HORSE CREEK STEWARDSHIP PROGRAM
HARDEE AND DESOTO COUNTIES, FLORIDA

2018 ANNUAL REPORT

Prepared for:

Mosaic

May 2020

Prepared by:

FLATWOODS
Consulting Group

8306 Laurel Fair Circle•Suite 120
Tampa, FL 33610•813-600-5747

Eesa G. Ali
Senior Water Quality Resource Analyst

Shannon M. Gonzalez
Senior Ecologist/Principal

EXECUTIVE SUMMARY

Introduction

This is the sixteenth annual report summarizing the status of the Horse Creek Stewardship Program (HCSP).

Background

Mining has been conducted in the Upper Horse Creek Basin for a number of years. Before the HCSP was implemented, some 12,000 acres had been mined. The Horse Creek Basin also is the home of substantial agricultural and other active land uses. In 2003, after a series of legal challenges to required mining permits, Mosaic Fertilizer, LLC (Mosaic) and the Peace River Manasota Regional Water Supply Authority (PRMRWSA) executed a settlement agreement to ensure that mining would not have negative impacts on Horse Creek, a major tributary of the Peace River, as a result of proposed mining activities by Mosaic in eastern Manatee and western Hardee Counties, Florida. A principal component of the agreement was the creation of the 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 or 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 the 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.

The program is limited to the investigation of the potential impacts of Mosaic's mining activities on the Horse Creek Basin and is not intended to investigate the potential impacts of other land uses or mining activities by other entities.

This program offers additional protection to Horse Creek; this protection is not usually present in the vast majority of regulatory scenarios.

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 any 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.

Monitoring for the HCSP began in April 2003, and this report presents the results of the entire 16 years of monitoring.

Mining and Reclamation

At the time the HCSP was initiated, some 12,000 acres of land in the Upper Horse Creek Basin had already been mined. From 2003 to 2017, about 4,103 additional acres were mined in the Horse Creek Basin upstream of the northernmost monitoring location, and an additional 1,856 acres were mined in the Brushy Creek basin upstream of two sampling stations, BCSW-1 and HCSW-2. In 2018, 162 additional acres were mined in the Horse Creek Basin upstream of the northernmost monitoring location, and an additional 282 acres were mined in the Brushy Creek basin upstream of BCSW-1 and HCSW-2. Reclamation in 2018 included 80 acres reclaimed to final contour in the Horse Creek basin and 223 acres in the Brushy Creek basin, as well as 94 and 42 acres reconnected in the Horse Creek and Brushy Creek basins respectively.

Monitoring Program Components

Four locations on Horse Creek were monitored for physical, chemical, and biological parameters; two of these sites are also long-term US Geological Survey (USGS) gauging stations.

- **Water quantity data** were collected continuously from the USGS gauging stations at two HCSP sampling stations, HCSW-1 and HCSW-4.
  Rainfall data were collected daily from three Mosaic rain gauges located in the Horse Creek Basin.
- **Water quality data** were collected during monthly sampling events at HCSP stations 1 to 4, continuously from one Horse Creek location (HCSW-1), and at all four stations during biological sampling events.
- **Biological (fish and benthic macroinvertebrates) sampling events** are scheduled to occur three times each year.

Water Quantity Results

As detailed below and in the report, the data show that there is no evidence that mining and reclamation activities in the basin caused any statistically significant decrease in total streamflow over the period of record – from 1978 to 2018.

The annual average daily streamflow at Horse Creek in 2018 at both HCSW-1 (59 cfs) and HCSW-4 (267 cfs) was above the long-term annual averages[1] of 32 and 191 cfs, respectively. Historical USGS flow records go back to mid-1977 at HCSW-1 and 1951 at HCSW-4. A ranking of annual average flows between 1978 and 2018 places 2018 as 2nd highest at HCSW-1 and 9th at HCSW-4; or 2nd and 3rd highest during the HCSP period (2003-2018).

Annual rainfall of 67.1 inches in 2018 was above the long-term average annual rainfall of 54 inches (1908-2018)[2]. A ranking of annual average rainfall for the period of record (1908-2018) NOAA (National Oceanic and Atmospheric Administration) stations in the Horse Creek watershed places 2018 as the 11th highest year; and 3rd highest during the HCSP period.

National Pollutant Discharge Elimination System (NPDES) discharge occurred for 115 days uninterrupted in 2018, between June 14th and October 6th. NPDES discharge from the Horse Creek outfalls usually does not occur until sufficient water storage accumulates in the circulation system, resulting in a lag. It appears that a wet 2017 and early 2018 contributed to a relatively shorter lag in summer of 2018.

There is no evidence that mining and reclamation activities in the basin caused any statistically significant decrease in total streamflow over the period of record (1978 to 2018), according to the double mass curve analysis. In a previous study (Robbins and Durbin 2011) that compared streamflow during dry years in reference and potentially impacted streams before and during phosphate mining, there was no evidence that phosphate mining practices caused lower monthly flows in the potentially impacted streams (including Horse Creek) than what would be expected given the conditions in a reference stream (Charlie Creek).

Water Quality Results

As detailed below and in the report, water quality data continue to show that there is no evidence that mining and reclamation activities in the basin are causing or contributing to adverse water quality changes in Horse Creek.

Water quality parameters in 2018 were almost always within the desirable range relative to trigger levels and water quality standards at the station with the highest percent of upstream mined lands (HCSW-1). Alkalinity was the only parameter above the trigger level at HCSW-1 during 2018, but the exceedance did not occur during an NPDES discharge.

Monthly sampling found one total ammonia and five Dissolved Oxygen (DO) percent saturation exceedances at HCSW-2 between May and November. HCSW-2 has historically had trigger level exceedances related to chlorophyll-a, nutrients, and, dissolved oxygen. These three parameters point to the same phenomenon which is eutrophication. Previous annual reports have indicated that HCSW-2 receives coarse organic material (nutrient source) from an upstream prairie. This added nutrient content is compounded by less flushing and an increased residence time due to the

---

[1] Long-term annual average of daily streamflow calculated for 1978 to 2018 for HCSW-1 and 1951 to 2018 for HCSW-4 using USGS gauging stations.

[2] Historical rainfall information came from the following stations and years: 1908 to 1943 NOAA station 148, 1944 to 2018 average of NOAA station 148 and 336.

impoundment upstream caused by a farm road crossing with above grade culverts. HCSW-2 is the only HCSP site with a mucky bottom. It is also the site with the least number of samples historically due to regular low and no-flow conditions.

There were six trigger-level exceedances at HCSW-3: DO (2), ammonia (1), Total Dissolved Solids (TDS) (2), and sulfate (1). There were eleven exceedances at HCSW-4: calcium (1), dissolved iron (6), TDS (2), ammonia (1) and sulfate (1). An impact assessment was conducted and found that the elevated dissolved ions (TDS, calcium, and sulfate) were isolated to sites HCSW-3 and HCSW-4 as well as tributaries to Horse Creek in the vicinity of the two sites (Appendix I). These tributaries that contributed to elevated dissolved solids were all draining land being utilized for agriculture. The six dissolved iron trigger-level exceedances at HCSW-4 were not elevated above values from the upstream sampling sites. HCSW-1 – HCSW-3's dissolved iron trigger-level is 1 mg/L whereas HCSW-4's trigger-level is 0.3 mg/L.

Fourteen water quality parameters showed statistically significant increasing or decreasing trends in 2018 at HCSW-1 or HCSW-4. Several of the trends detected during the statistical analysis either have an estimated slope that 1) was not in the direction of an adverse trend (dissolved oxygen saturation, color, chlorophyll-a, combine radium, and dissolved iron) or 2) was very small compared to the observed differences between primary and duplicate field samples (pH, turbidity, Total Kjeldahl Nitrogen (TKN), and fluoride).

Specific conductivity, TDS, calcium, and sulfate had reported trends with higher estimated rates of change. The potential trend for specific conductivity (with reference to TDS and other ions) was discussed in Appendix I of the 2017 annual report. That 2017 discussion indicated that the phenomenon of increasing specific conductivity was occurring regionally in streams with or without mining, before the HCSP program, at sites upstream of the HCSP sites, and, despite trends, the sites were meeting primary drinking and Class III water quality standards.

Benthic Macroinvertebrate Results

As detailed below and in the report, the data show that mining and reclamation activities in the basin are not having an adverse impact on the diversity or numbers of benthic macroinvertebrates, and in fact the 2018 data show that overall diversity was the second highest since 2003. Benthic macroinvertebrates are small aquatic animals and aquatic larval stages of insects that are large enough to see with the naked eye, have no backbone, and are found in and around water bodies during some period of their lives. They live among stones, logs, sediments and aquatic plants on the bottom of streams, rivers and lakes.

Habitat assessment scores ranged from 74 (marginal) to 116 (sub-optimal) at all stations in 2018, which is typical of previous scores for the HCSP. There has been a considerable drop in available quality habitat at sites HCSW-1, HCSW-3, and HCSW-4 due to bank erosion and resulting sand smothering. Despite this, Stream Condition Index (SCI) scores at the three stations remain above 35; Station HCSW-2 had two SCI sampling events with scores below 35, similar to past scores because of unique, natural upstream conditions (Horse Creek Prairie).

Benthic invertebrate taxa diversity and SCI metrics in Horse Creek exhibited both seasonal and year-to-year variation. Overall, taxa diversity indices and SCI metrics show few monotonic trends over time and are very similar between sampling events and stations. However, HCSW-2 has lower SCI scores than other stations (long term average of 32 compared to 60-65) because of natural conditions. Natural habitat conditions at HCSW-2 include lower dissolved oxygen, and lower pH than other Horse Creek stations; these conditions are related to the station experiencing regular low or no-flow conditions, increased residence time, the upstream impoundment, and the presence of Horse Creek Prairie, the large marsh located upstream of the biological sampling station.

Fish Results

As detailed below and in the report, the fish sampling data illustrate that there is no evidence that mining and reclamation activities in the basin are causing any decrease in fish taxa richness abundance or diversity. 2018 data showed the 3rd highest diversity score over the sixteen-year period at both the site closest to the outfall (HCSW-1) and across all four sites combined. When sampling dates were combined, HCSW-1 is also the most species diverse site.

Conclusions

As detailed in the report, sixteen years of sampling data illustrate that mining and reclamation activities in the basin have not caused or contributed to reduced water quantity, deterioration of water quality, or reduction quantity or diversity of benthic macroinvertebrates or fish populations.

This report covers the sixteenth year of an ongoing monitoring program, where some general conclusions can be drawn. Expected relationships between rainfall, runoff and streamflow were observed in the 2003 to 2018 water quantity data. Program trigger levels were exceeded for seven parameters in 2018 and fourteen parameters had statistically significant trends from 2003 to 2018, but the exceedances and trends are not related to mining operations (Appendix I). The benthic macroinvertebrate and fish communities found in Horse Creek in 2003 to 2018 were typical of those found in a Southwest Florida stream.

Contents

Appendices

Tables

Figures

1.0 INTRODUCTION

As a result of proposed mining operations by Mosaic Fertilizer, LLC (Mosaic) in eastern Manatee and western Hardee Counties, Florida, and a series of legal challenges to the permits required for such mining, Mosaic and 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 the physical, chemical, and biological characteristics of Horse Creek during Mosaic's mining activities in the watershed (Figure 1-1). This information would then allow the ability 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 program is limited to the investigation of the potential impact of Mosaic mining activities on the Horse Creek Basin and is not intended to investigate the potential impacts of other land uses or mining activities by other entities.

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 does 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 is 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 US 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 HCSW-1, 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[3]
- 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.

---

[3] In 2009, the list of parameters was reduced by three (total amines, total fatty acids, and FL-PRO were removed), and an additional station on Brushy Creek (tributary of Horse Creek) was added.

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 previously mined. From 2003 to 2018, about 4,265 acres were mined (by Mosaic or legacy CF Industries operations) in the Horse Creek Basin upstream of the northernmost monitoring location, and an additional 2,138 acres were mined in the Brushy Creek basin upstream of BCSW-1 and HCSW-2. Water quantity data are collected essentially continuously, water quality data are collected monthly, and biological data (fish and benthic macroinvertebrates) are collected three times annually (March to April, July to September, and October to December). 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 report, which is the sixteenth in a series of Annual Reports, presents the results of monitoring conducted from April 2003 through December 2018. All data presented in tables and figures was collected as part of the HCSP unless otherwise noted. Additional sources of data since 1990 have also been included in the box plots to provide a short historical perspective (Appendix C). A separate HCSP historical report (Durbin and Raymond 2006) contains a review and summary of all available historical water quality and biological information for Horse Creek.

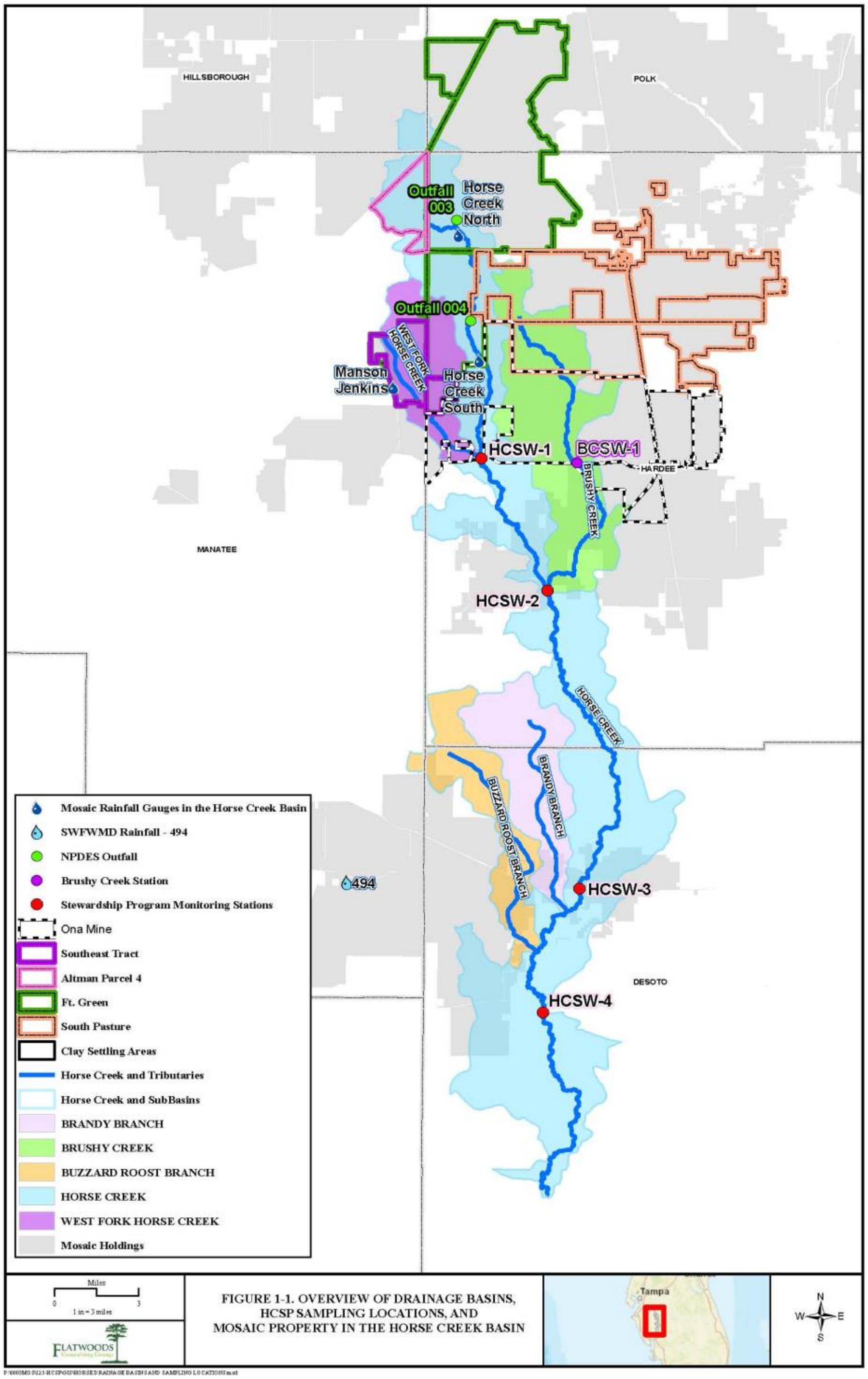


Figure 1-1 **Overview of drainage basins, HCSP sampling locations, and Mosaic property in the Horse Creek Basin**

2.0 DESCRIPTION OF THE HORSE CREEK BASIN

The Horse Creek basin is located in five counties of South-Central Florida: Hillsborough, Polk, Manatee, Hardee, and DeSoto, with the majority of the watershed spanning portions of western Hardee and DeSoto Counties (Figures 1-1 and 2-1). Horse Creek is a major tributary of the Peace River that drains into the southwestern portion of the Peace River Basin and supplies approximately 15 percent of the surface water runoff to the Peace River (Lewelling 1997).

The basin occupies some 241 square miles, and the length of the channel is approximately 43 miles. Horse Creek has 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, at least partially channelized, and have relatively rapid flows (Lewelling 1997). The remaining tributaries, occupying 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).

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 feet in the north to 30 feet in the south near the confluence of Horse Creek and the Peace River. The 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 National Geodetic Vertical Datum (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 enters the Peace River, the Gulf Coast Lowlands range in elevation from about 30 to 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 to 40 inches and are loamy below. The extreme northern basin of Horse Creek contains isolated areas of the Arents-Hydraquents-Neilhurst soils group, parts of 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 feet above present sea level (Cowherd et al. 1989). 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 to 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).

The climate of Horse Creek Basin is subtropical and humid with an average temperature of about 72ºF. Summer temperatures average 80ºF, and winter temperatures average 60ºF (Hammett, 1990). The average daily temperatures in Hardee County, in the northern Horse Creek Basin, range from 52ºF to 91ºF (Robbins et al. 1984). The average daily temperatures in DeSoto County, in the southern Horse Creek Basin, range from 49ºF to 92ºF. 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 (Cowherd et al. 1989).

The average annual rainfall in the Peace River Basin, which includes Horse Creek, is 54 inches, with more than half of that falling during localized thundershowers in the wet season (June to September)[4]. Rain during fall, winter, and spring is usually the result of large, broad frontal systems instead of local storms. November is typically the driest month of the year, averaging 1.75 inches over the historical period from 1908 to 2018. The months of December and January are also characteristically dry, averaging 1.9 and 2.2 inches, respectively. Dry conditions coincide with high evaporation rates and generally result in the lowest stream flows, lake stages, and ground-water levels of the year (Hammett, 1990). The wettest months of the year are typically August and June, each averaging 8.5 inches.

Horse Creek flows through a generally rural area. Major land use activities in the basin are primarily agricultural, with extractive mining activities occurring in the northern part of the 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 portion of the basin, Limestone, Lily, and Edgeville in the approximate center of the basin, and Arcadia, Fort Ogden and Nocatee near the southern end of the basin (Post et al. 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).

Total acreages in each land cover type and proportions of the various land uses differ between regions of the basin. The percent mining cover has increased between 1988 and 2009, according to Southwest Florida Water Management District (SWFWMD) land use maps for those years. The majority of land newly identified as mined in 2009 SWFWMD land use was agricultural or rangeland in 1988. Mining is the primary land use above State Road 64, but the percentage of land devoted to mining decreases rapidly downstream. Agricultural land use more than doubles in acreage from above County Road 663 (HCSW-2) to above SR 72 (HCSW-4). Rangeland covers about the same percentage of land in the northern part of the basin and in the southern portion. The percent upland forest and wetland cover also remains relatively constant in upstream and downstream sections of Horse Creek. Land use changes between 2009 and 2011 SWFWMD maps were very minor, with only 2% of the area upstream of State Road 64 or upstream of County Road 663 converted from agricultural or natural land use to mining or reclamation land use.

---

[4] Historical rainfall information came from the following stations and years: 1908-1943 NOAA station 148, 1944 to 2018 average of NOAA station 148 and 336.

Water quality sampling on Brushy Creek was added to the HCSP in 2009. Land use in 2009 in the Brushy Creek basin is primarily agricultural (38%), with a relatively small percentage of mining (6%) compared to Horse Creek above State Road 64 or County Road 663. Overall, the Brushy Creek basin has a similar percentage of rangeland (15%), upland forest (13%), and wetland (29%) land use as the Horse Creek Basin. Land use changes between 2009 and 2011 SWFWMD maps were very minor, with only 3% of the area within the Brushy Creek basin converted from agricultural or natural land use to mining or reclamation land use.

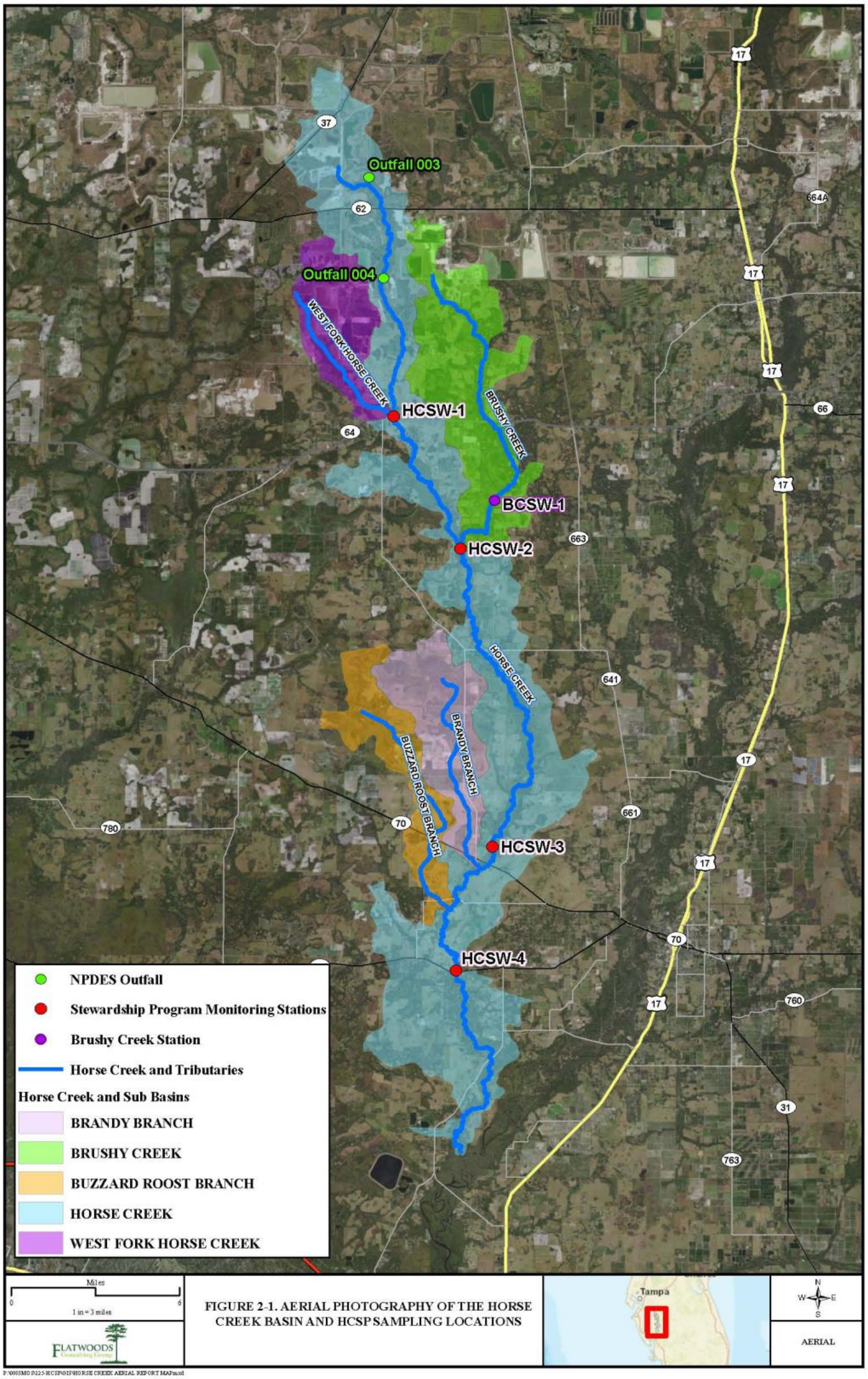


Figure 2-1 Aerial photograph of the Horse Creek Basin and the HCSP sampling locations

3.0 SUMMARY OF MINING AND RECLAMATION ACTIVITIES

3.1 Mining

Mining activities in the Horse Creek basin have occurred on two mines: Fort Green Mine (operated by Mosaic, previously International Minerals and Chemicals (IMC)) and South Pasture Mine (operated by Mosaic, previously CF Industries). A summary of all mining and reclamation activities from 2004 to 2018 is provided below in Table 3-1. Beginning in 2015, annual reports contained revised information when legacy CF Industries holdings became part of Mosaic (table 3-1 was updated with acres mined at South Pasture in Horse Creek and Brushy Creek basins, from 2004 to 2015). Total acres mined, reclaimed, and reconnected in each basin may be different in earlier reports. Information on pre-mining conditions in the Horse Creek Basin may be found in an Environmental Impact Statement prepared by Environmental Science and Engineering, Inc. (1982) and a Development of Regional Impact statement prepared by Ardaman and Associates and colleagues (1979).

Table 3-1 Total acres minded, reclaimed to final contour, and reconnected by Mosaic in the Horse Creek and Brushy Creek Basins from 2004 to 2018

Year	Acres Mined		Acres Reclaimed to Final Contour		Acres Reconnected	
	Horse Creek	Brushy Creek	Horse Creek	Brushy Creek	Horse Creek	Brushy Creek
2004	638	0	30	0	0	0
2005	590	169	205	0	38	0
2006	187	17	0	0	205	0
2007	0	146	106	42	0	0
2008	150	187	245	0	66	0
2009	137	16	711	95	315	0
2010	283	220	270	91	0	0
2011	100	164	114	12	0	0
2012	76	153	600	63	0	0
2013	198	96	71	85	0	0
2014	112	113	98	96	0	0
2015	378	126	318	81	793	183
2016	219	209	162	0	138	0
2017	183	236	396	73	125	0
2018	162	282	80	223	94	42
Total	**3413**	**2134**	**3406**	**861**	**1774**	**225**

There are four clay settling areas (CSAs) in the Horse Creek Basin at the Fort Green Mine (Figure 3-1). The FGH-3 clay settling area is located predominantly in Sections 5, 8, and 9, T33S, R23E. Construction of clay settling area FGH-3 was completed in 1999, and it was immediately put into service. The settling area was designed by Ardaman & Associates with a crest elevation of 151 feet NGVD, and a final pool elevation of 146 feet NGVD. The effective area of the CSA is approximately 933 acres. Clays are introduced into the settling area approximately midway on the east wall. Three decant spillways, two on the west wall and one on the north wall, were designed to return water to the Ft. Green plant. Flow can also be directed to the south, using the FTG-003 outfall, through spillways located in the return water ditch near the southwest corner of FGH-3. As of 2012, water from FGH-3 was sent either north to Four Corners to use in the mining process, or northeast out of the FTG-002 outfall to Payne Creek.

The FGH-4 clay settling area is located predominantly in Section 31, T33S, R23E. Construction of the CSA was completed in 2001, and it was put into service shortly thereafter. The settling area was designed by Ardaman & Associates with a crest elevation of 164.0 feet NGVD, and a final pool elevation of 159.0 feet NGVD. The effective area of the CSA is approximately 415 acres. Two decant spillways, one on the north wall, and one on the south wall were designed to return water to the Ft. Green central screening station (the smaller beneficiation plant located on SR39). Decant spillways located in the south return water ditch also have the capability of discharging water to the WIN-004 outfall. Clay slurry is introduced into the settling area at the southwest corner, and at a point approximately midway on the west wall of the dam. The settling area is also used to store mine pit water, which is pumped in at the northwest corner and at approximately the center of the south wall.

The third settling area, Fort Green Manatee-1 (FM-1) is located predominately in Section 1, T34S, R22E. FM-1 was constructed in 2006 to 2007 and put into service in March 2009. The settling area was designed by Ardaman and Associates with a crest elevation of 164 feet NGVD and a final pool elevation of 159 feet NGVD. The effective area of the CSA is approximately 350 acres. Two decant spillways, both located on the west wall of the dam, are designed to return water to a holding area at the base of the dam, which is then pumped via pipeline back to the Wingate Creek Mine. Water from this dam can also be routed via a series of pumps and surface water conveyance ditches to the WIN-004 outfall; thus, discharges from the clay settling area can be routed to either the Myakka or Horse Creek basins.

The fourth settling area, Fort Green Manatee-2 (FM-2) is located predominately in Section 12, T34S, R22E. FM-2 was constructed from 2013 to 2014 and put into service in July 2013 for below grade storage. The settling area was designed by AMEC with a crest elevation of 164 feet NGVD and a final pool elevation of 159 feet NGVD. The effective area of the CSA is approximately 426 acres. Two decant spillways, both located on the west wall of the dam, are designed to return water to a holding area at the base of the dam, which is then pumped via pipeline back to the Wingate Creek Mine. Water from this dam can also be routed via a series of pumps and surface water conveyance ditches to the WIN-004 outfall; thus, discharges from the clay settling area can be routed to either the Myakka or Horse Creek basins.

In an electronic submittal, “Proposed Modifications to Monitoring Methodology”, dated October 31, 2013, the previous methodologies utilized to monitor the FM-1 clay settling area were outlined, as a part of the 2003 settlement agreement between Mosaic and PRMRWSA. That submittal described historic issues encountered with the telemetric fluid level monitoring equipment, summarized the findings of Florida Engineering and Design’s (“FED”) letter report dated July 17, 2013, “Breach Discharge Analysis, Clay Settling Area FM-2”, and recommended discontinuing the existing telemetry monitoring in favor of reliance on already existing inspection and notification protocols found in the National Pollutant Discharge Elimination System (NPDES) permits and Florida Department of Environmental Protection (FDEP) rule criteria.

In response to this submittal, representatives from PRMRWSA indicated that they did not agree with relying solely on inspections. As an alternative, Mosaic then suggested using turbidity monitoring at the existing Horse Creek station (HCSW-1) located at Horse Creek and State Road 64 for the purposes of providing continuous monitoring of a potential dam breach, since this location is downstream of all currently operational clay settling areas in the Horse Creek basin and real time monitoring equipment was already in place at that location. In subsequent discussions, the Authority indicated that this approach might prove acceptable, but requested that Mosaic develop a specific proposal to utilize turbidity monitoring in lieu of the continuous level monitoring before granting approval.

Mosaic presented a monitoring proposal utilizing rolling averages of continuously measured turbidity values at this location, with a set point of 150 Nephelometric Turbidity Units (NTU). This set point was based on a review of historic data at the station and was selected to be sensitive enough to detect any potential turbidity excursions that might result from an upstream dam breach, but not so sensitive as to result in a number of false positives. Based on that set point, telemetric equipment would send text message and email alerts in two instances; the first, when the 3-hour rolling average exceeds the set point, and a second when the 6-hour rolling average exceeds the set point, with the 3-hour alert being sent to Mosaic representatives only, and the 6-hour alert sent to both Mosaic and PRMRWSA representatives. Three-hour alerts would trigger Mosaic investigation of the source of the high turbidity in the creek, and necessary follow-up with PRMRWSA staff in the event that the cause of the alarm was associated with a dam breach or other significant upset condition at Mosaic's operations. This alert system has since been modified due to the high incidence of false alarms. As of February 13, 2019, notifications are sent out to both Mosaic and the TAG after twelve consecutive reading of >150 NTU and is listed in Appendix B, change number 14.

3.2 Reclamation

Reclamation of Mosaic's mined lands is an ongoing process in the Horse Creek Basin. The reclamation process consists of a combination of backfilling, moving overburden to the required final contours, phased re-planting of both upland and wetland communities, and periodic compliance monitoring of hydrology and replanting success. In general, reclamation can take up to three years to meet applicable criteria for herbaceous wetlands and up to 15 years to meet applicable criteria for forested wetlands. The number of acres reclaimed to the final contour and the acres reconnected to Horse Creek are summarized in Table 3-1 and Figure 3-1.

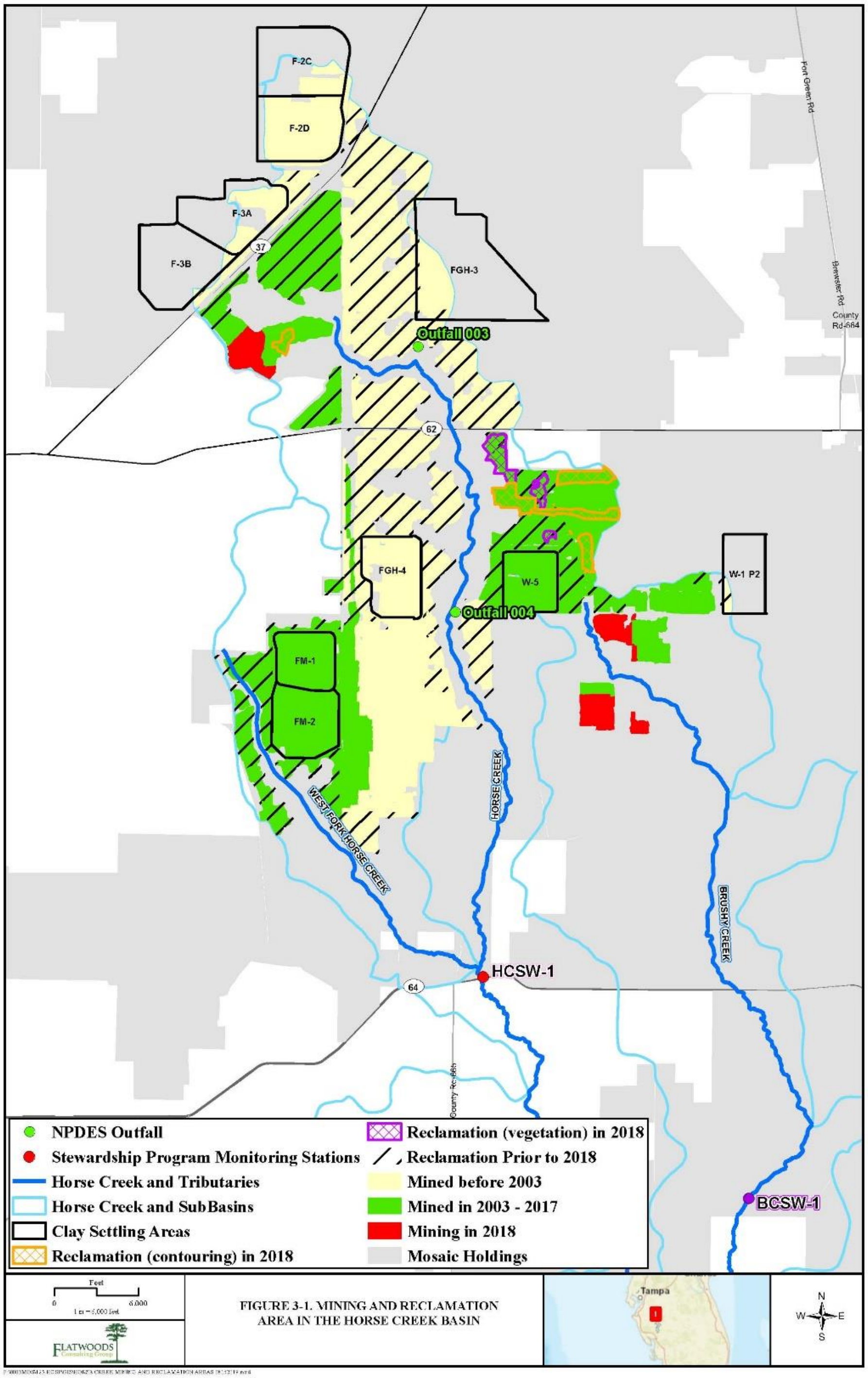


Figure 3-1 **Mining and reclamation areas in the Horse Creek Basin.**

4.0 METHODS

4.1 Station Locations and Sampling Schedule

Four Horse Creek locations are monitored for physical, chemical, and biological parameters (Figure 1-1):

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 (also known as Horse Creek at Wuthrich Road)
HCSW-4 - Horse Creek at State Road 72 (USGS Station 02297310)

As indicated above, HCSW-1 and HCSW-4 are also long-term USGS gauging stations, with essentially continuous stage and discharge records since 1977 and 1950, respectively. Water quality sampling has been conducted monthly beginning in April 2003, while biological sampling events have been conducted typically three times per year (Table 4-1).

In September 2009, based on recommendations of the PRMRWSA and the Technical Advisory Group (TAG), Mosaic began sampling water quality at an additional station on Brushy Creek (BCSW-1 at Post Plant Road). Brushy Creek is a tributary to Horse Creek and flows into Horse Creek between the HCSW-1 and HCSW-2 sampling stations.

This additional station was added for comparison purposes and will not be evaluated against the HCSP trigger levels and exceedances and because Mosaic does not have a NPDES discharge on Brushy Creek. The Brushy Creek location is also not included in the macroinvertebrate or fish sampling components of the program. In September 2009, Mosaic also discontinued water quality analysis for Petroleum Residual Organic (FL-PRO), total fatty acids, and total amines based on recommendations made in previous HCSP annual reports. Mosaic, PRMRWSA, and the TAG agree that the results for these parameters from 2003 to 2009 show that these substances are present only occasionally at very low concentrations and are not a cause for concern at this time.

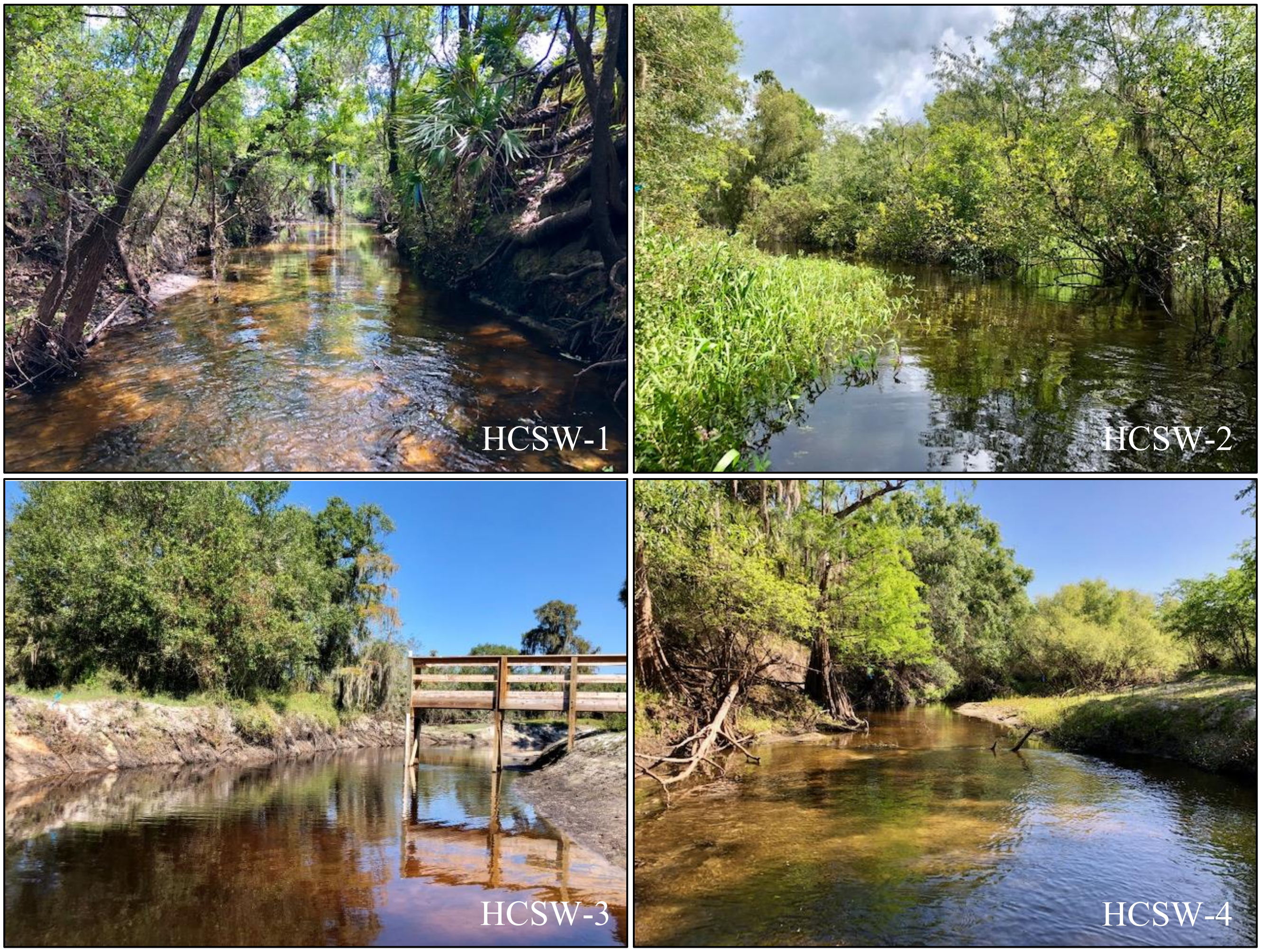


Figure 4-1 Representative Photographs of HCSP sampling locations[5]

---

[5] Photos taken on 3/29/18 (HCSW-1 and HCSW-4), 7/24/19 (HCSW-2), and 10/30/18 (HCSW-3).

Table 4-1 2018 Schedule of Water Quality and Biological Sampling Events of the HCSP.

Month	Horse Creek Water Quality Sampling Events	Horse Creek Biology Sampling Events	Brushy Creek Water Quality Sampling Events
January	Sampled January 17 (No flow at HCSW-2)		No flow
February	Sampled February 7		Sampled
March	Sampled March 21 (No flow at HCSW-2)		Low flow
April	Sampled April 18 (No flow at HCSW-2)	Sampled April 30 HCSW-1, 3, & 4	Dry
May	Sampled May 24		Sampled
June	Sampled June 20		Sampled
July	Sampled July 11		No access
August	Sampled August 2		No access
September	Sampled September 6		No access
October	Sampled October 2	Sampled October 30 & 31*	Sampled October 2
November	Sampled November 8		No flow-not sampled
December	Sampled December 12	Sampled December 17 & 18	No flow-not sampled

*electrofishing conducted on December 4th due to equipment malfunction.

4.2 Water Quantity

Approved discharge data were obtained from the USGS (http://waterdata.usgs.gov/fl/nwis/nwis) for HCSW-1 and HCSW-4. Staff gauges were installed, and stream cross sections were surveyed by Mosaic at HCSW-2 and HCSW-3; stage data were obtained at those stations during monthly water quality sampling. Daily flow and gauge data are not recorded in Brushy Creek, so there is no summary or analysis of water quantity for the Brushy Creek sampling location in this report. Discharge data were obtained for Mosaic's NPDES-permitted discharges into Horse Creek (FTG-003 and WIN-004 outfalls) for 2003 to 2018 (Figure 1-1). Daily rainfall data were obtained from Mosaic's rain gauges in the Horse Creek Basin (Figure 1-1). New Mosaic rainfall gauges (Pine Level 001 and 002) were installed late July 2011. However, because of the limited data set (only available for seven complete years), totals recorded at Pine Level 001 and 002 will not be used in this analysis, but monthly sums will be used to supplement months where data was missing from the two Horse Creek and the Manson Jenkins rain gauges. The general relationship between rainfall and streamflow was graphically evaluated. All rainfall gauges with an extended period of record are located in the upper portion of the Horse Creek basin (new Pine Level gauges are located parallel with HCSW-3 and HCSW-4 but only have a few years' worth of data), so longitudinal comparisons along the basin are not possible. A separate report (Durbin and Raymond 2006) addresses long-term rainfall patterns in the area.

4.3 Water Quality

A continuous monitoring unit is installed at HCSW-1 to record pH, specific conductivity, dissolved oxygen, and turbidity. Beginning in April 2003, data was recorded hourly, and daily mean, maximum, and minimum was downloaded at least monthly. This data provides for the characterization of natural background fluctuations and allows for the detection of instantaneous conditions or general water quality changes not observed during the collection of monthly grab samples.

Water quality samples were obtained monthly, when flow was present, by Mosaic at each of the four monitoring stations beginning in April 2003. The four locations were sampled the same day, working from downstream to upstream. In September 2009, based on recommendations of the PRMRWSA and the TAG, Mosaic began sampling water quality at an additional station on Brushy Creek (BCSW-1 at State Road 64). Brushy Creek is a tributary to Horse Creek and flows into Horse Creek between the HCSW-1 and HCSW-2 sampling stations. All activities affecting sample collection, sample handling, and field-testing activities were thoroughly documented. Field sample collection logs were completed at each station that include the following information: stream level elevations at the time of sampling (from on-site gauges or from the USGS real-time web site); stream size; a qualitative description of the water color, odor, and clarity; weather conditions; field measurements; sample preservation; and any anomalous or unusual conditions. Individual sample containers were labeled with identification codes, date and time of sampling, sample preservation, and the desired analysis. Sample transmittal chain-of-custody records were filled out during sampling listing locations, times, and required analysis.

Field measurements were taken for pH, dissolved oxygen[6], specific conductivity, and turbidity using meters that were operated and maintained according to manufacturer's instructions. Instruments were calibrated in the field prior to making measurements using the appropriate standards and acceptance limits (Table 4-2). All calibration activities were documented, and records checked for completeness and accuracy. Field measurements by Flatwoods in association with the three biological sampling events employed an YSI ProDSS multi-parameter data sonde with the same measuring methods and acceptance limits listed in Table 4-2. Flatwoods also employed a Hach 2100Q unit for turbidity measurement.

---

[6] In May 2013, Mosaic began collecting dissolved oxygen saturation (DO Sat) data in addition to mg/L because of the changes to the dissolved oxygen standard. The continuous recorder at HCSW-1 began recording DO Sat in January 2011. For all prior dates, reported DO Sat was calculated using DO (mg/L), temperature, and salinity. HCSP no longer records DO concentration as of 2018. See Section 4.3.1 for an explanation of the change in DO standards.

Table 4-2 HCSP water quality sampling field methods and acceptance limits associate with monthly sampling by Mosaic staff

Analyte	Meter Used	Method	Minimum Detection Limit	Acceptance Limit
pH	Hach HOD	150.1	1 su	+/- 0.2 standards units of the calibration standard
Temperature	Hach HOD	170.1	N/A	1 degree Centigrade
Specific Conductivity	Hach HOD	120.1	10 uS/cm	+/- 5% of the calibration standard
Dissolved Oxygen	Hach HOD	360.1	0.5 mg/L	+/- 0.2 mg/L of the correct Dissolved Oxygen - Temperature value
Turbidity	Hach 2100P	180.1	0.1 NTU	+/- 8% of the calibration standard

Surface water samples were collected in a manner that represented the physical and chemical characteristics of Horse Creek without contamination or bias in the sampling process. Water samples for chemical analysis were generally collected from mid-stream and from mid-depth to the upper portion of the water column unless flows were at either extreme (flood stage or nearly dry at the upper stations). Samples were usually obtained by wading into the stream (taking care not to disturb or stir up bottom sediments) and collecting samples upstream from the sampler. When flooded conditions precluded wading to collect samples (principally at HCSW-3), samples were taken from the top of the water column in the main flow path from the bridge. Samples were collected directly into unpreserved sample containers, which were used to fill the other sample containers. Pre-preserved sample containers (with either sulfuric or nitric acid) were filled with sample water and their pH levels checked. The sample containers were stored on ice prior to transport to laboratories for analysis. Sample containers were either taken directly to the laboratory or laboratory personnel picked them up in the field, using appropriate chain-of-custody procedures. The monthly surface water samples were analyzed for the parameters listed in Table 4-3. Table 4-3 also includes the laboratory analysis methods.

In addition to the continuous recorders and monthly water quality sampling, field measurements of temperature, pH, specific conductivity, turbidity and dissolved oxygen were collected during each biological sampling event (Table 4-1) using a YSI ProDSS data sonde. All sampling was conducted according to the FDEP's Standard Operating Procedures (SOPs) for field sampling. Laboratory analyses were performed by experienced personnel according to National Environmental Laboratory Accreditation Conference (NELAC) protocols.

Results were tabulated to allow for comparisons among stations and sampling events, through time, and to the "trigger values" established for the HCSP (Table 4-4). In addition, results were compared with applicable Florida surface water quality standards (which in many cases are the same as the trigger values).

While the numeric nutrient criteria (NNC) development has been ongoing since 2009, the adopted criteria did not go into effect until late October 2014. The trigger level and the NNC requires the evaluation of nutrient concentrations over different time scales. Monthly samples are compared to the trigger level and identify acute changes in nutrient concentrations that warrant investigation, while the NNC threshold is based on annual geometric mean concentrations and evaluate longer term trends. Also, the nutrient thresholds are only used in conjunction with biological metrics to determine compliance. A site must first pass the floral components (Rapid Periphyton Survey, Linear Vegetation Survey, and annual geometric mean for chlorophyll-a), then either be within the nutrient thresholds or SCI requirements in order to be in compliance according to 62-302.531(2)(c), F.A.C. Therefore, incorporating the NNC thresholds as standalone trigger levels for the HCSP would be inappropriate and would not accurately reflect the NNC.

Table 4-3 Parameters analyzed and laboratory methods for HCSP during 2003 to 2018 monthly water quality samples.

Parameter	Method	Hold Time	Preservation	Minimum Detection Limit Range	Container
Color	110.2	48 hours	Unpreserved	2-5 PCU	Clear HDPE bottle
Total Kjeldahl Nitrogen	351.2	28 days	Sulfuric Acid, pH < 2	0.008-0.24 mg/L	Clear HDPE bottle
Nitrate-Nitrite Nitrogen	353.2	28 days	Sulfuric Acid, pH < 2	0.0001-1.0 mg/L	Clear HDPE bottle
Total Ammonia Nitrogen	350.1	28 days	Sulfuric Acid, pH < 2	0.0008-0.05 mg/L	Clear HDPE bottle
Orthophosphate	365.1	48 hours	Unpreserved	0.002-0.75 mg/L	Clear HDPE bottle
Chlorophyll-*a*	SM 10200H	48 hours	Unpreserved	0.1-2.0 µg/l	Opaque plastic bottle
Specific Conductivity	120.1	28 days	Unpreserved	10 µS	Clear HDPE bottle
Total Alkalinity	310.1	14 days	Unpreserved	0.24-3.0 mg/L CaCO3	Clear HDPE bottle
Dissolved Calcium*	200.7	28 days	Unpreserved	0.008-0.8 mg/L	Clear HDPE bottle
Dissolved Iron*	200.7	28 days	Unpreserved	0.003-0.1 mg/L	Clear HDPE bottle
Chloride	300	28 days	Unpreserved	0.005-30 mg/L	Clear HDPE bottle
Fluoride	300	28 days	Unpreserved	0.003-5.0 mg/L	Clear HDPE bottle
Total Radium (Radium 226+228)	903	6 months	Nitric Acid, pH < 2	1 pCi/l	Clear HDPE bottle
Sulfate	300	28 days	Unpreserved	0.0007-100 mg/L	Clear HDPE bottle
Total Dissolved Solids	160.1	7 days	Unpreserved	5-25 mg/L	Clear HDPE bottle

- All water samples were preserved at 4°C while awaiting analysis.
- Orthophosphate samples were initially filtered in the laboratory rather than the field. While Mosaic is cognizant of the FDEP SOP for field sampling, the decision was made to have samples lab filtered (less risk of contamination and the guarantee of lab filtering within hours of lab delivery). Starting in January 2005, samples were field-filtered with a 0.45-micron filter.
- The analytical method for iron and calcium was changed during the 2003–2005 monitoring period.
- Total radium is the arithmetic sum of Radium 226 and Radium 228. Total nitrogen is reported as the arithmetic sum of nitrate-nitrite nitrogen and total Kjeldahl nitrogen. As requested by the PRMRWSA, if either of each pair is undetected, the MDL of the undetected constituent will be used as part of the total. This use of MDL for undetected constituents is contrary to both laboratory and FDEP SOPs.
- Petroleum Range Organics, Fatty Amido-amines, and Total Fatty Acid analysis were discontinued in September 2009.

Table 4-4 Parameters, general monitoring protocols, and corrective action trigger values for the HCSP.

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 beyond trigger level.
	Dissolved Oxygen Saturation(9)	Calibrated Meter	%	Monthly	<38% daily average	Excursions beyond range or statistically significant trend line predicting excursions beyond trigger level.
	Turbidity	Calibrated Meter	NTU(1)	Monthly	>29	Exceedance of or statistically significant trend line predicting concentrations in excess of trigger level.
	Color	EPA 110-2	PCU	Monthly	<25	Exceedance of or statistically significant trend line predicting concentrations in excess of trigger level.
Nutrients	Total Nitrogen	EPA 351 + 353	mg/L(2)	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.

Pollutant Category	Analytical Parameters	Analytical Method	Reporting Units	Monitoring Frequency	Trigger Level	Basis for Initiating Corrective Action Process
	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(5)	Petroleum Range Organics	EPA 8015 (FL-PRO)	mg/L	Monthly	>5.0	Exceedance of or statistically significant trend line predicting concentrations in excess of trigger level.
	Total Fatty Acids, Incl. Oleic, Linoleic, and Linolenic Acid	EPA/600/4-91/002	mg/L	Monthly	>NOEL	Statistically significant trend predicting concentrations in excess of the No Observed Effects Level (NOEL to be determined through standard toxicity testing with Mosaic 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	>NOEL	Statistically significant upward trend predicting concentrations in excess of No Observed Effects Level (NOEL to be determined through standard toxicity testing with Mosaic reagents early in monitoring program, NOEL expressed as a concentration – e.g., mg/L)
Biological Indices: Macro-invertebrates	Total Taxa	Stream Condition Index (SCI) sampling protocol, taxonomic analysis, calculation of indices according to SOP-002/01 LT 7200 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
	Ephemeropteran Taxa					
	Tricopteran Taxa					
	Percent Collector-Filterer Taxa					
	Long-lived Taxa					
	Clinger Taxa					
	Percent Dominant Taxon					
	Percent Tanytarsini					
	Sensitive Taxa					
	Percent Very Tolerant Taxa					
	Shannon-Wiener Diversity(a)					

Pollutant Category	Analytical Parameters	Analytical Method	Reporting Units	Monitoring Frequency	Trigger Level	Basis for Initiating Corrective Action Process
Biological Indices: Fish	Total Number of Taxa Abundance Shannon-Wiener Diversity[(a)] Species Turnover (Morisita Similarity Index[(a)] Species Accumulation Curves[(b)]	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

Notes:

(1) Nephelometric turbidity units.

(2) Milligrams per liter.

(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. Parameter sampling removed from program in September 2009 as agreed by TAG.

(6) At Station HCSW-4 only, recognizing that existing levels during low-flow conditions exceed the trigger level.

(7) At Stations HCSW-1, HCSW-2, and HCSW-3.

(8) Some metrics have been revised from original HCSP plan document due to revision of FDEP SCI Protocol.

(9) Revised from Dissolved Oxygen trigger of <5.0 mg/L based on changes to FDEP water quality standards,

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.

4.4 Benthic Macroinvertebrates

Benthic macroinvertebrate sampling was conducted at all stations during the October and December 2018 sampling events and at all stations but HCSW-2 during the April 2018 sampling event. The Brushy Creek location is not included in the macroinvertebrate sampling component of the HCSP.

At each Horse Creek station, a Stream Habitat Assessment (DEP Form FD 9000-5) was performed, and a Physical/Chemical Characterization Field Sheet (DEP Form FD 9000-3) was completed. The habitat assessment is comprised of a variety of physical criteria that are independently evaluated on a numerical scale, and the component values are summed to provide a quantitative rating for a stream segment that is presumed to be proportional to the quality of the stream for native macroinvertebrates. The Physical/Chemical form records a variety of other information and also provides for the delineation of various microhabitats in the stream into categories to allow for sampling of such microhabitats in general proportion to their abundance.

Macroinvertebrate sampling was performed in Horse Creek according to the Stream Condition Index (SCI) protocol developed by the FDEP (DEP-SOP-003/11, SCI 1000) by personnel with training and experience in the SCI protocol and who have successfully passed FDEP audits for the protocol. The SCI is a standardized macroinvertebrate sampling methodology that accounts for the various microhabitats available (e.g. leaf packs, snags, aquatic vegetation, roots/undercut banks) within a 100-meter segment of stream. Utilizing this methodology, 20 half-meter D-frame dip net sweeps are performed within a 100-meter segment of the stream. The number and quality of benthic macroinvertebrate microhabitats present during the sampling event determines the number of sweeps performed within each microhabitat type. Consistent with FDEP protocols, each benthic macroinvertebrate sample was processed and taxonomically analyzed.

