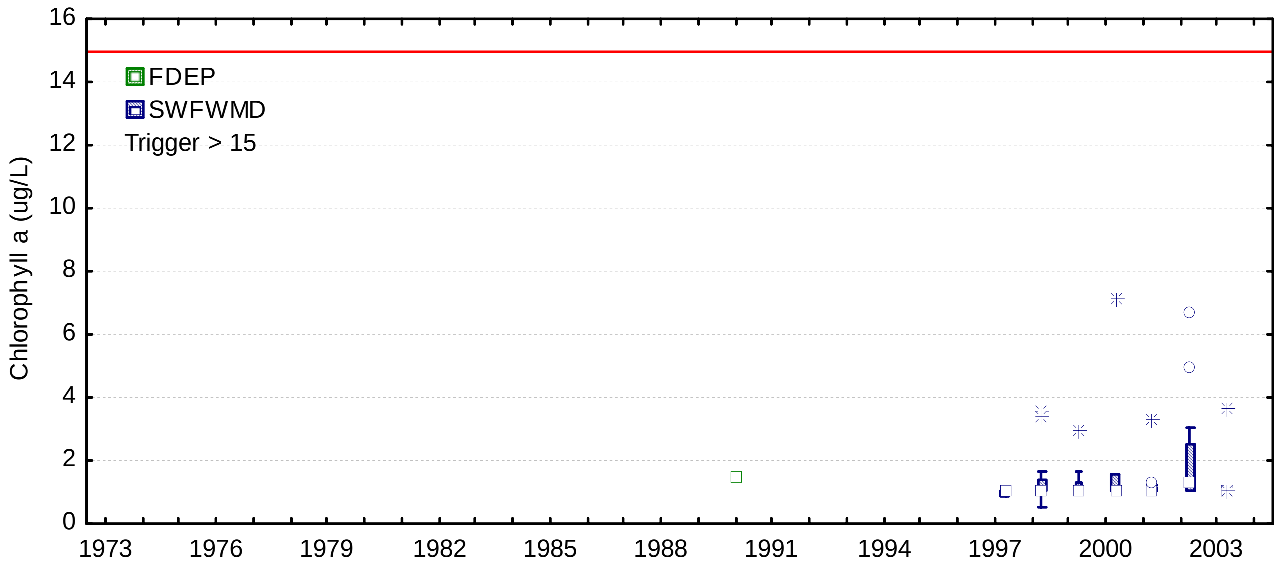


Figure 45. Annual Median Boxplots of Chlorophyll a Concentrations Collected by USGS, FDEP, and SWFWMD in Horse Creek at Myakka Head - SR 64 from 1962 to 2003.

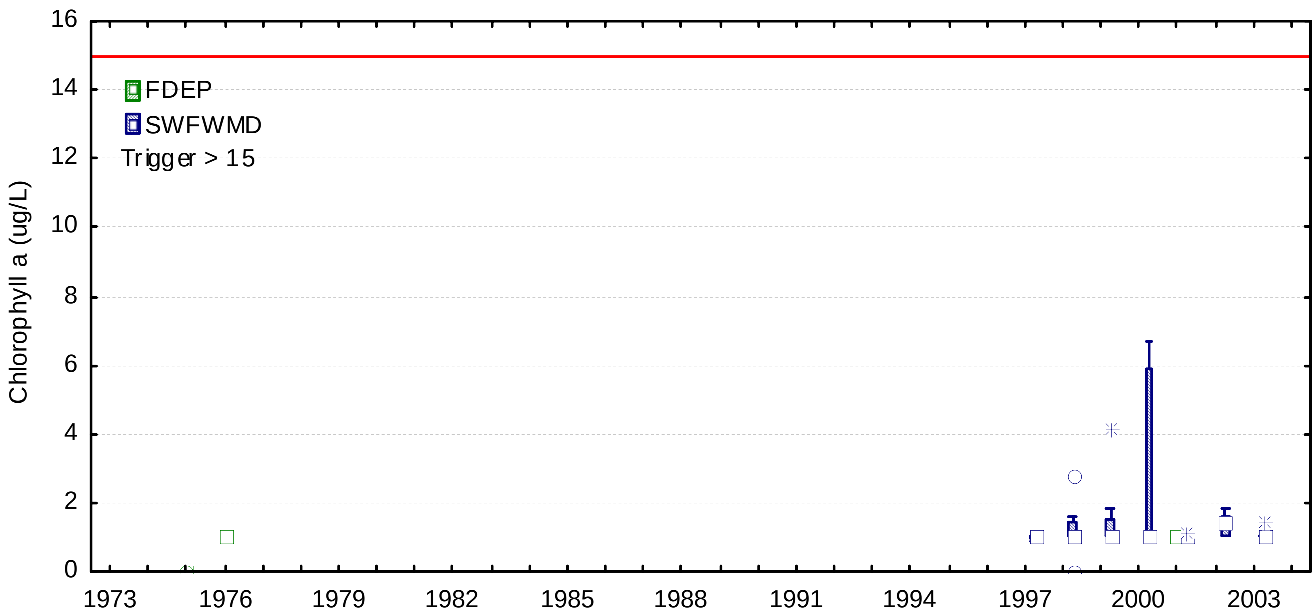


Figure 46. Annual Median Boxplots of Chlorophyll a Concentrations Collected by USGS, FDEP, and SWFWMD in Horse Creek at Arcadia - SR 72 from 1962 to 2003.

5.9 SPECIFIC CONDUCTIVITY

Specific conductivity is historically higher at downstream stations in Horse Creek. Conductivity never exceeded the HCSP trigger value of 1275 umhos/cm, but measurements at downstream stations may approach that. Median specific conductivity also appears to be rising in the past decade by 100 – 200 umhos/cm at all stations. Average annual conductivity shows a significant increasing trend at SR 64 (Seasonal Kendall's Tau slope = 3.9 umhos/cm per year) and SR 72 (slope = 3.7 (umhos/cm per year) (Tables 38 and 39), consistent with the findings of other trend analyses (CHEC 2001, SWFWMD 2001, Coastal Environmental 1996). Median conductivity is about 200 umhos/cm at SR 64 (HSCW-1) and 600 umhos/cm at SR 72 (HCSW-4) (Figures 47 and 48). High values of specific conductivity downstream in Horse Creek may indicate that groundwater is the primary water source, either by natural upward leakage into baseflow (Lewelling 1997, SWFWMD 2001) or through agricultural irrigation runoff (SWFWMD 2000, Coastal Environmental 1996, SWFWMD 2001, PBSJ 1999). Specific conductivity reached a peak at the end of the dry season (May-June) and a trough in the wet season (Figures 49 and 50). During the dry season, most of southern Horse Creek's streamflow is from groundwater, which has high concentrations of many dissolved minerals (Wade et al. 2003), thus increasing conductivity (Lewelling 1997, SWFWMD 2001). Specific conductivity was strongly correlated with other dissolved ions at SR 64 and SR 72 (Table 28), especially sulfate, chloride, calcium, and alkalinity.

Table 28. Pearson's Product Moment Correlations of Specific Conductivity and Dissolved Ions at Myakka Head (SR 64) and Arcadia (SR 72) Stations. (Only Correlations Significant at $p < 0.05$ Level are Listed.)

		Myakka Head					Arcadia				
		Sulfate	**Fluoride**	**Chloride**	**Calcium**	**Alkalinity**	**Sulfate**	**Fluoride**	**Chloride**	**Calcium**	**Alkalinity**
Specific Conductivity	r	0.70	0.49	0.80	0.86	0.84	0.94	0.35	0.70	0.94	0.62
	N	73	71	112	59	11	200	194	258	171	53

Table 29. Specific Conductivity Period of Record and Sampling Frequency of Each Data Source for Horse Creek at Myakka Head and Horse Creek at Arcadia.

Station	Time period	Measurement Frequency	Agency
Horse Creek at Myakka Head	1972-1977, 1984, 1989, 1990	Annual-quarterly	FDEP
	1979, 1981-1983	Bimonthly	FDEP
	1978-1999	Monthly-bimonthly	USGS
	1997-2003	Monthly	SWFWMD
Horse Creek at Arcadia	1962-1970	Annual-quarterly	USGS
	1971-1999	Monthly-bimonthly	FDEP
	1998-2001	Annual-quarterly	FDEP
	1997-2003	Monthly	SWFWMD

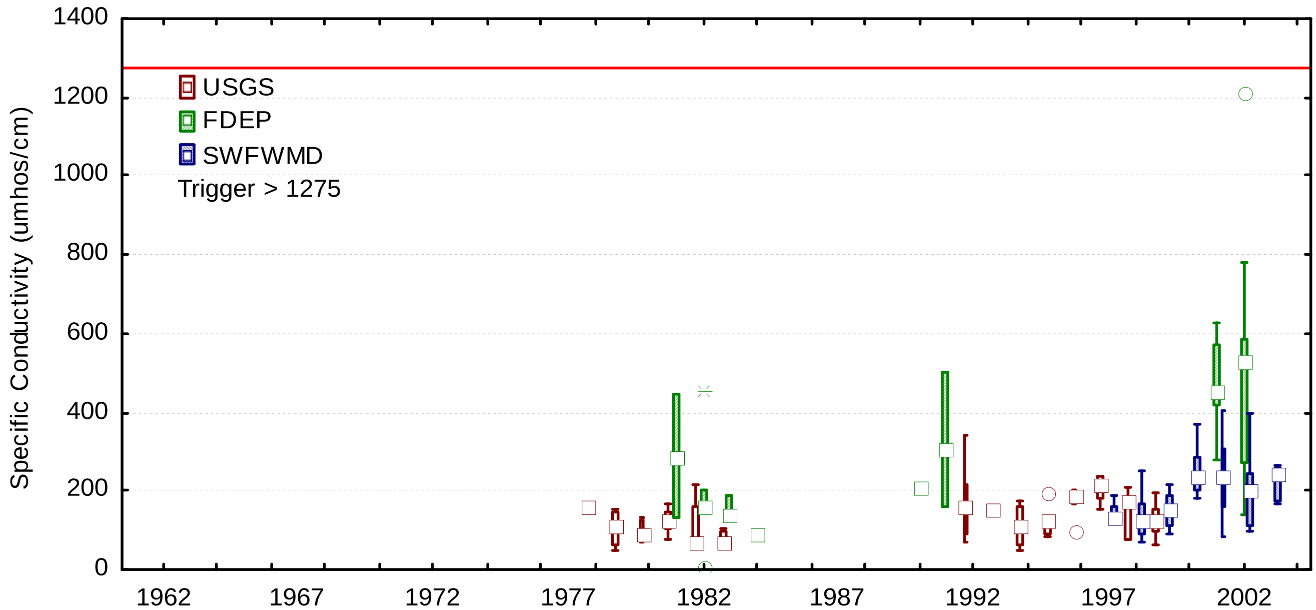


Figure 47. Annual Median Boxplots of Specific Conductivity Collected by USGS, FDEP, and SWFWMD in Horse Creek at Myakka Head - SR 64 from 1962 to 2003.

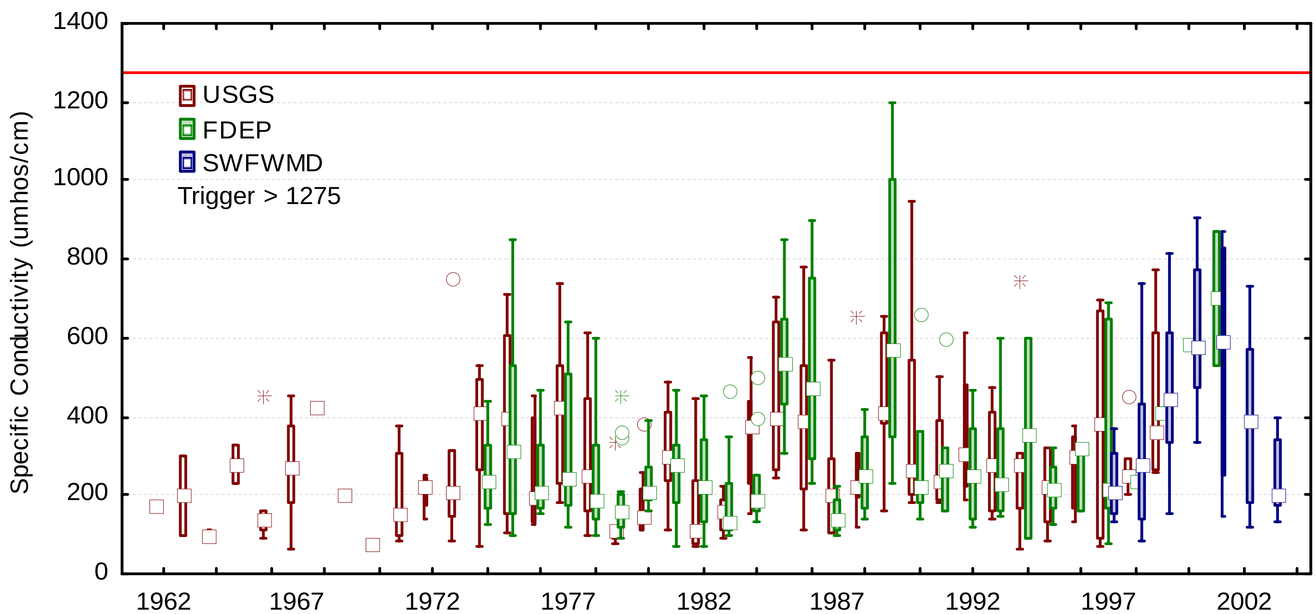


Figure 48. Annual Median Boxplots of Specific Conductivity Collected by USGS, FDEP, and SWFWMD in Horse Creek at Arcadia - SR 72 from 1962 to 2003.

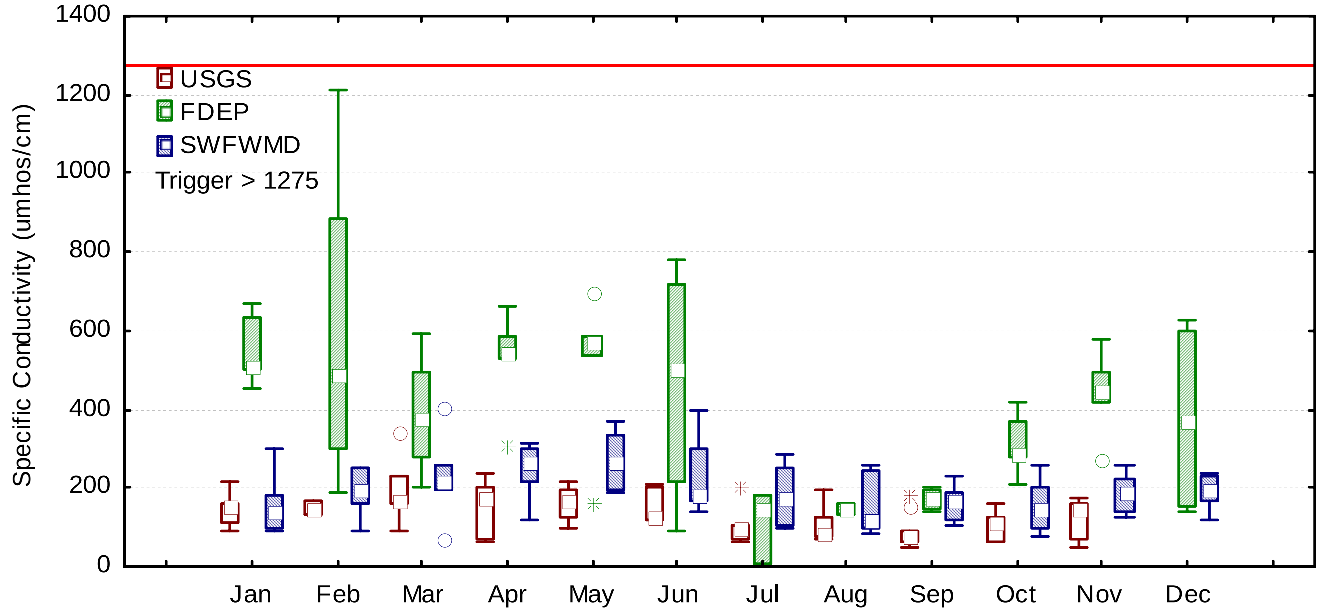


Figure 49. Monthly Median Boxplots of Specific Conductivity Collected by USGS, FDEP, and SWFWMD in Horse Creek at Myakka Head - SR 64 from 1962 to 2003.

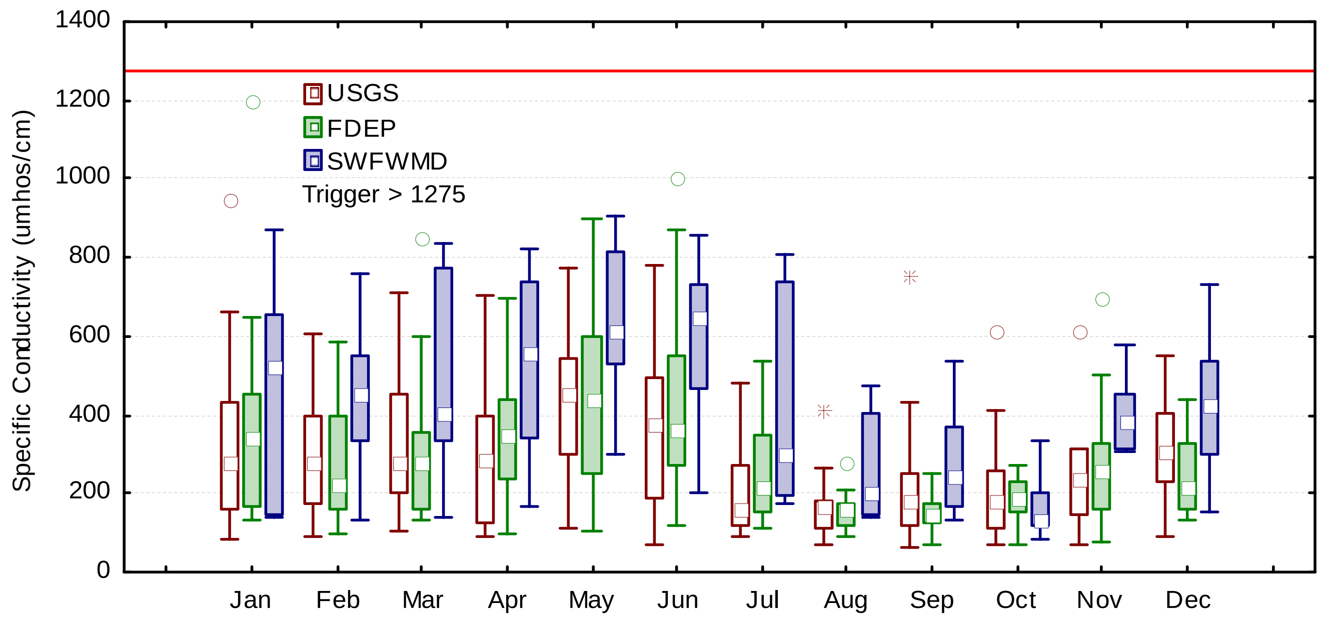


Figure 50. Monthly Median Boxplots of Specific Conductivity Collected by USGS, FDEP, and SWFWMD in Horse Creek at (b) Arcadia - SR 72 from 1962 to 2003.

5.10 ALKALINITY

Alkalinity data was only collected at two Horse Creek stations (SR 72 and SR 761) for more than a few years. Most alkalinity observations from these two stations were below the HCSP trigger value of 100 mg/L $CaCO_3$, with only a few outliers exceeding that value (Figure 52 and Appendix B). Median alkalinity of both stations was usually between 40 and 80 mg/L $CaCO_3$. Trend analysis for alkalinity was not possible because of insufficient data for the Seasonal Kendall Tau.

Table 30. Alkalinity Period of Record and Sampling Frequency of Each Data Source for Horse Creek at Myakka Head and Horse Creek at Arcadia.

Station	Time period	Measurement Frequency	Agency
Horse Creek at Myakka Head	1972, 1976	Annual	FDEP
	1982	Annual	USGS
	2002-2003	Monthly	SWFWMD
Horse Creek at Arcadia	1962-1968, 1970, 1978	Annual-quarterly	USGS
	1973-1976, 1992-1994, 1996-1997, 2001	Annual-quarterly	FDEP
	2002-2003	Monthly	SWFWMD

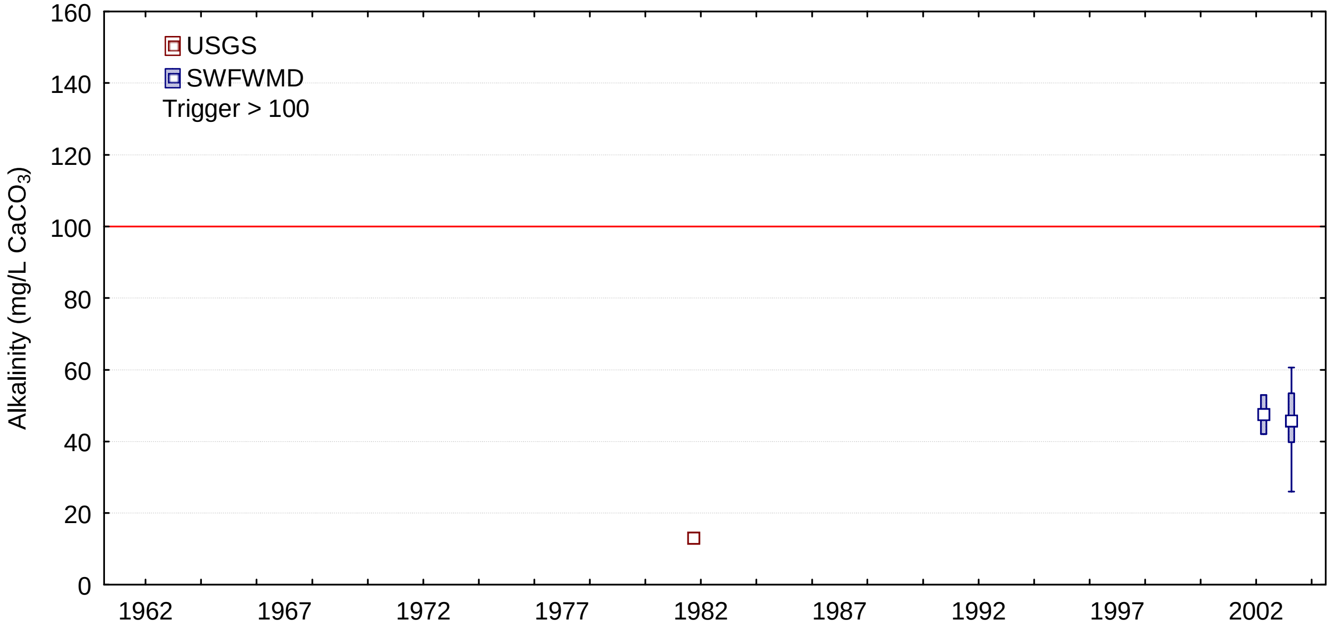


Figure 51. Annual Median Boxplots of Alkalinity Collected by USGS, FDEP, and SWFWMD in Horse Creek at Myakka Head - SR 64 from 1962 to 2003.

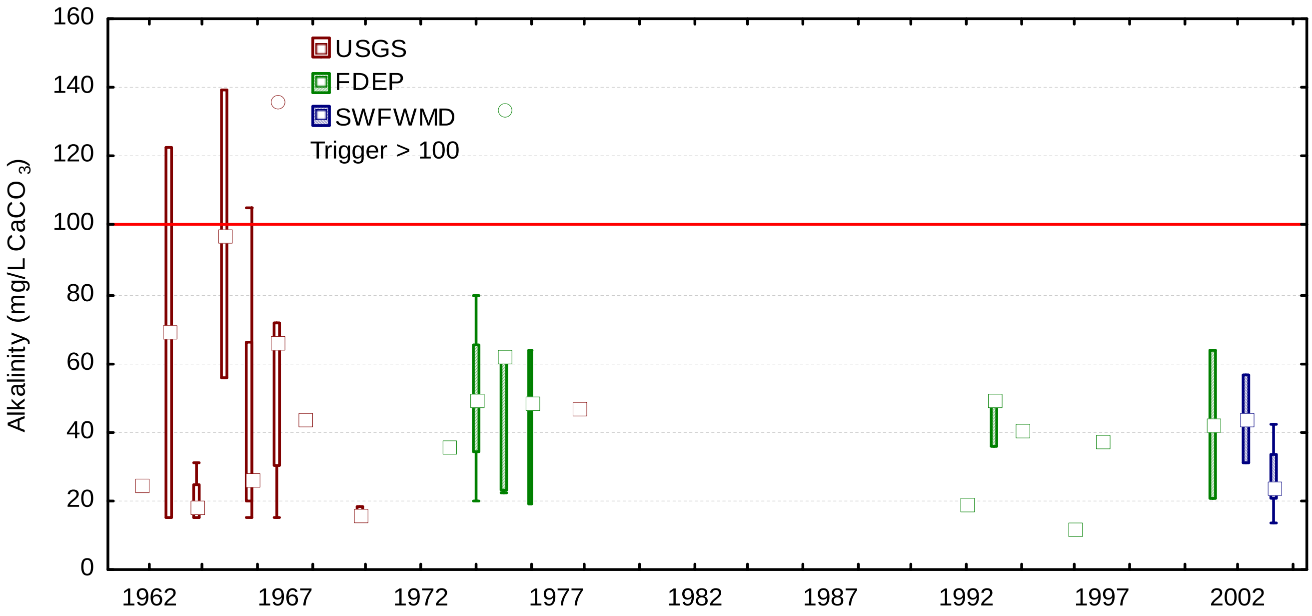


Figure 52. Annual Median Boxplots of Alkalinity Collected by USGS, FDEP, and SWFWMD in Horse Creek at Arcadia - SR 72 from 1962 to 2003.

5.11 CALCIUM

Dissolved calcium data is only available from the SR 64, SR 72, and SR 761 stations. Calcium levels at the two southern stations exceeded the HCSP trigger value (100 mg/L) after late-1980s (Figure 54). Annual median calcium ranged from 10 – 70 mg/L at SR 72 and from 20 –100 mg/L at SR 761. Median calcium was around 10 - 20 mg/L at the northern station (SR 64). Higher calcium levels in southern Horse Creek may be influenced by the increased baseflow from groundwater sources in this region compared to the northern Horse Creek Basin (SWFWMD 2000). Calcium concentrations are increasing over time by 1.63 mg/L/yr at SR 72 but show no trend at SR 64 (Tables 38 and 39).

Table 31. Calcium Period of Record and Sampling Frequency of Each Data Source for Horse Creek at Myakka Head and Horse Creek at Arcadia.

Station	Time period	Measurement Frequency	Agency
Horse Creek at Myakka Head	1972	Annual	FDEP
	1982, 1992-1999	Annual-quarterly	USGS
	2000-2003	Monthly	SWFWMD
Horse Creek at Arcadia	1962-1970, 1978-1984, 1986-1987, 1989-1999	Annual-quarterly	USGS
	1974-1976, 1982-1983	Monthly-bimonthly	FDEP
	1977, 1979, 1981, 1988, 1996-2001	Annual-quarterly	FDEP
	2000-2003	Monthly	SWFWMD

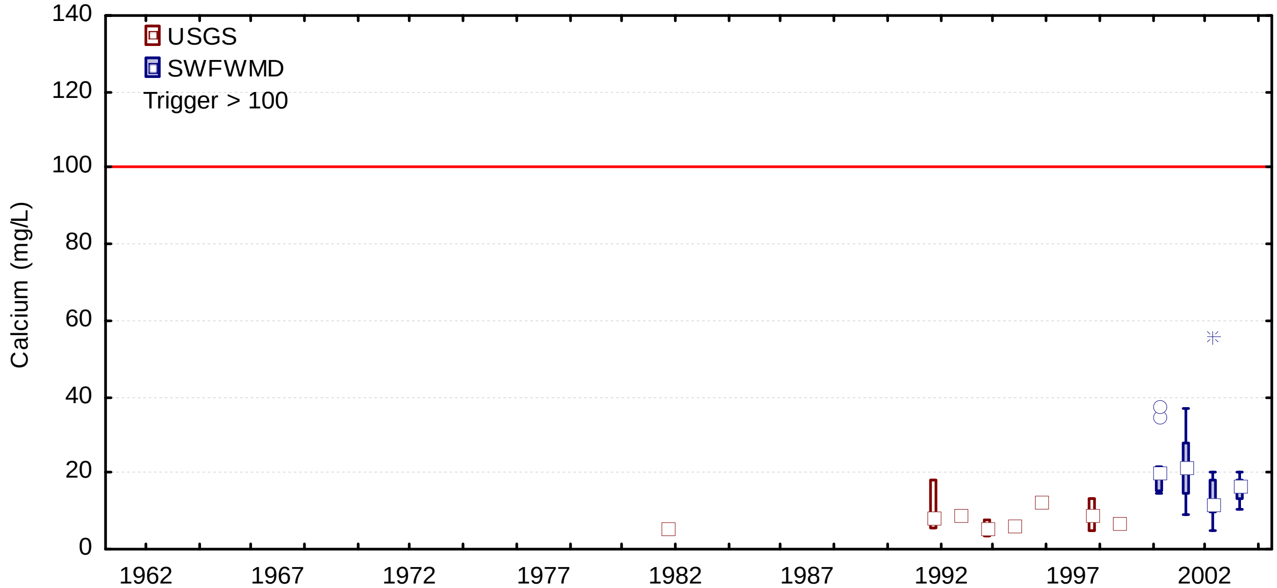


Figure 53. Annual Median Boxplots of Dissolved Calcium Concentrations Collected by USGS, FDEP, and SWFWMD in Horse Creek at Myakka Head - SR 64 from 1962 to 2003.

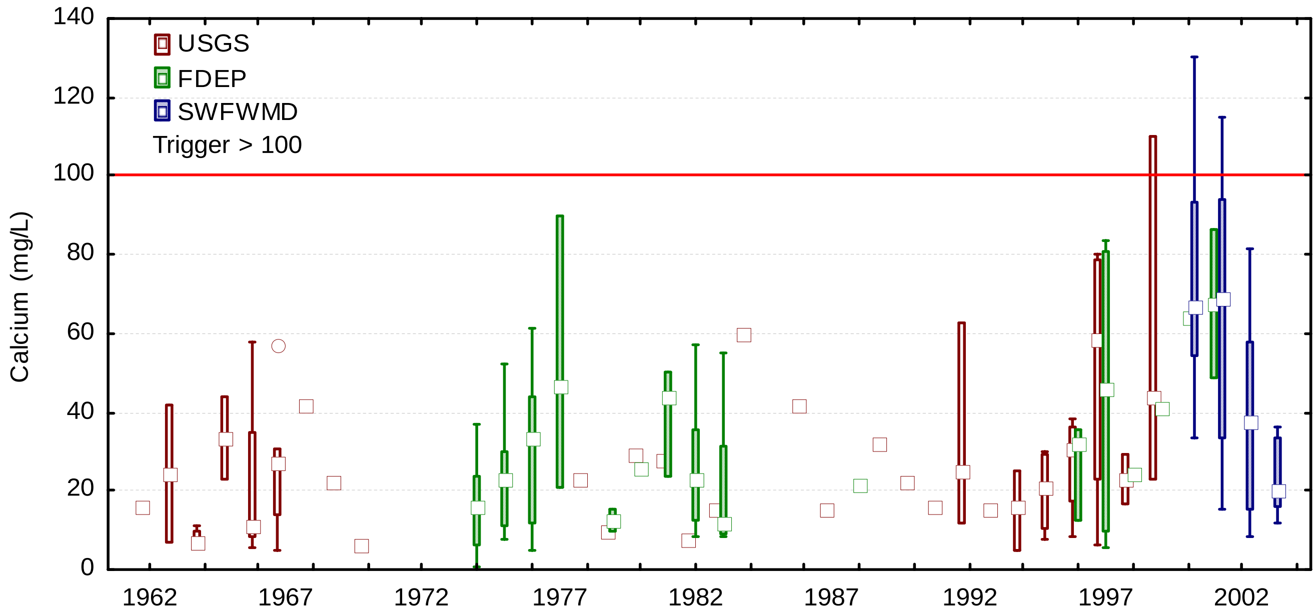


Figure 54. Annual Median Boxplots of Dissolved Calcium Concentrations Collected by USGS, FDEP, and SWFWMD in Horse Creek at Arcadia - SR 72 from 1962 to 2003.

5.12 IRON

More than a few isolated dissolved iron measurements were only available for the two southernmost stations, SR 72 (Figure 56) and SR 761 (Appendix B). At both sites, dissolved iron concentrations often exceeded the lower HCSP trigger value of 0.3 mg/L (Class I Waters), but very seldom exceeded the higher HCSP trigger value, 1.0 mg/L (Class III Waters) (Figure 56 and Appendix B). Trend analysis was not performed for dissolved iron concentrations because sufficient data was unavailable for the Seasonal Kendall Tau test.

Table 32. Dissolved Iron Period of Record and Sampling Frequency of Each Data Source for Horse Creek at Myakka Head and Horse Creek at Arcadia.

Station	Time period	Measurement Frequency	Agency
Horse Creek at Myakka Head	1972	Annual	FDEP
	2002	Annual	SWFWMD
Horse Creek at Arcadia	1964-1968, 1988-1991	Annual-quarterly	USGS
	1974-1977, 1982-1983	Monthly-bimonthly	FDEP
	1979-1981, 1984, 1986-1987, 1990-1991, 1999-2000	Annual-quarterly	FDEP
	2002	Annual	SWFWMD

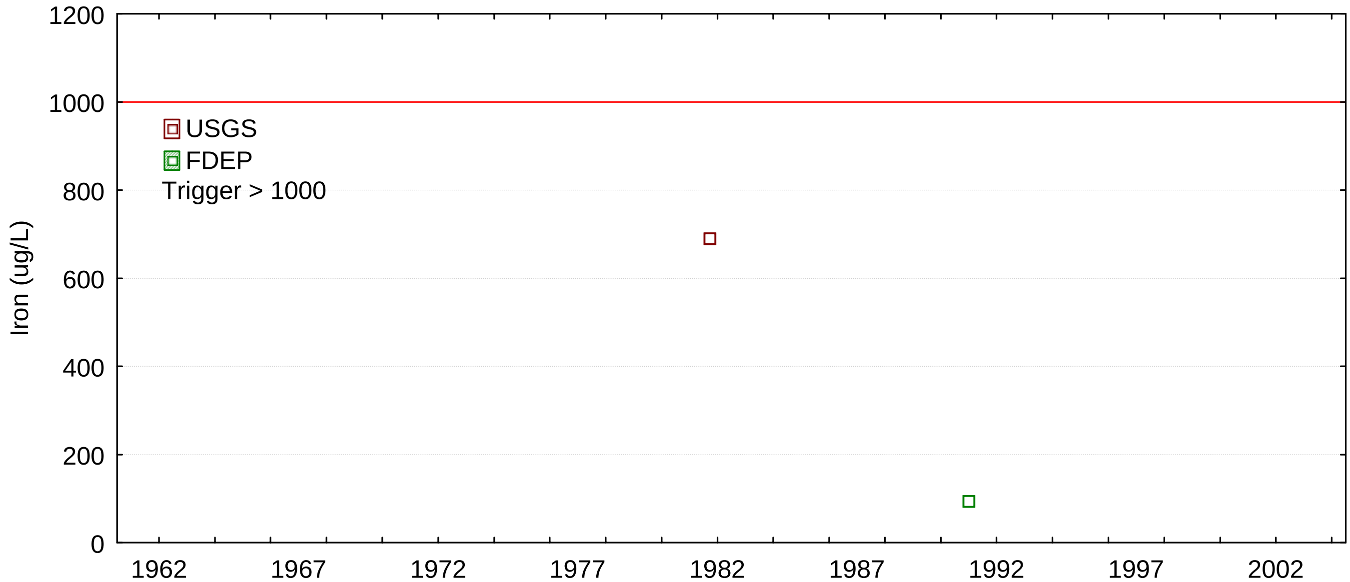


Figure 55. Annual Median Boxplots of Dissolved Iron Concentrations Collected by USGS, FDEP, and SWFWMD in Horse Creek at Myakka Head - SR 64 from 1962 to 2003.

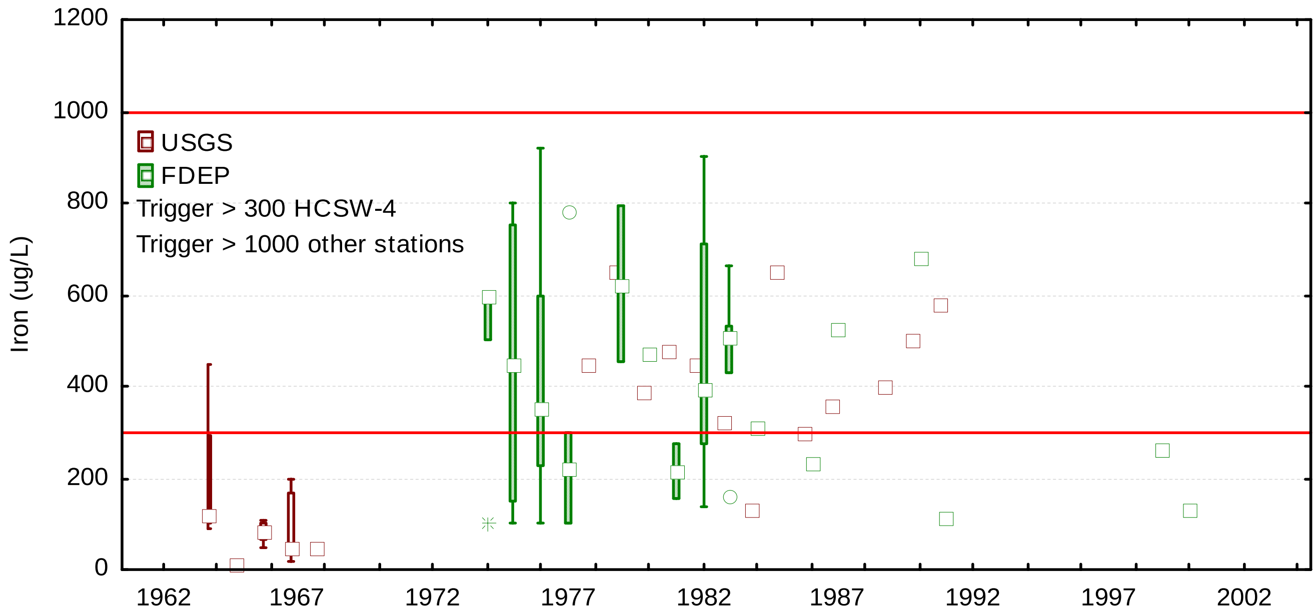


Figure 56. Annual Median Boxplots of Dissolved Iron Concentrations Collected by USGS, FDEP, and SWFWMD in Horse Creek at Arcadia - SR 72 from 1962 to 2003.

5.13 CHLORIDE

Dissolved chloride was measured at all six stations, and the HCSP trigger level of 250 mg/L was never exceeded at any station. Annual median chloride levels ranged from 5 – 30 mg/L at the four northern stations and from 10 – 40 mg/L at SR 72 and SR 761 (Figures 57 and 58). As with calcium, southern stations had higher dissolved chloride levels because of the high proportion of groundwater contributing to flow (SWFWMD 2000). Chloride concentrations are increasing over time at SR 72 (Seasonal Kendall's Tau slope = 0.28 mg/L/yr), but show no trend at SR 64 (Tables 38 and 39). Two outliers were removed for graphing from Horse Creek at Arcadia (85 and 126 mg/L).

Table 33. Chloride Period of Record and Sampling Frequency of Each Data Source for Horse Creek at Myakka Head and Horse Creek at Arcadia.

Station	Time period	Measurement Frequency	Agency
Horse Creek at Myakka Head	1972-1973, 1981-1984, 1989-1990	Annual-quarterly	FDEP
	1982, 1992-1996, 1998-1999	Annual-quarterly	USGS
	2000-2003	Monthly	SWFWMD
Horse Creek at Arcadia	1962-1974, 1978-1999	Annual-quarterly	USGS
	1975-1983, 1992, 1995-1996	Monthly-bimonthly	FDEP
	1972-1974, 1984, 1990-1991, 1993-1994, 1997-2001	Annual-quarterly	FDEP
	2000-2003	Monthly	SWFWMD

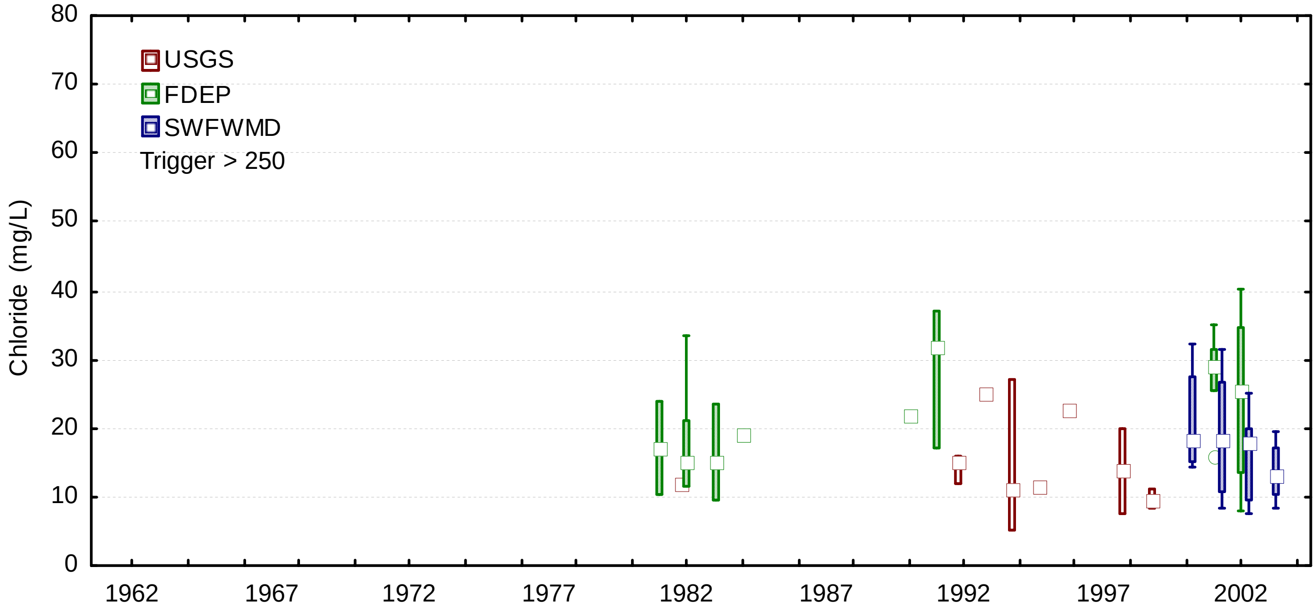


Figure 57. Annual Median Boxplots of Chloride Concentrations Collected by USGS, FDEP, and SWFWMD in Horse Creek at Myakka Head - SR 64 from 1962 to 2003.