Data from each invertebrate sample were used to calculate the various SCI metrics and resulting overall SCI values as per the methodology for the Florida Peninsula (Table 4-5). The calculation methodology for the SCI was revised by FDEP in June 2004, and sampling conducted from 2003 to 2006 uses that methodology. This change required a departure from the specific metrics listed for benthic macroinvertebrates in the HCSP plan; however, the plan contemplated such changes in methodology and the use of the revised protocol is acceptable with the plan. Between the 2004 and 2005 biological sampling events, individuals conducting biological sampling were trained and audited by the FDEP in SCI and Stream Habitat Assessment techniques. Because of this improvement, some SCI results from previous years may not be directly comparable with results from 2005 and beyond.

Fortunately, the revisions to the SCI protocol in 2004 were implemented before the previous methodology was used to calculate SCI values for the HCSP, so there was no need to retroactively adjust SCI values from 2003 sampling results. Changes made to the calculation protocol were fairly esoteric, essentially based upon a broad array of statistical analyses with invertebrate samples collected across Florida to determine the best correlates with human disturbance to stream habitats (Fore 2004).

In 2007, the FDEP SCI protocol was again revised, this time to include provisions for the taxonomic analysis of two aliquots for every SCI sample collected to account for variation in sample sorting (DEP-SOP-002/01 LT 7200). Under the new protocol, the SCI score for each sample is the arithmetic average of the SCI scores of the two aliquots. In addition, the recommended number of invertebrates per aliquot was raised from 100 to 120 in 2004 to 140 to 160 in 2007. Table 4-5 provides the 2007 list of metrics used in calculating SCI scores, while the parameter table from the HCSP methodology document (copied as Table 4-4 above) includes the metrics used in the original SCI protocol.

In 2012, FDEP again revised the calculations in the SCI scores and altered the bioregions[7] in the state. This revised protocol was finalized in March 2014 and officially went into effect in July 2014. The revised SCI protocol is in a single SOP (DEP-SOP-003/11 SCI 1000) that includes the field, lab, and calculations procedures. The revised calculations for each of the metrics are shown in Table 4-5 alongside the SCI 2007 method. The method of collection and sorting (number of aliquots, recommended number of invertebrates per sample, etc.) did not change between the 2007 and 2012 SCI protocols, so samples collected under the 2007 protocol can be rescored under the 2012 calculations. Appendix J lists the SCI scores for every sampling date calculated under the 2004 protocol (2003 to 2006) or the 2007 and 2012 protocols (2007 onward). The SCI scores reported in Section 5.3 of the 2018 Annual Report were calculated using the 2012 protocol. Scores from the 2004 SCI (2003 to 2006[8]) and the 2007 or 2012 SCI (2007 onward) may not be directly comparable, given the differences in how they were collected.

The Shannon-Wiener Diversity Index was calculated using Ecological Methodology Software, Version 7.0 (www.exetersoftware.com).

---

[7] The change in bioregions for the 2012 SCI protocol does not affect this project.

[8] The November 2006 sample was collected under the SCI 2007 protocol and rescored under the SCI 2012 calculations. However, statistical analyses do not include that sample because the other two 2006 samples were collected under the old protocol and are not comparable.

Table 4-5 Equations for calculating SCI metrics for Peninsular Florida (individual metric scores range from zero to ten)

SCI Metric	2004/2007* Peninsula Score	2012 Peninsula Score
Total Taxa	10*(X-16)/25	10*(X-15)/24
Ephemeropteran Taxa	10*X/5	10*X/5
Trichopteran Taxa	10*X/7	10*X/7
Percent Collector-Filterer Taxa	10*(X-1)/39	10*(X-0.7)/43
Long-lived Taxa	10*X/4	10*X/3
Clinger Taxa	10*X/8	10*X/7
Percent Dominant Taxa	10-(10*[(X-10)/44])	10-(10*[(X-14)/50])
Percent Tanytarsini	10*[ln(X+1)/3.3]	10*[ln(X+1)/3.4]
Sensitive Taxa	10*X/9	10*X/7
Percent Very Tolerant Taxa	10-(10*[ln(X+1)/4.1])	10-(10*[(ln(X+1)-0.7)/4.0])

Note: In each equation, "X" equals the number representing the count or percentage listed in the corresponding row of the left column. For calculated values greater than ten, the score is set to ten; for values calculated less than zero, the score is set to zero.
* 2004 and 2007 used the same metric calculations; only the number of individual invertebrates (100-120 for 2004 and 140-160 for 2007) and vial replicates (no replicate in 2004) differ.

4.5 Fish

Fish sampling was conducted at all stations during the October 2018 and December 2018 sampling events and at all stations but HCSW-2 during the April 2018 sampling events. The Brushy Creek location is not included in the fish sampling component of the HCSP.

Fish were collected with a 4-foot by 8-foot seine (3 mm mesh size) and by electrofishing with a Smith-Root, Inc. backpack unit (Model Apex Electrofisher). Electrofishing was timed (500 seconds), and the number of seine hauls (five) was recorded to standardize the sampling efforts among stations and between events.

Some fish (generally those larger than about 10 cm) were identified, weighed, measured, and released in the field, while some small fish (<10 cm) were preserved in the field for analysis in the laboratory. All fish collected were identified in the field or laboratory according to American Fisheries Society-accepted taxonomic nomenclature (American Fisheries Society 2004). Total length (mm) and weight (g) were recorded for each individual, with the following exceptions: for samples with very large numbers of fish of the same species (a common occurrence with species like eastern mosquitofish [Gambusia holbrooki], least killifish [Heterandria formosa], and sailfin molly [Poecilia latipinna]), a randomly selected subset of individuals (approximately 10) were measured for length and weight, while the remaining individuals were counted and then weighed en masse.

Taxa richness (number of species) and abundance were determined by station and for each sampling event, and data were compared among stations and across sampling events. The Shannon-Wiener Diversity Index and Morisita's Community Similarity Index were calculated using the Ecological Methodology Software. Species accumulation curves were plotted to estimate the efficacy of the sampling at producing a complete list of the species present in the sampled portions of the stream.

5.0 WATER QUANTITY RESULTS AND DISCUSSION

5.1 Rainfall

Mosaic Rain Gauges

Figure 5-1 includes 2018 total monthly rainfall data from the three Mosaic rain gauges located in the Horse Creek watershed[9] (see Figure 1-1 for locations) as well as the nearby SWFWMD Flatford Swamp gauge. Total and median monthly rainfall in 2018 was different at each gauge, but the heaviest rainfall was observed during May to September at all locations (Figure 5-1). 2018 was ranked as the 5th wettest year since 2003 when calculated using the average of the Mosaic[10], gauges and the wettest according to the Flatford gauge (Table 5-1, Figure 5-2).

NOAA Rain Gauges

A ranking of annual rainfall of the nearest NOAA (National Oceanic and Atmospheric Administration) gauges places 2018 as the 11th wettest year since 1908 and 3rd wettest year since 2003. The historic annual rainfall average for the closest long-term NOAA stations[11] between 1908 and 2018 is 53.9 inches- the annual average for 2018 was 67.1 inches.

---

[9] Continuous rainfall data collected by the SWFWMD at HCSW-3 (SWFWMD Station 494) ended in November 2011. Previous HCSP Annual reports used the USGS gauge at HCSW-1, which has been discontinued. At the end of July 2011, two new rainfall gauges (Pine Level 001 and 002) were installed by Mosaic in the lower basin west of stations HCSW-3 and HCSW-4, but they will not be used for general analysis purposes because there is only one complete year of data; these gauges may be used if the three upper basin gauges are all offline at the same time.

[10] Horse Creek South rain gauge was not functioning in March, 2018; only the Horse Creek North and Manson Jenkins gauges were used during this period.

[11] Historical rainfall information came from the following stations and years: 1908 to 1943 NOAA station 148, 1944 to 2018 average of NOAA station 148 and 336.

Table 5-1 Annual Total Rainfall in Inches at Gauges in the Horse Creek Watershed from 2003 to 2018

Gauge	Horse Creek North	Horse Creek South	Manson Jenkins	Average of Mosaic Gauges	SWFWMD Flatford
2003	53.4	59.75	30.10*	57.10	49.85*
2004	53.82	60.74	62.15	58.90	59.85
2005	54.52*	64.53	31.34*	66.04	42.40
2006	31.82*	34.17	41.26	37.35	31.11
2007	33.9	31.97	32.49	32.79	38.45
2008	40.49	36.8	37.48	38.26	44.94
2009	36.63	43.7	46.87	42.40	44.23
2010	32.53	37.47	41.84	37.28	41.11
2011	24.54*	31.73*	39.85	37.11	40.25
2012	19.99*	36.06*	37.96*	44.49	51.99
2013	38.54*	54.69	34.33*	48.63	47.39
2014	47.93	39.22*	40.37*	49.06	52.69
2015	37.20*	35.64*	45.38*	44.13	59.89
2016	46.76*	50.72	48.09	51.43	53.99
2017	47.12*	49.16	43.87	47.03	38.06*
2018	38.91	63.25*	49.06	51.29	69.6

* - Gauge was non-functional during portion of year.

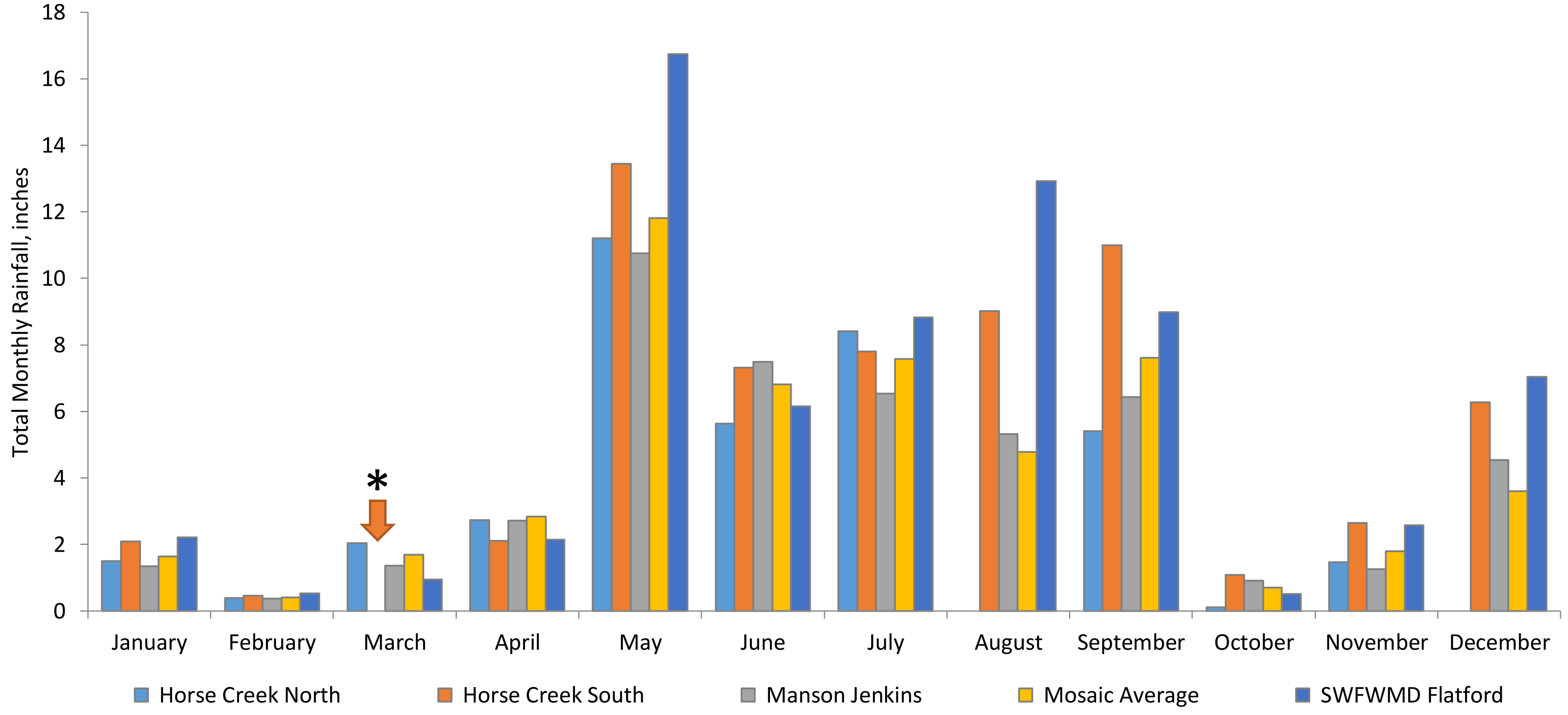


Figure 5-1 **Total monthly rainfall from three Mosaic gauges and one SWFWMD gauge in the Horse Creek watershed in 2018**

* Horse Creek south gauge was non-functional for 29 days between March 5th and April 2nd

Horse Creek North gauge registered 0” in August and December- Gauge was functional

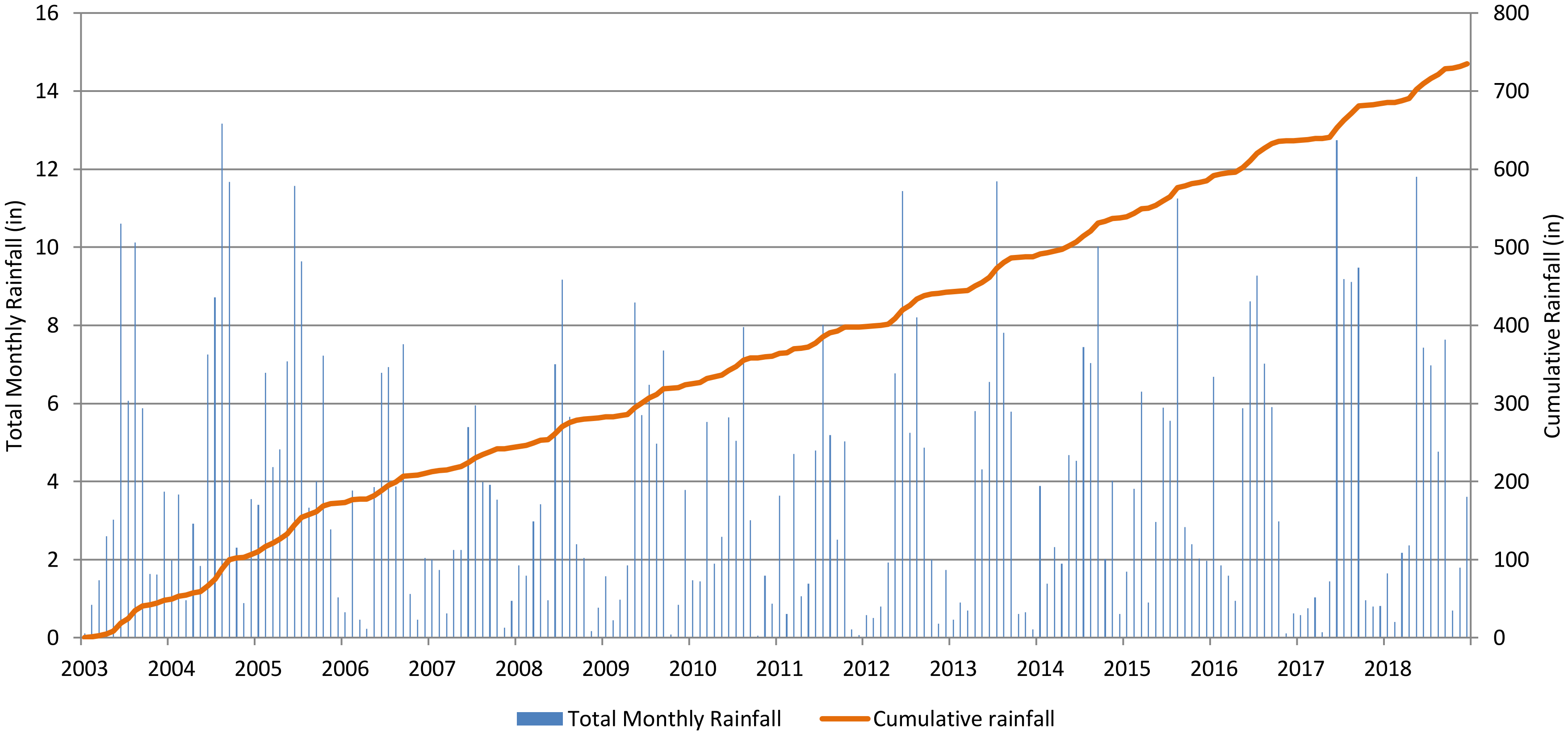


Figure 5-2 **Total monthly rainfall from the average of three Mosaic gauges in the Horse Creek watershed from 2003 to 2018**[12]

---

[12] When all three Mosaic gauges were out of service, the average of two Pine Level rain gauges was used; otherwise, the average of the operational Mosaic rain gauges was reported.

5.2 Stream Stage

Figure 5-3 illustrates the relationship between the staff gauge readings made during each Mosaic monthly water-quality sampling event. It also provides the average daily stage as recorded at the USGS gauging stations at HCSW-1 and HCSW-4. Patterns of daily stage levels were clearly temporally correlated among the four stations (Figure 5-3). Stage height (feet NAVD) collected monthly by Mosaic at four sites and continuously by the USGS at two sites was examined using Spearman's rank correlations (Zar 1999) because the gauge heights are not distributed normally (Shapiro-Wilk test for normality, $p < 0.05$). Gauge heights showed a strong and significant correlation between all Mosaic stations and USGS stations (Table 5-2). Such close correspondence is expected for a fairly small watershed in a low gradient setting like peninsular Florida.

Mean daily stage levels in 2018 were fairly low during the dry season, with little change in stage height through April 2018. Water elevations increased in early-May through early-October at both HCSW-1 and HCSW-4 (Figure 5-3). Stage duration curves for 2018 were developed for HCSW-1 and HCSW-4 (Figure 5-4) to indicate the percentage of time stream stage was above particular elevations. Stage at HCSW-1 varied by 4.1 feet between the curve's P10 (70.3 feet NAVD) and P90 (66.2 feet NAVD) in 2018, indicating that the stream stayed within its banks most of the time (P10 and P90 are commonly used to bracket the 'typical' fluctuation of a water body, thus omitting the highest and lowest 10 percent of the flows). Stream stage at HCSW-4 was more variable than at HCSW-1 between the P10 (21.2 feet NAVD) and P90 (11.4 feet NAVD) (9.7-foot difference).

Table 5-2 Coefficients of rank correlation (r_s) for Spearman's rank correlations of monthly gauge height (NAVD) from 2003 to 2018 ($p < 0.0001$)

	HCSW-1 (USGS)	HCSW-4 (USGS)	HCSW-1 (Mosaic)	HCSW-2 (Mosaic)	HCSW-3 (Mosaic)	HCSW-4 (Mosaic)
HCSW-1 (USGS)	1	0.90	0.99	0.84	0.80	0.90
HCSW-4 (USGS)		1	0.89	0.87	0.85	0.995
HCSW-1 (Mosaic)			1	0.83	0.77	0.89
HCSW-2 (Mosaic)				1	0.88	0.87
HCSW-3 (Mosaic)					1	0.85
HCSW-4 (Mosaic)						1

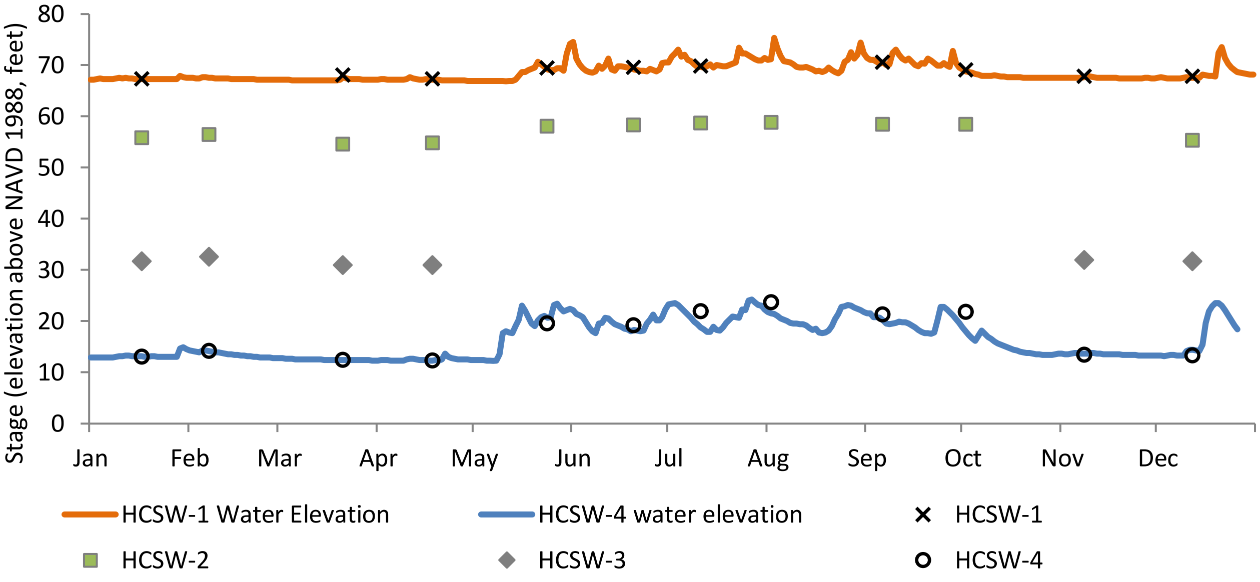


Figure 5-3 **Stream stage at HCSP monitoring stations in 2018. Individual data points are from Mosaic's monthly monitoring and continuous lines are average daily stage from USGS (Stations 02297155 and 02297310).**

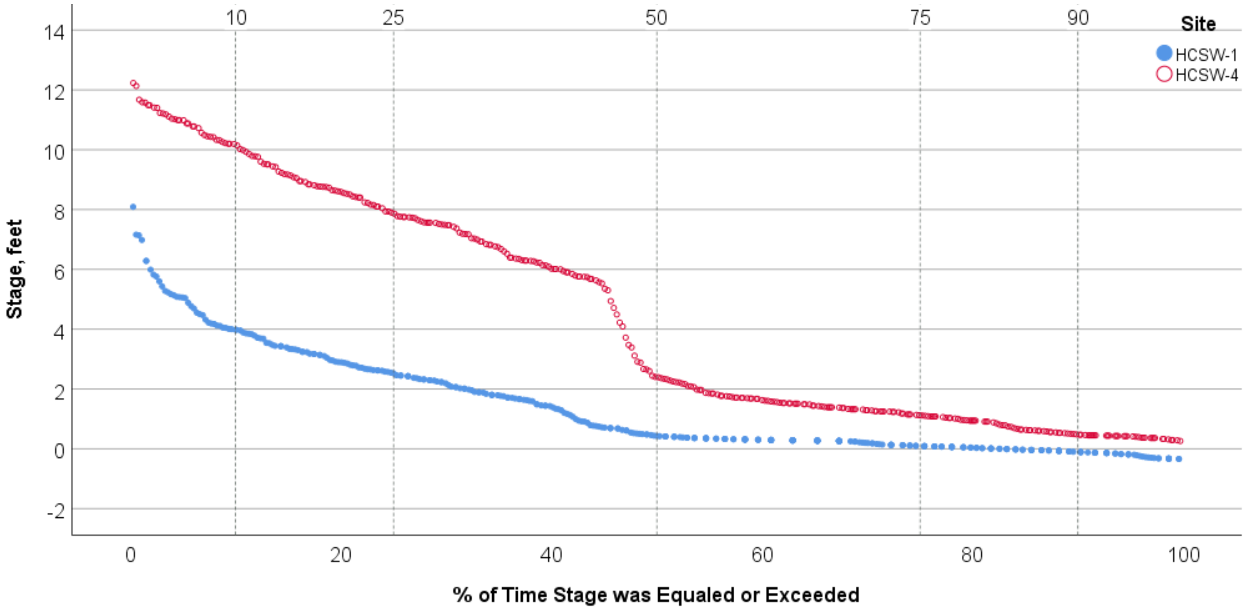


Figure 5-4 **Stage duration curves for HCSW-1 and HCSW-4 in 2018 showing percent of year water levels were at or above a given stage. Stage relativized by respective minimum gauge heights (MGH): HCSW-1 (66.3 ft. NAVD, 88) and HCSW-4 (10.96 ft. NAVD, 88).**

5.3 Streamflow

The average daily streamflow for 2018, obtained from the USGS continuous recorder data for HCSW-1 and HCSW-4, is presented in Figure 5-5. In 2018, flows were generally low from January through mid-May; flows then increased in mid-May and remained high through late-October ending the year with summer like flows in late-December. Average daily stream flows exhibited a similar pattern at both HCSW-1 and HCSW-4, with higher flows at HCSW-4 beginning earlier and ending later than HCSW-1 for the summer wet season (Figure 5-5).

At HCSW-1, annual average streamflow in 2018 was ranked 2nd since records began in 1978 as well as since HCSP began. At HCSW-4, annual average streamflow in 2018 was ranked 13th since records began in 1951, 9th since 1978, and 3rd since the HCSP began in 2003 (Figure 5-6).

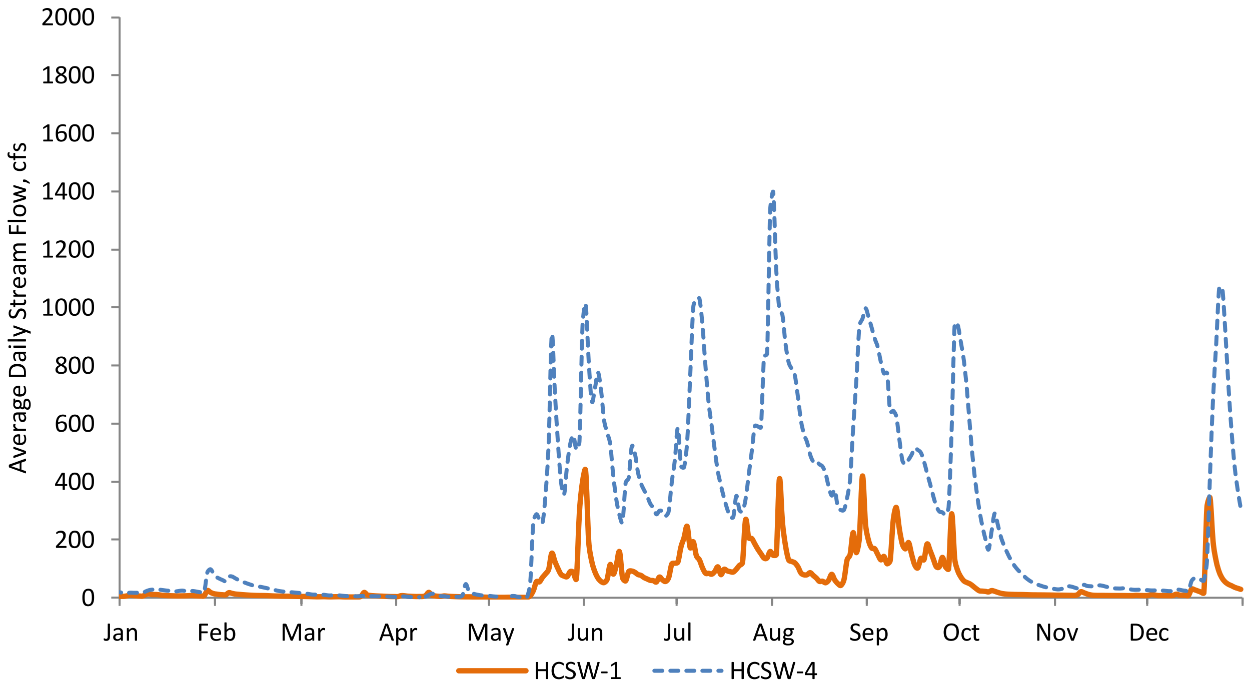
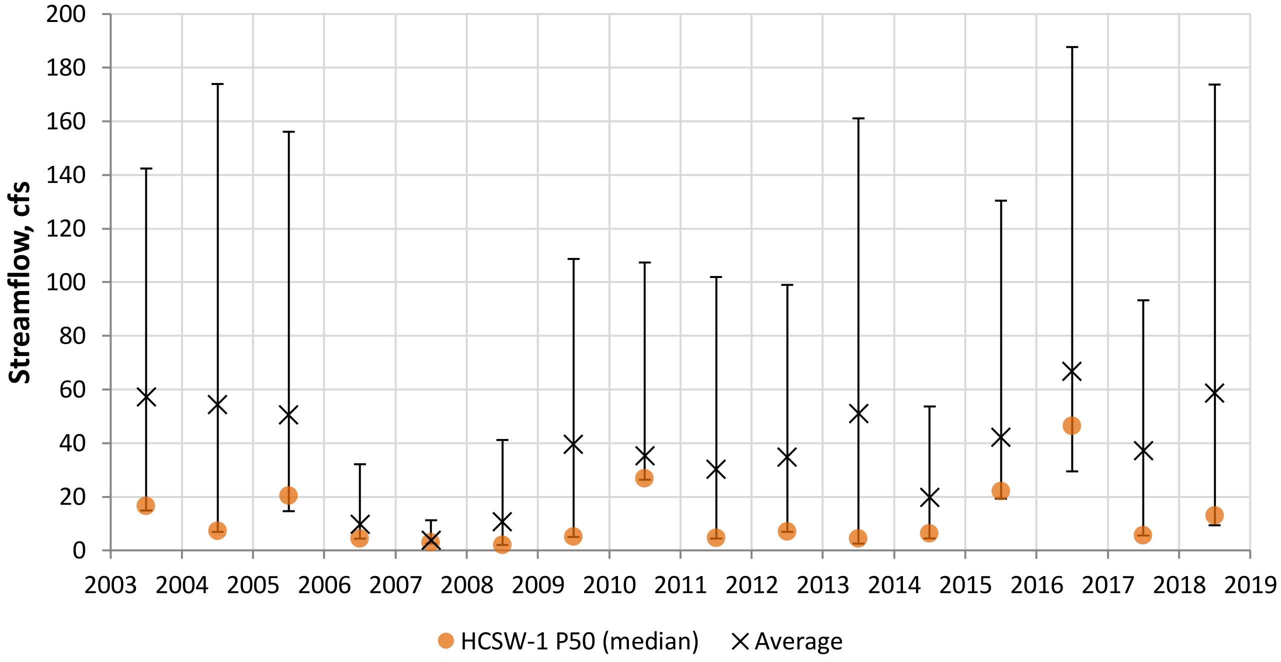


Figure 5-5 Average daily streamflow at HCSW-1 and HCSW-4 in 2018



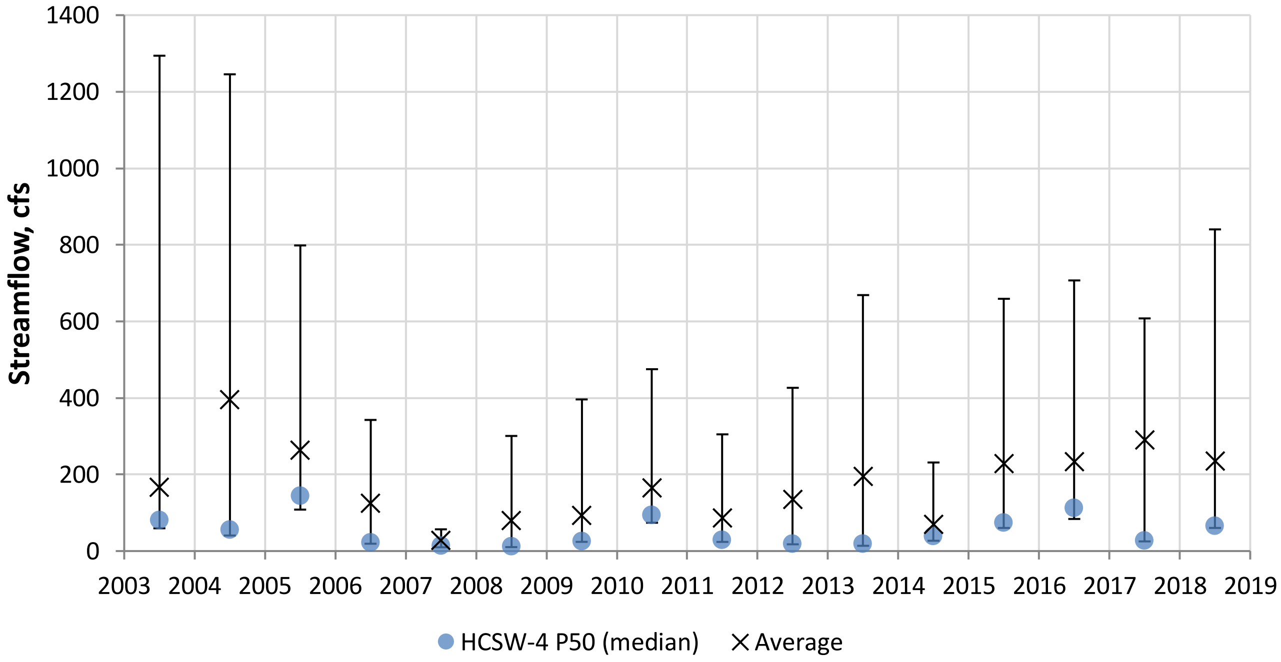


Figure 5-6 Annual average, Median (P50 marker), 10th percentile (lower bar), and 90th percentile (upper bar) streamflow at HCSW-1 and HCSW-4 from 2003 to 2018

5.4 Rainfall-Runoff Relationship

Stream discharge at HCSW-1 and the average daily rainfall for 2018 (average of daily rainfall at three Mosaic rain gauges upstream of Highway 64) are compared in Figure 5-7. To examine the strength of covariation between daily stream discharge and rainfall, Spearman's rank correlation procedure was used (Zar 1999). Average monthly streamflow at HCSW-1 was compared to total monthly rainfall at the SWFWMD Flatford Swamp gauge, the three Mosaic rain gauges, and the average total monthly rainfall of the Mosaic gauges for the years 2003 to 2018 (Table 5-3).

The correlation between stream discharge at HCSW-1 and rainfall was statistically significant for each rainfall gauge (Table 5-4). Although these results suggest that stream discharge and rainfall in Horse Creek covary more than would be expected by chance alone, not all of the variation in streamflow is explained by rainfall ($0.53 < r < 0.58$). The lag between rainfall and runoff, as well as other antecedent condition factors, are strongly affecting this relationship in the full dataset; however, there is very little lag between 2018 rainfall events and streamflow response in mid-May to early October (Figure 5-7). At the beginning of the wet season (May 12th in 2018), the lag effect between rainfall and streamflow is more apparent as the surrounding wetlands or small creeks either need to fill or resume flow. However, later in the wet season when the wetlands and small creeks are full, the lag is much shorter, as can be seen in Figure 5-7. To look at the relationship on a longer timeframe than the HCSP, Figure 5-8 shows the total monthly rainfall (NOAA) and the monthly average of daily stream discharge at HCSW-1 from 1978 to 2018.

Figure 5-9 illustrates the relationship between cumulative annual discharge at HCSW-1 and annual NOAA rainfall from 1978 to 2018[13]. Changes in the relationship between rainfall and stream discharge can be seen as inflection points in the overall trend line slope. Over the HCSW-1 period of record, there were three potential inflection points. In 2000 (red dotted line on Figure 5-9, slope = 0.29), cumulative discharge began to increase slightly relative to rainfall for a few years when rainfall was above average relative to the slope of the overall period of record, meaning there was more stream discharge per unit of rainfall. Between 2005 and 2008 (blue solid line on Figure 5-9, slope 0.06), which included several very dry years, cumulative discharge had almost no increase, despite changes in cumulative rainfall. Thus, as expected during a very dry period, the relationship changed, and less water entered the stream per unit rainfall than happened during wetter periods. After 2008 (orange dashed line on Figure 5-9, slope 0.25), the slope was again similar to the wet period of 2000 to 2004, and greater than the overall period of record slope (0.21), because rainfall began to return to average conditions and cumulative discharge began to resume previous patterns relative to cumulative rainfall. From 2016 to 2018, the trend line slope between those two points was 0.26 (not pictured), which is indicative of groundwater storage being replenished; if this

---

[13] To look at the relationship between stream discharge and rainfall over the stream gauge period of record, HCSW-1 discharge was converted from cubic feet per second (cfs) to cumulative discharge in thousands of cfs days. Cumulative historical rainfall was calculated from NOAA gauges 148 and 336, which have a longer period of record than the SWFWMD or Mosaic gauges. Potential inflection points are limited to changes in slope that last at least three (3) years.

pattern continues for several more years, it could turn into a new inflection point similar to the 2000 to 2005 period.

If mining was having a significant effect on the amount of water that reached Horse Creek at HCSW-1 compared to rainfall, then one would expect to see one or more large inflection points that correspond to the beginning of mining in the basin or the mining of large tracts lasting for many years. However, for the majority of the period of record (which included pre-mining data), the relationship is remarkably constant over time, with only a few minor inflection points that correspond to unusually wet and dry periods in the 2000s. These findings suggest that mining activities have not changed the overall relationship between annual rainfall and annual stream discharge at HCSW-1, based on the data available.

Table 5-3 Coefficients of rank correlation (r_s) for Spearman's rank correlations of HCSW-1 monthly average streamflow and total monthly rainfall at SWFWMD Flatford Swamp gauge and three Mosaic gauges from 2003 to 2018

Rainfall Gauge	r_s (with HCSW-1 Streamflow)	p value	N (Sample Size)
Horse Creek North	0.53	<0.0001	170*
Horse Creek South	0.56	<0.0001	183*
Manson Jenkins	0.54	<0.0001	176*
Average Mosaic Rainfall	0.58	<0.0001	156*
SWFWMD Flatford Swamp	0.53	<0.0001	188*

*Months missing >10 days were removed from analysis.

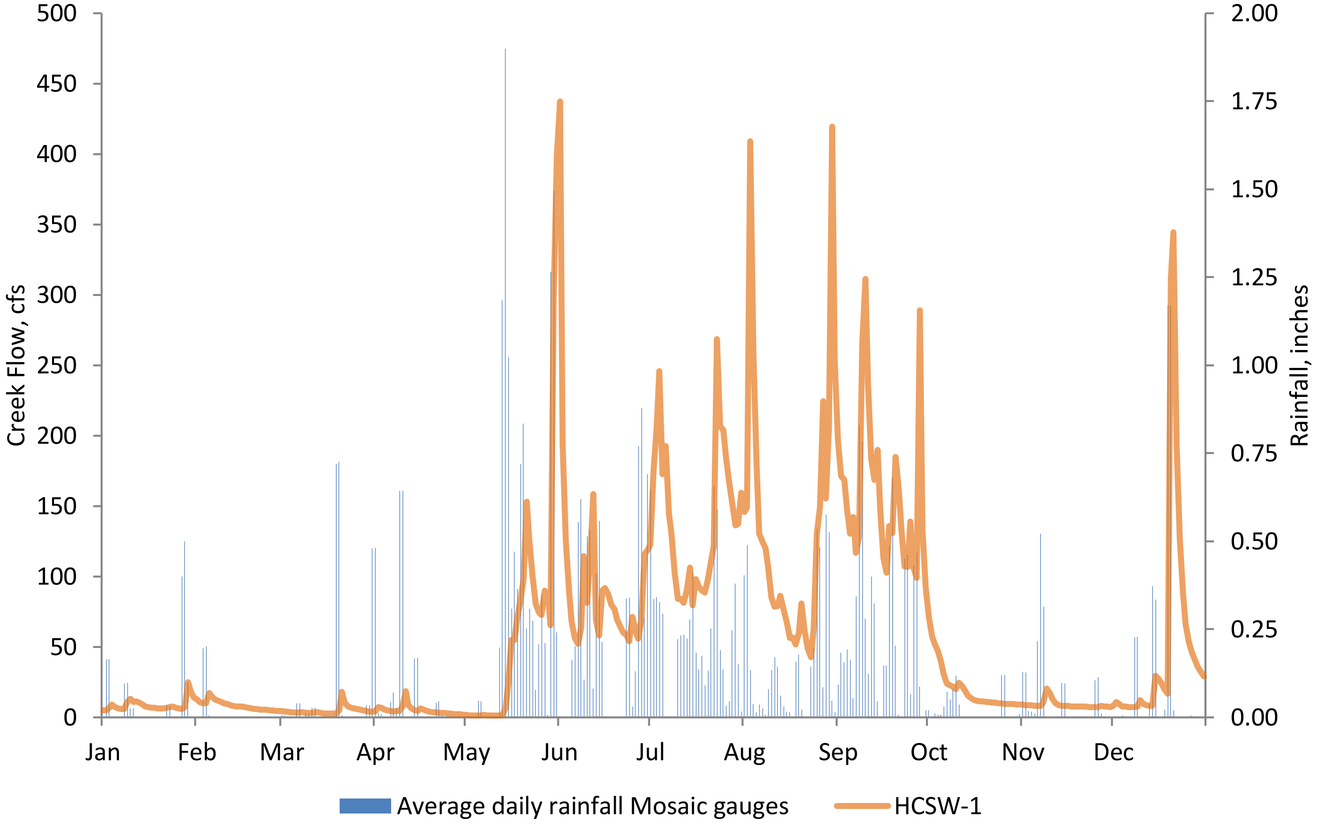


Figure 5-7 **Average daily streamflow at HCSW-1 and average daily rainfall (from three Mosaic gauges[14]) in the Horse Creek watershed in 2018.**

---

[14] Horse Creek South rain gauge was not functioning from March 5- April 2, 2018; only the Horse Creek North and Manson Jenkins gauges were used during this period.

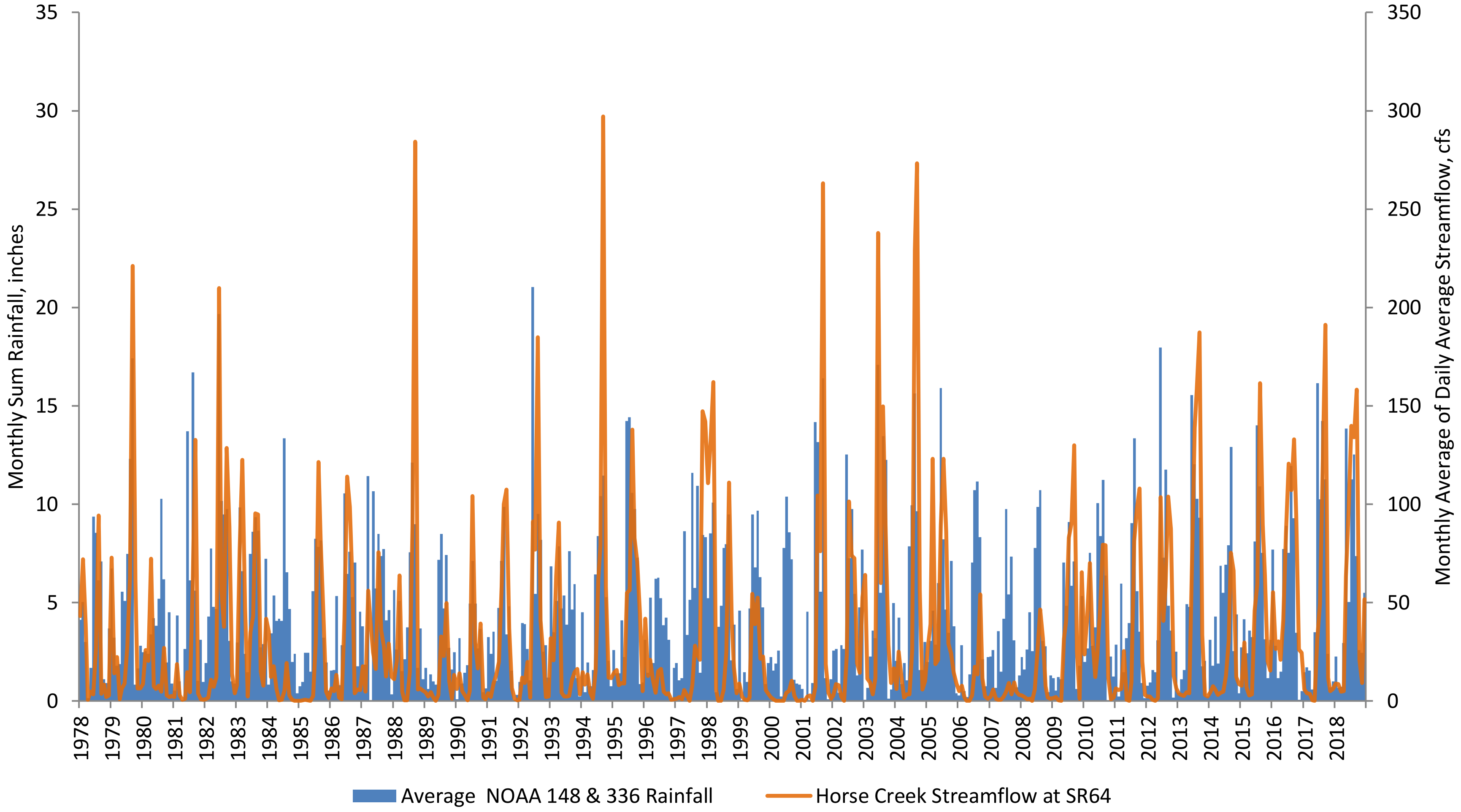


Figure 5-8 **Monthly average of average daily streamflow at HCSW-1 and monthly sum of rainfall (average of NOAA 148 and 336 gauges) in the Horse Creek watershed from 1978 to 2018.**

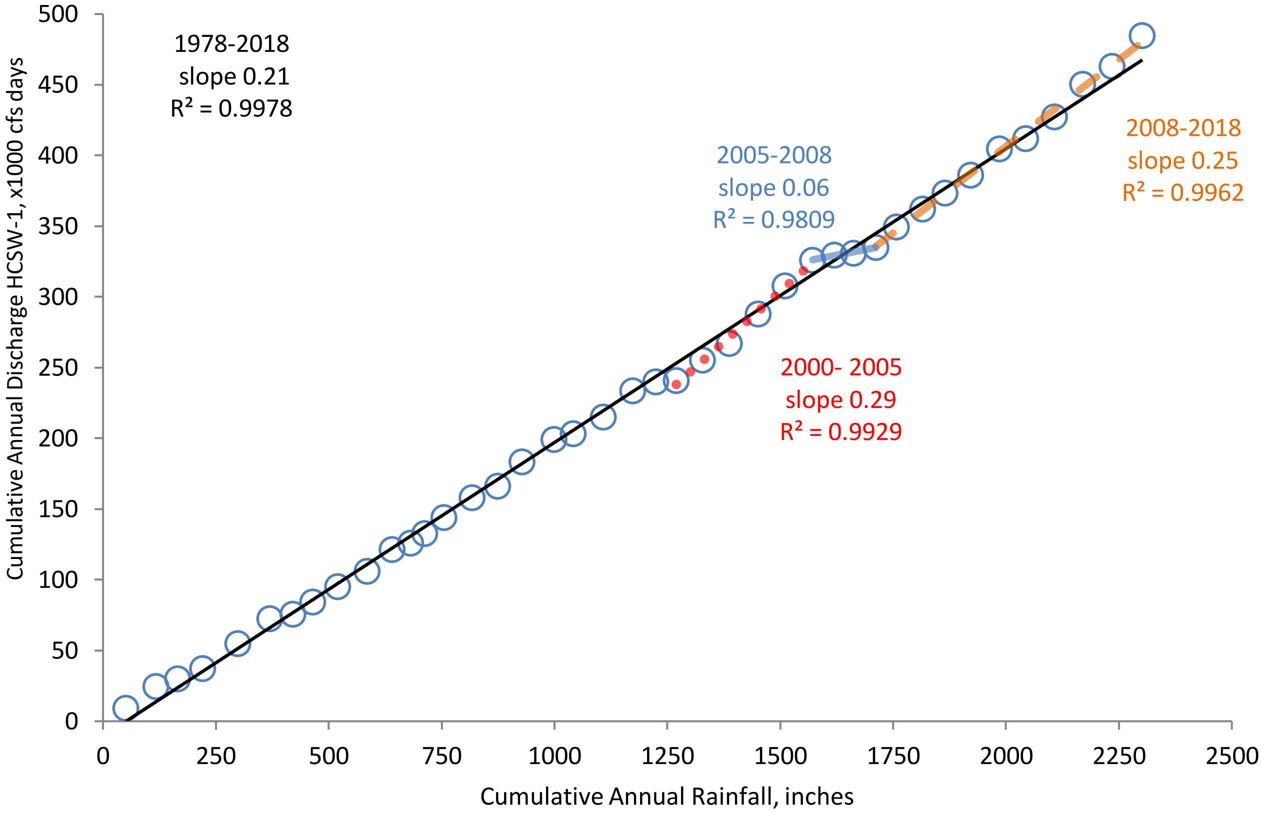


Figure 5-9 Double mass curve of cumulative daily discharge (USGS gauge at SR64) and rainfall (NOAA gauges 148 and 36) at HCSW-1 from 1978 to 2018

5.5 NPDES Discharges

Industrial wastewater is discharged to Horse Creek through two outfalls (FTG-003 on the Fort Green NPDES Permit FL0027600 and WIN-004 on the Wingate NPDES Permit FL0032522, see Figure 1-1). Both outfalls are 20-foot wide concrete flumes with continuous flow measurement. A mine wastewater system consists of clay settling areas, mined but not yet reclaimed land, and unmined but disturbed lands. The runoff from all these lands is contained within the industrial wastewater system boundaries. The "loop" of wastewater from the plant to the clay settling areas with the subsequent return of clarified water to the plant for reuse is the backbone of the system. The system has a finite storage capacity and excess wastewater (as a result of rainfall into the system) is discharged from permitted outfalls.

In 2018, there was no NPDES discharge from outfall FTG-003 and there had not been one since July 26th, 2009. Win-004 discharged 3.2 billion gallons between June 14th and October 6th, 2018 (Table 5-5, Figure 5-10 & 5-11) or the 9th largest discharge since discharges began in 2001. During that same period Horse Creek at HCSW-1 discharged 9.6 billion gallons. Prior to the June 2018 NPDES discharge, the last WIN-004 discharge ended in December of 2016. Mosaic has no other discharges to Horse Creek (including from the legacy CF Industries property), and no other known industrial wastewater discharges to Horse Creek or any of its tributaries by any other firm are known.

A spearman rank correlation was run to examine if the NPDES discharge and streamflow in Horse Creek were related. Comparing HCSW-1 stream discharge and NPDES discharge from 2003 to 2018 using a Spearman's rank correlation procedure (Zar 1999) indicates they covary strongly ($r_s = 0.72$, $p < 0.0001$). Thus, an increase in one parameter will correspond to an increase in the other. Just as streamflow at HCSW-1 was correlated with rainfall (Table 5-4), so too is streamflow correlated with NPDES discharge (Table 5-6), with lag times and antecedent conditions affecting this relationship.

There is a lag in the start of NPDES discharge relative to rainfall (similar to the lag between rainfall and streamflow), because the NPDES system must fill to the discharge elevation, which can occur further into the wet season. NPDES discharge can also continue after the wet season rains have stopped until water is once again below the discharge elevation in the circulation system.

Table 5-4 2018 total monthly Mosaic NPDES discharge to Horse Creek (FTG-003 and WIN-004 outfalls)

Month	Discharge to Horse Creek (MG)*
January	0
February	0
March	0
April	0
May	0
June	504
July	1273
August	708
September	676
October	42
November	0
December	0
Annual Total	**3201**

*All values represent WIN-004. There were no discharges through FTG-003 in 2018

Table 5-5 Coefficients of rank correlation (r_s) for Spearman's rank correlations of monthly average NPDES discharge and USGS daily streamflow, gauge height, and total monthly rainfall at three Mosaic gauges and a SWFWMD gauge from 2003 to 2018

Gauge	r_s (with NPDES Outfall)	p value	N (Sample Size)
HCSW-1 (USGS Streamflow)	0.72	< 0.0001	190*
HCSW-1 (USGS Gauge Height)	0.74	< 0.0001	177*
Horse Creek North (Rain)	0.36	< 0.0001	172*
Horse Creek South (Rain)	0.34	< 0.0001	185*
Manson Jenkins (Rain)	0.27	< 0.0001	178*
Average Mosaic Rainfall	0.36	< 0.0001	158*
SWFWMD Flatford Swamp (Rain)	0.31	< 0.0001	190*

*Months missing>10 days of data were removed from analysis

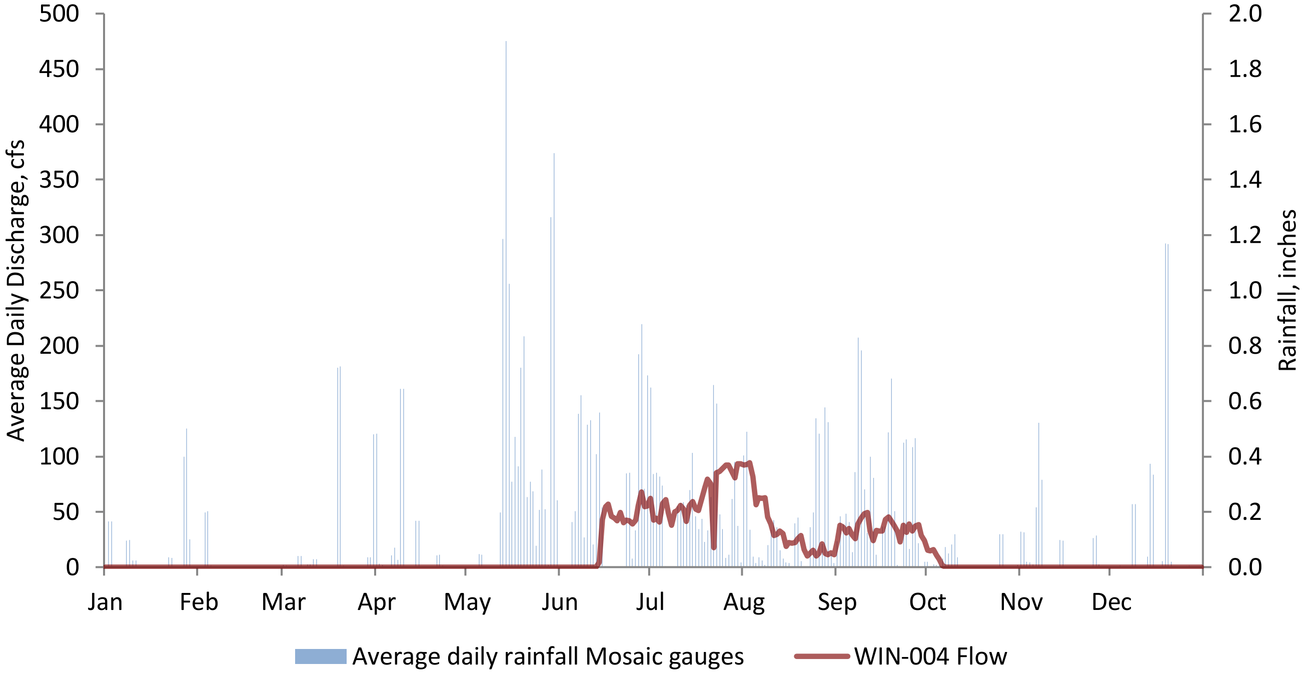


Figure 5-10 Combined Mosaic NPDES discharge and average daily rainfall in the Horse Creek watershed in 2018

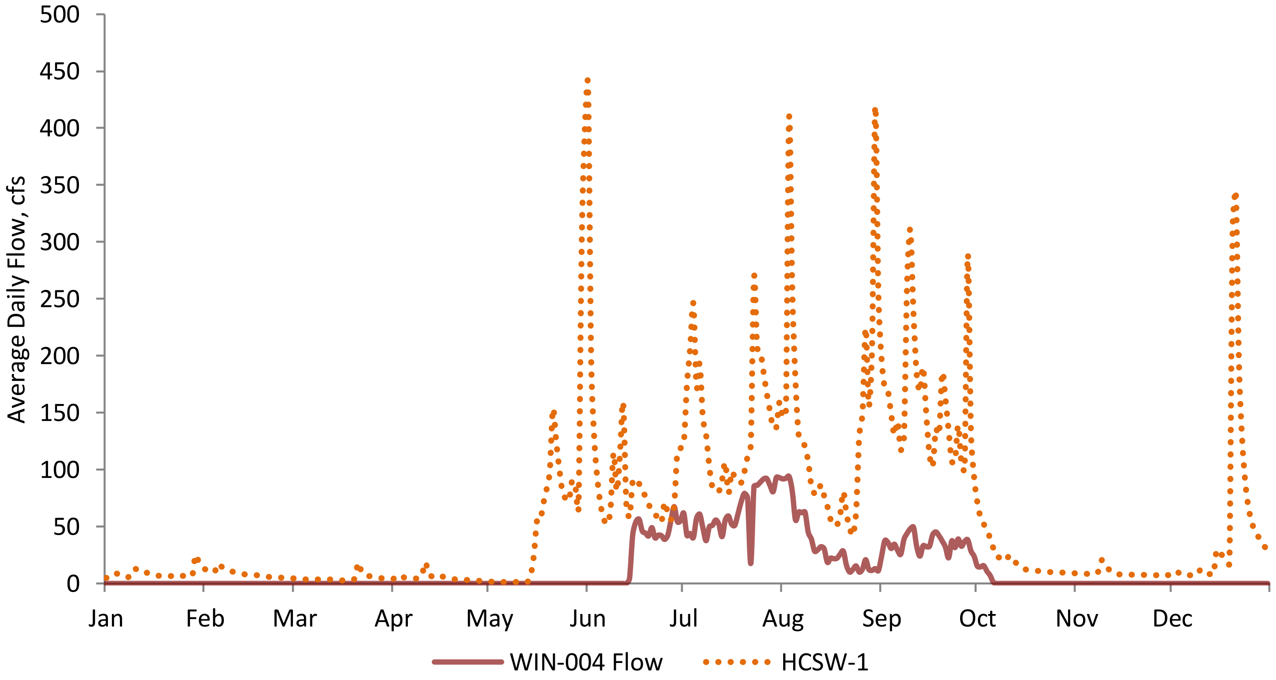


Figure 5-11 Daily streamflow at HCSW-1 and combined Mosaic NPDES discharge in 2018

5.6 Summary of Water Quantity Results

Based on the two long-term NOAA rain gauges in the Horse Creek Basin, 2018 was the 11th wettest year since records began in 1908[15] and the 3rd wettest year during the period of the HCSP (67 inches). Horse Creek flow[16] at HCSW-1 in 2018 was ranked the 2nd highest annual average flow (59 cfs) compared to all other years during the period of the HCSP; flow at HCSW-4 (235 cfs) was ranked 3rd. In 2018, the NPDES outfalls discharged the 9th largest output since discharges began in 2001 (3.2 billion gallons) at an annual average flow rate of 13.6 cfs (or a daily average of 43 cfs over the 115 days of discharge). NPDES discharges began 33 days after the summer rains began and contributed between 1-31% (median =2.95%) of the flow measured at HCSW-1. There was no NPDES discharge in 2017.

There is no evidence that mining and reclamation activities in the basin caused any statistically significant decrease in total streamflow over the period of record (1978 to 2018), according to the double mass curve analysis. In a previous study (Robbins and Durbin 2011) that compared streamflow during dry years in reference and potentially impacted streams before and during phosphate mining, there was no evidence that phosphate mining practices caused lower monthly flows in the potentially impacted streams (including Horse Creek) than what would be expected given the conditions in a reference stream (Charlie Creek).

---

[15] Historical rainfall information came from the following stations and years: 1908 to 1943 NOAA station 148, 1944 to 2018 average of NOAA station 148 and 336.

[16] Long-term annual average of daily streamflow calculated for 1978 to 2018 for HCSW-1 and 1951 to 2018 for HCSW-4 using USGS gauging stations.

6.0 WATER QUALITY RESULTS AND DISCUSSION

The results of field measurements and laboratory analyses of water samples obtained monthly during 2018 at each HCSP monitoring station are presented in this section (see Appendix C for water quality figures from 2003 through present). Continuous recorder data for pH, dissolved oxygen, turbidity, and specific conductivity are also presented, along with the field measurements obtained during benthic macroinvertebrate and fish sampling on 30 April, 30 October, and 12 December 2018. Water quality raw data are included in a database on the attached compact disc.

In September 2009, based on recommendations of the PRMRWSA and the TAG, Mosaic began sampling water quality at an additional station on Brushy Creek (BCSW-1 at Post Plant Road). Brushy Creek is a tributary to Horse Creek and flows into Horse Creek between the HCSW-1 and HCSW-2 sampling stations. This additional station was added for comparison purposes and will not be evaluated against the HCSP trigger levels and exceedances. Mosaic does not currently have a NPDES outfall on Brushy Creek. While the Brushy Creek data has been included in the graphs of the 2018 water quality data, it was not included in any other plots or analyses.

In September 2009, Mosaic discontinued water quality analysis for FL-PRO, total fatty acids, and total amines based on recommendations made in previous HCSP annual reports. Mosaic, PRMRWSA, and the TAG agree that the results for these parameters from 2003 to 2009 show that these parameters are present only occasionally at very low concentrations and are not a cause for concern at this time. Beginning with the 2014 report, the revised HCSP trigger level for DO is the time of day translation of the 38 percent saturation daily average criterion. DO saturation collected as part of the HCSP in 2018 was compared to the new trigger level and DO concentration was dropped from monitoring in 2018 (except at the continuous monitoring site). Water quality of the NPDES discharge is normally obtained periodically when water is discharged from Outfalls FTG-003 and WIN-004.

6.1 Data Analysis

Monthly and continuous water quality data for 2018 are presented on scatter plots. HCSP samples for the duration of the HCSP are presented in Appendix C. Graphical representations of HCSP data include undetected values, represented by the respective Minimum Detection Levels (MDLs) for each parameter, except for total nitrogen and total radium. Total nitrogen and total radium are composite parameters without MDLs. Values of these parameters for which one or both components were undetected are marked. Undetected results for all parameters were changed to one-half of the MDL for any statistical analyses.

Based on a literature review on tests for water quality data trend detection (Appendix D), the best monotonic trend detection method for use in the HCSP is the Seasonal Kendall. Because the USGS recommends a minimum of five years of data collection before applying the Seasonal Kendall test (Schertz et al. 1991), the 2008 Annual Report was the first report to include this analysis. The Seasonal Kendall method is a frequently recommended method for detecting trends in water quality data (Lettenmaier 1988, Hirsch et al. 1982, Harcum et al. 1992, Helsel et al. 2006). The Seasonal Kendall was developed by and is now the method of choice for the USGS (Hirsch et al. 1982, Helsel et al. 2006).

The Seasonal Kendall test determines water quality trends after correcting for seasonality by only comparing values between similar seasons over time (Schertz et al. 1991). The Seasonal Kendall test selects one value for each season (average, median, or subsample) and makes all pair-wise comparisons between time-ordered seasonal values (Harcum et al. 1992). A test statistic (Tau) 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). Results for the Seasonal Kendall include the magnitude of the statistic Tau, its significance (p), its slope (Sen slope estimator), and the direction of significant trends. The trend (Sen) slope is the median slope of all pairwise comparisons. The direction of this slope (positive or negative) is more resistant to the effects of observations below minimum detection limits and missing data than the magnitude of the slope. The slope is a measure of the monotonic trend; the actual temporal variation may include step trends or trend reversals. If alternate seasons exhibit trends in opposite directions, the Seasonal Kendall test will not detect an overall trend (Lettenmaier 1988).

Trend detection in this report is limited by several factors. With sixteen years of data, the power of the test to detect trends of small magnitude is not limited (Harcum et al. 1992, Hirsch et al. 1982). Data for parameters whose method detection limits have changed several times over the HCSP (fluoride, nitrate-nitrite, ammonia) would have to be truncated to the highest detection limit, thereby reducing the available data for the test. As a result, trends were evaluated using alternative data collected by SWFWMD for these parameters; SWFWMD reduced sampling frequency in 2011, so seasonal trend tests may not be as accurate for those parameters. Because HCSW-1 and HCSW-4 were the only stations with USGS flow data that is necessary for interpreting trends in flow-dependent parameters, they were the only stations used in this trend analysis. Any changes over time detected using the Seasonal Kendall test should be further examined to determine if the perceived change is caused by a data bias, if its magnitude is ecologically significant, and if the cause of the trend is related to Mosaic mining activities. If warranted, an impact analysis can be performed on statistically significant trends to determine if trends are caused by Mosaic mining activities and if a corrective action by Mosaic is necessary.

A summary of the Seasonal Kendall Tau results for all parameters is presented in Table 6-1 with an in-depth discussion of trends presented for each individual parameter. The year was split into three seasons, corresponding to wet/dry periods. Season one encompassed the first part of peninsular Florida’s dry season, January through April. Season two spanned May to September (the wet season along with May, which in this region tends to be fairly rainy), and season three represented the second dry season during the calendar year, October through December. The Sen slope estimate for a parameter was only reported if the trend was statistically significant (significant p values [less than 0.05] are in **bold** in Table 6-2). For those parameters where SWFWMD data was used for trend analysis (fluoride, nitrate-nitrite, and ammonia), the magnitude of the slope estimate may not be accurate because in October 2011, SWFWMD went from monthly sampling to every other month, making the slope estimates for the third season inconsistent with the analysis that used the HCSP data.

Parameters that were significantly correlated with USGS streamflow were corrected for the effect of annual variation in log streamflow using a Locally Estimated Scatterplot Smoothing (LOESS) smooth (F=0.5) before the Seasonal Kendall-tau was performed. LOESS (local polynomial regression) in the seasonal Kendall-tau describes the relationship between the concentrations of a water quality parameter and streamflow using a weighted regression. The residuals of the smooth have the effect of streamflow subtracted and are called flow-adjusted concentrations (Hirsch et al. 1991). Flow-adjusted concentrations are necessary when the variable in question has an inherent relationship with streamflow, which can confound any comparisons made of water quality between stations or times with different instantaneous flow. If the variability of a water quality parameter could be completely explained by streamflow, then during smoothing, all of the data points would fall along a single best-fit line, and all of the residuals (distance between the points and the line) would be zero. For real data, the differences between the data points and the best-fit line show the part of the variability in water quality that is not caused by changes in streamflow, i.e. the flow-adjusted concentrations. Kendall-tau analyses were performed in R (version 3.1.1) using the R function EnvStats: KendallTrendTest (Millard 2013). LOESS smoothing was done using log of streamflow within the R function stats: loess (R Core Team 2014), with a smoothing factor (span) of 0.5, symmetric family, and degree of 1 for polynomials.

Differences in water quality between stations from 2003 to 2018 for each water quality parameter were evaluated using Analysis of Variance (ANOVA) and Duncan’s post hoc test (Table 6-2). This analysis will help to identify potential differences among stations that can be examined in more detail as the HCSP continues. A summary of the ANOVA results for all parameters is presented in Table 6-2 with detailed discussion presented under each parameter heading below. Parameters whose MDLs have changed over the course of the program were omitted from ANOVA because of limited comparable data between sampling events and stations (i.e., fluoride, nitrate-nitrite, ammonia).

Water quality parameters were compared with water quantity variables recorded during the same month from 2003 to 2018, including average daily streamflow for the month, average daily NPDES discharge for the month, and total monthly rainfall. Because these three water quantity variables are correlated to each other (Table 5-6), a statistically significant correlation between NPDES discharge and water quality does not prove a causal relationship between water quality and mining discharge. The results of this correlation analysis are presented in Table 6-3. Each of these correlations is discussed further in each water quality parameter section.

Table 6-1 Summary of Seasonal Kendall-tau with LOESS (F=0.5) for HCSW-1 and HCSW-4 from 2003 to 2018

Parameter	HCSW-1				HCSW-4			
	tau	p-value	slope	2018 Median	tau	p-value	slope	2018 Median
Alkalinity	**0.44**	**<0.001**	**2.32**	74.3	**0.24**	**0.024**	**0.54**	31
Calcium, Dissolved	**0.5**	**<0.001**	**1.1**	36.6	0.17	0.125	N/A	36.6
Chloride	-0.14	0.185	N/A	13.5	-0.06	0.621	N/A	19.2
Chlorophyll-a[2]	**-0.22**	**0.045**	**-0.03**	0.86	**-0.27**	**0.012**	**-0.05**	1.18
Color, Apparent	0.07	0.533	N/A	150	**0.24**	**0.027**	**2.82**	250
Dissolved Solids, Total	**0.47**	**<0.001**	**9.04**	301	0.12	0.264	N/A	354
Fluoride*	**0.38**	**0.009**	**0.01**	0.56	0.2	0.18	N/A	0.485
Iron, Dissolved	**-0.39**	**<0.001**	**-0.01**	0.247	**-0.28**	**0.012**	**-0.01**	0.309
Nitrogen, Ammonia*	**-0.39**	**<0.001**	<0.001	0.014	0	1	N/A	0.042
Nitrogen, Nitrate-nitrite*	0.07	0.51	N/A	0.038	0.04	0.735	N/A	0.239
Nitrogen, Total	0.1	0.363	N/A	1.005	0.19	0.082	N/A	1.415
Nitrogen, Total Kjeldahl	0.08	0.45	N/A	0.955	**0.22**	**0.045**	**0.02**	1.11
Orthophosphate[2]	0.04	0.697	N/A	0.356	0.02	0.856	N/A	0.362
Oxygen, Dissolved (mg/L)	**0.26**	**0.018**	**0.04**	6.83	0.03	0.815	N/A	5.35
Oxygen[1], Dissolved (%Sat)	0.04	0.735	N/A	84.7	-0.15	0.168	N/A	67.2
pH	**0.51**	**<0.001**	**0.04**	7.49	**0.22**	**0.045**	**0.02**	7.01
Specific Conductance	**0.48**	**<0.001**	**12.1**	389	**0.24**	**0.024**	**5.69**	380
Sulfate	**0.43**	**<0.001**	**4.24**	97.5	0.21	0.058	N/A	95.7
Turbidity	0.11	0.311	N/A	4.2	**0.36**	**0.001**	**0.09**	3.6

*SWFWMD data was used from April 2003 to November 2018. Sampling was reduced to every other month starting October 2011, making slope estimates approximate.

[1] Percent DO calculated from DO saturation (mg/L) and temperature. Temperature data was not available for samples prior to June 2006. Analysis period for DO % saturation is from June 2006 to December 2018.

[2] Data was not correlated with streamflow for either station; LOESS was not used.

Table 6-2 Summary of results from ANOVA for differences between stations from 2003 to 2018

Group	Parameter	F	p-value
Anions	Alkalinity	67.52	<0.001
	Chloride	38	<0.001
	Fluoride	62.71	<0.001
	Sulfate	70.15	<0.001
Cations	Calcium, Dissolved	73.06	<0.001
	Iron, Dissolved	0.19	0.902
Nutrients	Chlorophyll-*a*	42	<0.001
	Nitrogen, Ammonia	4.11	0.007
	Nitrogen, Nitrate-Nitrite	89.47	<0.001
	Nitrogen, Total	4.72	<0.001
	Nitrogen, Total Kjeldahl	21.48	<0.001
	Orthophosphate	11.27	<0.001
Physical	Color, Apparent	9.7	<0.001
	Dissolved Solids, Total	62.12	<0.001
	Oxygen, Dissolved (%Sat)	193.9	<0.001
	Oxygen, Dissolved (mg/L)	220.29	<0.001
	pH	59.83	<0.001
	Specific Conductance	56.022	<0.001
	Turbidity	0.772	0.510
Radiological	Radium, Combined	6.03	<0.001

[1] DO saturation (%) calculated from DO concentration (mg/L) and temperature. Temperature data was not available for samples prior to June 2006. Analysis period for DO % saturation is from June 2006 to December 2018.

Table 6-3 Spearman's Rank Correlation between water quality and water quantity at HCSW-1 and HCSW-4, as represented by average daily streamflow, average daily NPDES discharge, and total rainfall for the same month from 2003 to 2018

Group	Parameter	HCSW-1			HCSW-4		
		Rainfall	NPDES	Streamflow	Rainfall	NPDES	Streamflow
Anions	Alkalinity (mg/L)	-0.25*	0.12	-0.08	-0.51*	-0.47*	-0.83*
	Chloride (mg/L)	-0.36*	-0.62*	-0.78*	-0.33*	-0.61*	-0.86*
	Fluoride (mg/L)††	0.07	0.268*	0.11*	-0.272*	-0.504*	-0.891*
	Sulfate (mg/L)	-0.12	0.35*	0.17*	-0.29*	-0.56*	-0.77*
Cations	Calcium, Dissolved (mg/L)	-0.22*	0.25*	0.03	-0.78*	-0.61*	-0.83*
	Iron, Dissolved (mg/L)	0.58*	0.28*	0.60*	0.46*	0.50*	0.81*
Nutrients	Ammonia, Total (mg/L)††	0.114	0.261*	0.394*	0.156	0.164	0.325*
	Chlorophyll-*a* (mg/m^3)	0.14	0.24*	0.22*	0.22*	0.07	0.01
	Nitrate-Nitrite (mg/L)††	0.24*	0.149	0.15	-0.174*	-0.35*	-0.347*
	Nitrogen, Total (mg/L)	0.40*	0.27*	0.51*	0.16*	0.13	0.31*
	Nitrogen, Total Kjeldahl (mg/L)	0.41*	0.31*	0.55*	0.32*	0.43*	0.63*
	Orthophosphate (mg/L)	-0.06	0.09	-0.02	0.07	0.07	0.00
Physical	Color, Apparent (pcu)	0.44*	0.38*	0.64*	0.33*	0.55*	0.83*
	Dissolved Solids, Total (mg/L)	-0.10	0.34*	0.20*	-0.26*	-0.52*	-0.75*
	Oxygen Dissolved (% Sat)†	-0.50*	-0.57*	-0.74*	-0.60*	-0.55*	-0.74*
	Oxygen, Dissolved (mg/L)	-0.54*	-0.46*	-0.54*	-0.53*	-0.50*	-0.72*
	pH (su)	-0.37*	-0.17*	-0.33*	-0.29*	-0.30*	-0.51*
	Specific Conductance (µS)	-0.20*	0.24*	0.03*	-0.32*	-0.56*	-0.82*
	Turbidity (NTU)	0.33*	0.40*	0.64*	0.26*	0.35*	0.59*
Radiological	Radium, Total (pCi/L)	0.00	-0.24*	-0.22*	0.09	-0.28*	-0.29*

* - Statistically significant at $p < 0.05$

†Percent DO calculated from DO saturation (mg/L) and temperature. Temperature data was not available for samples prior to June 2006. Analysis period for DO % saturation is from June 2006 to December 2018.

††SWFWMD data

6.2 Physio-Chemical Parameters

6.2.1 pH

Measurements of pH, dissolved oxygen, turbidity, and specific conductivity were obtained in the field during each monthly water-quality sampling event. Values of pH were within the range of established trigger levels during all of 2018 sampling events at all stations (Figure 6-1). Continuous pH data obtained daily at HCSW-1 in 2018 was within a range similar to that obtained during monthly water quality sampling (one daily minimum was below lower trigger on April 26, 2018 most likely due to repeated sensor failures that occurred between 0915 and 1115, Figure 6-2).

There was a slightly increasing monotonic trend for pH at HCSW-1 and HCSW-4 (Seasonal Kendall-tau with LOESS, slope = 0.04 SU and 0.02 SU per year flow-adjusted concentrations). The slope for these potential trends is very small compared to limits in laboratory prediction or the observed differences between primary and duplicate field samples. The evaluation of changes in pH over time for this report would be very similar to what was discussed in previous reports (2017 Annual Report – Appendix I); therefore, pH was not included in this year's impact assessment. Based on previous reports, pH is not having an ecologically significant increase at HCSW-1 over the course of the HCSP program and is not of concern at this time.

Levels of pH were different among stations from 2003 to 2018 (ANOVA, Table 6-2); HCSW-2 had lower pH than other stations and HCSW-1 had the highest pH (Duncan's multiple range-test, $p < 0.05$). HCSW-2 lies just downstream of the Horse Creek Prairie, a blackwater swamp complex that has the potential to add substantial organic acids from plant decomposition and decrease the pH (Reid and Wood 1976). Brushy Creek also contributes to HCSW-2, and similarly has a relatively low pH compared to HCSW-1 (Figure 6-1). At HCSW-1 and HCSW-4, pH was significantly negatively correlated with rainfall, NPDES discharge, and streamflow, at respective gauging stations (Spearman's rank correlation, Table 6-3). pH was highly correlated to rainfall and streamflow at HCSW-1 and to a lesser extent, the NPDES discharge.

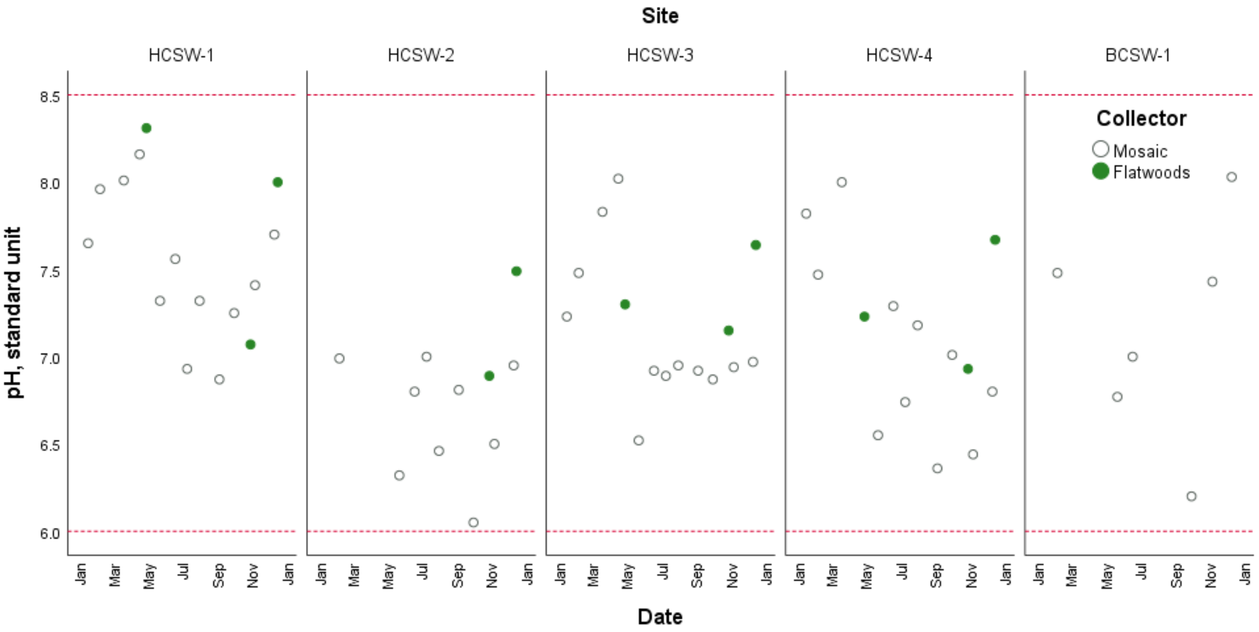


Figure 6-1 Values of pH obtained during monthly HCSP water quality sampling and biological sampling events in 2018

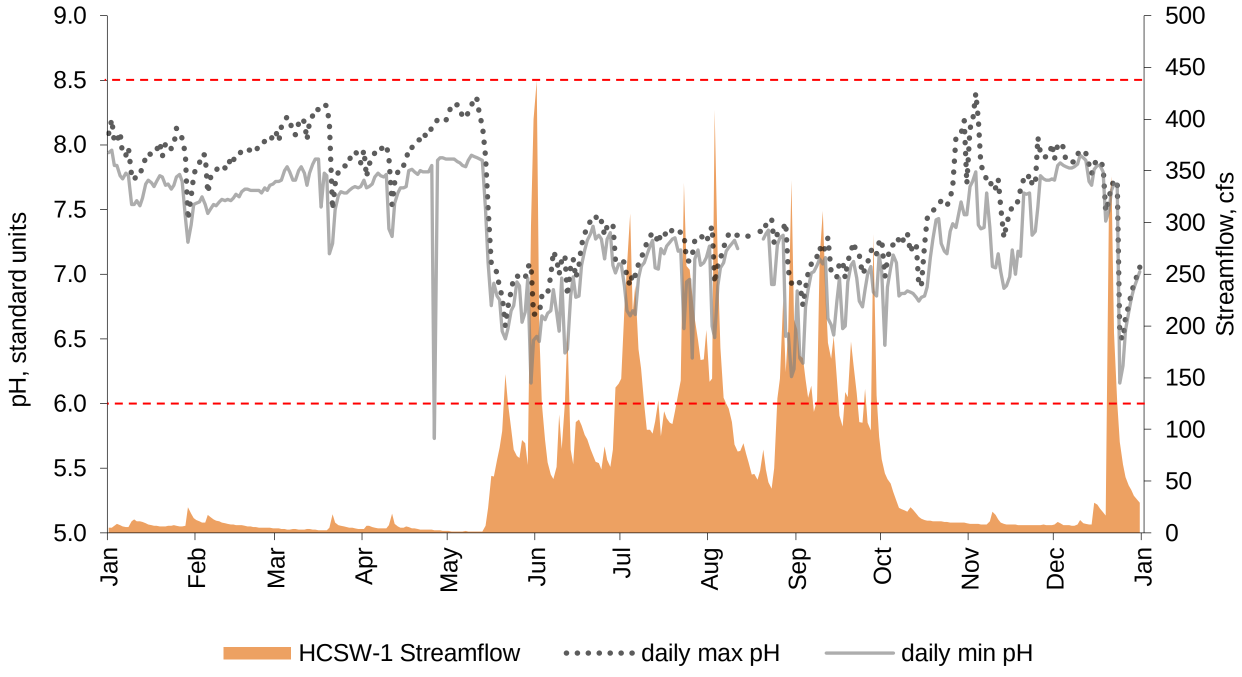


Figure 6-2 **Relationship between daily mean pH (obtained from the continuous recorder at HCSW-1) and daily mean streamflow for 2018. Minimum pH detection limit = 0.1 SU.**

6.2.2 Dissolved Oxygen

The Class III Dissolved Oxygen (DO) standard was updated by FDEP in 2013 from 5.0 mg/L to be a daily average of 38 percent, which is adjusted for time of day when being compared to a single grab sample. Beginning with the 2014 report, the revised HCSP trigger level is the time of day translation of the 38 percent saturation daily average criterion. DO saturation collected as part of the HCSP in 2018 was compared to the new trigger level and DO concentration was dropped from monitoring (however continued for HCSW-1 continuous monitoring station). While no longer a trigger value, the DO concentration in mg/L was used to calculate and extend the DO saturation record when corresponding temperature and conductivity data were available (June 2006 to April 2013). All HCSP monthly sampling from May 2013 to present include DO percent saturation.

There were seven DO saturation exceedances detected during monthly sampling- five at HCSW-2 (May- November) and two downstream at HCSW-3 (May and June). All apparent continuous monitoring exceedances are related to increased streamflow events, from which DO saturation values quickly recover (Figure 6-4).

For parts of the year the creek is disconnected due to the impoundment caused by the roadway/culvert upstream of HCSW-2. This impoundment, coupled with the organic inputs from the upstream prairie, has created a situation where HCSW-2 experiences frequent low or no flow conditions, consistently slower water velocities (when compared to other HCSP monitoring stations), increased residence time, deposition of coarse organic matter, and the formation of an anaerobic mucky streambed.

DO saturation at HCSW-1 and HCSW-4 measured by the HCSP are consistent with other water quality data sources at these same locations (Appendix C, Figures C-24 and C-25). DO saturation at HCSW-1 and HCSW-4 exhibited no monotonic trend between 2006 and 2018 (Seasonal Kendall-tau with LOESS, $p > 0.05$, Table 6-1).

DO saturation was different among stations from 2006 to 2018 (ANOVA, Table 6-2), with lowest values occurring at HCSW-2 and the highest at HCSW-1 (Duncan's multiple range test, $p < 0.05$). Dissolved oxygen saturation was negatively correlated with all water quantity variables at both HCSW-1 and HCSW-4 (rainfall, streamflow, and NPDES discharge, Spearman's rank correlations, Table 6-3); because streamflow and NPDES discharge are positively correlated with rainfall (with lag times), this means that dissolved oxygen is lowest during or following periods of high rainfall. During the wet season, higher temperatures in the stream drive down the oxygen saturation, and the decomposition of woody debris washed into the stream during high rains can increase oxygen demand.

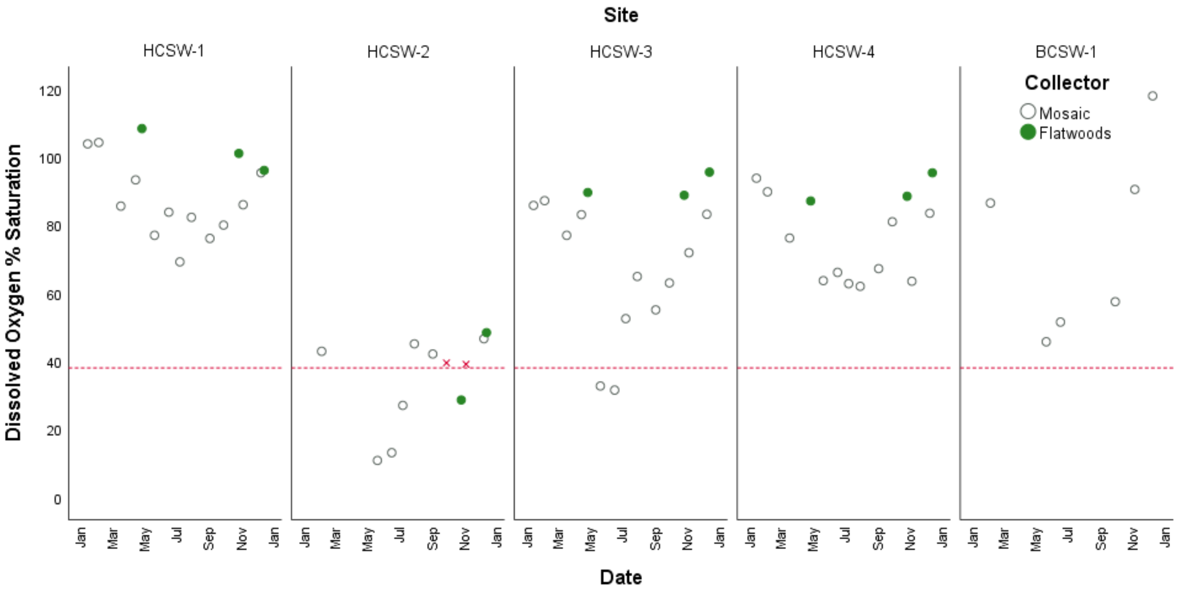


Figure 6-3 **Dissolved oxygen percent saturations obtained during monthly HCSP water quality sampling and biological sampling events in 2018. Red "X" denotes values that were >38% but failed to meet time-of-day criteria for DO saturation (both were collected by Mosaic).**

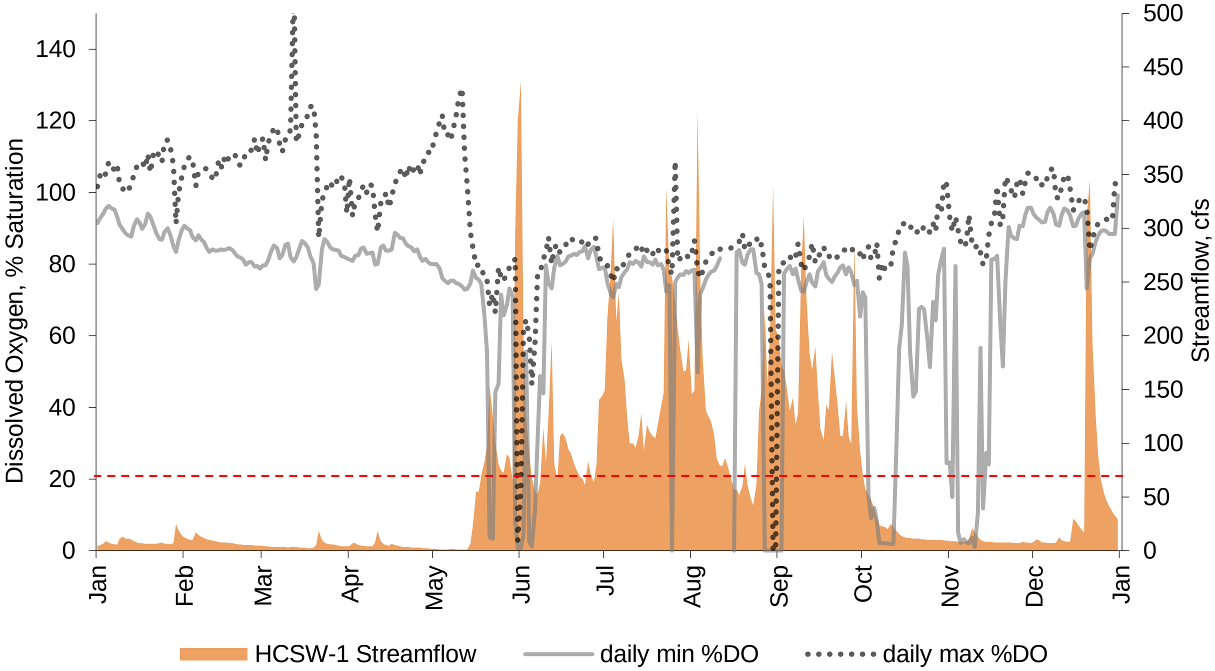


Figure 6-4 **Relationship between daily mean DO percent saturation (obtained from the continuous recorder at HCSW-1) and daily mean streamflow for 2018. Minimum DO detection limit = 1%.**

6.2.3 Turbidity

Turbidity levels at all stations in 2018 were below the trigger level and Class III Surface Water Quality Standard of 29 nephelometric turbidity units (NTUs). Turbidity measured at HCSW-1 by the continuous recorder was similar to monthly measurements with the exception of a few isolated higher measurements that most likely coincide with higher rainfall events or material becoming lodged in the deployment structure (Figure 6-6). Some of the higher continuous recorder turbidity measurements did cause an alert for potential CSA dam breach (twelve consecutive readings of > 150 NTUs). All of the alerts were investigated and found to be false alarms as either water levels were too low for the sensor, debris from upstream became lodged within the deployment structure, or organisms (crayfish) became lodged in the deployment structure. There have been no actionable turbidity alerts since the program came online.

The turbidity levels at HCSW-1 and HCSW-4 measured by the HCSP are consistent with other water quality data sources at these same locations (Appendix C, Figures C-26 and C-27) and between 2003 and 2018 there was no trend detected at HCSW-1 and a monotonic trend of 0.04NTU/year at HCSW-4 (Seasonal Kendall-tau with LOESS, $p > 0.05$, Table 6-1). This slope is small and does not appear to be related to NPDES discharge as there was no trend at HCSW-1; it is not of ecological concern at this point but will continue to be monitored in the future.

Turbidity levels were not different among stations from 2003 to 2018 (ANOVA, Table 6-2). Turbidity was positively correlated with all water quantity parameters at HCSW-1 and HCSW-4 (rainfall, streamflow, and NPDES discharge, Spearman's rank correlation, Table 6-3); because streamflow and NPDES discharge are positively correlated with rainfall (with lag times), this means that generally turbidity is highest during or following periods of high rainfall and periods of high flow (Figure 6-6). Turbidity measurements at Brushy Creek were similar to Horse Creek stations during most events (Figure 6-5).

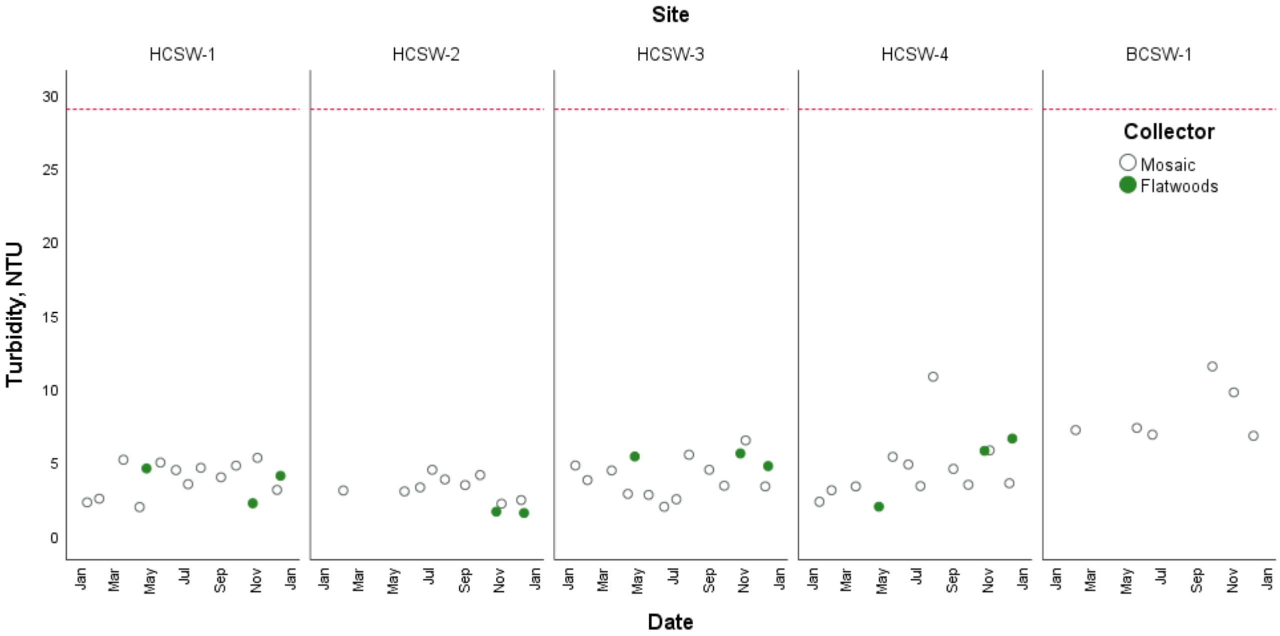


Figure 6-5 **Turbidity levels obtained during monthly HCSP water quality sampling and biological sampling events in 2018**

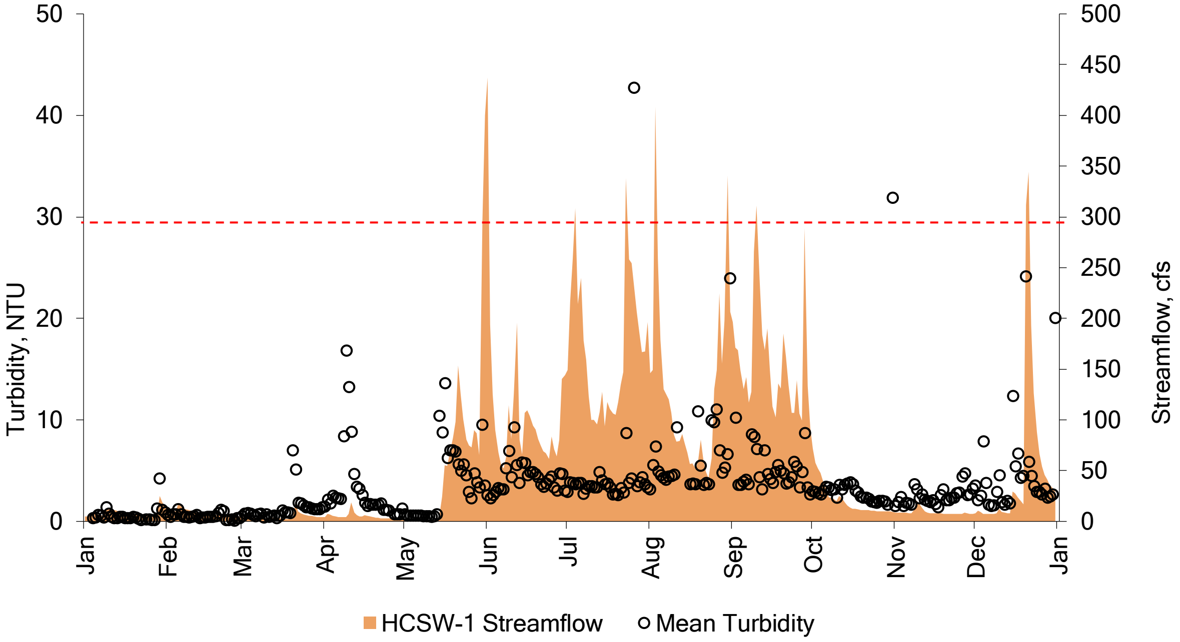


Figure 6-6 **Relationship between daily mean turbidity (obtained from the continuous recorder at HCSW-1) and daily mean streamflow for 2018. Minimum detection limit = 0.1 NTU**

6.2.4 Apparent Color

All color values in 2018 were above the trigger level of 25 Platinum-Cobalt units (PCU) (indicating desirable conditions) during all events at all stations (Figure 6-7). The color levels at HCSW-1 measured by the HCSP are consistent with other water quality data sources at this same location (Appendix C, Figure C-28) and did not exhibit any monotonic trends from 2003 to 2018 (Seasonal Kendall-tau with LOESS, $p > 0.05$, Table 6-1). However, HCSW-4 exhibited an increasing monotonic trend over the 2003 to 2018 time period (slope = 2.82 PCU per year flow-adjusted concentration, Table 6-1). The trigger level for color in the HCSP is expressed as a minimum, so the observed upward trend at HCSW-4 is not of concern as it relates to a defined HCSP trigger level; over time, the program will continue to monitor this trend.

Color levels were different among stations from 2003 to 2018 (ANOVA, Table 6-2), with HCSW-2 having higher color than other stations (Duncan's multiple range test, $p < 0.05$). HCSW-2 receives input from Horse Creek Prairie which contributes higher color levels to this station. Brushy Creek generally has higher color than the Horse Creek stations and also flows into Horse Creek above HCSW-2 (Figure 6-7). Color was positively correlated with all water quantity variables at HCSW-1 and HCSW-4 (rainfall, streamflow, and NPDES discharge, Spearman's rank correlations, Table 6-3). As streamflow and NPDES discharge are positively correlated with rainfall (with lag times), this means that color values are highest during or following periods of high rainfall.

The similar pattern among the stations, with higher color in the wet, summer months, and lower levels in the dry, winter months, suggest that color is affected by the differential inputs of surface water and groundwater seepage. During the wet season when surface flows from wetland areas are highest, the transport of tannins to Horse Creek adds more color to the water (Reid and Wood 1976). This was very evident during and after Hurricane Charley in 2004 (Appendix C). As the dry season begins, groundwater seepage provides a proportionally higher contribution of clearer water to Horse Creek, thereby decreasing the color of the water. It is likely that agricultural irrigation return flows also have some impact on color in the stream by introducing clearer groundwater during the drier parts of the year or during dry years like 2006 and 2007. This agricultural influence is also noted below with respect to several other parameters.

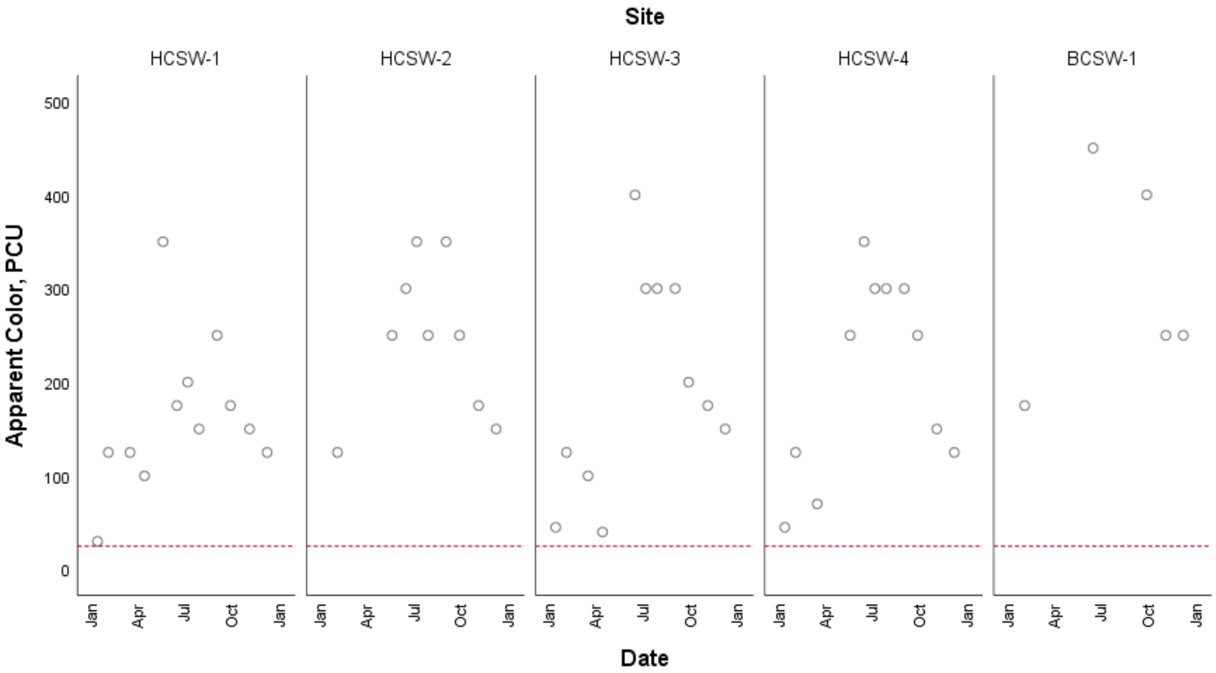


Figure 6-7 Color levels obtained during monthly HCSP water quality sampling in 2018.

6.3 Nutrients

6.3.1 Total Nitrogen

Total nitrogen[17] concentrations were between 0.74 and 2.00 mg/L during all sampling events at all Horse Creek stations in 2018, consistently below the trigger value of 3.0 mg/L at all stations. The major component of total nitrogen in nearly all samples was organic nitrogen. The total nitrogen concentrations at HCSW-1 and HCSW-4 measured by the HCSP are consistent with other water quality data sources at these locations (Appendix C, Figures C-30 and C-31) and exhibited no monotonic trend since 2003 (Seasonal Kendall-tau with LOESS, $p > 0.05$, Table 6-1). Total nitrogen concentrations were different among stations from 2003 to 2018 (ANOVA, Table 6-2), with lower concentrations at HCSW-1 than other stations (Duncan's multiple range test, $p < 0.05$). Total nitrogen was positively correlated with all water quantity variables at HCSW-1 (rainfall, streamflow, and NPDES discharge), and with rainfall and streamflow at HCSW-4 (Spearman's rank correlations, Table 6-3). As streamflow and NPDES discharge are positively correlated with rainfall (with lag times), this means that total nitrogen values are highest during or following periods of high rainfall. Total nitrogen concentrations at Brushy Creek were slightly higher than most concentrations at the Horse Creek stations (Figure 6-8).

In addition to the trigger level for TN, HCSW-1, the station with the highest percent of upstream mined lands, was evaluated against the recently approved state numeric nutrient standards. Under those standards, in order to avoid being listed as impaired for nutrients, a stream must pass a combination of biological and/or numerical criteria. According to 62-302 and 62-303 F.A.C., biological and nutrient data collected during the HCSP at HCSW-1 indicate no nutrient impairment (Appendix I, 2017 Annual Report). As of December 2018, HCSW-1 meets the nutrient criteria set in 62-302.351(2)(c), because it shows no imbalance of flora and fauna (chlorophyll, RPS, and LVS) and has healthy benthic macroinvertebrate conditions (SCI). HCSW-1 shows no evidence of persistent algal blooms, has annual geometric mean concentrations of chlorophyll < 3.2 µg/L, and has 11 passing Rapid Periphyton Surveys (RPS) and Linear Vegetation Surveys (LVS) from 2012 to 2018. The HCSW-1 average of SCI scores is > 40, with neither of the two most recent scores < 35. HCSW-1 also meets the SCI portion of the Biological Health Assessment in 62-303.330 with the two most recent SCI scores > 35 and within 20 points of the historic maximum (if the historic maximum is above 64).

---

[17] Total nitrogen is calculated as the arithmetic sum of TKN and nitrate-nitrite. As requested by the PRMRWSA, if either TKN or nitrate-nitrite is undetected, the MDL of the undetected constituent will be used as part of the total nitrogen calculation. Note that this use of MDL for undetected constituents is inconsistent with typical laboratory and DEP SOPs and may result in artificially high estimates of total nitrogen.

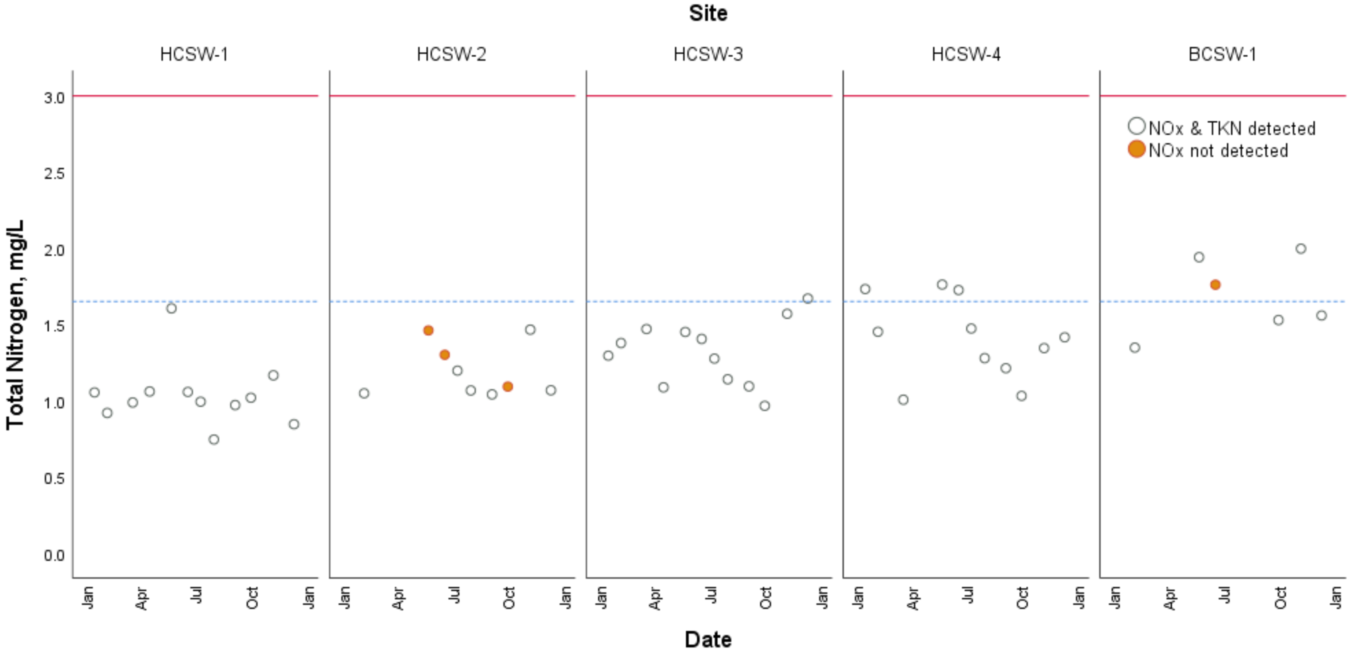


Figure 6-8 Total nitrogen concentrations obtained during monthly HCSP water quality sampling in 2018. Red solid line is the HCSP trigger level. Blue dotted line is the West Central Florida Numeric Nutrient Criteria.

6.3.2 Total Kjeldahl Nitrogen

Total Kjeldahl Nitrogen (TKN) comprised the majority (63 to 99.5 percent) of total nitrogen in most samples in 2018, and the majority of the TKN concentration was from organic nitrogen (Figure 6-9, compare with Figures 6-8 and 6-10). The HCSP does not have an independent trigger value for TKN.

The TKN concentrations at HCSW-1 and HCSW-4 measured by the HCSP are consistent with other water quality data sources for these locations (Appendix C, Figures C-32 and C-33) and HCSW-1 exhibited no monotonic trend since 2003 (Seasonal Kendall-tau with LOESS, $p > 0.05$, Table 6-1). There was a slight increasing trend in TKN at HCSW-4 from 2003 to 2018 (slope = 0.02 mg/L per year, flow-adjusted concentration, Table 6-1); because the slope was very small and there was no trend shown for HCSW-1 closer to mining, the trend at HCSW-4 is not of concern at this time.

Concentrations of TKN were different among stations from 2003 to 2018 (ANOVA, Table 6-2), with HCSW-2 having a higher concentration than the other three stations (Duncan's multiple range test, $p < 0.05$). Brushy Creek, which contributes to HCSW-2, has higher TKN concentrations than the Horse Creek stations (Figure 6-9). TKN was positively correlated with rainfall, streamflow, and NPDES discharge at HCSW-1 and HCSW-4

(Spearman's rank correlations, Table 6-3). As streamflow and NPDES discharge are positively correlated with rainfall (with lag times), this means that TKN values are highest during or following periods of high rainfall.

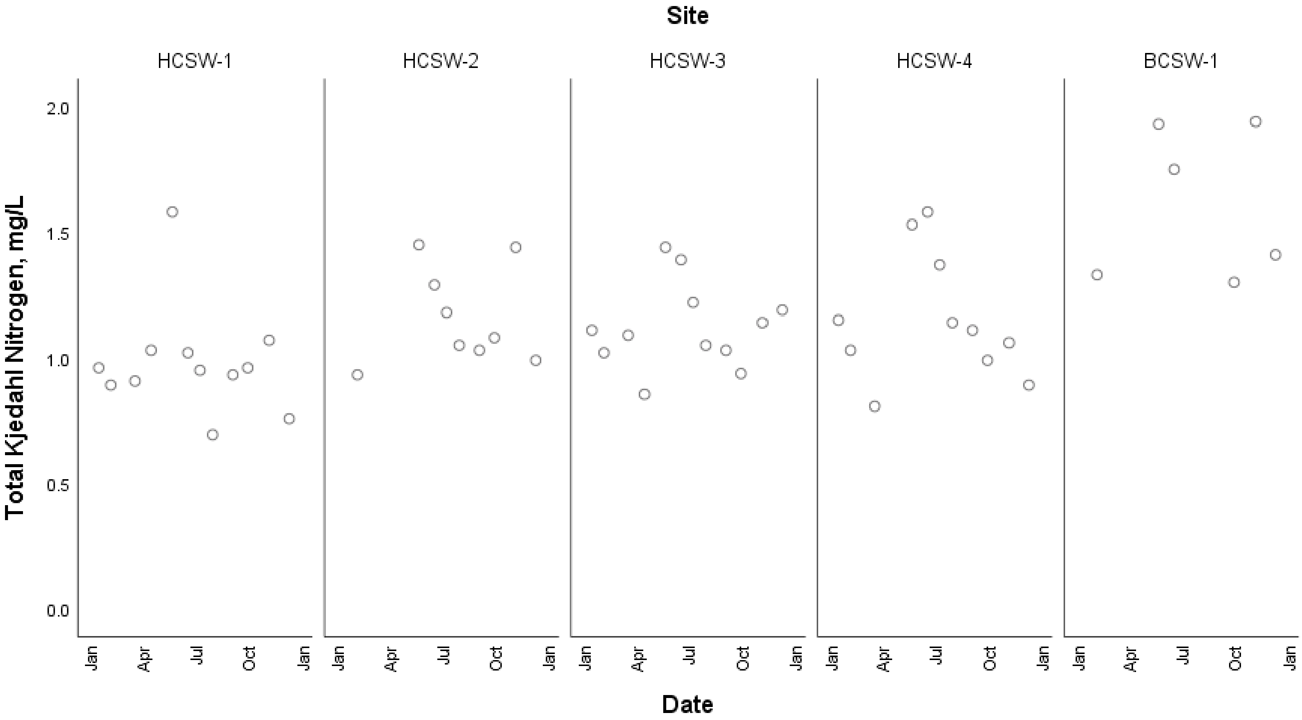


Figure 6-9 TKN concentrations obtained during monthly HCSP quality sampling in 2018

6.3.3 Nitrate-Nitrite Nitrogen

Concentrations of nitrate-nitrite were different among stations from 2003 to 2018 (ANOVA, Table 6-2), with HCSW-2 having the lowest mean concentration followed by HCSW-1, HCSW-3, then HCSW-4 (Duncan's multiple range test, $p < 0.05$). Nitrate-nitrate concentrations at the two upstream locations (HCSW-1 and HCSW-2) made up less than 10 percent of total nitrogen, while concentrations at the downstream locations (HCSW-3 and HCSW-4) accounted for up to 37 percent of total nitrogen (average of 9.6 percent) in 2018.

Nitrate-nitrite concentrations at HCSW-1 and HCSW-4 measured by the HCSP are consistent with other water quality data sources (Appendix C, Figures C-33 and C-34), but the HCSP data could not be analyzed for monotonic trends, correlations with water quantity, or differences between the four HCSP stations because of changes in MDL's over the course of the HCSP (Appendix C). Based on trend analysis performed with data collected by SWFWMD from 2003 to 2018, there are no monotonic trends in nitrate-nitrite for HCSW-1 or HCSW-4 (Seasonal Kendall-tau with LOESS, $p > 0.05$, Table 6-1).