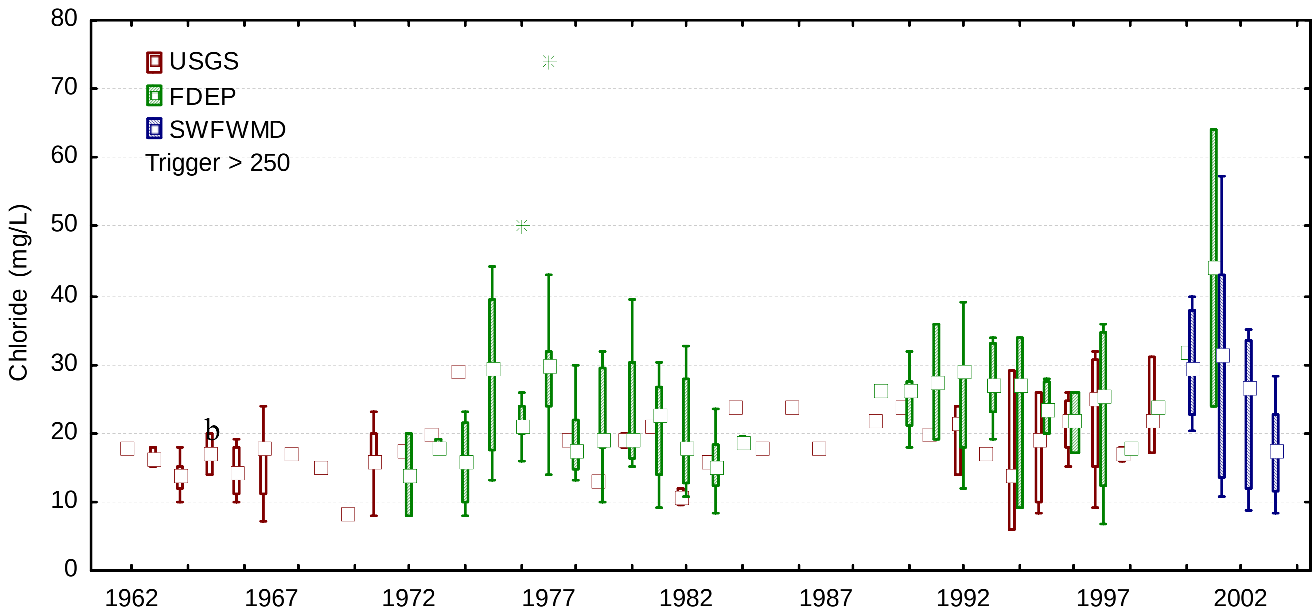


Figure 58. Annual Median Boxplots of Chloride Concentrations Collected by USGS, FDEP, and SWFWMD in Horse Creek at Arcadia - SR 72 from 1962 to 2003.

5.14 FLUORIDE

Dissolved fluoride was not consistently measured at most stations, but the southernmost station, SR 761, did have fluoride concentrations above the 1.5 mg/L HCSP trigger value, probably because of the high mineral content of groundwater baseflow. Median fluoride concentrations (Figures 59 and 60) were around 0.5 mg/L at all stations except SR 761, where concentrations ranged from 0.5 to 1.5 mg/L (Appendix B). Fluoride concentrations are increasing over time at SR 64 (Seasonal Kendall's Tau slope = 0.002 mg/L/yr, outlier removed), but are decreasing at SR 72 (slope = -0.004 mg/L/yr) (Tables 38 and 39). At Myakka Head, the station nearest to phosphate mining in Horse Creek, conversion of rangeland and agricultural land to phosphate mines may be responsible for the increasing concentrations of fluoride because the mined rock contains fluoride. One outlier was removed for graphing from Horse Creek near Myakka Head (6.2 mg/L, 6 May 1998).

Although fluoride concentrations at State Road 64 show an overall rise since the early 1980's, their relationship with mining activities is not clear. The increase in fluoride concentration does not track directly with the mining rate in the Horse Creek basin. The increase in mined acres starting in the basin in 1993 did not result in an increase in fluoride concentrations. The recognized fluoride increase did not begin until 2000. Nor does the fluoride behavior seem to correlate with mine water discharge to Horse Creek. Mine water discharges are greatest during periods of increased rainfall. The fluoride increase began during a historic dry period (2000 – 2001) that resulted in a minimal amount of mine water discharge to Horse Creek. The agency data from 2004 and 2005 (when published) will be very helpful in assessing fluoride behavior and its possible relationship to mining. If fluoride concentrations increase over this period (as mining moves closer to State Road 64 and there was some meaningful mine water discharge to Horse Creek), then there would be evidence of a potential correlation between mining and fluoride concentrations. If concentrations do not rise or they drop off, then the fluoride increase seen in 2000 – 2003 may be a result of hydrological conditions or simply variation within the normal range of behavior from a system that has not generated a lot of historical fluoride information for comparison.

Table 34. Fluoride Period of Record and Sampling Frequency of Each Data Source for Horse Creek at Myakka Head and Horse Creek at Arcadia.

Station	Time period	Measurement Frequency	Agency
Horse Creek at Myakka Head	1976, 1981-1984, 1989-1990	Annual-quarterly	FDEP
	1982, 1992-1996, 1998-1999	Annual-quarterly	USGS
	2000-2003	Monthly	SWFWMD
Horse Creek at Arcadia	1962-1968, 1970-1972, 1978-1999	Annual-quarterly	USGS
	1978-1983	Monthly-bimonthly	FDEP
	1976-1977, 1984, 1989-1992, 1997-2000	Annual-quarterly	FDEP
	2000-2003	Monthly	SWFWMD

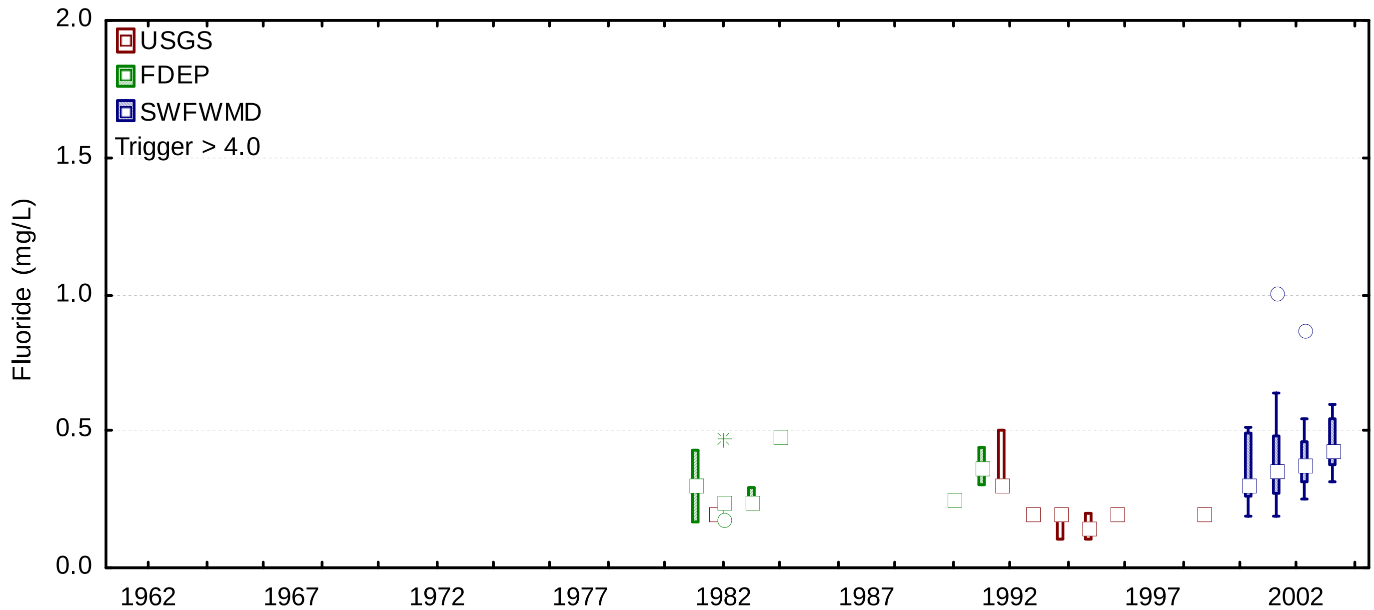


Figure 59. Annual Median Boxplots of Fluoride Concentrations Collected by USGS, FDEP, and SWFWMD in Horse Creek at Myakka Head - SR 64 from 1962 to 2003.

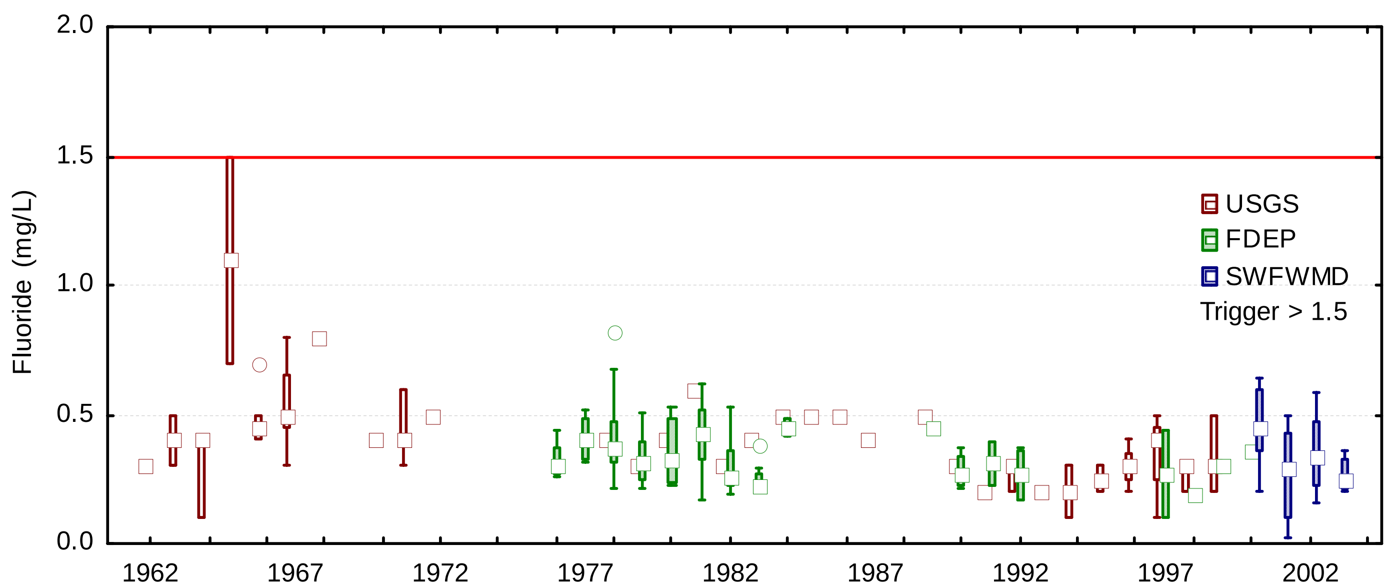


Figure 60. Annual Median Boxplots of Fluoride Concentrations Collected by USGS, FDEP, and SWFWMD in Horse Creek at Arcadia - SR 72 from 1962 to 2003.

5.15 SULFATE

Sulfate concentrations, like those of other dissolved minerals in Horse Creek, are also much higher at the downstream stations over this 30-year period (Figures 61 and 62). At the three upstream stations, sulfate concentrations range between 0 and 60 mg/L, while at the southern three stations, sulfate concentrations may be as high as (or higher than) the HCSP trigger value (250 mg/L). Again, sulfate concentrations are high in groundwater sources, which contribute more baseflow to downstream Horse Creek than to the more elevated upstream (SWFWMD 2000, Lewelling 1997). Sulfate concentrations are increasing over time at SR 72 (Seasonal Kendall's Tau slope = 1.6 mg/L/yr), but show no trend at SR 64 (Tables 38 and 39). One outlier was removed for graphing from Horse Creek at Arcadia (507 mg/L, 9 May 2001).

Table 35. Fluoride Period of Record and Sampling Frequency of Each Data Source for Horse Creek at Myakka Head and Horse Creek at Arcadia.

Station	Time period	Measurement Frequency	Agency
Horse Creek at Myakka Head	1975-1976, 1981-1984, 1989-1990	Annual-quarterly	FDEP
	1982, 1992-1996, 1998-1999	Annual-quarterly	USGS
	2000-2003	Monthly	SWFWMD
Horse Creek at Arcadia	1962-1970, 1978-1987, 1989-1999	Annual-quarterly	USGS
	1975-1978,1981-1983, 1990, 1992-1997	Monthly-bimonthly	FDEP
	1979-1980, 1984, 1991, 1998, 2000-2001	Annual-quarterly	FDEP
	2000-2003	Monthly	SWFWMD

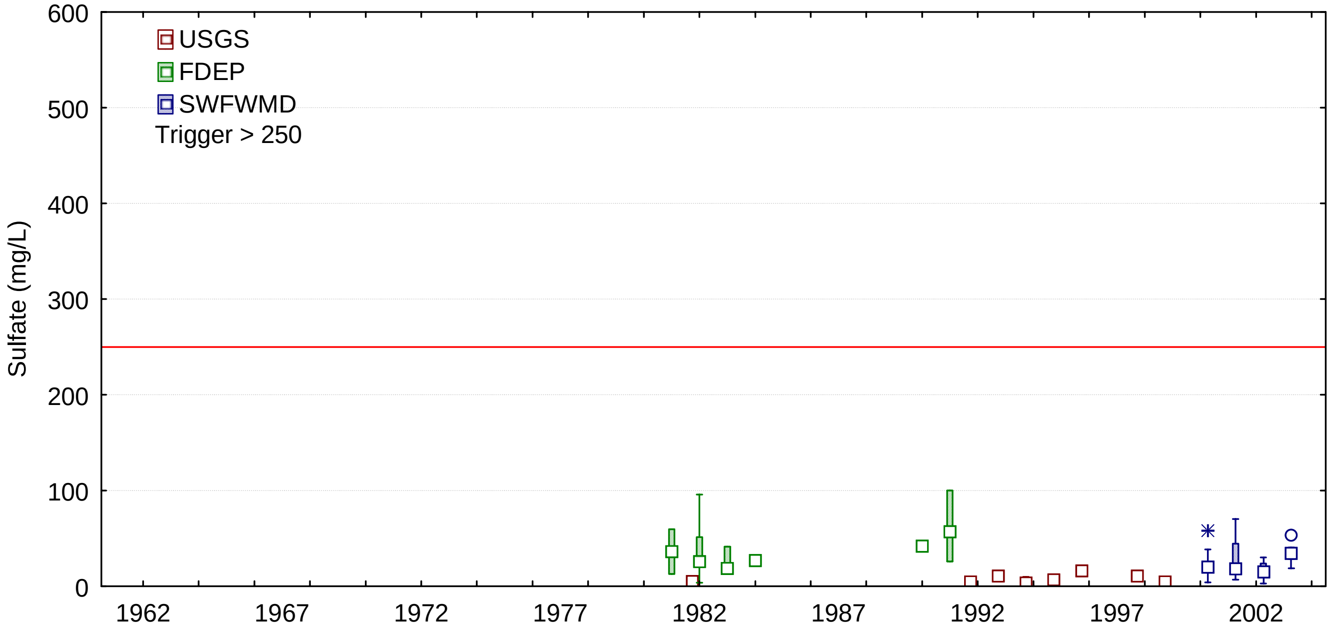


Figure 61. Annual Median Boxplots of Sulfate Concentrations Collected by USGS, FDEP, and SWFWMD in Horse Creek at Myakka Head - SR 64 from 1962 to 2003.

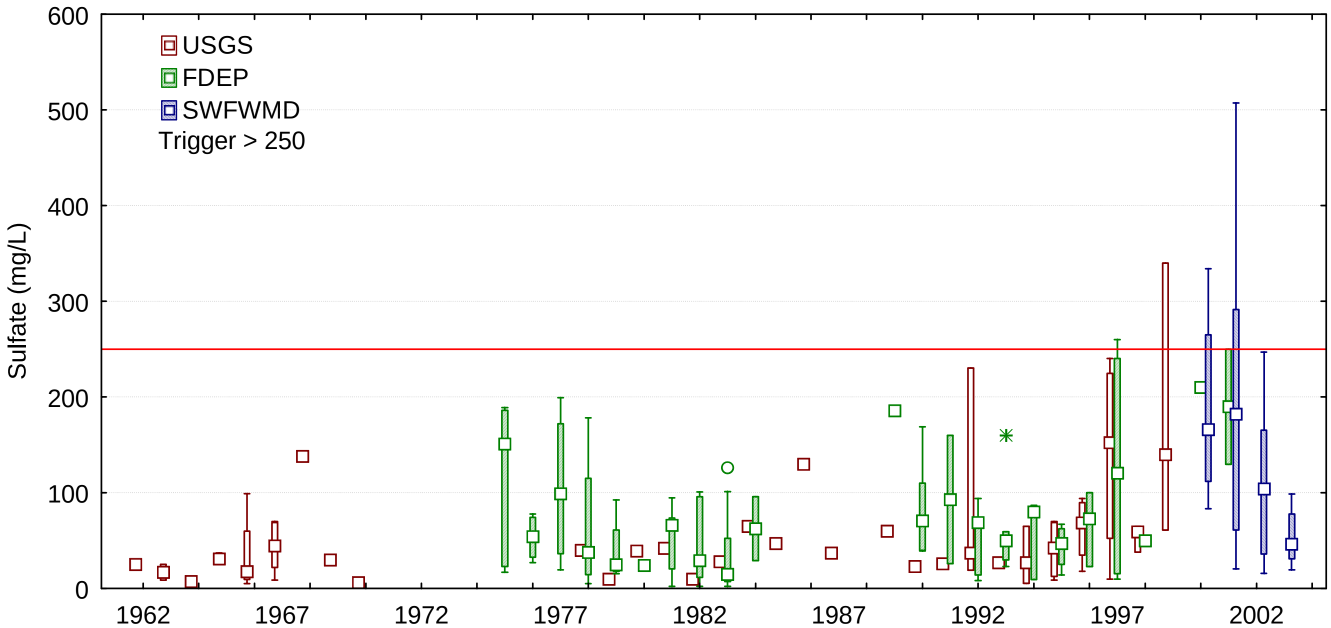


Figure 62. Annual Median Boxplots of Sulfate Concentrations Collected by USGS, FDEP, and SWFWMD in Horse Creek at Arcadia - SR 72 from 1962 to 2003.

5.16 WATER QUALITY SUMMARY

Many of the water quality parameters measured in Horse Creek are historically correlated with discharge or rainfall (Tables 36 and 37). Parameters positively correlated with discharge or rainfall, such as turbidity, ammonia, organic and total nitrogen, color, and iron, had higher concentrations in Horse Creek during the wet season. Negatively correlated parameters, such as pH, dissolved oxygen, phosphorus, nitrogen oxides, chlorophyll a, conductivity, and other dissolved minerals, had higher concentrations in the dry season when temperatures were cooler and groundwater and agricultural runoff contributed more to baseflow. Any analysis of historical or future trends in these data should take this seasonal relationship with flow into account.

Table 36. Pearson's Product Moment Correlations of Water Quality Parameters and Daily Mean Discharge at Horse Creek Near Myakka Head. Provisional USGS Discharge Data was Used for this Analysis. (Only Correlations Significant at $p < 0.05$ Level are Listed.)

		Turbidity (NTU)	pH	Dissolved Oxygen	TKN	Total Nitrogen	Total Phosphorus	Orthophosphate	Chlorophyll a	Specific Conductivity	Color	Chloride	Calcium	Fluoride	Temperature
Log (Discharge)	r	0.60	-0.51	-0.29	0.67	0.44	-0.34	-0.45	-0.23	-0.50	0.71	-0.66	-0.59	-0.37	0.33
	N	71	161	162	57	37	130	117	74	202	105	113	60	73	163

Table 37. Pearson's Product Moment Correlations of Water Quality Parameters and Daily Mean Discharge at Horse Creek Near Arcadia. Provisional USGS Discharge Data and NOAA (via SWFWMD) Rainfall Data was Used for this Analysis. (Only Correlations Significant at $p < 0.05$ Level are Listed.)

		Turbidity (NTU)	pH	Dissolved Oxygen	TKN	Total Nitrogen	Ammonia	Nitrate + Nitrite	Chlorophyll a	Color	Specific Conductivity	Alkalinity	Chloride	Calcium	Fluoride	Iron	Sulfate	Temperature
Log (Discharge)	r	0.42	-0.62	-0.44	0.59	0.44	0.16	-0.23	-0.28	0.71	-0.69	-0.78	-0.60	-0.69	-0.66	0.52	-0.60	0.09
	N	93	523	547	259	56	301	345	81	415	502	57	269	174	205	86	205	571
Log (Rainfall)	r	0.29	-0.14	-0.21	0.18	0.31	0.13			0.17					-0.15			0.15
	N	93	523	547	259	56	301			415					205			571

Long-term trends in the Horse Creek Basin indicate that nitrogen concentrations are decreasing and specific conductivity and fluoride concentrations are increasing at the upstream station, Horse Creek near Myakka Head (Seasonal Kendall Tau, Table 38). At Horse Creek near Arcadia, ammonia, phosphorus, and fluoride are decreasing, but dissolved oxygen, nitrogen oxides, conductivity, and other dissolved minerals are increasing (Table 39). All other water quality parameters show no trend at either station. At Myakka Head, the station nearest to phosphate mining in Horse Creek, conversion of rangeland and agricultural land to phosphate mines (Figure 7) may be responsible for the decreasing concentrations of nitrogen and increasing concentrations of specific conductivity and fluoride. In the southern Horse Creek Basin, organic and ammonia nitrogen has declined, but nitrogen oxides have increased, reflecting the conversion of lands to agricultural plots requiring nitrate or nitrite fertilizers (SWFWMD 2000, Coastal Environmental 1996). The highest levels of phosphate in the southern Horse Creek Basin occurred before the initiation of mining in the Basin (Fraser 1991, Wade et al 2003). Increased levels of many dissolved minerals in southern Horse Creek over time may be evidence of changes in groundwater quality or percent contribution to baseflow (SWFWMD 2000, Wade et al. 2003, SWFWMD 2001, PBSJ 1999).

Dissolved mineral concentrations (calcium, chloride, fluoride, etc.) and specific conductivity were higher at downstream stations in Horse Creek, given the available data from 1972-2002 (Wade et al. 2003). As the elevation of Horse Creek Basin decreases from the north (130 ft NGVD) to the south (40 ft NGVD), artesian flow of groundwater from the surficial and intermediate aquifers becomes more likely (Wade et al. 2003). Groundwater usually has a higher concentration of many dissolved minerals than surface runoff, thus affecting the chemistry of downstream Horse Creek (SWFWMD 2000, SWFWMD 2001, PBSJ 1999). The predominance of agriculture along central and southern Horse Creek also can contribute to a higher proportion of groundwater in the Creek via irrigation runoff (Hammett 1990, Coastal Environmental 1996, SWFWMD 2001).

Agricultural practices have also affected nutrient levels in Horse Creek, especially nitrogen. Nitrate and nitrite levels were elevated at downstream sites compared to upstream sites, reflecting the influence of fertilizing citrus and other row crops in the southern Horse Creek Basin (SWFWMD 2001, SWFWMD 200, Coastal Environmental 1996, Fraser 1991). Other forms of nitrogen, as reflected by Total Kjedahl Nitrogen levels, do not show as clear a trend; organic nitrogen could come from other sources than fertilizer, such as cattle waste (Hammett 1990).

Natural landscape features have also influenced certain water quality parameters in Horse Creek Basin. Horse Creek Prairie, immediately upstream from the SR 663 and SR 665 stations, is a slow-moving, hypoxic swamp. Water at the two stations downstream of the swamp was more acidic and hypoxic than water at stations below and above the prairie; dissolved oxygen was below the HCSP trigger value of 5 mg/L for all observations at SR 663. Color was also affected at SR 663, with color levels well above other stations because of decomposing organic matter (SWFWMD 2000). Color levels decreased downstream on Horse Creek as groundwater inflow increased, diluting the tannins from runoff upstream (Hammett 1990).

Without adequate safeguards, phosphate mining in the northern Horse Creek Basin could potentially affect water quality in many ways. However, the only effect of phosphate mining that can be seen in the historical data set is a slightly higher concentration of orthophosphate at the Horse Creek station nearest mining activities. Otherwise, phosphate levels in Horse Creek are higher than the Florida stream average because of phosphatic soils (SWFWMD 2000), but are well below concentrations seen in the northern Peace River (Bone Valley) (Hammett 1990). In fact, there is a slightly decreasing trend in phosphate and orthophosphate concentrations in Horse Creek Basin since the mid-1980s (Tables 38 and 39) (Wade et al. 2003, SWFWMD 2001, PBSJ and Dexter Bender 1999, CHEC 2001).

Table 38. Seasonal Kendall Tau Trend Analysis of Water Quality Parameters at Horse Creek Near Myakka Head. Number of Seasons, Period of Record, and Flow Correction Model (FAC) are Given for Each Analysis. Trends were Considered Significant at the $p < 0.05$ Level.

Parameter	Seasons	FAC model	Begin year	End year	Nobs	Tau	P value	Slope	Trend?
pH	2		1977	2003	35	-0.076	0.556	-0.004	
Dissolved oxygen	2		1977	2003	37	-0.123	0.316	-0.026	
Temperature	2		1977	2003	37	-0.033	0.796	-0.010	
Ammonia	1		1981	2003	13	-0.141	0.539	-0.001	
Orthophosphate	3		1992	2003	31	0.158	0.277	0.007	
Color	2		1979	2003	28	-0.010	0.970	0.000	
TKN	2		1981	2003	22	-0.354	0.034	-0.036	Decreasing
TKN	2	Log flow loess	1981	2003	22	-0.109	0.544	-0.013	
Nitrate+nitrite	2		1981	2003	32	-0.233	0.079	-0.005	Decreasing
Phosphorus	2		1981	2003	31	-0.106	0.442	-0.003	
Specific Conductivity	2		1978	2003	37	0.330	0.006	3.910	Increasing
Sulfate	1		1981	2003	15	-0.104	0.620	-0.355	
Fluoride	2		1981	2003	23	0.283	0.083	0.002	Increasing
Chloride	2		1981	2003	25	-0.026	0.896	-0.002	
Calcium	1		1992	2003	10	0.400	0.126	1.300	

Table 39. Seasonal Kendall Tau Trend Analysis of Water Quality Parameters at Horse Creek Near Arcadia. Number of Seasons, Period of Record, and Flow Correction Model (FAC) are Given for Each Analysis. Trends were Considered Significant at the $p < 0.05$ Level.

Parameter	Seasons	FAC model	Begin year	End year	Nobs	Tau	P value	Slope	Trend?
pH	2		1962	2003	72	0.036	0.667	0.0004	
Dissolved oxygen	2		1968	2003	67	0.179	0.037	0.037	Increasing
Temperature	2		1962	2003	74	-0.232	0.004	-0.083	Decreasing
Ammonia	1		1971	2003	31	-0.322	0.010	-0.001	Decreasing
Total Nitrogen	2		1979	2003	16	0.157	0.477	0.0005	
Total Nitrogen	2	Log flow loess	1979	2003	16	0.228	0.304	0.004	
Orthophosphate	2		1962	2003	41	-0.514	0.000006	-0.016	Decreasing
Color	2		1962	2003	71	-0.051	0.541	0.000	
TKN	2		1977	2001	45	-0.061	0.575	-0.007	
TKN	2	Log flow loess	1977	2001	45	0.008	0.953	0.0004	
Nitrate+nitrite	2		1973	2003	58	0.363	0.0009	0.011	Increasing
Phosphorus	2		1971	2003	63	-0.273	0.002	-0.005	Decreasing
Specific Conductivity	2		1962	2003	77	0.291	0.0002	3.732	Increasing
Sulfate	2		1962	2003	62	0.353	0.00008	1.636	Increasing
Fluoride	2		1962	2003	62	-0.290	0.001	-0.004	Decreasing
Chloride	2		1962	2003	69	0.334	0.00008	0.285	Increasing
Calcium	2		1962	2003	56	0.337	0.0003	0.578	Increasing

Exceedance of HCSP trigger values in historical water quality data was most common for parameters at the three Horse Creek stations with the longest period of record, Horse Creek at SR 64, at SR 72, and at SR 761 (Table 40). Most water quality exceedances were isolated instances, with only 1-3 measurements exceeding HCSP trigger values at stations near SR 64 and SR 72 (Table 40). A few water quality parameters, such as pH and dissolved oxygen, exceeded HCSP trigger values at nearly every station over the entire period of record, usually seasonally. This suggests that current HCSP trigger values for these parameters ($6 > pH > 8.5$, $DO < 5.0$ mg/L) may not reflect historical conditions in Horse Creek and may represent an unrealistic expectation for future water quality measurements. At the southern station near SR 72, orthophosphate and alkalinity exceeded trigger values before 1980, while calcium and sulfate exceeded HCSP trigger values after 1980. None of these exceedances can be attributed to phosphate mining in Horse Creek Basin, which did not begin in the basin until the late 1980's. Although calcium and sulfate levels have risen in southern Horse Creek since mining began, stations upstream of SR 72 (and closer to mining) show no exceedances or upward trends for these parameters. Increased concentrations in dissolved ions in southern Horse Creek may reflect increased contributions of agricultural runoff or changes in groundwater water quality (Fraser 1991, PBSJ 1999, Wade et al. 2003, SWFWMD 2001, Coastal Environmental 1996). Dissolved iron at SR 72 always exceeded the lower HCSP trigger value for Class I waters, but not the HCSP trigger value for Class III waters that applies to upstream Horse Creek; again, the Class I HCSP trigger value may represent an unrealistic expectation for dissolved iron concentrations at SR 72 given historical conditions. Most of the water quality parameters measured at the SR 761 station on Horse Creek showed numerous exceedances of HCSP trigger values. Data at this station, however, was taken from the PRMRWSA's EQL sampling, which may have different methodology or quality control than the agencies from which the remainder of the Horse Creek data was obtained (FDEP, USGS, and SWFWMD).

Table 40. Historical Exceedance of Water Quality Parameters at Six Stations in Horse Creek Over Trigger Values Set by the Horse Creek Stewardship Program. Numbers in Parentheses Indicate where Exceedances Consist of Only a Few Instances.

	Myakka Head (SR 64)	SR 663	SR 665	SR 70	Arcadia (SR 72)	SR 761
Turbidity	above (1)				above (1)	above
pH	below	below			above/below	above/below
Dissolved Oxygen	below	below	below	below	below	below
Nitrate + Nitrite	above (1)				above (3)	above (2)
TKN	above (1)				above (1)	above
Total Nitrogen						
Ammonia	above (2)		above (1)		above (1)	above
Orthophosphate					above	
Total Phosphorus		above (1)				above
Color	below (1)				below (2)	below
Chlorophyll a	above (2)				above (1)	above
Specific Conductivity						
Alkalinity					above	above
Calcium					above	above
Iron					above (lower trigger)	above (both triggers)
Chloride						
Fluoride	above (1)					above (lower trigger)
Sulfate					above	above (3)

Historically, water quality in the Horse Creek Basin has been considered to be higher than water quality in the nearby Peace River. Before mining began in the Horse Creek Basin, nutrient and dissolved ion concentrations were at least 2-3 times higher in the Peace River than in Horse Creek (Fraser 1991).

More recently, however, the gap between nutrient and ion levels in the two waterbodies has narrowed, although the Peace River still posts the highest levels of specific conductivity, nitrogen, phosphorus, and pH (CHEC 2001, Coastal Environmental 1996, PBSJ and Dexter Bender 1999). Long-term trends in nitrogen oxides (increasing) and phosphorus (decreasing) are similar at Horse Creek near Arcadia and Peace River near Arcadia (Table 39, Wade et al. 2003). Phosphorus, nitrogen oxide, and specific conductivity levels in the Myakka River are lower than those in both the Peace River and Horse Creek, but organic nitrogen and ammonia levels in the Myakka River are higher than those in Horse Creek (CHEC 2001, Coastal Environmental 1996, PBSJ and Dexter Bender 1999).

Non-point source loading of runoff, total nitrogen, total phosphorus, and total suspended solids were estimated for the Horse Creek basin using detailed rainfall, SWFWMD 1999 land cover, and USDA soil data (PBSJ and Dexter Bender 1999, CHEC 2002). Total estimated annual runoff for the Horse Creek basin was 116 million cubic meters, and estimated annual pollutant loads were 356 tons of total nitrogen, 104 tons of total phosphorus, and 2,502 tons of total suspended solids. Agricultural lands (primarily pasture and groves) contributed 63 million cubic meters of runoff, 184 tons nitrogen, 52 tons phosphorus, and 669 total suspended solids. In 1999, 6.4 percent of the Horse Creek basin was used for mining, so mining contributed very little to pollutant load in this study.

The historic water quality data contained in this report may be used as a basis for future trend analysis when combined with data collected by the Horse Creek Stewardship Program. We recommend using data from three major data sources (SWFWMD, USGS, FDEP) in combination with the HCSP monthly water quality measurements. Although analyses combining data from different sources may be affected by differences in sampling and/or analytical methods, each of the three major sources of historical data for Horse Creek encompasses important aspects of the historical data set and should be included (Section 5.1). In this historic report, we used Seasonal Kendall Tau analysis for long-term trend analysis. This method may have some limitations when used on multiple-source, inconsistent datasets (Section 5.1), but future monthly sampling by the HCSP will improve its performance. Trend analysis should be continued in future HCSP annual reports, but we do not expect changes in water quality trends to be evident for several more years. Therefore, we recommend that for the next several HCSP annual reports, the historical data analyzed in this report should primarily be used to bracket the current conditions in Horse Creek within a historical context. For example, examination of historical dissolved oxygen values in Horse Creek indicates that it is not unusual for dissolved oxygen to be below the Class III Water standard of 5.0 mg/L throughout the period of record at most stations in Horse Creek. This would be an important component of any evaluation of HCSP trigger level exceedances and whether the exceedances are a consequence of mining activites in the basin.

6.0 AQUATIC BIOLOGY

6.1 BENTHIC MACROINVERTEBRATES

The purpose of the HCSP (including this historical report) is to investigate the general condition of Horse Creek in the past and present. Chemical and physical water quality parameters can only provide partial evidence of the ecological condition of a water body because potential pollutants and other stressors may not persist long enough to be detected by periodic sampling (Barbour, et al. 1996). To supplement chemical analyses, biomonitoring also may be used to evaluate water quality. Resident organisms respond to both frequent and transient water pollution, their cumulative effects, and surrounding habitat quality. Macroinvertebrates are commonly used as indicators in biomonitoring in Florida water bodies. The FDEP has studied the macroinvertebrate communities throughout Florida and developed and/or adopted several indicies that correlate stream quality with macroinvertebrate taxa and abundance. Generally, the FDEP has found that indicies which combine several metrics to describe communites correlate better with water quality than the presence or absence of particular taxa (Barbour, et al. 1996). The historic record for macroinvertebrate sampling Horse Creek is limited and intermittent. However, existing studies can be compiled to draw some conclusions about previous conditions. The known macroinvertebrate sampling efforts in the Horse Creek Basin are summarized in Table 41. A complete list for macroinvertebrate taxa presence/absence during historical sampling was compiled from the HCSP 2003 Annual Report, ES&E (1982), Durbin and Lancaster (2003), Lancaster and Durbin (1999), and the FDEP and is provided in Appendix C.

Environmental Science and Engineering (1982) conducted a survey of benthic macroinvertebrates at four stations on Horse Creek and its tributaries between September 1978 and June 1979 (Table 42). Species richness and abundance were usually higher at the upstream station (Horse Creek near SR 70) than the downstream station (Horse Creek near SR 72). Invertebrate diversity was highest during the beginning of the wet season (June), and lowest at the end of the wet season (Sept). Invertebrates captured in Horse Creek and its tributaries, Brandy Branch and Buzzard's Roost Branch, were mostly of the groups Diptera, Tubificidae, Naidida, and Mollusca. The main Horse Creek channel had lower diversity than its tributaries. Diversity was higher in Horse Creek than in surrounding lentic areas (e.g. wetlands), which are commonly enriched with organic debris that discourages colonization by taxa intolerant of disturbance (ES&E 1982).

Rutter et al. (1985) collected macroinvertebrates from October 1983 through September 1984 at two sites along Horse Creek, SR 64 and SR 72 and one site on the tributary, Brushy Creek, at SR 64. Species richness was highest in Brushy Creek (averaged 72 taxa) and was higher at the upstream Horse Creek station (SR 64) than at the downstream station (SR 72), averaging 60 and 47 taxa, respectively. During this time period, the State of Florida used the "Florida Biotic Index" in an attempt to evaluate the quality of stream communities. In general, this index relied on consideration of the presence of a relatively small group of taxa as indicators of good water quality (primarily in relation to their intolerance of depressed oxygen levels). Florida Biotic Index scores were highest at Horse Creek near SR 64, indicating that this segment of the stream was the least impaired. Florida Biotic Index organisms in the lower Peace River Basin were well represented among the mayflies, dragonflies, damselflies, caddisflies, and midges, indicating that overall water quality was good during this study (Rutter et al. 1985).

Table 41. Summary of Macroinvertebrate Sampling Performed in the Horse Creek Basin from 1971-2000 by Various Methods.

Investigator	Stations	Methods	Date Range	No. events
ESE_A	Horse Creek at SR 70, Horse Creek at SR 72, Buzzard's Roost Branch, Brandy Branch	Core grab samples, Hester Dendy	1978-1979	4
BRA_B	Horse Creek at SR 64, West Fork Horse Creek, Horse Creek exit of Ft. Green, Brushy Creek	SCI, Hester-Dendy	1999	2
BRA_C	Horse Creek at SR 62, Horse Creek at SR 64, Horse Creek Upstream, Horse Creek Downstream	Bio-Recon	2002-2003	4 for SR 62, 3 for other stations
$FDEP_D$	Horse Creek at SR 64, Horse Creek at SR 72, Brushy Creek	D-frame net	1983-1984	4
$FDEP_E$	Horse Creek at SR 72	Hester Dendy	1971-1983	77
FDEP	Horse Creek at SR 72	Dipnet	1971-1979	5
FDEP	Horse Creek at SR 72	Petite Ponar	1974-1983	36
FDEP	Horse Creek at SR 72	Ekman Dredge	1982	1
FDEP	Horse Creek at SR 72	SCI	1993-2000	7
FDEP	Horse Creek at SR 72	Bio-Recon	1997-2000	3
FDEP	Horse Creek at SR 72	D-frame net	1999-2000	2
FDEP	Horse Creek at SR 663	Dipnet	1978-1980	3
FDEP	Horse Creek at SR 70	Petite Ponar	1975	1
FDEP	Horse Creek at CR 665, Horse Creek at CR 769	SCI	2000	1
FDEP	Horse Creek at SR 64	Bio-Recon	2002	1

A – ESE 1982
B – Lancaster and Durbin 1999
C – Durbin and Lancaster 2003, Lancaster and Durbin 2004
D – Rutter et al. 1985
E – P. Morgan, pers. com.

Table 42 Benthic Invertebrate Captures in Core Samples of Water Column and Artificial Substrates from 1978-1979 by Environmental Science and Engineering (1982) in Horse Creek.

	CORE SAMPLES															
Station	**Station 12 (Buzzard's Roost Branch)**				**Station 14 (Brandy Branch)**				**Station 15 (Horse Creek near SR 70)**				**Station 17 (Horse Creek near SR 72)**			
Sample	**Sep 1978**	**Dec 1978**	**Mar 1979**	**Jun 1979**	**Sep 1978**	**Dec 1978**	**Mar 1979**	**Jun 1979**	**Sep 1978**	**Dec 1978**	**Mar 1979**	**Jun 1979**	**Sep 1978**	**Dec 1978**	**Mar 1979**	**Jun 1979**
$Ind/m^2{}_A$	1274	30011	7109	34077	15869	2300	4357	4973	616	4809	1972	10484	123	1726	164	15661
$Diversity_b$	2.25	2.37	3.00	2.60	1.87	2.80	2.31	3.32	2.20	2.97	3.08	3.40	1.59	3.04	1.00	3.16
$Evenness_C$	0.71	0.53	0.65	0.50	0.46	0.78	0.63	0.72	0.85	0.70	0.81	0.76	1.00	0.91	1.00	0.66
Number of taxa	9	23	25	37	17	12	13	24	6	19	14	22	3	10	2	28
	ARTIFICIAL SUBSTRATE SAMPLES															
Ind/m^2	5472	11617	3208	10001	4149	4988	4645	224	3438	3255	2821	4599	4178	31	8226	1152
Diversity	3.60	3.81	3.25	4.35	4.11	3.26	4.05	0.96	2.85	3.67	4.03	3.33	2.89	2.00	3.08	3.73
Evenness	0.63	0.64	0.62	0.72	0.71	0.60	0.70	0.38	0.58	0.63	0.78	0.58	0.58	0.86	0.60	0.73
Number of taxa	52	61	39	64	55	42	54	6	31	57	36	53	31	5	36	35

A – ind = individuals,B – Shannon Wiener, base unknown,C – Based on Pielou

Benthic macroinvertebrate sampling in 1999 on potential mining areas in the northern Horse Creek Basin includes data from collections on Horse Creek (2 stations) and its tributaries, West Fork Horse Creek and Brushy Creek (Lancaster and Durbin 1999). Species richness, abundance, and diversity were higher during the winter than the summer (Table 43). In the winter, the Horse Creek tributaries showed evidence of impairment according to their SCI scores, but the main Horse Creek channel was not impaired. Rainfall, NPDES discharge, and overall stream discharge were higher during the summer sampling period. Diversity in the tributaries had less seasonal variation because of large pooled reaches that varied little in velocity or depth between the wet and dry seasons (Lancaster and Durbin 1999).

Another study of the IMC Phosphates Fort Green Mine compared macroinvertebrate data collected during 2002 to data collected in 1997 and 1999 (Durbin and Lancaster 2003). During the 2002 sampling event, the two Horse Creek stations downstream of IMC's NPDES outfalls yielded both more taxa and more individuals than the two stations upstream (Table 43). The authors state that while part of this difference in diversity and abundance is likely because of the overall size of the stream, which generally increases downstream, this difference is also a strong indication that the outfalls have not compromised the stream's ability to provide invertebrate habitat (Durbin and Lancaster 2003). During a similar 2003 sample, invertebrate taxa and number of individuals were again highest downstream of the mining outfalls (Lancaster and Durbin 2004).

When compared to 1999 sampling in Horse Creek, sampling in 2002 produced lower numbers of both taxa and individuals, probably because only four dip-net sweeps were made at each station in 2002 (the "Bio-Recon" method) while 20 were used in 1999 (the "SCI" method) (Durbin and Lancaster 2003). However, the same general pattern of habitat quality by station was evident in 1999; more taxa were found at the stations downstream of IMC's outfalls than the station upstream of the outfall (Durbin and Lancaster 2003). The authors concluded there was no evidence of degradation of aquatic invertebrate habitat by phosphate mining based on the 1999 and 2002 events; in fact, the habitat quality below the outfalls may have been improved by the increased streamflow and dissolved oxygen (Durbin and Lancaster 2003).

The Florida Department of Environmental Protection sampled macroinvertebrate communities at Horse Creek at SR 72 Bridge from 1971-1983, and from 1994-2000 using a variety of sampling techniques (Table 44) (Morgan, pers. com.). The FDEP has also sampled a few times at other locations on Horse Creek, including Horse Creek at SR 663, at SR 70, upstream of CR 665, downstream of CR 769, and upstream of SR 64 on mine property (Table 44).

Comparison of results over time and among investigators is difficult because of differences between sampling methods. For example, the Biorecon method involves taking four dipnet sweeps, while the SCI method takes 20 sweeps; some of the other methods (Dipnet, D-frame net) involve taking only one net sweep. Artificial substrate methods, like Hester Dendy, sample the epifaunal invertebrate community, while sediment grab samples, like Petite Ponar, sample the infaunal community. The number of macroinvertebrate genera and individuals collected differed between methods; methods used in the 1970s and 1980s (Hester Dendy, Ekman Dredge, Petite Ponar) captured fewer taxa but more individuals than methods used in the 1990s (SCI, Biorecon) (Figures 63 and 64).

Table 43. Benthic Invertebrate Captures in Dip-Net Sweeps by BRA from 1997-2003 in Horse Creek (Lancaster and Durbin 1999, Durbin and Lancaster 2003, Lancaster and Durbin 2004). Stations are Presented Left-to-Right from Upstream to Downstream on Horse Creek. Columns with Bold Bordered Boxes Represent the Same Sampling Station Among Different Events. Bold Values Represent More Intense Sampling (20 Dip-Net Sweeps Instead of 4 sweeps).

	DIP NET SWEEPS																				
Station	**Station A**	**HC-U**			**Station B**	**HC-62**				**Station C**	**HC-D**			**Station D**	**Ona SW-2**		**Ona SW-3**		**HC-64**		
Sample	**Sep 97**	**Oct 02**	**Feb 03**	**Sep 03**	**Sep 97**	**May 02**	**Oct 02**	**Feb 03**	**Sep 03**	**Sep 97**	**Oct 02**	**Feb 03**	**Sep 03**	**Sep 97**	**Feb 99**	**Aug 99**	**Feb 99**	**Aug 99**	**Oct 02**	**Feb 03**	**Sept 03**
Total Individuals	**248**	27	100	348	**230**	57	15	153	168	**95**	94	315	282	**19**	**1278**	**124**	**684**	**97**	80	74	894
Total Taxa	**16**	10	10	39	**24**	11	6	14	32	**35**	15	39	50	**10**	**53**	**29**	**30**	**16**	23	15	40
Florida Index	**2**	1	0	16	**1**	1	1	1	5	**3**	3	16	25	**5**	**25**	**15**	**18**	**4**	5	8	9
EPT Index	**0**	1	2	4	**1**	0	0	1	1	**2**	3	7	11	**1**	**10**	**6**	**4**	**5**	5	4	6

Considerably more sampling has been done at or near the SR 72 bridge than at any other sampling location. It is unclear whether the apparent increase in invertebrate taxa at Horse Creek at SR 72 (Figure 39) is an artifact of the sampling methods, or an actual upward trend in taxa richness at this station, although the former is more plausible. Chironomids (midges), Molluscs, and Ephemeropterans were the dominant taxa during most sampling events at all stations, but some sampling methods showed more diversity in dominant taxa than others (Table 44)

When samples from within each sampling method were compared, more macroinvertebrate taxa and individuals were collected during the dry season (October – April) than during the wet season (May – September) (Figures 63 and 64). Benthic communities are sensitive to abiotic conditions, such as stream velocity and discharge. Extreme rainfall events during the wet season may flush invertebrates downstream or allow them to become “diluted” into a larger water volume in the stream. Under normal conditions, however, invertebrates may appear to more abundant in the dry season because habitat substrates are easier to sample when the water is lower and invertebrates may become concentrated as the water level falls. Therefore, trend analysis of invertebrate richness and diversity must account for seasonal changes before attributing changes in community structure to changes in water quality.

Table 44. Summary of Macroinvertebrate Sampling Performed in the Horse Creek Basin by the FDEP from 1971-2000 by Various Methods.

Station	Method	Date Range	No. events	Avg. Total Taxa	Avg Total Ind	Index	Avg EPT	Avg DBar	Avg FL Index	Dominant Taxa
SR 72	Hester Dendy	1971-1983	77	26	497	-	8.8	3.2	20.1	Diptera-Chiromomidae (dry season), Ephemeroptera-Hepatageniidae (wet/dry season), Trichoptera-Hydropsychidae (wet season)
SR 72	Dipnet	1971-1979	5	39	-	-	10.4	-	21.2	-
SR 72	Petite Ponar	1974-1983	36	22	470	-	4.6	1.9	10.1	Bivalvia, Diptera-Chiromomidae, Ephemeroptera-Caenidae
SR 72	Ekman Dredge	1982	1	11	82	-	4	1.4	8	Bivalvia
SR 72	SCI	1993-2000	7	38	242	SCI 31 - Excellent	10.3	-	22	Diptera-Chiromomidae, Ephemeroptera-Caenidae, Bivalvia, Coleroptera-Elmidae
SR 72	Biorecon	1997-2000	3	37	238	Biorecon 3 - Healthy	12	-	21.3	Diptera-Chiromomidae
SR 72	Dframe net	1999-2000	2	51	56	-	12.5	-	22	Diptera-Chiromomidae
SR 663	Dipnet	1978-1980	3	29	-	-	2.3	-	7.6	-
SR 70	Petite Ponar	1975	1	17	303	-	5	1.51	8	-
CR 665	SCI	2000	1	34	126	SCI 25 - Good	3	-	10	Diptera-Chiromomidae
CR 769	SCI	2000	1	26	135	SCI 21 - Good	2	-	3	Gastropoda (very tolerant)
SR 64	Biorecon	2002	1	0	0		-	-	-	-

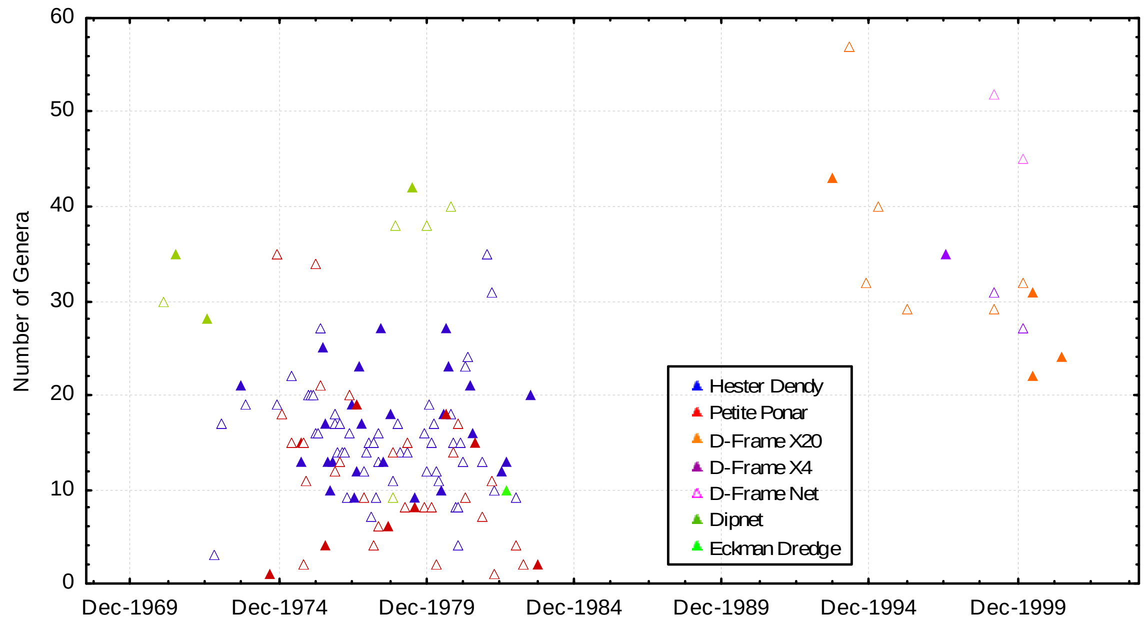


Figure 63. Number of Macroinvertebrate Genera Collected at Horse Creek at SR 72 by the FDEP from 1971-2000 by Various Methods. Wet season (May-September) and Dry Season (October-April) Sampling Events are Symbolized by Closed and Open Symbols, Respectively.

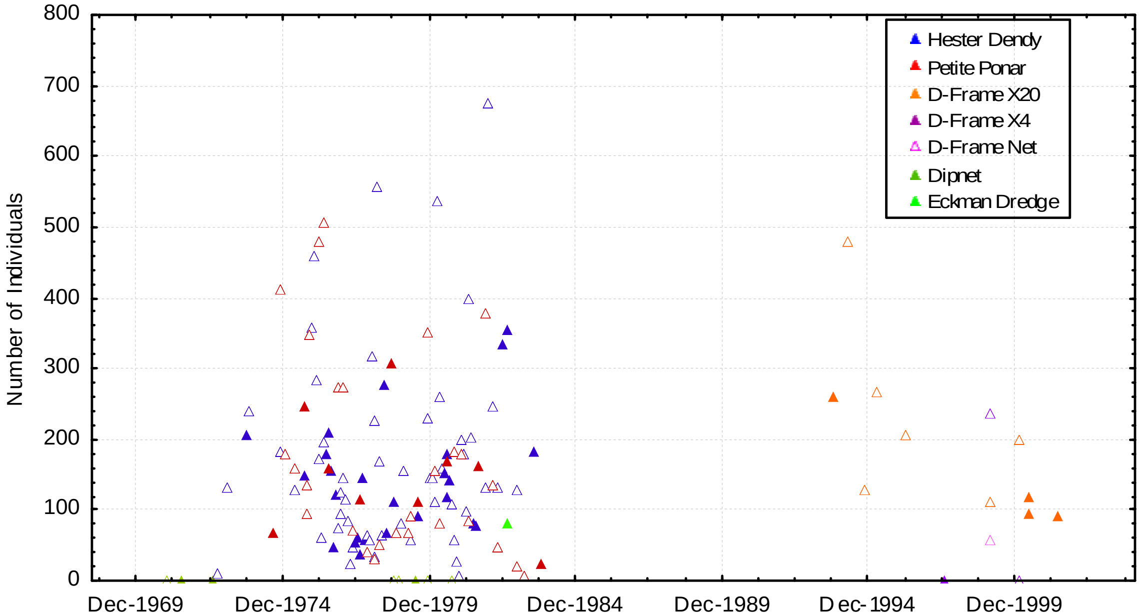


Figure 64. Number of Macroinvertebrate Individuals Collected at Horse Creek at SR 72 by the FDEP From 1971-2000 by Various Methods. Wet Season (May-September) and Dry Season (October-April) Sampling Events are Symbolized by Closed and Open Symbols, Respectively.

6.2 FISH

Biomonitoring methods using fish as indicators of water quality are not as refined as macroinvertebrate biomonitoring approaches. However, fish can be an important indicator of higher trophic structure, and they play an integral role in freshwater ecosystems, serving as both predators and prey in the food web. In Florida, fish belonging to families Cyprinodontidae (killifishes and topminnows) and Centrarchidae (sunfishes and basses) are some of the most important (ES&E, 1982). However, fish sampling has rarely been conducted in Horse Creek prior to the initiation of the Stewardship Program. In fact, the Stewardship Program will rapidly become the most comprehensive source of fish monitoring data available for Horse Creek. A complete list for fish taxa presence/absence during historical sampling was compiled from the HCSP 2003 Annual Report, ES&E (1982), and ES&E (1983) and is provided in Appendix D.

A 1978-1979 study of fish populations in Horse Creek and Big Slough (Table 45 and Figure 65) found that the open and relatively fast moving streams of the Horse Creek Basin had more species but fewer individuals than the more lentic Big Slough (ES&E, 1982). More than 23,000 individuals from nine families were collected in Horse Creek, with over 80 percent of individuals from family Poeciliidae (mosquitofish and least killifish) (ES&E, 1982). Although Centrarchids (largemouth bass and pygmy sunfish) comprised a small percentage of individuals captured during the study, centrarchids were estimated to comprise the highest percentage of the total fish biomass (ES&E, 1982). The relative abundance of fish from Poeciliidae and Centrarchidae is affected by the hydrological regime, density of macrophytic vegetation, and dominant substrate (ES&E, 1982). Centrarchids were most abundant in open, flowing areas of Horse Creek, where sand was the dominant substrate. Poeciliids were predominant in low flow, densely vegetated areas where macrophytic vegetation and other structure gave shelter (ES&E 1982).

Table 45. Fish Captures in Seine Nets from 1978-1979 by Environmental Science and Engineering (1982) in Horse Creek. [*Shannon-Weiner (Natural Log) Diversity Calculated by BRA from ES&E (1982) Species Tables.]*

	FISH SEINING RESULTS															
Station	**Station 12 (Buzzard's Roost Branch)**				**Station 14 (Brandy Branch)**				**Station 15 (Horse Creek near SR 70)**				**Station 17 (Horse Creek near SR 72)**			
Sample	**Sep 1978**	**Dec 1978**	**Mar 1979**	**Jun 1979**	**Sep 1978**	**Dec 1978**	**Mar 1979**	**Jun 1979**	**Sep 1978**	**Dec 1978**	**Mar 1979**	**Jun 1979**	**Sep 1978**	**Dec 1978**	**Mar 1979**	**Jun 1979**
Number of Individuals	57	184	61	268	27	19	117	74	102	70	59	63	70	93	208	5
Diversity*	1.52	0.47	0.23	1.07	1.56	0.91	0.33	0.85	1.39	1.06	0.65	1.73	1.56	1.38	0.53	1.33
Number of taxa	7	5	3	9	7	8	5	8	9	4	5	10	8	5	2	4
Dominant taxa	Mosquitofish				Mosquitofish				Coastal shiner, Seminole killifish, Mosquitofish, Brook silverside, Taillight shiner				Coastal shiner, Seminole killifish, Sailfin molly Mosquitofish, Golden shiner			

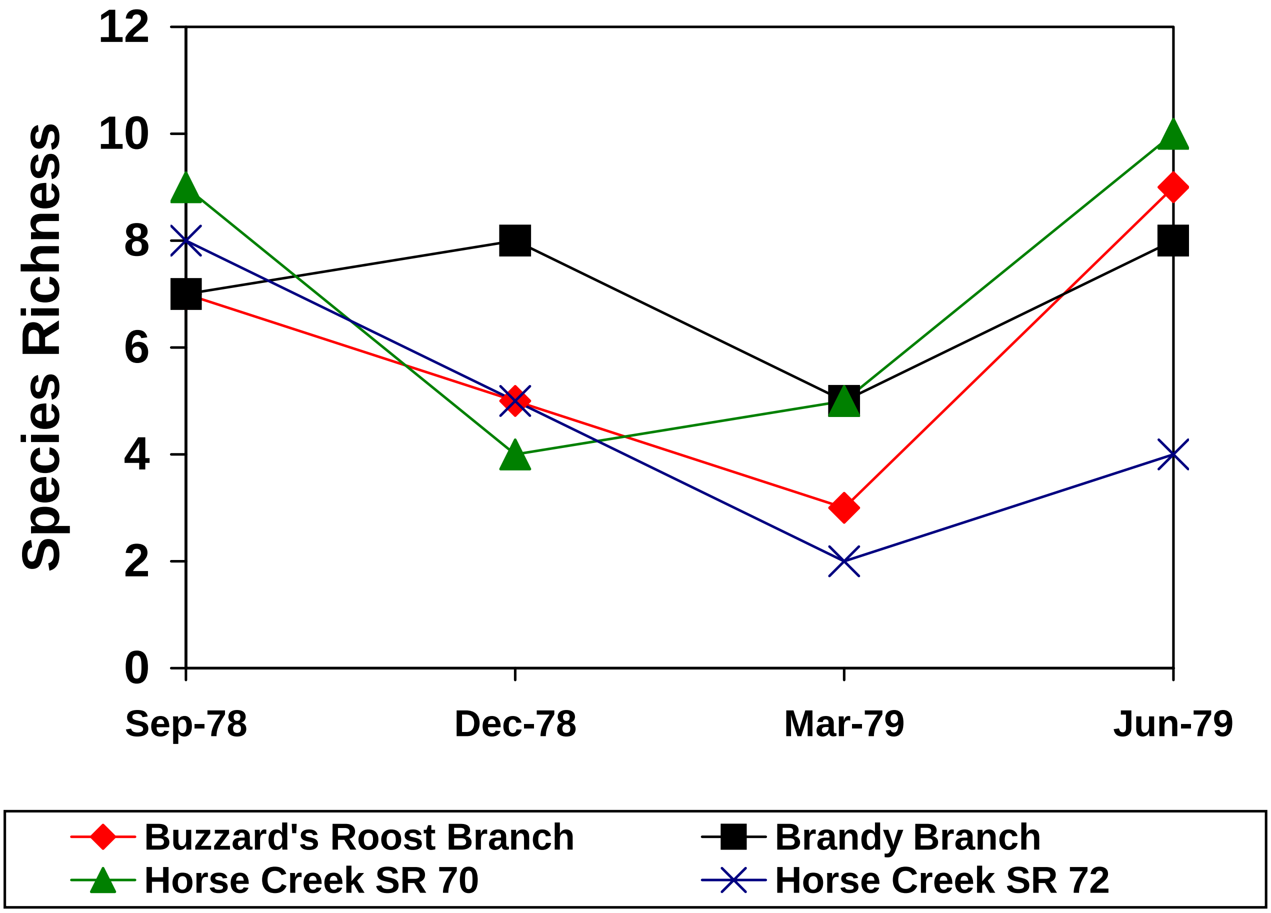


Figure 65. **Species Richness of Fish Captures in Seine Nets from 1978-1979 by Environmental Science and Engineering (1982) in Horse Creek.**

In a DRI application prepared for Farmland Industries, Inc., fish samples were collected throughout the Peace River Basin. Most of the data are not attributable directly to Horse Creek, but the authors stated that stream habitat stations on Brushy Creek and Horse Creek provide relatively satisfactory fish habitat, since 19 of the 24 species captured in the Peace River were also collected there (Ardaman and Associates, Inc. et al., 1979).

7.0 LITERATURE CITED

Ardaman and Associates, Inc., Armac Engineers, Inc., J.C. Dickinson, Environmental Science and Engineering, Inc., P.E. Lamoreaux and Associates, Inc., and Zellars-Williams, Inc. 1979. Development of Regional Impact Application for Development Approval Phosphate Mining and Chemical Fertilizer Complex, Hardee County, Florida.

Barbour, M. T., J. G. Gerritsen, and J. S. White. 1996. Development of the Stream Condition Index (SCI) for Florida. Prepared for Stormwater and Nonpoint Source Management Section, FDEP, by Terta Tech, Inc. Tallahassee, Florida.

Charlotte Harbor Environmental Center, Inc. (CHEC) 2001. Annual Report on Water Quality Status and Trends in the Peace and Myakka River Basins. Prepared for Charlotte Harbbor National Estuary Program. Punta Gorda, Florida.

Charlotte Harbor Environmental Center, Inc. (CHEC) 2002. Peace and Myakka River Water Quality Summary. Prepared for Southwest Florida Water Management District and Peace River Manasota Regional Water Supply Authority. Punta Gorda, Florida.

Coastal Environmental, Inc. 1995. Estimates of Total Nitrogen, Total Phosphorous, and Total Suspended Solids Loadings to Charlotte Harbor, Florida. Prepared for: Surface Water Improvement and Management Department, SWFWMD, Tampa, FL.

Coastal Environmental, Inc. 1996. Review and Analyses of Meteorological, Tributary Flow, and Water Quality Data from the Charlotte Harbor Estuarine System. Prepared for: Surface Water Improvement and Management Department, SWFWMD, Tampa, FL.

Cowherd, D., W.G. Henderson, Jr., E.J. Sheehan, and S. T. Ploetz. 1989. Soil Survey of DeSoto County, Florida. United States Department of Agriculture, Soil Conservation Service in cooperation with the University of Florida, Institute of Food and Agriculture Services, Agricultural Experiment Stations, and Soil Science Department, and with the Florida Department of Agriculture and Consumer Services.

Durbin, D.J. and J.S. Lancaster. 2003. Ecological Assessment of Horse Creek on IMC Phosphates Fort Green Mine. Prepared for: IMC Phosphates, Mulberry, FL. Prepared by: Biological Research Associates.

Environmental Science and Engineering, Inc. (ESE) 1982. Draft Environmental Impact Statement, U.S. Environmental Protection Agency Region IV, Resource Document, Section K, Aquatic Ecology. Gainesville, Florida.

Environmental Science and Engineering, Inc. (ESE) 1986. Water Quality Continuing Monitoring report for 1984-1985. Prepared for AMAX Chemical Corp. Gainesville, Florida.

EPA STORET Database, http://www.epa.gov/storet/dbtop.html, accessed on 11/8/04.

Fraser, T.H. 1991. The Lower Peace River and Horse Creek: Flow and Water Quality Characteristics, 1976-1986. Chapter 9 in *The Rivers of Florida*. R. Livingston (ed.). Springer-Verlag, Inc. New York, New York.

Hammett, K.M. 1990. Land Use, Water Use, Streamflow Characteristics, and Water Quality Characteristics of the Charlotte Harbor Inflow Area, Florida. U.S.Geological Survey. Water-Supply Paper 2359-A. Tallahassee, Florida.

Lancaster, J.S. and D.J. Durbin. 1999. Biological Assessment of the IMC-Agrico Ona Mine. Prepared for: IMC-Agrico Company, Mulberry, FL. Prepared by: Biological Research Associates.

Lewelling, R.R. 1997. Hydrologic and Water Quality Conditions in the Horse Creek Basin, October 1992 – February 1995. U.S. Geological Survey Water-Resources Investigations Report 97-4077. Tallahassee, Florida.

Meyer, S. C. 2002. Investigation of impacts of urbanization on base flow and recharge rates, northeastern Illinois: summary of Year 2 activities. Proceedings of the 12th Annual Illinois Groundwater Consortium Conference. Southern Illinois University, Carbondale, Illinois.

Montgomery, R.T., B.F. McPherson, and E.E. Simmons. 1991. Effects of Nitrogen and Phosphorous Additions on Phytoplankton Productivity and Chlorophyll *A* in a Subtropical Estuary, Charlotte Harbor, Florida. U.S. Geological Survey Water-Resources Investigations Report 91-4077. Tallahassee, FL.

Morgan, P. 2005. Florida Department of Environmental Protection, Tampa, Florida. *Personal communication.*

Palmer, C.E. and F.P. Bone. 1977. Some Aspects of Rainfall Deficits in West-Central Florida, 1961-1976. SWFWMD Hydrometeorological Report No. 1. Brooksville, FL.

Post, Buckley, Schuh, and Jernigan, Inc. (PBSJ) 1999. Summary of Historical Information Relevant to the Hydrobiological Monitoring of the Lower Peace River and the Upper Charlotte Estuarine System. Prepared for Peace Ri ver Manasota Regional Water Supply Authority. Tampa, FL.

Post, Buckley, Schuh, and Jernigan, Inc. (PBSJ) and W. Dexter Bender and Associates, Inc. 1999. Synthesis of Technical Information, Volume 1: A Characterization of Water Quality, Hydrologic Alterations, and Fish and Wildlife Habitat in the Greater Charlotte Harbor Watershed. Technical Report No. 99-02. Prepared for: Charlotte Harbor National Estuary Program.

Robbins, J.M., R.D. Ford, J.T. Werner, and W.D. Cowherd. 1984. Soil Survey of Hardee County, Florida. United States Department of Agriculture In cooperation with University of Florida, Institute of Food and Agriculture Sciences, Agricultural Experiment Stations and Soil Science Department, and Florida Department of Agriculture and Consumer Services.

Rutter, R.P., D.E. Sessions, and D.A. Winkler. 1985. Basin Assessment Lower Peace River, Myakka River, October 1983 – September 1984. Florida Department of Environmental Regulation, South Florida District.

Schertz, T.L., R.B. Alexander, and D.J. Ohe. 1991. The computer program EStimate TREND (ESTREND), a system for the detection of trends in water-quality data:\. U.S. Geological Survey Water-Resources Investigations Report 91-4040. 63 p.

Southwest Florida Water Management District. (SWFWMD) 2001. Peace River Comprehensive Watershed Management Plan, Volume 1, Draft.

Southwest Florida Water Management District. (SWFWMD) 2000. Resource Evaluation of the Horse Creek Project, Draft. Brooksville, Florida.

StatSoft, Inc. (1995). STATISTICA for Windows [Computer program manual]. Tulsa, OK. StatSoft, Inc.

Stoker, Y.E., S.E. Henderson, and B.F. McPherson. 1989. Hydraulic and Salinity Characteristics of the Tidal Reach of the Peace River, Southwestern Florida. U.S. Geological Survey Water-Resources Investigations Report 88-4162. Tallahassee, FL.

Texas Instruments, Inc. 1979. Biological Survey Program for the Proposed DeSoto Site Development. Prepared for: Florida Power and Light Company. Dallas, Texas.

United States Department of Agriculture, Natural Resource Conservation Service. 1977-1991. Detailed soil maps. Represent information found in county level soils atlases. From Southwest Florida Water Management District: http://www.swfwmd.state.fl.us/data/gis/libraries/physical_dense/soils.htm

United States Geological Survey. (USGS) 2004a. Surface Water Data for Florida: Calendar Year Streamflow Statistics. http://nwis.waterdata.usgs.gov/fl/nwis/annual/?site_no=02297310&agency_cd=USGS, accessed on 11/8/04.

United States Geological Survey. (USGS) 2004b. Surface Water Data for Florida: Calendar Year Streamflow Statistics. http://nwis.waterdata.usgs.gov/fl/nwis/annual/?site_no=02297155&agency_cd=USGS, accessed on 1/6/04.

United States Geological Survey. (USGS) 2004c. USGS Peace River Drainage Basin Rainfall DataSummary, 1915-2004. http://www.swfwmd.state.fl.us/data/wmdbweb/files/surf.xls accessed on 11/1/04.

Wade, D., A. Janicki, S. Janicki, and M. Winowitch. 2003. Water Quality Analysis and report for the Charlotte Harbor National Estuary Program. Prepared for the Charlottle Harbor National Estuary Program by Janicki Environmental, St. Petersburg, Florida.

Zar, J. H. 1999. Biostatistical Analysis. 4th ed. Prentice-Hall, Inc. Upper Saddle River, New Jersey.

APPENDICES

Appendix A

Horse Creek Stewardship Program

Original 2003 Methodology Document

Horse Creek
Stewardship Program

Intent

The purpose of this program is two-fold. First, it provides a protocol for the collection of information on physical, chemical and biological characteristics of Horse Creek during IMC Phosphates' (IMC) mining activities in the watershed in order to detect any adverse conditions or significant trends that may occur as a result of mining. Second, it provides mechanisms for corrective action with regard to detrimental changes or trends caused by IMC's' activities, if any are found.

The overall goals of the program are to ensure that IMC Phosphates' mining activities do not interfere with the ability of the Peace River/Manasota Regional Water Supply Authority (Authority) to withdraw water from the Peace River for potable use nor adversely affect Horse Creek, the Peace River or Charlotte Harbor.

There are three basic components to this stewardship program:

- Monitoring and Reporting on Stream Quality,
- Investigating Adverse Conditions or Significant Trends Identified Through Monitoring, and
- Implementing Corrective Action for Adverse Stream Quality Changes Attributable to IMC Activities

An important aspect of this program is that it will not rely solely upon the exceedence of a standard or threshold to bring about further investigation and, where appropriate, corrective action. The presence of a significant temporal trend alone will be sufficient to initiate such steps. This protection mechanism is not present in the vast majority of regulatory scenarios.

The mission of the Authority is to provide a reliable and safe drinking water supply to the citizens of the four counties comprising the Authority, Charlotte, DeSoto, Manatee and Sarasota Counties. The Peace River Facility is a critical component of the Authority's water supply system. The Peace River Facility located in DeSoto County utilizes the Peace River as its supply source.

It is critical for the Authority to protect the Peace River from impacts that would be detrimental to the operation of the Peace River Facility. As a tributary to the Peace River, the Authority's goal for the Horse Creek Stewardship Program is to provide assurance that the quantity and quality of Horse Creek flow as it contributes to the Peace River does not adversely impact the operation of the Peace River Facility.

Program Implementation and Oversight

IMC will implement and fund the Horse Creek Stewardship Program with oversight by the Authority. The Authority will create and coordinate a Technical Advisory Group (TAG) to consist of a representative from each of its members to review and provide input on the program throughout the duration of the monitoring. IMC will create a project-specific quality assurance and quality control (QA/QC) plan for the program detailing all sampling, laboratory procedures, benthic and fish monitoring protocols and data analysis. The QA/QC plan will be consistent with the analogous protocols established in the HydroBiological Monitoring Program (HBMP) for the Lower Peace River/Upper Charlotte Harbor.

Historical, Background and Contemporaneous Data

IMC will compile available data collected by others on water quality, quantity and aquatic biology of Horse Creek. This is expected to include, but is not limited to, information collected by the U.S. Geological Survey (USGS), the Florida Department of Environmental Protection (DEP), the Southwest Florida Water Management District (SWFWMD), the Charlotte Harbor Environmental Center (CHEC). Horse Creek data contained in the U.S. Environmental Protection Agency's (EPA) STORET database will also be obtained. Historic data will be reviewed to provide background information on Horse Creek, and data from ongoing collection efforts will be obtained to supplement that collected by IMC.

Monitoring Period

Water quantity, water quality, macroinvertebrates and fish will be monitored as outlined below during the time that IMC Phosphates is conducting mining and reclamation in the Horse Creek watershed. Monitoring will begin no later than April 2003. In the event of temporary interruptions in mining activities (up to one year), this monitoring will continue during the period of inactivity. Monitoring will cease when mining and reclamation operations are completed in the Horse Creek watershed.

1.0 Surface Water Monitoring Stations

Four locations on Horse Creek will be monitored for physical, chemical and biological parameters:

HCSW-1 - Horse Creek at State Road 64 (USGS Station 02297155)
HCSW-2 - Horse Creek at County Road 663A (Goose Pond Road)
HCSW-3 - Horse Creek at State Road 70
HCSW-4 - Horse Creek at State Road 72 (USGS Station 02297310)

As indicated above by their station ID numbers, HCSW-1 and HCSW-4 are also long-term US Geological Survey (USGS) gaging stations, with essentially continuous stage and discharge records since 1977 and 1950, respectively.

2.0 Water Quantity Monitoring and Analysis

Discharge data will be obtained from the USGS for stations HCSW-1 and HCSW-4 for compilation with other data collected through this monitoring program. If not already present, staff gages will be installed in the stream at HCSW-2 and HCSW-3 and surveyed to NGVD datum. If not already available, stream cross sections will be surveyed at those locations, extending to the approximate limits of the 25-year floodplain. Staff gage readings will be recorded at the time of any sampling efforts at those stations. Data on rainfall will be obtained using IMC's rain gage array (including any additional gages installed in the Horse Creek basin in the future).

Data analysis will focus upon, but not necessarily be limited to, the ongoing relationship between rainfall and streamflow in the Horse Creek watershed. This relationship can be established from data collected early in the monitoring program and used to track the potential effects of mining on streamflow. Analytical approaches are outlined under Water Quality below and such methods will be more fully described in the QA/QC plan to be developed as part of this stewardship program.

3.0 Surface Water Quality Monitoring and Analysis

Water quality data will be obtained monthly at each station where flow is present. Field measurements will be made of temperature, pH, specific conductance, turbidity and dissolved oxygen. Grab samples will be collected and analyzed for:

Nitrate + Nitrite
Total Kjeldahl Nitrogen
Total Nitrogen
Total Ammonia Nitrogen
Ortho Phosphate
Chlorophyll *a*
Calcium
Iron
Color
Total Alkalinity
Chloride
Fluoride
Radium 226 + 228
Sulfate
Mining Reagents (petroleum-based organics, fatty acids, fatty amido amines).

At Station HCSW-1, a continuous monitoring unit will be installed to record temperature, pH, conductivity, dissolved oxygen and turbidity. Because this station is located at a bridge crossing for a highway, the unit will be located some distance (within 100 m) upstream or downstream from the bridge to minimize the likelihood of vandalism. The unit will be permanently installed and its location surveyed. Data will be recorded frequently (at least hourly) and will be downloaded at least monthly. This data will provide for the characterization of natural background fluctuations and may allow for the detection of general water quality changes not observed during the collection of monthly grab samples.

Table 1 presents the analytical schedules and procedures. All sampling will be conducted according to DEP's Standard Operating Procedures (SOP) for field sampling. Laboratory analyses will be performed by experienced personnel according to National Environmental Laboratory Accreditation Council (NELAC) protocols, including quality assurance/quality control considerations. Invertebrate sampling will be conducted by personnel with training and experience in the DEP's SOP for such sampling.

Results will be tabulated to allow for comparisons among stations and sampling events and through time. Results will be compared with available historic data for Horse Creek and its tributaries, and with applicable Florida surface water quality standards. Typical parametric and non-parametric statistics will be used to describe the results. In particular, regression analysis is expected to be employed to examine the relationship between each parameter and time. Both linear and non-linear regression will be considered, depending upon the patterns observed in the data. Since at least some of the parameters can be expected to vary seasonally, use of methods such as the Seasonal Kendall's Tau Test is anticipated. Other potential methods include Locally Weighted Scatterplot Smooth (LOWESS). In addition to trend analyses, annual reports will contain general statistics such as mean, median, standard deviation and coefficient of variance for each numerical parameter. Such general statistics will be calculated on both an annual and seasonal basis. Because the data will be maintained in a standard software format (i.e., MS Excel or MS Access), there will be virtually no logistical limitations on the types of analyses that can be conducted. The only limitations will result from the nature of the data itself (i.e., data quantity, distributions, etc.).

For each parameter, data analysis will focus upon, but not necessarily be limited to, (1) the relationship between measured values and the "trigger values" as presented in Table 1 and (2) temporal patterns in the data which may indicate a statistically significantly trend toward the trigger value. Statistical significance will be based upon $\alpha=0.05$, unless data patterns/trends or other related information indicate that use of another significance level is more appropriate. Since the purpose of this monitoring is to detect trends toward the trigger values, should they be present, trend analyses and other statistical tests will generally focus only upon changes toward the trigger values. This will increase the statistical power for detecting such changes.

At least initially, the term over which trends are analyzed will be dependent upon the data collected to date. As the period of record increases, data analysis can move from a comparison of months, to seasons, to years. As noted above, seasonal patterns will always be considered during data analysis and attention will be given to differentiation between natural seasonal/climatic variation and anthropogenic effects (including mining), where possible. Where historic data exist for a given parameter or station, such data can be evaluated relative to that collected through this effort, although sampling frequency and consistency may not be sufficient to conduct standard trend analysis methods. Analytical methods will be more fully described in the QA/QC plan to be developed as part of this stewardship program.

4.0 Aquatic Macroinvertebrate Sampling and Analysis

Macroinvertebrate sampling will be performed three times annually and, in general, will be conducted concurrently with a monthly water quality sampling event. The first event would occur in March or April, the second event in July or August, and the third event in October or November. Specific months when sampling occurs may change from year to year to avoid very low or very high flows which would impede representative sampling.

In accordance with the DEP Standard Operating Procedures (DEP-SOP-001/01 FS 7000 General Biological Community Sampling), invertebrate sampling will not be conducted ". . . during flood stage or recently dry conditions." This is interpreted here to mean that a given sampling station will not be sampled for macroinvertebrates if (a) water is above the top of the stream bank, or is too deep or fast-moving to sample safely, or (b) if the stream has been dry during the preceding 30 days. In the event either of these situations occurs, the station will be revisited approximately one month later to determine whether sampling is appropriate at that time. If the stream is still in flood, or has again been dry during the preceding 30 days, invertebrate sampling will be postponed until the next season's sampling event. Note that the above situations are expected to be quite rare at the Horse Creek stations, and sampling efforts will generally be planned to avoid such conditions.

Sampling will be conducted at the same four stations on Horse Creek used for flow and water quality monitoring. The aquatic habitats at each station will be characterized, streamside vegetation surveyed, and photostations established. Qualitative macroinvertebrate sampling will be performed according to the Stream Condition Index (SCI) protocol developed by DEP (DEP-SOP-002/01 LT 7200) or subsequently DEP-approved sampling methodology. Consistent with DEP protocols, each invertebrate sample will be processed and taxonomically analyzed. Data from the samples will be used to determine the ecological index values presented in Table 1. Additional indices may also be calculated to further evaluate the invertebrate community. As noted in Table 1, the focus of the analysis will be to screen for statistically significant declining trends with respect to presence, abundance and distribution of native species, as well as SCI values. Results may also be compared with available historic macroinvertebrate data for Horse Creek and its tributaries, or with data from other concurrent collecting efforts in the region, if appropriate. Analysis of invertebrate community characteristics will include consideration of flow conditions, habitat conditions and selected water quality constituents.

Analytical approaches are outlined under Water Quality Monitoring and Analysis section above and such methods will be more fully described in the QA/QC plan to be developed as part of this Horse Creek Stewardship Program.

5.0 Fish Sampling and Analysis

Fish sampling will be conducted three times annually, concurrent with aquatic macroinvertebrate sampling at the same four stations on Horse Creek. Based upon stream morphology, flow conditions and in-stream structure (logs, sand bars, riffles, pools, etc.), several methods of sampling may be used, including seining, dipnetting, and electrofishing. Sample collection will be timed to standardize the sampling efforts among stations and between events.

All fish collected will be identified in the field according to the taxonomic nomenclature in *Common and Scientific Names of Fishes from the United States and Canada* (American Fisheries Society 1991, or subsequent editions). Voucher specimens will be taken of uncommonly encountered species and of individuals that cannot be readily identified in the field; with such specimens being preserved and logged in a reference collection maintained for this monitoring program. All fish will be enumerated and recorded. Total length and weight will be determined and recorded for individuals, however, for seine hauls with very large numbers of fish of the same species (a common occurrence with species like *Gambusia holbrooki, Heterandria formosa* and *Poecilia latipinna*), individuals of the same species may be counted and weighed *en masse*, with only a randomly selected subset (approximately 10 to 20 individuals of each such species) being individually measured for length and weight. Any external anomalies observed on specimens will be recorded.

Taxa richness and abundance and mean catch per unit effort will be determined for each station and each event, and data can be compared among stations and across sampling events. The ecological indices presented in Table 1 will be calculated and additional indices may also be calculated to evaluate the fish community, including similarity indices, species accumulation/rarefaction curves, diversity indices and evenness indices. As noted in Table 1, the focus of the analysis will be to screen for statistically significant declining trends with respect to presence, abundance and distribution of native species. Results may also be compared with available historic fisheries data for Horse Creek and its tributaries, and with data from other concurrent regional collecting efforts, if applicable. Analysis of fish community characteristics will include consideration of flow conditions, habitat conditions and selected water quality constituents.

Analytical approaches are outlined under Water Quality above and such methods will be more fully described in the QA/QC plan to be developed as part of this stewardship program.

6.0 Reporting

All data collected through this monitoring program will be compiled annually (January - December records) and a report will be generated summarizing the results. This report will include narrative, tabular and graphical presentation of the discharge records, surface water quality data, macroinvertebrate and fish sampling results. Results of statistical analyses will also be provided. Discussion will be included comparing across the sampling stations, as well as among seasons and sampling years. Emphasis will be placed upon identifying spatial and/or temporal trends in water quality and/or biological conditions. Where available, data collected from the same stations prior to the initiation of this program will be reviewed and incorporated to allow for longer-term evaluation of Horse Creek. In addition, data available from sampling/monitoring efforts by agencies or other public entities will be reviewed and incorporated, where pertinent. Each report will also provide general information on the location and extent of IMC mining activities in the Horse Creek watershed, as they relate to this monitoring effort. Reports will be submitted to the Authority, as well as to the DEP Bureau of Mine Reclamation (BMR) and Southwest Florida Water Management District (SWFWMD).

In addition to the reporting outlined above, raw data compiled through sampling will be provided to the Authority monthly. This data will be submitted within six (6) weeks of each sampling event (pending the completion of laboratory/taxonomic analyses).

Monitoring Program Evaluation

To ensure this program is providing useful information throughout its tenure, it will be evaluated regularly. Each annual report will include a section devoted to a summary of the immediate and long-term utility of each information type being collected. Recommendations will also be provided in the report regarding possible revisions, additions or deletions to the monitoring program to ensure that it is appropriately focused. Based upon such recommendations, IMC Phosphates will coordinate with the Authority and TAG on a regular basis regarding amendments to the monitoring program. Coordination on this issue may be initiated at any time by either party and will occur at least once every five years, whether or not either party individually requests it.

Protocol for Addressing Potential Problems Identified Through Monitoring

An important element of the monitoring program will be the ongoing analyses of data to detect exceedences of specific trigger values (see Table 1) as well as statistically significant temporal trends toward, but not necessarily in excess of, those values. The analyses will evaluate the data collected through this Horse Creek Stewardship Program, as well as that reported by other entities where appropriate.

Impact Assessment/Characterization

In the event the annual data evaluation identifies trigger value exceedences or statistically significant trends in Horse Creek, IMC will conduct an impact assessment to identify the cause of the adverse trend.

The impact assessment may include more intensive monitoring of water quality in terms of frequency of sampling, laboratory analyses conducted, or locations monitored. In all cases, however, the impact assessment will include supplemental quantitative and qualitative data evaluations and consultation with Authority scientists, as well as perhaps other investigations within the basin (e.g., examination of land use changes, discharge monitoring records reviews of others, water use permit reports of others, etc.).