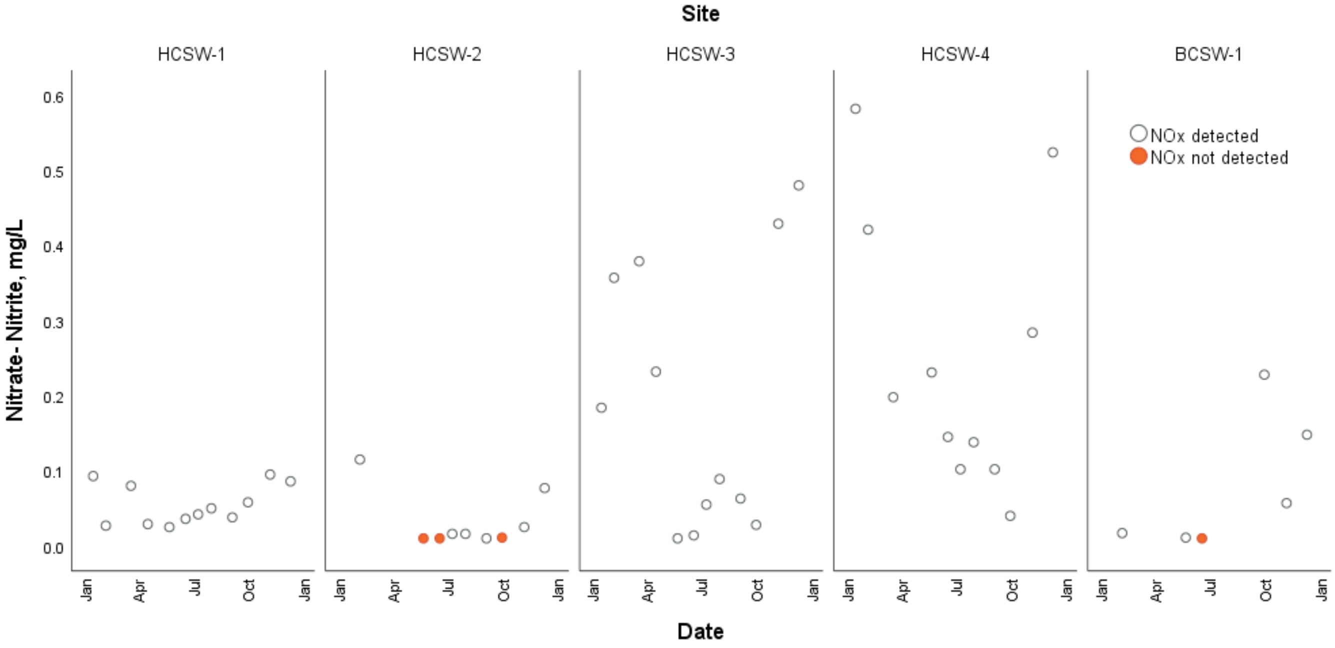


Figure 6-10 Nitrate-nitrite nitrogen concentrations obtained during monthly HCSP water quality sampling in 2018

6.3.4 Total Ammonia Nitrogen

Total ammonia nitrogen levels were within a similar range during almost all sampling events at all stations, (Figure 6-11). The exceedances that occurred at station HCSW-2, HCSW-3 and HCSW-4 occurred on the same day, July 11 (Table 6-4). On July 11, both HCSW-1 and BCSW-1 saw their respective highest total ammonia values in 2018, though below the trigger values. This phenomenon might be attributable to samples being collected following a period of high streamflow (Figure 5-3 & Figure 5-5).

The ammonia concentrations at HCSW-1 and HCSW-4 measured by the HCSP have been at levels within the normal range for the last decade of data (Appendix C, Figures C-36 and C-37). The HCSP data could not be analyzed for monotonic trends, correlations with water quantity, or differences between the four HCSP stations because of changes in MDL's over the course of the HCSP (Appendix C). Based on trend analysis performed using data collected by SWFWMD since 2003, there are no monotonic trends in total ammonia nitrogen at HCSW-1 or HCSW-4 (Seasonal Kendall-tau with LOESS, $p > 0.05$, Table 6-1).

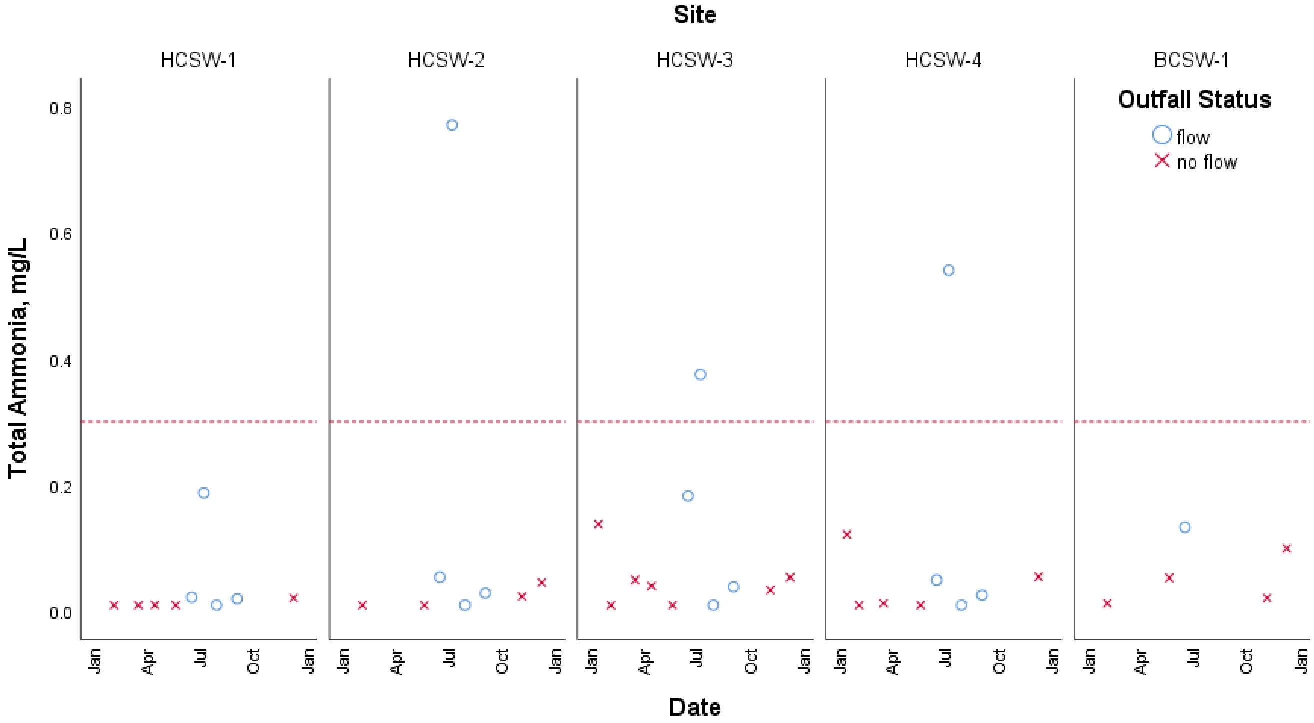


Figure 6-11 **Total ammonia nitrogen concentrations obtained during monthly HCSP water quality sampling in 2018.**

6.3.5 Orthophosphate

Orthophosphate concentrations were well below the trigger level of 2.5 mg/L in 2018 at all stations and events (Figure 6-12). Orthophosphate concentrations at Brushy Creek were similar to Horse Creek during sampling events in 2018. The orthophosphate concentrations at HCSW-1 and HCSW-4 measured by the HCSP are consistent with other water quality data sources at these locations (Appendix C, Figures C-38 and C-39).

Orthophosphate concentrations were different among stations from 2003 to 2018 (ANOVA, Table 6-2), with concentrations lowest at HCSW-2 (Duncan's multiple range test, $p < 0.05$). Orthophosphate was not correlated with any water quantity parameter at HCSW-1 or HCSW-4 (Spearman's rank correlation, Table 6-3). There are no increasing or decreasing monotonic trends at HCSW-1 or HCSW-4 over the 2003 to 2018 time period (Seasonal Kendall-tau, $p > 0.05$, Table 6-1).

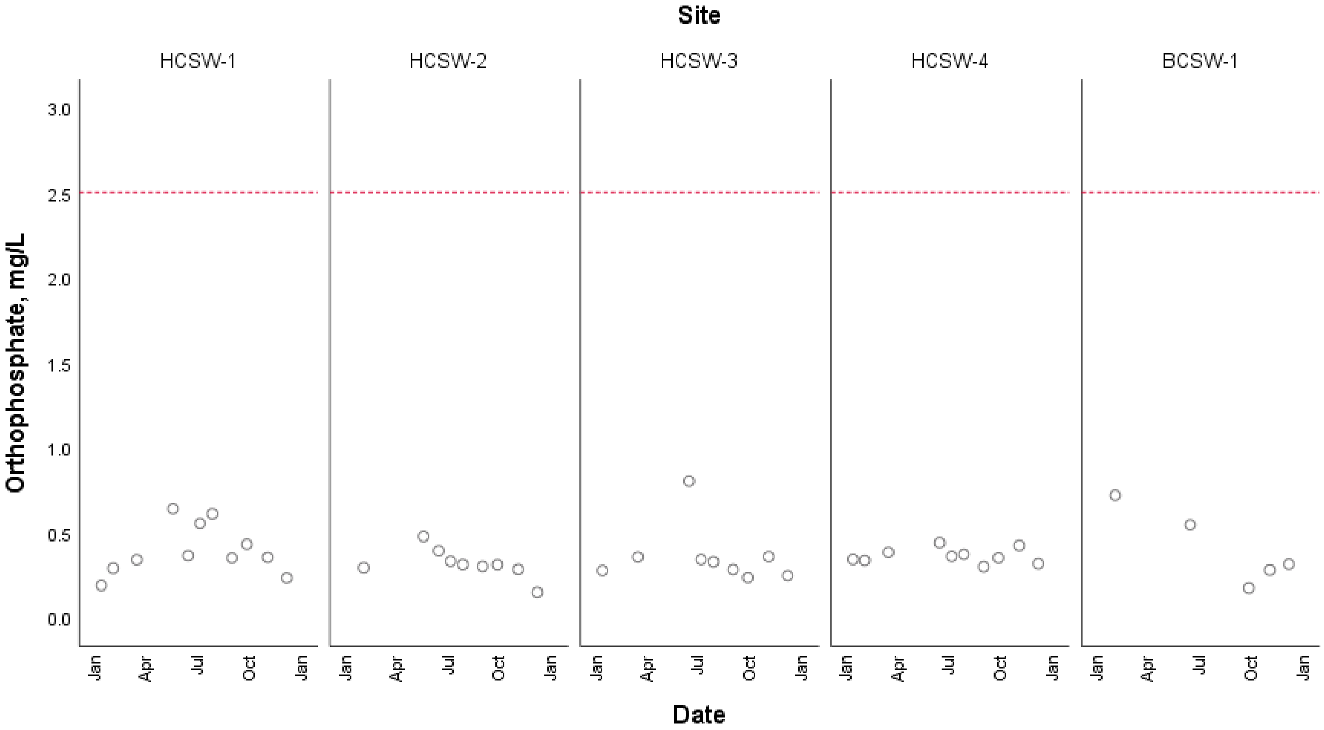


Figure 6-12 Orthophosphate concentrations obtained during monthly HCSP water quality sampling in 2018.

6.3.6 Chlorophyll-*a*

Chlorophyll-a values were well below the trigger level of 15 mg/m^3 during all sampling events at all four Horse Creek stations in 2018, (Figure 6-13). The chlorophyll-a concentrations at HCSW-1 and HCSW-4 measured by the HCSP are consistent with other water quality data sources at these locations (Appendix C, Figure C-40 and C-41) and exhibited a negative monotonic trend for the 2003 – 2018 period at HCSW-1 and HCSW-4 (Seasonal Kendall-tau with LOESS, $p > 0.05$, Table 6-1).

Chlorophyll-a concentrations were different between stations from 2003 to 2018 (ANOVA, Table 6-2), with concentrations at HCSW-2 (downstream of Horse Creek Prairie) higher than other stations (Duncan’s multiple range test, $p < 0.05$). Chlorophyll-a was weakly positively correlated with NPDES discharge and streamflow at HCSW-1, and chlorophyll-a was weakly positively correlated with rainfall at HCSW-4 (Spearman’s rank correlation, Table 6-3). Chlorophyll-a concentrations at Brushy Creek were higher than concentrations at all Horse Creek stations with one value (26 mg/m^3, November) exceeding the trigger values established for Horse Creek (Figure 6-13).

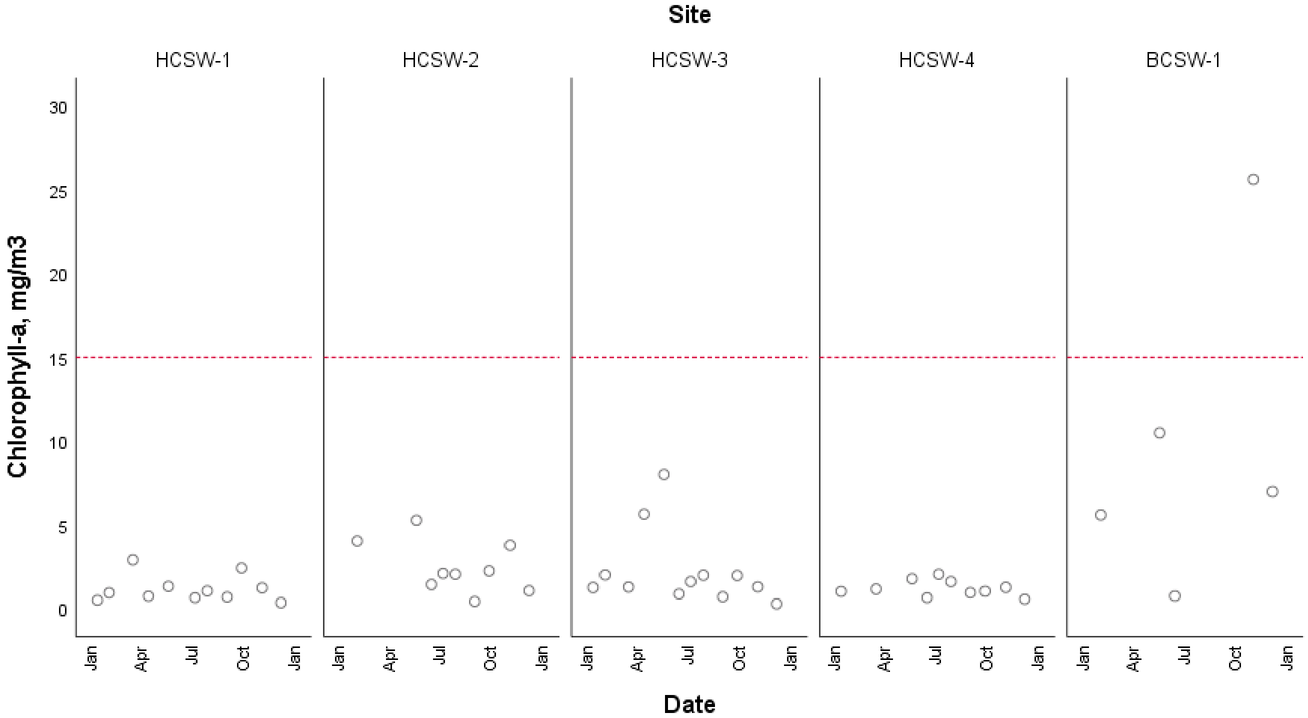


Figure 6-13 Chlorophyll-*a* concentrations obtained during monthly HCSP water quality sampling in 2018

6.4 Dissolved Minerals, Mining Reagents, and Radionuclides

6.4.1 Specific Conductivity

During all sampling events and at all stations, specific conductivity levels were well below the trigger level of 1275 µS in 2018 (Figure 6-14). Levels of specific conductivity in 2018 followed the same general pattern at all stations, with lower values during higher rainfall months and higher values during low rainfall months (Figure 6-15). The specific conductivity at both HCSW-1 and HCSW-4 measured by the HCSP are consistent with other water quality data sources (Appendix C, Figure C-42 and C-43). Specific conductivity values at Brushy Creek were lower than Horse Creek stations throughout 2018.

Specific conductivity exhibited an increasing trend since 2003 at HCSW-1 and HCSW-4 (Seasonal Kendall-tau with LOESS, Sen slope = 12.1 µS and 5.7 µS per year flow-adjusted concentrations, respectively, Table 6-1). The monotonic trends as well as a change point analyses for HCSW-1 were discussed in the 2017 impact analysis.

The change-point analysis of the dissolved ion data for HCSW-1 showed change-point increases around drought periods (1999 and 2007 for SWFWMD specific conductivity; 2006 to 2007 for HCSP specific conductivity, alkalinity, calcium, fluoride, sulfate, and TDS). Following the 2006 to 2007 drought period, specific conductivity and other ions had either relatively stable concentrations (fluoride, alkalinity), or had a cyclical pattern of step-changes (specific conductivity, sulfate, calcium, TDS), that ended with conditions similar in 2016-2017 to those seen in 2007. The trend for specific conductivity and other ions may have been influenced by regional factors unrelated to mining activities, drought-period baseflow contributions, upstream conditions, and increased influence of groundwater in current mining activities, but the current concentrations are stable and not at biologically harmful concentrations.

Any small portion of the change in specific conductivity that may have been affected by changes in NPDES water quality is likely to stay relatively constant at HCSW-1 in the near future given planned mining practices and the stable range of concentrations shown since Wingate mine began discharging to Horse Creek in 2008. The biological data from HCSW-1 do not indicate any significant effects of the step-change in conductivity, but the program will continue to monitor this closely.

Specific conductivity was different among stations over the 2003 to 2018 time period (ANOVA, Table 6-2), with the lowest overall readings at HCSW-2 followed by HCSW-1, HCSW-3, and then HCSW-4 (Duncan’s multiple range test, $p < 0.05$). Specific conductivity was negatively correlated with rainfall, streamflow, and NPDES discharge at HCSW-4 (Spearman’s rank correlations, Table 6-3). At HCSW-1, specific conductivity was positively correlated with NPDES discharge and streamflow and negatively correlated with rainfall (Table 6-3). Higher conductivity in the Lower Horse Creek Basin over the course of the historical record is discussed in the Historical Impact Assessment (Appendix I). The report found elevated specific conductivity is related to periods of low streamflow, and inputs from tributaries under which are heavily influenced by agriculture and irrigation return flows.

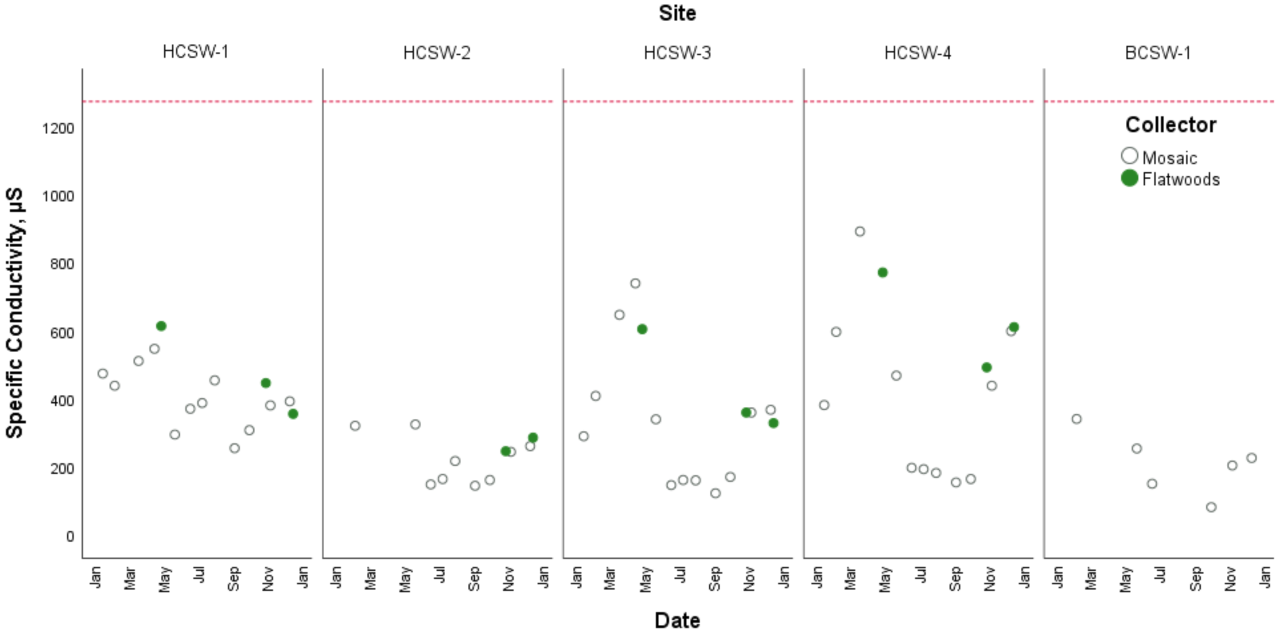


Figure 6-14 Specific conductivity measurements obtained during monthly HCSP water quality sampling and biological sampling events in 2018.

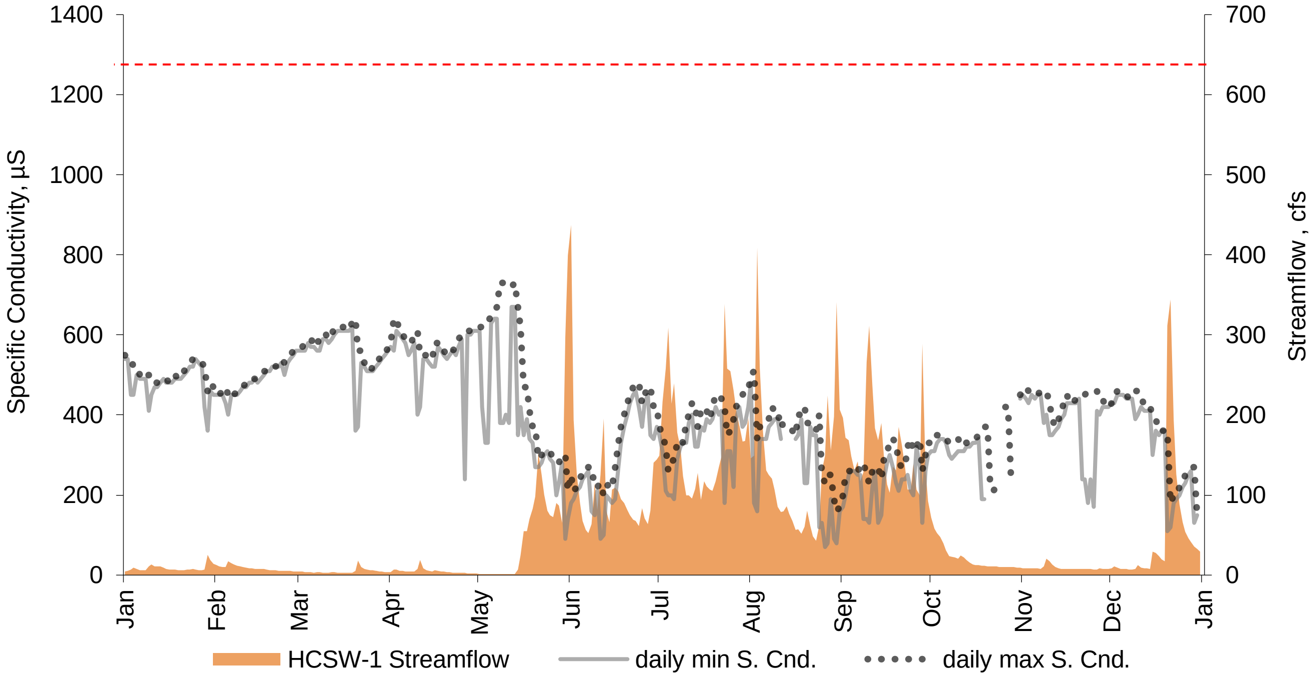


Figure 6-15 Relationship between daily mean specific conductivity (obtained from the continuous recorder at HCSW-1) and daily mean streamflow for 2018. Minimum detection limit = 10 µS.

6.4.2 Dissolved Calcium

Dissolved calcium concentrations were lower than the trigger value of 100 mg/L at all Horse Creek stations during all events in 2018 with the exception of the April sampling event at HCSW-4 (Figure 6-16). Brushy Creek had lower calcium concentrations than the Horse Creek stations. Dissolved calcium exhibited an increasing monotonic trend from 2003 to 2018 at HCSW-1 (Seasonal Kendall-tau with LOESS, Sen slope = 1.1 mg/L per year flow-adjusted concentrations, Table 6-1). The 2003 – 2017 trend for calcium at HCSW-1 was 1.18 mg/L/year. The observed 2003 – 2017 dissolved calcium trend at HCSW-4 vanished with the addition of the 2018 data. The relationship between historical dissolved calcium values, stream flow, baseflow, NPDES discharge and land use is discussed in detail in Appendix I.

Concentrations of calcium were different between stations from 2003 to 2018 (ANOVA, Table 6-2), with the lowest overall concentrations at HCSW-2, followed by HCSW-1, HCSW-3, and then HCSW-4 (Duncan's multiple range test, $p < 0.05$). Calcium was negatively correlated with rainfall, streamflow, and NPDES discharge at HCSW-4 (Spearman's rank correlations, Table 6-3), but at HCSW-1, it was positively correlated with NPDES discharge and negatively correlated with rainfall (Table 6-3).

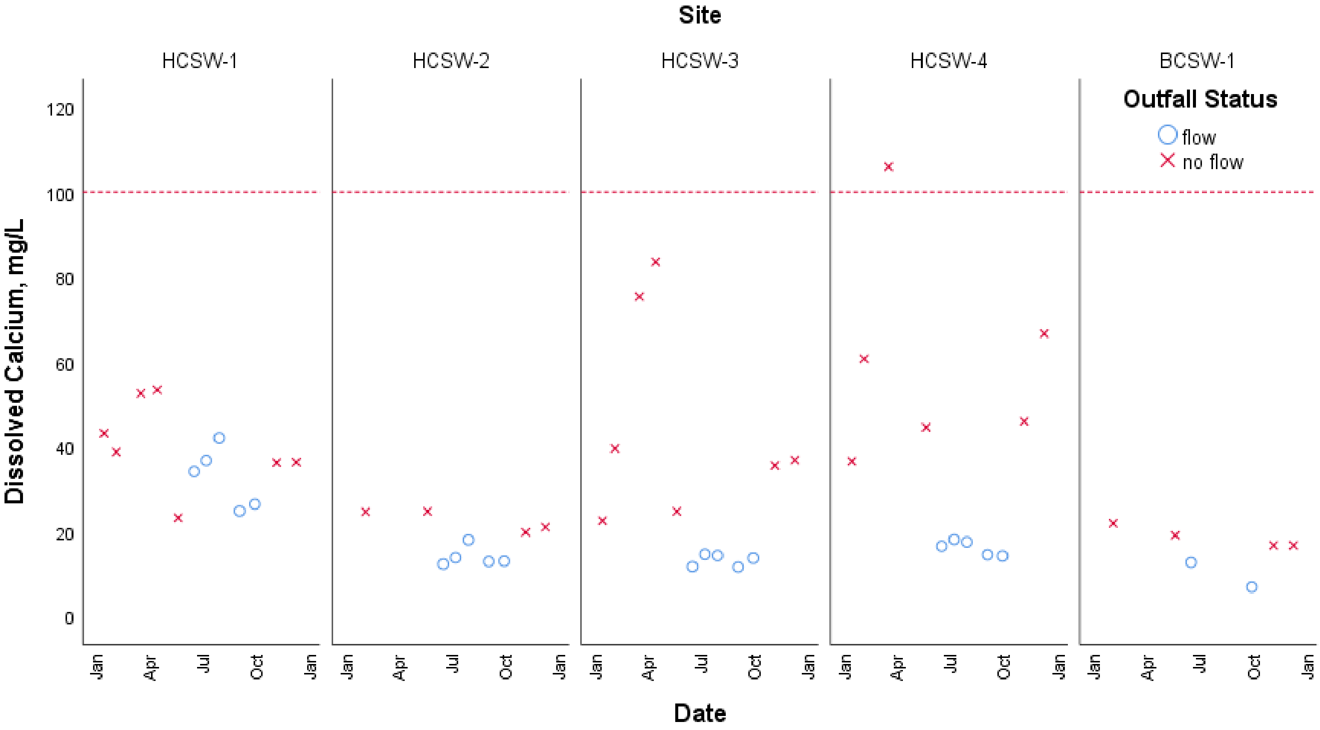


Figure 6-16 Dissolved calcium concentrations obtained during monthly HCSP water quality sampling in 2018

6.4.3 Dissolved Iron

Dissolved iron concentrations at all stations were below 1 mg/L (the trigger level established for HCSW-1, HCSW-2, and HCSW-3) during all sampling events in 2018 (Figure 6-17). Dissolved iron concentrations at HCSW-4 exceeded the trigger value of 0.3 mg/L established for that sampling station from June to October 2018. HCSW-4 has a different trigger level for iron because of its location upstream of a segment of the Peace River that is designated as Class I waters, which carries a lower standard value for iron (0.3 mg/L) than Class III waters (1.0 mg/L). The iron concentrations at HCSW-1 and HCSW-4 measured by the HCSP were not compared to data collected by other sources because the historical data is limited for this water quality parameter.

There were decreasing monotonic trends for dissolved iron since 2003 at both HCSW-1 and HCSW-4 (Seasonal Kendall-tau with LOESS, slope = -0.01 mg/L per year flow-adjusted concentration at both stations, Table 6-1). Because the direction of this potential trend is opposite that of the HCSP trigger level, it is not of concern. The program will continue to monitor this condition over time.

Dissolved iron concentrations were not different among stations over the 2003 to 2018 time period (ANOVA, Table 6-2). Iron was positively correlated with all water quantity variables at HCSW-1 and HCSW-4 (rainfall, streamflow, and NPDES discharge, Spearman's rank correlations, Table 6-3); because streamflow and NPDES discharge are positively correlated with rainfall (with lag times), this means that iron is generally highest during or following periods of high rainfall. Brushy Creek had slightly higher iron concentrations than most Horse Creek stations in 2018.

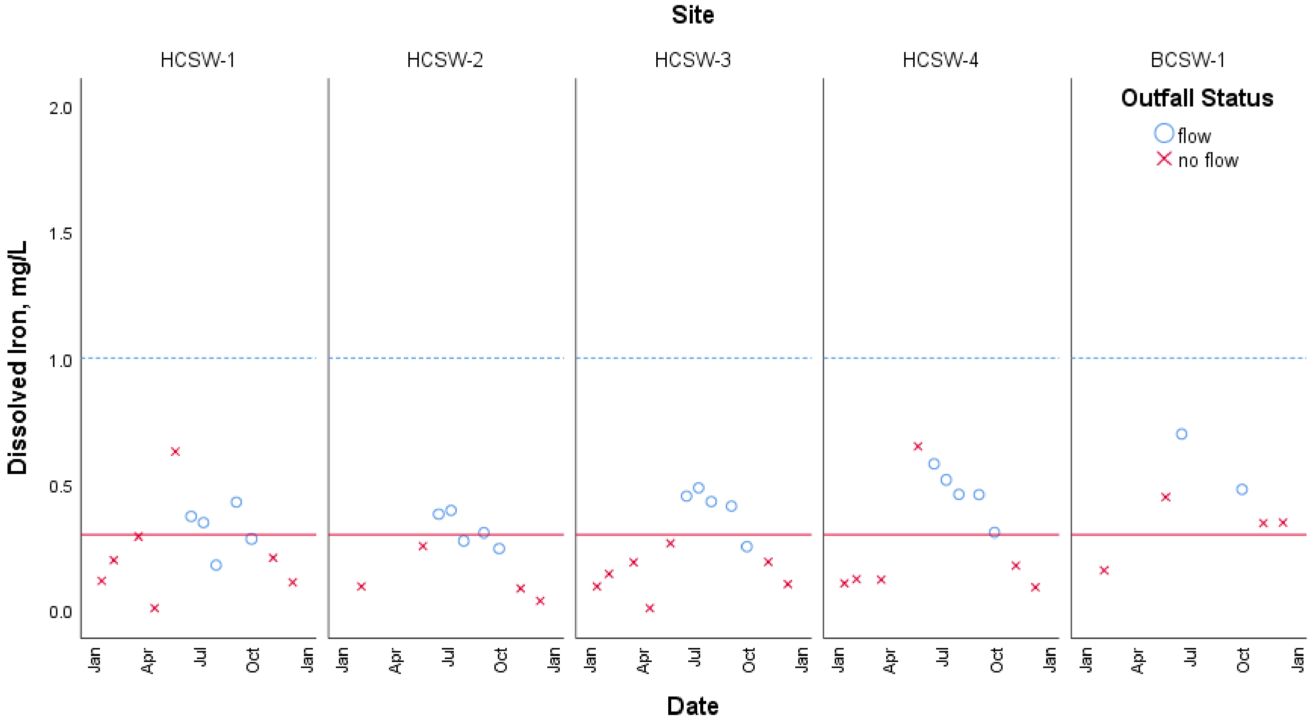


Figure 6-17 Dissolved iron concentrations obtained during monthly HCSP water quality sampling in 2018. The blue dotted line and red solid line represent the trigger values for sites HCSW-1 through HCSW-3, and HCSW-4, respectively.

6.4.4 Total Alkalinity

Total alkalinity concentrations were below the trigger value of 100 mg/L during 2018 at all stations with the exception of a single occurrence at HCSW-1 in April 2018 (Figure 6-18). The alkalinity concentrations at HCSW-1 and HCSW-4 measured by the HCSP are consistent with other water quality data sources at these locations (Appendix C, Figures C-46 and C-47). There was an increasing monotonic trend present from 2003 to 2018 at both HCSW-1 (Seasonal Kendall-tau with LOESS, slope = 2.32 mg/L per year flow-adjusted concentration) and HCSW-4 (slope = 0.54 mg/L per year flow-adjusted concentration, Table 6-1). The estimated slope for HCSW-1 and HCSW-4 is small compared to the differences between primary and field duplicate samples (≤16 mg/L). The trend for alkalinity, like specific conductivity, may have been influenced by regional factors unrelated to mining activities, drought-period baseflow contributions, upstream conditions, and increased influence of groundwater in current mining activities, but the current concentrations are stable and not biologically harmful (2017 Impact Assessment).

Total alkalinity was different among stations from 2003 to 2018 (ANOVA, Table 6-2), with values highest at HCSW-1 followed by HCSW-4, HCSW-3, then HCSW-2 (Duncan's multiple range test, $p < 0.05$, Figure 6-18). Alkalinity was negatively correlated with rainfall, streamflow, and NPDES discharge at HCSW-4 (Spearman's rank correlation, Table 6-3), which is consistent with the concept that higher flows from rainfall would reflect the lower alkalinity of rainwater, compared with dry season inputs of groundwater. This condition suggests that groundwater seepage and agriculture irrigation runoff may also contribute to higher levels of alkalinity at HCSW-4. Alkalinity at HCSW-1 was negatively correlated with rainfall and streamflow and not correlated to NPDES discharge (Table 6-3). The one alkalinity exceedance in 2018 occurred at HCSW-1 in April with no NPDES discharge and the last discharge occurring 495 days before. High levels of alkalinity at HCSW-1 may be partly attributed to the exposed limestone substrate in the stream banks that is unique to that station and other upstream factors that were discussed as part of the 2017 specific conductivity impact assessment.

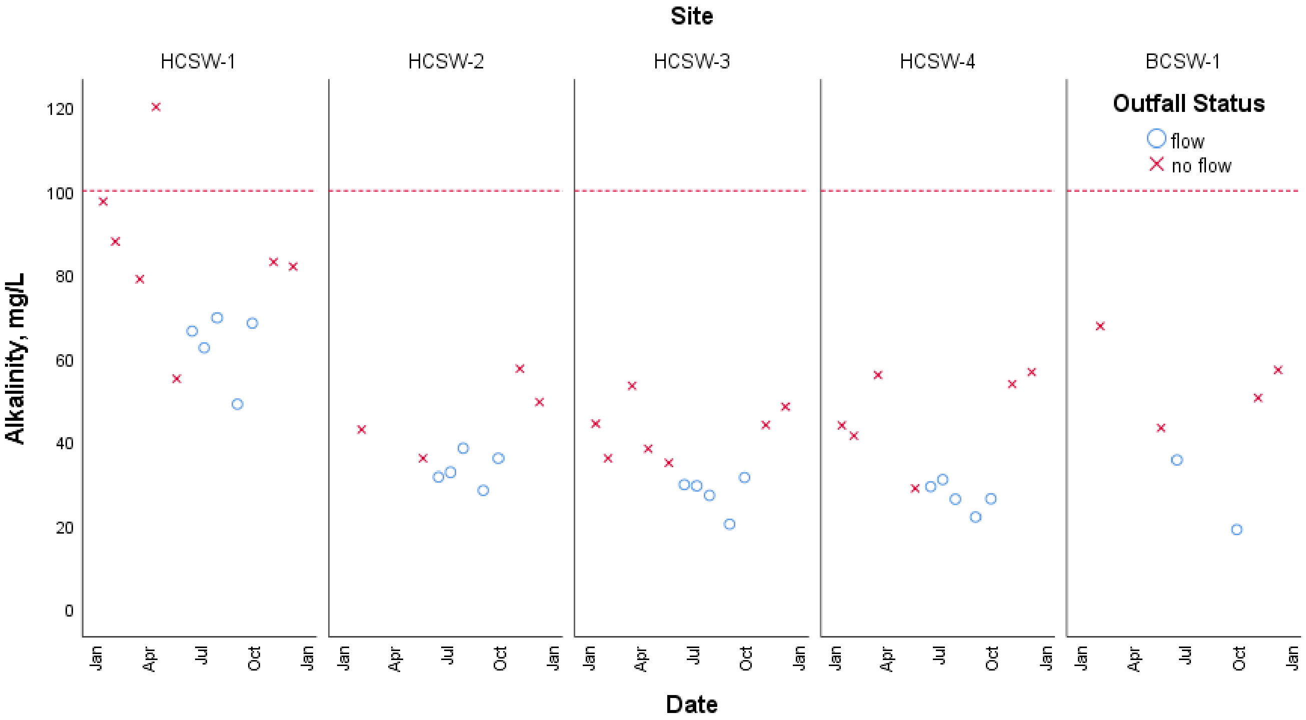


Figure 6-18 Total alkalinity concentrations obtained during monthly HCSP water quality sampling in 2018

6.4.5 Chloride

The highest chloride value measured in Horse Creek in 2018 was 28 mg/L at HCSW-4, which was considerably lower than the trigger level of 250 mg/L (Figure 6-19). The chloride concentrations at HCSW-1 and HCSW-4 measured by the HCSP are consistent with other water quality data sources at those locations (Appendix C, Figures C-48 and C-49) and exhibited no monotonic trend since 2003 (Seasonal Kendall-tau with LOESS, $p > 0.05$, Table 6-1).

Chloride concentrations were different among stations during all sampling events from 2003 to 2018 (ANOVA, Table 6-2), with a pattern of increasing concentrations from upstream to downstream, suggesting again the possible influence from groundwater seepage and agriculture irrigation runoff (Figure 6-19). Chloride was negatively correlated with all water quantity parameters at HCSW-1 and HCSW-4 (rainfall, streamflow, and NPDES discharge, Spearman's rank correlations, Table 6-3); because streamflow and NPDES discharge are positively correlated with rainfall (with lag times), this means that chloride tends to be lowest during or following periods of high rainfall. Brushy Creek had similar concentrations to the Horse Creek stations.

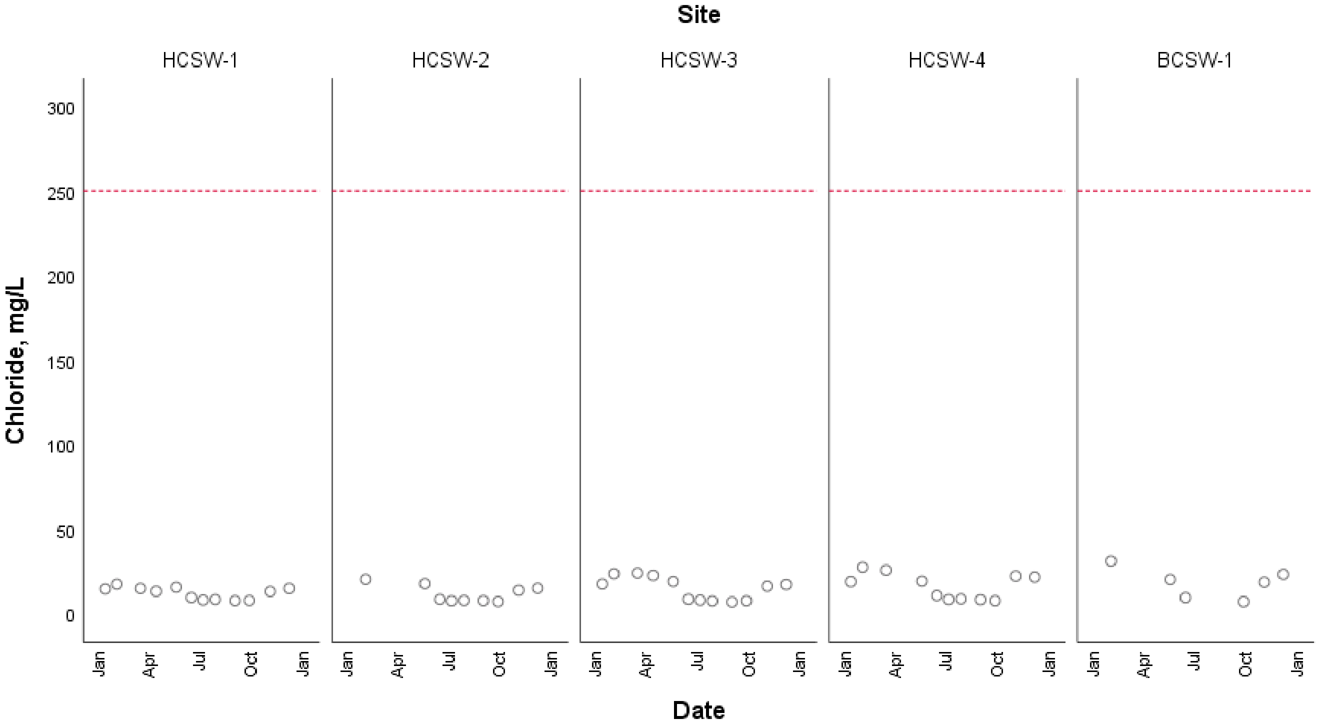


Figure 6-19 Chloride concentrations obtained during monthly HCSP water quality sampling in 2018. (HCSP trigger value for chloride is 250 mg/L.)

6.4.6 Fluoride

Fluoride concentrations were well below the trigger levels of 4.0 mg/L established for HCSW-1, HCSW-2, and HCSW-3, as well as the 1.5 mg/L trigger level for HCSW-4 in 2018 (Figure 6-20). Brushy Creek had similar concentrations to the Horse Creek stations during most of 2018. The HCSP data could not be analyzed for monotonic trends, correlations with water quantity, or differences between the four HCSP stations because of changes in MDL's over the course of the HCSP (Appendix C). After changes with the MDL for fluoride in 2007, the MDLs have now been minimized and did not change from April 2008 through 2018. The fluoride concentrations at HCSW-1 and HCSW-4 measured by the HCSP are consistent with other water quality data sources at those locations (Appendix C, Figures C-50 and C-51).

Using monthly SWFWMD data, fluoride showed no monotonic trend from 2003 to 2018 at both HCSW-1 and HCSW-4 (Seasonal Kendall-tau with LOESS, Table 6-1). Fluoride concentrations were different among stations during all sampling events from 2003 to 2018 (ANOVA, Table 6-2). The lowest concentrations of fluoride occur at station HCSW-2, followed by HCSW-3, HCSW-4, and then HCSW-1 (Duncan's multiple range test, $p < 0.05$, Figure 6-20). Fluoride was negatively correlated with all water quantity parameters at HCSW-4 (rainfall, streamflow, and NPDES discharge, Spearman's rank correlations, Table 6-3) and positively correlated with streamflow and NPDES discharge at HCSW-1. The positive relationship with streamflow at HCSW-1 and the negative relationship with streamflow at HCSW-4 suggest a different process at work at HCSW-1 from the rest of the monitoring sites with respect to fluoride. Brushy Creek had similar concentrations to the Horse Creek stations.

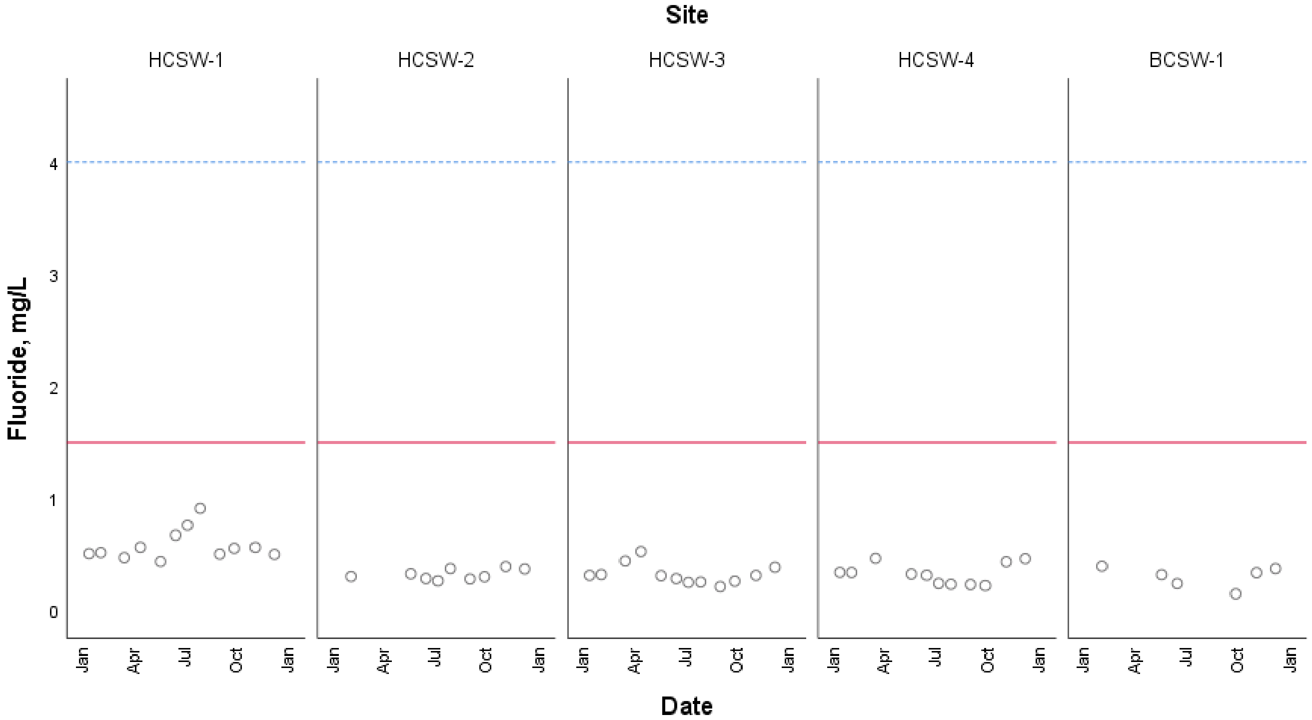


Figure 6-20 Fluoride concentrations obtained during monthly HCSP water quality sampling in 2018

6.4.7 Sulfate

There were two sulfate exceedances in 2018, one at HCSW-3 in April and another at HCSW-4 in March (Table 6-4, Figure 6-21). Brushy Creek concentrations were lower than at Horse Creek stations during all events in 2018. The sulfate concentrations at HCSW-1 and HCSW-4 measured by the HCSP are consistent with other water quality data sources at these locations (Appendix C, Figures C-52 and C-53), and there was a slight increasing trend observed at HCSW-1 (Seasonal Kendall-tau with LOESS, slope = 4.24 µS per year flow-adjusted concentration) and no trend detected at HCSW-4. The trend for sulfate, like conductivity, may have been influenced by regional factors unrelated to mining activities, drought-period baseflow contributions, upstream conditions, and increased influence of groundwater in current mining activities, but the current concentrations are stable and not biologically harmful (Appendix I).

From 2003 to 2018 sulfate concentrations were different among stations (ANOVA, Table 6-2), with lowest levels at HCSW-2, followed by HCSW-1, HCSW-3, then HCSW-4 (Duncan’s multiple range test, $p < 0.05$). As with specific conductivity and calcium, sulfate concentrations were found to be higher during periods of low stream flow, and within proximity to agricultural runoff (Appendix I). At HCSW-4, sulfate was negatively correlated with rainfall, streamflow, and NPDES discharge (Spearman's rank correlation, Table 6-3), but at HCSW-1 was positively correlated with stream flow and NPDES discharge and negatively correlated with rainfall (Table 6-3). There have been no sulfate trigger exceedances at HCSW-1 or HCSW-2 over the period of record (Appendix I).

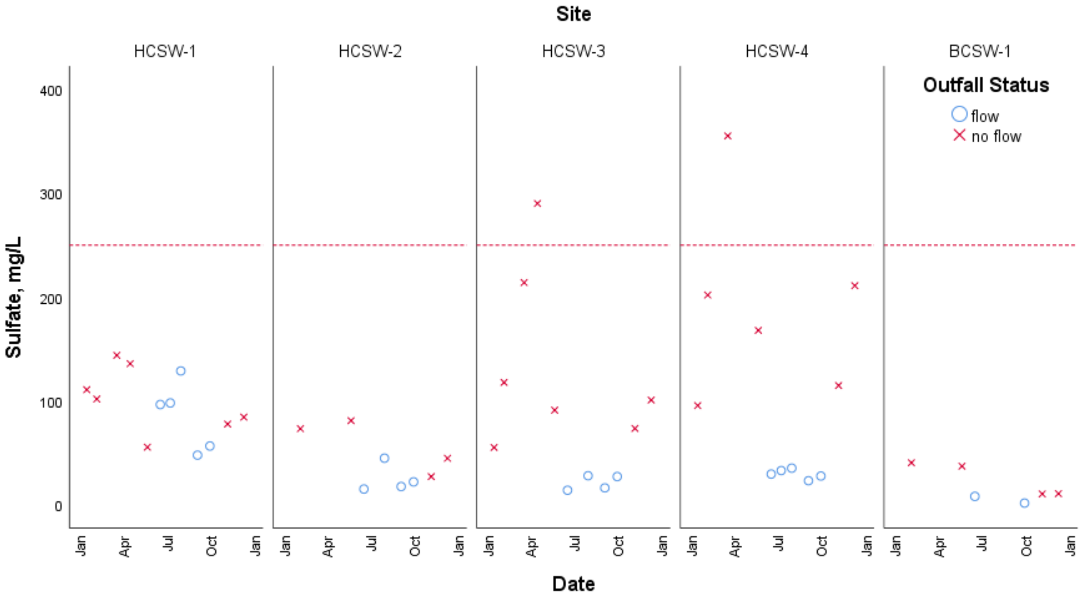


Figure 6-21 Sulfate concentrations obtained during monthly HCSP water quality sampling in 2018

6.4.8 Total Dissolved Solids

There were three Total Dissolved Solids (TDS) exceedances of the trigger level occurred during January (HCSW-3 & HCSW-4) and April (HCSW-3) 2018 (Table 6-4 & Figure 6-22). Brushy Creek concentrations were lower than at Horse Creek stations. The TDS concentrations at HCSW-1 and HCSW-4 measured by the HCSP are consistent with other water quality data sources at those locations (Appendix C, Figures C-54 and C-55). HCSW-1 exhibited increasing trends since 2003 (Seasonal Kendall-tau with LOESS, slope = 9.04 mg/L per year flow-adjusted concentration, Table 6-1) and no trend was detected at HCSW-4. The trend for TDS and other ions may have been influenced by regional factors unrelated to mining activities, drought-period baseflow contributions, upstream conditions, and increased influence of groundwater in current mining activities, but the current concentrations are stable and not biologically harmful (Appendix I). There has been only one exceedance of TDS at HCSW-1 during the period of record: 524 mg/L on April 11, 2017- 100 days after the last discharge.

As with sulfate concentrations, TDS concentrations over the course of the 2003 to 2018 period of record were lowest at HCSW-2 and HCSW-1 then increased when moving downstream (ANOVA, Duncan's multiple range test, $p < 0.05$, Table 6-2). TDS concentrations were negatively correlated with rainfall, streamflow, and NPDES discharge at HCSW-4 (Spearman's rank correlation, Table 6-3), but positively correlated with streamflow and NPDES discharge at HCSW-1 (Table 6-3). Both sulfate and TDS at downstream stations are probably affected by agricultural irrigation return flows and groundwater seepage downstream in the same manner as discussed above for conductivity and calcium and in Appendix I.

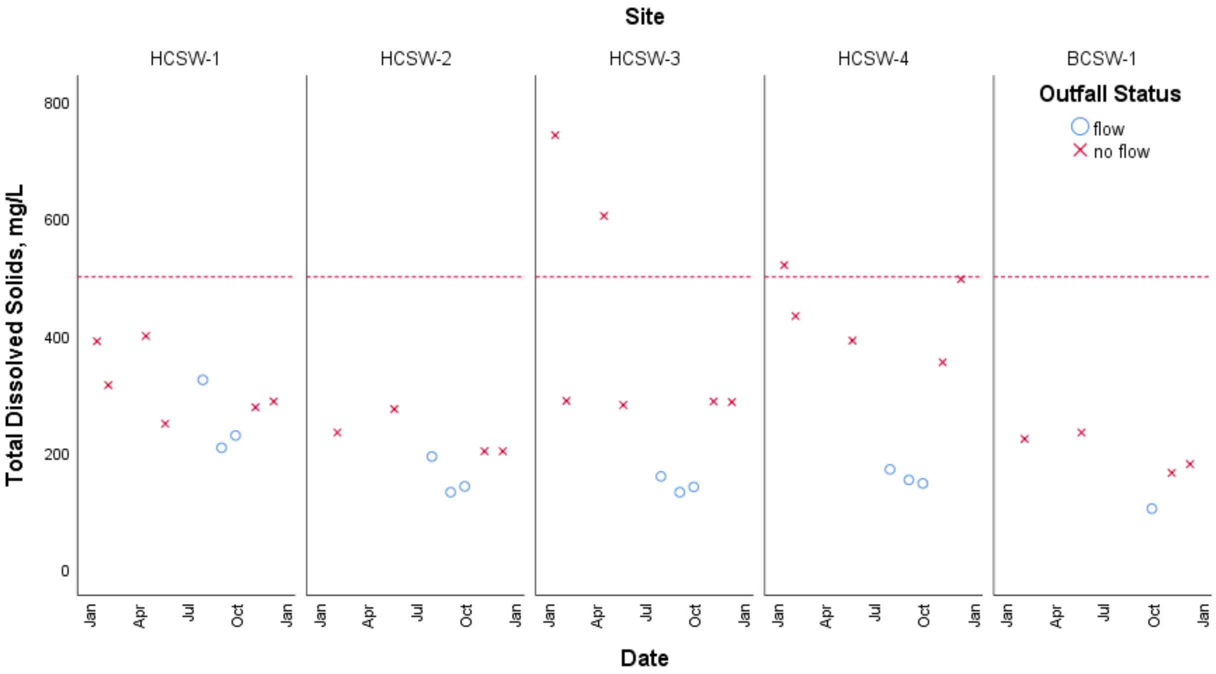


Figure 6-22 Total dissolved solids concentrations obtained during monthly HCSP water quality sampling in 2018

6.4.9 Total Radium

Phosphate ore is a source of radioactivity as naturally occurring uranium-238 disintegrates into isotopes of radium and radon, which emit alpha particles in water. A water quality study of unmined and reclaimed basins in phosphate-mining areas found that radium concentrations of surface waters were slightly higher in unmined areas than in reclaimed basins, probably because of undisturbed phosphate deposits near the surface of unmined lands (Lewelling and Wylie 1993). Clay-settling areas may trap radioactive chemicals associated with clay slurry but release only small amounts of radioactive chemicals into surface waters (Lewelling and Wylie 1993).

In Horse Creek during 2018, total radium[18] levels were below the trigger level of 5 pCi/L (Figure 6-23) at all stations during all sampling events. Brushy Creek concentrations were similar to Horse Creek stations. There were no monotonic trends observed since 2003 for total radium at HCSW-1. (Seasonal Kendall-tau, $p > 0.05$, Table 6-1). The Seasonal Kendall Trend test suggested a trend of -0.02 pCi/L/Year Total Radium at HCSW-4 but this was calculated using mostly non-detect data expressed at equal to the MDL which can range from 0.7- 0.9 pCi/L. Total radium levels from 2003 to 2018 were different among stations (ANOVA, Table 6-2) with lowest levels at HCSW-2, followed by HCSW-4, HCSW-1, then HCSW-3 (Duncan's multiple range test, $p < 0.05$). Total radium was negatively correlated with NPDES discharge and streamflow at HCSW-1 and HCSW- 4 (Spearman's rank correlations, Table 6-3), indicating that radium was higher when NPDES discharge and streamflow were low. Some of the correlation analyses with radium and water quantity may be affected by an apparent step decrease that occurred in 2008, coincident with a change in analytical laboratories (Appendix K).