If the "impact assessment" demonstrates to the satisfaction of IMC and Authority scientists that IMC's activities in the Horse Creek watershed did not cause the exceedence or trend, IMC would support the Authority's efforts to implement actions to reverse or abate the conditions. IMC's support will focus upon scientific solutions where IMC can assist in the abatement of others' problems.

If the impact assessment indicates or suggests that IMC is the cause of the exceedences or trend, then IMC shall take immediate corrective actions. The intensity of such actions would be based upon the potential for ecological harm to the ecology of Horse Creek or the integrity of the potable water supply to the Authority.

Corrective Action Alternatives Evaluation and Implementation

The first step in the corrective action process shall be to prepare quantitative projections of the short-term and long-term impacts of the trigger value exceedence or adverse trends. Quantitative models and other analytical tools will provide IMC and Authority scientists with the analyses necessary to determine: (1) whether the impacts will persist or subside over the long term; (2) the cause(s) of the adverse trend(s) in terms of specific IMC activities that are contributing to the trend(s); and (3) alternative steps that IMC could effectuate to reverse the adverse trend, if needed.

If impact modeling confirms that adverse trends in water quality or a trigger value exceedance is caused by IMC activities in the Horse Creek watershed, IMC shall meet with Authority within 30 days of detection of the adverse trend or trigger exccedence to evaluate alternative solutions developed by IMC. IMC shall begin implementation of its proposed alternative solution selected by the Authority within 30 days and report to Authority as implementation milestones are reached. Throughout the modeling, alternatives assessment, and preferred alternative implementation steps of the corrective action process, more intensive impact assessment monitoring will continue to track the continuation, or the abatement, of the trigger value exceedance or adverse trend. Only when the impact assessment monitoring demonstrated conclusively that the condition has been reversed, with respect to the particular parameter(s) of concern, would IMC reduce its efforts back to the general monitoring and reporting program.

Alternative solutions may include conventional strategies such as the implementation of additional best management practices, raw material substitutions, hydraulic augmentation of wetlands, etc. IMC shall consider "out of the box" solutions (such as discharges of water to result in lower downstream concentrations of a parameter of concern, where the pollutant does not originate from IMC's activities) and emerging principles and technologies for water quantity management, water quality treatment and watershed protection, as well as other innovative solutions recommended by Authority.

Table 1. Parameters, General Monitoring Protocols and Corrective Action Trigger Values for the Horse Creek Stewardship Plan

Pollutant Category	Analytical Parameters	Analytical Method	Reporting Units	Monitoring Frequency	Trigger Level	Basis for Initiating Corrective Action Process
General Physio-chemical Indicators	pH	Calibrated Meter	Std. Units	Monthly	<6.0->8.5	Excursions beyond range or statistically significant trend line predicting excursions from trigger level minimum or maximum.
	Dissolved Oxygen	Calibrated Meter	mg/L[1]	Monthly	<5.0	Excursions below trigger level or statistically significant trend line predicting concentrations below trigger level.
	Turbidity	Calibrated Meter	NTU[2]	Monthly	>29	Exceedance of, or statistically significant trend line predicting concentrations in excess of, trigger level.
	Color	EPA 110-2	PCU	Monthly	<25	Excursions below trigger level or statistically significant trend line predicting concentrations below trigger level.
Nutrients	Total Nitrogen	EPA 351 + 353	mg/L	Monthly	>3.0	Exceedance of, or statistically significant trend line predicting concentrations in excess of, trigger level.
	Total Ammonia	EPA 350.1	mg/L	Monthly	>0.3	Exceedance of, or statistically significant trend line predicting concentrations in excess of, trigger level.
	Ortho Phosphate	EPA 365	mg/L	Monthly	>2.5	Exceedance of, or statistically significant trend line predicting concentrations in excess of, trigger level.
	Chlorophyll *a*	EPA 445	mg/L	Monthly	>15	Exceedance of, or statistically significant trend line predicting concentrations in excess of, trigger level.
Dissolved Minerals	Specific Conductance	Calibrated Meter	µs/cm[3]	Monthly	>1,275	Exceedance of, or statistically significant trend line predicting concentrations in excess of, trigger level.
	Total Alkalinity	EPA 310.1	mg/L	Monthly	>100	Exceedance of, or statistically significant trend line predicting concentrations in excess of, trigger level.
	Calcium	EPA 200.7	mg/L	Monthly	>100	Exceedance of, or statistically significant trend line predicting concentrations in excess of, trigger level.
	Iron	EPA 200.7	mg/L	Monthly	>0.3 [6]; >1.0[7]	Exceedance of, or statistically significant trend line predicting concentrations in excess of, trigger level.
	Chloride	EPA 325	mg/L	Monthly	>250	Exceedance of, or statistically significant trend line predicting concentrations in excess of, trigger level.
	Fluoride	EPA 300	mg/L	Monthly	>1.5[6]; >4[7]	Exceedance of, or statistically significant trend line predicting concentrations in excess of, trigger level.
	Radium 226+228	EPA 903	pCi/L[4]	Quarterly	>5	Exceedance of, or statistically significant trend line predicting concentrations in excess of, trigger level.
	Sulfate	EPA 375	Mg/L	Monthly	>250	Exceedance of, or statistically significant trend line predicting concentrations in excess of, trigger level.
	Total Dissolved Solids	EPA 160	Mg/L	Monthly	>500	Exceedance of, or statistically significant trend line predicting concentrations in excess of, trigger level.
Mining Reagents	Petroleum Range Organics	EPA 8015 (FL-PRO)	mg/L	Monthly[5]	>5.0	Exceedance of, or statistically significant trend line predicting concentrations in excess of, trigger level.
	Total fatty acids, including Oleic, Linoleic, and Linolenic acid.	EPA/600/4-91/002	mg/L	Monthly[5]	>NOEL	Statistically significant trend line predicting concentrations in excess of the No Observed Effects Level (NOEL to be determined through standard toxicity testing with IMC reagents early in monitoring program, NOEL to be expressed as a concentration – e.g., mg/L)
	Fatty amido-amines	EPA/600/4-91-002	mg/L	Monthly[5]	>NOEL	Statistically significant upward trend line predicting concentrations in excess of No Observed Effects Level (NOEL to be determined through standard toxicity testing with IMC reagents early in monitoring program, NOEL to be expressed as a concentration – e.g., mg/L)
Biological Indices: Macroinvertebrates	Total Number of Taxa	Stream Condition Index (SCI) sampling protocol, taxonomic analysis, calculation of indices according to SOP-002/01 LT 7200 Stream Condition Index (SCI) Determination	Units vary based upon metric or index	3 times per year	N/A	Statistically significant declining trend with respect to SCI values, as well as presence, abundance or distribution of native species
	Abundance					
	Percent Diptera					
	Number of Chironomid Taxa					
	Shannon Weaver Diversity[a]					
	Florida Index					
	EPT Index					
	Percent Contribution of Dominant Taxon					
	Percent Suspension Feeders/Filterers					
Biological Indices: Fish	Total Number of Taxa	Various appropriate standard sampling methods, taxonomic analysis, calculation of indices using published formulas	Units vary based upon metric or index	3 times per year	N/A	Statistically significant declining trend with respect to presence, abundance or distribution of native species
	Abundance					
	Shannon-Weaver Diversity[a]					
	Species Turnover (Morisita Similarity Index[a]					
	Rarefaction/Species Accumulation Curves[b]					

Notes:

(1) Milligrams per liter.
(2) Nephelometric turbidity units.
(3) Microsiemens per centimeter.
(4) PicoCuries per liter.
(5) If reagents are not detected after two years, sampling frequency will be reduced to quarterly - if subsequent data indicate the presence of reagents, monthly sampling will be resumed.
(6) At Station HC SW-4 only, recognizing that existing levels during low-flow conditions exceed the trigger level.
(7) At Stations HC SW-1, HC SW-2, and HC SW-3.

References:

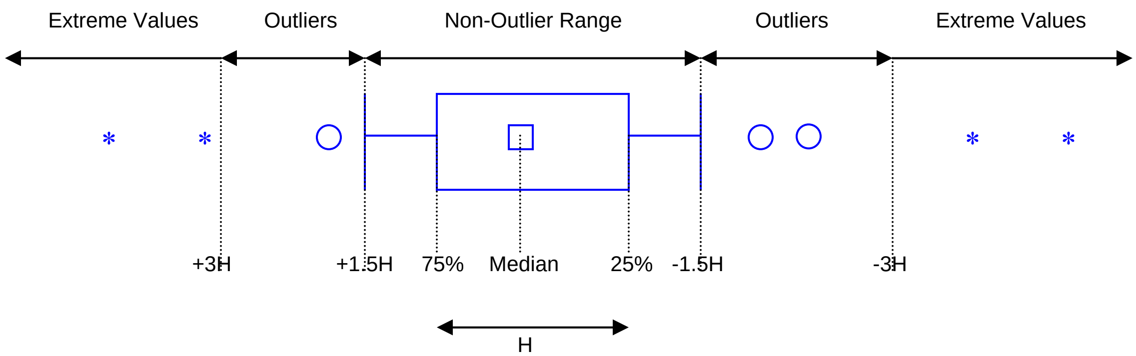
(a) Brower, J. E., Zar, J. H., von Ende, C. N. Field and Laboratory Methods for General Ecology. 3rd Edition. Wm. C. Brown Co., Dubuque, IA. pp. 237; 1990
(b) Gotelli, N.J., and G.R. Graves. 1996. Null Models in Ecology. Smithsonian Institution Press, Washington, DC.

Appendix B

Water Quality Annual Median Boxplots for Horse Creek Stations at SR 663, SR 665, SR 70 and SR 761

All available historical water quality data from 1972 – 2002 collected from USGS, FDEP, SWFWMD, and PRMRWSA EQL is presented in box-and-whisker plots. Plots are arranged alphabetically by parameter, with the six Horse Creek stations (if available) arranged from north to south. The station plots for each parameter are arranged like the following: (top row, l-r) Horse Creek at SR 64 (Myakka Head), SR 663, SR 665, (bottom row, l-r) Horse Creek at SR 70, SR 72 (Arcadia), and SR 761. Data is plotted from all sources available at each site (Table #). Box-and-whisker plots with extreme outliers are on the page following the parameter graphs at the common scale.

Water quality data for Horse Creek is represented by box and whisker plots. In median box-and-whisker plots, the small center square is the median of the distribution, and the large box is bounded by the 25% (mean – standard error) and 75% (mean + standard error) quartiles of the distribution. The length of the large box is designated H, and the "whiskers" represent the range of values between the box limits and 1.5H above and below the box limits. Outside the whiskers lie outliers and extreme values. Outliers are values that lie between 1.5H and 3H from the box limits, and extreme values lie beyond 3H from the box limits (StatSoft, Inc 1995).



Section 1: Annual Median Boxplots of Water Quality Parameters Collected by FDEP in Horse Creek at SR 663 From 1972 to 1990.

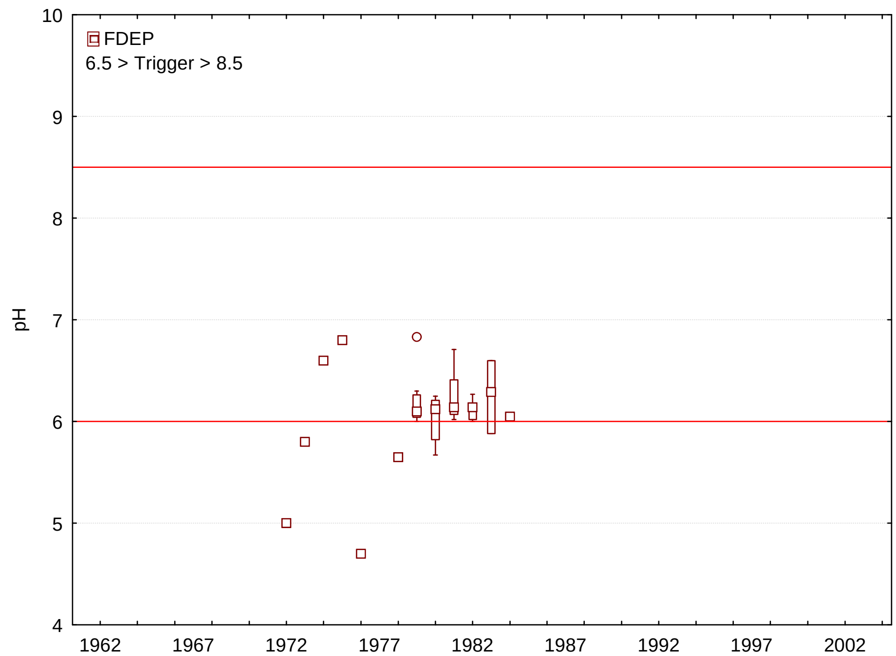


Figure B1-1. Annual Median Boxplots of pH Collected by FDEP in Horse Creek at SR 663 From 1972 to 1990.

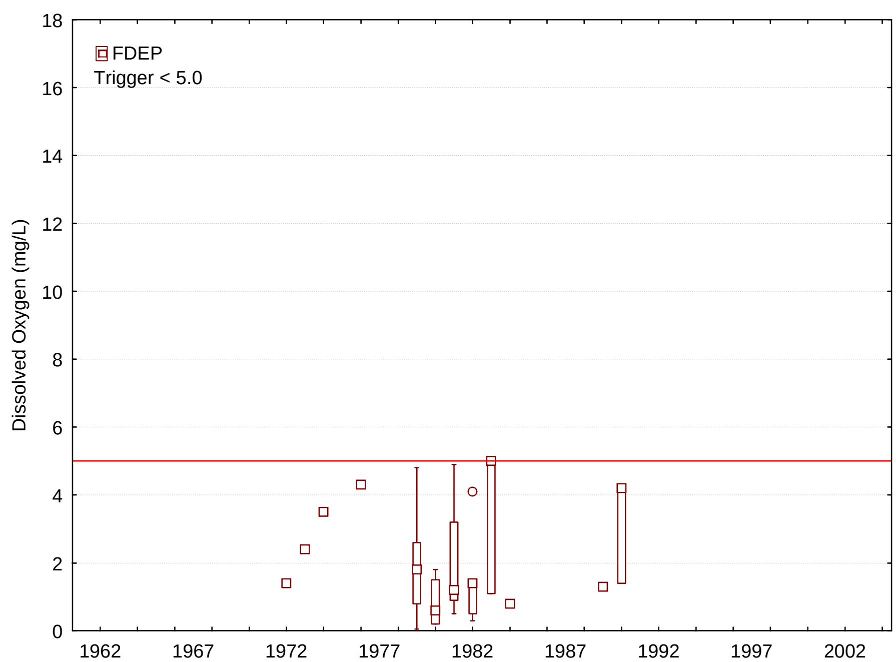


Figure B1-2. Annual Median Boxplots of Dissolved Oxygen Concentrations Collected by FDEP in Horse Creek at SR 663 From 1972 to 1990.

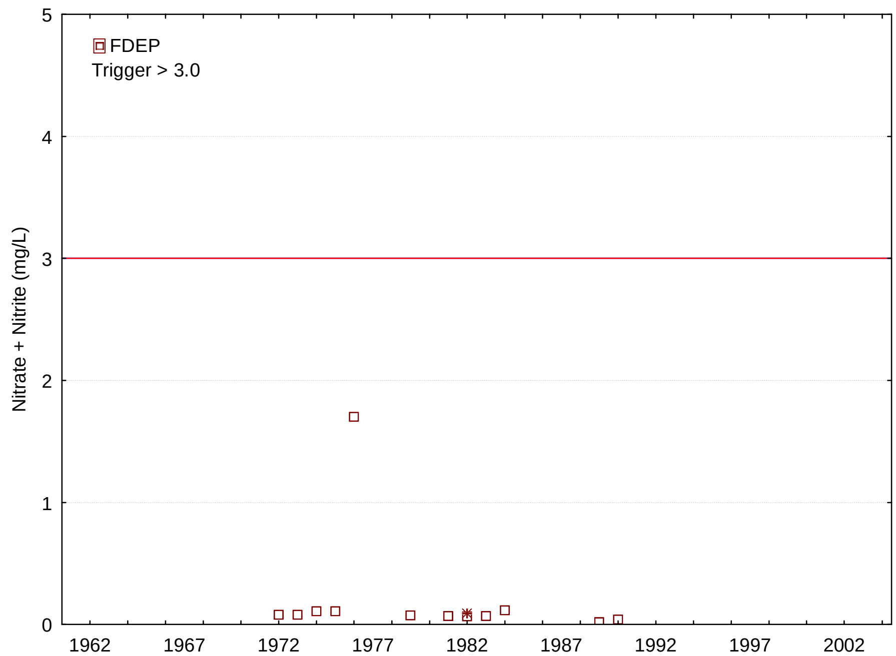


Figure B1-3. Annual Median Boxplots of Nitrate Plus Nitrite Concentrations Collected by FDEP in Horse Creek at SR 663 From 1972 to 1990.

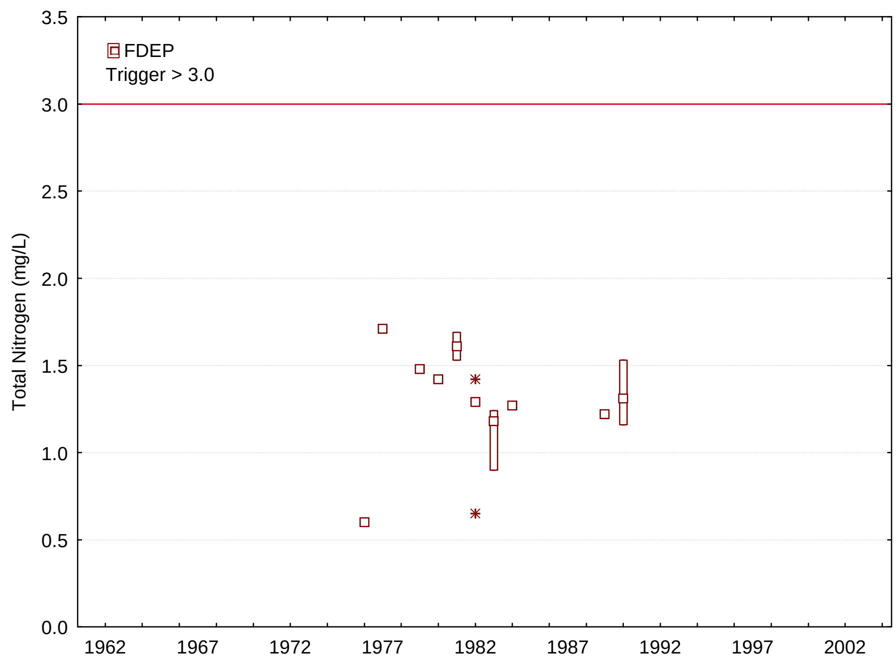


Figure B1-4. Annual Median Boxplots of Total Nitrogen Concentrations Collected by FDEP in Horse Creek at SR 663 From 1972 to 1990.

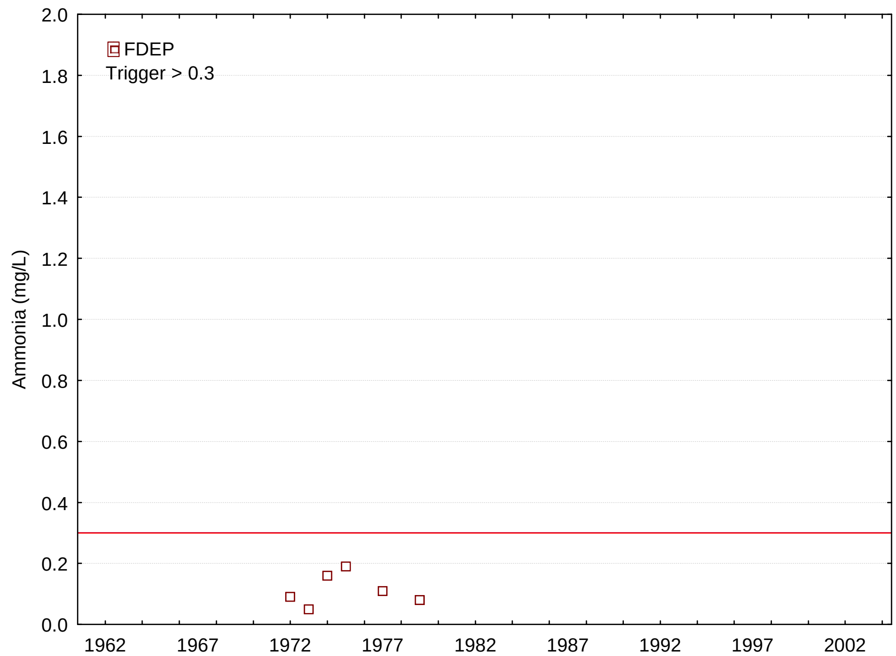


Figure B1-5. Annual Median Boxplots of Ammonia Concentrations Collected by FDEP in Horse Creek at SR 663 From 1972 to 1990.

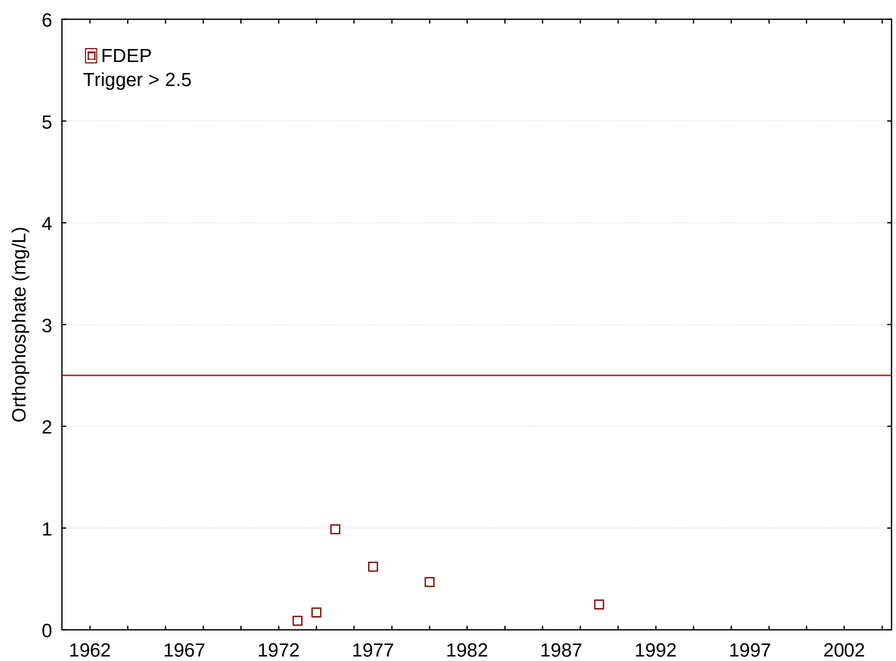


Figure B1-6. Annual Median Boxplots of Orthophosphate Concentrations Collected by FDEP in Horse Creek at SR 663 From 1972 to 1990.

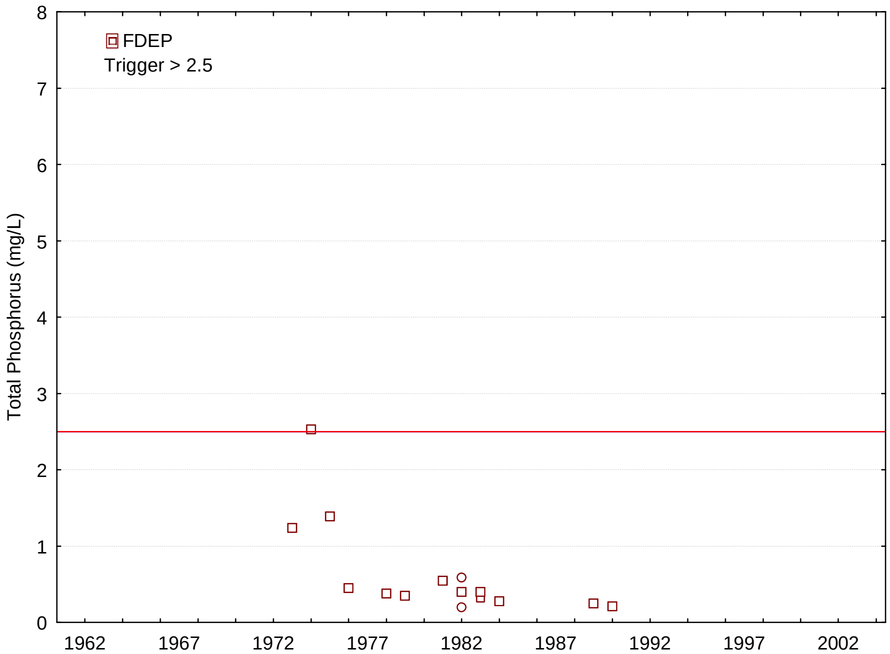


Figure B1-7. Annual Median Boxplots of Total Phosphorus Concentrations Collected by FDEP in Horse Creek at SR 663 From 1972 to 1990.

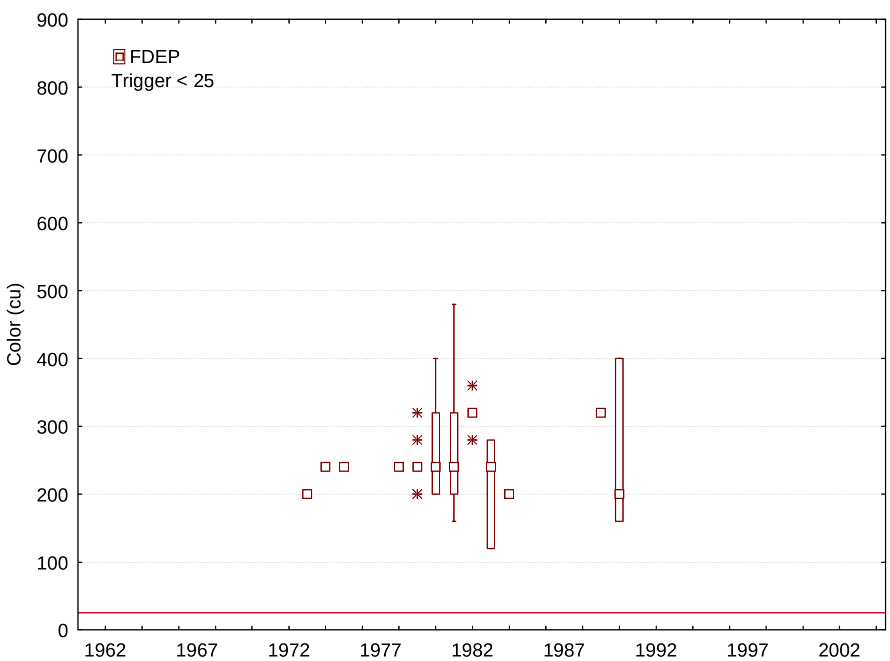


Figure B1-8. Annual Median Boxplots of Color Collected by FDEP in Horse Creek at SR 663 From 1972 to 1990.

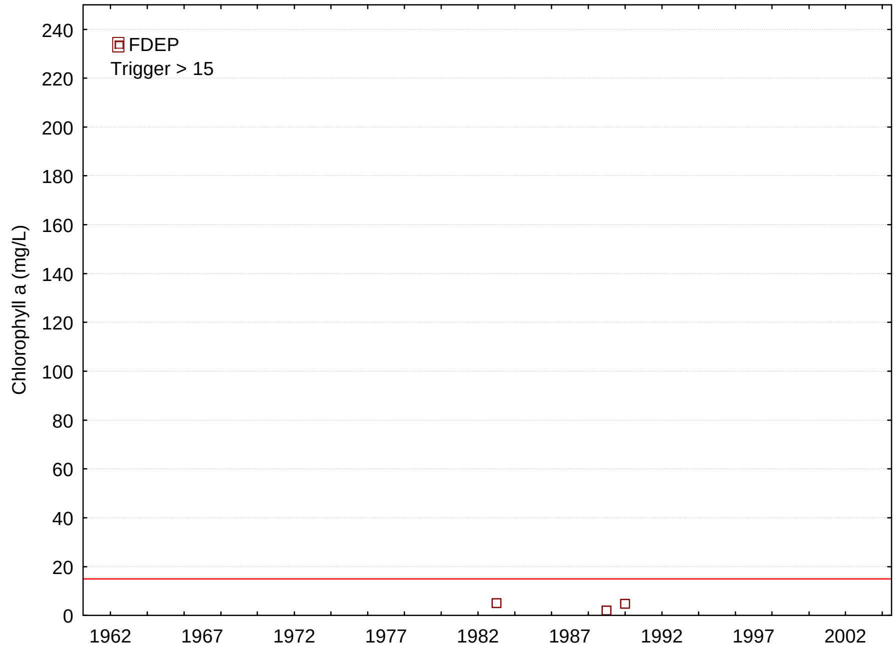


Figure B1-9. Annual Median Boxplots of Chlorophyll-a Concentrations Collected by FDEP in Horse Creek at SR 663 From 1972 to 1990.

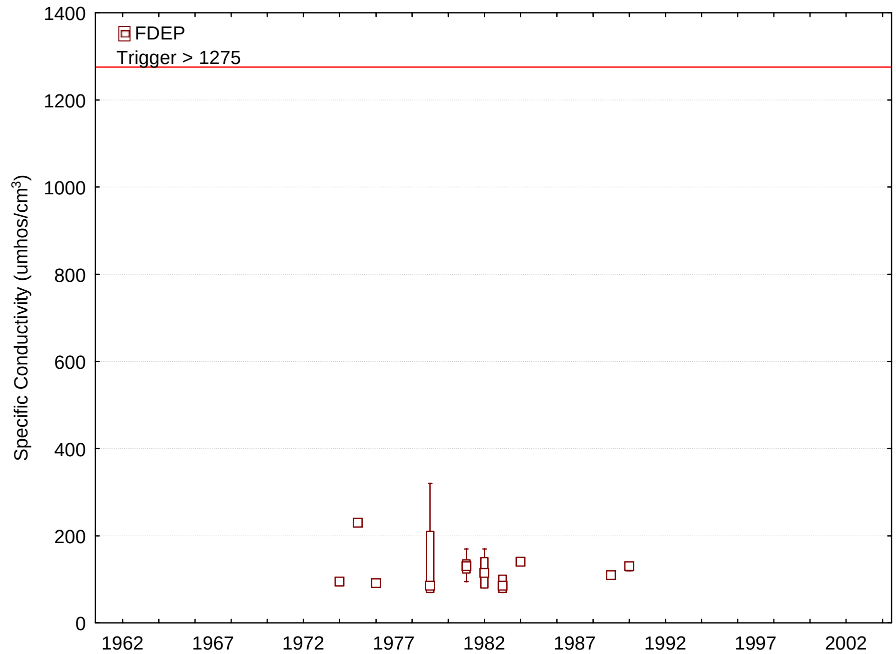


Figure B1-10. Annual Median Boxplots of Specific Conductivity Collected by FDEP in Horse Creek at SR 663 From 1972 to 1990.

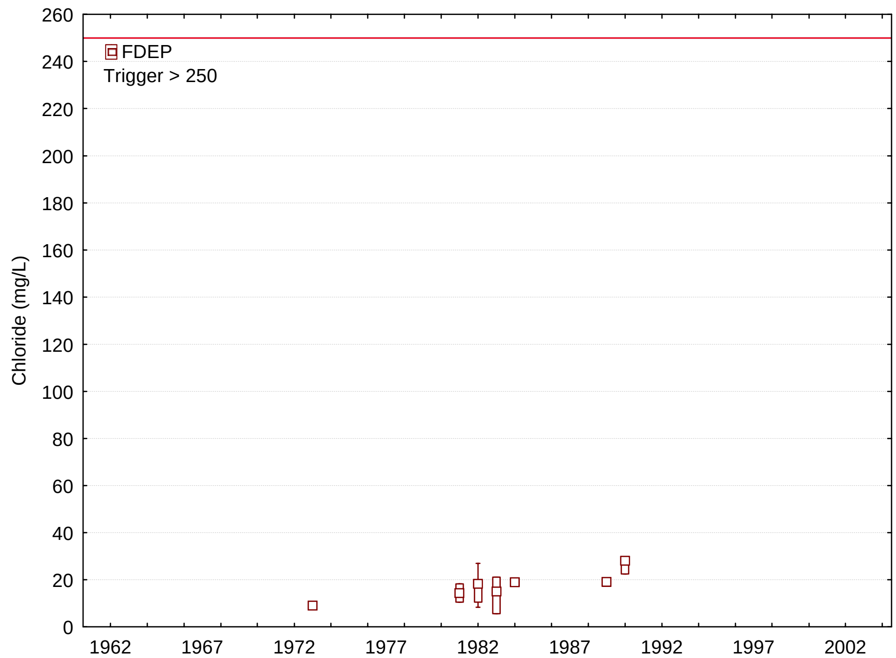


Figure B1-11. Annual Median Boxplots of Chloride Concentrations Collected by FDEP in Horse Creek at SR 663 From 1972 to 1990.

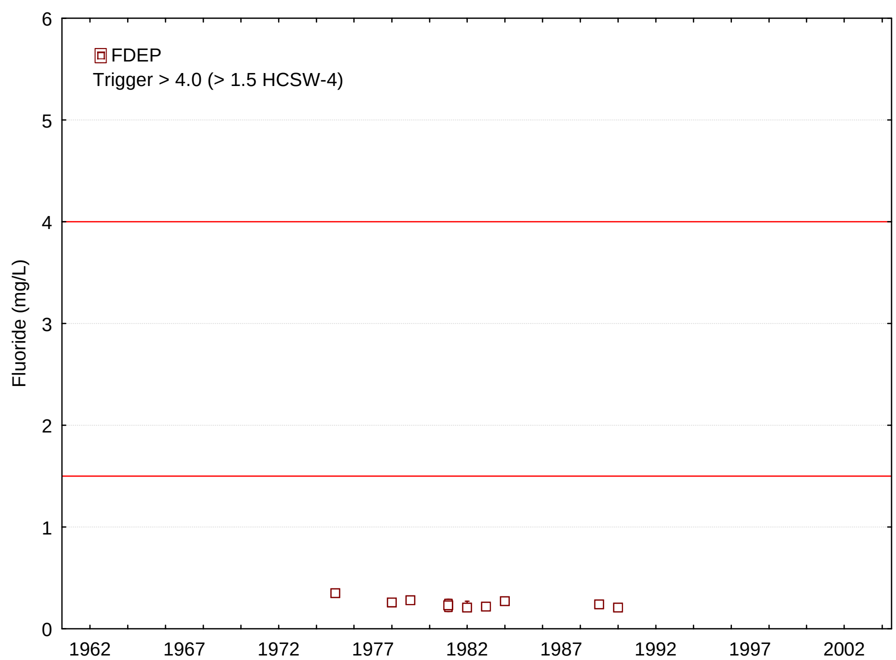


Figure B1-12. Annual Median Boxplots of Fluoride Concentrations Collected by FDEP in Horse Creek at SR 663 From 1972 to 1990.

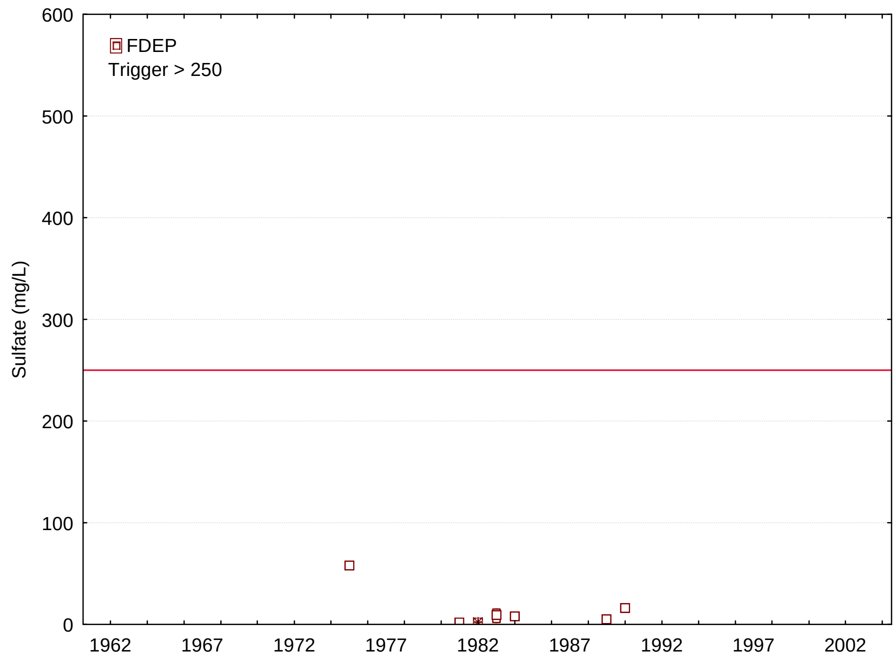


Figure B1-13. Annual Median Boxplots of Sulfate Concentrations Collected by FDEP in Horse Creek at SR 663 From 1972 to 1990.

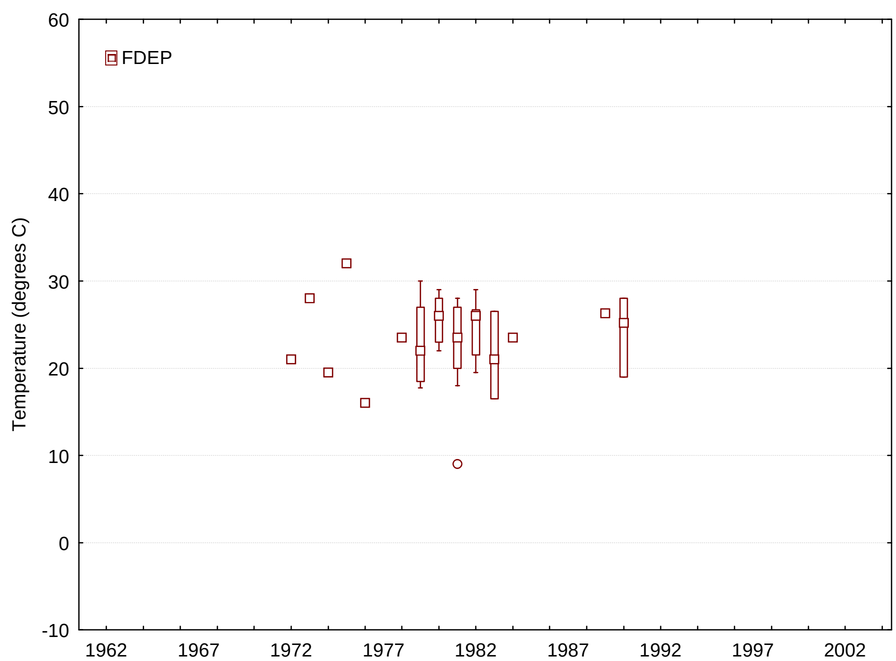


Figure B1-14. Annual Median Boxplots of Water Temperature Collected by FDEP in Horse Creek at SR 663 From 1972 to 1990.

Section 2: Annual Median Boxplots of Water Quality Parameters Collected by FDEP in Horse Creek at SR 665 From 1972 to 1990.

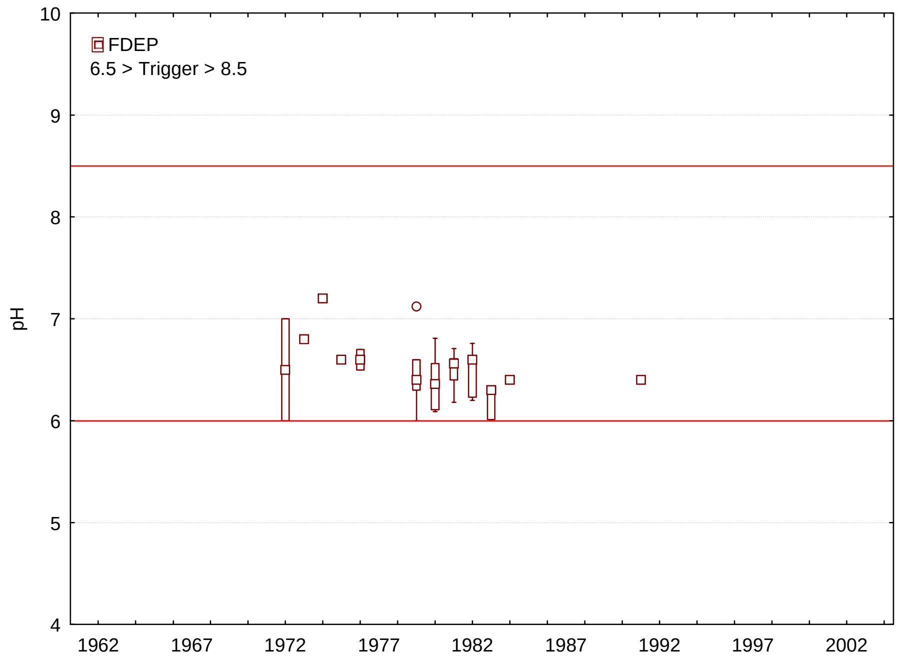


Figure B2-1. Annual Median Boxplots of pH Collected by FDEP in Horse Creek at SR 70 From 1972 to 1991.

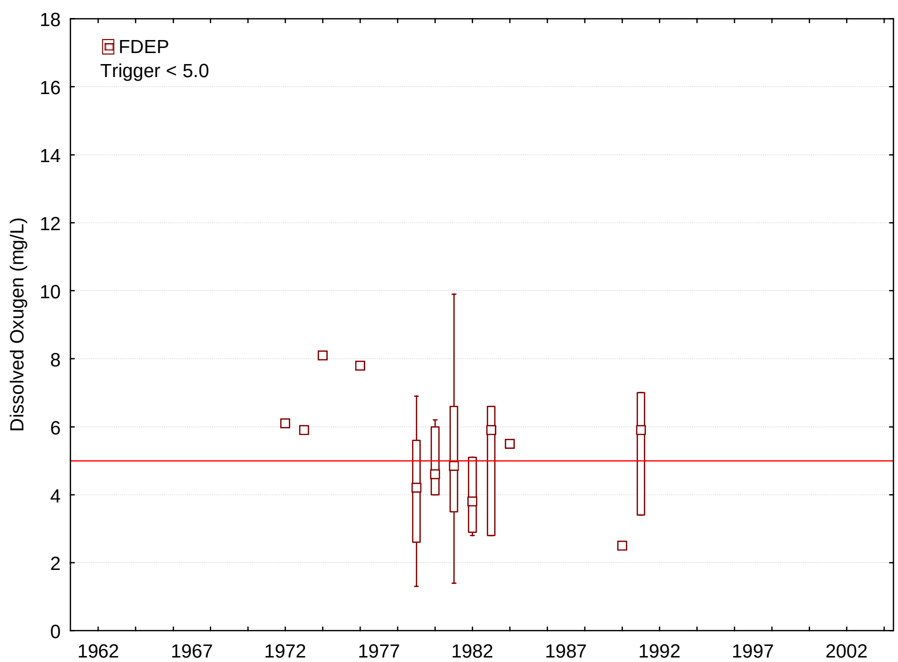


Figure B2-2. Annual Median Boxplots of Dissolved Oxygen Concentrations Collected by FDEP in Horse Creek at SR 70 From 1972 to 1991.