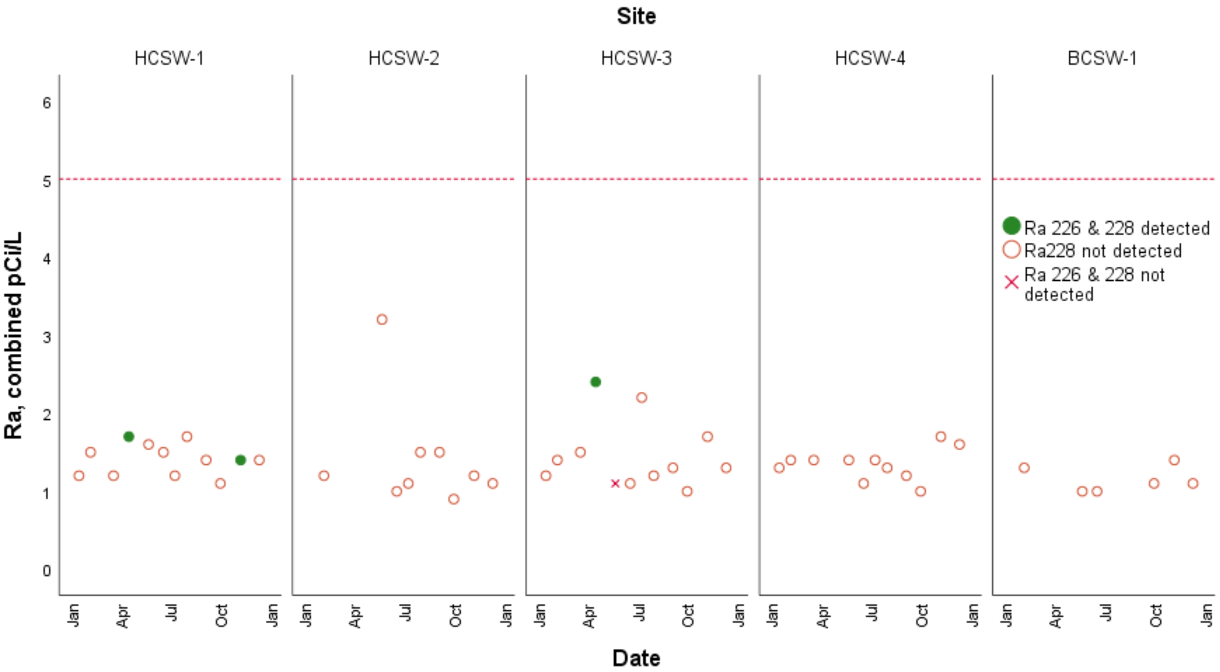


Figure 6-23 Levels of total radium obtained during monthly HCSP water quality sampling in 2018.

---

[18] The HCSP methodology specifies that "Radium 226 + 228" be analyzed as part of the monthly sampling. This data has been reported as both individual constituents and as a total (Appendix E). Starting in December 2003 and continuing through the present, the data has been analyzed and reported as Radium 226 and Radium 228 separately and an arithmetic sum of the two numbers ("Radium 226 + 228"). As requested by the PRMRWSA, if either Radium 226 or Radium 228 is undetected, the MDL of the undetected constituent will be used as part of the "Radium 226 + 228." This use of MDL for undetected constituents as part of a calculated constituent is contrary to both laboratory and DEP SOPs.

6.5 Summary of Water Quality Results

Water quality parameters in 2018 were almost always within the desirable range relative to trigger levels and water quality standards at the station with the highest percent of upstream mined lands (HCSW-1, Table 6-4). Alkalinity was the only parameter above the trigger level at HCSW-1 during 2018, but the exceedance did not occur during times of NPDES discharge (Table 6-4). The dissolved oxygen trigger level was exceeded during most of the year at HCSW-2 (May to November 2018). Based upon historical conditions in Horse Creek (Durbin and Raymond 2006), the reported values for dissolved oxygen at HCSW-2 are the result of natural conditions (proximity to hypoxic segment of stream – Horse Creek Prairie) and are not related to mining activities.

Total Ammonia, as Nitrogen was above the trigger value at sites HCSW-2 – HCSW-4 in June 2018, but ammonia was detected in the field blank as well. Dissolved iron concentrations consistently exceeded the trigger value set at HCSW-4 (May to October 2018), but Mosaic and the PRMRWSA agree that the trigger value at that station has been set too low given historical and upstream concentrations of dissolved iron. Other ion concentrations (dissolved calcium, sulfate, and TDS) were above the trigger levels during dry season months (January- April) at HCSW-4 and/or HCSW-3. Based on impact assessments already completed, none of the observed exceedances pose a significant adverse ecological impact to Horse Creek that would be attributable to mining (Appendix I).

Thirteen water quality parameters showed statistically significant increasing or decreasing trends in 2018 at HCSW-1 (10) or HCSW-4 (8). Several of the trends detected during the statistical analysis either have an estimated slope that 1) was not in the direction of an adverse trend (dissolved oxygen saturation, color, and dissolved iron) or 2) was very small compared to the observed differences between primary and duplicate field samples (pH, turbidity, TKN, and fluoride) (Table 6-5). Specific conductivity, TDS, and various dissolved ions had reported trends with higher estimated rates of change (i.e. the trend slope is decreasing as the record gets longer). The potential trends for pH and specific conductivity (with reference to TDS and other ions) were discussed in the 2017 Impact Assessment.

For parameters with trends, concentrations at HCSW-1 in recent years still meet all applicable state drinking water and Class III surface water standards, except where otherwise noted in previous monthly impact assessments. In addition, the current specific conductivity concentrations at HCSW-1 are within the preferred range of Horse Creek freshwater fish species, and the diversity and composition of fish populations have remained steady over the HCSP study period with no correlation with specific conductivity. SCI scores, an indicator of benthic macroinvertebrate community health, have also remained steady over the HCSP study period and show no relationship with specific conductivity.

Significant differences between stations were evident for several parameters. When stations were compared, HCSW-2 was the most dissimilar from the other three stations, especially in pH, dissolved oxygen, color, chlorophyll-*a*, and some dissolved ions. Some nutrients (nitrate-nitrite) and dissolved ions (specific conductivity, calcium, chloride, and sulfate) had higher concentrations downstream in Horse Creek, probably because of increased groundwater seepage and agricultural irrigation runoff in the lower Horse Creek basin during dry periods. Differences in topography, geology, and land use that could account for these station differences in Horse Creek are examined in the Horse Creek Stewardship Program Historical Report (Durbin and Raymond 2006).

Water quality parameters were compared with water quantity variables recorded during the same month: average daily streamflow for the month, average daily NPDES discharge for the month, and total monthly rainfall (Table 6-3). In general, pH, dissolved oxygen, and most dissolved ion concentrations are higher when the overall quantity of water in the Horse Creek system is low. (In this report, chlorophyll-a, specific conductivity, calcium, alkalinity, sulfate, and TDS showed the opposite pattern with NPDES discharge at HCSW-1.) Conversely, turbidity, color, iron, and nitrogen are high when the water quantity is also high. When water quantity in Horse Creek is low, the stream is often pooled or slow-moving, leading to algal blooms that may increase pH and chlorophyll-a. In addition, the majority of water in the stream during low quantity periods may be from groundwater (seepage or agricultural runoff); groundwater has a higher concentration of dissolved ions than surface water. When water quantity is high because of rainfall or streamflow, an increased amount of sediment and organic debris is washed into the stream, leading to increases in turbidity, color, iron, and nitrogen.

Table 6-4 Instances of trigger level exceedance observed in 2018 HCSP monthly monitoring

Sampling Location	Station ID	Date	Analyte	Concentration	Trigger Level
Horse Creek at State Road 64	HCSW-1	4/18/2018	Alkalinity (mg/L)	120	100
Horse Creek at State Road 72	HCSW-4	3/21/2018	Calcium, Dissolved (mg/L)	106	100
Horse Creek at Goose Pond Road	HCSW-2	5/24/2018	Dissolved Oxygen (%Saturation)	10.8	37.5
Horse Creek at Goose Pond Road	HCSW-2	6/20/2018	Dissolved Oxygen (%Saturation)	13.1	42.7
Horse Creek at Goose Pond Road	HCSW-2	7/11/2018	Dissolved Oxygen (%Saturation)	27	38.5
Horse Creek at Goose Pond Road	HCSW-2	10/2/2018	Dissolved Oxygen (%Saturation)	39.5	39.8
Horse Creek at Goose Pond Road	HCSW-2	11/8/2018	Dissolved Oxygen (%Saturation)	39.1	40.6
Horse Creek at State Road 70	HCSW-3	5/24/2018	Dissolved Oxygen (%Saturation)	32.7	35.9
Horse Creek at State Road 70	HCSW-3	6/20/2018	Dissolved Oxygen (%Saturation)	31.5	36.4
Horse Creek at State Road 72	HCSW-4	5/24/2018	Dissolved Iron (mg/L)	0.651	0.3
Horse Creek at State Road 72	HCSW-4	6/20/2018	Dissolved Iron (mg/L)	0.581	0.3
Horse Creek at State Road 72	HCSW-4	7/11/2018	Dissolved Iron (mg/L)	0.518	0.3
Horse Creek at State Road 72	HCSW-4	8/2/2018	Dissolved Iron (mg/L)	0.461	0.3
Horse Creek at State Road 72	HCSW-4	9/6/2018	Dissolved Iron (mg/L)	0.460	0.3
Horse Creek at State Road 72	HCSW-4	10/2/2018	Dissolved Iron (mg/L)	0.309	0.3
Horse Creek at State Road 70	HCSW-3	1/17/2018	Dissolved Solids, Total (mg/L)	742	500
Horse Creek at State Road 70	HCSW-3	4/18/2018	Dissolved Solids, Total (mg/L)	604	500
Horse Creek at State Road 72	HCSW-4	1/17/2018	Dissolved Solids, Total (mg/L)	520	500
Horse Creek at State Road 72	HCSW-4	3/21/2018	Dissolved Solids, Total (mg/L)	697V	500
Horse Creek at Goose Pond Road	HCSW-2	7/11/2018	Nitrogen, Ammonia (mg/L)	0.77 V	0.3
Horse Creek at State Road 70	HCSW-3	7/11/2018	Nitrogen, Ammonia (mg/L)	0.38 V	0.3
Horse Creek at State Road 72	HCSW-4	7/11/2018	Nitrogen, Ammonia (mg/L)	0.54 V	0.3
Horse Creek at State Road 70	HCSW-3	4/18/2018	Sulfate (mg/L)	290	250
Horse Creek at State Road 72	HCSW-4	3/21/2018	Sulfate (mg/L)	355	250

V -qualifier indicates that the analyte was detected in both the sample and the method blank.

Table 6-5 Summary of trends over time (2003 to 2018) from Seasonal Kendall-tau analysis

Parameter	HCSW-1 Slope	HCSW-4 Slope	Discussion
Alkalinity	2.32 mg/L/yr	0.54 mg/L/yr	Discussed in Historical Assessment (See Appendix I)
Calcium	1.1 mg/L/yr		Discussed in Historical Assessment (See Appendix I)
Chlorophyll-a	-0.03	-0.05	Not an adverse trend
Color		2.82 PCU/yr	Not an adverse trend
DO (mg/L)	0.04 mg/L/yr		Not an adverse trend
Fluoride	0.01 mg/L/yr		Slope very small in magnitude. Isolated step change. Not of concern.
Iron	-0.01 mg/L/yr	-0.01 mg/L/yr	Not an adverse trend
Nitrogen, Total Kjeldahl		0.02 mg/L/yr	Slope very small in magnitude; not at upstream station. Not of concern.
pH	0.04 SU/yr	0.02 SU/yr	Slope very small in magnitude. Isolated step change. Not of concern.
Radium, Combined		-0.02 pCi/L/yr	Not an adverse trend
Specific Conductance	12.1 µS/yr	5.7 µS/yr	Discussed in Historical Assessment (See Appendix I)
Sulfate	4.24 mg/L/yr		Discussed in Historical Assessment (See Appendix I)
TDS	9.04 mg/L/yr		Discussed in Historical Assessment (See Appendix I)
Turbidity		0.09 NTU/yr	Slope very small in magnitude; not at upstream station. Not of concern.

7.0 BIOLOGICAL RESULTS AND DISCUSSION

7.1 Benthic Macroinvertebrates

Benthic macroinvertebrate sampling was conducted at all stations during the 30 October and 12 December sampling events and at all stations but HCSW-2 during the 30 April 2018 sampling event. The Brushy Creek location is not included in the macroinvertebrate sampling component of the HCSP.

As discussed in Section 4.4, the calculation methodology for the SCI was initially revised by FDEP in June 2004, and sampling conducted from 2003 to 2006 uses that methodology. In 2007, the FDEP SCI protocol[19] was again revised, this time to include provisions for the taxonomic analysis of two aliquots for every SCI sample collected to account for variation in sample sorting (DEP-SOP-002/01 LT 7200). Under the new protocol, the SCI score for each sample is the arithmetic average of the SCI scores of the two aliquots. In addition to the change in aliquots in 2007, the new protocol also gives a slightly different ecological interpretation of SCI scores (Table 4-5). The SCI protocol was revised again in 2012 (DEP-SOP-003/11 SCI 1000), making changes to the SCI

---

[19] Appendix J includes SCI 2004, 2007, and 2012 scores for comparison.

calculation but not the sampling methodology. This report has scores in the tables and graphics updated to the 2012 methodology. Scores from the 2004 SCI formulae (collected from 2003 to 2006) and the 2012 SCI formulae (collected from 2007 to 2018 with two vials) may not be directly comparable, given the differences in how they were collected (noted in Figures 7-2 to 7-5). Any statistical analysis conducted on the invertebrate sampling in this report omits the samples collected under the 2004 SCI (collected from 2003 to 2006).

7.2 Stream Habitat Assessment

The majority of the habitat assessment parameters evaluated through the FDEP procedure are not directly related to mining, but are generally related to the nature of the system being examined and its surroundings (e.g., substrate diversity and availability, artificial channelization, bank stability, buffer width, and vegetation quality). Parameters that might be hypothesized to have some linkage to mining are water velocity and habitat smothering, primarily as a result of NPDES discharges to a stream. The Stream Habitat Assessment (HA) is best looked at as qualifier to water quality and biodiversity outcomes: if a stream scores high on the HA, the expectation is the biological response (e.g. SCI & Shannon-Wiener) will also score higher, unless there is some other effect inhibiting life (e.g. water quality, environmental perturbation). If a stream scores low on a HA and the expectation is the site will have a low biological response score regardless of water quality.

For the habitat assessment metric on smothering, the productive habitats are evaluated and the degree to which they are smothered is recorded (none, slight, moderate, or severe). HCSW-1 is higher up in the basin and receives less sediment load that could smother the various habitats (roots, snags, and rock) from upstream sources. The more downstream locations have a larger basin area that contributes both sediment and flowing water. HCSW-3 and HCSW-4 have higher smothering that occurs in the productive habitats (roots, snags, and aquatic vegetation) usually after high flows when sediment settles out after flow decreases.

The habitat quality of Horse Creek ranged between 74 and 116 during all sampling events in 2018 (Table 7-1, Figure 7-1). All sampling events resulted in categorical scores of “sub-optimal” except at HCSW-3 in April. The lower scores at HCSW-3 were due to a reexamination of the riparian buffer quality, low available quality habitat and bank erosion no doubt due to the very high flows that occurred in 2017 and cattle activity. Some of the minor variation among the sampling events for a given station primarily reflects differences in habitat quality and quantity caused by changes in stream stage, which affects the availability and ratios of in-stream habitats, and also the inherent variability in the habitat scoring protocol itself. The fall sampling event is usually immediately following summer high flows where the banks are scoured (lower habitat stability) and there may not be any vegetation in the water to sample as a productive habitat (lower substrate diversity and availability). For those reasons, the overall habitat assessment score tends to be lower in the summer or fall.

Table 7-1 Habitat scores obtained during HCSP biological sampling events in 2018

Habitat Characteristic†		HCSW-1			HCSW-2			HCSW-3			HCSW-4		
		30-Apr-18	31-Oct-18	18-Dec-18	30-Apr-18	30-Oct-18	17-Dec-18	30-Apr-18	30-Oct-18	17-Dec-18	30-Apr-18	30-Oct-18	17-Dec-18
Substrate Diversity (20)		10	14	13	No flow	9	6	3	5	6	12	9	5
Substrate Availability (20)		11	7	7		4	3	1	1	2	3	3	1
Water Velocity (20)		12	15	19		5	12	12	16	19	15	19	18
Habitat Smothering (20)		13	15	13		16	19	8	13	11	10	11	13
Artificial Channelization (20)		15	15	15		16	16	20	20	20	19	18	18
Bank Stability (10 each bank)	Right Bank	5	5	3		10	10	9	9	9	9	9	9
	Left Bank	5	5	4		4	3	6	6	6	9	9	9
Riparian Buffer Zone Width (10 each bank)	Right Bank	10	10	10		10	10	5	5	5	10	10	10
	Left Bank	9	9	10		10	10	1	1	1	9	10	10
Riparian Zone Vegetation Quality (10 each bank)	Right Bank	10	10	9		10	10	6	6	5	8	9	9
	Left Bank	9	9	9		9	9	3	3	2	7	9	9
Total Score*		**109**	**114**	**112**		**103**	**108**	**74**	**85**	**86**	**111**	**116**	**111**

† Max scores for each metric in parentheses.

* - The maximum possible score under this protocol is 160 (121-160 Optimal, 81-120 Suboptimal, 41-80 Marginal, <40 Poor).

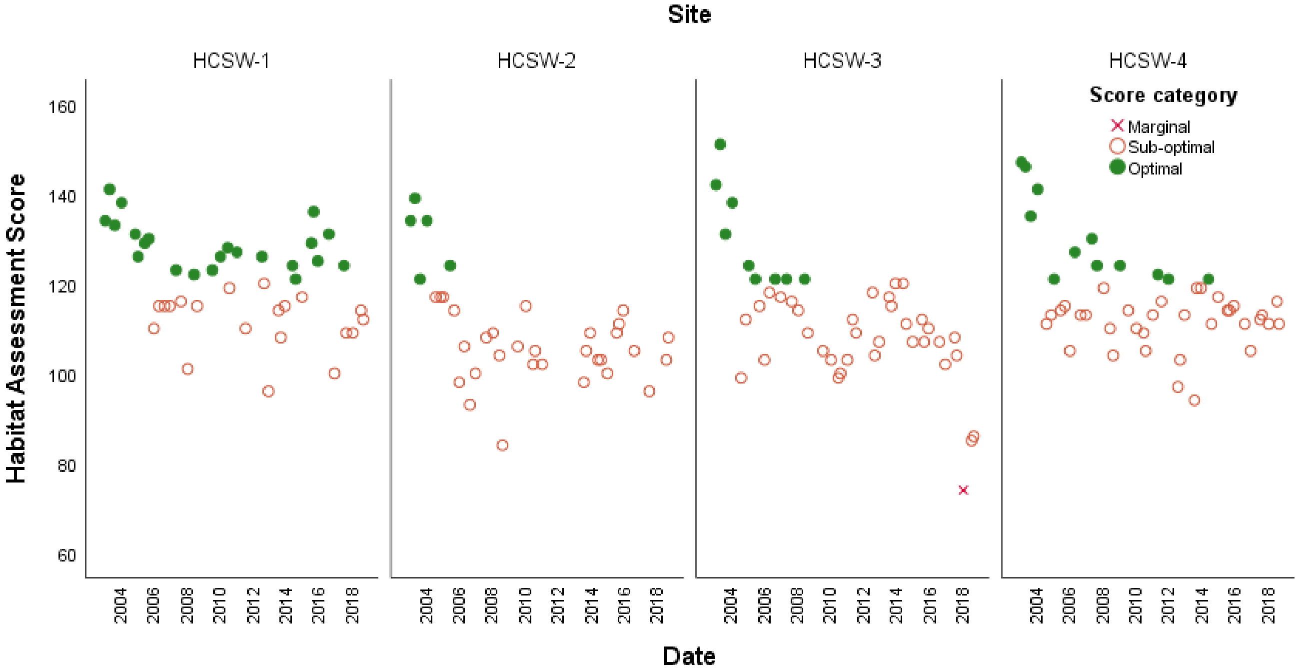


Figure 7-1 Aquatic Habitat Assessment scores obtained during HCSP biological sampling events at all locations from 2003 to 2018

7.3 Stream Condition Index

A database containing a list of the benthic macroinvertebrate taxa collected from 2003 to 2018 is on the attached compact disc[20]. Table 7-2 provides the SCI metrics, resulting SCI values, and total SCI scores calculated as a vial average for the benthic macroinvertebrates collected at the four stations during each sampling event in 2018. The numbers of individuals included in Table 7-2 represent the number extracted from the whole sample for identification (i.e., all 20 dipnet sweeps), which were analyzed by the taxonomist (only a portion of each sample is sorted and processed, per the SOP). The SCI scores in 2018 were above 35 (considered "Healthy) for all stations and events except HCSW-2 in October and December 2018; the biological sampling location at HCSW-2 frequently has lower flow and lower dissolved oxygen conditions than the other stations.

Final SCI scores for the samples ranged from 23 (HCSW-2 in December) to 81 (HCSW-1 in April) in 2018, similar to other years (Table 7-2 and Figure 7-2). When considered over time from 2007 to 2018 (period when the 2012 SCI formulae can be used), the overall SCI scores were variable at each station; when all stations were combined, neither the annual median, nor the spring SCI scores showed significant trends over time.

---

[20] Beginning with the 2010 annual report (Appendix J), the HCSP SCI data was reevaluated with strict interpretation of FDEP SOP guidance, including the upper and lower limits of the SOP target number of individuals, the SOP target of a minimum velocity of 0.05 m/sec 28 days prior to sampling, the SOP target of waiting at least 90 days after abatement of a stream dessication event (i.e. no refugia for organisms), and the SOP target of less than a 0.5 m water level increase in the previous 28 days. As a result of this evaluation, some SCI scores have been removed from the analysis (Appendix J, *red italics*). In addition, some SCI results with more than the target number of individuals were randomly resampled to provide an unbiased result.

A Seasonal Kendall trend analysis was performed for each site and found no significant trends at any of the stations. An annual Kendall trend test was then run on the spring SCI scores for each respective site and found a positive 2.33 units/year trend at HCSW-1 (Kendall-tau= 0.55, $p < 0.05$). No other SCI score trends were detected at the other HCSP monitoring sites. Because of low streamflow and dissolved oxygen concentrations related to the upstream prairie system, the SCI scores were lower at HCSW-2 than other stations (ANOVA: $F = 41.3$, $p < 0.0001$; Duncan's multiple range test: $p < 0.05$, long term average of 30 compared to 61-65).

Table 7-2 SCI 2012 metrics calculated for benthic macroinvertebrates collected at four locations in Horse Creek during 2018.

SCI Metric	HCSW-1						HCSW-2					
	30-Apr-18		31-Oct-18		18-Dec-18		30-Apr-18		30-Oct-18		17-Dec-18	
	Raw Score	SCI Value	Raw Score	SCI Value	Raw Score	SCI Value	Raw Score	SCI Value	Raw Score	SCI Value	Raw Score	SCI Value
Total Taxa	31.50	**6.88**	25.00	**4.17**	29.00	**5.83**	No Sample - flow conditions not met for SCI		24.50	**3.96**	21.50	**2.71**
Ephemeropteran Taxa	4.00	**8.00**	2.50	**5.00**	3.00	**6.00**			2.00	**4.00**	1.00	**2.00**
Trichopteran Taxa	5.50	**7.86**	4.50	**6.43**	2.00	**2.86**			2.50	**3.57**	0.00	**0.00**
Percent Filterer Taxa	31.27	**7.11**	14.22	**3.15**	8.69	**1.86**			2.03	**0.31**	10.66	**2.32**
Long-lived Taxa	6.00	**8.57**	6.50	**9.29**	5.50	**7.86**			2.50	**3.57**	0.50	**0.71**
Clinger Taxa	1.50	**5.00**	1.50	**5.00**	0.00	**0.00**			1.00	**3.33**	0.50	**1.67**
Percent Dominant Taxon	18.57	**9.09**	21.71	**8.46**	23.10	**8.18**			57.81	**1.24**	57.03	**1.39**
Percent Tanytarsini	31.27	**10.00**	6.70	**6.00**	6.70	**6.00**			0.00	**0.00**	17.05	**8.50**
Sensitive Taxa	2.00	**2.86**	2.50	**3.57**	2.50	**3.57**			0.50	**0.71**	0.00	**0.00**
Percent Very Tolerant Taxa	4.56	**7.46**	2.70	**8.69**	5.01	**7.27**			79.38	**0.79**	65.24	**1.27**
Total SCI Score	**81**		**60.5**						**23.5**			
Score Category	**Exceptional**		**Healthy**						**Impaired**			
Total Number of Individuals	**154**		**150**		**150**				**163**		**153**	

Table 7-2 cont'd. SCI 2012 metrics calculated for benthic macroinvertebrates collected at four locations in Horse Creek during 2018

SCI Metric	HCSW-3						HCSW-4					
	30-Apr-18		30-Oct-18		17-Dec-18		30-Apr-18		30-Oct-18		17-Dec-18	
	Raw Score	SCI Value	Raw Score	SCI Value	Raw Score	SCI Value	Raw Score	SCI Value	Raw Score	SCI Value	Raw Score	SCI Value
Total Taxa	45.00	**10.00**	29.00	**5.83**	31.50	**6.88**	35.50	**8.54**	27.50	**5.21**	28.00	**5.42**
Ephemeropteran Taxa	6.50	**10.00**	2.50	**5.00**	2.00	**4.00**	4.00	**8.00**	4.00	**8.00**	4.50	**9.00**
Trichopteran Taxa	3.00	**4.29**	4.00	**5.71**	2.50	**3.57**	3.50	**5.00**	3.50	**5.00**	3.50	**5.00**
Percent Filterer Taxa	12.76	**2.80**	10.28	**2.23**	9.42	**2.03**	8.92	**1.91**	16.24	**3.62**	6.97	**1.46**
Long-lived Taxa	5.00	**7.14**	4.50	**6.43**	5.00	**7.14**	5.50	**7.86**	6.00	**8.57**	6.50	**9.29**
Clinger Taxa	0.50	**1.67**	3.00	**10.00**	2.50	**8.33**	0.00	**0.00**	2.00	**6.67**	1.50	**5.00**
Percent Dominant Taxon	10.00	**10.00**	24.05	**7.99**	16.88	**9.42**	30.55	**6.69**	19.39	**8.92**	22.94	**8.21**
Percent Tanytarsini	4.52	**4.94**	0.64	**1.46**	6.07	**5.59**	4.20	**4.71**	0.94	**1.56**	4.66	**5.07**
Sensitive Taxa	2.00	**2.86**	3.50	**5.00**	2.50	**3.57**	2.50	**3.57**	4.00	**5.71**	4.00	**5.71**
Percent Very Tolerant Taxa	14.86	**4.88**	7.81	**6.61**	6.98	**6.56**	9.15	**6.25**	8.41	**6.40**	4.65	**7.42**
Total SCI Score	**65**		**63.5**				**58**		**67**			
Healthy/Impaired	**Healthy**		**Healthy**				**Healthy**		**Healthy**			
Total Number of Individuals	**155**		**156**		**151**		**154**		**160**		**151**	

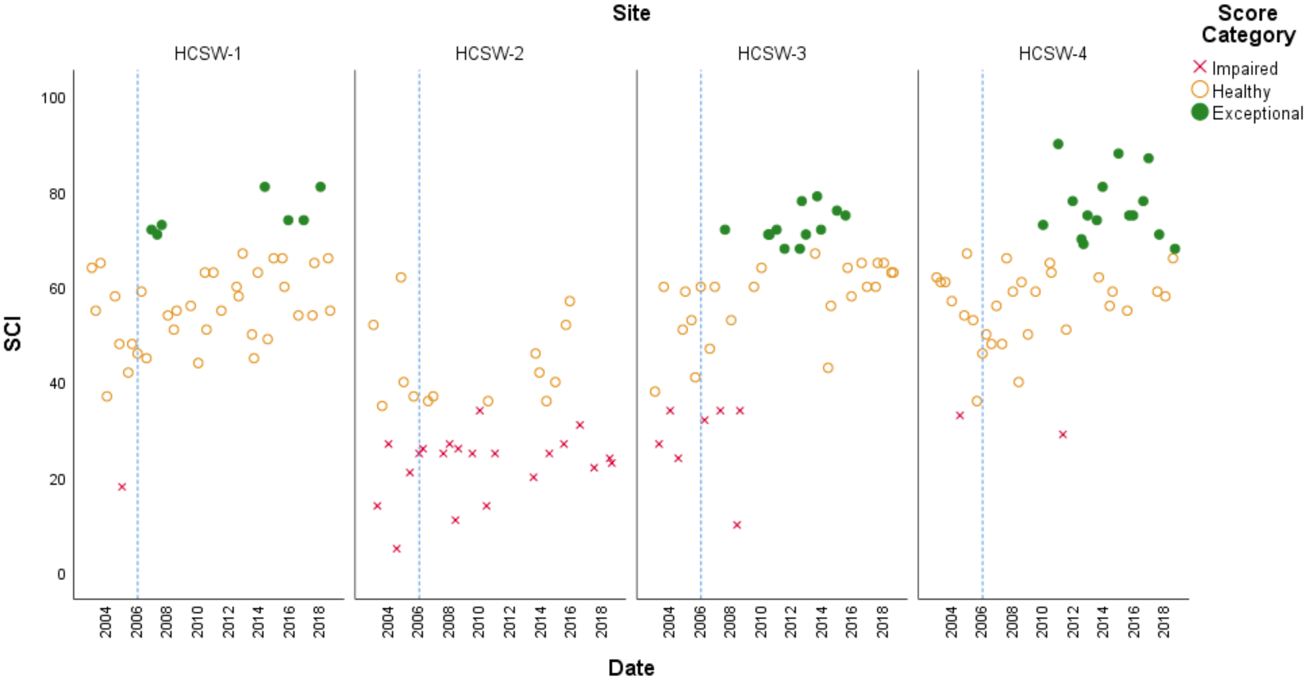


Figure 7-2 SCI scores for samples collected at all HCSP locations from 2003 to 2018. Dotted vertical line indicates change in SCI calculation method.

7.3.1 SCI Metrics

A healthy stream system will generally support a higher number of taxa than a disturbed stream. This is reflected in the Total Taxa SCI metric. In order to achieve an SCI score above zero for this metric, at least 16 taxa must be identified in a sample. Over 16 taxa were collected in at least one of the two replicates at all sampling locations (Figure 7-3).

Ephemeropterans, or mayflies, are typically associated with more pristine waters and better habitat conditions; therefore, a higher count for the Ephemeropterans Taxa metric results in a higher SCI score. At least one mayfly taxon must be present to score this SCI metric above zero. Ephemeropterans were collected in at least one of the two replicates at all sampling locations.

Trichopterans, or caddisflies, are also associated with more pristine waters and better habitats; therefore, higher counts for the Trichopterans Taxa metric are also associated with better ecological conditions. At least one caddisfly taxon must be collected in order for this SCI metric to be above zero. Trichopterans were collected in at least one of the two replicates at all locations except at HCSW-2 in December 2018.

Disruption of food webs has long been associated with human influence, especially organic pollution. Of the functional feeding group measures, the relative abundance of filterers or suspension feeders (percentage of filterer individuals) had the highest correlation and most consistent relationship with human disturbance. Filter feeders extract nutrients by straining food particles from the water column. If the water flow or quality of the organic matter in the water is compromised, a reduction in filter feeders will occur. To score above zero for this Percent Filterers metric, more than one percent of the sample must be comprised of collector-filterers. All sampling locations exhibited greater than one percent collector-filterers in each replicate sampled.

Clingers are those taxa morphologically adapted to hold onto substrates during routine flow conditions and would be expected to decline as humans alter a stream's hydrograph (e.g., channelization), especially during abrasive events caused by high stormwater inputs from impervious surfaces. This Clinger Taxa metric increases as the number of clinger taxa increases within a sample. To score above zero for this SCI metric, at least one clinger taxon must be present in a sample. Clinger taxa were absent in the HCSW-1 December 2018 samples and the HCSW-4 April 2018 samples.

Long-lived taxa are those that require more than one year to complete their life cycles; thus, they would not be expected in great numbers in intermittent streams or tributaries that go dry before the life cycle can be completed. Long-lived taxa richness would be expected to decrease if a disturbance event occurred at a site within a year of sampling. To score above zero for this SCI metric, at least one long-lived taxon must be present in a sample. Long-lived taxa were collected in at least one of the two replicates at all locations in 2018.

Substantial shifts in proportions of major groups of organisms, compared to reference conditions, may indicate degradation. Percent dominant taxon increases in conditions where a few pollution tolerant organisms are very abundant, to the exclusion of other taxa. The SCI score is zero if the Percent Dominant Taxa metric reaches or surpasses 64%. The range for all four sites was 10% (HCSW-3, April) – 57.8% (HCSW-2, October).

Species in the Chironomid assemblage Tanytarsini (midges) are commonly associated with less disturbed sites. Therefore, as the percentage of Tanytarsini increases for a sampling site there is a corresponding increase in the Percent Tanytarsini metric score. If there are no Tanytarsini individuals in a sample, this SCI metric score is zero. Tanytarsini individuals were found in all sample replicates across all sites. The range of Percent Tanytarsini for all four sites was 0% (HCSW-2, October) –31.3% (HCSW-1, April).

Sensitive taxa are those that have been identified as sensitive to human disturbance; therefore, more sensitive taxa would be present in undeveloped "natural" areas as opposed to developed watersheds. At least one sensitive taxon must be collected to raise this Number of Sensitive Taxa metric score above zero. The range for all four sites was 0 (HCSW-2, December) to 5.7 (HCSW-4, October & December).

A number of taxa have been classified as "very tolerant", meaning they are commonly present in areas with marked human disturbance (although they may also be found in undisturbed sites as well). Therefore, more disturbed and/or developed areas would be expected to have a higher percentage of tolerant taxa in comparison to areas that have not experienced human disturbance. This Percent Very Tolerant Taxa metric is similar to the percent contribution of Dominant Taxa metric in that, as the fraction of a sample comprised by these taxa increases, the calculated metric decreases. All replicates at all sites contained very tolerant taxa. The range of Percent Very Tolerant Taxa for all six sites across replicates was 2.7% (HCSW-1, October) – 79.4% (HCSW-2, October).

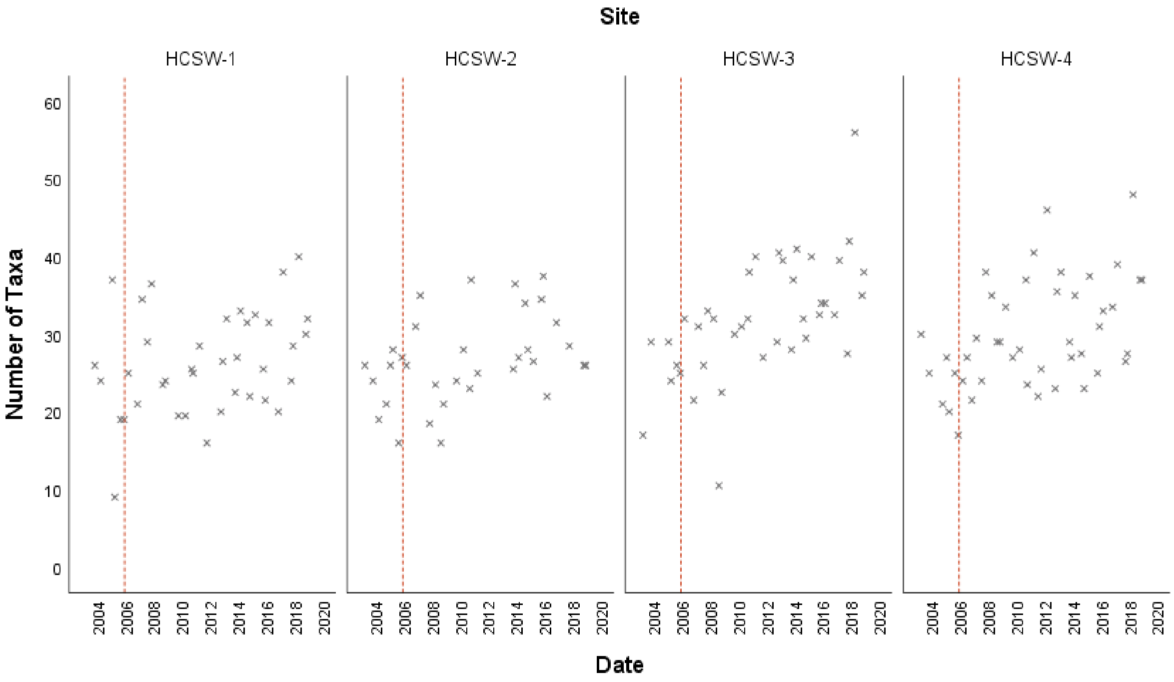


Figure 7-3 Number of invertebrate taxa collected at all locations for the HCSP from 2003 to 2018

7.3.2 Shannon-Wiener Diversity Index

Although not a component of the SCI protocol, the Shannon-Wiener Diversity Index is calculated for generic diversity for each benthic macroinvertebrate sampling event at each location. This index, one of the most popular measures of diversity, is based on information theory and is a measure of the degree of uncertainty in predicting what taxa would be drawn at random from a collection of taxa and individuals (Ludwig and Reynolds 1988). The Shannon-Wiener Index assumes that all taxa are represented in a sample and that the sample was obtained randomly:

$$H' = \sum_{i=1}^{S} (p_i)(\log_2 p_i)$$

where, H' = Information content of sample (bits/individual), index of taxa diversity,
S = Number of taxa, and
p_i = Proportion of total sample belonging to i^{th} taxa.

The Shannon-Wiener Index, H', increases with the number of taxa in the community and theoretically can reach very large values (Krebs 1998). In practice, however, H' does not generally exceed 5.0 for biological communities. The index is affected both by the number of taxa and their relative abundance; a greater number of taxa and a more even distribution of individuals across taxa both increase diversity as measured by H'. For example, consider two communities, each with 100 individuals of 10 taxa captured. Community A is dominated by one taxon (91 of 100 individuals), while only one individual was captured for each of the other nine taxa. Community B, however, is even, with 10 individuals captured for each of the ten taxa. While taxa richness is the same for both communities, the Shannon-Wiener Diversity Index shows that Community B is much more diverse than Community A (H’ = 3.3 and 0.7, respectively), because Community A is dominated by only one taxon.

For the Horse Creek data, generic diversity[21], rather than species diversity, was used to account for the high variability of species present from year to year. In Horse Creek in 2018, the Shannon-Wiener Diversity Index ranged from 2.48 (December, HCSW-2) to 4.93 (April, HCSW-3, Figure 7-4). When considered over time from 2007 to 2018, diversity increased at each station except at HCSW-1 and increased over time at all stations combined at 0.06 units/year (Seasonal Kendall-tau, $p > 0.001$). When stations and dates within years were combined, diversity was different among years from 2007 to 2018 (ANOVA: $F = 2.9$, $p = 0.001$, Figure 7-5). When results from all events from 2007 to 2018 were combined by station (Figure 7-6), there was a difference between stations (ANOVA: $F = 9.4$, $p < 0.0001$), where HCSW-4 and HCSW-3 had higher diversity than HCSW-2 and HCSW-1 (Duncan’s multiple range test, $p < 0.05$).

---

[21] After a conversation with Dr. John Epler (entomologist) about updates to the accuracy of the species identification of a few Tanytarsini spp., an overall review of the data was performed. Some of the taxonomic classifications of older data (prior to 2006) had changed, so the database had multiple names for the class, family, or genus of some individuals. Taxonomic names were updated and consolidated where appropriate, which changed the number of individual genera counted for each sampling event. The richness and diversity stats were rerun for each sampling event, along with the combined diversity measures for the year and sampling location. All graphs and tables represent the updated generic diversity scores after data review and consolidation.

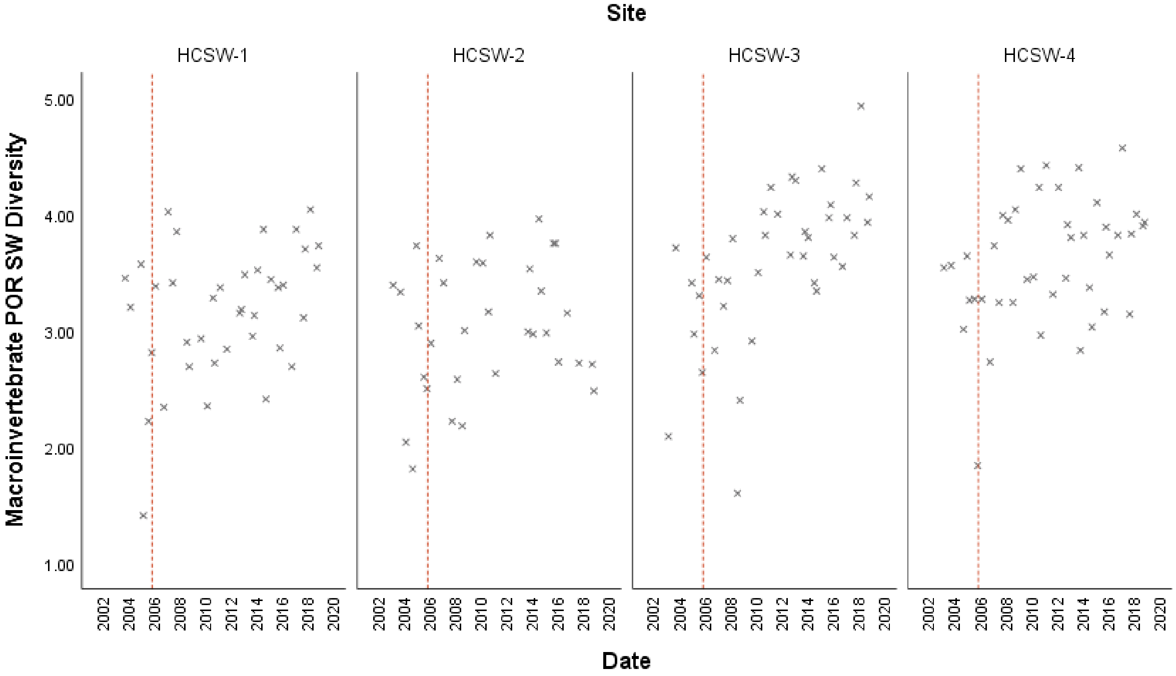


Figure 7-4 **Shannon-Wiener diversity indices for benthic macroinvertebrate genera from all HCSP locations from 2003 to 2018.**

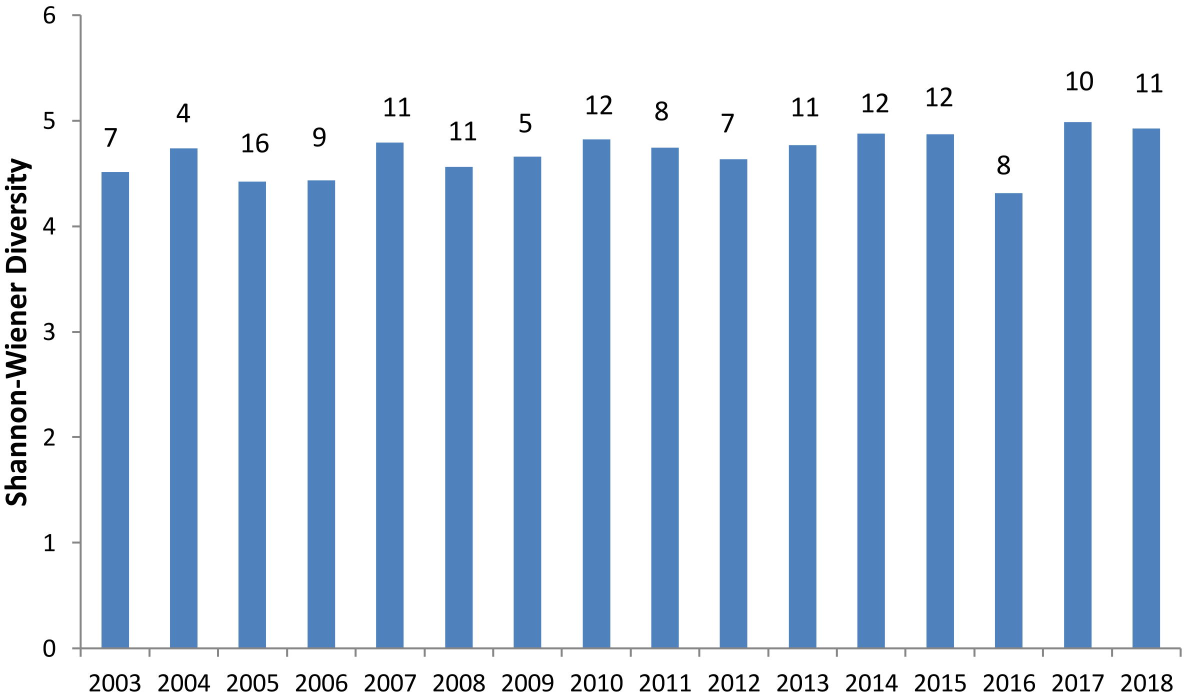


Figure 7-5 **Shannon-Wiener diversity indices for benthic macroinvertebrate genera per year from Horse Creek for Combined sample dates and stations.**

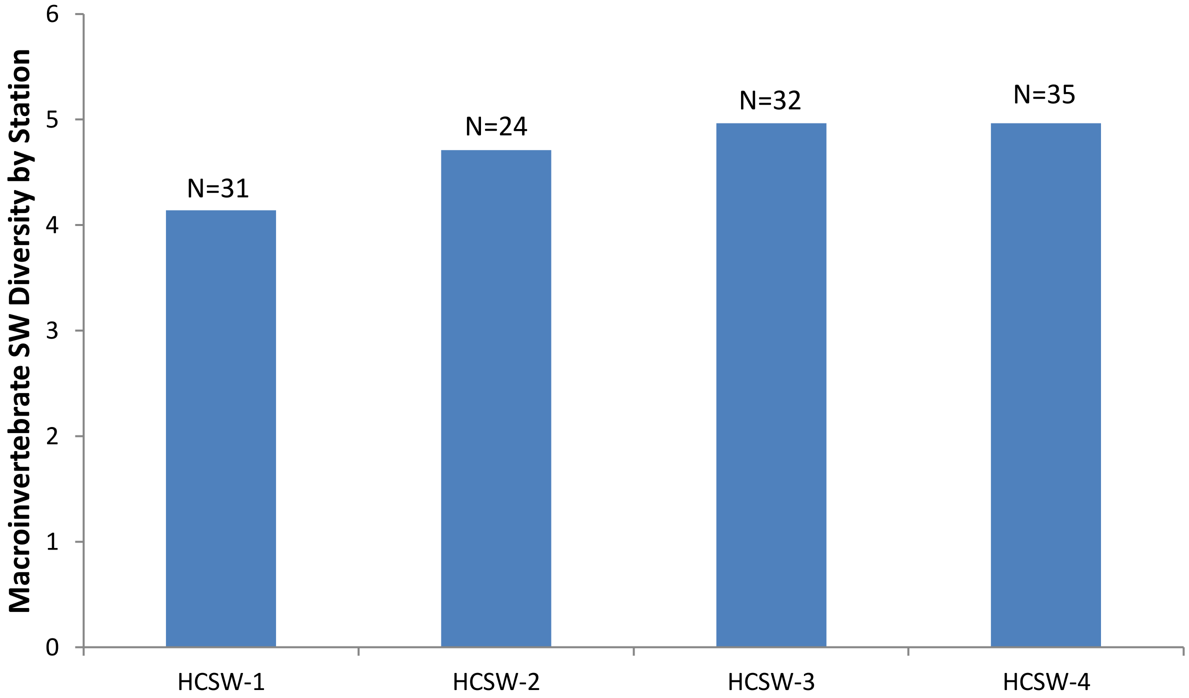


Figure 7-6 Shannon-Wiener diversity indices for benthic macroinvertebrate genera per station at Horse Creek for combined sample dates.

7.3.3 Summary of Benthic Macroinvertebrate Results

Aquatic Habitat Assessment scores at all sites in 2018 were within the categorical score of "sub-optimal" (81-120) except HCSW-3 in April, which scored a "marginal" 74. The lower scores in HCSW-3 were primarily due to a reevaluation of the riparian buffer quality (which prior to 2018, had been scored in the "optimal" range), lower water velocity, and habitat smothering. The 100m reach of HCSW-3 had a relatively bare riparian buffer compared to the reach immediately upstream. Despite the lower habitat assessment score, HCSW-3 SCI scores were consistently in the healthy range through 2018.

SCI scores at HCSW-1, HCSW-3, and HCSW-4 in 2018 were in the "healthy" category (>35), with the April sample at HCSW-1 attaining an "exceptional" score (>68). HCSW-1, the site closest to the NPDES outfalls, is the only site that has consistently scored in the "healthy" to "exceptional" SCI range[22], and the only station with a detected SCI trend (+2.33/year). HCSW-4, the site furthest from the NPDES outfalls, has the highest SCI average over the 2007 - 2018 period. The differing strengths at both sites can be attributed to the respective stream orders in which both stations are situated. HCSW-1 is located in the sheltered 3rd order reach of Horse Creek with a robust buffer, moderate canopy, and

---

[22] Based on 2007-present scores i.e. scores calculated with the current 2012 SCI methodology.

perennial flow, with water quality that meets its designated use. HCSW-4 is located in a 4th order reach with an open-light canopy, fed by a number of 1st, 2nd, and 3rd order stream confluences, as well as the Peace River, and it has a drainage area an order of magnitude larger than Horse Creek at HCSW-1. Despite its highly variable flows and water quality, HCSW-4 remains a highly productive site because it connected to sources of habitat and forage.

HCSW-2 was not sampled in April due to the site not meeting the required velocity of $>0.05 \text{m} \cdot \text{sec}^{-1}$. Despite the frequent episodes of low or no flow conditions at HCSW-2, the site consistently scored in the optimal - sub-optimal (>81) habitat assessment range over the entire HCSP period. Considering the site has adequate habitat, a robust riparian buffer, and good water chemistry (relative to HCSP parameters), despite being situated directly downstream from a large prairie system, what appears to be lacking is continuous streamflow and conditions conducive to keeping oxygen in the water and supporting a diverse population of macroinvertebrates.

7.4 Fish

Fish sampling was conducted at all stations during the 30 October and 17 December sampling events and at all stations but HCSW-2 during the 30 April 2018 sampling event. The Brushy Creek location is not included in the fish sampling component of the HCSP.

During 2018, 20 species of fish were collected from the four Horse Creek sampling stations; they are listed in Table 7-3. In Horse Creek overall, there were no new fish species observed in 2018 that were not previously observed at one of the stations. When the species list is considered at the station level, one new invasive fish species was observed at HCSW-1 (vermiculated sailfin catfish – *Pterygoplichthys disjunctivus*) during all three 2018 events, and one new invasive fish species was observed at HCSW-3 during the October 2018 event (Asian swamp eel – *Monopterus javanensis*). A total of 44 species of fish[23] have been observed in Horse Creek from 2003 to 2018, with a range of 18 to 32 species seen each year.

---

[23] HCSP fish samples have been periodically sent to the fish collection of Florida Museum of Natural History (FLMNH). Fish species identifications from the museum collection were used to update the HCSP database and all diversity and richness calculations.

Of the native species collected, most are quite common regionally, and none were unexpected for this portion of Florida. Silversides, killifishes, shiners, and sunfishes were the most commonly collected groups. Eleven of the 44 species collected from 2003 to 2018 are not native to Florida: the African jewelfish (*Hemichromis letourneuxi*), Asian swamp eel, blue tilapia (*Oreochromis aureus*), brown hoplo (*Hoplosternum littorale*), leopard pleco (*Pterygoplichthys gibbiceps*), Nile tilapia[24] (*Oreochromis niloticus*), oriental weatherfish (*Misgurnus anguillicaudatus*), Orinoco sailfin catfish (*Pterygoplichthys multiradiatus*), sailfin catfish (*Pterygoplichthys pardalis*), vermiculated sailfin catfish[25], and walking catfish (*Clarias batrachus*).

7.4.1 Taxa Richness and Abundance

Most of the individuals collected at each sampling station consisted of eastern mosquitofish (*Gambusia holbrooki*), golden silverside (*Labidesthes vanhyningi*), or coastal shiners (*Notropis petersoni*). This can generally be attributed to conditions that are conducive to seining for small species. Eastern mosquitofish were collected at all sampling stations during all the 2018 sampling events. Sailfin mollies (*Poecilia latipinna*) and walking catfish were collected at all four sampling stations but not at every event. Coastal shiners, golden silversides[26], ironcolor shiners (*Notropis chalybaeus*), and bluegills (*Lepomis macrochirus*) were collected at three of four sampling stations in 2018. During all three sampling events, a slightly lower number of taxa were collected at HCSW-2 (3 to 5) compared to the other stations (7 to 13) (Table 7-3, Figure 7-7). Taxa richness showed no monotonic trend over time at stations HCSW-1, HCSW-3, and HCSW-4 (Kendall-tau of annual median, $p > 0.05$). A trend of -0.07 units/ year was detected at HCSW-2 for the 2003-2018 period (Kendall-tau of annual median, $p < 0.01$).

---

[24] Previously identified in 2014 Annual Report as *Oreochromis aureus* (blue tilapia). Confirmation identification as *O. niloticus* by FLMNH.

[25] Previously identified in 2004 Annual Report as *Hypostomus plecostomus* (suckermouth catfish). Confirmation identification as *P. disjunctivus* by FLMNH.

[26] This species was previously considered brook silversides (*Labidesthes sicculus*), but was confirmed by the FLMNH to actually be the golden silverside. Any previous reference to brook silverside should be considered a golden silverside.

Table 7-3 Fish collected from Horse Creek during sampling events in 2018

Scientific Name	Common Name	HCSW-1			HCSW-2			HCSW-3			HCSW-4		
		30-Apr	18-Oct	17-Dec	30-Apr	18-Oct	17-Dec	30-Apr	18-Oct	17-Dec	30-Apr	18-Oct	17-Dec
Ameiurus natalis	Yellow bullhead				No flow						1		
Clarias batrachus	Walking catfish		7	2		3			1		2	3	
Fundulus seminolis	Seminole killifish							5	6	11	2		2
Gambusia holbrooki	Eastern mosquitofish	14	9	94		408	81	198	2	66	301	16	2
Hemichromis letourneuxi	African jewelfish			10									1
Ictalurus punctatus	Channel catfish										2		
Labidesthes vanhyningi	Golden silverside	5	8	4				66	6		2	24	
Lepisosteus platyrhincus	Florida gar	1				2						4	1
Lepomis gulosus	Warmouth							1					
Lepomis macrochirus	Bluegill	9	17	9			5	27	25	2	18	21	10
Lepomis marginatus	Dollar sunfish			1			1						
Lepomis microlophus	Redear sunfish			1				6					
Micropterus salmoides	Largemouth bass		1					5	11		1	6	1
Monopterus javanensis	Swamp eel		2	1								1	
Notropis chalybaeus	Ironcolor shiner		30	8					62			138	2
Notropis petersoni	Coastal shiner	103	13	24				27	18	37	21	10	44
Oreochromis aureus	Blue tilapia							1	18			5	1
Poecilia latipinna	Sailfin molly	1		7		2		33		26		1	3
Pterygoplichthys disjunctivus	Vermiculated sailfin catfish	1	1					1		2		1	
Trinectes maculatus	Hogchoker					1		17	6	4	19	4	
Total Taxa		**8**	**9**	**11**		5	3	13	10	7	10	13	10
Number of Individuals		**134**	**88**	**161**		**416**	**87**	**387**	**155**	**148**	**369**	**234**	**67**
% Invasive		**0.8**	**11.4**	**8.1**		**0.7**	**0**	**0.5**	**12.3**	**1.4**	**0.5**	**4.3**	**2.1**

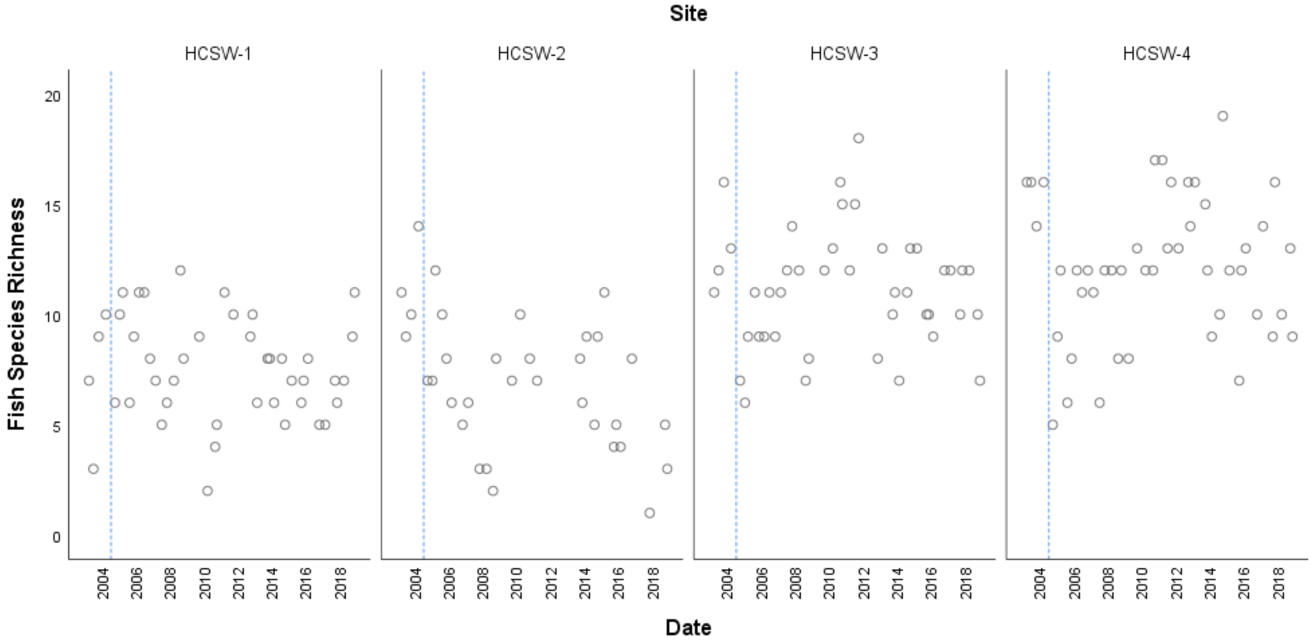


Figure 7-7 **Species richness for fish at all HCSP locations from 2003 to 2018[27]. Dotted line indicates passage of Hurricane in 2004.**

7.4.2 Shannon-Wiener Diversity Index

Fish diversity by sampling event and station in 2018 ranged from 0.17 (HCSW-2, October) to 2.62 (HCSW-3, October), similar to the ranges during events from 2003 to 2017 (Figure 7-8). When fish samples were combined across all sampling events within a year, HCSW-3 in 2018 had the highest species diversity (Figure 7-9). HCSW-4 was the most diverse site for twelve of the sixteen years of the HCSP. HCSW-1 and HCSW-3 are usually tied for diversity with HCSW-2 being the least diverse site in all years except 2005.