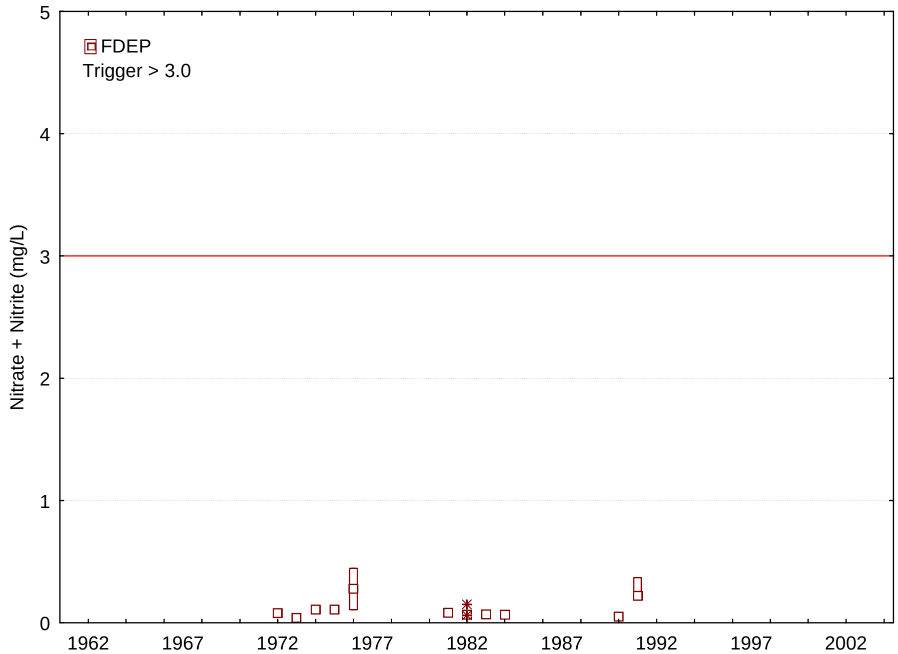


Figure B2-3. Annual Median Boxplots of Nitrate Plus Nitrite Concentrations Collected by FDEP in Horse Creek at SR 70 From 1972 to 1991.

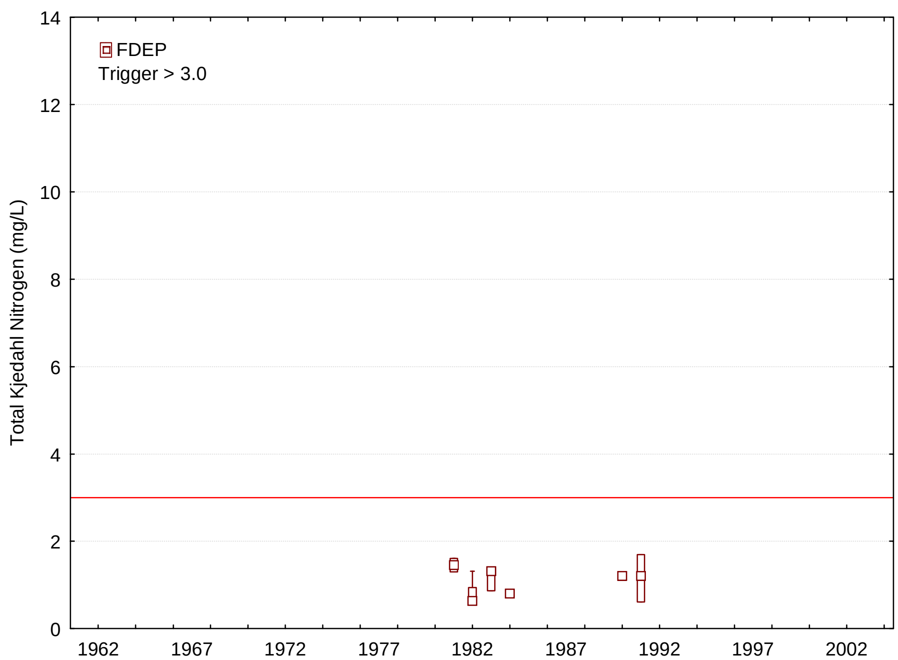


Figure B2-4. Annual Median Boxplots of Total Kjedahl Nitrogen Concentrations Collected by FDEP in Horse Creek at SR 70 From 1972 to 1991.

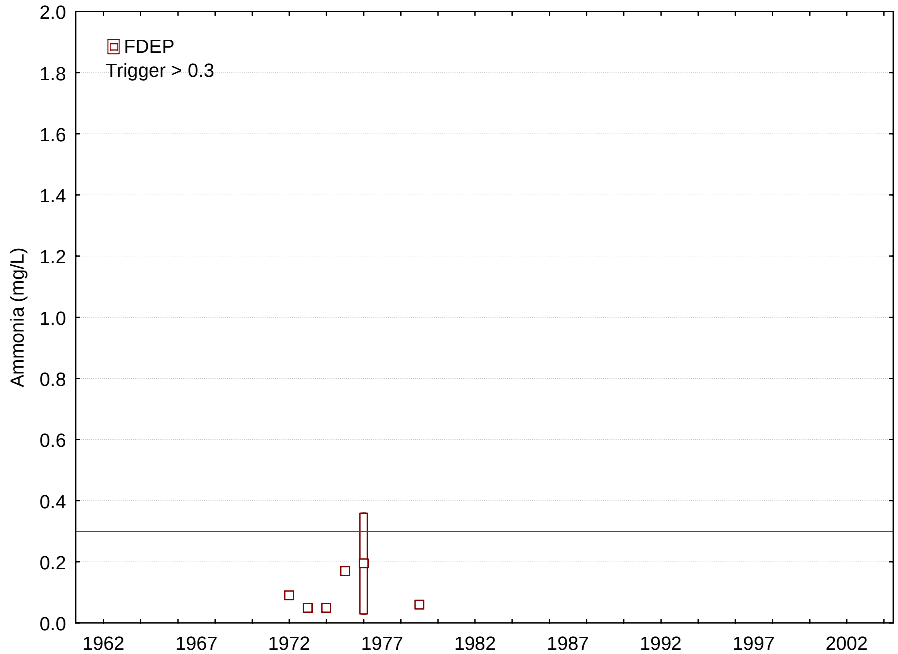


Figure B2-5. Annual Median Boxplots of Ammonia Concentrations Collected by FDEP in Horse Creek at SR 70 From 1972 to 1991.

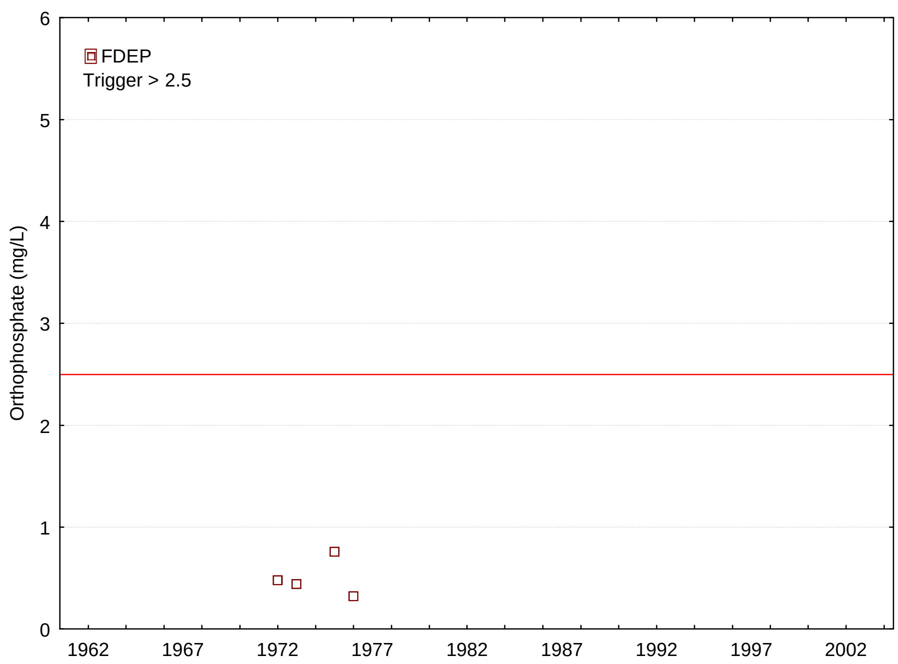


Figure B2-6. Annual Median Boxplots of Orthophosphate Concentrations Collected by FDEP in Horse Creek at SR 70 From 1972 to 1991.

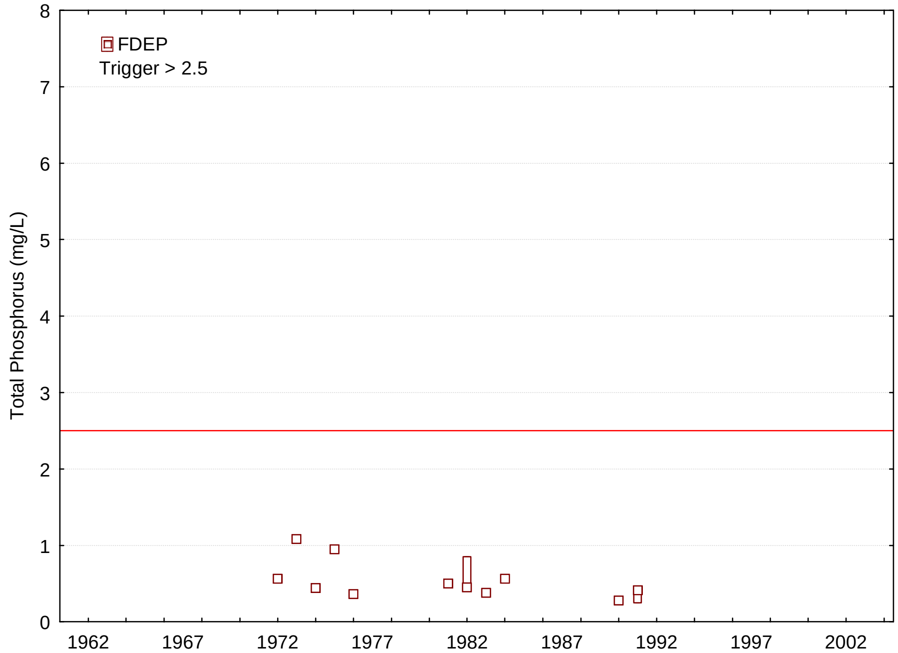


Figure B2-7. Annual Median Boxplots of Total Phosphorus Concentrations Collected by FDEP in Horse Creek at SR 70 From 1972 to 1991.

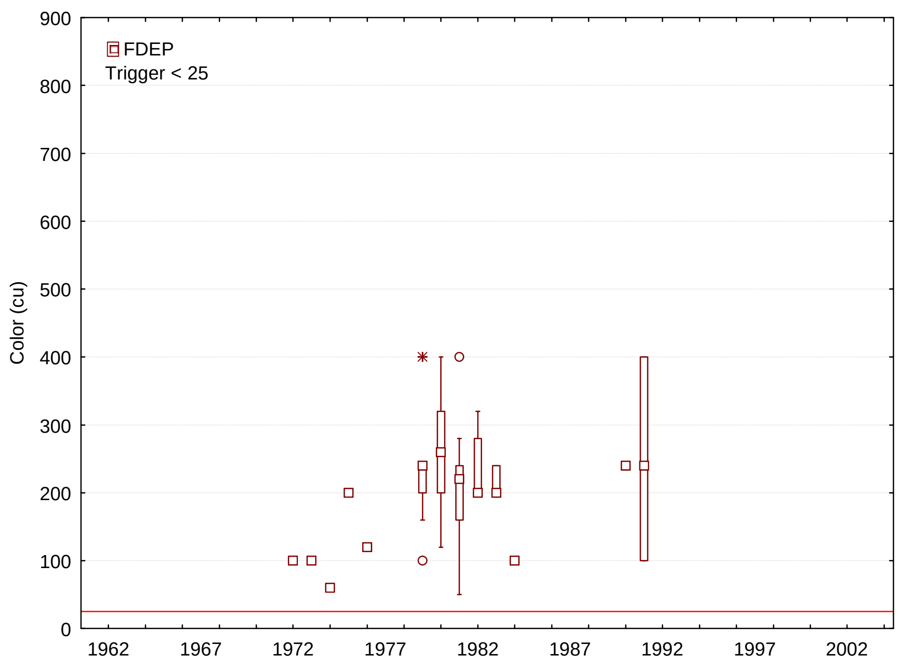


Figure B2-8. Annual Median Boxplots of Color Collected by FDEP in Horse Creek at SR 70 From 1972 to 1991.

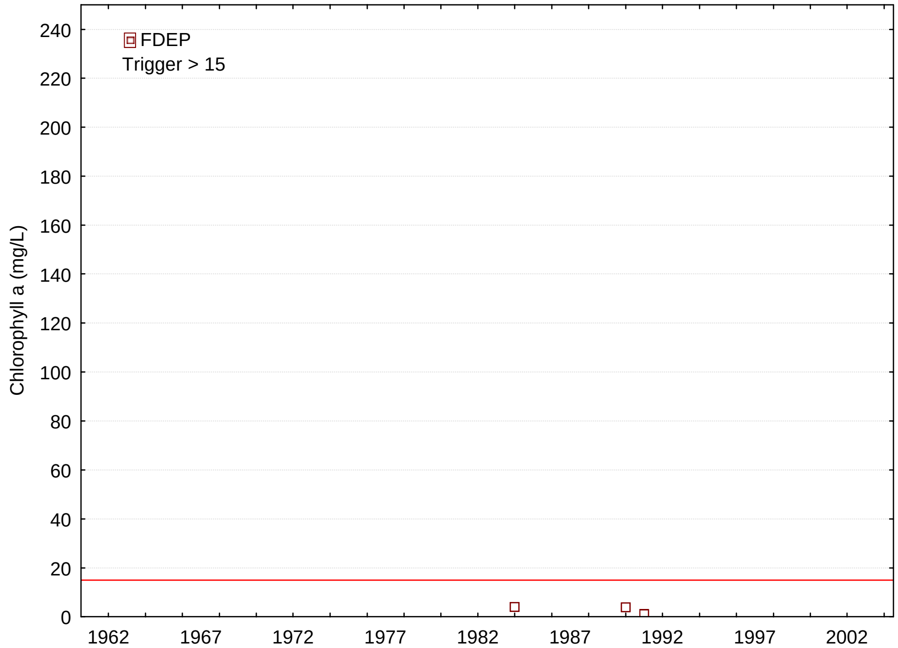


Figure B2-9. Annual Median Boxplots of Chlorophyll-a Concentrations Collected by FDEP in Horse Creek at SR 70 From 1972 to 1991.

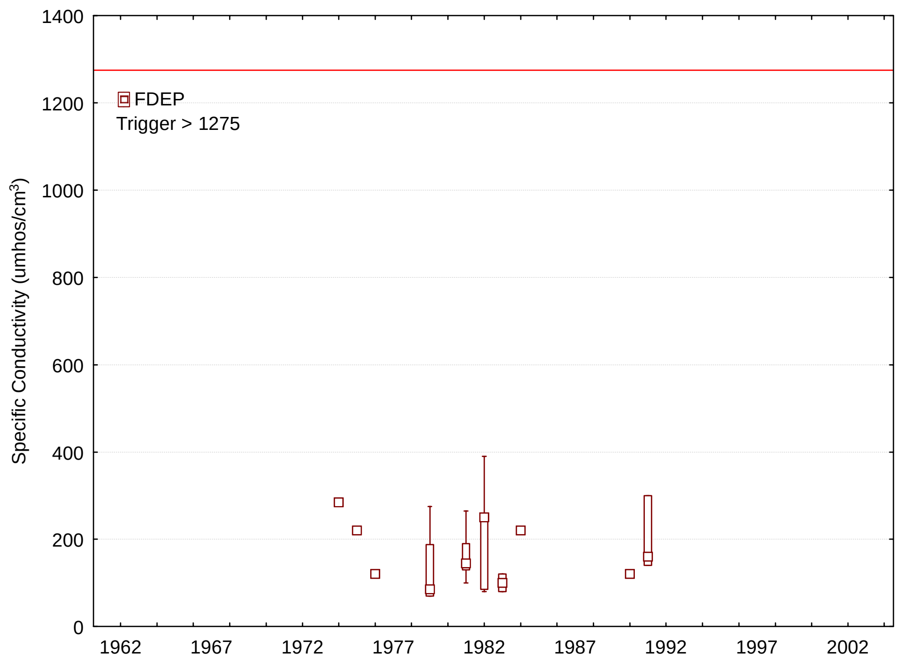


Figure B2-10. Annual Median Boxplots of Specific Conductivity Collected by FDEP in Horse Creek at SR 70 From 1972 to 1991.

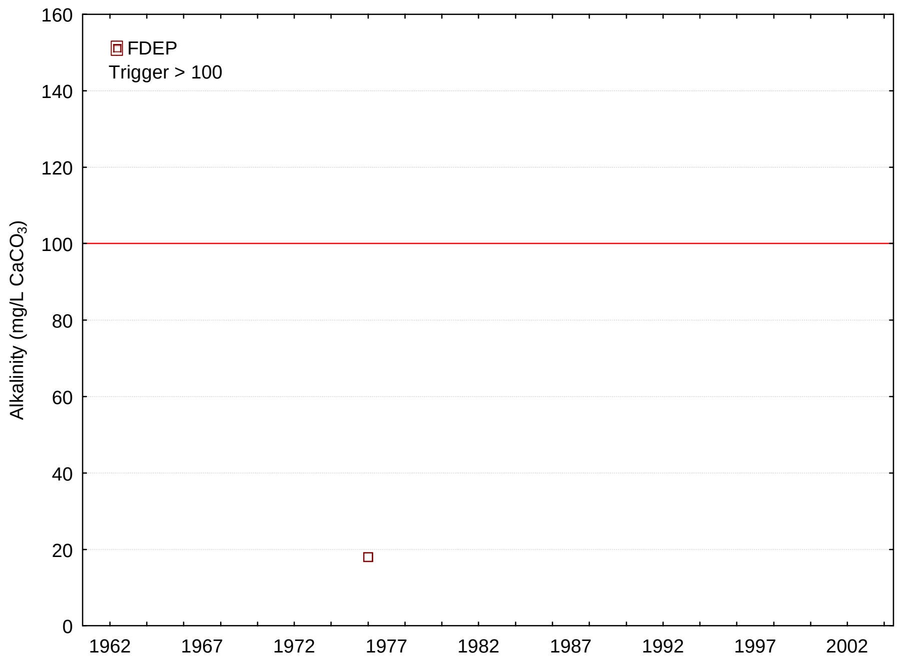


Figure B2-11. Annual Median Boxplots of Alkalinity Collected by FDEP in Horse Creek at SR 70 From 1972 to 1991.

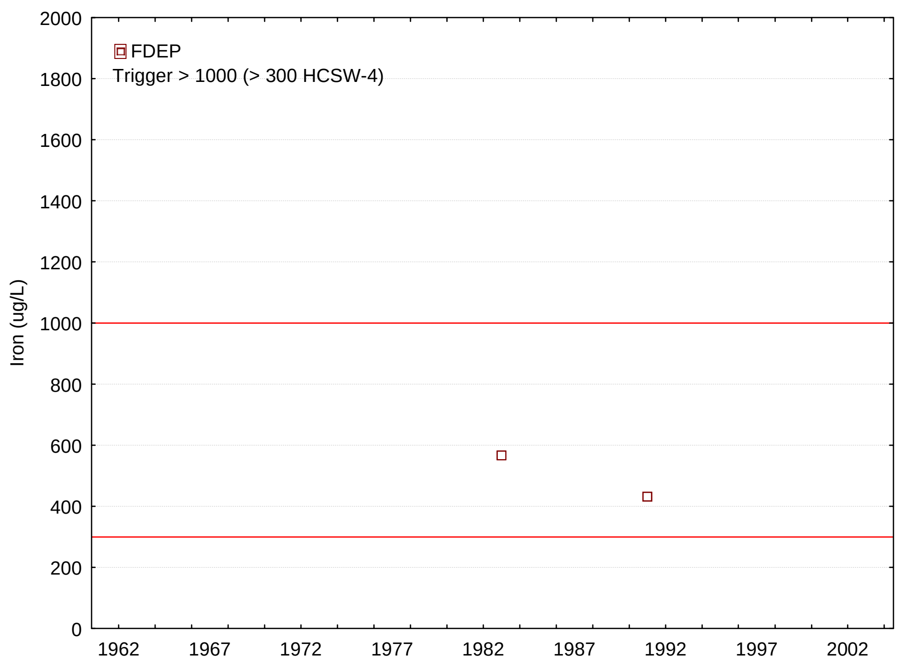


Figure B2-12. Annual Median Boxplots of Iron Concentrations Collected by FDEP in Horse Creek at SR 70 From 1972 to 1991.

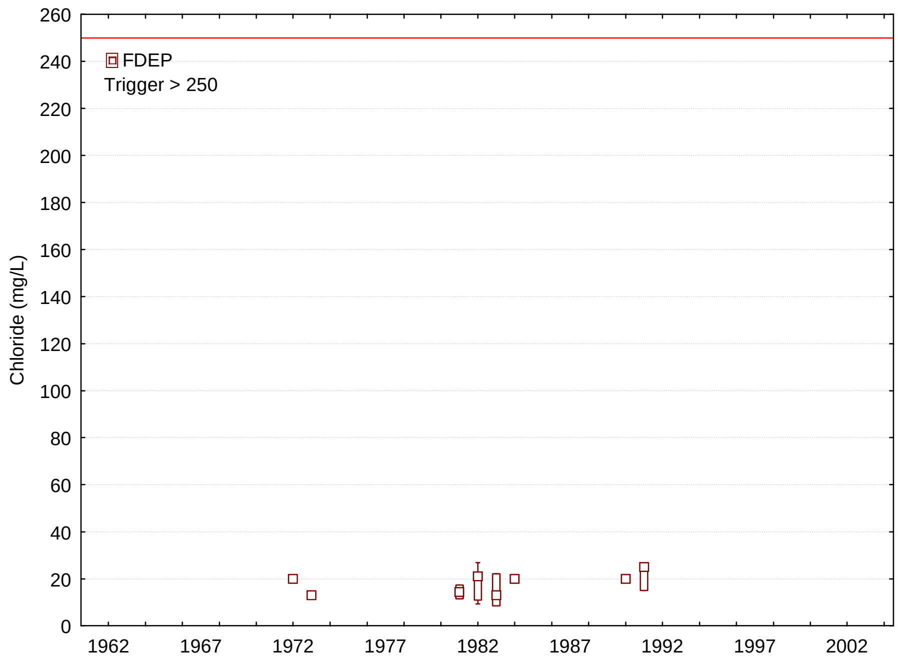


Figure B2-13. Annual Median Boxplots of Chloride Concentrations Collected by FDEP in Horse Creek at SR 70 From 1972 to 1991.

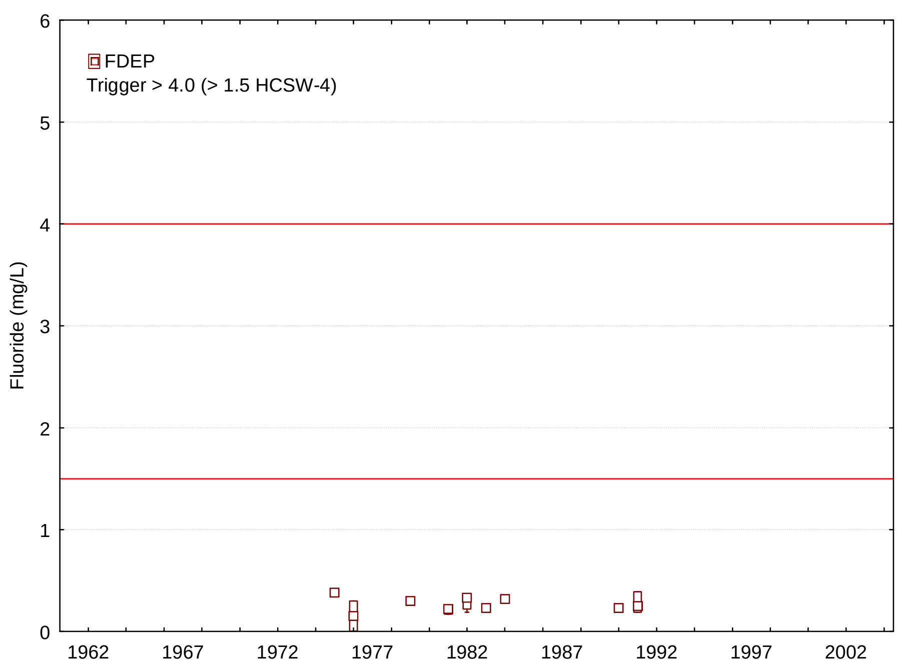


Figure B2-14. Annual Median Boxplots of Fluoride Concentrations Collected by FDEP in Horse Creek at SR 70 From 1972 to 1991.

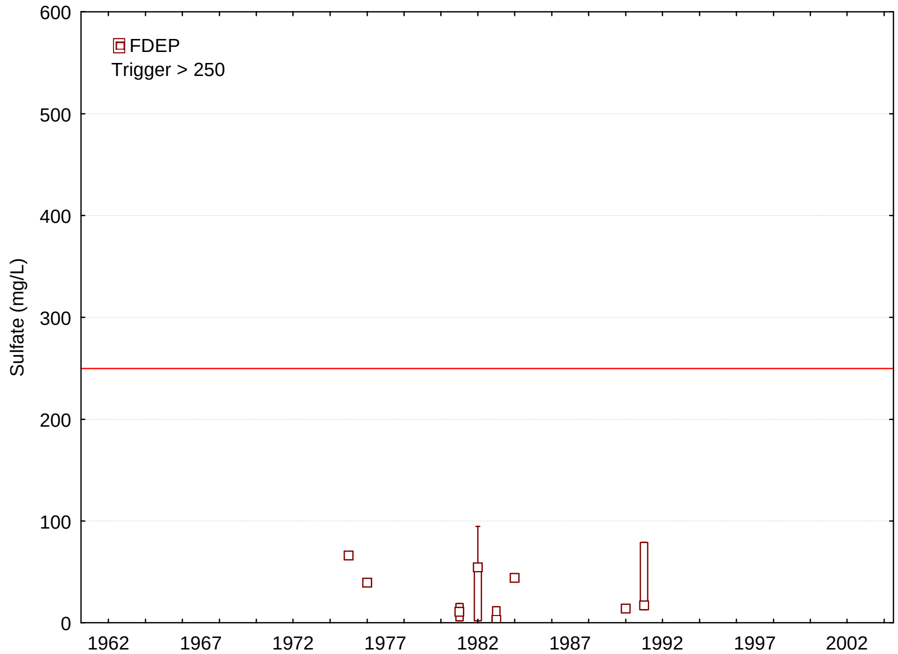


Figure B2-15. Annual Median Boxplots of Sulfate Concentrations Collected by FDEP in Horse Creek at SR 70 From 1972 to 1991.

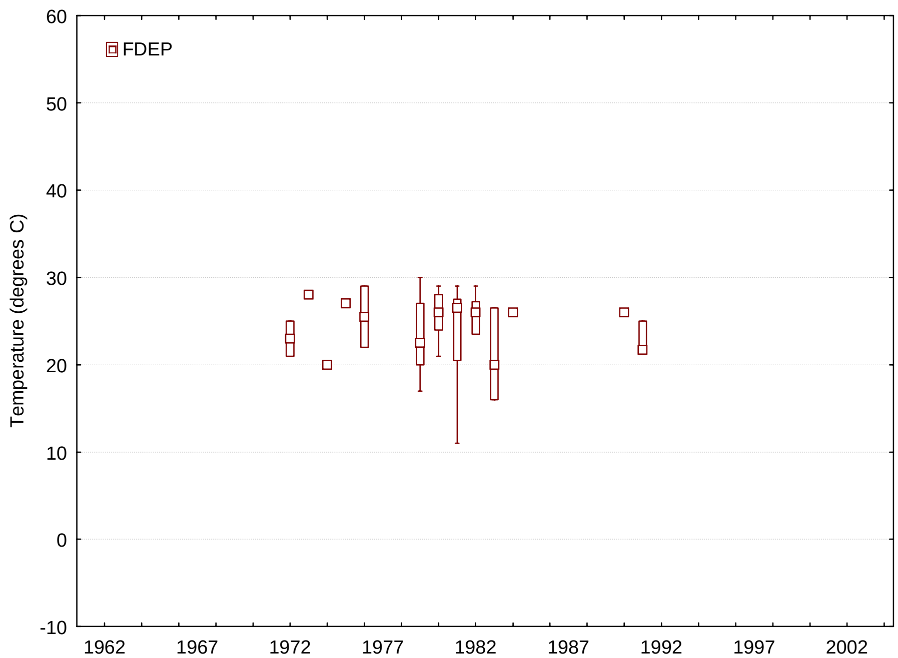


Figure B2-16. Annual Median Boxplots of Water Temperature Collected by FDEP in Horse Creek at SR 70 From 1972 to 1991.

Section 3: Annual Median Boxplots of Water Quality Parameters Collected by FDEP in Horse Creek at SR 70 From 1972 to 1991.

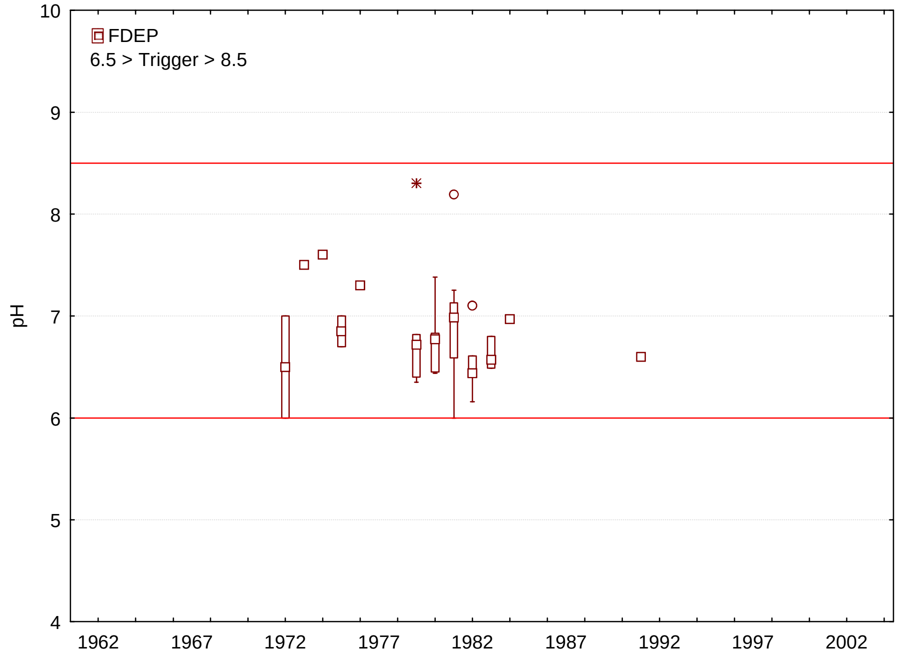


Figure B3-1. Annual Median Boxplots of pH Collected by FDEP in Horse Creek at SR 70 From 1972 to 1991.

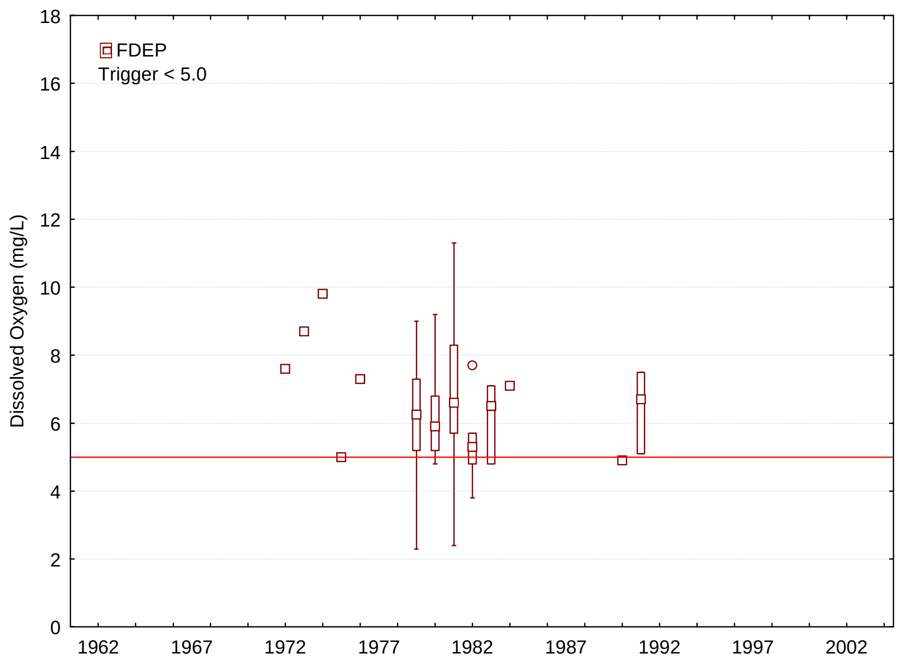


Figure B3-2. Annual Median Boxplots of Dissolved Oxygen Concentrations Collected by FDEP in Horse Creek at SR 70 From 1972 to 1991.

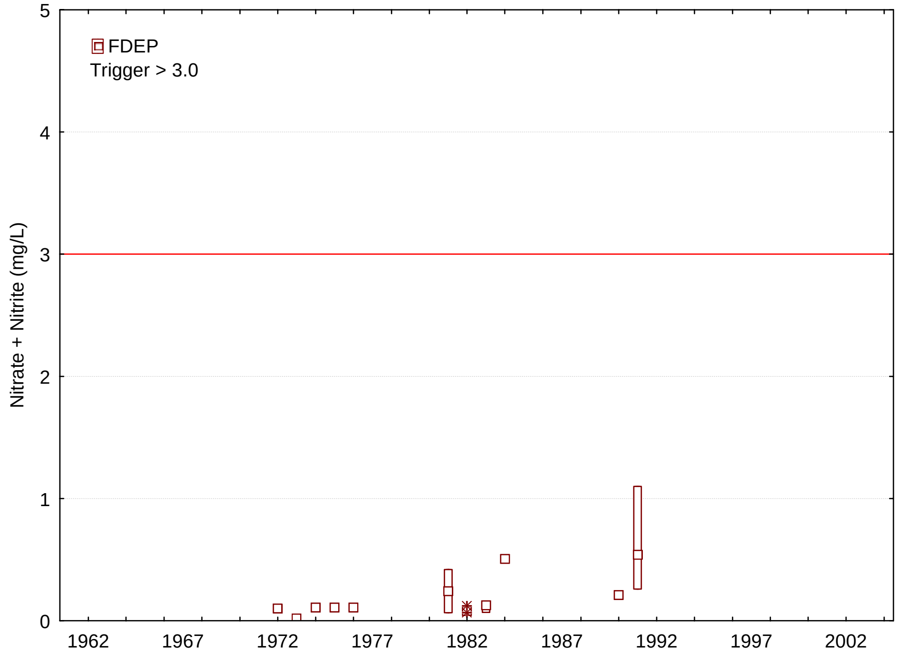


Figure B3-3. Annual Median Boxplots of Nitrate Plus Nitrite Concentrations Collected by FDEP in Horse Creek at SR 70 From 1972 to 1991.

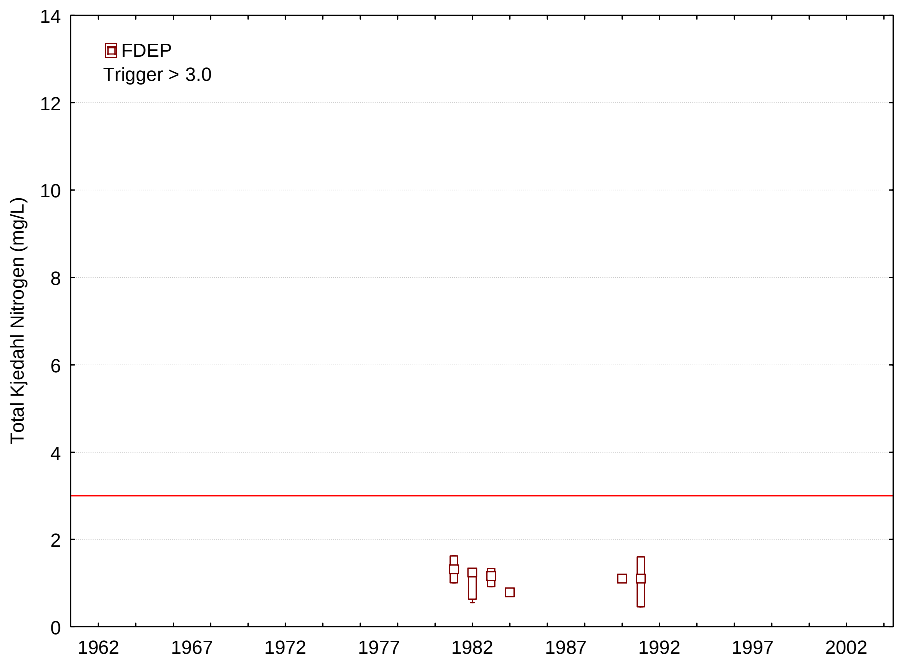


Figure B3-4. Annual Median Boxplots of Total Kjedahl Nitrogen Concentrations Collected by FDEP in Horse Creek at SR 70 From 1972 to 1991.

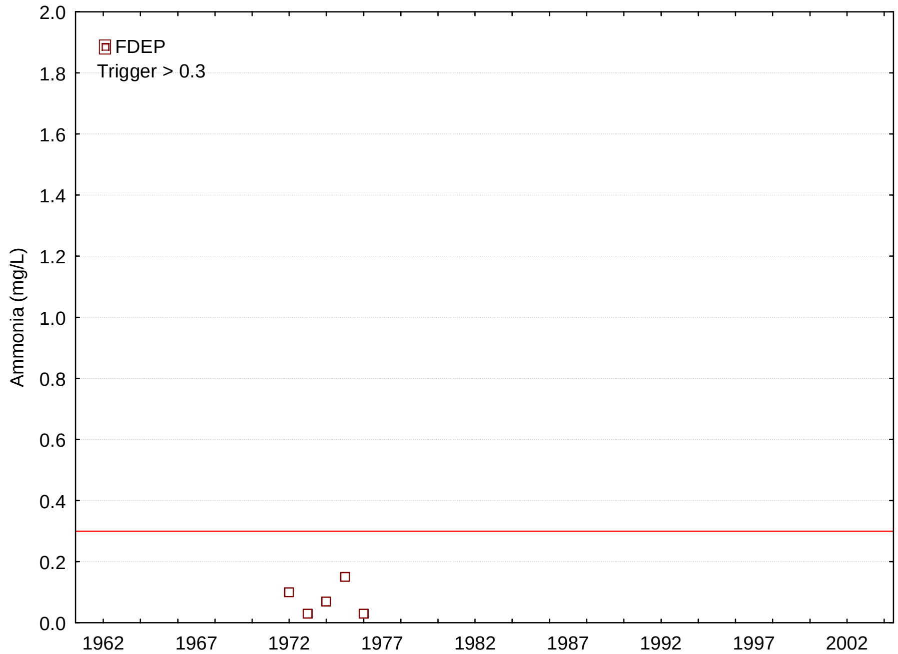


Figure B3-5. Annual Median Boxplots of Ammonia Concentrations Collected by FDEP in Horse Creek at SR 70 From 1972 to 1991.

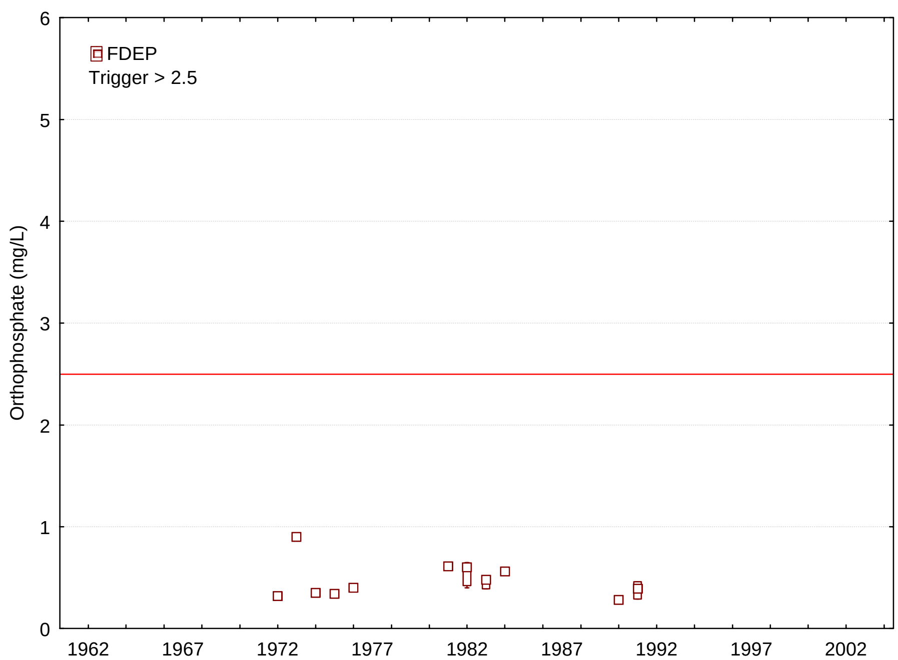


Figure B3-6. Annual Median Boxplots of Orthophosphate Concentrations Collected by FDEP in Horse Creek at SR 70 From 1972 to 1991.