Overall combined years (Figure 7-11), fish diversity was lower at HCSW-2 than at the other stations and higher at HCSW-4 (ANOVA, $F = 12.73$, $p < 0.001$, Duncan's multiple range test, $p < 0.05$) (Figure 7-11). HCSW-2 was the only station with a detected trend of -0.05 units/year (Seasonal Kendall-tau, $p < 0.05$) for the 2003-2018 period.

Fish diversity trend analysis throughout Horse Creek was compared across sites (i.e. combining all sites) seasonally and annually, with and without HCSW-2 to detect changes in the entire HCSP reach. No fish diversity trend was detected in Horse Creek between 2003 and 2018 (Annual and Seasonal Kendall-tau, $p > 0.05$).

---

[27] Because of a malfunction with the backpack electrofishing unit, fish were only collected using the seine method during the 27 October 2015 sampling event. Data may not be comparable to other sampling events.

Diversity was different between dates when stations were combined (ANOVA, F= 2.23, p = 0.001, Figure 7-10). When data was combined by year (Figure 7-12), fish diversity was lowest in 2010 and highest in 2013 (ANOVA F = 2.06, $p < 0.05$) with 2018 being ranked 6th most diverse. There were no increasing or decreasing trends in diversity by year from 2003 to 2018 (Kendall-tau of medians, $p > 0.05$). There were no increasing or decreasing trends for all stations combined or for individual stations with respect to annual median diversity; and no trends for spring, summer, or, winter event diversity (Kendall-tau, $p > 0.05$).

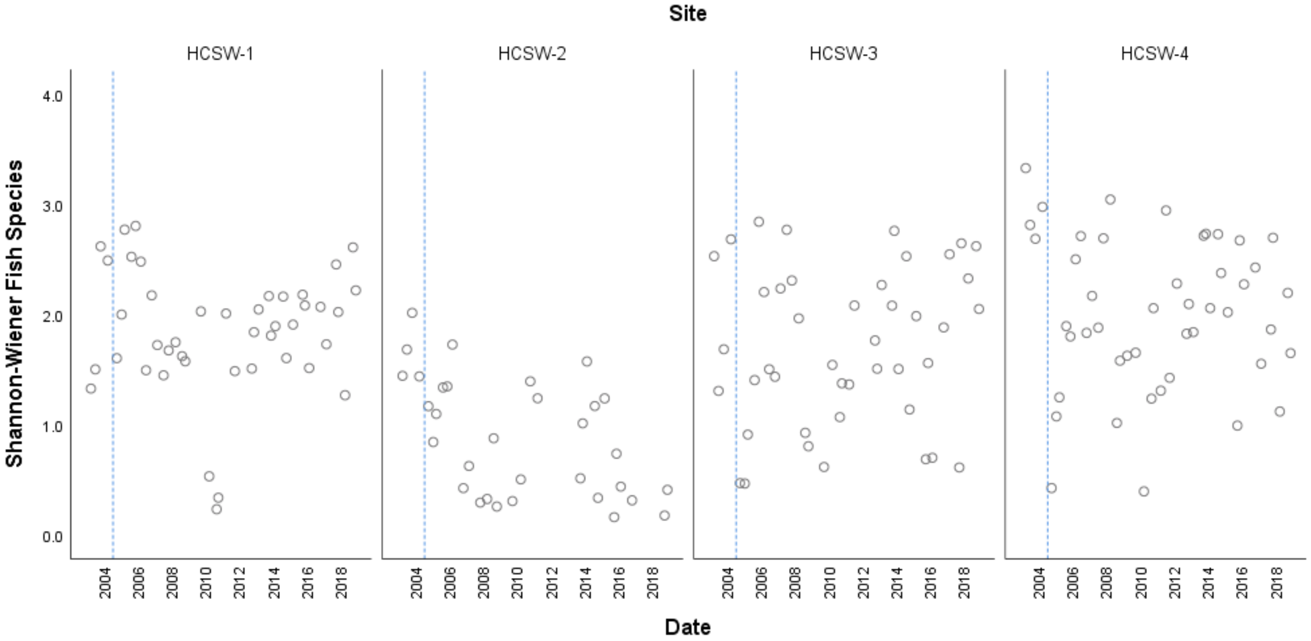


Figure 7-8 Shannon-Wiener diversity indices for fish samples from all HCSP locations from 2003 to 2018[28]. Dotted line indicates passage of Hurricane in 2004.

---

[28] Because of a malfunction with the backpack electrofishing unit, fish were only collected using the seine method during the 27 October 2015 sampling event. Data may not be comparable to other sampling events.

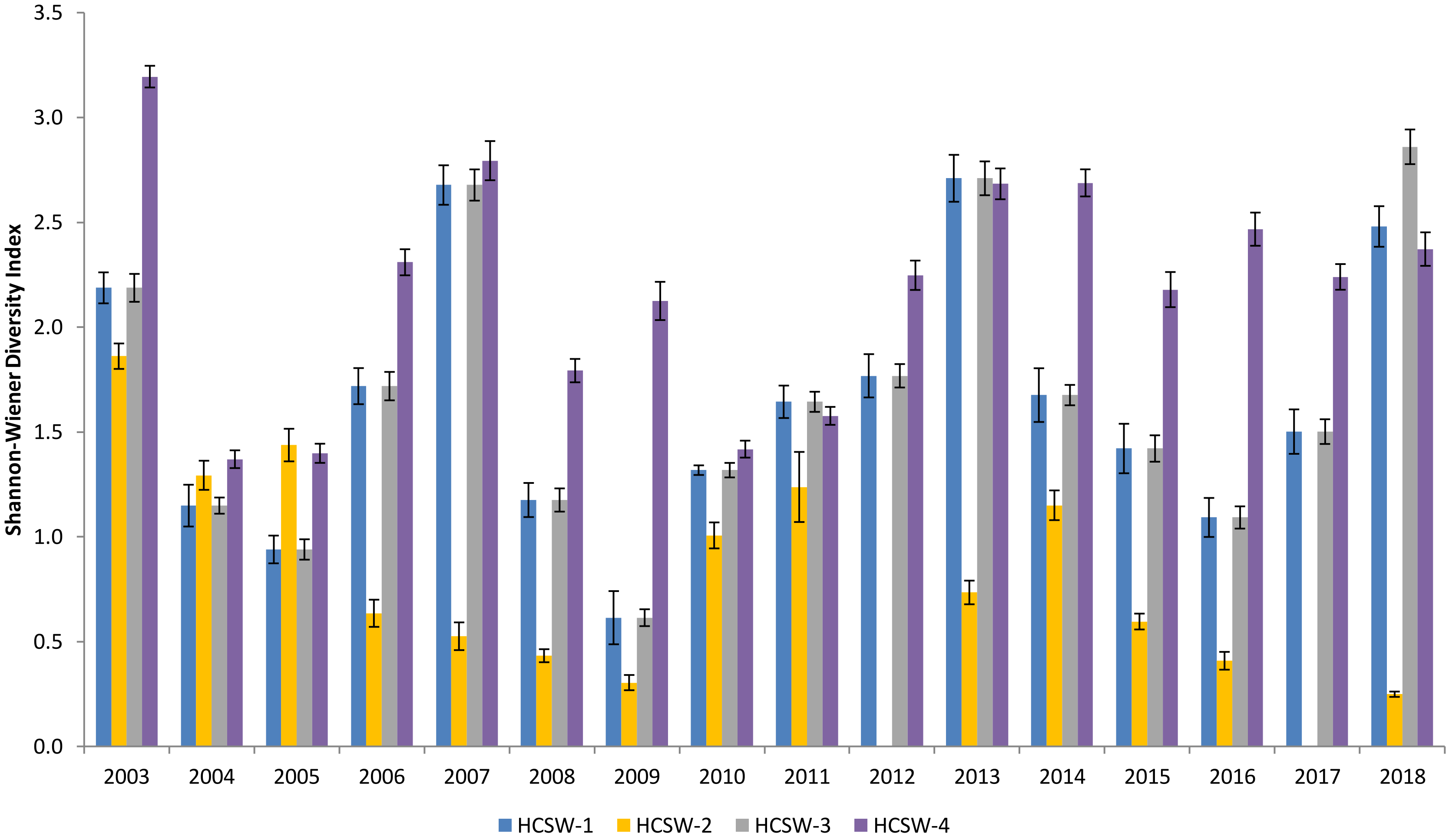


Figure 7-9 **Shannon-Wiener diversity indices and 95% confidence limits for fish samples from four stations in Horse Creek, summarized over sampling events within each year[29].**

---

[29] Because of a malfunction with the backpack electrofishing unit, fish were only collected using the seine method during the 27 October 2015 sampling event. Data may not be comparable to other sampling events. Missing HCSW-2 values = 0- 1 species caught and SW score = 0.

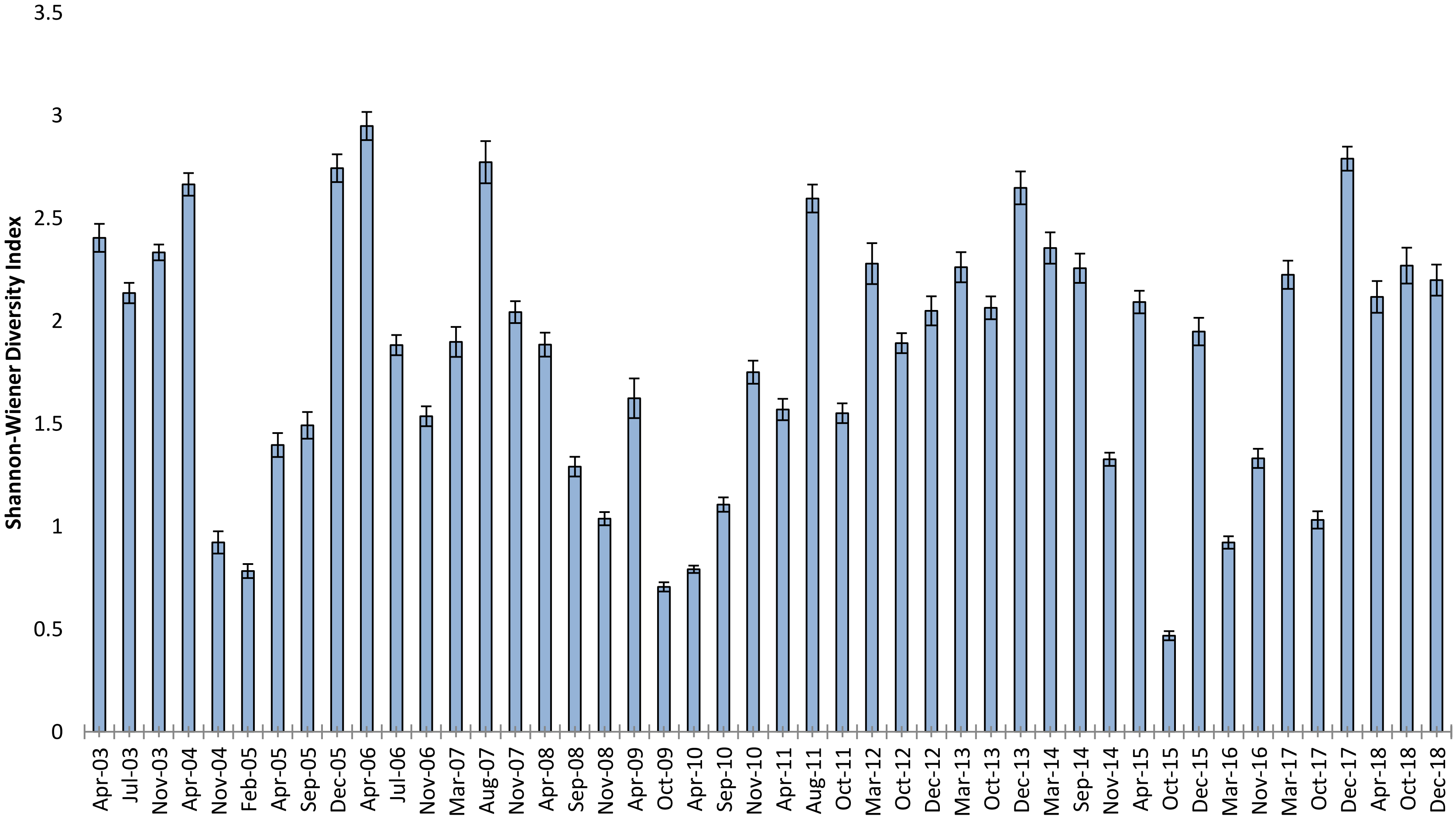


Figure 7-10 Shannon-Wiener diversity indices and 95% confidence limits for fish samples from Horse Creek summarized over all stations per sampling event[30].

---

[30] Because of a malfunction with the backpack electrofishing unit, fish were only collected using the seine method during the 27 October 2015 sampling event. Data may not be comparable to other sampling events.

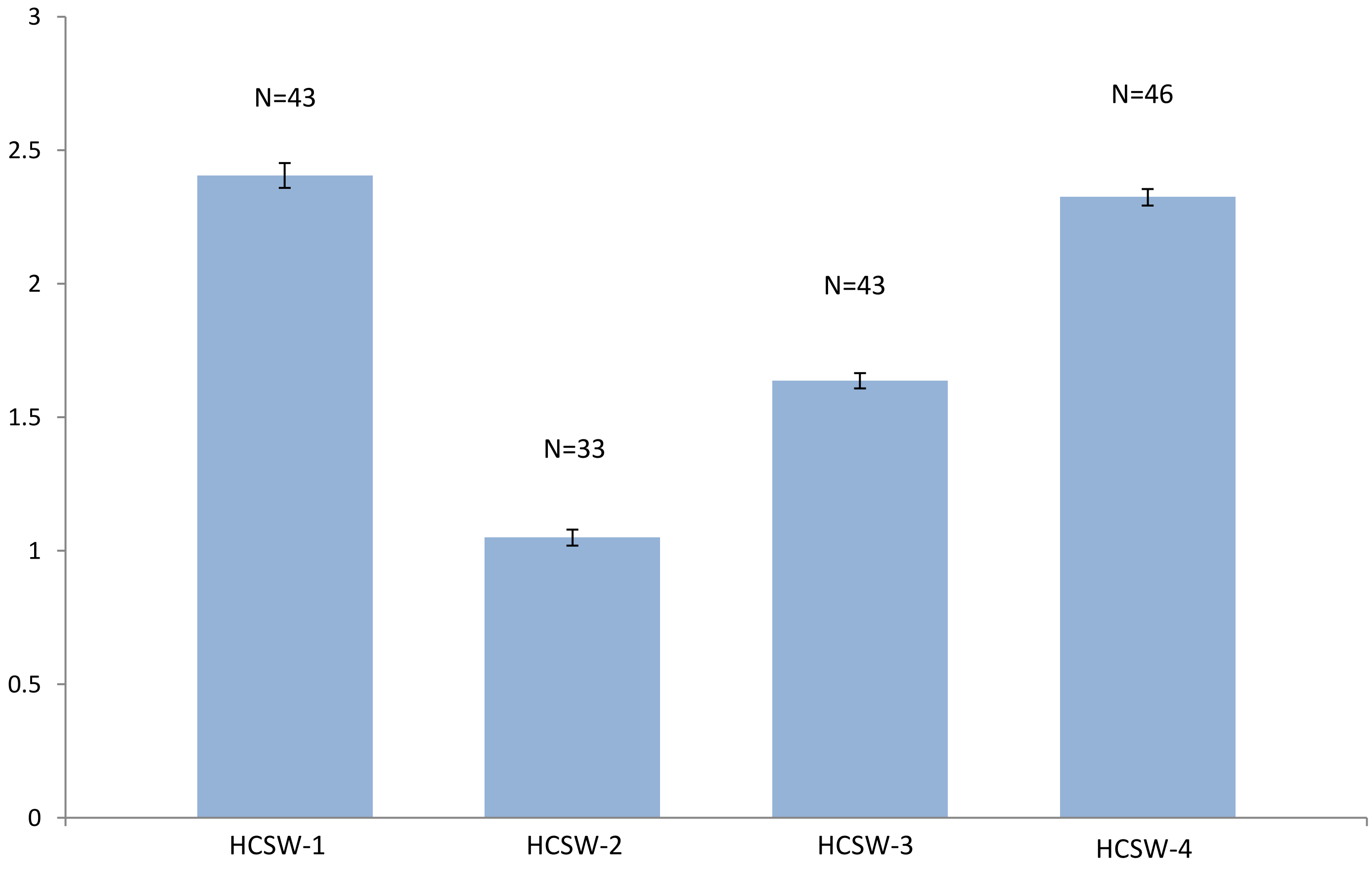


Figure 7-11 Shannon-Wiener diversity indices and 95% confidence limits for fish samples from four stations in Horse Creek summarized over all sampling dates[31].

---

[31] Because of a malfunction with the backpack electrofishing unit, fish were only collected using the seine method during the 27 October 2015 sampling event. Data may not be comparable to other sampling events.

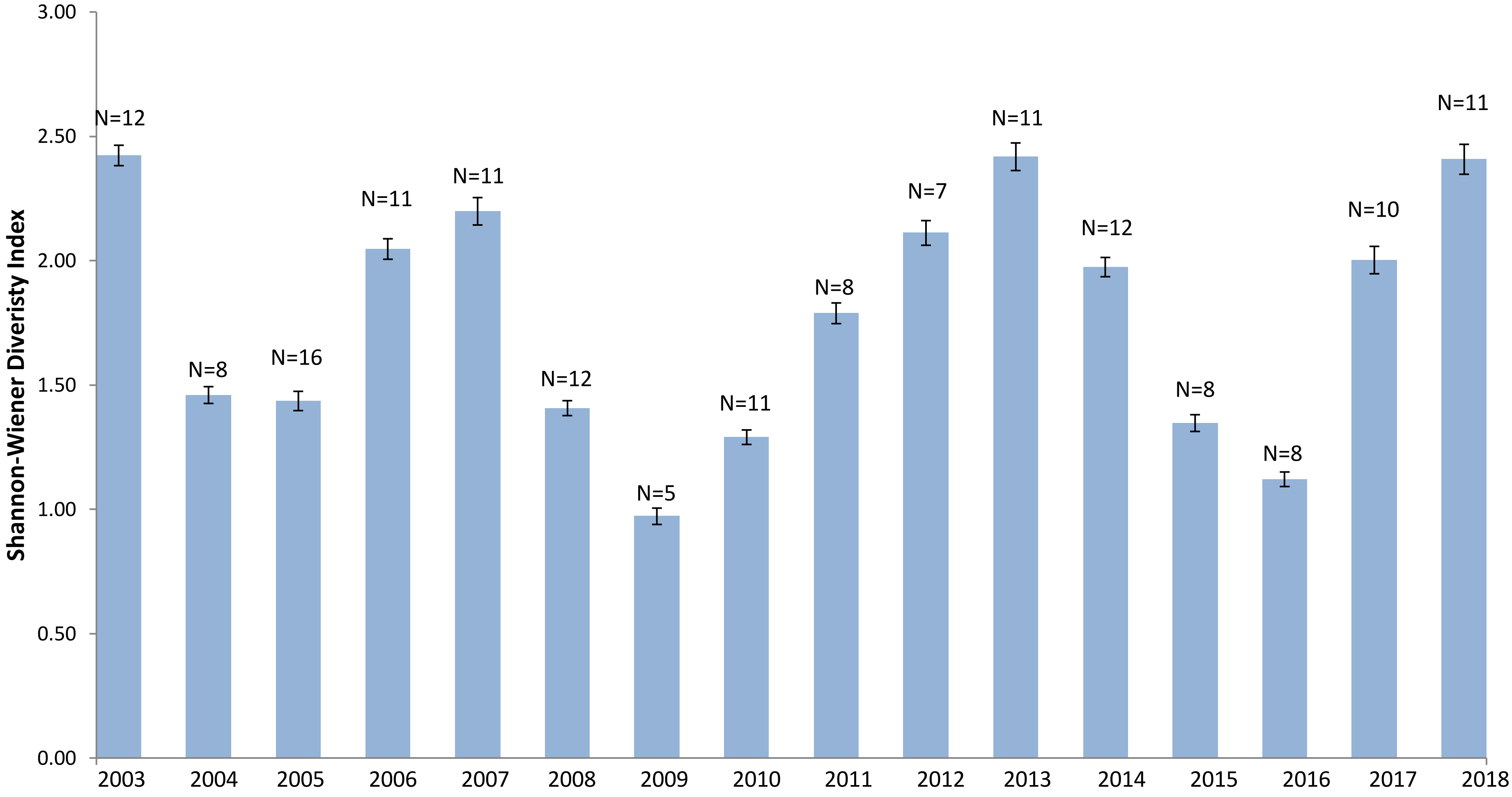


Figure 7-12 **Shannon-Wiener diversity indices and 95% confidence limits for fish samples from sixteen years at Horse Creek summarized over all stations combined[32].**

---

[32] Because of a malfunction with the backpack electrofishing unit, fish were only collected using the seine method during the 27 October 2015 sampling event. Data may not be comparable to other sampling events.

7.4.3 Morisita's Index of Similarity

Morisita's Index of Similarity measures the similarity of two communities by comparing the relative abundance of each species within and between communities. Of the similarity measures available, this index is preferred because it is nearly independent of sample size (Krebs 1998). Morisita's Index of Similarity is calculated as:

$$C_\lambda = \frac{2\sum X_{ij} X_{ik}}{(\lambda_1 + \lambda_2) N_j N_k}$$

Where C_λ = Morisita's index of similarity between sample *j* and *k*

X_{ij}, X_{ik} = Number of individuals of species *i* in sample *j* and sample *k*

$N_j = \Sigma X_{ij}$ = Total number of individuals in sample *j*

$N_k = \Sigma X_{ik}$ = Total number of individuals in sample *k*

Morisita's Index varies from 0 (no similarity – no species in common) to about 1 (complete similarity – all species in common) (Krebs 1998).

Table 7-4 includes Morisita's Index values combined by year or station. When all sampling events for a given station are combined, fish communities were very similar (88% - 99%, Table 7-4), with HCSW-1 being the least similar to other stations because it has a higher percentage of non-Poecilid fish captures compared to the other stations. When all sampling events for a given year are combined, fish communities were very similar (87% - 100%, Table 7-4), with 2005, 2009, and 2016 being the least similar and 2007 and 2017 the most similar to 2018.

Table 7-4 Morisita's Similarity Index matrix comparing sapling dates within stations or within years for 2003 to 2018 samples.

	HCSW-1	HCSW-2	HCSW-3	HCSW-4
HCSW-1	1	0.80	0.84	0.93
HCSW-2		1	0.99	0.94
HCSW-3			1	0.97
HCSW-4				1

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
2003	1	0.96	0.96	0.99	0.99	0.96	0.92	0.94	0.98	0.98	0.97	0.99	0.95	0.93	0.96	0.96
2004		1	0.98	0.99	0.95	1	0.99	1	0.99	0.95	0.9	0.99	0.99	0.99	0.92	0.9
2005			1	0.98	0.94	0.97	0.94	0.97	0.99	0.94	0.88	0.98	0.96	0.96	0.89	0.88
2006				1	0.99	0.99	0.96	0.98	0.99	0.98	0.95	1	0.98	0.97	0.95	0.95
2007					1	0.96	0.93	0.94	0.97	0.99	0.98	0.99	0.95	0.93	0.98	0.97
2008						1	0.99	1	0.99	0.95	0.9	0.99	1	1	0.93	0.9
2009							1	1	0.96	0.93	0.87	0.97	0.99	1	0.91	0.88
2010								1	0.98	0.95	0.89	0.98	1	1	0.91	0.89
2011									1	0.96	0.92	0.99	0.98	0.97	0.93	0.92
2012										1	0.98	0.98	0.96	0.94	0.97	0.95
2013											1	0.95	0.91	0.88	0.97	0.96
2014												1	0.98	0.97	0.95	0.94
2015													1	1	0.92	0.9
2016														1	0.91	0.88
2017															1	0.97
2018																1

7.4.4 Summary of Fish Results

Forty-four species of fish were collected from 2003 to 2018, with most captured individuals belonging to one of five families (Table 7-5). System wide, very few additional species are expected to be collected during future monitoring events, as there has only been the addition of five (5) species over the last 10 years (a total of 39 species were collected in 2006, 40 species in 2008, 41 species at the end of 2012, and 44 species at the end of 2016), and the species accumulation curves based on the samples collected through 2018 appear to have reached a threshold (Figure 7-13). Most of the recent species additions have come after review by the Florida Museum of Natural History. Some native species may be present in Horse Creek but were not collected during the HCSP from 2003 to 2018. These include the American eel (*Anguilla rostrata*) and black crappie (*Pomoxis nigromaculatus*).

Samples collected from 2003 to 2018 for the HCSP included 11 exotic species: African jewelfish, Asian swamp eel, blue tilapia, brown hoplo, leopard pleco, Nile tilapia, oriental weatherfish, Orinoco sailfin catfish, sailfin catfish, vermiculated sailfin catfish, and walking catfish. Over 30 species of exotic fish have established reproducing populations in Florida (http://floridafisheries.com), and more will likely continue to be introduced in spite of laws restricting such introductions; thus, additional exotic species are expected to be collected in Horse Creek during future monitoring events as new introductions occur and as such species expand their ranges in Florida.

Table 7-6 presents a summary of the number of individual fish captured for several major fish groups at each station per year, including exotic fish species. At each station, the number of individuals per fish groups varies considerably over time and is heavily influenced by sampling conditions. The inherent variability of the data, as well as small differences in sampling effort between years and stations, makes it difficult to look for trends in fish group abundance over time, but a visual examination shows no general trends of increase or decrease in the exotic group or the native fish groups.

During 2018, 20 species of fish were collected from the four Horse Creek sampling stations. Abnormally cold winters in 2009 to 2010 and 2010 to 2011 may have led to decreased fish diversity at some stations in 2010 and 2011, with evidence of recovery and recruitment in 2012 and 2013. Over the period of record, fish richness and diversity were lowest at HCSW-2, the only station with a detected trend, and the only station with a water supply problem. When all stations were combined, the year 2010 saw the lowest fish diversity and 2013 saw the highest diversity, with 2018 having the 6th highest score over sixteen years. There were no increasing or decreasing trends when all stations were combined and analyzed annually or seasonally adjusted, nor was a trend detected for individual stations by annual median diversity; spring, summer, or, winter diversity. No consistent patterns over time were evident in the abundance of fish from exotic and native fish groups (Table 7-6).

Table 7-5 Percentage of individual fish captures per year for most abundant fish families/groups in Horse Creek from 2003 to 2018 as part of the HCSP

Fish Family	HCSW-1	HCSW-2	HCSW-3	HCSW-4	Total
Poeciliidae	51.38%	97.12%	87.59%	70.64%	84.32%
Cyprinidae	31.44%	0.01%	3.94%	12.73%	6.52%
Centrarchidae	6.89%	0.57%	2.08%	5.46%	2.69%
Cyprinodontidae	1.07%	1.05%	2.12%	3.85%	2.12%
Atherininidae	5.01%	0.00%	1.63%	2.58%	1.57%
Exotics	2.09%	0.76%	1.765	2.63%	1.67%

Table 7-6 **Number of individual fish captured per year for major native and exotic fish groups in Horse Creek from 2003 to 2018 as part of the HCSP**[30]

HCSW-1																
	2003	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**
Native Poecilids	181	78	75	341	25	275	47	328	308	213	42	61	57	47	13	125
Native Sunfish	46	26	31	20	23	24	14	7	14	9	23	12	4	2	4	37
Native Catfish	5	9	3	4	3	2	0	1	2	1	2	1	2	0	0	0
Native Other	25	69	57	140	87	268	33	4	164	155	148	168	58	18	85	197
Exotics	2	1	5	0	0	1	7	0	1	6	19	7	2	1	8	24
Total Fish	259	183	171	505	138	570	101	340	489	384	234	249	123	68	110	383
Sampling Events	3	2	4	3	3	3	1	3	2	2	3	3	3	2	3	3
HCSW-2																
	2003	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**
Native Poecilids	363	1735	3093	568	908	1335	2519	1695	394	0	981	1514	2702	1062	233	491
Native Sunfish	41	15	9	13	2	1	1	1	1	0	12	8	5	0	0	6
Native Catfish	1	2	0	0	0	0	0	0	0	0	0	0	2	0	0	0
Native Other	21	61	43	1	6	12	4	50	13	0	15	38	34	6	0	3
Exotics	4	2	22	1	4	40	3	2	0	0	48	17	4	3	0	3
Total Fish	430	1815	3167	583	920	1388	2527	1748	408	0	1056	1577	2747	1071	233	503
Sampling Events	3	2	4	2	2	3	1	2	1	0	2	3	3	2	1	2

Table 7-6 Cont'd Number of individual fish captured per year for major native and exotic fish groups in Horse Creek from 2003 to 2018 as part of the HCSP[30]

HCSW-3																
	2003	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**
Native Poecilids	669	1606	4125	727	489	3122	1677	2874	1364	2092	383	738	2117	1011	755	325
Native Sunfish	49	24	35	31	44	19	5	78	78	28	35	28	20	7	13	61
Native Catfish	1	0	0	0	4	1	0	1	1	2	7	0	0	0	1	0
Native Other	180	114	23	145	202	106	11	215	143	299	211	101	162	30	152	281
Exotics	1	14	37	12	17	23	53	7	3	80	67	52	38	34	11	23
Total Fish	900	1758	4220	915	756	3271	1746	3175	1589	2501	703	919	2337	1082	932	690
Sampling Events	3	2	4	3	3	3	1	3	2	2	3	3	3	2	3	3
HCSW-4																
	2003	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**
Native Poecilids	172	713	705	280	62	794	409	2423	2112	998	772	276	248	113	100	323
Native Sunfish	52	27	5	67	54	62	66	38	97	74	84	41	21	15	43	49
Native Catfish	6	2	2	0	0	1	0	0	1	1	17	1	1	5	5	2
Native Other	77	52	12	53	174	173	311	205	188	425	465	146	198	55	313	282
Exotics	15	6	31	20	4	12	5	19	3	20	129	64	17	14	24	14
Total Fish	322	800	755	420	294	1042	791	2685	2401	1518	1467	528	485	202	485	670
Sampling Events	3	2	4	3	3	3	2	3	3	3	3	3	3	2	3	3

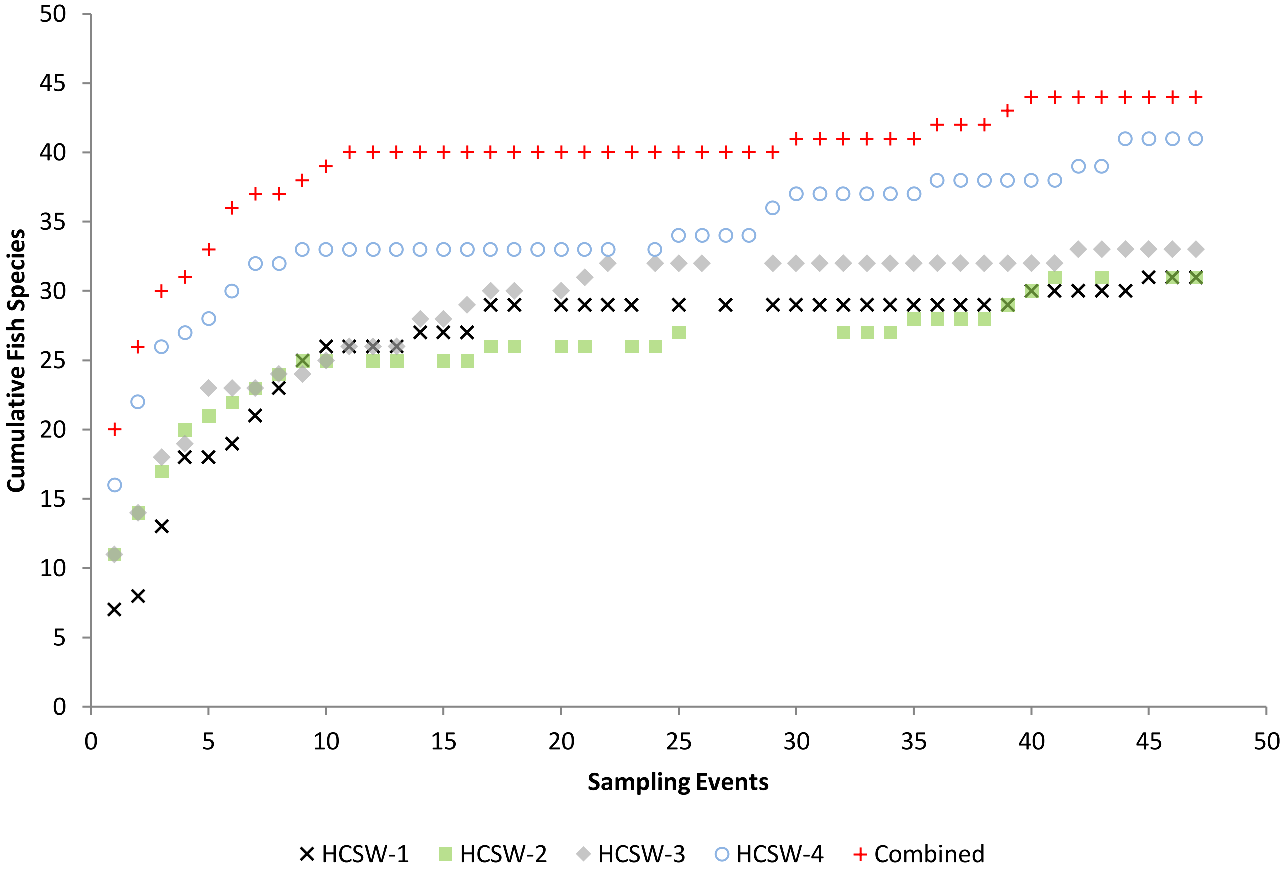


Figure 7-13 Species accumulation curve for each HCSP station and at all stations combined from 2003 to 2018

8.0 CONCLUSIONS

8.1 Water Quantity Results

Annual average flow at HCSW-1 and HCSW-4 in 2018 was the 2nd highest and 3rd highest, respectively, since the HCSP started in 2003. Most of the high flow occurred between mid-May through October with a renewed high flows in late December. 2018 total annual rainfall in the Horse Creek Basin was the 5th wettest according to the Mosaic rain gauge network and the 3rd wettest according to the two nearest NOAA gauges since 2003. The NPDES discharge that did occur was the 9th largest that had occurred in the 18 years the outfalls have been online.

There is no evidence that mining and reclamation activities in the basin caused any statistically significant decrease in total streamflow over the period of record (1978 to 2018), according to the double mass curve analysis. In a previous study (Robbins and Durbin 2011) that compared streamflow during dry years in reference and potentially impacted streams before and during phosphate mining, there was no evidence that phosphate mining practices caused lower monthly flows in the potentially impacted streams (including Horse Creek) than what would be expected given the conditions in a reference stream (Charlie Creek).

8.2 Water Quality Results

Across all parameters monitored during the HCSP monthly sampling program, HCSW-1, the sampling station closest to the NPDES outfalls, had one exceedance of a trigger level- an alkalinity value of 120 mg/L (alkalinity trigger level is 100 mg/L) in April of 2018. At the time of the alkalinity exceedance outfalls were not discharging and had not discharged in 496 days and they would not begin discharging for another 58 days. This suggests this exceedance is related to baseflow inputs to Horse Creek. All other parameters were well below the respective HCSP established trigger levels and HCSW-1. The trends that were detected at HCSW-1 were studied in the 2017 and 2018 impact assessments which both point to land use changes and non-point sources throughout the Horse Creek Basin.

Five of the HCSW-2 monthly samples exceeded the time-of-day criteria for dissolved oxygen saturation. HCSW-2 is unlike the other three sites primarily due to the road crossing immediately upstream of the site that impounds the system except during periods of high flow. The impoundment coupled with the organic inputs from the upstream prairie has created a system with frequent low or no flow conditions, increased residence time, accretion of coarse organic material, and a thick anaerobic benthos, and a higher oxygen demand. The impacts of these conditions are evident in the aquatic habitat assessment, the diversity of macroinvertebrate and fish communities in HCSW-2.

The two stations furthest from the outfalls, HCSW-3 and HCSW-4 have historically had more exceedances than HCSW-1. In 2018 there were exceedances in dissolved calcium (HCSW-4), dissolved oxygen (HCSW-3), dissolved iron (HCSW-4), TDS (HCSW-3 & 4), ammonia (HCSW-3 & 4), and sulfate (HCSW-3 & 4). The ammonia exceedances may be a lab error as there was a detectable amount of ammonia in the blank samples. There were six dissolved iron exceedances during periods of elevated streamflow, between May and October 2018. HCSW-4 has a lower trigger level (0.3 mg/L vs 1.0 mg/L) than the upstream stations since it is located within the class I portion of Horse Creek. An ANOVA of dissolved iron at all four sites over the HCSP period found no difference between sites and the Seasonal Kendall trend analysis found a -0.01 mg/L per year trend at both HCSW-1 and HCSW-4. Dissolved iron is typically higher in Brushy Creek (which has no NPDES inputs) than in Horse Creek. Dissolved iron in Horse Creek is correlated to streamflow, rainfall, and NPDES discharge. This does not mean that NPDES is a source, NPDES discharge itself is also correlated to rainfall.

The 2018 impact assessment analyzed all available surfacewater and groundwater data for TDS, sulfate, and calcium in Horse Creek and its major tributaries. TDS, sulfate, and calcium values have approached and exceeded the HCSP trigger levels in the lower basin before the HCSP period. Exceedances of TDS, sulfate, and calcium often occurred when there was no discharge or long after there has been a discharge through either outfall. Exceedances also often occurred when the stream was in a state of low flow and dominated by base flow (i.e. consisting mostly of groundwater seepage) which suggests a non-point source input. Groundwater data collected near the Wingate Mine (located in the Upper Horse Creek Basin and upstream of HCSW-1) suggests that surficial groundwater from the mine was not contributing to elevated TDS, sulfate or calcium in Horse Creek. The historical water quality record for two tributaries that discharge near HCSW-3 and HCSW-4, Brandy Branch and Buzzard Roost Branch, indicates both systems have had elevated TDS, calcium, sulfate and specific conductivity values through their reach. Both creeks cross an intensive sod farm operation.

8.3 Benthic Macroinvertebrate Results

Overall diversity in 2018 across all four stations was the 2nd highest since 2003. The highest SCI score attained in 2018 occurred at HCSW-1, the station closest to the NPDES outfalls. It is the only station with a detected trend in SCI scores for the period 2007-2018 (+2.33/year). HCSW-1 has the highest average habitat assessment score of all for stations over the HCSP period. It is the only station with consistently “healthy” or better SCI scores since 2007. It does have a lower period of record diversity score than the other three sites which has to do with the station being located in a lower order reach of Horse Creek relative to the others.

8.4 Fish Results

Over the period of record, fish richness and diversity were lowest at HCSW-2, the only station with a detected trend, and the only station with a water supply problem. When all stations were combined, the year 2009 saw the lowest fish diversity and 2003 saw the highest diversity, with 2018 having the 3rd highest score over sixteen years. There were no increasing or decreasing trends when all stations were combined and analyzed annually or seasonally adjusted, nor was a trend detected for individual stations by annual median diversity; spring, summer, or, winter diversity. No consistent patterns over time were evident in the abundance of fish from exotic and native fish groups. When years were combined, HCSW-1, the station closest to the NPDES outfalls, showed the highest diversity of the four stations.

9.0 RECOMMENDATIONS

9.1 Previous TAG and Annual Report Recommendations

9.1.1 TAG Recommendations

- TAG members will submit any additional comments on the 2017 annual report to the Authority by
- February 8, 2019.
    - **Last set of comments sent to Cardno by the Authority on February 12, 2019.**
- Cardno will provide a PDF version of the PowerPoint presentation to the TAG members.
    - **Completed January 30, 2019.**
- Cardno will provide a Word document of all reviewers' questions/comments and responses to the Authority for transmittal to TAG members for the 2017 annual report.
    - **Submitted with the finalized version of the 2017 report.**
- Mosaic will get in touch with USGS to determine if moving the flow/water level gauge at SR64 is
  feasible.
- Cardno will work with Mosaic to obtain reclamation acre totals for 2017.
    - **Included in the comments response document for the 2016 annual report, finalized on January 30, 2019.**

9.1.2 Annual Report Recommendations

- Cardno will update the fish diversity graphs to clarify which data was used in the annual and station graphs.
    - **Included in the finalized 2017 annual report.**
- Weather and/or isolated extreme events will be better described in the water quantity section to help explain some of the rainfall and streamflow graphs.
    - **Included in the water quantity summary sections and Appendix K of the finalized 2017 annual report.**
- More detailed information will be added to the inflection points of the double mass curve graph
    - **Included in the finalized 2017 annual report.**
- A more descriptive write-up will be provided on the dual purpose of the HCSW-1 continuous recorder (continuous data and elevated turbidity indicating potential CSA breech).
    - **Included in the finalized 2017 annual report.**
- 2017 Annual Report
  Horse Creek Stewardship Program
  March 2019, Final Cardno Recommendations 9-100
  2017_HCSP_Annual_Report_Final_032819
- Update the orthophosphate graphs in the main report and Appendix C to reflect the correct November 2017 concentration.
    - **Included in the finalized 2017 annual report.**

9.2 Current TAG Recommendations

This section has been left intentionally blank. This section will be updated after the TAG meeting.

9.3 Current Annual Report Recommendations

This section has been left intentionally blank. This section will be updated after the TAG meeting.

10.0 REFERENCES

American Fisheries Society. 2004. Common and Scientific Names of Fishes from the United States, Canada and Mexico. 6th ed. American Fisheries Society Publication. Maryland.

Ardaman and Associates, Inc., Armac Engineers, Inc., Joshua 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.

Berryman, D., B. Bobee, D. Cluis, and J. Haemmerli. 1988. Nonparametric tests for trend detection in water quality time series. Water Resources Bulletin of American Water Resources Association. 24(3): 545 – 556.

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 K. M. N. Raymond. 2006. Horse Creek Stewardship Program: Summary of Historical Information on Water Quantity, Quality, and Aquatic Biology. Prepared by Biological Research Associates for the Mosaic Company.

Durbin, D. J. and K. M. N. Raymond. 2007. Horse Creek Stewardship Program: 2005 Annual Report. Prepared by Biological Research Associates for the Mosaic Company.

Durbin, D. J. and K. M. N. Robbins. 2008. Horse Creek Stewardship Program: 2006 Annual Report. Prepared by Biological Research Associates for the Mosaic Company.

Durbin, D. J. and K. M. N. Robbins. 2009. Horse Creek Stewardship Program: 2007 Annual Report. Prepared by ENTRIX Inc. for the Mosaic Company.

Durbin, D. J., K. M. N. Robbins, and S. Huelster. 2010. Horse Creek Stewardship Program: 2008 Annual Report. Prepared by ENTRIX Inc. for the Mosaic Company.

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

Florida Department of Environmental Protection (FDEP). 2013. Technical Support Document: Derivation of Dissolved Oxygen Criteria to Protect Aquatic Life in Florida's Fresh and Marine Waters. Division of Environmental Assessment and Restoration. DEP-SAS-001/13. March 2013.

Fore, L. S. 2004. Development and Testing of Biomonitoring Tools for Macroinvertebrates in Florida Streams. Prepared for the FDEP.

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.

Harcum, J. B., J. C. Loftis, and R. C. Ward. 1992. Selecting trend tests for water quality series with serial correlation and missing values. Water Resources Bulletin of American Water Resources Association. 28(3): 469 – 478.

Harrel, R. C., B. J. Davis, and T. C. Dorris. 1967. Stream order and species diversity of fishes in an intermittent Oklahoma stream. American Midland Naturalist 78:428-436.

Heath, R. C. and C. S. Conover. 1981. Hydrological Almanac of Florida. US Geological Survey Open File Report 81-1107, Tallahassee, Florida.

Helsel, D. R., D. K. Mueller, and J. R. Slack. 2006. Computer program for the Kendall family of trend tests. U.S. Geological Survey Scientific Investigations Report: 2005-5275. 4 p.

Hirsch, R. M., J. R. Slack, and R. A. Smith. 1982. Techniques of trend analysis for monthly water quality data. Water Resources Research 18(1): 107 – 121.

Krebs, C. J. 1998. Ecological Methodology, 2nd Edition. Harper Collins Publishers, Inc., New York, New York.

Lettenmaier, D. P. 1988. Multivariate nonparametric tests for trend in water quality. Water Resources Bulletin of American Water Resources Association. 24(3): 505 – 512.

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.

Lewelling, B. R. and R. W. Wylie. 1993. Hydrology and water quality of unmined and reclaimed basins in phosphate-mining areas, west-central Florida. U.S. Geological Survey. Water-Resources Investigations Report 93-4002. Tallahassee, FL.

Ludwig, J. A. and J. F. Reynolds. 1988. Statistical Ecology: A Primer on Methods and Computing. John Wiley and Sons, Inc, New York, New York.

Merritt R.W. and K. W. Cummins. 1996. An Introduction to the Aquatic Insects of North America. Kendall/Hunt Publishing Company, Dubuque, Iowa.

R Core Team. 2014. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL http://www.R-project.org/.

Patel, S. K. and A. E. Schreiber. 2001. Fate and Consequences to the Environment of Reagents Associated with Rock Phosphate Processing. Prepared for Florida Institute of Phosphate Research, FIPR Project #94-02-104. Bartow, Florida.

Parker, I. M., D. Simberloff, W. M. Lonsdale, K. Goodell, M. Wonham, P. M. Kareiva, M. H. Williamson, B. Von Holle, P. B. Moyle, J. E. Byers, and L. Goldwasser. 1999. Impact: Toward a framework for understanding the ecological effects of invaders. Biological Invasions 1:3-19.

Post, Buckley, Schuh, and Jernigan, Inc. 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.

R Core Team. 2014. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL http://www.R-project.org/.

Reid, G. K. and R. D. Wood. 1976. Ecology of Inland Waters and Estuaries, 2nd ed. D. Van Nostrand Company, New York, New York.

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.

Robbins, K.M.N. and D.J. Durbin. 2011. Analysis of Streamflow Differences Between Pre-Mining and During-Mining for Dry Years for Impacted and Reference Streams: A BACI (Before, After, Control, Impact) Paired Series Test. Prepared for The Mosaic Company. Riverview, Florida.

Robbins, K.M.N., and S.A. Huelster. 2015. Horse Creek Stewardship Program: 2011 Annual Report. Prepared by Cardno for Mosaic Fertilizer, LLC.

Robbins, K.M.N., and S.A. Huelster. 2015. Horse Creek Stewardship Program: 2012 Annual Report. Prepared by Cardno for Mosaic Fertilizer, LLC.

Robbins, K.M.N., and S.A. Huelster. 2016. Horse Creek Stewardship Program: 2013 Annual Report. Prepared by Cardno for Mosaic Fertilizer, LLC.

Robbins, K.M.N., and S.A. Huelster. 2017. Horse Creek Stewardship Program: 2014 Annual Report. Prepared by Cardno for Mosaic Fertilizer, LLC.

Robbins, K.M.N., and S.A. Huelster. 2018. Horse Creek Stewardship Program: 2015 Annual Report. Prepared by Cardno and Brown & Caldwell for Mosaic Fertilizer, LLC.

Robbins, K.M.N., and S.A. Huelster. 2018. Horse Creek Stewardship Program: 2016 Annual Report. Prepared by Cardno and Brown & Caldwell for Mosaic Fertilizer, LLC.

Robbins, K.M.N., S.A. Huelster, and D.J. Durbin. 2011. Horse Creek Stewardship Program: 2009 Annual Report. Prepared by Cardno for Mosaic Phosphates Company.

Robbins, K.M.N., S.A. Huelster, and D.J. Durbin. 2014. Horse Creek Stewardship Program: 2010 Annual Report. Prepared by Cardno for the Mosaic Company.

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.

Sheldon, A. L. 1988. Conservation of stream fishes: Patterns of diversity, rarity, and risk. Conservation Biology 2:149-156.

South West Florida Water Management District. 2000. Resource Evaluation of the Horse Creek Project, Draft. Brooksville, Florida.

StatSoft, Inc. (2005). STATISTICA (data analysis software system), version 7.1. www.statsoft.com.

Whiteside, B. G. and R. M. McNatt. 1972. Fish species diversity in relation to stream order and physiochemical conditions in the Plum Creek drainage basin. American Midland Naturalist 88:90-101.

Wilson, E. O. 1992. The Diversity of Life. W.W. Norton & Company, New York.

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

Appendix A

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 (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 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 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 most regulatory scenarios.

The mission of the PRMRWSA is to provide a reliable and safe drinking water supply to the citizens of the four counties comprising the PRMRWSA, Charlotte, DeSoto, Manatee, and Sarasota Counties. The Peace River Facility is a critical component of the PRMRWSA'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 PRMRWSA 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 PRMRWSA'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 PRMRWSA. The PRMRWSA 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 (FDEP), 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.

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 USGS gauging stations, with essentially continuous stage and discharge records since 1977 and 1950, respectively.

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 gauges will be installed in the stream at HCSW-2 and HCSW-3 and surveyed to National Geodetic Vertical Datum (NGVD). If not already available, stream cross sections will be surveyed at those locations, extending to the approximate limits of the 25-year floodplain. Staff gauge readings will be recorded at the time of any sampling efforts at those stations. Data on rainfall will be obtained using IMC's rain gauge array (including any additional gauges 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.

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

Color
Total Alkalinity
Chloride
Fluoride
Radium 226 + 228
Sulfate
Iron

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 the FDEP'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 FDEP'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. 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 enough 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.

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 FDEP 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 photo stations established. Qualitative macroinvertebrate sampling will be performed according to the Stream Condition Index (SCI) protocol developed by FDEP (DEP-SOP-002/01 LT 7200) or subsequently FDEP-approved sampling methodology. Consistent with FDEP 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.

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, dip netting, 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.

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 PRMRWSA, as well as to the DEP Bureau of Mine Reclamation (BMR) and SWFWMD.

In addition to the reporting outlined above, raw data compiled through sampling will be provided to the PRMRWSA 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 PRMRWSA 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 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 exceedances 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 exceedances 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 PRMRWSA 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 PRMRWSA scientists that IMC’s activities in the Horse Creek watershed did not cause the exceedance or trend, IMC would support the PRMRWSA’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 exceedances 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 PRMRWSA.

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 exceedance or adverse trends. Quantitative models and other analytical tools will provide IMC and PRMRWSA 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 PRMRWSA within 30 days of detection of the adverse trend or trigger exceedance to evaluate alternative solutions developed by IMC. IMC shall begin implementation of its proposed alternative solution selected by the PRMRWSA within 30 days and report to PRMRWSA 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 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 PRMRWSA.

Table A-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	SM 2120B	PCU	Monthly	<25	Excursions below trigger level or statistically significant trend line predicting concentrations below trigger level.
Nutrients	Total Nitrogen	EPA 351.2 + 353.2	mg/L	Monthly	>3.0	Exceedance of or statistically significant trend line predicting concentrations in excess of, trigger level.
	Total Ammonia	EPA 350.1 + FDEP SOP 10_03_83	mg/L	Monthly	>0.3	Exceedance of or statistically significant trend line predicting concentrations in excess of, trigger level.
	Ortho Phosphate	EPA 365.1	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.