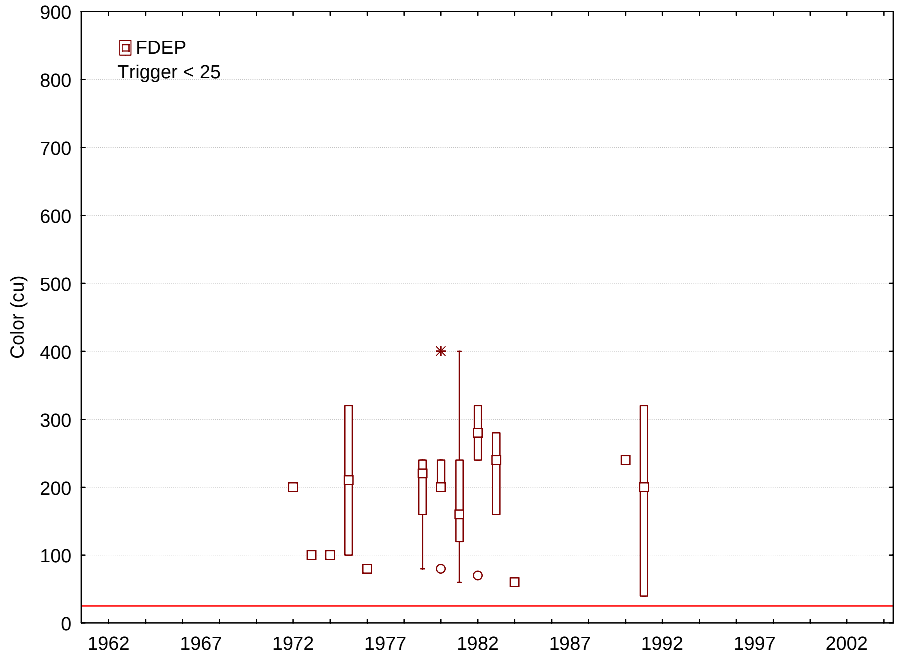


Figure B3-7. Annual Median Boxplots of Color Collected by FDEP in Horse Creek at SR 70 From 1972 to 1991.

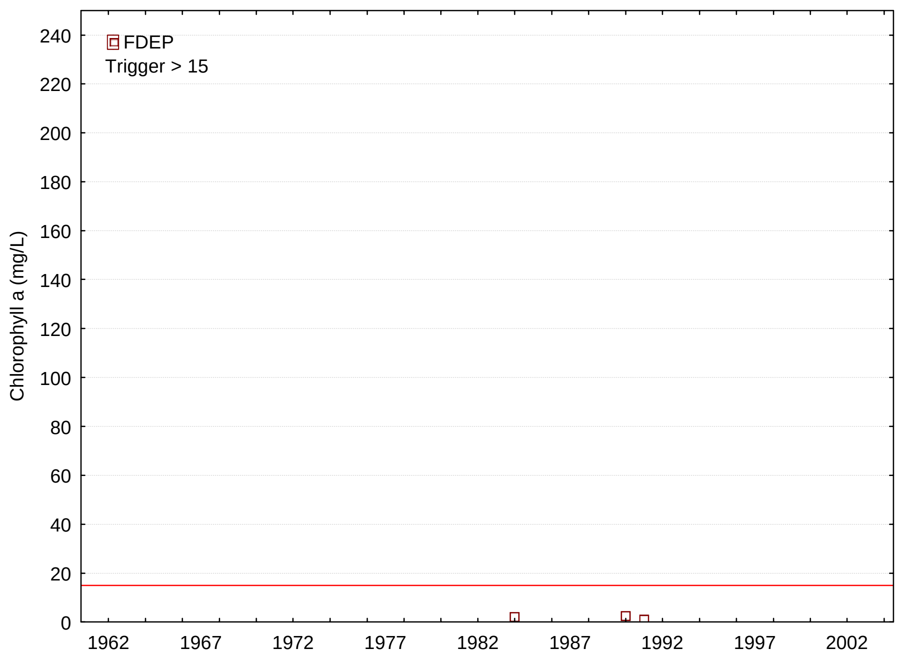


Figure B3-8. Annual Median Boxplots of Chlorophyll-a Concentrations Collected by FDEP in Horse Creek at SR 70 From 1972 to 1991.

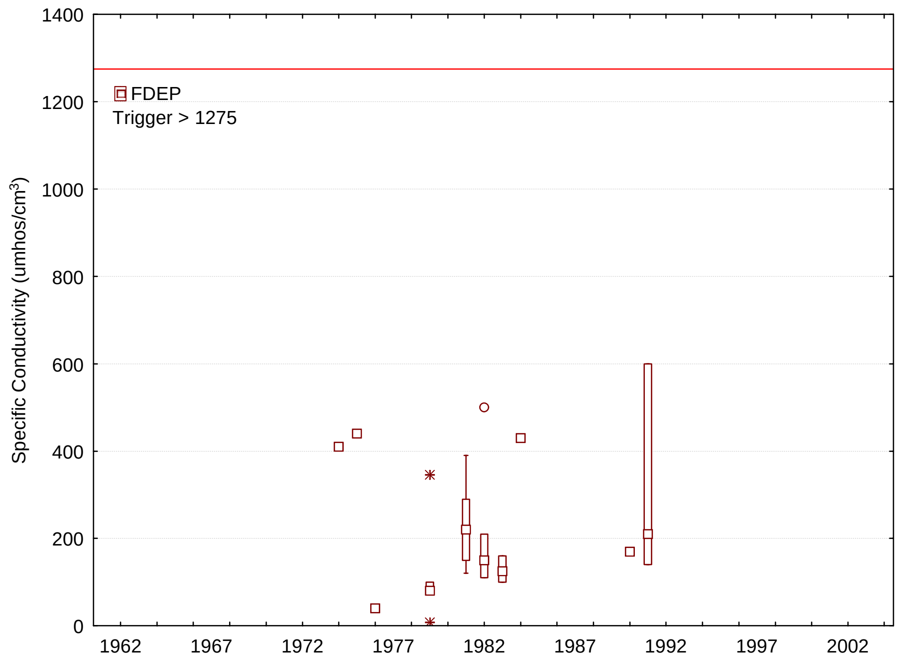


Figure B3-9. Annual Median Boxplots of Specific Conductivity Collected by FDEP in Horse Creek at SR 70 From 1972 to 1991.

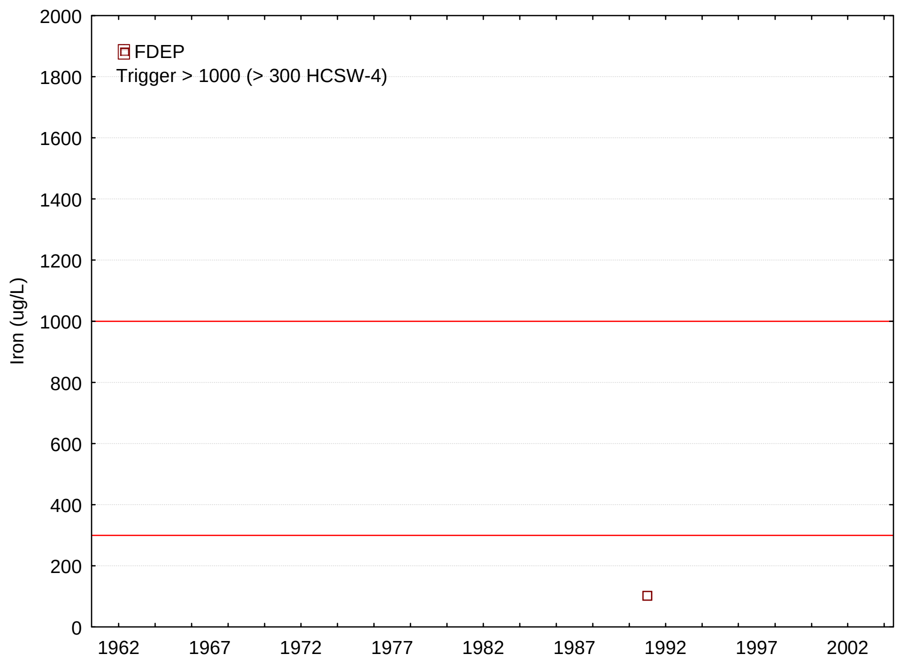


Figure B3-10. Annual Median Boxplots of Iron Concentrations Collected by FDEP in Horse Creek at SR 70 From 1972 to 1991.

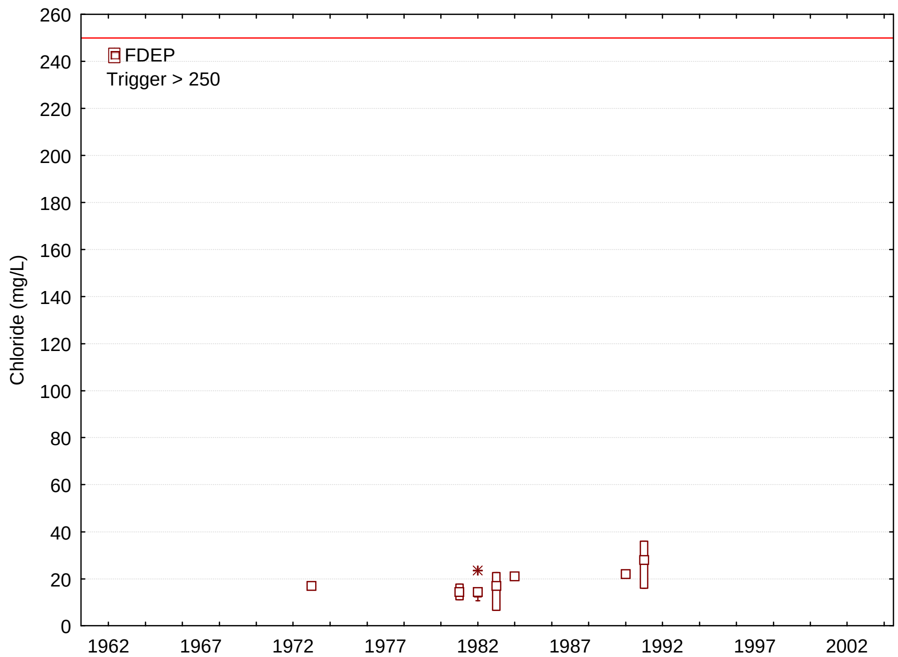


Figure B3-11. Annual Median Boxplots of Chloride Concentrations Collected by FDEP in Horse Creek at SR 70 From 1972 to 1991.

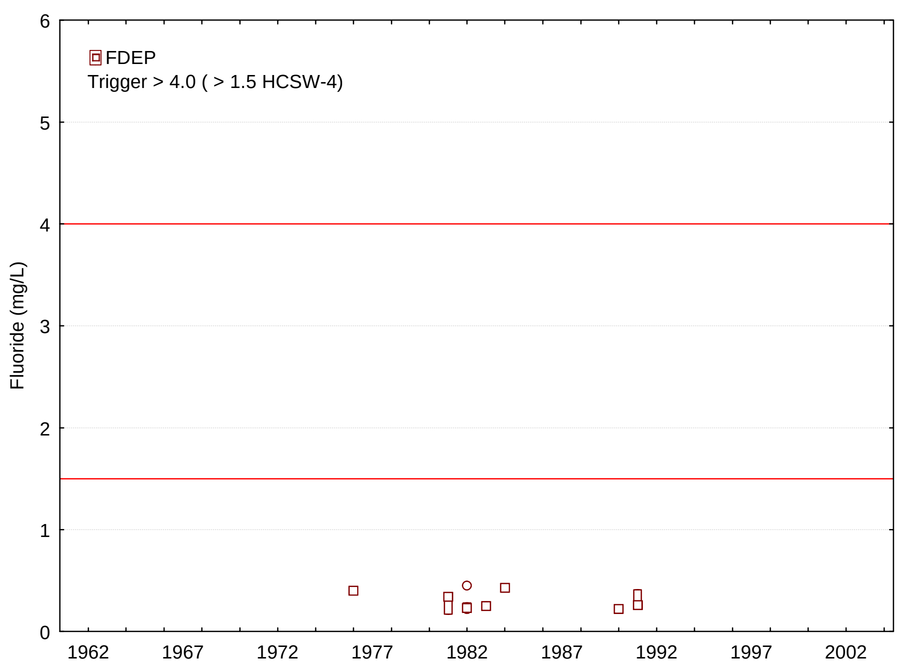


Figure B3-12. Annual Median Boxplots of Fluoride Concentrations Collected by FDEP in Horse Creek at SR 70 From 1972 to 1991.

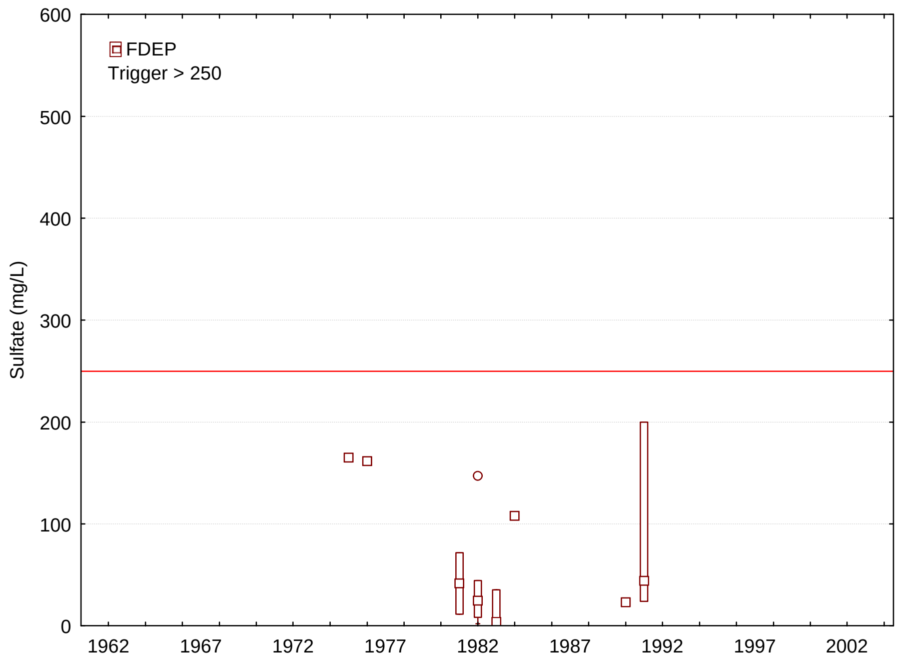


Figure B3-13. Annual Median Boxplots of Sulfate Concentrations Collected by FDEP in Horse Creek at SR 70 From 1972 to 1991.

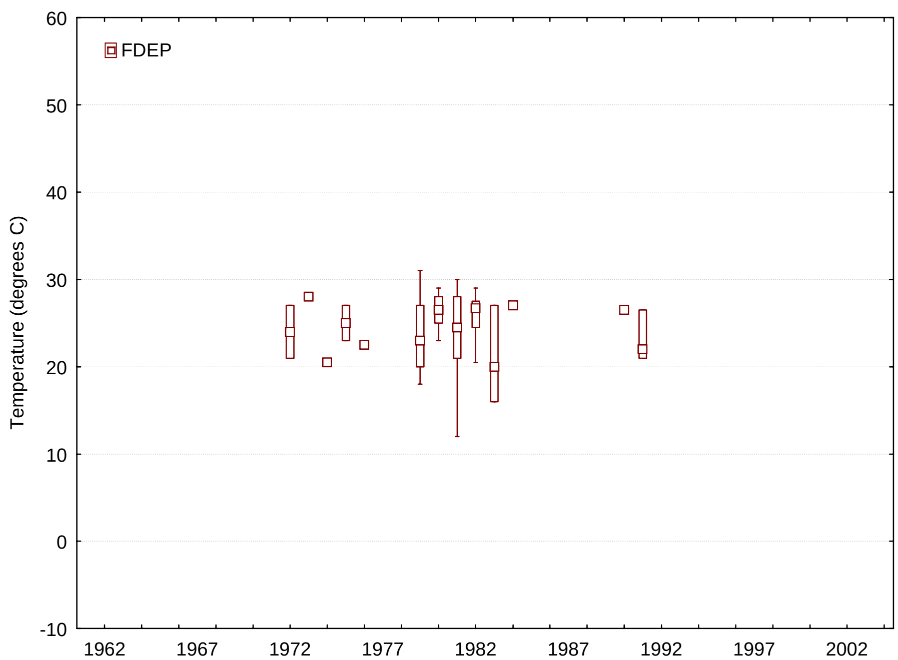


Figure B3-14. Annual Median Boxplots of Water Temperature Collected by FDEP in Horse Creek at SR 70 From 1972 to 1991.

Section 4: Annual Median Boxplots Water Quality Parameters Collected by PRMRWMA EQL and FDEP in Horse Creek at SR 761 From 1972 to 2003.

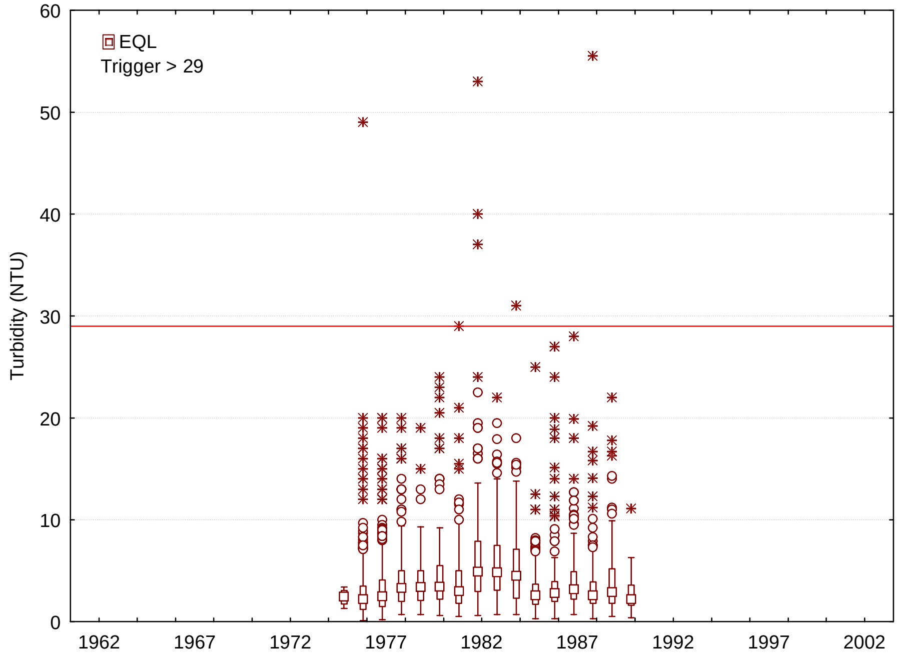


Figure B4-1. Annual Median Boxplots of Turbidity (NTU) Collected by PRMRWMA EQL and FDEP in Horse Creek at SR 761 From 1972 to 2003.

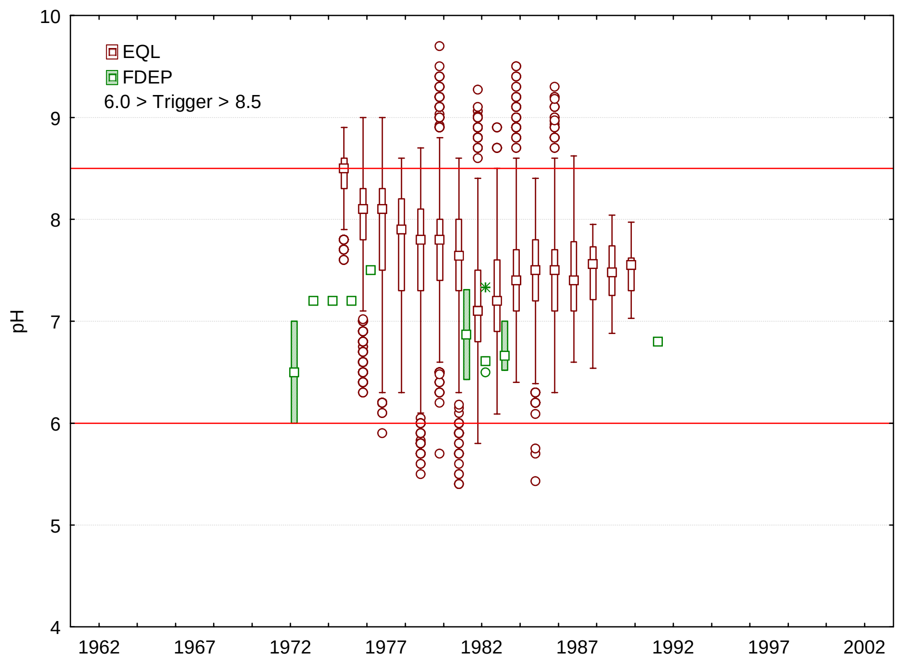


Figure B4-2. Annual Median Boxplots of pH Collected by PRMRWMA EQL and FDEP in Horse Creek at SR 761 From 1972 to 2003.

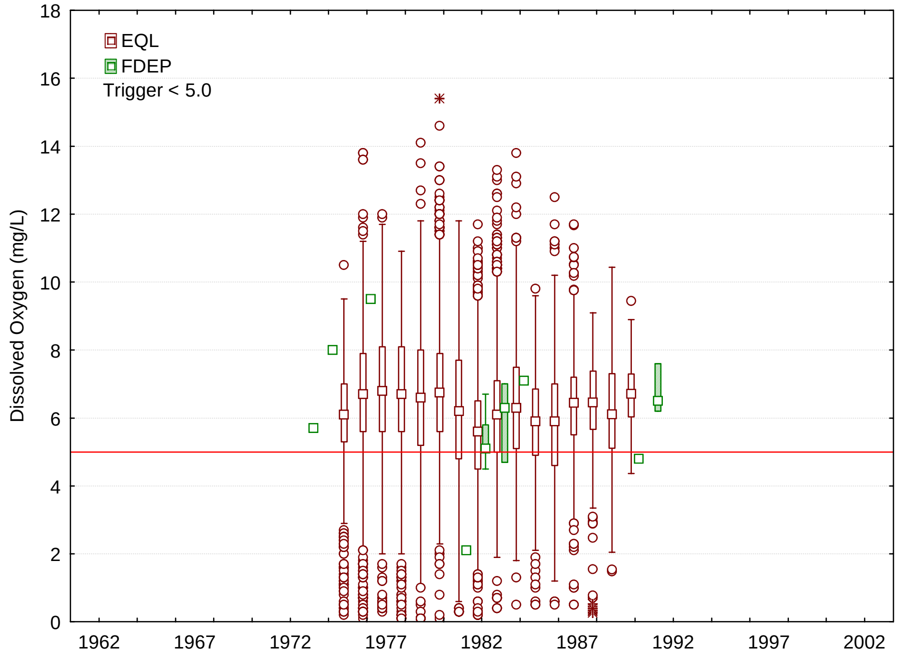


Figure B4-3. Annual Median Boxplots of Dissolved Oxygen Concentrations Collected by PRMRWMA EQL and FDEP in Horse Creek at SR 761 From 1972 to 2003.

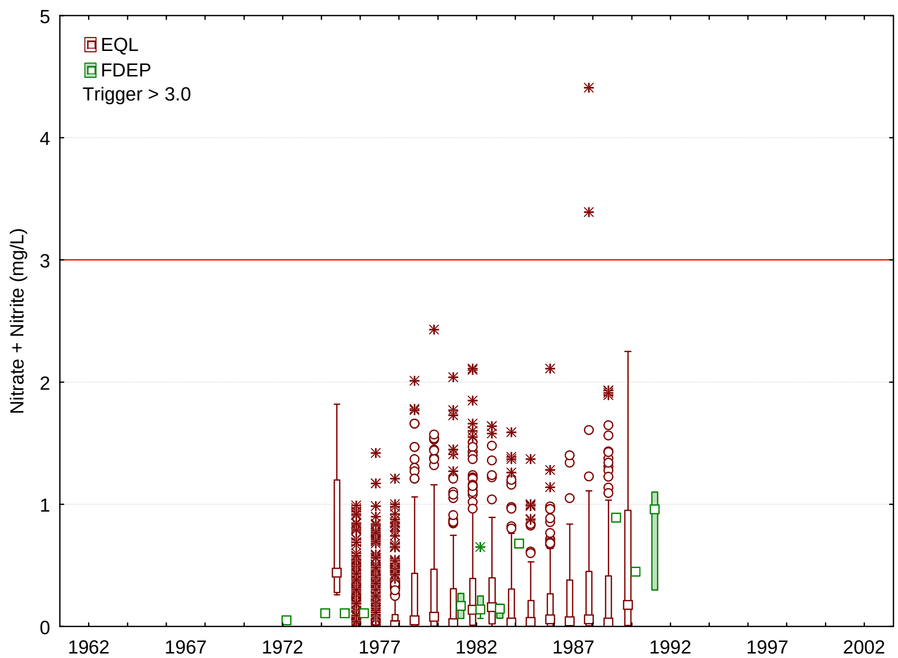


Figure B4-4. Annual Median Boxplots of Nitrate Plus Nitrite Concentrations Collected by PRMRWMA EQL and FDEP in Horse Creek at SR 761 From 1972 to 2003.

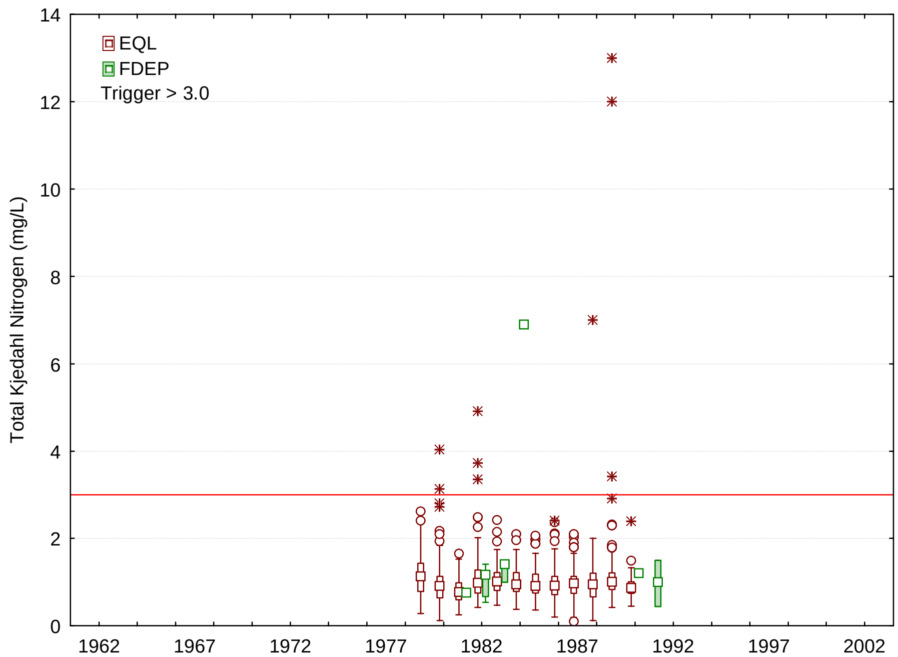


Figure B4-5. Annual Median Boxplots of Total Kjedahl Nitrogen Concentrations Collected by PRMRWMA EQL and FDEP in Horse Creek at SR 761 From 1972 to 2003.

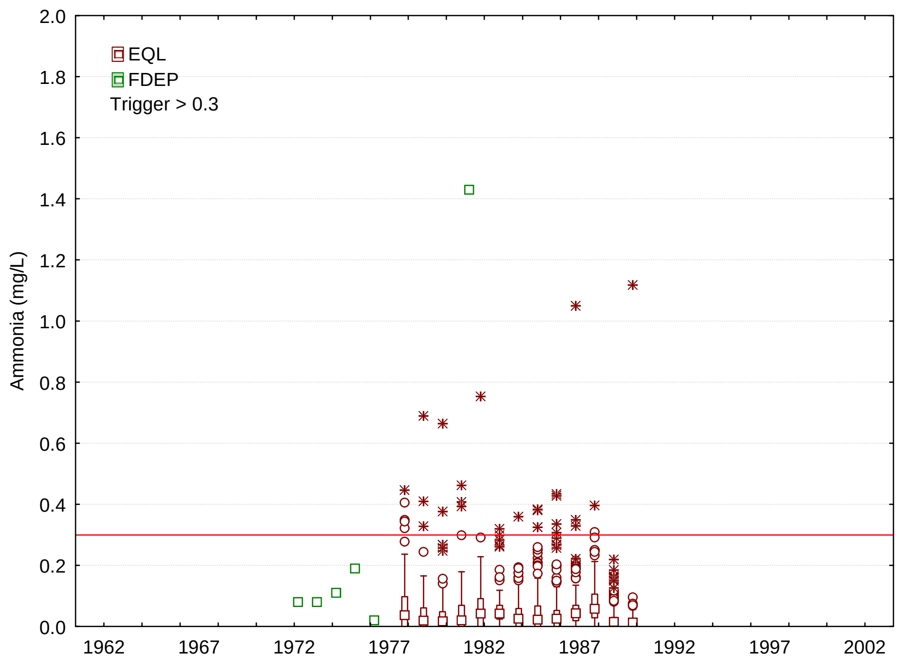


Figure B4-6. Annual Median Boxplots of Ammonia Concentrations Collected by PRMRWMA EQL and FDEP in Horse Creek at SR 761 From 1972 to 2003.

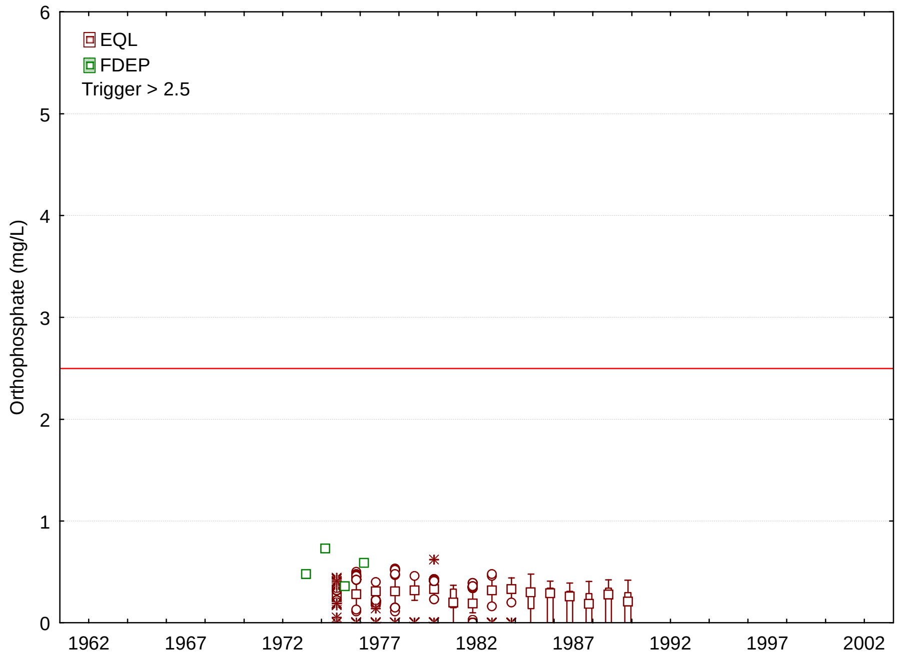


Figure B4-7. Annual Median Boxplots of Orthophosphate Concentrations Collected by PRMRWMA EQL and FDEP in Horse Creek at SR 761 From 1972 to 2003.

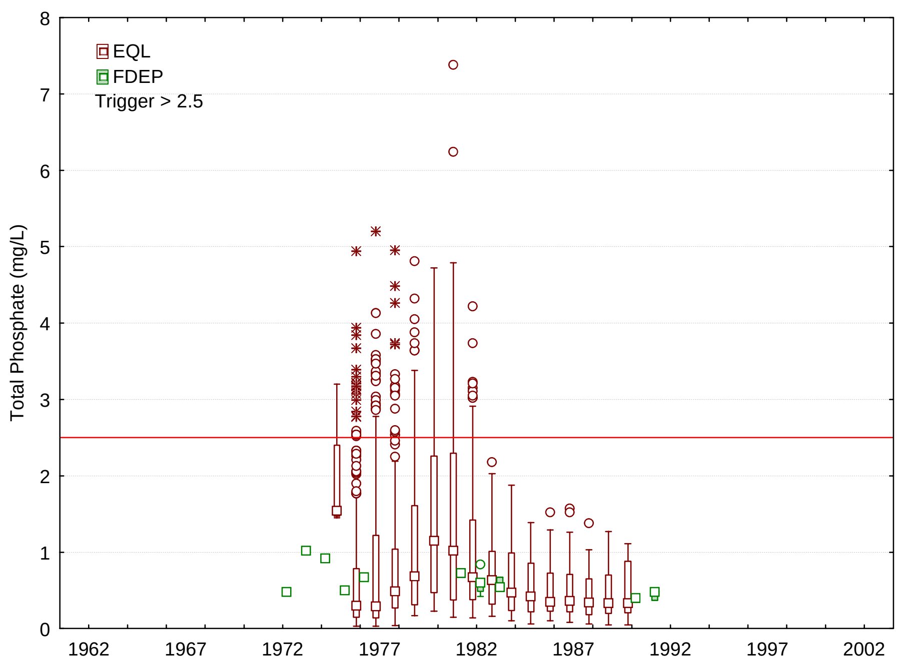


Figure B4-8. Annual Median Boxplots of Total Phosphorus Concentrations Collected by PRMRWMA EQL and FDEP in Horse Creek at SR 761 From 1972 to 2003.

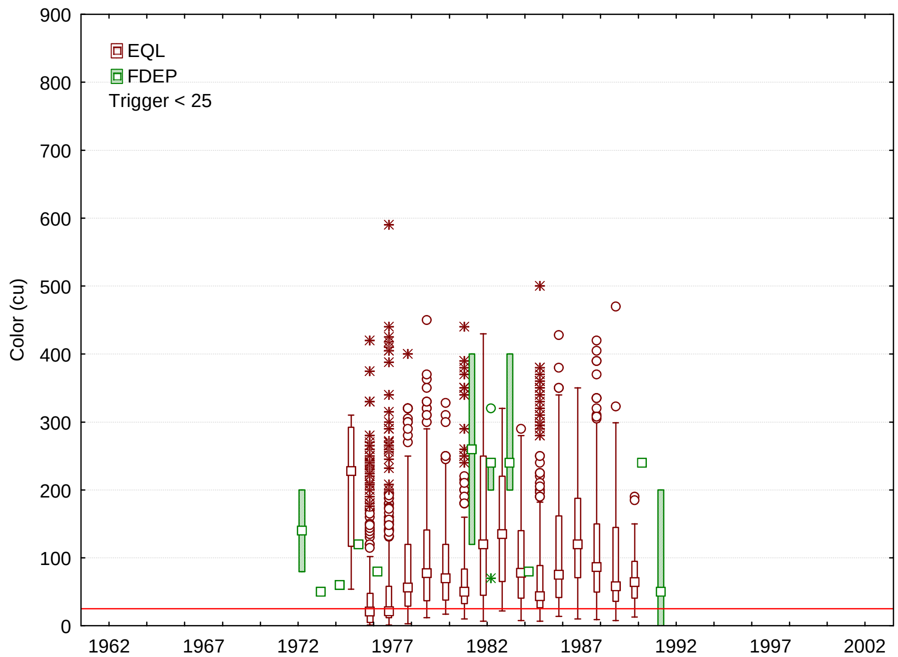


Figure B4-9. Annual Median Boxplots of Color Collected by PRMRWMA EQL and FDEP in Horse Creek at SR 761 From 1972 to 2003.

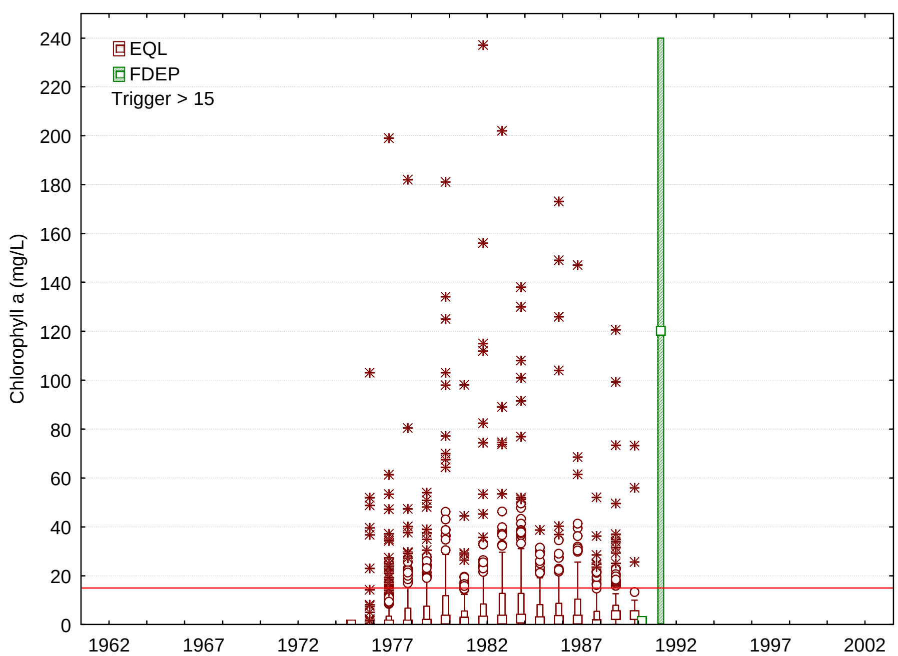


Figure B4-10. Annual Median Boxplots of Chlorophyll-a Concentrations Collected by PRMRWMA EQL and FDEP in Horse Creek at SR 761 From 1972 to 2003.

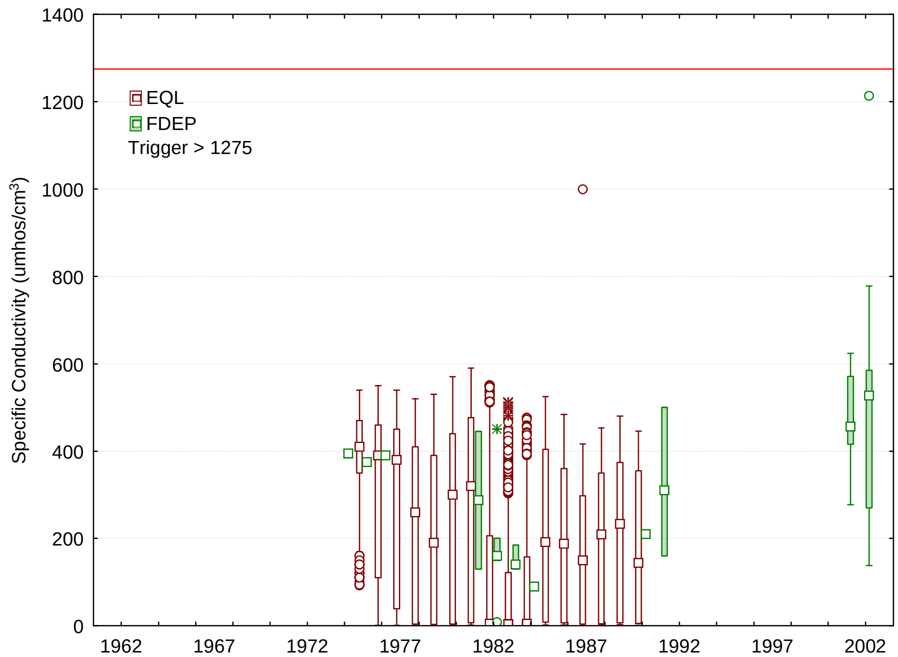


Figure B4-11. Annual Median Boxplots of Specific Conductivity Collected by PRMRWMA EQL and FDEP in Horse Creek at SR 761 From 1972 to 2003.

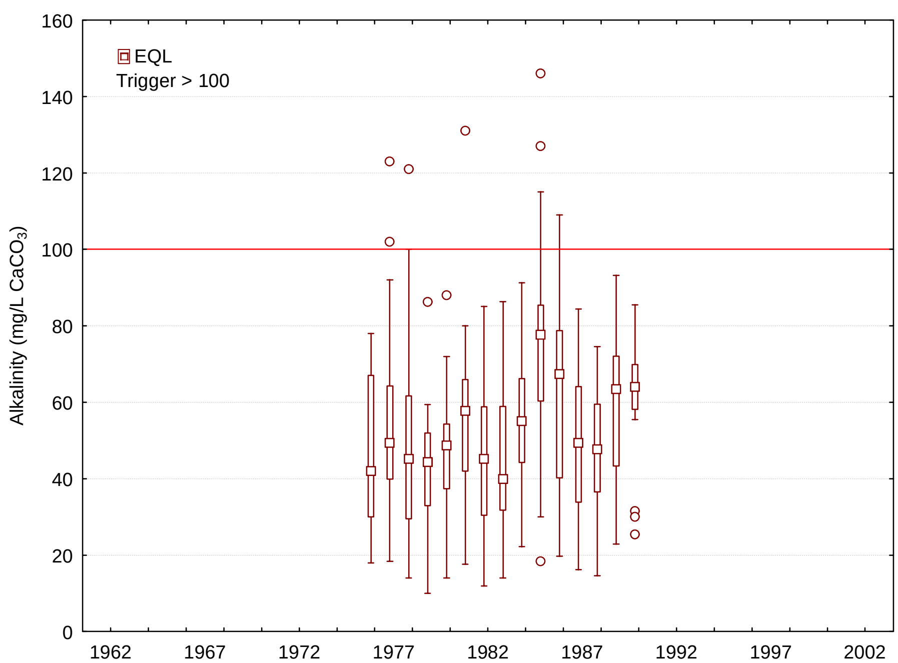


Figure B4-12. Annual Median Boxplots of Alkalinity Collected by PRMRWMA EQL and FDEP in Horse Creek at SR 761 From 1972 to 2003.

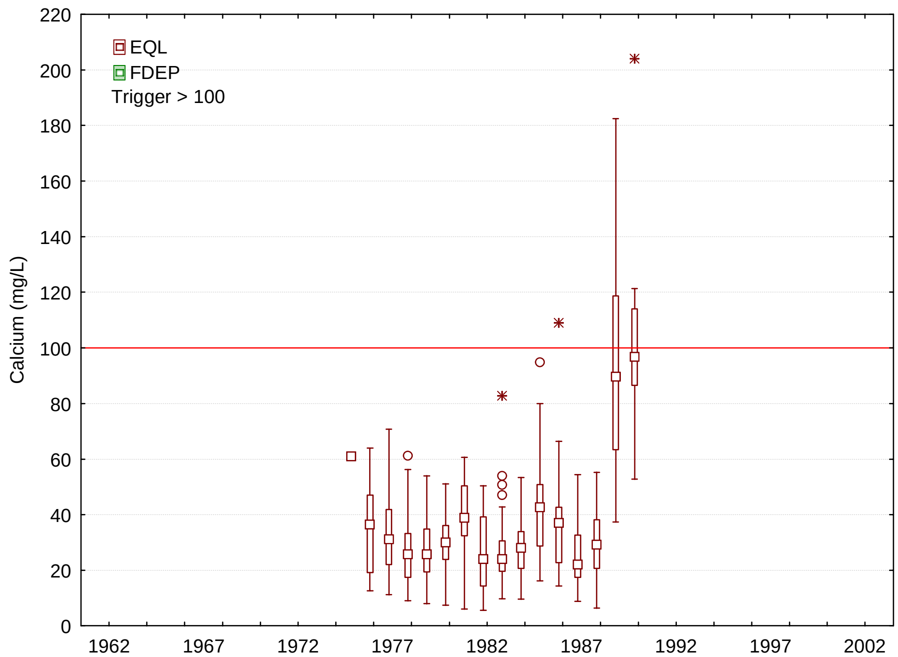


Figure B4-13. Annual Median Boxplots of Calcium Concentrations Collected by PRMRWMA EQL and FDEP in Horse Creek at SR 761 From 1972 to 2003.

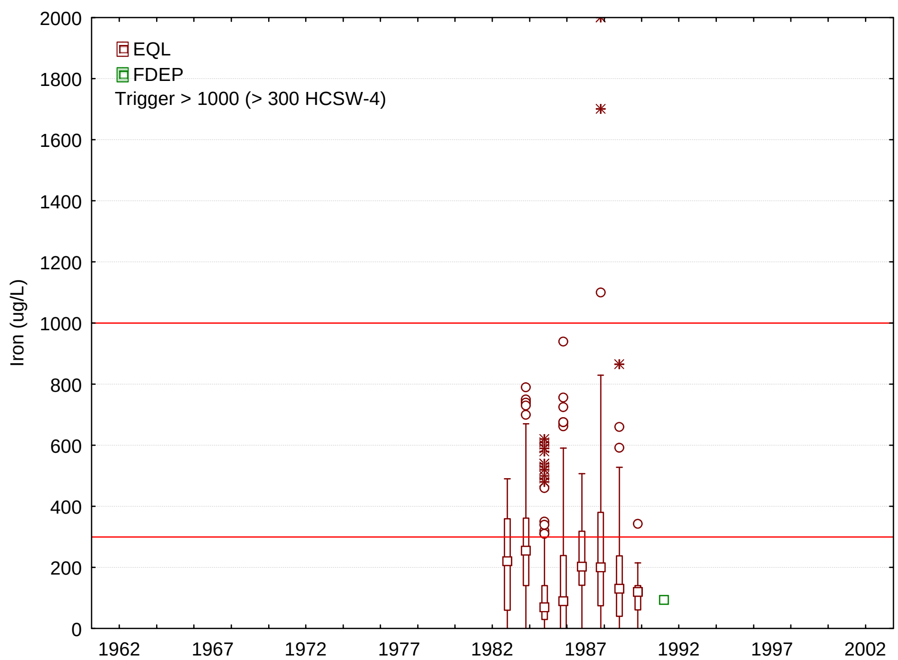


Figure B4-14. Annual Median Boxplots of Iron Concentrations Collected by PRMRWMA EQL and FDEP in Horse Creek at SR 761 From 1972 to 2003.

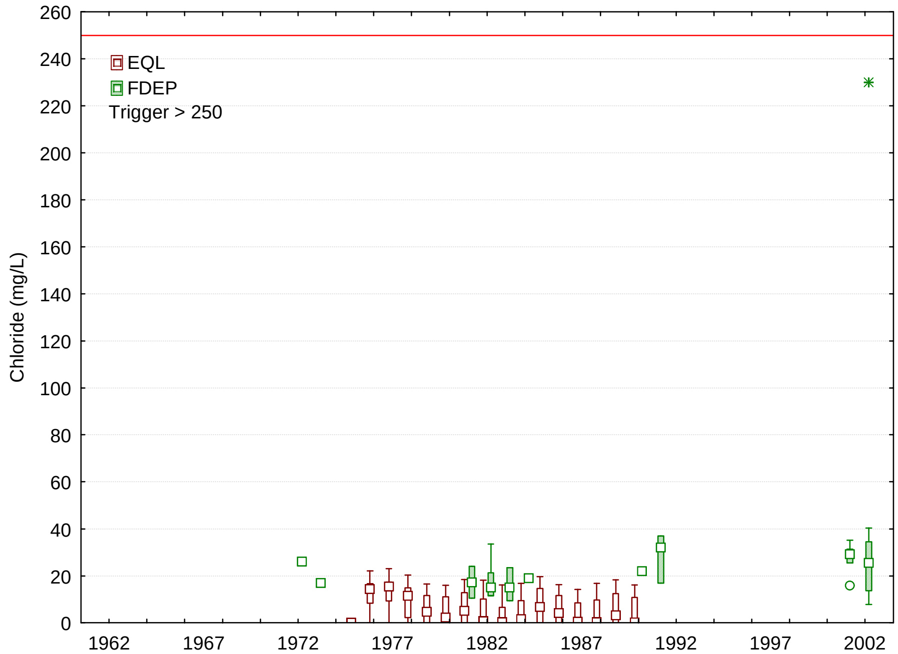


Figure B4-15. Annual Median Boxplots of Chloride Concentrations Collected by PRMRWMA EQL and FDEP in Horse Creek at SR 761 From 1972 to 2003.

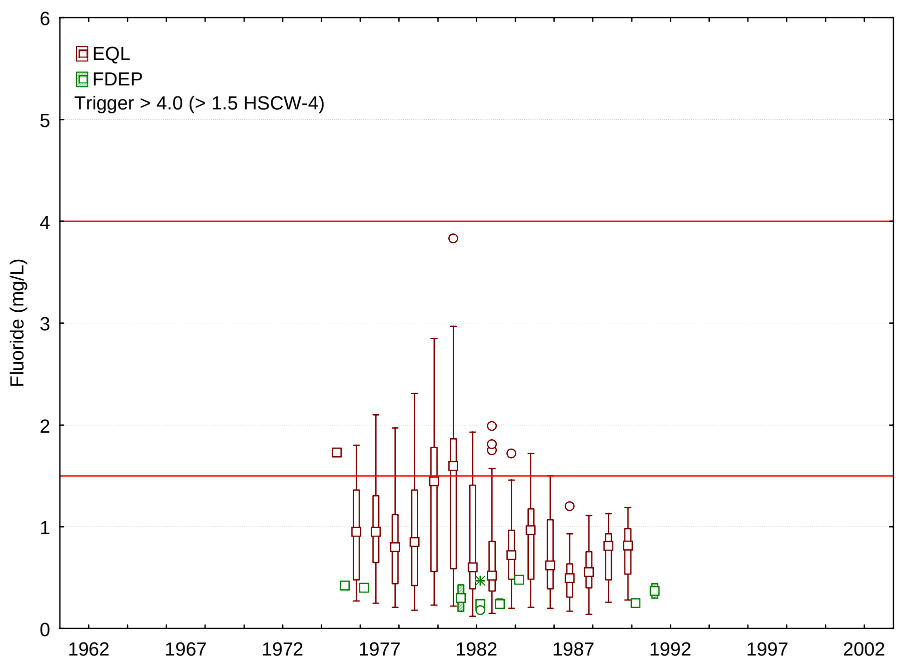


Figure B4-16. Annual Median Boxplots of Fluoride Concentrations Collected by PRMRWMA EQL and FDEP in Horse Creek at SR 761 From 1972 to 2003.

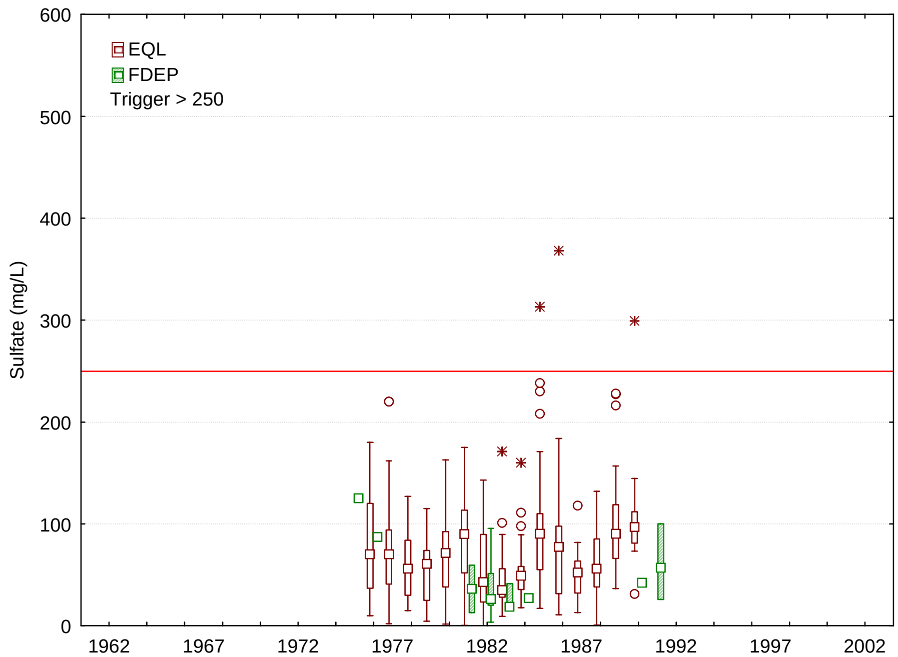


Figure B4-17. Annual Median Boxplots of Sulfate Concentrations Collected by PRMRWMA EQL and FDEP in Horse Creek at SR 761 From 1972 to 2003.

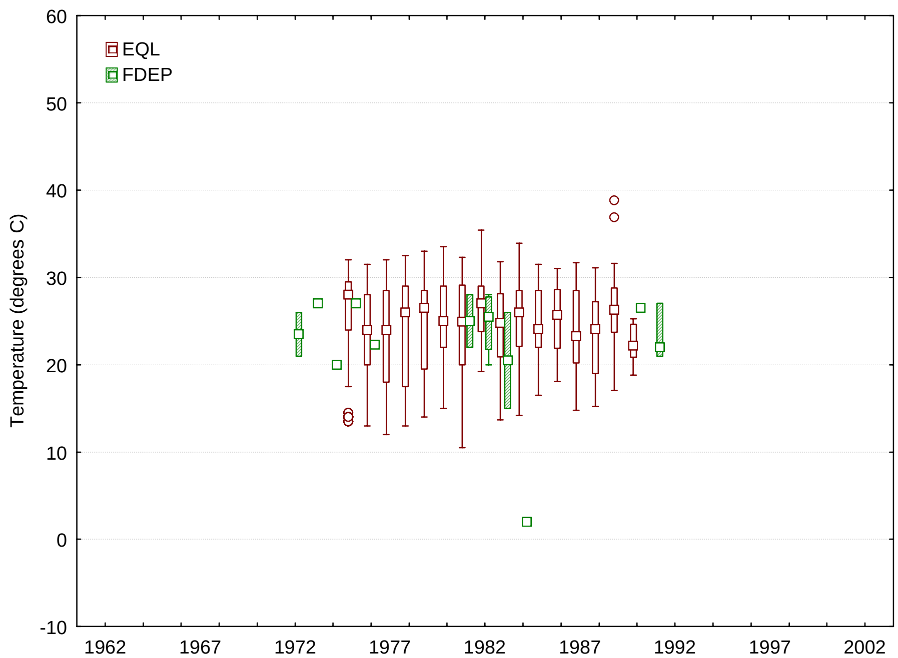


Figure B4-18. Annual Median Boxplots of Water Temperature Collected by PRMRWMA EQL and FDEP in Horse Creek at SR 761 From 1972 to 2003.

Appendix C

Macroinvertebrate Species List
for
Historical Sampling in the Horse Creek Basin

Phylum	Subphylum/ Class/ Subclass	Order/SubClass	Family	Genus	Species	ES&E 1982	BRA Durbin and Lancaster 2003	BRA Lancaster and Durbin 1999	HCSP 2003	FDEP 25020430, 1978-1980	FDEP 25020111, 1971-2000
Annelida	Hirudinea	Arhynchobdellida	Erpobdellidae	*Erpobdella*		X					
Annelida	Hirudinea	Arhynchobdellida	Erpobdellidae	*Mooreobdella*	*microstoma*					X	X
Annelida	Hirudinea	Rhynchobdellida	Glossiphoniidae	*Desserobdella*	*phalera*			X	X	X	X
Annelida	Hirudinea	Rhynchobdellida	Glossiphoniidae	*Gloiobdella*	*elongata*				X		
Annelida	Hirudinea	Rhynchobdellida	Glossiphoniidae	*Helobdella*	*stagnalis*				X		X
Annelida	Hirudinea	Rhynchobdellida	Glossiphoniidae	*Helobdella*	*triserialis*				X	X	X
Annelida	Hirudinea	Rhynchobdellida	Glossiphoniidae	*Helobdella*		X					
Annelida	Hirudinea	Rhynchobdellida	Glossiphoniidae	*Placobdella*	*multilineata*					X	
Annelida	Hirudinea	Rhynchobdellida	Glossiphoniidae	*Placobdella*	*ornata*	X					
Annelida	Hirudinea	Rhynchobdellida	Glossiphoniidae	*Placobdella*	*papillifera*					X	X
Annelida	Hirudinea	Rhynchobdellida	Glossiphoniidae	*Placobdella*	*parasitica*						
Annelida	Hirudinea	Rhynchobdellida	Glossiphoniidae	*Placobdella*		X					
Annelida	Hirudinea	Rhynchobdellida	Glossiphoniidae			X					
Annelida	Hirudinea	Rhynchobdellida	Piscicolidae	*Myzobbella*	*lugubris*						
Annelida	Hirudinea	Rhynchobdellida	Piscicolidae	*Myzobbella*	*moorei*	X					
Annelida	Hirudinea	Rhynchobdellida	Piscicolidae	*Piscicolaria*	*reducta*						
Annelida	Hirudinea										X
Annelida	Oligochaeta	Haplotaxida	Enchytraeidae			X					
Annelida	Oligochaeta	Haplotaxida	Lumbriculidae	*Eclipidrilus*	*palustris*						
Annelida	Oligochaeta	Haplotaxida	Lumbriculidae			X			X		
Annelida	Oligochaeta	Haplotaxida	Megascolecidae								
Annelida	Oligochaeta	Haplotaxida	Naididae	*Allonais*							X
Annelida	Oligochaeta	Haplotaxida	Naididae	*Bratislavia*	*unidentata*	X					
Annelida	Oligochaeta	Haplotaxida	Naididae	*Chaetogaster*	*cristallinus*	X					
Annelida	Oligochaeta	Haplotaxida	Naididae	*Dero*	*digitata*	X					X
Annelida	Oligochaeta	Haplotaxida	Naididae	*Dero*	*evelinae*	X					
Annelida	Oligochaeta	Haplotaxida	Naididae	*Dero*	*furcatus*	X					

Phylum	Subphylum/ Class/ Subclass	Order/SubClass	Family	Genus	Species	ES&E 1982	BRA Durbin and Lancaster 2003	BRA Lancaster and Durbin 1999	HCSP 2003	FDEP 25020430, 1978-1980	FDEP 25020111, 1971-2000
Annelida	Oligochaeta	Haplotaxida	Naididae	*Dero*	*nivea*	X			X		
Annelida	Oligochaeta	Haplotaxida	Naididae	*Dero*	*obtusa*	X					
Annelida	Oligochaeta	Haplotaxida	Naididae	*Dero*	*pectinata*	X					
Annelida	Oligochaeta	Haplotaxida	Naididae	*Dero*	*sawayai*	X					
Annelida	Oligochaeta	Haplotaxida	Naididae	*Dero*	*stephensoni*	X					
Annelida	Oligochaeta	Haplotaxida	Naididae	*Dero*	*trifida*	X					
Annelida	Oligochaeta	Haplotaxida	Naididae	*Dero*	*vaga*	X					
Annelida	Oligochaeta	Haplotaxida	Naididae	*Dero*							X
Annelida	Oligochaeta	Haplotaxida	Naididae	*Haemonais*	*waldvogeli*	X					
Annelida	Oligochaeta	Haplotaxida	Naididae	*Nais*	*communis*	X					
Annelida	Oligochaeta	Haplotaxida	Naididae	*Nais*	*elinguis*						X
Annelida	Oligochaeta	Haplotaxida	Naididae	*Nais*	*pardalis*						X
Annelida	Oligochaeta	Haplotaxida	Naididae	*Nais*	*simplex*						
Annelida	Oligochaeta	Haplotaxida	Naididae	*Nais*	*variablis*	X					X
Annelida	Oligochaeta	Haplotaxida	Naididae	*Nais*							X
Annelida	Oligochaeta	Haplotaxida	Naididae	*Pristina*	*aequiseta*	X					
Annelida	Oligochaeta	Haplotaxida	Naididae	*Pristina*	*leidyi*	X					
Annelida	Oligochaeta	Haplotaxida	Naididae	*Pristina*	*longiseta*	X					
Annelida	Oligochaeta	Haplotaxida	Naididae	*Pristina*	*longisoma*	X					
Annelida	Oligochaeta	Haplotaxida	Naididae	*Pristina*	*macrochaeta*	X					
Annelida	Oligochaeta	Haplotaxida	Naididae	*Pristina*	*proboscidea*	X					
Annelida	Oligochaeta	Haplotaxida	Naididae	*Pristina*	*sima*	X					
Annelida	Oligochaeta	Haplotaxida	Naididae	*Pristina*	*synclites*	X					
Annelida	Oligochaeta	Haplotaxida	Naididae	*Pristina*							X
Annelida	Oligochaeta	Haplotaxida	Naididae	*Pristinella*	*osborni*						X
Annelida	Oligochaeta	Haplotaxida	Naididae	*Slavina*	*appendiculata*	X					X
Annelida	Oligochaeta	Haplotaxida	Naididae	*Stylaria*	*lacustris*	X					
Annelida	Oligochaeta	Haplotaxida	Naididae								X

Phylum	Subphylum/ Class/ Subclass	Order/SubClass	Family	Genus	Species	ES&E 1982	BRA Durbin and Lancaster 2003	BRA Lancaster and Durbin 1999	HCSP 2003	FDEP 25020430, 1978-1980	FDEP 25020111, 1971-2000
Annelida	Oligochaeta	Haplotaxida	Opistocystidae			X					
Annelida	Oligochaeta	Haplotaxida	Tubificidae	*Aulodrilus*	*piguetti*	X		X			X
Annelida	Oligochaeta	Haplotaxida	Tubificidae	*Aulodrilus*	*pluriseta*						X
Annelida	Oligochaeta	Haplotaxida	Tubificidae	*Bothrioneurum*	*vejdovskyanum*	X					
Annelida	Oligochaeta	Haplotaxida	Tubificidae	*Limnodrilus*	*hoffmeisteri*	X		X	X	X	X
Annelida	Oligochaeta	Haplotaxida	Tubificidae	*Limnodrilus*							X
Annelida	Oligochaeta	Haplotaxida	Tubificidae	*Psammoryctides*	*convolutus*	X					
Annelida	Oligochaeta	Haplotaxida	Tubificidae	*Spirosperma*							X
Annelida	Oligochaeta	Haplotaxida	Tubificidae	*Spirosperma*	*ferox*						
Annelida	Oligochaeta	Haplotaxida	Tubificidae	*Tubifex*	*harmoni*	X					
Annelida	Oligochaeta	Haplotaxida	Tubificidae			X	X	X	X		X
Annelida	Oligochaeta						X	X	X	X	X
Arthropoda	Arachnida	Araneae	Pisauridae	*Dolomedes*	*triton*				X		
Arthropoda	Arachnida	Araneae	Pisauridae	*Dolomedes*				X			
Arthropoda	Arachnida	Trombidiformes	Krendowskiidae	*Krendowskia*							
Arthropoda	Arachnida	Trombidiformes	Unionicolidae	*Unionicola*							
Arthropoda	Arachnida	Trombidiformes									X
Arthropoda	Arachnida	Trombidiformes	Torrenticolidae	*Torrenticola*				X			
Arthropoda	Arachnida	Trombiformes	Arrenuridae	*Arrenurus*							X
Arthropoda	Arachnida	Trombiformes	Hygrobatidae	*Atractides*				X			X
Arthropoda	Arachnida	Trombiformes	Mideopsidae	*Mideopsis*							X
Arthropoda	Arachnida	Trombiformes	Unionicolidae	*Koenikea*	*angulata*						X
Arthropoda	Crustacea	Amphipoda	Crangonyctidae	*Crangonyx*	*floridanus*					X	X
Arthropoda	Crustacea	Amphipoda	Crangonyctidae	*Crangonyx*	*serratus*	X					
Arthropoda	Crustacea	Amphipoda	Talitridae	*Hyalella*	*azteca*	X	X		X	X	X
Arthropoda	Crustacea	Arguloida	Argulidae	*Argulus*						X	
Arthropoda	Crustacea	Arguloida	Argulidae	*Argulus*	*meehani*						
Arthropoda	Crustacea	Cladocera				X					

Phylum	Subphylum/ Class/ Subclass	Order/SubClass	Family	Genus	Species	ES&E 1982	BRA Durbin and Lancaster 2003	BRA Lancaster and Durbin 1999	HCSP 2003	FDEP 25020430, 1978-1980	FDEP 25020111, 1971-2000
Arthropoda	Crustacea	Copepoda				X					
Arthropoda	Crustacea	Decapoda	Cambaridae	*Procambarus*	*alleni*	X		X	X		
Arthropoda	Crustacea	Decapoda	Cambaridae	*Procambarus*		X	X			X	X
Arthropoda	Crustacea	Decapoda	Cambaridae				X	X	X		
Arthropoda	Crustacea	Decapoda	Palaemonidae	*Palaemonetes*	*paludosus*	X	X		X	X	X
Arthropoda	Crustacea	Decapoda	Palaemonidae	*Palaemonetes*					X		X
Arthropoda	Crustacea	Isopoda	Asellidae	*Asellus*		X					X
Arthropoda	Crustacea	Isopoda	Asellidae	*Asellus*	*obtusus*					X	
Arthropoda	Crustacea	Ostracoda				X					
Arthropoda	Insecta	Coleoptera	Carabidae			X					
Arthropoda	Insecta	Coleoptera	Chrysomelidae			X					
Arthropoda	Insecta	Coleoptera	Dryopidae	*Pelonomus*	*obscurus*				X		
Arthropoda	Insecta	Coleoptera	Dryopidae						X		X
Arthropoda	Insecta	Coleoptera	Dytiscidae	*Agabus*	*johannis*						
Arthropoda	Insecta	Coleoptera	Dytiscidae	*Bidessonotus*	*longovalis*						
Arthropoda	Insecta	Coleoptera	Dytiscidae	*Bidessonotus*							
Arthropoda	Insecta	Coleoptera	Dytiscidae	*Bidessus*		X					
Arthropoda	Insecta	Coleoptera	Dytiscidae	*Celina*			X				
Arthropoda	Insecta	Coleoptera	Dytiscidae	*Copelatus*		X					
Arthropoda	Insecta	Coleoptera	Dytiscidae	*Coptotomus*	*interrogatus*						X
Arthropoda	Insecta	Coleoptera	Dytiscidae	*Coptotomus*	*interrogatus obscurus*						
Arthropoda	Insecta	Coleoptera	Dytiscidae	*Coptotomus*	*venustus*		X		X		
Arthropoda	Insecta	Coleoptera	Dytiscidae	*Coptotomus*		X			X		
Arthropoda	Insecta	Coleoptera	Dytiscidae	*Cybister*						X	
Arthropoda	Insecta	Coleoptera	Dytiscidae	*Desmopachria*	*grana*						
Arthropoda	Insecta	Coleoptera	Dytiscidae	*Hydroporus*	*vittatipennis*						
Arthropoda	Insecta	Coleoptera	Dytiscidae	*Hydroporus*						X	
Arthropoda	Insecta	Coleoptera	Dytiscidae	*Laccophilus*	*gentilus*						

Phylum	Subphylum/ Class/ Subclass	Order/SubClass	Family	Genus	Species	ES&E 1982	BRA Durbin and Lancaster 2003	BRA Lancaster and Durbin 1999	HCSP 2003	FDEP 25020430, 1978-1980	FDEP 25020111, 1971-2000
Arthropoda	Insecta	Coleoptera	Dytiscidae	*Laccophilus*	*proximus*		X				
Arthropoda	Insecta	Coleoptera	Dytiscidae	*Liodessus*	*pullus floridanus*						
Arthropoda	Insecta	Coleoptera	Dytiscidae	*Pachydrus*	*princeps*		X				
Arthropoda	Insecta	Coleoptera	Dytiscidae	*Thermonectus*	*basillaris*		X				
Arthropoda	Insecta	Coleoptera	Dytiscidae								X
Arthropoda	Insecta	Coleoptera	Elmidae	*Dubiraphia*	*vittata*			X	X		X
Arthropoda	Insecta	Coleoptera	Elmidae	*Dubiraphia*	*vittigera*	X					
Arthropoda	Insecta	Coleoptera	Elmidae	*Dubiraphia*		X		X		X	X
Arthropoda	Insecta	Coleoptera	Elmidae	*Dubiraphia*	*quadrinotata*						X
Arthropoda	Insecta	Coleoptera	Elmidae	*Microcylloepus*	*pusillus*		X	X	X		X
Arthropoda	Insecta	Coleoptera	Elmidae	*Microcylloepus*	*pusillus lodingi*	X					
Arthropoda	Insecta	Coleoptera	Elmidae	*Microcylloepus*							X
Arthropoda	Insecta	Coleoptera	Elmidae	*Stenelmis*	*fuscata*						X
Arthropoda	Insecta	Coleoptera	Elmidae	*Stenelmis*	*hungerfordi*				X		X
Arthropoda	Insecta	Coleoptera	Elmidae	*Stenelmis*	*lignicola*		X				
Arthropoda	Insecta	Coleoptera	Elmidae	*Stenelmis*	*parva*	X					
Arthropoda	Insecta	Coleoptera	Elmidae	*Stenelmis*		X	X	X	X		X
Arthropoda	Insecta	Coleoptera	Elmidae	*Stenelmis*	*antennalis*						X
Arthropoda	Insecta	Coleoptera	Elmidae								X
Arthropoda	Insecta	Coleoptera	Gyrinidae	*Dineutus*	*carolinus*						
Arthropoda	Insecta	Coleoptera	Gyrinidae	*Dineutus*	*serralatus*		X	X	X		
Arthropoda	Insecta	Coleoptera	Gyrinidae	*Dineutus*	*serralatus serralatus*				X		
Arthropoda	Insecta	Coleoptera	Gyrinidae	*Dineutus*		X		X	X		X
Arthropoda	Insecta	Coleoptera	Gyrinidae	*Gyrinus*	*elevatus*						
Arthropoda	Insecta	Coleoptera	Gyrinidae	*Gyrinus*				X	X		X
Arthropoda	Insecta	Coleoptera	Halipildae	*Peltodytes*	*dietrichi*				X		
Arthropoda	Insecta	Coleoptera	Halipildae	*Peltodytes*	*floridensis*		X				
Arthropoda	Insecta	Coleoptera	Halipildae	*Peltodytes*	*sexmaculatus*						

Phylum	Subphylum/ Class/ Subclass	Order/SubClass	Family	Genus	Species	ES&E 1982	BRA Durbin and Lancaster 2003	BRA Lancaster and Durbin 1999	HCSP 2003	FDEP 25020430, 1978-1980	FDEP 25020111, 1971-2000
Arthropoda	Insecta	Coleoptera	Halipildae	*Peltodytes*		X					X
Arthropoda	Insecta	Coleoptera	Helodidae	*Cyphon*						X	
Arthropoda	Insecta	Coleoptera	Helodidae	*Prionocyphon*			X	X	X		
Arthropoda	Insecta	Coleoptera	Helodidae	*Scirtes*		X	X	X	X		
Arthropoda	Insecta	Coleoptera	Histeridae			X					
Arthropoda	Insecta	Coleoptera	Hydraenidae	*Hydraena*	*marginicollis*						
Arthropoda	Insecta	Coleoptera	Hydrochidae	*Hydrochus*					X		
Arthropoda	Insecta	Coleoptera	Hydrophilidae	*Berosus*	*striatus*						
Arthropoda	Insecta	Coleoptera	Hydrophilidae	*Berosus*		X					X
Arthropoda	Insecta	Coleoptera	Hydrophilidae	*Helobata*	*larvalis*				X		
Arthropoda	Insecta	Coleoptera	Hydrophilidae	*Helobata*							X
Arthropoda	Insecta	Coleoptera	Hydrophilidae	*Helochares*	*maculicollis*						
Arthropoda	Insecta	Coleoptera	Hydrophilidae	*Hydrobius*	*tumidus*						
Arthropoda	Insecta	Coleoptera	Hydrophilidae	*Hydrophilus*							
Arthropoda	Insecta	Coleoptera	Hydrophilidae	*Tropisternus*	*blatchleyi*		X				
Arthropoda	Insecta	Coleoptera	Hydrophilidae	*Tropisternus*	*lateralis nimbatus*		X				
Arthropoda	Insecta	Coleoptera	Hydrophilidae	*Tropisternus*		X			X	X	
Arthropoda	Insecta	Coleoptera	Hydrophilidae								X
Arthropoda	Insecta	Coleoptera	Noteridae	*Hydrocanthus*	*oblongus*		X		X		
Arthropoda	Insecta	Coleoptera	Noteridae	*Hydrocanthus*		X			X		
Arthropoda	Insecta	Coleoptera	Noteridae	*Hydrocanthus*	*regius*						X
Arthropoda	Insecta	Coleoptera	Noteridae	*Mesonoterus*	*addendus*		X				
Arthropoda	Insecta	Coleoptera	Noteridae	*Suphis*	*inflatus*						X
Arthropoda	Insecta	Coleoptera	Noteridae	*Suphisellus*	*gibbulus*		X				
Arthropoda	Insecta	Coleoptera	Noteridae	*Suphisellus*	*insularis*						X
Arthropoda	Insecta	Coleoptera	Noteridae	*Suphisellus*					X		
Arthropoda	Insecta	Coleoptera	Staphylinidae	*Emplenota*		X					

Phylum	Subphylum/ Class/ Subclass	Order/SubClass	Family	Genus	Species	ES&E 1982	BRA Durbin and Lancaster 2003	BRA Lancaster and Durbin 1999	HCSP 2003	FDEP 25020430, 1978-1980	FDEP 25020111, 1971-2000
Arthropoda	Insecta	Coleoptera		*Enochrus*		X					
Arthropoda	Insecta	Coleoptera							X		X
Arthropoda	Insecta	Collembola	Isotomidae	*Isotomurus*	*palustris*						
Arthropoda	Insecta	Collembola				X					
Arthropoda	Insecta	Diptera	Athericidae	*Atherix*							X
Arthropoda	Insecta	Diptera	Ceratopogonidae	*Alluaudomyia*				X			
Arthropoda	Insecta	Diptera	Ceratopogonidae	*Atrichopogon*		X		X			X
Arthropoda	Insecta	Diptera	Ceratopogonidae	*Bezzia*	*xantocephala*	X					
Arthropoda	Insecta	Diptera	Ceratopogonidae	*Bezzia*		X					
Arthropoda	Insecta	Diptera	Ceratopogonidae	*Bezzia/Palpomyia*	*group* sp.	X			X		X
Arthropoda	Insecta	Diptera	Ceratopogonidae	*Ceratopogon*		X					
Arthropoda	Insecta	Diptera	Ceratopogonidae	*Culicoides*		X					X
Arthropoda	Insecta	Diptera	Ceratopogonidae	*Dasyhelea*		X					
Arthropoda	Insecta	Diptera	Ceratopogonidae	*Forcipoymia*							
Arthropoda	Insecta	Diptera	Ceratopogonidae	*Mallochohelea*		X					
Arthropoda	Insecta	Diptera	Ceratopogonidae	*Palpomyia*	*lineata*	X					
Arthropoda	Insecta	Diptera	Ceratopogonidae	*Palpomyia*	sp	X					X
Arthropoda	Insecta	Diptera	Ceratopogonidae	*Probezzia*		X					
Arthropoda	Insecta	Diptera	Ceratopogonidae			X	X	X	X	X	X
Arthropoda	Insecta	Diptera	Chaoboridae	*Chaoborus*	*punctipennis*				X		
Arthropoda	Insecta	Diptera	Chaoboridae	*Chaoborus*		X					
Arthropoda	Insecta	Diptera	Chironomidae	*Ablabesmyia*	*aspera*	X					X
Arthropoda	Insecta	Diptera	Chironomidae	*Ablabesmyia*	*mallochi*			X			X
Arthropoda	Insecta	Diptera	Chironomidae	*Ablabesmyia*	*ornata*	X					
Arthropoda	Insecta	Diptera	Chironomidae	*Ablabesmyia*	*parajanta*	X					
Arthropoda	Insecta	Diptera	Chironomidae	*Ablabesmyia*	*peleensis*						X
Arthropoda	Insecta	Diptera	Chironomidae	*Ablabesmyia*	*philosphangnos*	X					
Arthropoda	Insecta	Diptera	Chironomidae	*Ablabesmyia*	*rhamphe group*			X	X	X	X

Phylum	Subphylum/ Class/ Subclass	Order/SubClass	Family	Genus	Species	ES&E 1982	BRA Durbin and Lancaster 2003	BRA Lancaster and Durbin 1999	HCSP 2003	FDEP 25020430, 1978-1980	FDEP 25020111, 1971-2000
Arthropoda	Insecta	Diptera	Chironomidae	*Ablabesmyia*	*tarella*	X					
Arthropoda	Insecta	Diptera	Chironomidae	*Ablabesmyia*		X		X			X
Arthropoda	Insecta	Diptera	Chironomidae	*Anatopynia*		X					
Arthropoda	Insecta	Diptera	Chironomidae	*Anopheles*							X
Arthropoda	Insecta	Diptera	Chironomidae	*Apsectrotanypus*						X	
Arthropoda	Insecta	Diptera	Chironomidae	*Chironomini*		X					X
Arthropoda	Insecta	Diptera	Chironomidae	*Chironomus*	*calligraphus*	X					
Arthropoda	Insecta	Diptera	Chironomidae	*Chironomus*	*decorus group*				X		
Arthropoda	Insecta	Diptera	Chironomidae	*Chironomus*	*stigmaterus*				X		
Arthropoda	Insecta	Diptera	Chironomidae	*Chironomus*		X		X		X	X
Arthropoda	Insecta	Diptera	Chironomidae	*Cladopelma*		X					X
Arthropoda	Insecta	Diptera	Chironomidae	*Cladotanytarsus*	*cf. daviesi*				X		
Arthropoda	Insecta	Diptera	Chironomidae	*Cladotanytarsus*		X		X	X		X
Arthropoda	Insecta	Diptera	Chironomidae	*Clinotanypus*	*pinguis*	X					
Arthropoda	Insecta	Diptera	Chironomidae	*Clinotanypus*				X		X	X
Arthropoda	Insecta	Diptera	Chironomidae	*Coelotanypus*	*concinnus*						
Arthropoda	Insecta	Diptera	Chironomidae	*Coelotanypus*	*scapularis*						X
Arthropoda	Insecta	Diptera	Chironomidae	*Coelotanypus*	*tricolor*						
Arthropoda	Insecta	Diptera	Chironomidae	*Conchapelopia*		X		X			
Arthropoda	Insecta	Diptera	Chironomidae	*Corynoneura*	*lobata*						
Arthropoda	Insecta	Diptera	Chironomidae	*Corynoneura*	sp.	X					X
Arthropoda	Insecta	Diptera	Chironomidae	*Corynoneura*	sp. B Epler						
Arthropoda	Insecta	Diptera	Chironomidae	*Corynoneura*	sp. D Epler			X			
Arthropoda	Insecta	Diptera	Chironomidae	*Corynoneura*	*taris*						X
Arthropoda	Insecta	Diptera	Chironomidae	*Corynoneura*	*celeripes*						X
Arthropoda	Insecta	Diptera	Chironomidae	*Coryphaeschna*	*ingens*					X	
Arthropoda	Insecta	Diptera	Chironomidae	*Cricotopus*	*bicinctus*	X		X			X
Arthropoda	Insecta	Diptera	Chironomidae	*Cricotopus*	*sylvestris grp.*						

Phylum	Subphylum/ Class/ Subclass	Order/SubClass	Family	Genus	Species	ES&E 1982	BRA Durbin and Lancaster 2003	BRA Lancaster and Durbin 1999	HCSP 2003	FDEP 25020430, 1978-1980	FDEP 25020111, 1971-2000
Arthropoda	Insecta	Diptera	Chironomidae	*Cricotopus*							X
Arthropoda	Insecta	Diptera	Chironomidae	*Cryptochironomus*	*blarina*	X					X
Arthropoda	Insecta	Diptera	Chironomidae	*Cryptochironomus*	*fulvus*	X				X	X
Arthropoda	Insecta	Diptera	Chironomidae	*Cryptochironomus*		X		X	X		X
Arthropoda	Insecta	Diptera	Chironomidae	*Cryptotendipes*	*pseudotener*	X					
Arthropoda	Insecta	Diptera	Chironomidae	*Cryptotendipes*		X			X		X
Arthropoda	Insecta	Diptera	Chironomidae	*Demicryptochironomous*				X	X		
Arthropoda	Insecta	Diptera	Chironomidae	*Dicrotendipes*	*modestus*	X					X
Arthropoda	Insecta	Diptera	Chironomidae	*Dicrotendipes*	*neomodestus*	X					X
Arthropoda	Insecta	Diptera	Chironomidae	*Dicrotendipes*	*nervosus*	X					
Arthropoda	Insecta	Diptera	Chironomidae	*Dicrotendipes*	*simpsoni*				X		
Arthropoda	Insecta	Diptera	Chironomidae	*Dicrotendipes*		X					X
Arthropoda	Insecta	Diptera	Chironomidae	*Einfeldia*	*austini*						X
Arthropoda	Insecta	Diptera	Chironomidae	*Einfeldia*	*natchtocheae*						
Arthropoda	Insecta	Diptera	Chironomidae	*Einfeldia*		X				X	X
Arthropoda	Insecta	Diptera	Chironomidae	*Endochironomus*	*nigricans*	X					
Arthropoda	Insecta	Diptera	Chironomidae	*Endochironomus*	*subtendens*						
Arthropoda	Insecta	Diptera	Chironomidae	*Eukiefferiella*							X
Arthropoda	Insecta	Diptera	Chironomidae	*Fissimentum*							
Arthropoda	Insecta	Diptera	Chironomidae	*Glyptotendipes*	*lobiferous*	X					
Arthropoda	Insecta	Diptera	Chironomidae	*Glyptotendipes*		X				X	
Arthropoda	Insecta	Diptera	Chironomidae	*Goeldichironomus*	*amazonicus*				X		X
Arthropoda	Insecta	Diptera	Chironomidae	*Goeldichironomus*	*carus*						
Arthropoda	Insecta	Diptera	Chironomidae	*Goeldichironomus*	*cf. natans*				X		
Arthropoda	Insecta	Diptera	Chironomidae	*Goeldichironomus*	*fluctans*						
Arthropoda	Insecta	Diptera	Chironomidae	*Goeldichironomus*	*holoprasinus*	X			X		X
Arthropoda	Insecta	Diptera	Chironomidae	*Goeldichironomus*		X					
Arthropoda	Insecta	Diptera	Chironomidae	*Guttipelopia*		X					

Phylum	Subphylum/ Class/ Subclass	Order/SubClass	Family	Genus	Species	ES&E 1982	BRA Durbin and Lancaster 2003	BRA Lancaster and Durbin 1999	HCSP 2003	FDEP 25020430, 1978-1980	FDEP 25020111, 1971-2000
Arthropoda	Insecta	Diptera	Chironomidae	*Harnischia*							X
Arthropoda	Insecta	Diptera	Chironomidae	*Hemerodromia*							
Arthropoda	Insecta	Diptera	Chironomidae	*Hemerodromia*							X
Arthropoda	Insecta	Diptera	Chironomidae	*Kiefferulus*	*dux*	X					
Arthropoda	Insecta	Diptera	Chironomidae	*Kiefferulus*							
Arthropoda	Insecta	Diptera	Chironomidae	*Labrundinia*	*becki*			X			
Arthropoda	Insecta	Diptera	Chironomidae	*Labrundinia*	*johannseni*	X					X
Arthropoda	Insecta	Diptera	Chironomidae	*Labrundinia*	*neopilosella*	X					
Arthropoda	Insecta	Diptera	Chironomidae	*Labrundinia*	*pilosella*			X			X
Arthropoda	Insecta	Diptera	Chironomidae	*Labrundinia*	*virescens*	X					
Arthropoda	Insecta	Diptera	Chironomidae	*Labrundinia*		X					X
Arthropoda	Insecta	Diptera	Chironomidae	*Larsia*	*decolorata*						
Arthropoda	Insecta	Diptera	Chironomidae	*Larsia*		X					
Arthropoda	Insecta	Diptera	Chironomidae	*Larsia*	*lurida*						X
Arthropoda	Insecta	Diptera	Chironomidae	*Limonia*							
Arthropoda	Insecta	Diptera	Chironomidae	*Lopescladius*							X
Arthropoda	Insecta	Diptera	Chironomidae	*Micropsectra*							X
Arthropoda	Insecta	Diptera	Chironomidae	*Microtendipes*							
Arthropoda	Insecta	Diptera	Chironomidae	*Monopelopia*	*boliekae*	X					X
Arthropoda	Insecta	Diptera	Chironomidae	*Nanocladius*	*alternantherae*	X					
Arthropoda	Insecta	Diptera	Chironomidae	*Nanocladius*	*crassicornus*						
Arthropoda	Insecta	Diptera	Chironomidae	*Nanocladius*		X					
Arthropoda	Insecta	Diptera	Chironomidae	*Nilothauma*		X					X
Arthropoda	Insecta	Diptera	Chironomidae	*Nilothauma*	*bicorne*						X
Arthropoda	Insecta	Diptera	Chironomidae	*Odontomyia/Heriodiscus*							X
Arthropoda	Insecta	Diptera	Chironomidae	*Orthocladis*		X					
Arthropoda	Insecta	Diptera	Chironomidae	*Pagastiella*							
Arthropoda	Insecta	Diptera	Chironomidae	*Parachironomus*	*alatus*	X					