Pollutant Category	**Analytical Parameters**	**Analytical Method**	**Reporting Units**	**Monitoring Frequency**	**Trigger Level**	**Basis for Initiating Corrective Action Process**
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	SM 2320 B	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 300.0	mg/L	Monthly	>250	Exceedance of or statistically significant trend line predicting concentrations in excess of, trigger level.
	Fluoride	EPA 300.0	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 903.1 + Ra-05	pCi/L(4)	Quarterly	>5	Exceedance of or statistically significant trend line predicting concentrations in excess of, trigger level.
	Sulfate	EPA 300.0	Mg/L	Monthly	>250	Exceedance of or statistically significant trend line predicting concentrations in excess of, trigger level.
	Total Dissolved Solids	SM 2540 C	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)

Pollutant Category	Analytical Parameters	Analytical Method	Reporting Units	Monitoring Frequency	Trigger Level	Basis for Initiating Corrective Action Process
Biological Indices: Macroinvertebrates	Total Number of Taxa Abundance Percent Diptera Number of Chironomid Taxa Shannon Weaver Diversity(a) Florida Index EPT Index Percent Contribution of Dominant Taxon Percent Suspension Feeders/Filterers	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
Biological Indices: Fish	Total Number of Taxa Abundance Shannon-Weaver Diversity(a) Species Turnover (Morisita Similarity Index(a) Rarefaction/Species Accumulation Curves(b)	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

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

Cumulative Chronological List of Procedural Changes to the HCSP

Change 1: Summer Biological sampling from July – Aug to July – Sep.
Year Implemented: 2004
Comments: Allows flexibility with sampling during high flows.
Provisional Acceptance: 2004
Final Acceptance: April 4, 2007

Change 2: Fall Biological sampling from Oct – Nov to Oct – Dec.
Year Implemented: 2004
Comments: Allows flexibility with sampling during high flows.
Provisional Acceptance: 2004
Final Acceptance: April 4, 2007

Change 3: Biological sampling should be separated by at least 6 weeks in time.
Year Implemented: 2004
Comments: Ensures that sample results capture seasonal variation.
Provisional Acceptance: 2004
Final Acceptance: April 4, 2007

Change 4: Accept that historical background levels of dissolved iron at HCSW-4 exceeds the trigger level of 0.3 mg/l.
Year Implemented: 2004
Comments: Station HCSW-4 trigger levels reflect the more stringent Class I levels. Historically Station HCSW-4 background levels for dissolved iron are similar to the rest of the basin but also higher than 0.3.
Provisional Acceptance: 2004
Final Acceptance: April 4, 2007

Change 5: Accept that historical background levels of dissolved oxygen and chlorophyll at HCSW-2 exceeds the trigger level.
Year Implemented: 2004
Comments: Station HCSW-2 is directly downstream of Horse Creek Prairie which routinely delivers slow moving water low in dissolved oxygen and high in chlorophyll to station HCSW-2
Provisional Acceptance: 2004
Final Acceptance: April 4, 2007

Change 6: Continue to compile, compare, present and discuss ongoing Horse Creek Data from WMD, FDEP and USGS with Horse Creek Stewardship Program (HCSP) data.
Year implemented: 2005
Comments: Enhances program
Provisional Acceptance: July 2006
Final Acceptance: April 4, 2007

Change 7: Biological Sampling stage level criteria from > 10 ft at HCSW-1 & > 5 ft at HCSW-4 to > 10 ft at HCSW-1 & > 4 ft at HCSW-4
Year implemented: 2007
Comments: Biological samples will be collected when stage levels are below these stated levels to ensure safety and quality samples.
Provisional Acceptance: July 2006
Final Acceptance: April 4, 2007

Change 8: The data range used in the historical water quality comparison should be static historical data beginning somewhere around 1990-1993.
Year Implemented: Beginning with the 2007 Annual Report.
Comments: Historical water quality comparison should be static instead of a moving window allowing consistent and continuous comparison with historical data.
Provisional Acceptance: June 2008
Final Acceptance: November 4, 2009

Change 9: Add clay settling area (CSA) FM-1 to existing monitoring program.
Year Implemented: Prior to 2009 wet season.
Comments: Recently constructed SCA FM-1 will be added to existing CSA's providing real time monitoring to Peace River Manasota River Water Authority (PRMRWA).
Provisional Acceptance: March 2009
Final Acceptance: November 4, 2009

Change 10: Deletion of three water quality parameters: FL-PRO, Fatty Acids, and Total Amines.
Year Implemented: 2009
Comments: These parameters have rarely been above the detection limit and chemical processing plants are not found in the Horse Creek watershed.
Provisional Acceptance: March 2009
Final Acceptance: November 4, 2009

Change 11: Addition of new water quality sample location for Brushy Creek @ Hwy 64.
Year Implemented: 2009
Comments: In lieu of deleted three parameters Mosaic will collect samples and provide data monthly from this location minus trigger levels and impact assessments.
Provisional Acceptance: March 2009
Final Acceptance: November 4, 2009

Change 12: Modifications to CSA monitoring methodology.
Year Implemented: 2014
Comments: Mosaic presented a monitoring proposal utilizing rolling averages of continuously measured turbidity values at HCSW-1, with a set point of 150 NTU. This set point was based on a review of historic data at the station and was selected to be sensitive enough to detect any potential turbidity excursions that might result from an upstream CSA dam breach, but not so sensitive as to result in a number of false positives. The telemetric equipment would send text messages and email alerts to Mosaic when the 3-hour rolling average exceeds 150 NTU and send alerts to Mosaic and PRMRWSA when the 6-hour rolling average exceeds 150 NTU. Three-hour alerts would trigger Mosaic investigation of the source of high turbidity, and necessary follow-up with PRMRWSA staff in the event that the cause of the alarm was associated with a dam breach or other significant upset condition at Mosaic's operations. Three tests were conducted, and following the final test, PRMRWSA staff authorized the removal of the old liquid level monitoring equipment located in the field on Mosaic property and the equipment located at the PRMRWSA's facility.
Provisional Acceptance: February 2014
Final Acceptance: July 14, 2014

Change 13: Change of the dissolved oxygen trigger level from concentration (mg/L) to percent saturation.
Year Implemented: 2014 Annual Report, November 2015 Monthly Report
Comments: In 2013, FDEP changed the Class III state water quality standard from concentration in mg/L to percent saturation. For the Florida peninsula region, the new daily average standard is 38% for continuous recorder data and time of day translation saturation for grab samples. A memo describing these changes was provided to the Technical Advisory Group (TAG) on November 18, 2015.
Provisional Acceptance: November 9, 2015
Final Acceptance: January 21, 2016

Change 14: Changed turbidity alert protocol to alert TAG and Mosaic after 12 consecutives >150 NTU measurements.
Year Implemented: 2019
Comments: Previous protocol alerted Mosaic and TAG after a 3-hour and 6-hour >150 NTU rolling average, respectively. This system produced only false alarms.
Final Acceptance: February 13, 2019

Change 15: Dropped 0.3mg/L dissolved iron trigger level at HCSW-4. HCSW-4 will be compared to the same 1 mg/L trigger level sites, HCSW-1, HCSW-2 and HCSW-3 have been assessed with.
Year Implemented: 2019
Comments: ANOVA showed that there was no difference in iron concentrations at the four sample sites. The TAG that met on December 2019 decided to drop the more stringent standard at site HCSW-4. The change will take effect in 2019 annual report.
Final Acceptance: December 12, 2019

Appendix C

Additional Water Quality Graphs

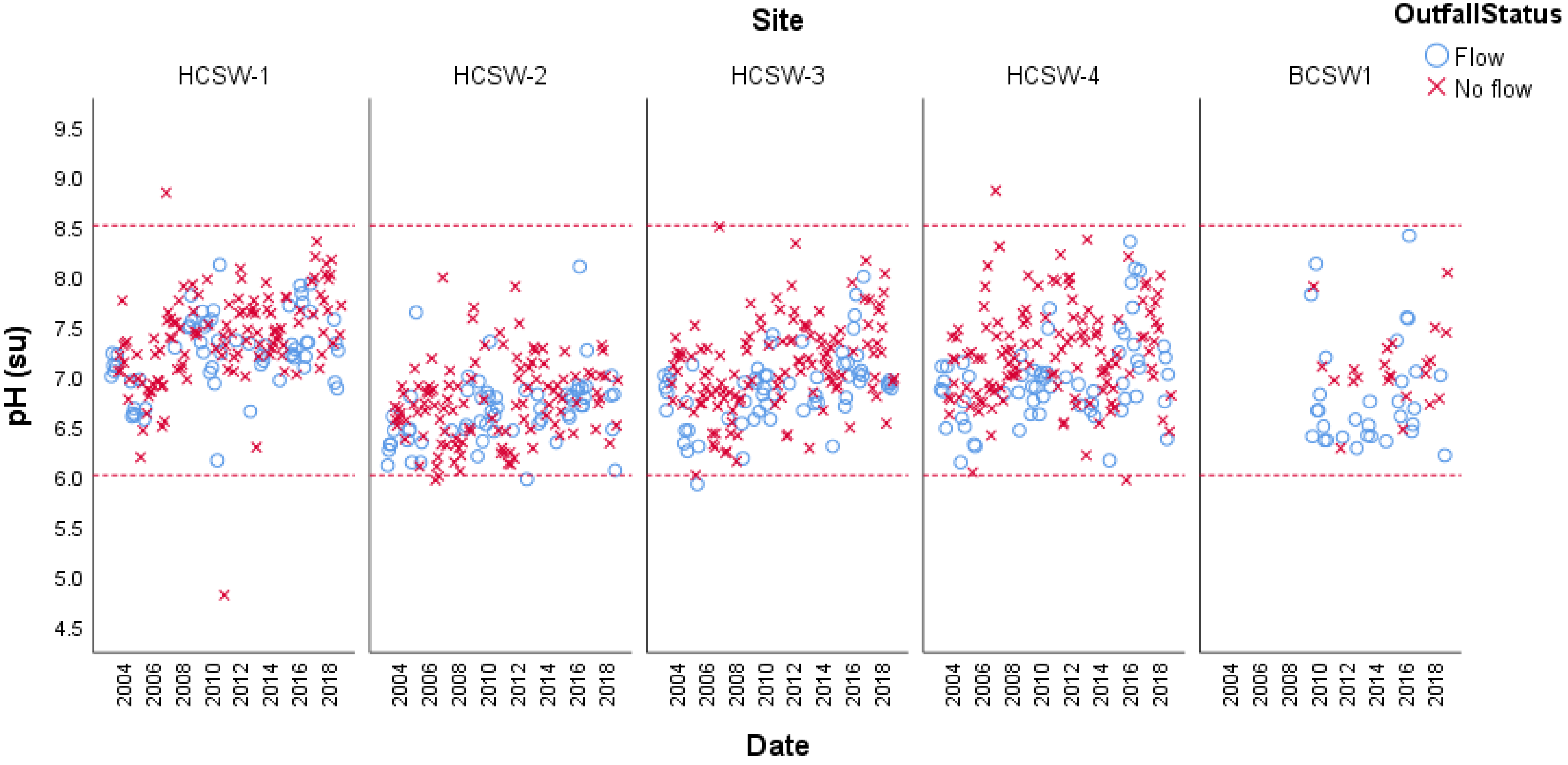


Figure C-1 Values of pH obtained during monthly HCSP water quality sampling and biological sampling events from 2003 to 2018. Analyte trigger level represented by dotted red line.

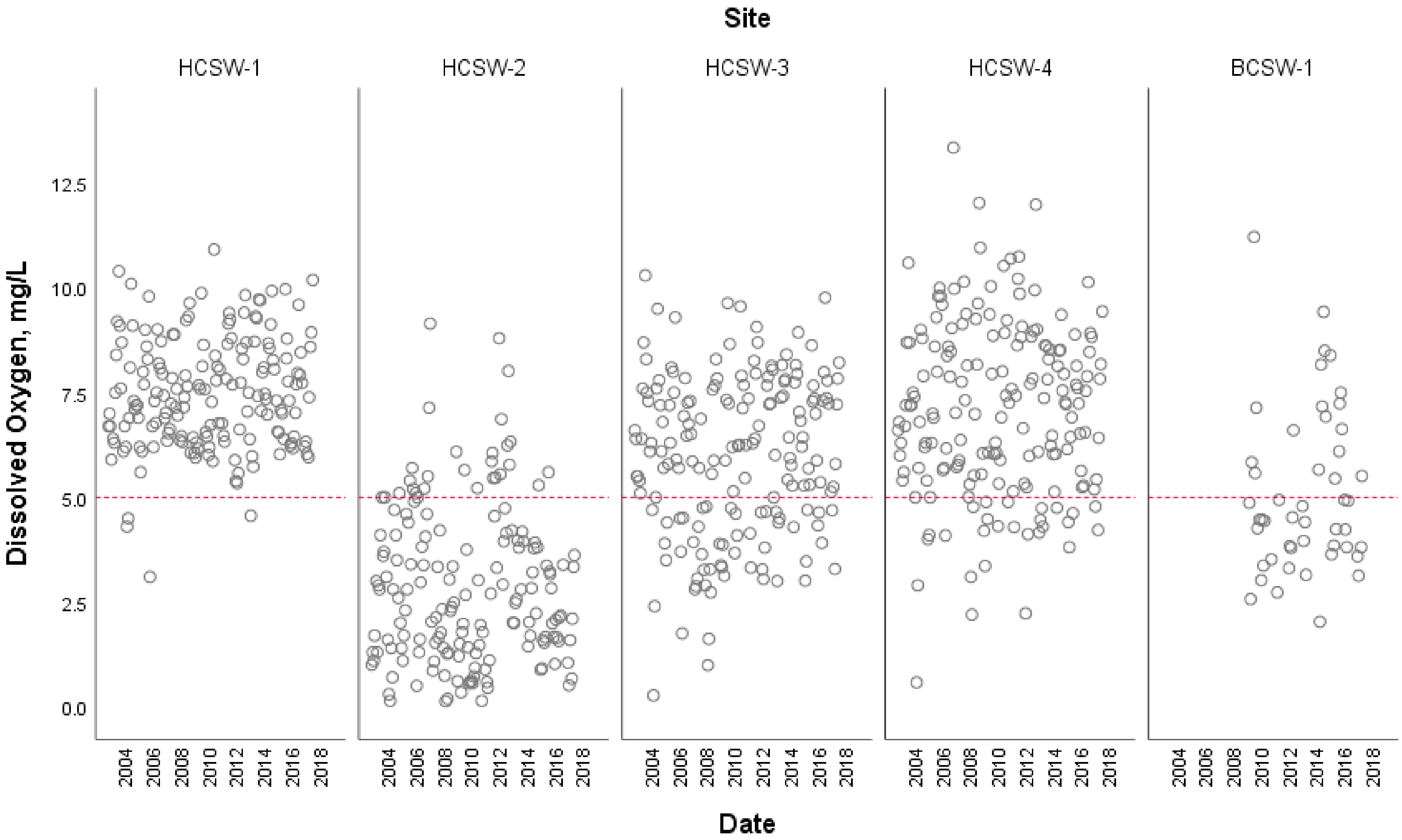


Figure C-2 **Dissolved Oxygen Concentrations obtained during monthly HCSP water quality sampling and biological sampling events from 2003 to 2018. Analyte trigger level represented by dotted red line.**

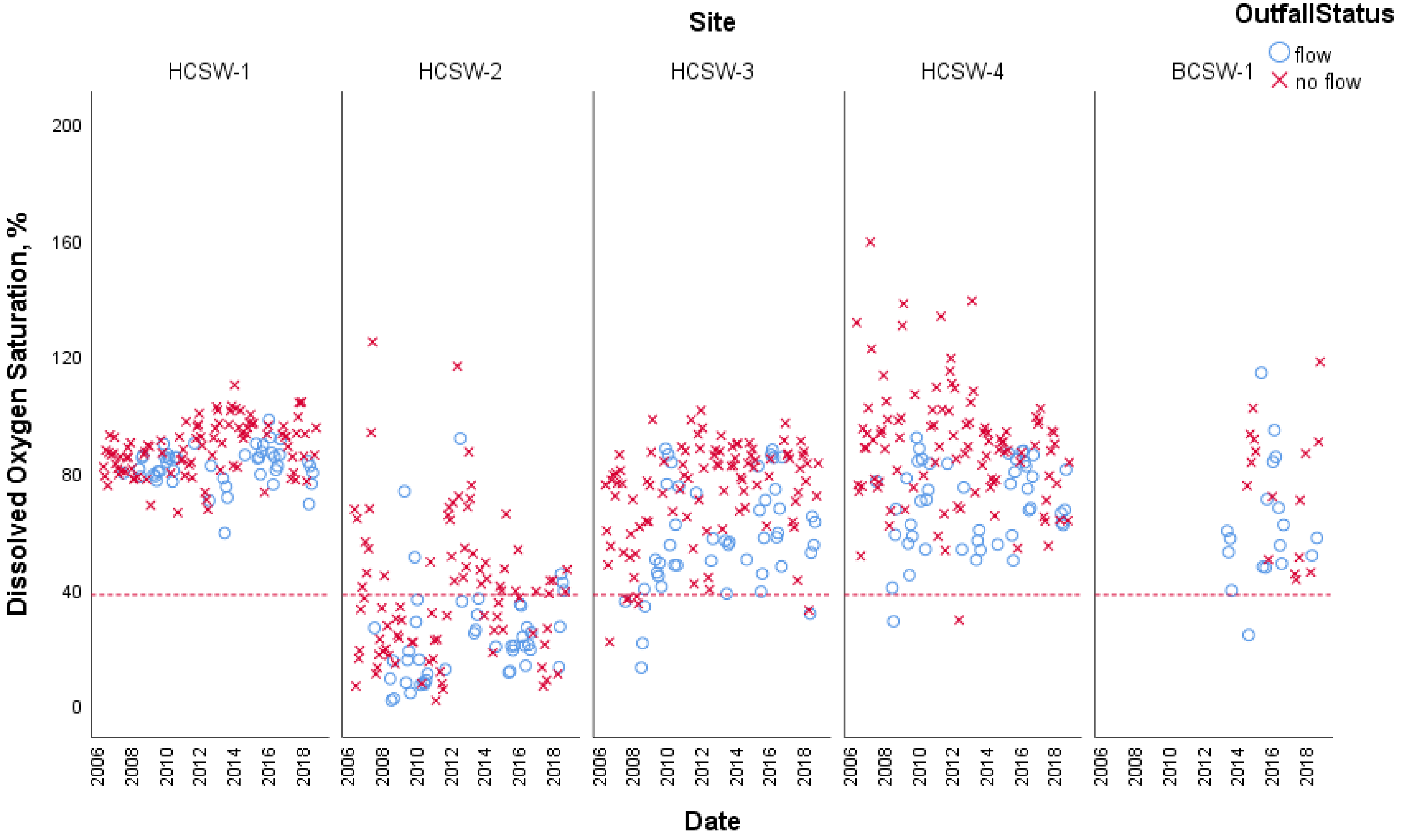


Figure C-3 **Dissolved Oxygen Percent Saturation obtained during monthly HCSP water quality sampling and biological sampling events from 2003 to 2018. Analyte trigger level represented by dotted red line.**

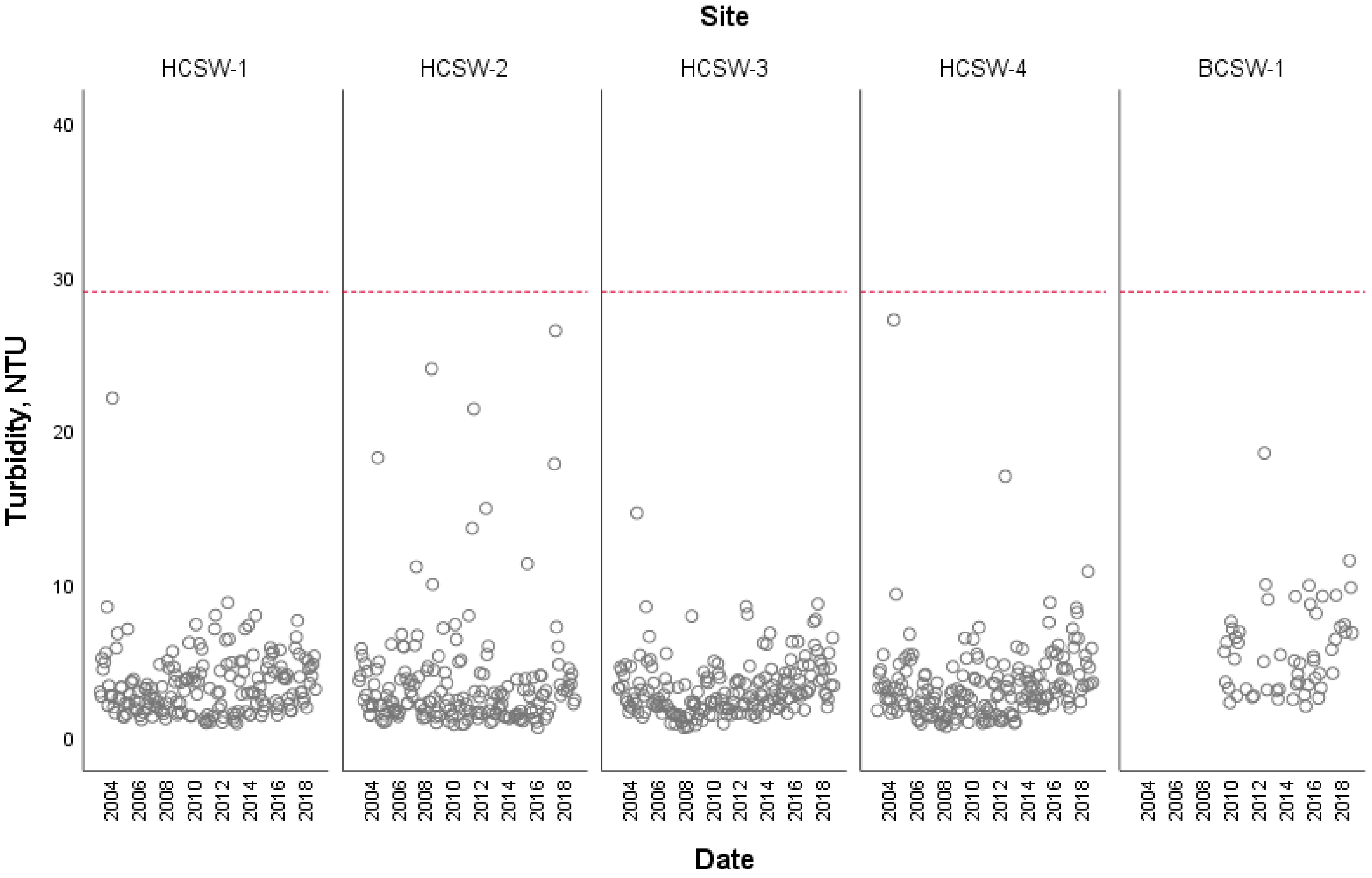


Figure C-4 **Turbidity levels obtained during monthly HCSP water quality sampling and biological sampling events from 2003 to 2018. Analyte trigger level represented by dotted red line.**

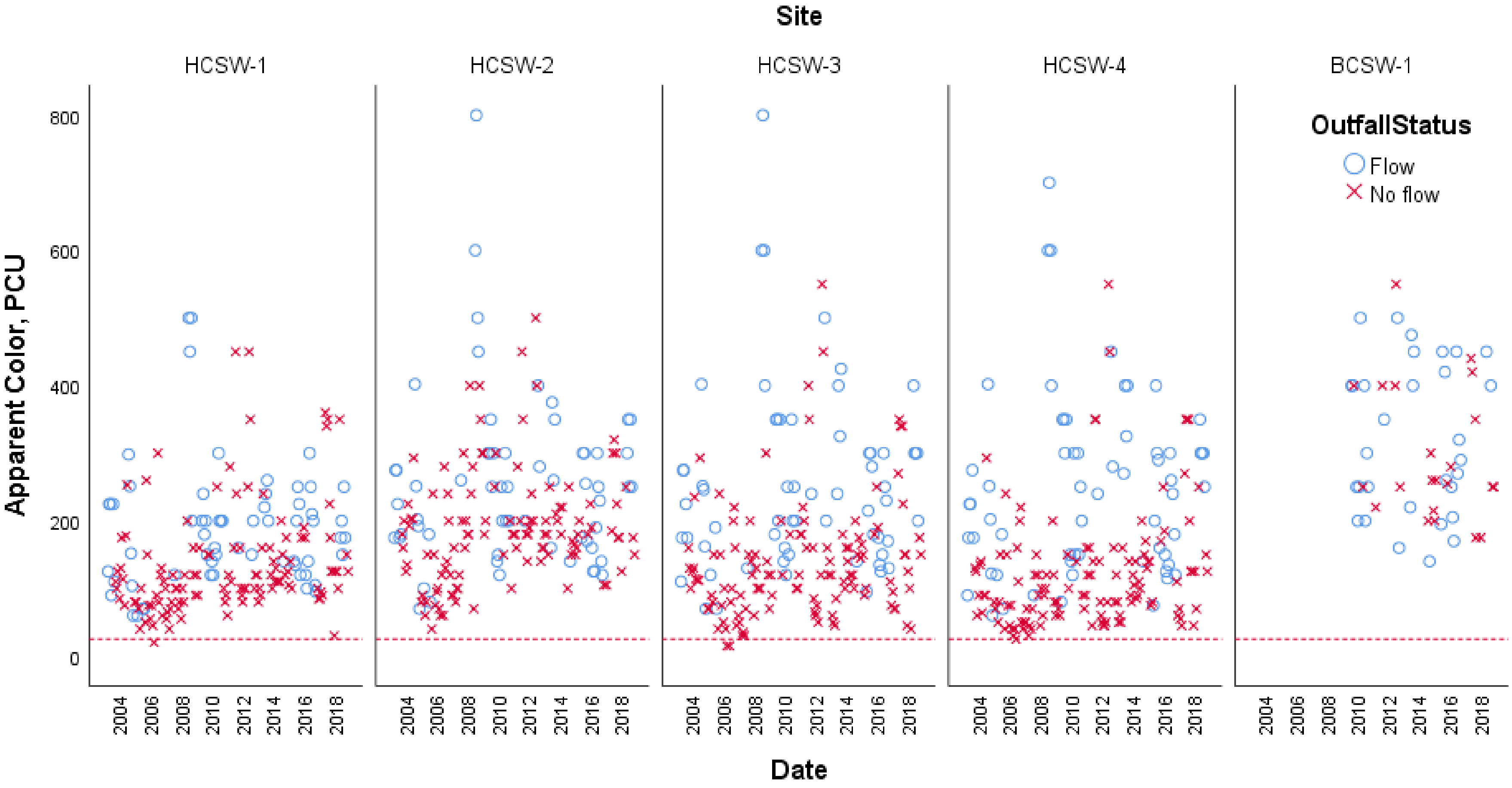


Figure C-5 Color levels obtained during monthly HCSP water quality sampling from 2003 to 2018. Analyte trigger level represented by dotted red line.

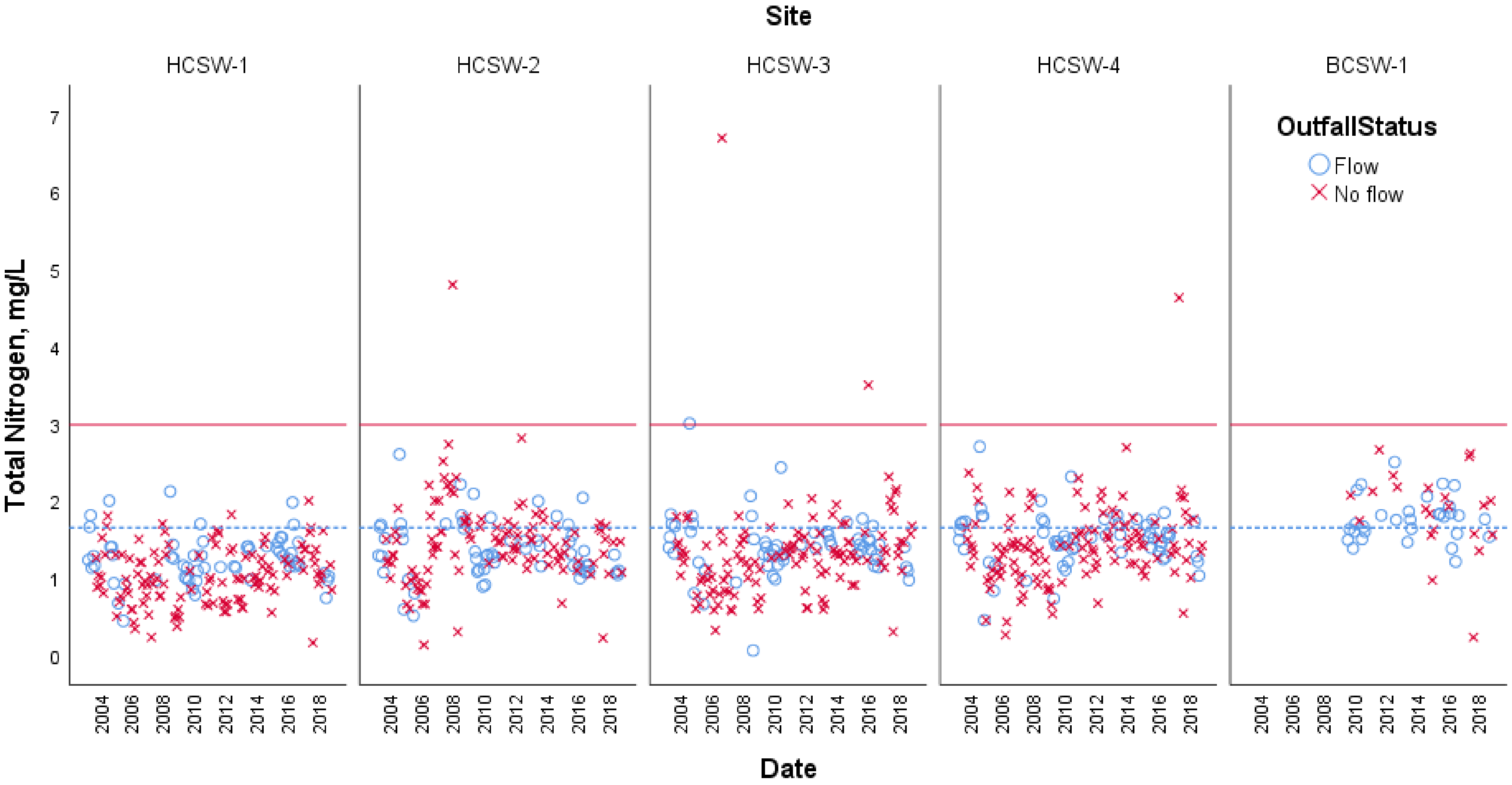


Figure C-6 **Total Nitrogen concentrations obtained during monthly HCSP water quality sampling from 2003 to 2018. Analyte trigger level represented by solid red line. Numeric Nutrient Criteria for West Central Florida represented by dotted blue line.**

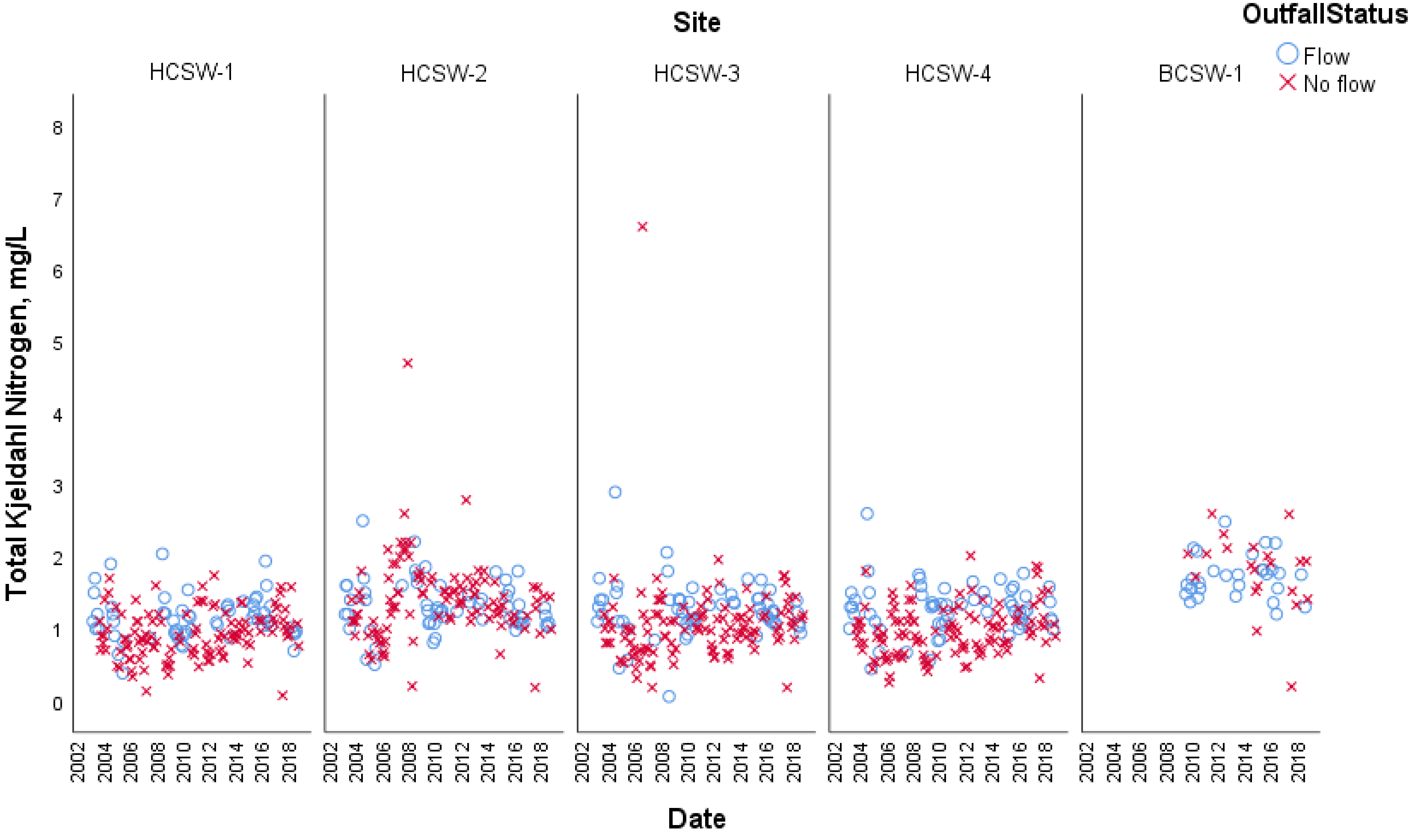


Figure C-7 Total Kjeldahl Nitrogen concentrations obtained during monthly HCSP water quality sampling from 2003 to 2018

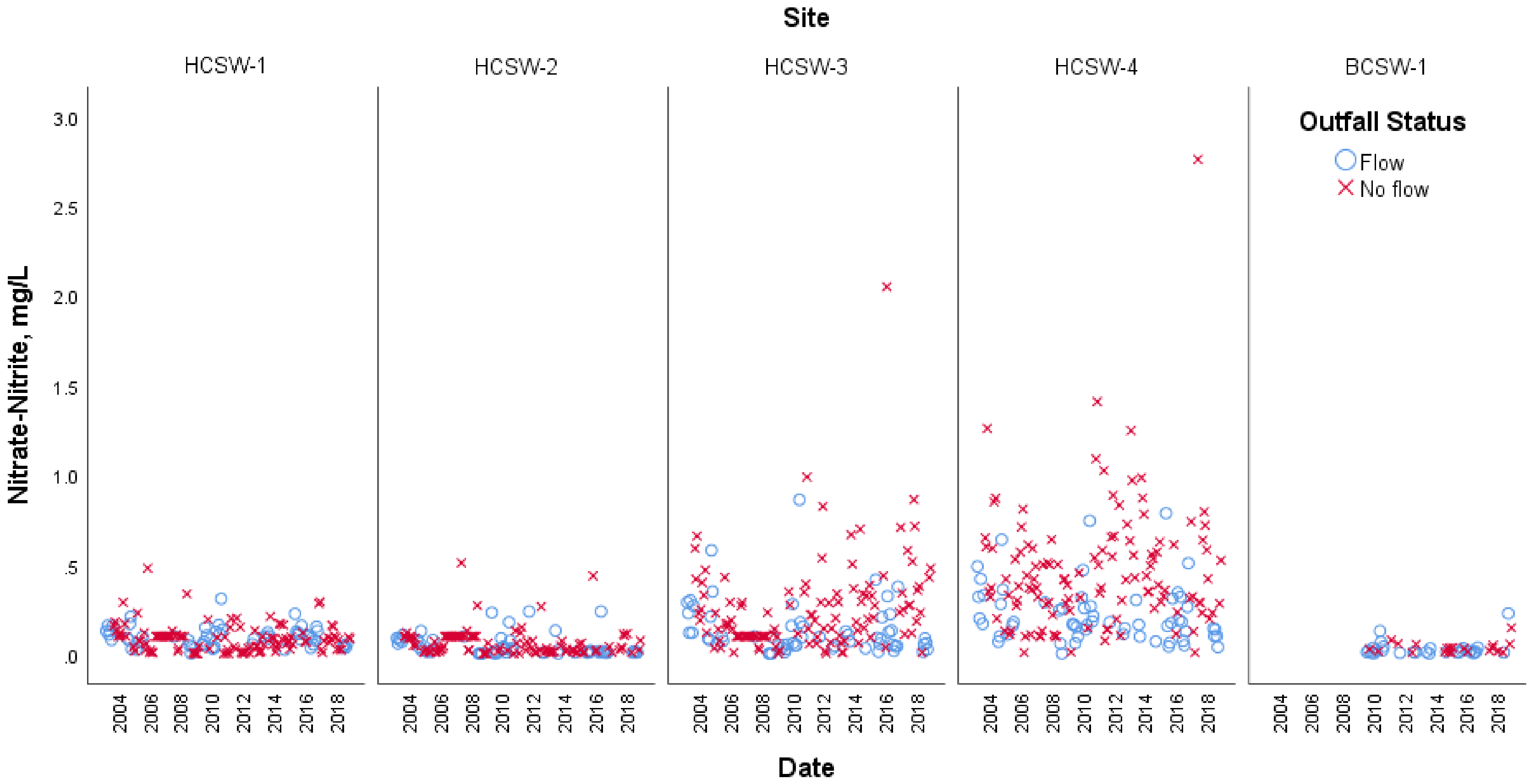


Figure C-8 Nitrate-Nitrite as Nitrogen concentrations obtained during monthly HCSP water quality sampling from 2003 to 2018

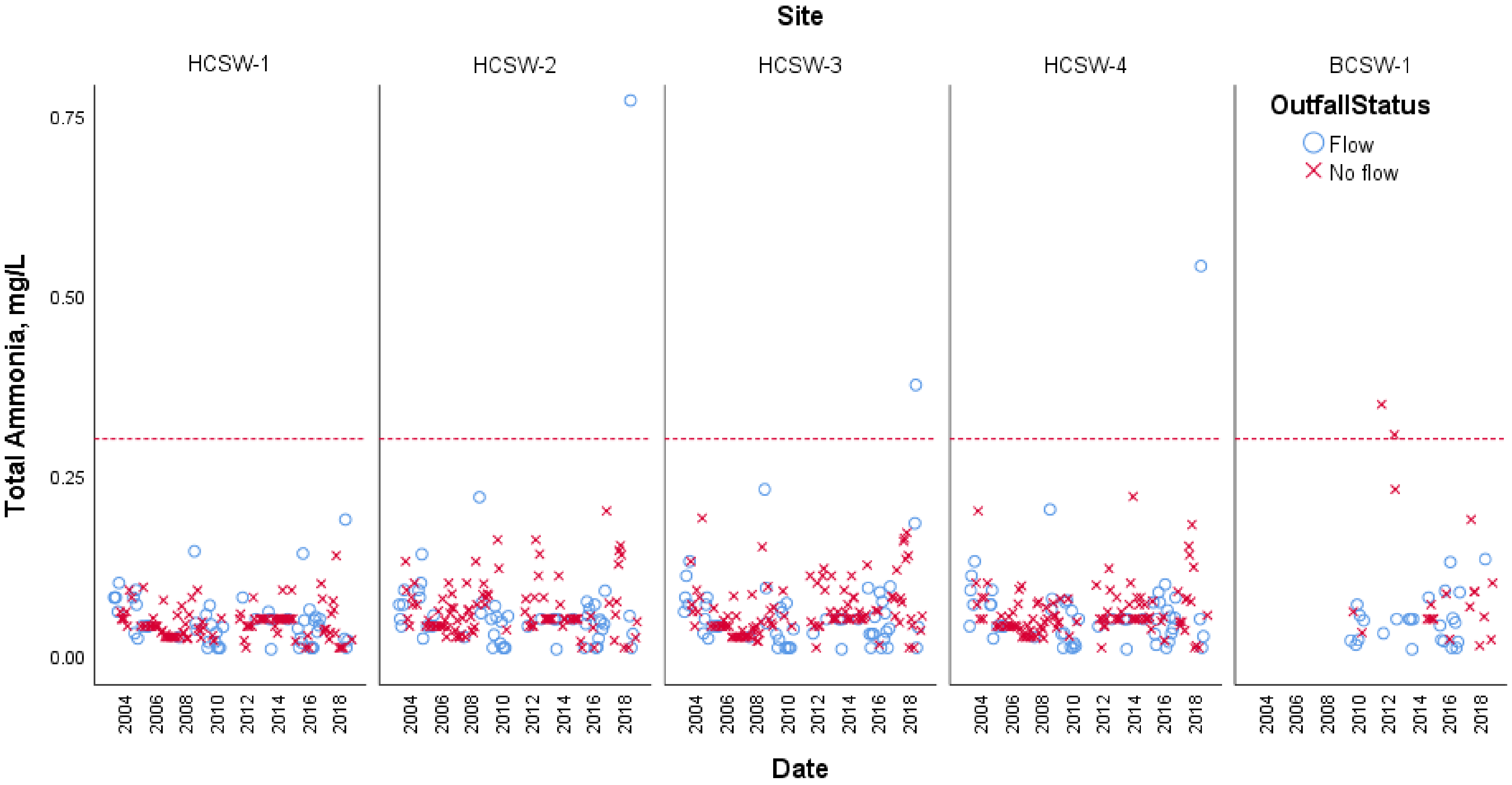


Figure C-9 **Total Ammonia as Nitrogen concentrations obtained during monthly HCSP water quality sampling from 2003 to 2018. Analyte trigger level represented by dotted red line.**

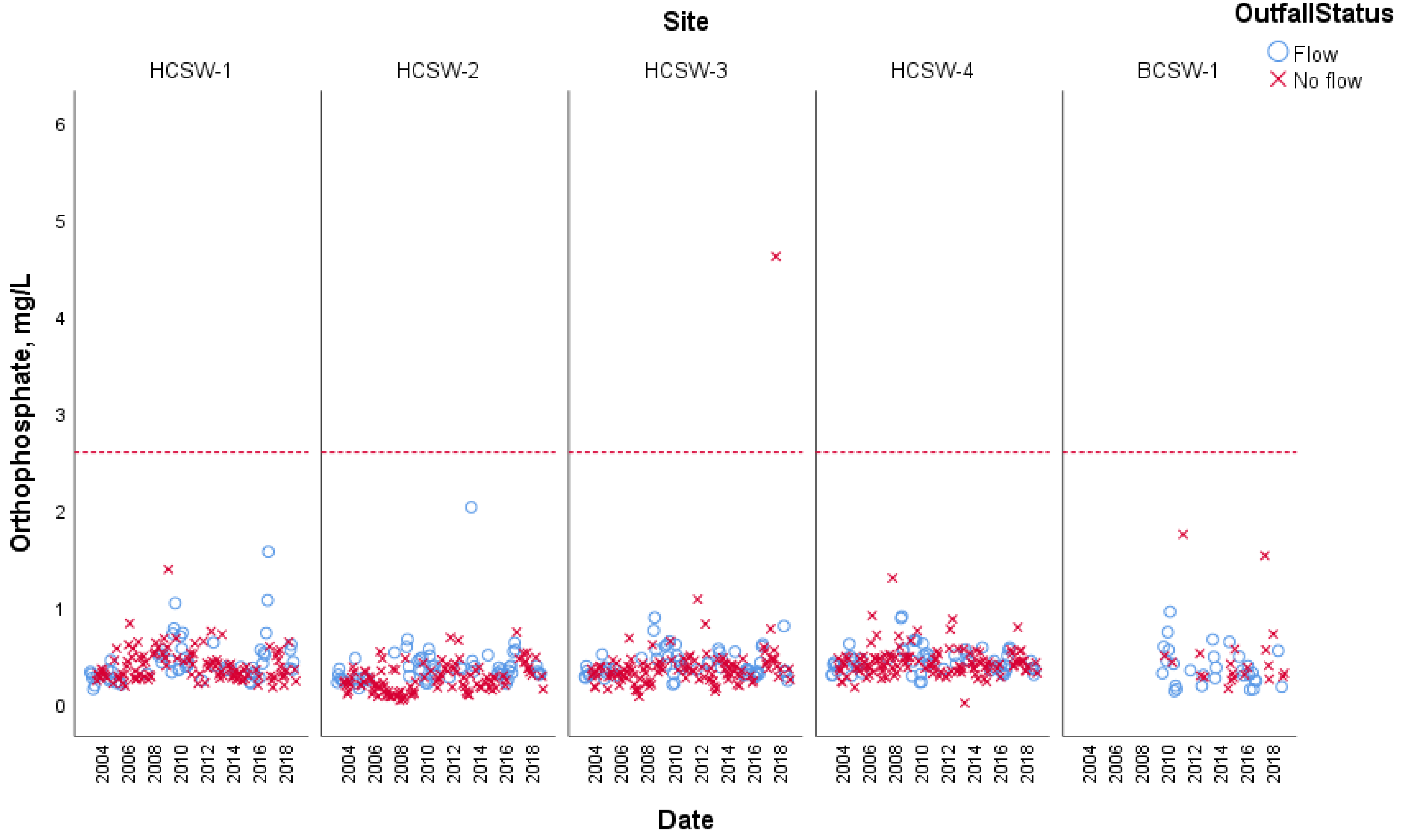


Figure C-10 **Orthophosphate concentrations obtained during monthly HCSP water quality sampling from 2003 to 2018. Analyte trigger level represented by dotted red line.**

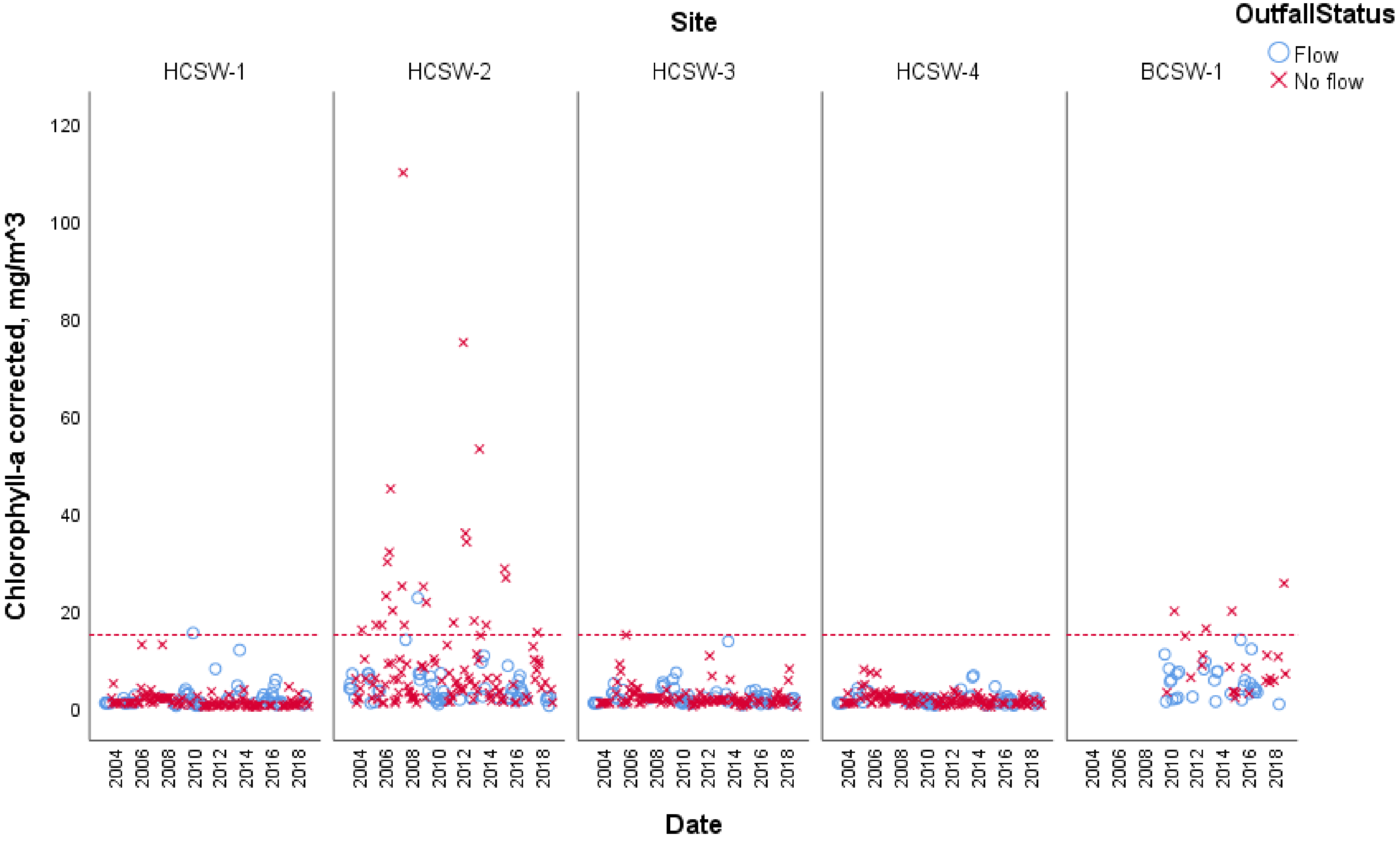


Figure C-11 **Chlorophyll-*a* concentrations obtained during monthly HCSP water quality sampling from 2003 to 2018. Analyte trigger level represented by dotted red line.**

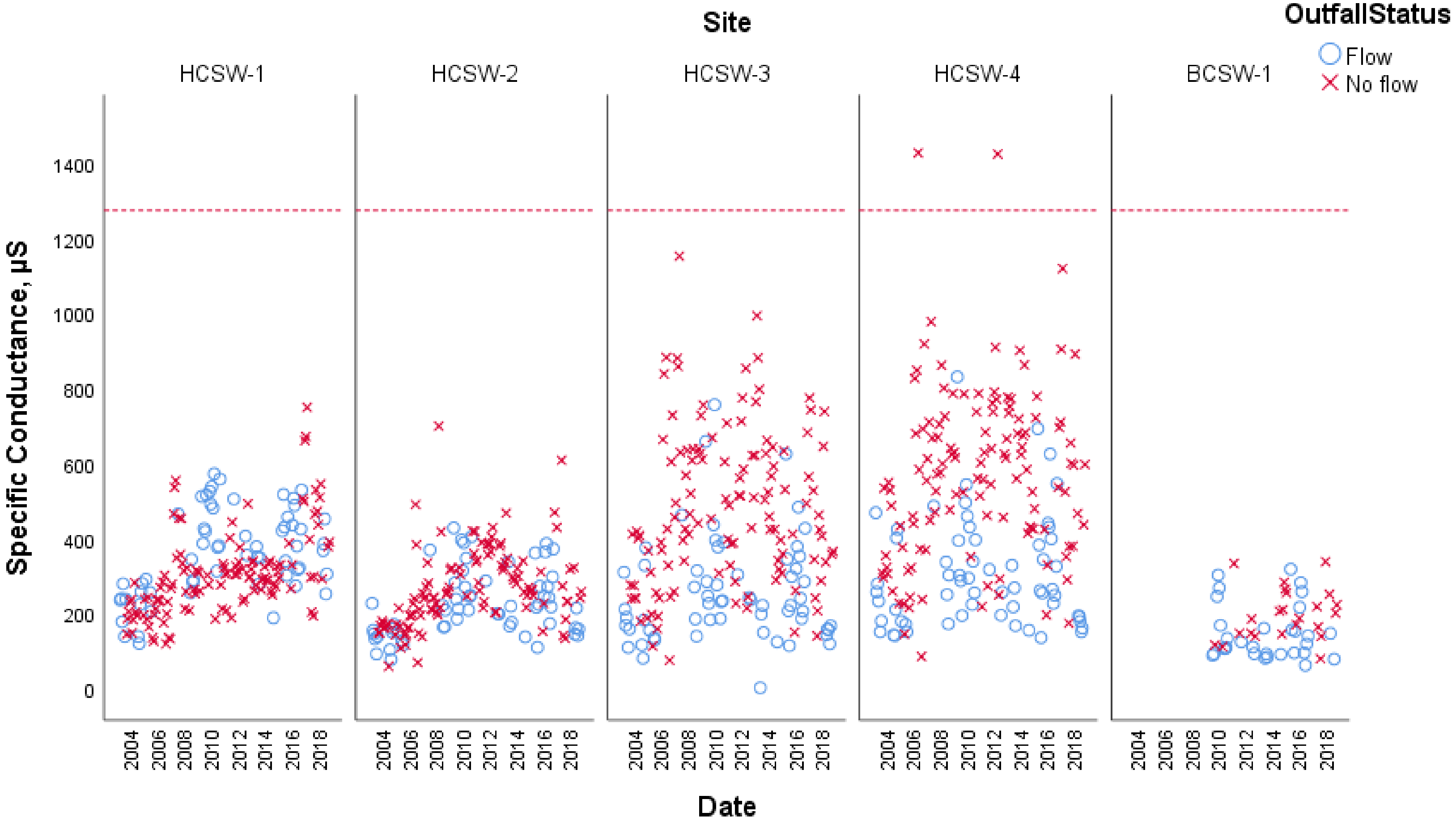


Figure C-12 **Levels of specific conductivity obtained during monthly HCSP water quality sampling and biological sampling events from 2003 to 2018. Analyte trigger level represented by dotted red line.**

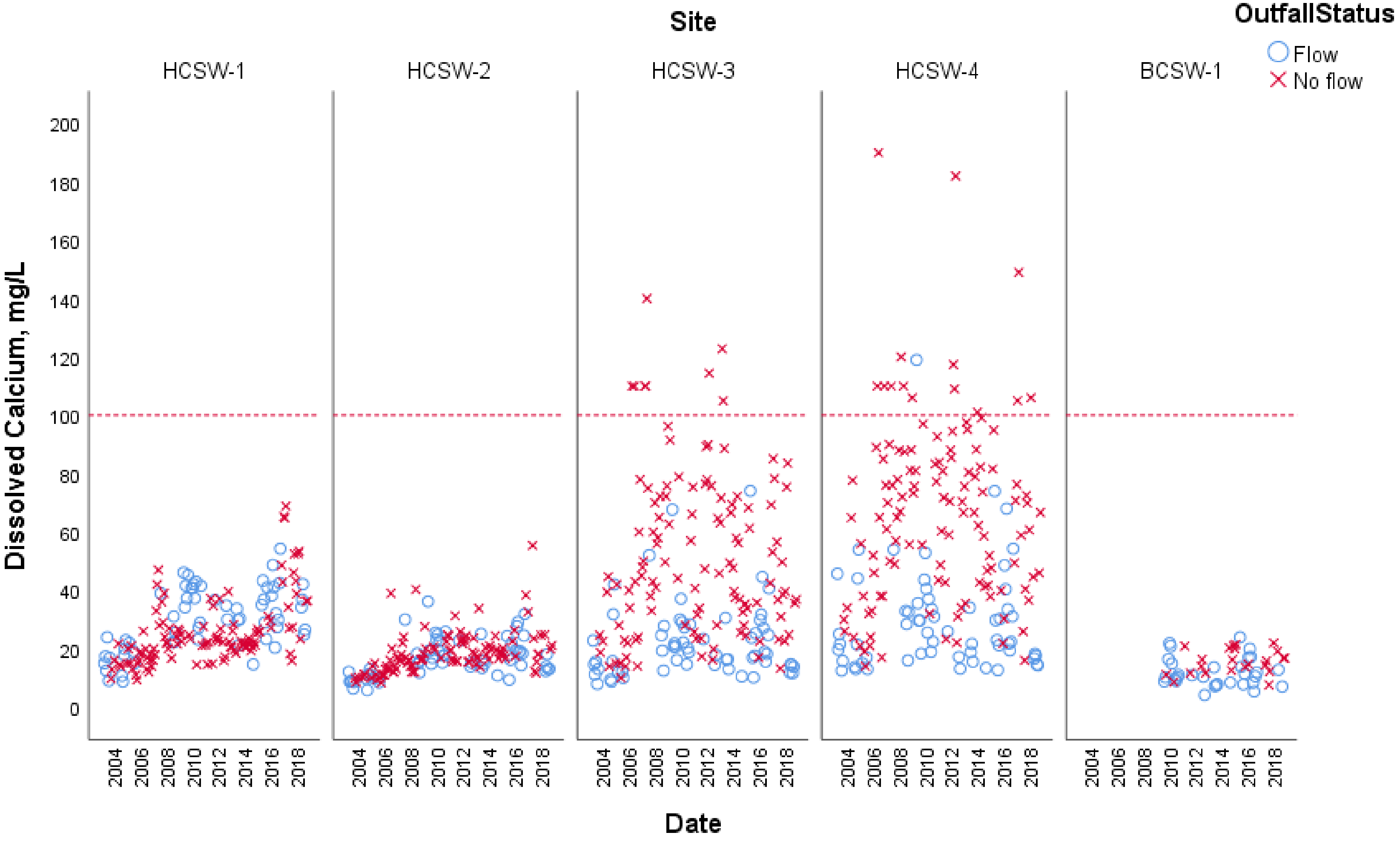


Figure C-13 Dissolved calcium concentrations obtained during monthly HCSP water quality sampling from 2003 to 2018. Analyte trigger level represented by dotted red line.

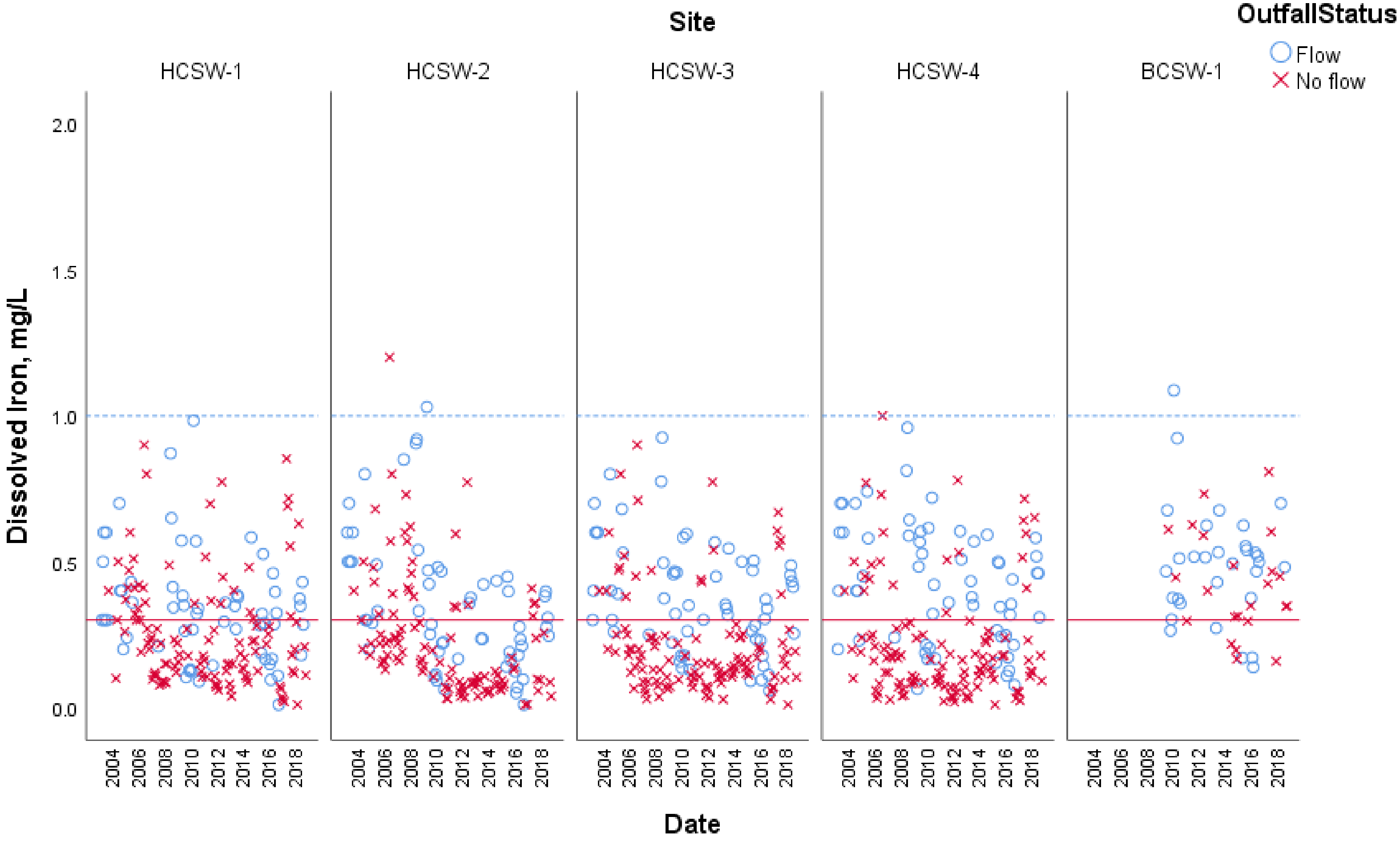


Figure C-14 Dissolved iron concentrations obtained during monthly HCSP water quality sampling from 2003 to 2018. Analyte trigger level for HCSW-4 represented by solid red line; analyte trigger level for HSCW-1, HCSW-2, and HSCW-3 represented by dotted blue line.