Phylum	Subphylum/ Class/ Subclass	Order/SubClass	Family	Genus	Species	ES&E 1982	BRA Durbin and Lancaster 2003	BRA Lancaster and Durbin 1999	HCSP 2003	FDEP 25020430, 1978-1980	FDEP 25020111, 1971-2000
Arthropoda	Insecta	Diptera	Chironomidae	*Parachironomus*	*carinatus*	X					
Arthropoda	Insecta	Diptera	Chironomidae	*Parachironomus*	*directus*						
Arthropoda	Insecta	Diptera	Chironomidae	*Parachironomus*	*schneideri*					X	
Arthropoda	Insecta	Diptera	Chironomidae	*Parachironomus*		X				X	
Arthropoda	Insecta	Diptera	Chironomidae	*Paracladopelma*	*rolli*	X					
Arthropoda	Insecta	Diptera	Chironomidae	*Paracladopelma*						X	
Arthropoda	Insecta	Diptera	Chironomidae	*Parakierlleriella*	*coronata*						
Arthropoda	Insecta	Diptera	Chironomidae	*Paralauterborniella*	*nigrohalteralis*	X					X
Arthropoda	Insecta	Diptera	Chironomidae	*Paratanytarsus*							
Arthropoda	Insecta	Diptera	Chironomidae	*Paratendipes*	*connectens*	X					
Arthropoda	Insecta	Diptera	Chironomidae	*Paratendipes*		X					
Arthropoda	Insecta	Diptera	Chironomidae	*Pedionomus*	*beckae*	X					
Arthropoda	Insecta	Diptera	Chironomidae	*Pentaneura*	*inconspicua (=inculta)*			X	X		X
Arthropoda	Insecta	Diptera	Chironomidae	*Pentaneura*		X					X
Arthropoda	Insecta	Diptera	Chironomidae	*Phaenopsectra*	*obediens grp.* sp.			X			
Arthropoda	Insecta	Diptera	Chironomidae	*Polypedilum*	*convictum*	X					X
Arthropoda	Insecta	Diptera	Chironomidae	*Polypedilum*	*fallax*	X		X			X
Arthropoda	Insecta	Diptera	Chironomidae	*Polypedilum*	*flavum*			X	X		X
Arthropoda	Insecta	Diptera	Chironomidae	*Polypedilum*	*halterale group*	X		X	X		X
Arthropoda	Insecta	Diptera	Chironomidae	*Polypedilum*	*illinoense group*	X		X	X	X	X
Arthropoda	Insecta	Diptera	Chironomidae	*Polypedilum*	*scalaenum group*	X		X	X		X
Arthropoda	Insecta	Diptera	Chironomidae	*Polypedilum*	*trigonus*				X		
Arthropoda	Insecta	Diptera	Chironomidae	*Polypedilum*				X	X		X
Arthropoda	Insecta	Diptera	Chironomidae	*Procladius*		X				X	X
Arthropoda	Insecta	Diptera	Chironomidae	*Psectrocladius*							X
Arthropoda	Insecta	Diptera	Chironomidae	*Psuedochironomus*	*prasinatus*	X					
Arthropoda	Insecta	Diptera	Chironomidae	*Psuedochironomus*							X

Phylum	Subphylum/ Class/ Subclass	Order/SubClass	Family	Genus	Species	ES&E 1982	BRA Durbin and Lancaster 2003	BRA Lancaster and Durbin 1999	HCSP 2003	FDEP 25020430, 1978-1980	FDEP 25020111, 1971-2000
Arthropoda	Insecta	Diptera	Chironomidae	*Psuedosmitta*							
Arthropoda	Insecta	Diptera	Chironomidae	*Rheocricotopus*	*robacki*						
Arthropoda	Insecta	Diptera	Chironomidae	*Rheotanytarsus*	*distinctissimus grp.* sp.			X			X
Arthropoda	Insecta	Diptera	Chironomidae	*Rheotanytarsus*	*exiguus group*			X	X		X
Arthropoda	Insecta	Diptera	Chironomidae	*Rheotanytarsus*	*pellucidus*						
Arthropoda	Insecta	Diptera	Chironomidae	*Rheotanytarsus*	sp	X					X
Arthropoda	Insecta	Diptera	Chironomidae	*Stelechomyia*	*perpulchra*						X
Arthropoda	Insecta	Diptera	Chironomidae	*Stempellina*					X		X
Arthropoda	Insecta	Diptera	Chironomidae	*Stempellinella*				X			X
Arthropoda	Insecta	Diptera	Chironomidae	*Stenochironomus*		X		X	X		X
Arthropoda	Insecta	Diptera	Chironomidae	*Stenochironomus*	*hilaris*					X	X
Arthropoda	Insecta	Diptera	Chironomidae	*Tabanus*				X			
Arthropoda	Insecta	Diptera	Chironomidae	*Tanypus*	*carinatus*	X					
Arthropoda	Insecta	Diptera	Chironomidae	*Tanytarsus*	sp. A			X	X		X
Arthropoda	Insecta	Diptera	Chironomidae	*Tanytarsus*	sp. C Epler			X			X
Arthropoda	Insecta	Diptera	Chironomidae	*Tanytarsus*	sp. D Epler			X			
Arthropoda	Insecta	Diptera	Chironomidae	*Tanytarsus*	sp. F				X		
Arthropoda	Insecta	Diptera	Chironomidae	*Tanytarsus*	sp. G Epler				X		X
Arthropoda	Insecta	Diptera	Chironomidae	*Tanytarsus*	sp. K Epler						X
Arthropoda	Insecta	Diptera	Chironomidae	*Tanytarsus*	sp. L Epler			X	X		X
Arthropoda	Insecta	Diptera	Chironomidae	*Tanytarsus*	sp. M Epler			X			
Arthropoda	Insecta	Diptera	Chironomidae	*Tanytarsus*	sp. O Epler			X	X		
Arthropoda	Insecta	Diptera	Chironomidae	*Tanytarsus*	sp. P Epler			X	X		
Arthropoda	Insecta	Diptera	Chironomidae	*Tanytarsus*	sp. S Epler			X			
Arthropoda	Insecta	Diptera	Chironomidae	*Tanytarsus*	sp. T Epler			X	X		
Arthropoda	Insecta	Diptera	Chironomidae	*Tanytarsus*		X		X	X	X	X
Arthropoda	Insecta	Diptera	Chironomidae	*Thienemanniella*	*xena*			X			

Phylum	Subphylum/ Class/ Subclass	Order/SubClass	Family	Genus	Species	ES&E 1982	BRA Durbin and Lancaster 2003	BRA Lancaster and Durbin 1999	HCSP 2003	FDEP 25020430, 1978-1980	FDEP 25020111, 1971-2000
Arthropoda	Insecta	Diptera	Chironomidae	*Thienemanniella*		X		X	X		X
Arthropoda	Insecta	Diptera	Chironomidae	*Tribelos*	*fuscicorne*			X	X		X
Arthropoda	Insecta	Diptera	Chironomidae	*Tribelos*	*jucundum*						
Arthropoda	Insecta	Diptera	Chironomidae	*Tribelos*		X					X
Arthropoda	Insecta	Diptera	Chironomidae	*Tvetinia*	*vitracies*						
Arthropoda	Insecta	Diptera	Chironomidae	*Xenochironomus*	*xenolabis*					X	X
Arthropoda	Insecta	Diptera	Chironomidae	*Zavreliella*	*marmorata*						
Arthropoda	Insecta	Diptera	Chironomidae				X			X	X
Arthropoda	Insecta	Diptera	Culicidae	*Culex*							X
Arthropoda	Insecta	Diptera	Dolichopodidae			X					
Arthropoda	Insecta	Diptera	Empididae			X					X
Arthropoda	Insecta	Diptera	Ephydridae								X
Arthropoda	Insecta	Diptera	Simuliidae	*Simulium*		X		X	X		X
Arthropoda	Insecta	Diptera	Simuliidae								X
Arthropoda	Insecta	Diptera	Stratiomyidae								X
Arthropoda	Insecta	Diptera	Tabanidae	*Chrysops*		X					
Arthropoda	Insecta	Diptera	Tipulidae	*Megistocera*	*longipennis*				X		
Arthropoda	Insecta	Diptera	Tipulidae	*Megistocera*				X			
Arthropoda	Insecta	Diptera	Tipulidae	*Tipula*		X			X		X
Arthropoda	Insecta	Diptera	Tipulidae				X				
Arthropoda	Insecta	Diptera									X
Arthropoda	Insecta	Ephemeroptera	Baetidae	*Acentrella*	*alachua*						
Arthropoda	Insecta	Ephemeroptera	Baetidae	*Acerpenna*	*pygmaea*			X			
Arthropoda	Insecta	Ephemeroptera	Baetidae	*Baetis*	*intercalaris*	X					X
Arthropoda	Insecta	Ephemeroptera	Baetidae	*Baetis*	*spiethi*	X					X
Arthropoda	Insecta	Ephemeroptera	Baetidae	*Baetis*	*spinosus grp.*	X					X
Arthropoda	Insecta	Ephemeroptera	Baetidae	*Baetis*		X					X
Arthropoda	Insecta	Ephemeroptera	Baetidae	*Baetis*	*ephippiatus*						X

Phylum	Subphylum/ Class/ Subclass	Order/SubClass	Family	Genus	Species	ES&E 1982	BRA Durbin and Lancaster 2003	BRA Lancaster and Durbin 1999	HCSP 2003	FDEP 25020430, 1978-1980	FDEP 25020111, 1971-2000
Arthropoda	Insecta	Ephemeroptera	Baetidae	*Baetis*	*propinquus*						X
Arthropoda	Insecta	Ephemeroptera	Baetidae	*Callibaetis*	*floridanus*	X			X	X	X
Arthropoda	Insecta	Ephemeroptera	Baetidae	*Callibaetis*	*pretiosus*						
Arthropoda	Insecta	Ephemeroptera	Baetidae	*Callibaetis*							X
Arthropoda	Insecta	Ephemeroptera	Baetidae	*Centroptilum*	*viridocularis*	X				X	X
Arthropoda	Insecta	Ephemeroptera	Baetidae	*Centroptilum*							X
Arthropoda	Insecta	Ephemeroptera	Baetidae	*Centroptilum*	*hobbsi*						X
Arthropoda	Insecta	Ephemeroptera	Baetidae	*Labiobaetis*	*propinquus*			X			
Arthropoda	Insecta	Ephemeroptera	Baetidae	*Labiobaetis*							X
Arthropoda	Insecta	Ephemeroptera	Baetidae	*Procloeon*	*hobbsi*						
Arthropoda	Insecta	Ephemeroptera	Baetidae	*Procloeon*	*viridocularis*			X	X		
Arthropoda	Insecta	Ephemeroptera	Baetidae	*Procloeon*							
Arthropoda	Insecta	Ephemeroptera	Baetidae	*Pseudocloeon*	*alachua*	X					X
Arthropoda	Insecta	Ephemeroptera	Baetidae	*Pseudocloeon*	*ephippiatum*						
Arthropoda	Insecta	Ephemeroptera	Baetidae	*Pseudocloeon*	*frondale*						
Arthropoda	Insecta	Ephemeroptera	Baetidae	*Pseudocloeon*	*propinquum*		X		X		
Arthropoda	Insecta	Ephemeroptera	Baetidae	*Pseudocloeon*					X		X
Arthropoda	Insecta	Ephemeroptera	Baetidae					X			X
Arthropoda	Insecta	Ephemeroptera	Caenidae	*Brachycercus*	*maculatus*				X		X
Arthropoda	Insecta	Ephemeroptera	Caenidae	*Brachycercus*							X
Arthropoda	Insecta	Ephemeroptera	Caenidae	*Caenis*	*diminuta*	X	X	X	X	X	X
Arthropoda	Insecta	Ephemeroptera	Caenidae	*Caenis*	*hilaris*				X		X
Arthropoda	Insecta	Ephemeroptera	Caenidae	*Caenis*				X	X		X
Arthropoda	Insecta	Ephemeroptera	Caenidae	*Cercobrachys*	*etowah*						
Arthropoda	Insecta	Ephemeroptera	Ephemerellidae	*Eurylophella*	*doris*			X			
Arthropoda	Insecta	Ephemeroptera	Ephemeridae	*Hexagenia*	*limbata*						
Arthropoda	Insecta	Ephemeroptera	Heptageniidae	*Stenacron*	*interpunctatum*	X				X	X
Arthropoda	Insecta	Ephemeroptera	Heptageniidae	*Stenacron*			X	X	X		

Phylum	Subphylum/ Class/ Subclass	Order/SubClass	Family	Genus	Species	ES&E 1982	BRA Durbin and Lancaster 2003	BRA Lancaster and Durbin 1999	HCSP 2003	FDEP 25020430, 1978-1980	FDEP 25020111, 1971-2000
Arthropoda	Insecta	Ephemeroptera	Heptageniidae	*Stenonema*	*exiguum*	X	X	X	X		X
Arthropoda	Insecta	Ephemeroptera	Heptageniidae	*Stenonema*	*integum*	X					
Arthropoda	Insecta	Ephemeroptera	Heptageniidae	*Stenonema*							X
Arthropoda	Insecta	Ephemeroptera	Heptageniidae	*Stenonema*	*interpunctatum*						X
Arthropoda	Insecta	Ephemeroptera	Heptageniidae	*Stenonema*	*proximum*						X
Arthropoda	Insecta	Ephemeroptera	Leptohyphidae	*Tricorythodes*	*albilineatus*	X			X		X
Arthropoda	Insecta	Ephemeroptera	Leptohyphidae	*Tricorythodes*							X
Arthropoda	Insecta	Ephemeroptera	Leptophlebiidae	*Choroterpes*	*basalis*			X			
Arthropoda	Insecta	Ephemeroptera	Leptophlebiidae	*Choroterpes*	*hubbelli*	X				X	X
Arthropoda	Insecta	Ephemeroptera	Leptophlebiidae	*Choroterpes*					X		
Arthropoda	Insecta	Ephemeroptera	Leptophlebiidae				X	X			
Arthropoda	Insecta	Ephemeroptera									X
Arthropoda	Insecta	Hemiptera	Belostomatidae	*Belostoma*	*lutarium*				X		
Arthropoda	Insecta	Hemiptera	Belostomatidae	*Belostoma*	*testaceum*			X			
Arthropoda	Insecta	Hemiptera	Belostomatidae	*Belostoma*					X		X
Arthropoda	Insecta	Hemiptera	Belostomatidae	*Benacus*		X					
Arthropoda	Insecta	Hemiptera	Corixidae	*Sigara*	*bradleyi*				X		
Arthropoda	Insecta	Hemiptera	Corixidae	*Trichocorixa*	*louisianae*						
Arthropoda	Insecta	Hemiptera	Corixidae	*Trichocorixa*	*naias*	X					
Arthropoda	Insecta	Hemiptera	Corixidae	*Trichocorixa*							X
Arthropoda	Insecta	Hemiptera	Corixidae								X
Arthropoda	Insecta	Hemiptera	Gerridae	*Gerris*		X					
Arthropoda	Insecta	Hemiptera	Gerridae	*Limnoporus*	*canaliculatus*						
Arthropoda	Insecta	Hemiptera	Gerridae	*Metrobates*	*anomalus*			X	X		
Arthropoda	Insecta	Hemiptera	Gerridae	*Metrobates*							X
Arthropoda	Insecta	Hemiptera	Gerridae	*Rhemobates*							
Arthropoda	Insecta	Hemiptera	Gerridae	*Trepobates*	*pictus*						
Arthropoda	Insecta	Hemiptera	Gerridae						X		

Phylum	Subphylum/ Class/ Subclass	Order/SubClass	Family	Genus	Species	ES&E 1982	BRA Durbin and Lancaster 2003	BRA Lancaster and Durbin 1999	HCSP 2003	FDEP 25020430, 1978-1980	FDEP 25020111, 1971-2000
Arthropoda	Insecta	Hemiptera	Homoptera			X					
Arthropoda	Insecta	Hemiptera	Mesoveliidae	*Mesovelia*	*amoena*	X					
Arthropoda	Insecta	Hemiptera	Mesoveliidae	*Mesovelia*	*mulsanti*						
Arthropoda	Insecta	Hemiptera	Mesoveliidae	*Mesovelia*				X			X
Arthropoda	Insecta	Hemiptera	Naucoridae	*Pelocoris*			X		X		X
Arthropoda	Insecta	Hemiptera	Nepidae	*Ranatra*	*australis*		X				
Arthropoda	Insecta	Hemiptera	Nepidae	*Ranatra*		X			X	X	X
Arthropoda	Insecta	Hemiptera	Veliidae	*Microvelia*	*hinei*						
Arthropoda	Insecta	Hemiptera	Veliidae	*Platyvelia*	*brachialis*						
Arthropoda	Insecta	Hemiptera	Veliidae	*Rhagovelia*	*choreutes*						X
Arthropoda	Insecta	Heteroptera	Pleidae	*Paraplea*							
Arthropoda	Insecta	Heteroptera	Pleidae								X
Arthropoda	Insecta	Lepidoptera	Pyralidae	*Acentropus*		X					
Arthropoda	Insecta	Lepidoptera	Pyralidae	*Parapoynx*				X			
Arthropoda	Insecta	Lepidoptera	Pyralidae	*Samea*	*multiplicalis*						
Arthropoda	Insecta	Lepidoptera	Pyralidae						X		
Arthropoda	Insecta	Lepidoptera								X	
Arthropoda	Insecta	Megaloptera	Corydalidae	*Corydalus*	*cornutus*	X			X		X
Arthropoda	Insecta	Megaloptera	Corydalidae	*Corydalus*		X					
Arthropoda	Insecta	Megaloptera	Corydalidae			X					
Arthropoda	Insecta	Neuroptera	Sisyridae	*Climacia*						X	
Arthropoda	Insecta	Odonata	Aeshnidae	*Anax*	*amazili*	X					
Arthropoda	Insecta	Odonata	Aeshnidae	*Anax*	*junius*	X					
Arthropoda	Insecta	Odonata	Aeshnidae	*Boyeria*	*vinosa*	X				X	
Arthropoda	Insecta	Odonata	Aeshnidae	*Nasiaeschna*	*pentacantha*				X	X	X
Arthropoda	Insecta	Odonata	Aeshnidae								X
Arthropoda	Insecta	Odonata	Calopterygidae	*Calopteryx*	*maculata*						
Arthropoda	Insecta	Odonata	Calopterygidae	*Calopteryx*			X	X			

Phylum	Subphylum/ Class/ Subclass	Order/SubClass	Family	Genus	Species	ES&E 1982	BRA Durbin and Lancaster 2003	BRA Lancaster and Durbin 1999	HCSP 2003	FDEP 25020430, 1978-1980	FDEP 25020111, 1971-2000
Arthropoda	Insecta	Odonata	Calopterygidae	*Hetaerina*	*titia*	X			X		X
Arthropoda	Insecta	Odonata	Calopterygidae	*Hetaerina*		X					X
Arthropoda	Insecta	Odonata	Calopterygidae								X
Arthropoda	Insecta	Odonata	Coenagrionidae	*Argia*	*fumipennis*	X				X	X
Arthropoda	Insecta	Odonata	Coenagrionidae	*Argia*	*moesta*	X			X		X
Arthropoda	Insecta	Odonata	Coenagrionidae	*Argia*	*sedula*	X				X	X
Arthropoda	Insecta	Odonata	Coenagrionidae	*Argia*		X		X	X		X
Arthropoda	Insecta	Odonata	Coenagrionidae	*Enallagma*	*cardenium*				X	X	X
Arthropoda	Insecta	Odonata	Coenagrionidae	*Enallagma*	*durum*						
Arthropoda	Insecta	Odonata	Coenagrionidae	*Enallagma*	*pollutum*					X	
Arthropoda	Insecta	Odonata	Coenagrionidae	*Enallagma*	*weewa*						X
Arthropoda	Insecta	Odonata	Coenagrionidae	*Enallagma*			X	X	X		X
Arthropoda	Insecta	Odonata	Coenagrionidae	*Ischnura*	*hastata*						X
Arthropoda	Insecta	Odonata	Coenagrionidae	*Ischnura*	*posita*						
Arthropoda	Insecta	Odonata	Coenagrionidae	*Ischnura*	*ramburri*						
Arthropoda	Insecta	Odonata	Coenagrionidae	*Ischnura*		X			X		X
Arthropoda	Insecta	Odonata	Coenagrionidae	*Nehalennia*							X
Arthropoda	Insecta	Odonata	Coenagrionidae								X
Arthropoda	Insecta	Odonata	Cordulegastridae	*Epitheca*	*sepia*						
Arthropoda	Insecta	Odonata	Cordulegastridae	*Epitheca*		X			X	X	X
Arthropoda	Insecta	Odonata	Cordulegastridae	*Epitheca*	*princeps regina*						X
Arthropoda	Insecta	Odonata	Corduliidae	*Epicordulia*	*princeps regina*						
Arthropoda	Insecta	Odonata	Corduliidae	*Macromia*	*illinoensis*	X					
Arthropoda	Insecta	Odonata	Corduliidae	*Macromia*	*illinoiensis georgina*				X		X
Arthropoda	Insecta	Odonata	Corduliidae	*Macromia*	*taeniolata*			X		X	X
Arthropoda	Insecta	Odonata	Corduliidae	*Macromia*				X	X		X
Arthropoda	Insecta	Odonata	Corduliidae	*Neurocordulia*	*alabamensis*						X
Arthropoda	Insecta	Odonata	Corduliidae	*Neurocordulia*		X	X				X

Phylum	Subphylum/ Class/ Subclass	Order/SubClass	Family	Genus	Species	ES&E 1982	BRA Durbin and Lancaster 2003	BRA Lancaster and Durbin 1999	HCSP 2003	FDEP 25020430, 1978-1980	FDEP 25020111, 1971-2000
Arthropoda	Insecta	Odonata	Gomphidae	*Aphylla*	*williamsoni*		X				
Arthropoda	Insecta	Odonata	Gomphidae	*Aphylla*		X					
Arthropoda	Insecta	Odonata	Gomphidae	*Arigomphus*	*pallidus*						
Arthropoda	Insecta	Odonata	Gomphidae	*Dromogomphus*	*spinosus*	X					X
Arthropoda	Insecta	Odonata	Gomphidae	*Dromogomphus*							X
Arthropoda	Insecta	Odonata	Gomphidae	*Gomphoides*	*obscura*	X					
Arthropoda	Insecta	Odonata	Gomphidae	*Gomphus*	*dilataus*						X
Arthropoda	Insecta	Odonata	Gomphidae	*Gomphus*	*minutus*	X				X	X
Arthropoda	Insecta	Odonata	Gomphidae	*Gomphus*			X	X	X		X
Arthropoda	Insecta	Odonata	Gomphidae	*Gomphus*	*exilis*						X
Arthropoda	Insecta	Odonata	Gomphidae	*Gomphus*	*pallidus*					X	
Arthropoda	Insecta	Odonata	Gomphidae	*Gomphus*	*plagiatus*						X
Arthropoda	Insecta	Odonata	Gomphidae	*Hagenius*	*brevistylus*						X
Arthropoda	Insecta	Odonata	Gomphidae	*Progomphus*	*alachuensis*						X
Arthropoda	Insecta	Odonata	Gomphidae	*Progomphus*							X
Arthropoda	Insecta	Odonata	Gomphidae	*Stylurus*	*plagiatus*						X
Arthropoda	Insecta	Odonata	Gomphidae	*Stylurus*							X
Arthropoda	Insecta	Odonata	Libellulidae	*Celithemus*							
Arthropoda	Insecta	Odonata	Libellulidae	*Epicordulia*	*princeps*	X					X
Arthropoda	Insecta	Odonata	Libellulidae	*Erythemis*	*simplicicollis*	X			X		X
Arthropoda	Insecta	Odonata	Libellulidae	*Erythemis*						X	
Arthropoda	Insecta	Odonata	Libellulidae	*Libellula*	*auripennes*	X					
Arthropoda	Insecta	Odonata	Libellulidae	*Libellula*	*incesta*	X				X	
Arthropoda	Insecta	Odonata	Libellulidae	*Libellula*			X	X	X	X	
Arthropoda	Insecta	Odonata	Libellulidae	*Orthemis*	*ferruginea*						
Arthropoda	Insecta	Odonata	Libellulidae	*Pachydiplax*	*longipennis*	X			X	X	X
Arthropoda	Insecta	Odonata	Libellulidae	*Pachydiplax*							X
Arthropoda	Insecta	Odonata	Libellulidae	*Perithemis*	*tenera seminole*						

Phylum	Subphylum/ Class/ Subclass	Order/SubClass	Family	Genus	Species	ES&E 1982	BRA Durbin and Lancaster 2003	BRA Lancaster and Durbin 1999	HCSP 2003	FDEP 25020430, 1978-1980	FDEP 25020111, 1971-2000
Arthropoda	Insecta	Odonata	Libellulidae	*Perithemis*						X	
Arthropoda	Insecta	Odonata	Libellulidae	*Tauriphila*		X					
Arthropoda	Insecta	Odonata	Libellulidae	*Tramea*	*abdominalis*	X					
Arthropoda	Insecta	Odonata	Libellulidae								X
Arthropoda	Insecta	Odonata									X
Arthropoda	Insecta	Odonta	Libellulidae	*Miathyria*	*marcella*		X				
Arthropoda	Insecta	Symphypleona	Sminthuridae	*Sminthurides*							
Arthropoda	Insecta	Trichoptera	Hydropsychidae	*Cheumatopsyche*		X	X	X	X		X
Arthropoda	Insecta	Trichoptera	Hydropsychidae	*Hydropsyche*	*incommoda*						X
Arthropoda	Insecta	Trichoptera	Hydropsychidae	*Hydropsyche*	*rossi*				X		
Arthropoda	Insecta	Trichoptera	Hydropsychidae	*Hydropsyche*		X			X		X
Arthropoda	Insecta	Trichoptera	Hydropsychidae	*Potamyia*	*flava*	X					
Arthropoda	Insecta	Trichoptera	Hydropsychidae	*Potamyia*		X					
Arthropoda	Insecta	Trichoptera	Hydropsychidae			X					
Arthropoda	Insecta	Trichoptera	Hydroptilidae	*Hydroptila*		X					X
Arthropoda	Insecta	Trichoptera	Hydroptilidae	*Mayatrichia*	*ayama*						
Arthropoda	Insecta	Trichoptera	Hydroptilidae	*Mayatrichia*							X
Arthropoda	Insecta	Trichoptera	Hydroptilidae	*Neotrichia*				X			X
Arthropoda	Insecta	Trichoptera	Hydroptilidae	*Orthotrichia*		X					X
Arthropoda	Insecta	Trichoptera	Hydroptilidae	*Oxyethira*		X		X			X
Arthropoda	Insecta	Trichoptera	Hydroptilidae								X
Arthropoda	Insecta	Trichoptera	Leptoceridae	*Athripsodes*							X
Arthropoda	Insecta	Trichoptera	Leptoceridae	*Ceraclea*	*cancellata*						X
Arthropoda	Insecta	Trichoptera	Leptoceridae	*Ceraclea*	*transversa*						X
Arthropoda	Insecta	Trichoptera	Leptoceridae	*Nectopsyche*	*candida*			X			
Arthropoda	Insecta	Trichoptera	Leptoceridae	*Nectopsyche*	*exquisita*			X	X		X
Arthropoda	Insecta	Trichoptera	Leptoceridae	*Nectopsyche*	*pavida*						X
Arthropoda	Insecta	Trichoptera	Leptoceridae	*Nectopsyche*							X

Phylum	Subphylum/ Class/ Subclass	Order/SubClass	Family	Genus	Species	ES&E 1982	BRA Durbin and Lancaster 2003	BRA Lancaster and Durbin 1999	HCSP 2003	FDEP 25020430, 1978-1980	FDEP 25020111, 1971-2000
Arthropoda	Insecta	Trichoptera	Leptoceridae	*Oecetis*	*cinerascens*						
Arthropoda	Insecta	Trichoptera	Leptoceridae	*Oecetis*	*inconspicua complex*			X	X		X
Arthropoda	Insecta	Trichoptera	Leptoceridae	*Oecetis*	*nocturna*						
Arthropoda	Insecta	Trichoptera	Leptoceridae	*Oecetis*	*persimilis*			X	X		
Arthropoda	Insecta	Trichoptera	Leptoceridae	*Oecetis*		X		X	X		X
Arthropoda	Insecta	Trichoptera	Leptoceridae	*Triaenodes*				X	X		X
Arthropoda	Insecta	Trichoptera	Philopotamidae	*Chimarra*	*florida*				X		
Arthropoda	Insecta	Trichoptera	Philopotamidae	*Chimarra*		X		X	X		X
Arthropoda	Insecta	Trichoptera	Polycentropodidae	*Cernotina*				X			X
Arthropoda	Insecta	Trichoptera	Polycentropodidae	*Cernotina*	*spicata*						X
Arthropoda	Insecta	Trichoptera	Polycentropodidae	*Cyrnellus*	*fraternus*	X		X			X
Arthropoda	Insecta	Trichoptera	Polycentropodidae	*Cyrnellus*	*marginalis*						X
Arthropoda	Insecta	Trichoptera	Polycentropodidae	*Neureclipsis*	*crepuscularis*						
Arthropoda	Insecta	Trichoptera	Polycentropodidae	*Neureclipsis*		X					X
Arthropoda	Insecta	Trichoptera	Polycentropodidae	*Nyctiophylax*	*moestus*						
Arthropoda	Insecta	Trichoptera	Polycentropodidae	*Polycentropus*		X					X
Arthropoda	Insecta	Trichoptera	Polycentropodidae	*Polycentropus*	*cinereus*						X
Arthropoda	Insecta	Trichoptera									X
Arthropoda	Malacostraca	Amphipoda	Gammaridae	*Gammarus*						X	
Cnidaria	Hydrozoa	Hydroida	Hydridae	*Hydra*		X					
Ectoprocta						X					
Mollusca	Bivalvia	Unionoida	Unionidae	*Elliptio*	*buckleyi*	X					X
Mollusca	Bivalvia	Unionoida	Unionidae	*Elliptio*							X
Mollusca	Bivalvia	Unionoida	Unionidae	*Lampsilis*							X
Mollusca	Bivalvia	Unionoida	Unionidae	*Popenaias*	*buckleyi*			X			
Mollusca	Bivalvia	Unionoida	Unionidae	*Uniomerus*	*carolinianus*						
Mollusca	Bivalvia	Unionoida	Unionidae	*Villosa*	*amygdala*						
Mollusca	Bivalvia	Unionoida	Unionidae				X		X		X

Phylum	Subphylum/ Class/ Subclass	Order/SubClass	Family	Genus	Species	ES&E 1982	BRA Durbin and Lancaster 2003	BRA Lancaster and Durbin 1999	HCSP 2003	FDEP 25020430, 1978-1980	FDEP 25020111, 1971-2000
Mollusca	Bivalvia	Veneroida	Corbiculidae	*Corbicula*	*fluminea (=manilensis)*	X	X	X	X		X
Mollusca	Bivalvia	Veneroida	Lucinidae								X
Mollusca	Bivalvia	Veneroida	Pisidiidae	*Eupera*	*cubensis*	X					
Mollusca	Bivalvia	Veneroida	Pisidiidae	*Eupera*						X	
Mollusca	Bivalvia	Veneroida	Pisidiidae	*Musculium*	*lacustre*				X		
Mollusca	Bivalvia	Veneroida	Pisidiidae	*Musculium*	*securis*	X					
Mollusca	Bivalvia	Veneroida	Pisidiidae	*Musculium*				X	X	X	X
Mollusca	Bivalvia	Veneroida	Pisidiidae	*Musculium*	*transversum*					X	
Mollusca	Bivalvia	Veneroida	Pisidiidae	*Pisidium*	*punctiferum*						X
Mollusca	Bivalvia	Veneroida	Pisidiidae	*Pisidium*		X		X	X		X
Mollusca	Bivalvia	Veneroida	Pisidiidae	*Sphaerium*		X				X	X
Mollusca	Bivalvia	Veneroida	Pisidiidae				X				X
Mollusca	Gastropoda	Basommatophora	Ancylidae	*Ferrissia*	*hendersoni*			X			X
Mollusca	Gastropoda	Basommatophora	Ancylidae	*Ferrissia*		X		X			X
Mollusca	Gastropoda	Basommatophora	Ancylidae	*Hebetancylus*	*excentricus*			X	X	X	X
Mollusca	Gastropoda	Basommatophora	Ancylidae	*Laevapex*	*fuscus*						X
Mollusca	Gastropoda	Basommatophora	Ancylidae	*Laevapex*	*peninsulae*						
Mollusca	Gastropoda	Basommatophora	Ancylidae	*Laevapex*		X		X	X		X
Mollusca	Gastropoda	Basommatophora	Ancylidae			X					X
Mollusca	Gastropoda	Basommatophora	Lymnaeidae	*Pseudosuccinea*	*columella*				X		
Mollusca	Gastropoda	Basommatophora	Lymnaeidae	*Pseudosuccinea*		X					X
Mollusca	Gastropoda	Basommatophora	Physidae	*Physa*	*pumilus*	X					
Mollusca	Gastropoda	Basommatophora	Physidae	*Physa*			X		X	X	X
Mollusca	Gastropoda	Basommatophora	Physidae	*Physella*				X			X
Mollusca	Gastropoda	Basommatophora	Physidae	*Physella*	*cubensis*						X
Mollusca	Gastropoda	Basommatophora	Planorbidae	*Gyraulus*	*parvus*						
Mollusca	Gastropoda	Basommatophora	Planorbidae	*Gyraulus*							X

Phylum	Subphylum/ Class/ Subclass	Order/SubClass	Family	Genus	Species	ES&E 1982	BRA Durbin and Lancaster 2003	BRA Lancaster and Durbin 1999	HCSP 2003	FDEP 25020430, 1978-1980	FDEP 25020111, 1971-2000
Mollusca	Gastropoda	Basommatophora	Planorbidae	*Helisoma*						X	X
Mollusca	Gastropoda	Basommatophora	Planorbidae	*Micromenetus*	*dilatatus*			X	X		X
Mollusca	Gastropoda	Basommatophora	Planorbidae	*Micromenetus*	*dilatatus avus*						
Mollusca	Gastropoda	Basommatophora	Planorbidae	*Planorbella*	*duryi*						
Mollusca	Gastropoda	Basommatophora	Planorbidae	*Planorbella*	*trivolvis intertexta*				X		
Mollusca	Gastropoda	Basommatophora	Planorbidae	*Promenetus*		X					X
Mollusca	Gastropoda	Mesogastropoda	Pilidae	*Pomacea*	*paludosa*						X
Mollusca	Gastropoda	Mesogastropoda	Pilidae	*Pomacea*		X					X
Mollusca	Gastropoda	Mesogastropoda	Viviparidae	*Viviparus*	*geogianus*						
Mollusca	Gastropoda	Mesogastropoda	Viviparidae	*Viviparus*							X
Mollusca	Gastropoda	Neotaenioglossa	Bithyniidae								X
Mollusca	Gastropoda	Neotaenioglossa	Hydrobiidae	*Amnicola*		X	X		X		X
Mollusca	Gastropoda	Neotaenioglossa	Hydrobiidae	*Amnicola*	*dalli*						X
Mollusca	Gastropoda	Neotaenioglossa	Hydrobiidae	*Amnicola*	*dalli johnsoni*						X
Mollusca	Gastropoda	Neotaenioglossa	Hydrobiidae	*Pyrogophorus*	*platyrachis*				X		X
Mollusca	Gastropoda	Neotaenioglossa	Hydrobiidae	*Pyrogophorus*							X
Mollusca	Gastropoda	Neotaenioglossa	Hydrobiidae								X
Mollusca	Gastropoda	Neotaenioglossa	Thiaridae	*Melanoides*	*tuberculata*				X		X
Mollusca	Gastropoda										X
Nemata						X					
Nematomorpha	Gordioida										
Nemertea	Enopla	Hoplonemertea	Tetrastemmatidae	*Prostoma*	*graecense*						X
Nemertea	Enopla	Hoplonemertea	Tetrastemmatidae	*Prostoma*	*rubrum*	X					
Nemertea	Enopla	Hoplonemertea	Tetrastemmatidae	*Prostoma*				X			
Platyhelminthes	Turbellaria	Tricladida	Planariidae	*Planaria*							X
Platyhelminthes	Turbellaria					X				X	X
Platyhelminthes	Turbellaria	Tricladida	Planariidae	*Dugesia*				X		X	X
Porifera	Demospongea	Haplosclerida	Spongillidae								
Porifera											X

Appendix D

Fish Species List

for Historical Sampling in the Horse Creek Basin

Order	Family	Genus	Species	Common Name	Alternate Name	HCSP 2003	EPA EIS CF Mining (from ESE 1983), cf Complex II Site, Aug 1981 to Feb 1982				ESE 1982 EIS AMAX pine level mine			
							Horse Creek North	Horse Creek Middle	Horse Creek South	Brushy Creek	Buzzard Roost Branch Station 12	Brandy branch Station 14	HC SR 70 Station 15	HC SR 72 Station 17
Amiiformes	Amiidae	*Amia*	*calva*	bowfin										
Anguilliformes	Anguillidae	*Anguilla*	*rostrata*	American eel										
Atheriniformes	Atherinidae	*Labidesthes*	*sicculus*	brook silverside		X			X		X	X	X	X
Atheriniformes	Cyprinodontidae	*Fundulus*	*chrysotus*	golden topminnow		X								
Atheriniformes	Cyprinodontidae	*Fundulus*	*cingulatus*	redfaced topminnow	*Fundulus rubrifrons*									
Atheriniformes	Cyprinodontidae	*Fundulus*	*seminolis*	Seminole killifish		X					X	X	X	X
Atheriniformes	Cyprinodontidae	*Fundulus*	sp.	minnow sp.				X	X					
Atheriniformes	Cyprinodontidae	*Jordanella*	*floridae*	flagfish		X	X	X	X					
Atheriniformes	Cyprinodontidae	*Lucania*	*goodei*	bluefin killifish		X			X					
Atheriniformes	Poeciliidae	*Gambusia*	*affinis*	mosquitofish	*Gambusia holbrooki*	X	X	X	X	X	X	X	X	
Atheriniformes	Poeciliidae	*Heterandria*	*formosa*	least killifish		X	X	X	X	X				
Atheriniformes	Poeciliidae	*Poecilia*	*latipinna*	sailfin molly		X	X		X	X	X	X	X	X
Clupeiformes	Clupeidae	*Dorosoma*	*cepedianum*	gizzard shad										
Clupeiformes	Clupeidae	*Dorosoma*	*petenese*	threadfin shad										
Cypriniformes	Catostomidae	*Erimyzon*	*oblongus*	creek chubsucker					X					
Cypriniformes	Catostomidae	*Erimyzon*	*sucetta*	lake chubsucker		X								
Cypriniformes	Cobititae	*Misgurnus*	*anguilllicaudatus*	oriental weatherfish		X								
Cypriniformes	Cyprinidae	*Notemigonus*	*crysoleucas*	golden shiner					X					
Cypriniformes	Cyprinidae	*Notropis*	*chalybaeus*	ironcolor shiner										
Cypriniformes	Cyprinidae	*Notropis*	*maculatus*	taillight shiner		X							X	X
Cypriniformes	Cyprinidae	*Notropis*	*petersoni*	coastal shiner		X					X		X	X
Perciformes	Centrarchidae	*Chaenobryttus*	*gulosus*	warmouth	*Lepomis gulosus*	X			X				X	
Perciformes	Centrarchidae	*Enneacanthus*	*gloriosus*	bluespotted sunfish		X								
Perciformes	Centrarchidae	*Lepomis*	*auritus*	redbreast sunfish										
Perciformes	Centrarchidae	*Lepomis*	*macrochirus*	bluegill		X			X			X		
Perciformes	Centrarchidae	*Lepomis*	*marginatus*	dollar sunfish					X					X
Perciformes	Centrarchidae	*Lepomis*	*microlophus*	redear sunfish		X					X	X		X

Order	Family	Genus	Species	Common Name	Alternate Name	HCSP 2003	EPA EIS CF Mining (from ESE 1983), cf Complex II Site, Aug 1981 to Feb 1982				ESE 1982 EIS AMAX pine level mine			
							Horse Creek North	Horse Creek Middle	Horse Creek South	Brushy Creek	Buzzard Roost Branch Station 12	Brandy branch Station 14	HC SR 70 Station 15	HC SR 72 Station 17
Perciformes	Centrarchidae	*Lepomis*	*punctatus*	spotted sunfish		X								
Perciformes	Centrarchidae	*Lepomis*	sp.	sunfish sp.					X				X	
Perciformes	Centrarchidae	*Micropterus*	*salmoides*	largemouth bass		X			X		X	X	X	X
Perciformes	Centrarchidae	*Pomoxis*	*nigromaculatus*	black crappie										
Perciformes	Cichlidae	*Hemichromis*	*letourneauxi*	African jewelfish		X								
Perciformes	Cichlidae	*Oreochromis*	*aurea*	blue tilapia	*Tilapia aurea*									
Perciformes	Elassomatidae	*Elassoma*	*evergladei*	Everglades pygmy sunfish		X	X		X					
Perciformes	Percidae	*Etheostoma*	*fusiforme*	swamp darter		X								
Percopsiformes	Aphredoderidae	*Aphredoderus*	*sayanus*	pirate perch										
Pleuronectiformes	Soleidae	*Trinectes*	*maculatus*	hogchoker		X							X	X
Salmoniformes	Esocidae	*Esox*	*americanus*	redfin pickerel										
Salmoniformes	Esocidae	*Esox*	*niger*	chain pickerel										
Semionotiformes	Lepisosteidae	*Lepisosteus*	*osseus*	longnose gar		X								
Semionotiformes	Lepisosteidae	*Lepisosteus*	*platyrhincus*	Florida gar		X								
Siluriformes	Callichtyidae	*Hoplosternum*	*littorale*	brown hoplo										
Siluriformes	Clariidae	*Clarias*	*batrachus*	walking catfish		X								
Siluriformes	Ictaluridae	*Ameiurus*	*natalis*	yellow bullhead	*Ictalurus natalis*	X			X					
Siluriformes	Ictaluridae	*Ameiurus*	*nebulosus*	brown bullhead	*Ictalurus nebulosus*	X			X					
Siluriformes	Ictaluridae	*Ictalurus*	*punctatus*	channel catfish		X								
Siluriformes	Ictaluridae	*Noturus*	*gyrinus*	tadpole madtom		X	X							
Siluriformes	Loricariidae	*Hypostomus*	*plecostomus*	suckermouth catfish										
Siluriformes	Loricariidae	*Pterygoplichthys*	*multirandians*	sailfin catfish		X								
					TOTAL TAXA:	**30**	**6**	**4**	**17**	**3**	**7**	**7**	**10**	**9**