Figure C-15 Total alkalinity concentrations obtained during monthly HCSP water quality sampling from 2003 to 2018. Analyte trigger level represented by dotted red line.

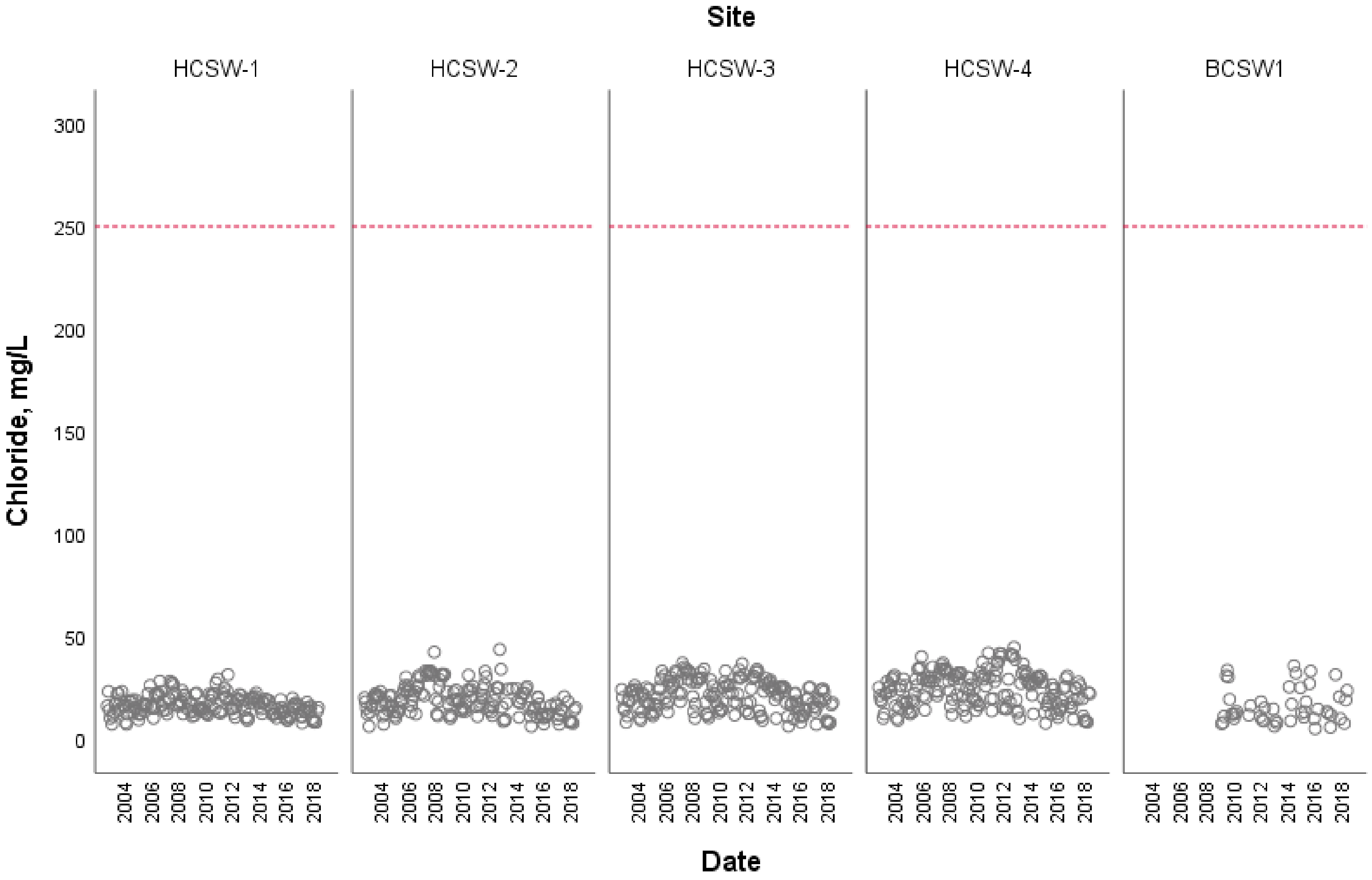


Figure C-16 **Chloride concentrations obtained during monthly HCSP water quality sampling from 2003 to 2018. Analyte trigger level represented by dotted red line.**

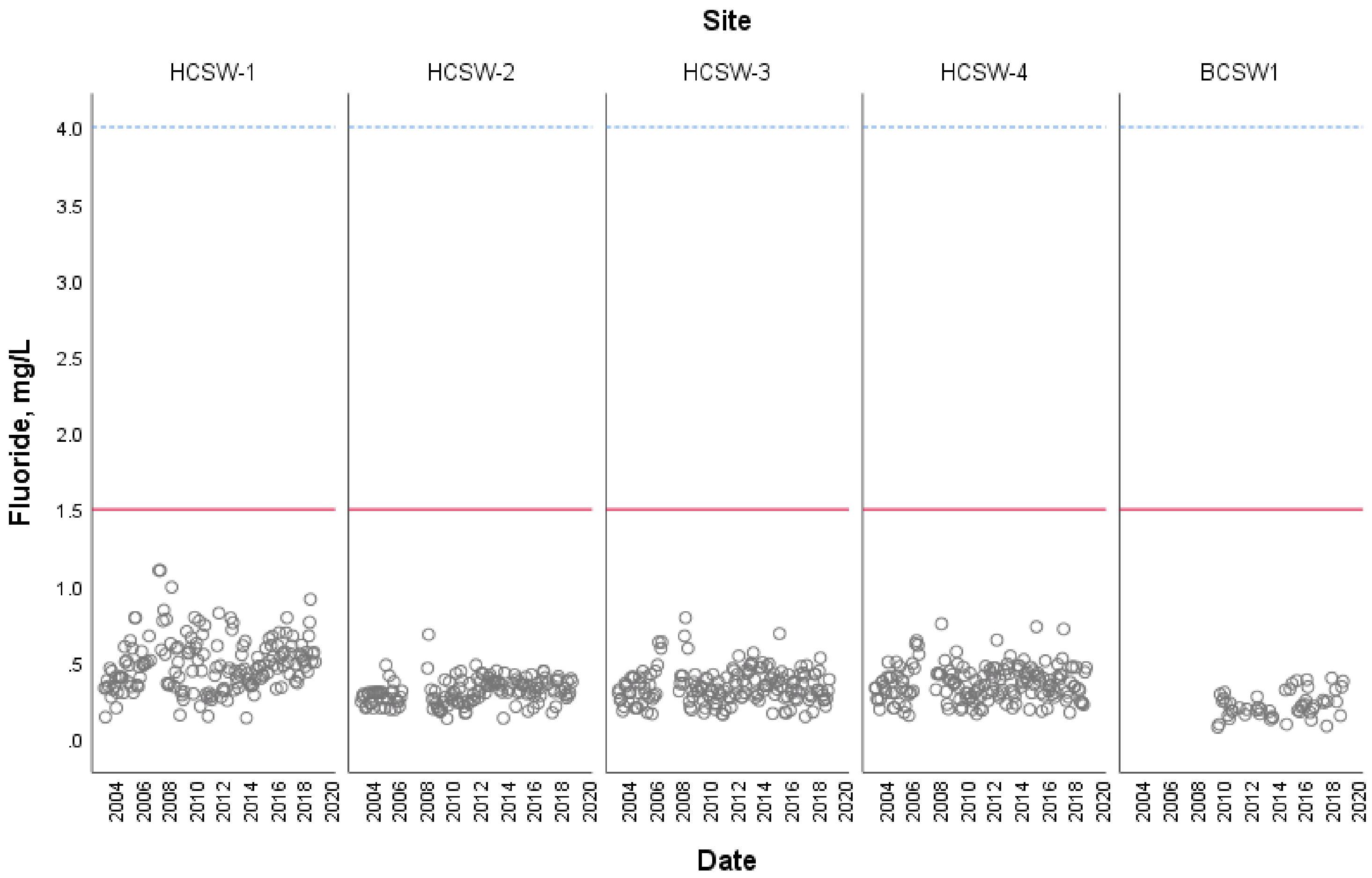


Figure C-17 **Fluoride concentrations obtained during monthly HCSP water quality sampling from 2003 to 2018. Analyte trigger level for HCSW-4 represented by solid red line; analyte trigger level for HSCW-1, HCSW-2, and HSCW-3 represented by dotted blue line.**

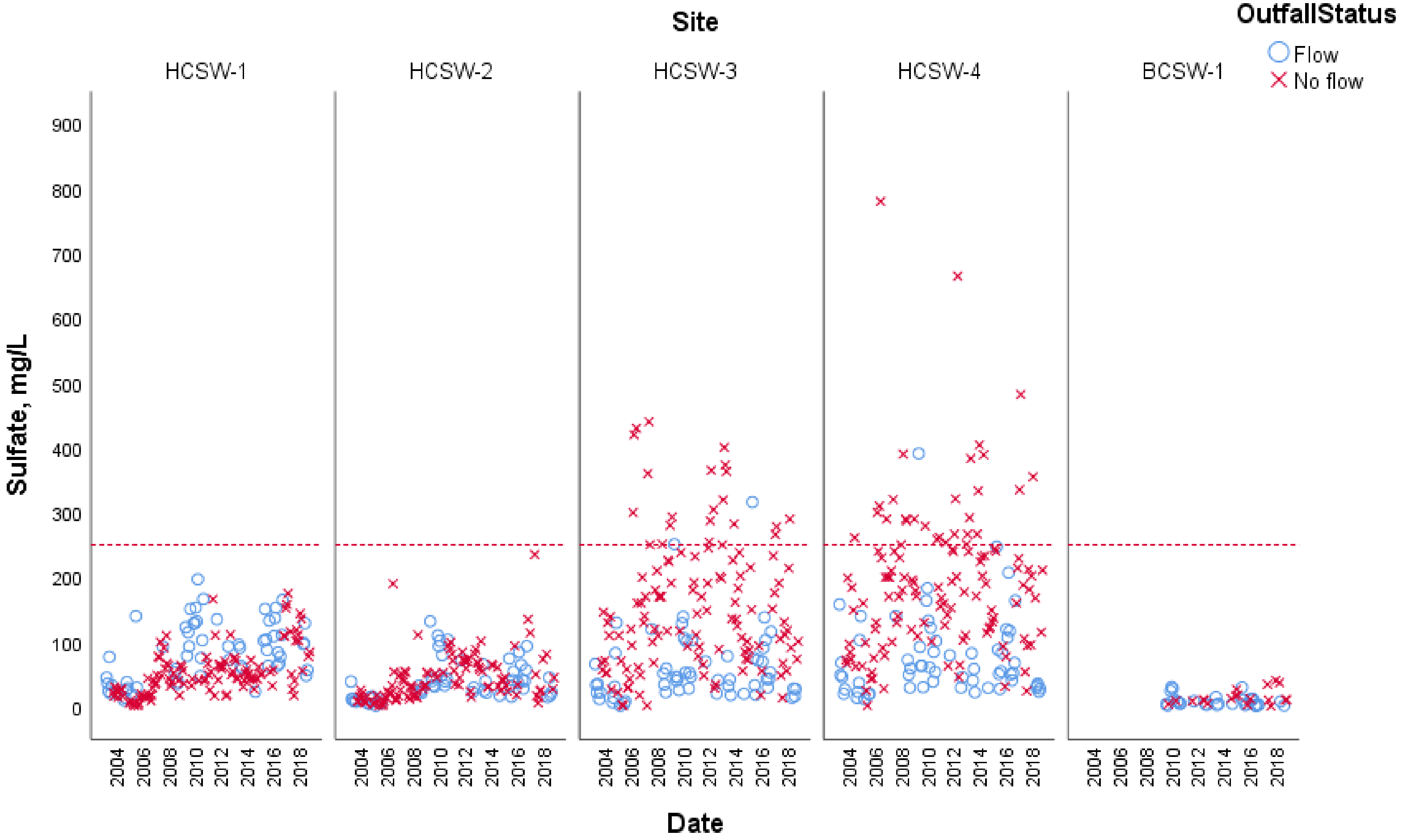


Figure C-18 **Sulfate concentrations obtained during monthly HCSP water quality sampling from 2003 to 2018. Analyte trigger level represented by dotted red line.**

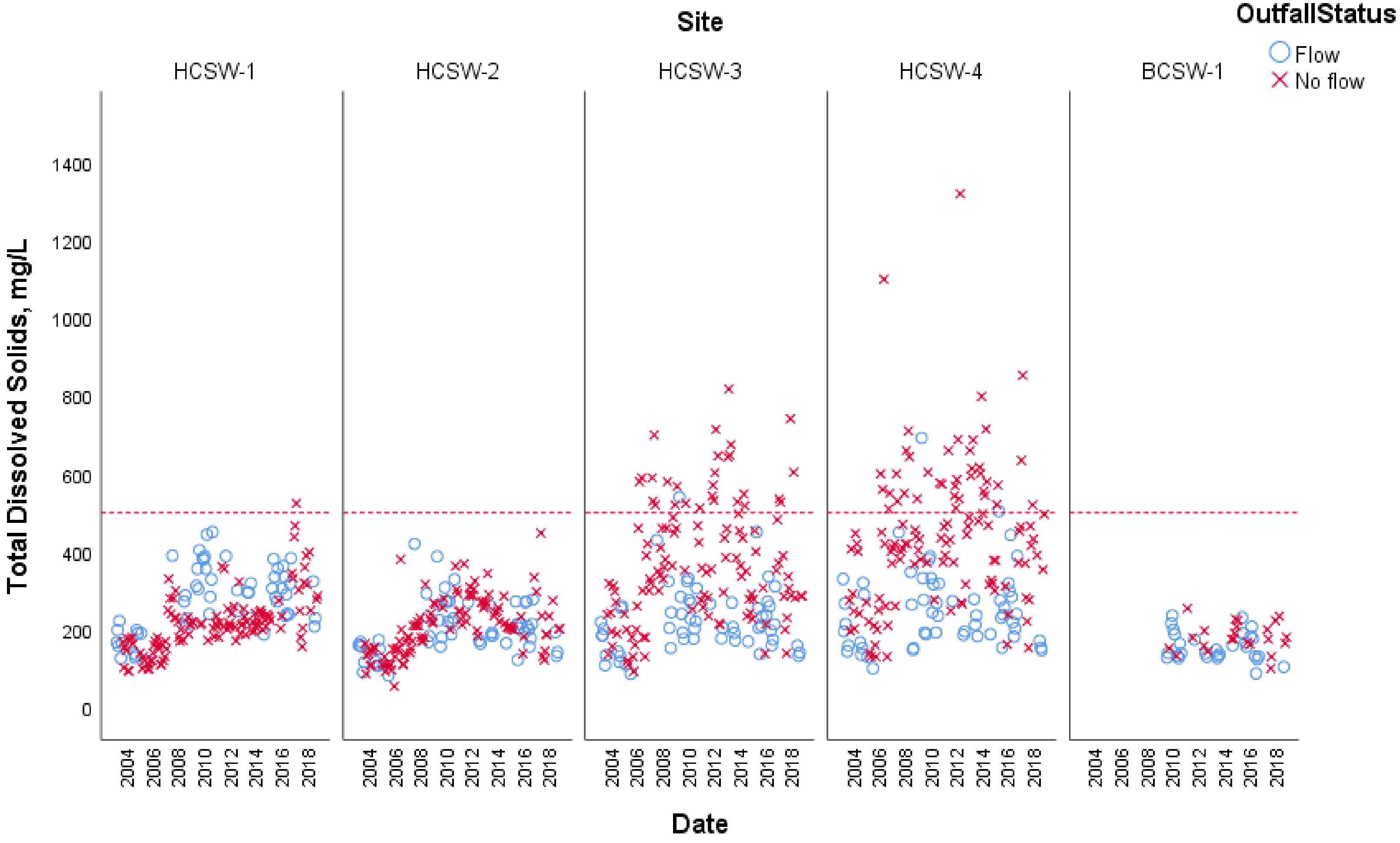


Figure C-19 **Total dissolved solids concentrations obtained during monthly HCSP water quality sampling from 2003 to 2018. Analyte trigger level represented by dotted red line.**

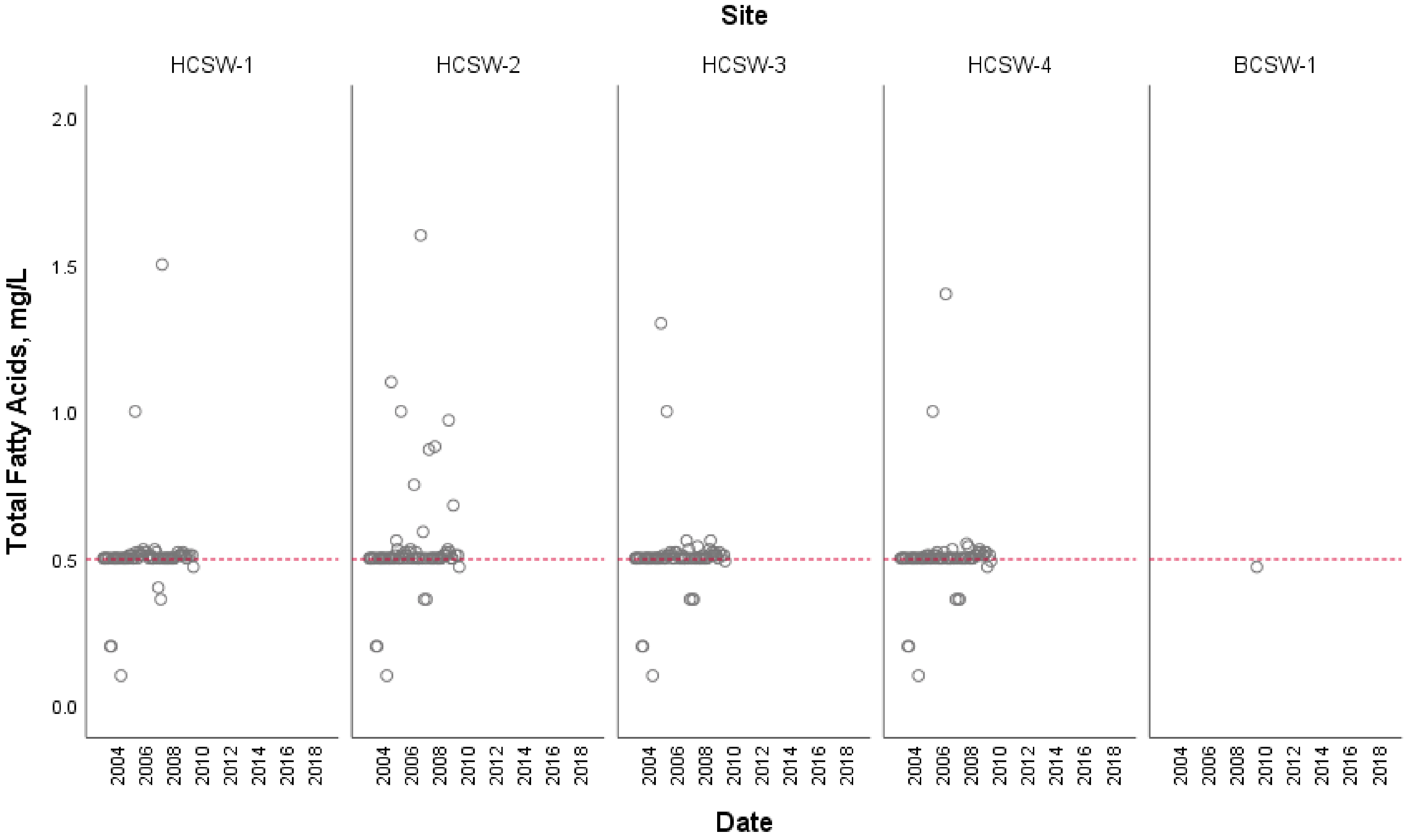


Figure C-20 Total fatty acids (above MDL only) concentrations obtained during monthly HCSP water quality sampling from 2003 to 2009. Analyte trigger level represented by dotted red line.

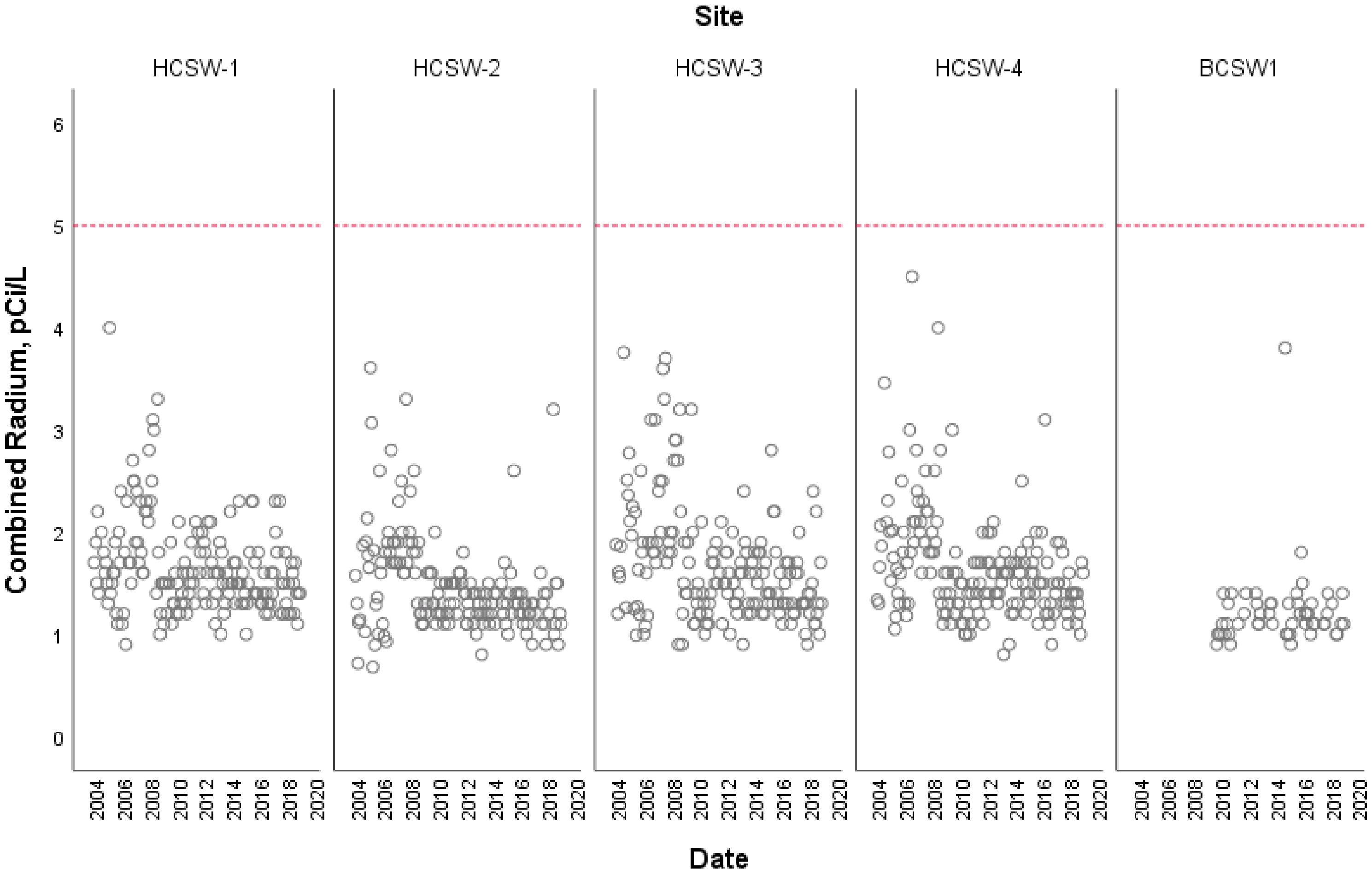


Figure C-21 **Levels of total radium (combination of radium 226 and radium 228) obtained during monthly HCSP water quality sampling from 2003 to 2018. Analyte trigger level represented by dotted red line.**

C.2 WATER QUALITY BOXPLOTS: PUBLIC SOURCES AND HCSP FROM 1990 TO 2018.

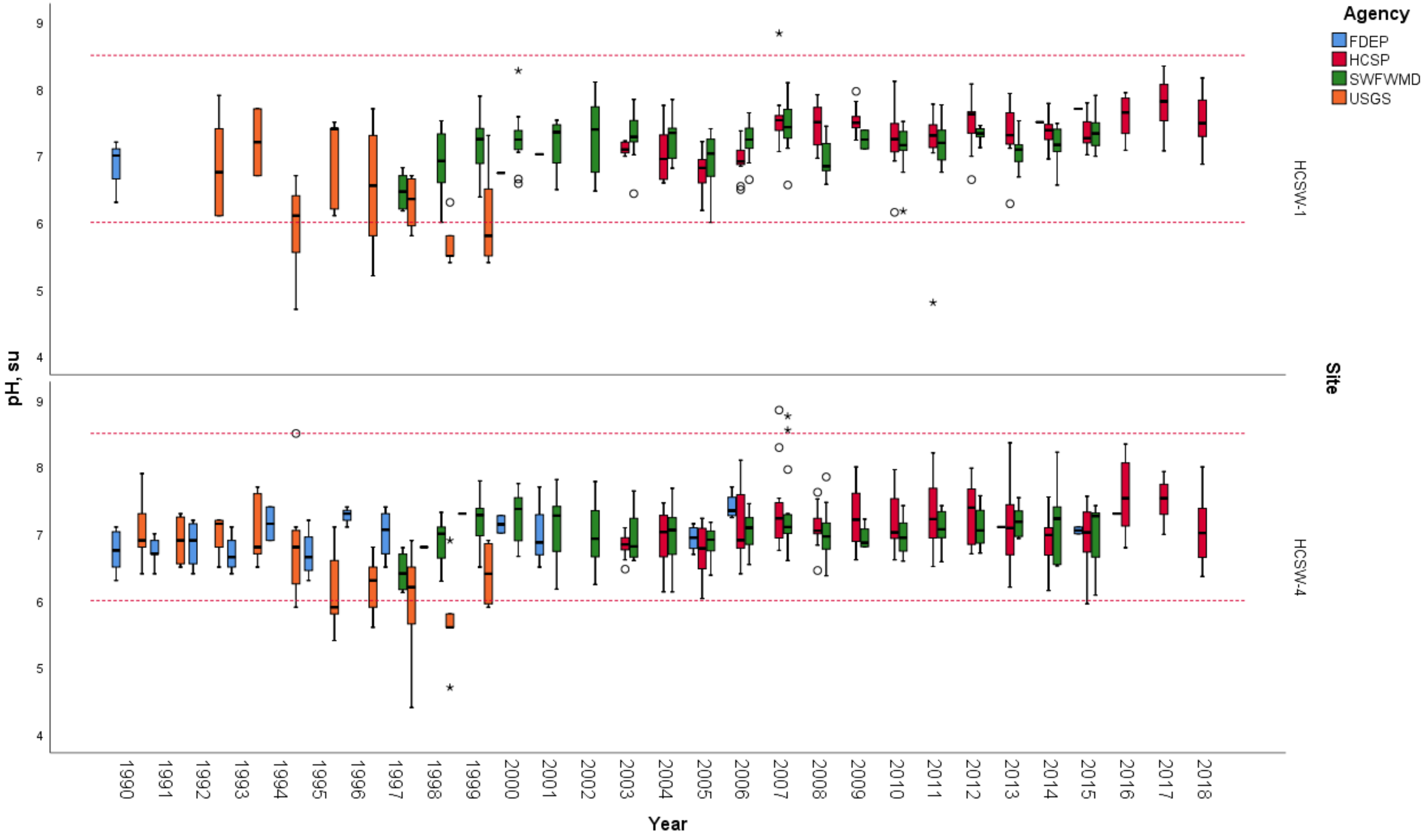


Figure C-22 HCSW-1 and HCSW-4 values of pH obtained from various data sources (FDEP, SWFWMD, and USGS Data from EPA STORET and HCSP) from 1990 to 2018. Analyte trigger levels represented by dotted red lines.

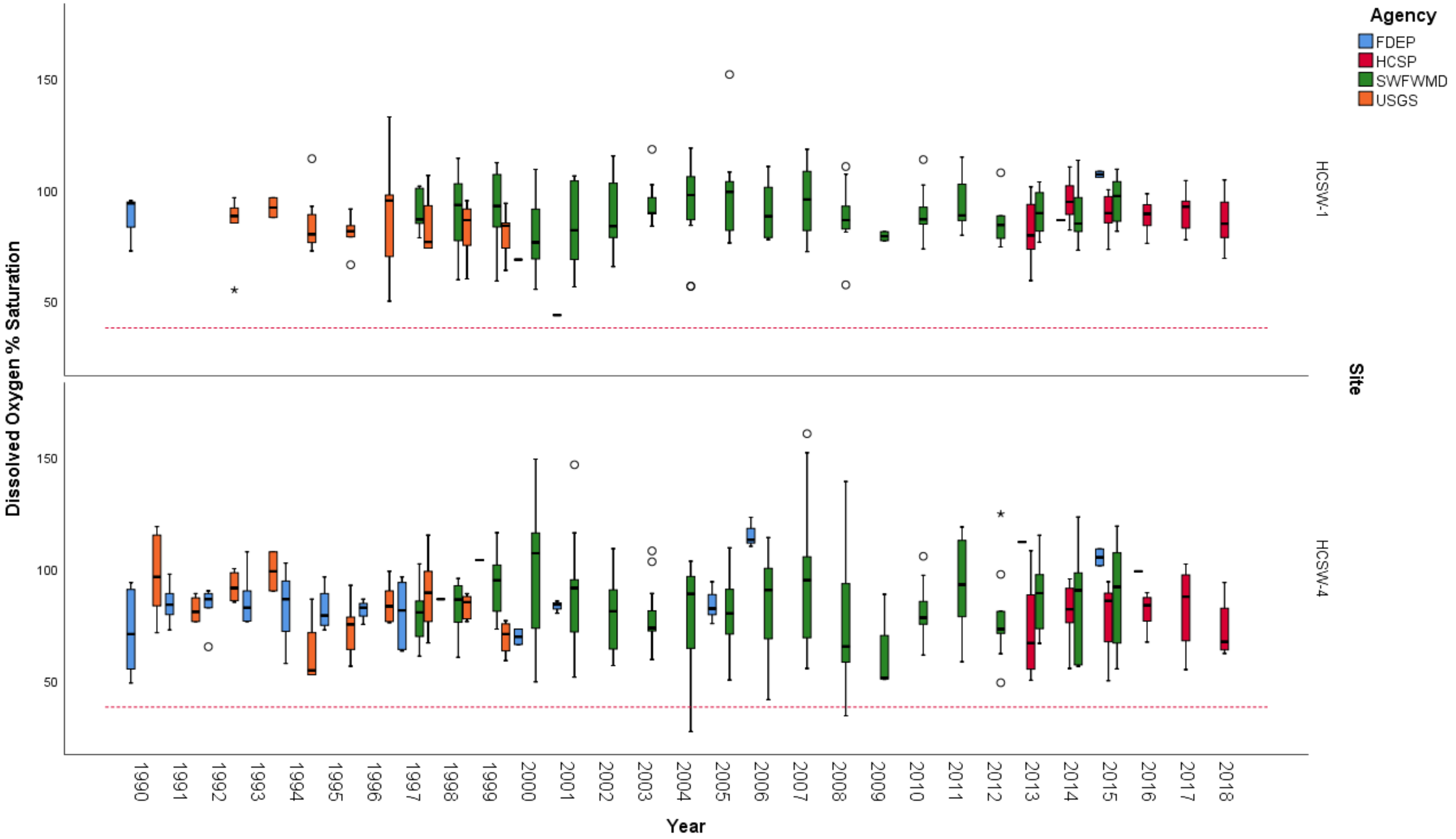


Figure C-23 HCSW-1 and HCSW-4 DO saturation obtained from various data sources (FDEP, SWFWMD, and USGS Data from EPA STORET and HCSP) from 1990 to 2018. Analyte trigger level represented by dotted red line.

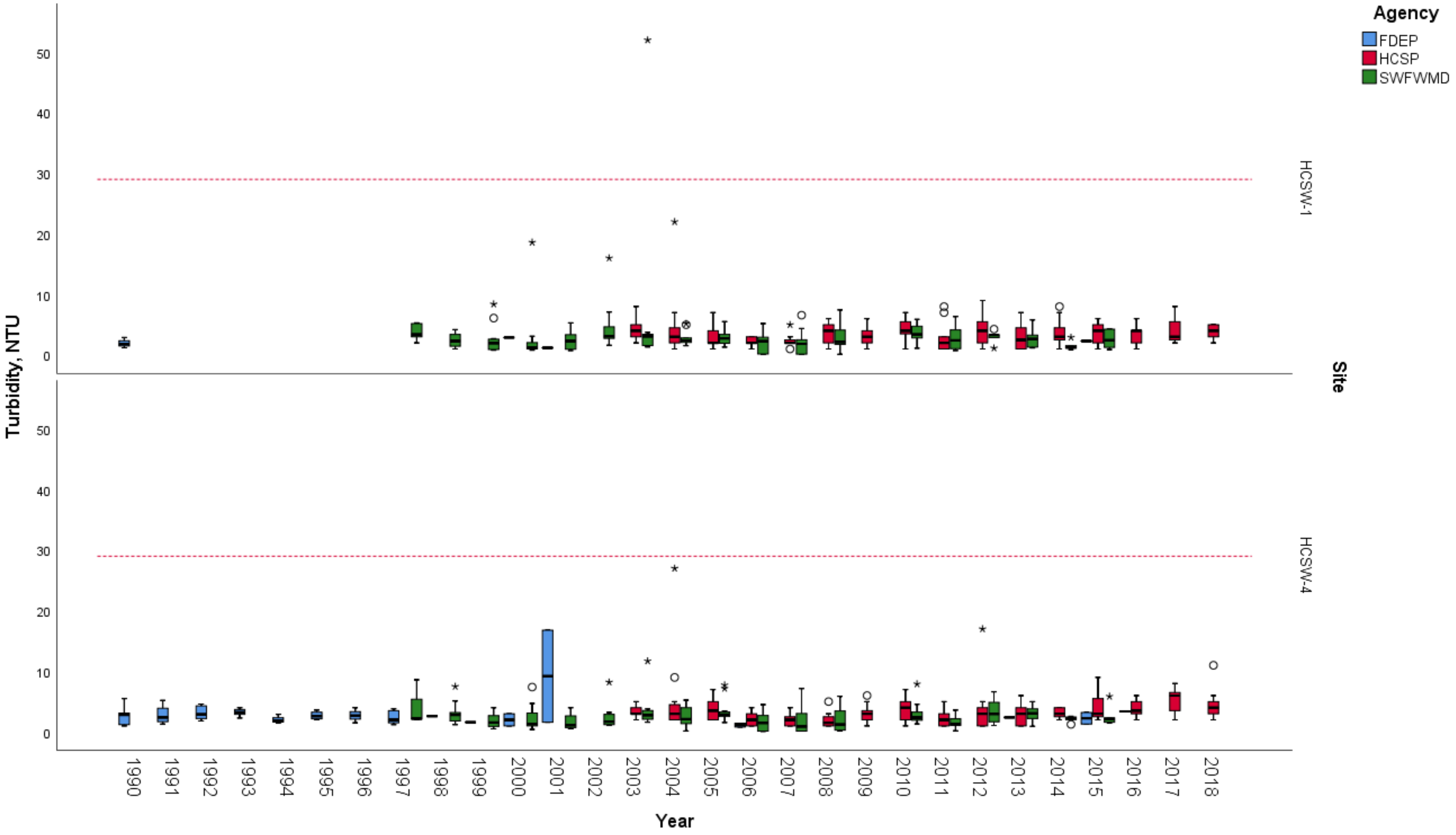


Figure C-24 HCSW-1 and HCSW-4 values of turbidity obtained from various data sources (FDEP, SWFWMD, and USGS Data from EPA STORET and HCSP) from 1990 to 2018. Analyte trigger level represented by dotted red line.

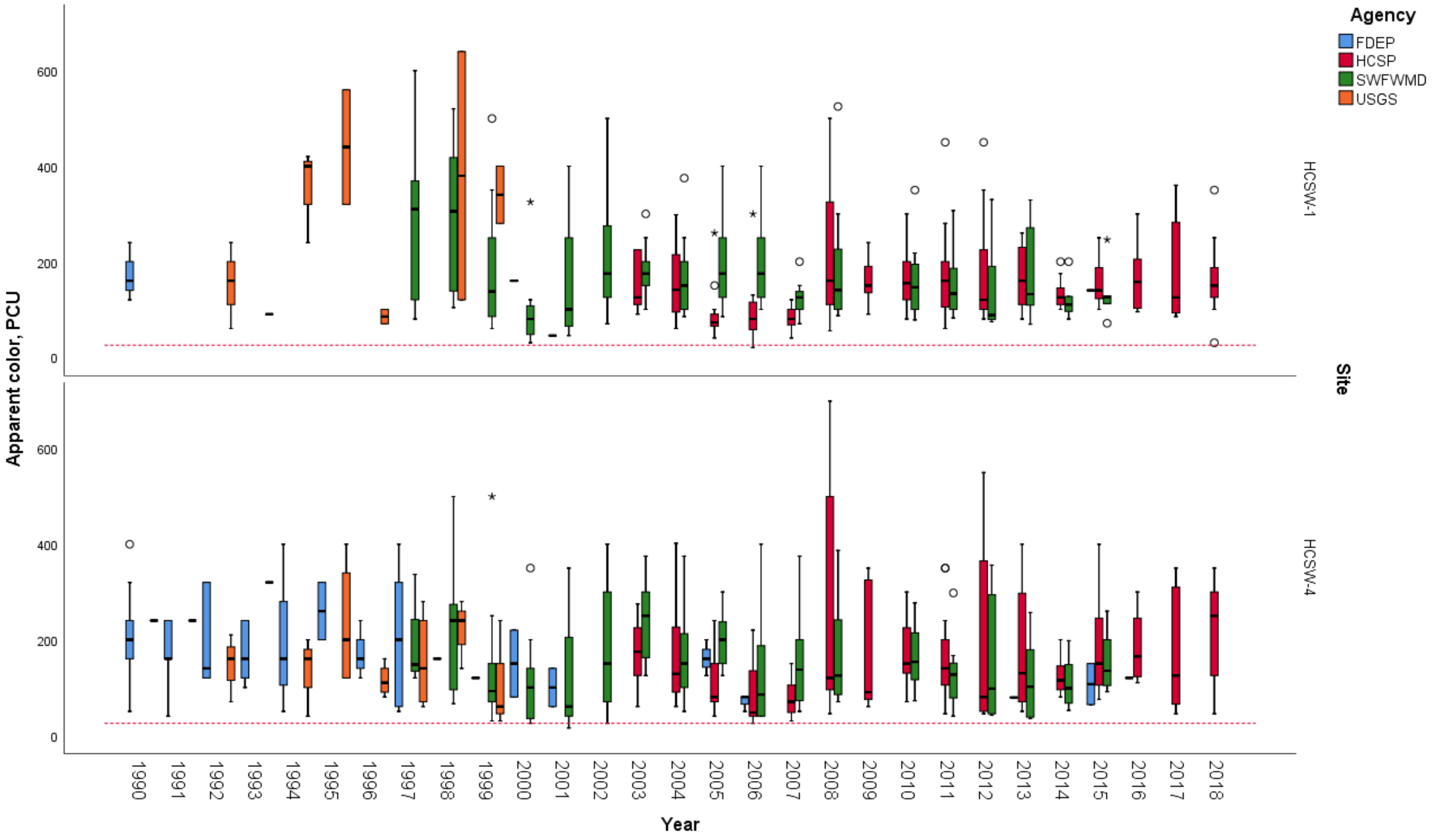


Figure C-25 HCSW-1 and HCSW-4 values of color obtained from various data sources (FDEP, SWFWMD, and USGS Data from EPA STORET and HCSP) from 1990 to 2018. Analyte trigger level represented by dotted red line.

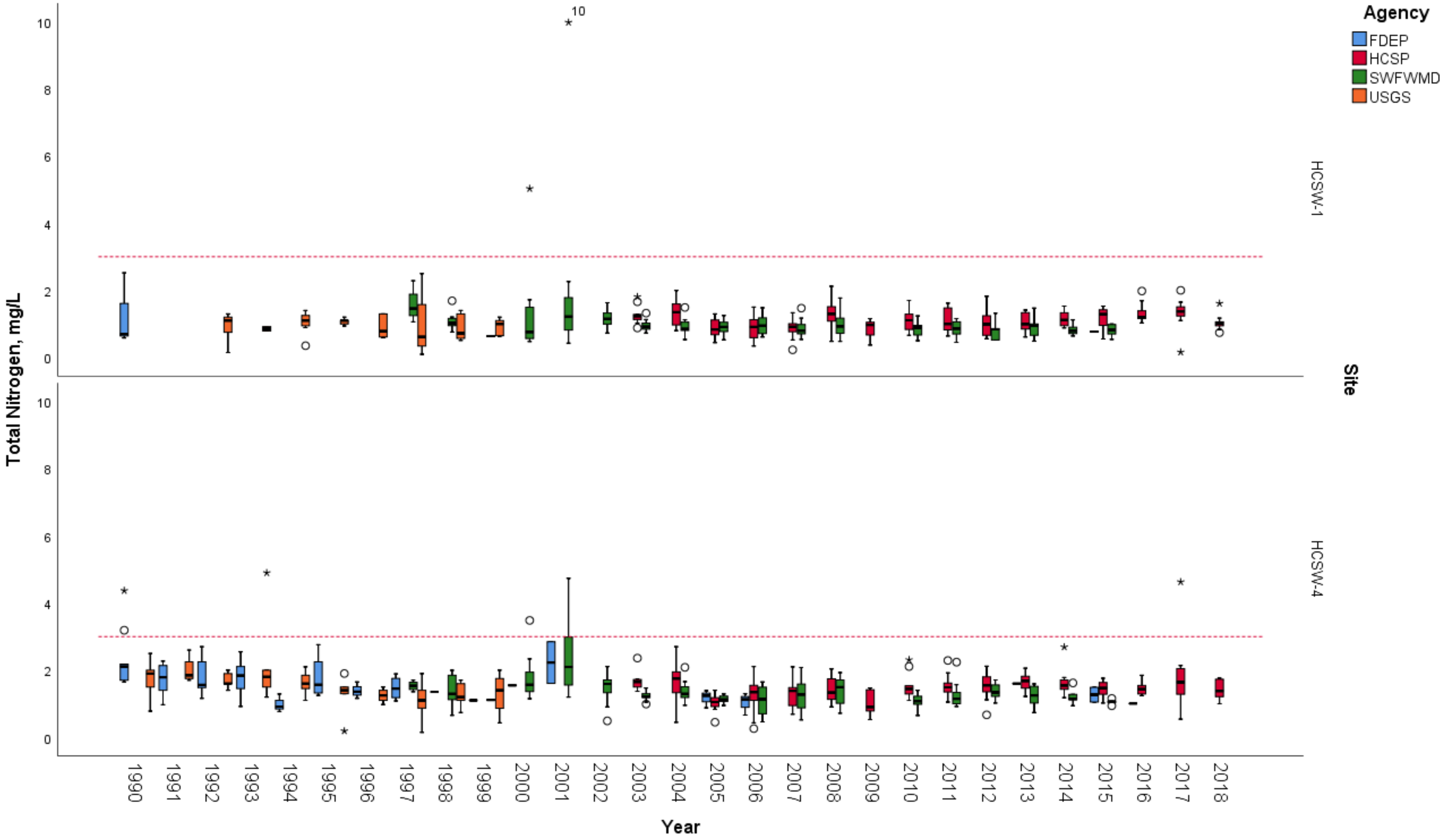


Figure C-26 HCSW-1 and HCSW-4 total nitrogen concentrations obtained from various data sources (FDEP, SWFWMD, and USGS Data from EPA STORET and HCSP) from 1990 to 2018. Analyte trigger level represented by dotted red line.

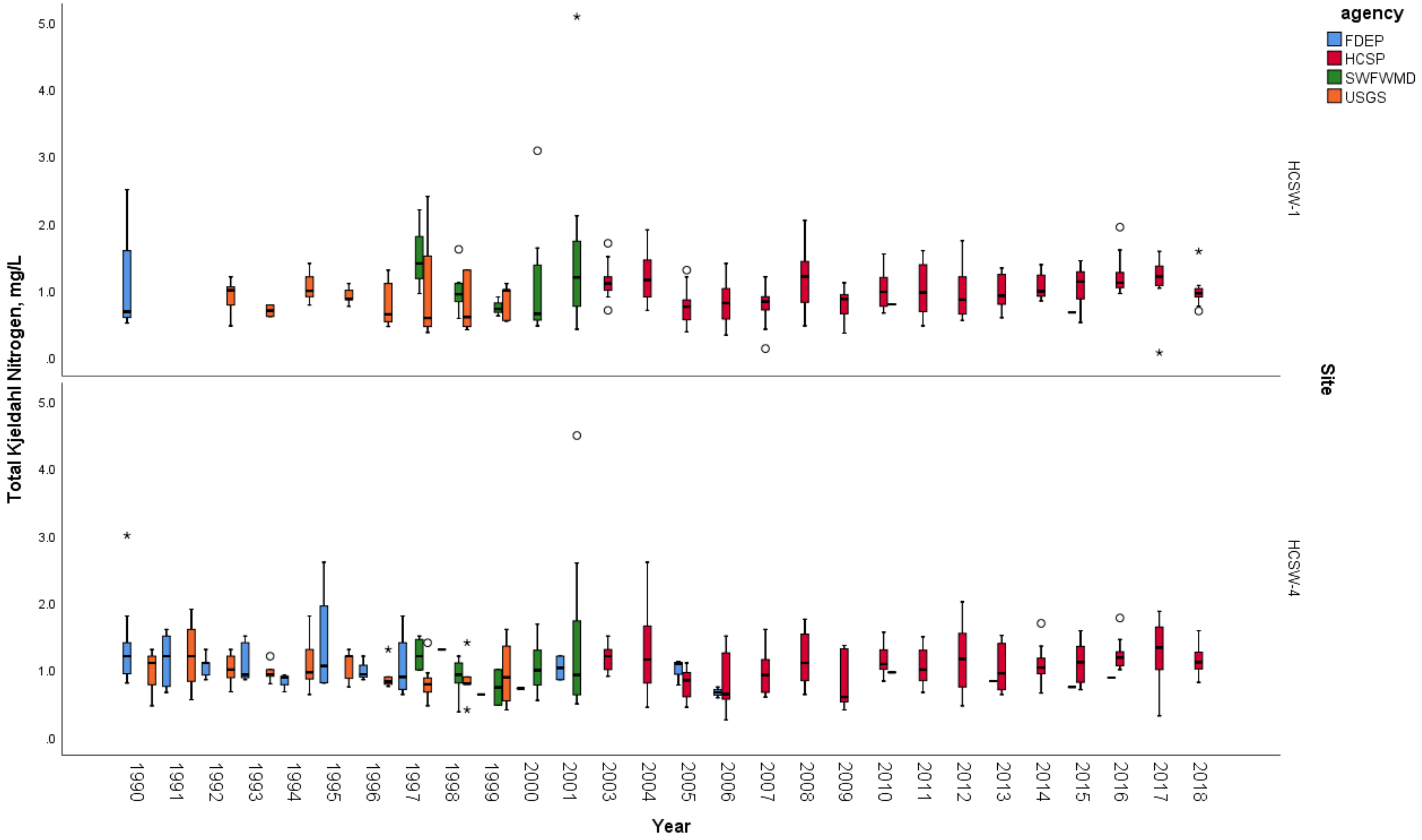


Figure C-27 HCSW-1 and HCSW-4 TKN concentrations obtained from various data sources (FDEP, SWFWMD, and USGS Data from EPA STORET and HCSP) from 1990 to 2018. Analyte trigger level represented by dotted red line.

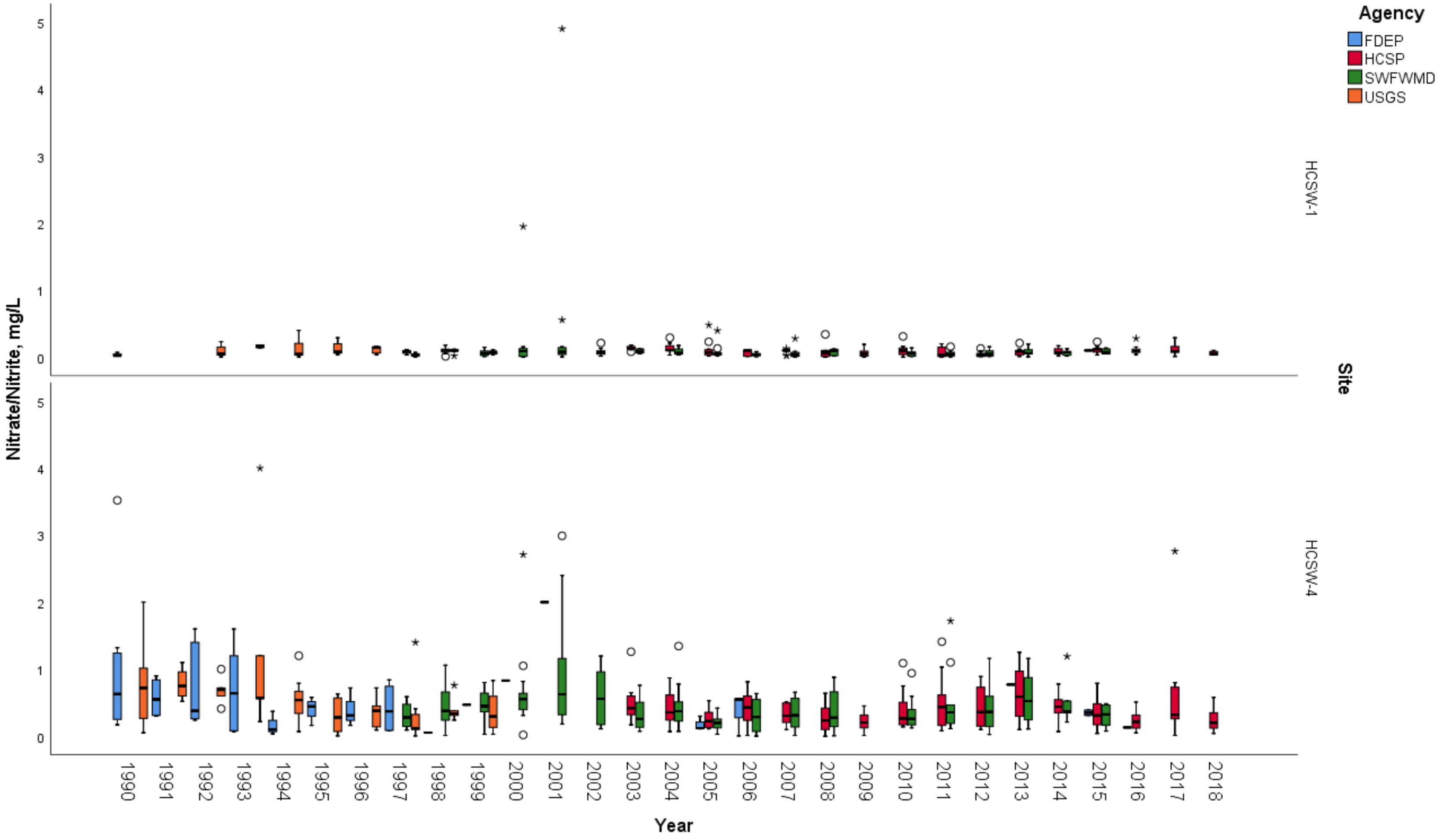


Figure C-28 HCSW-1 and HCSW-4 nitrate-nitrite concentrations obtained from various data sources (FDEP, SWFWMD, and USGS Data from EPA STORET and HCSP) from 1990 to 2018. Analyte trigger level represented by dotted red line.

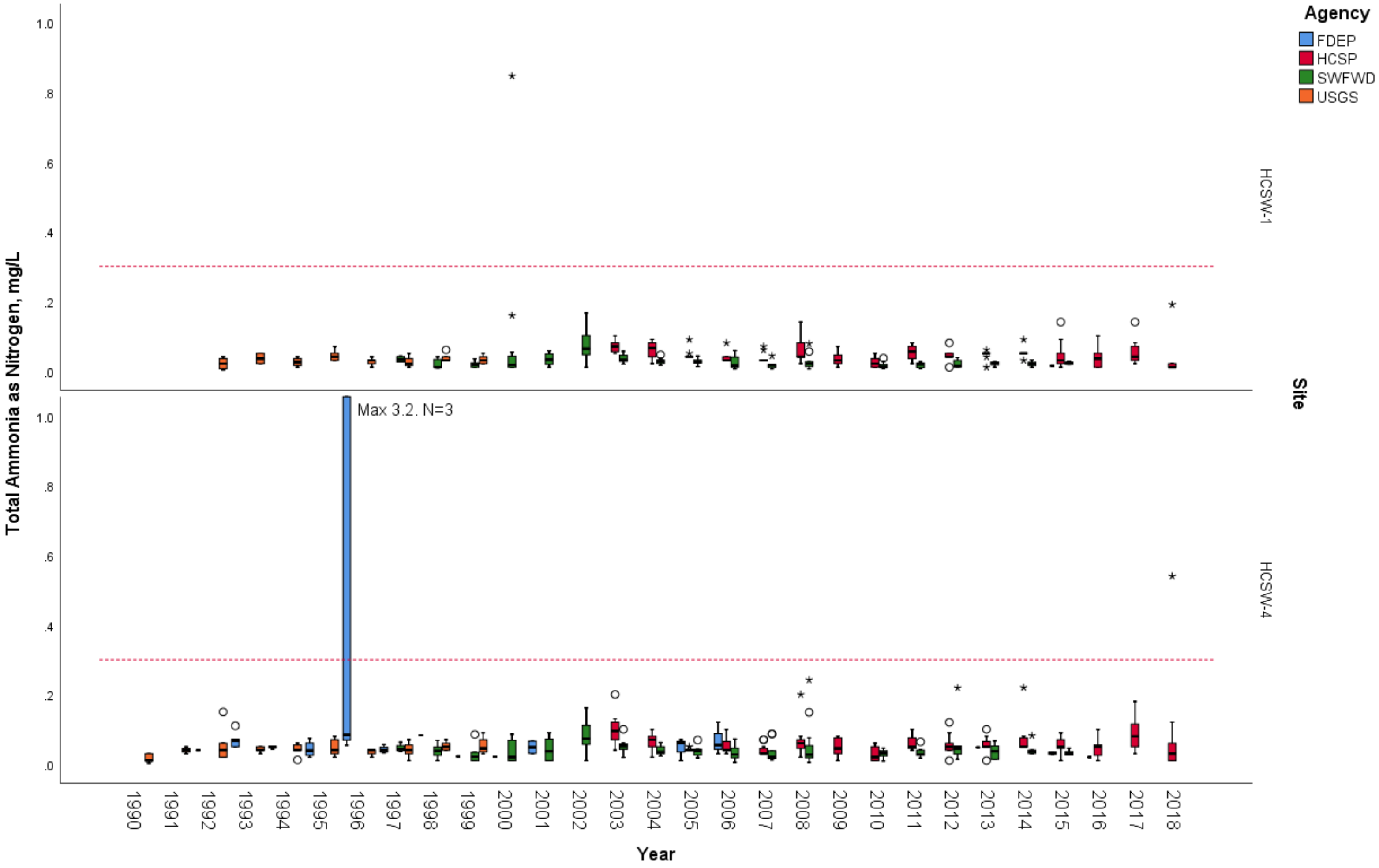


Figure C-29 HCSW-1 and HCSW-4 ammonia concentrations obtained from various data sources (FDEP, SWFWMD, and USGS Data from EPA STORET and HCSP) from 1990 to 2018. Analyte trigger level represented by dotted red line.

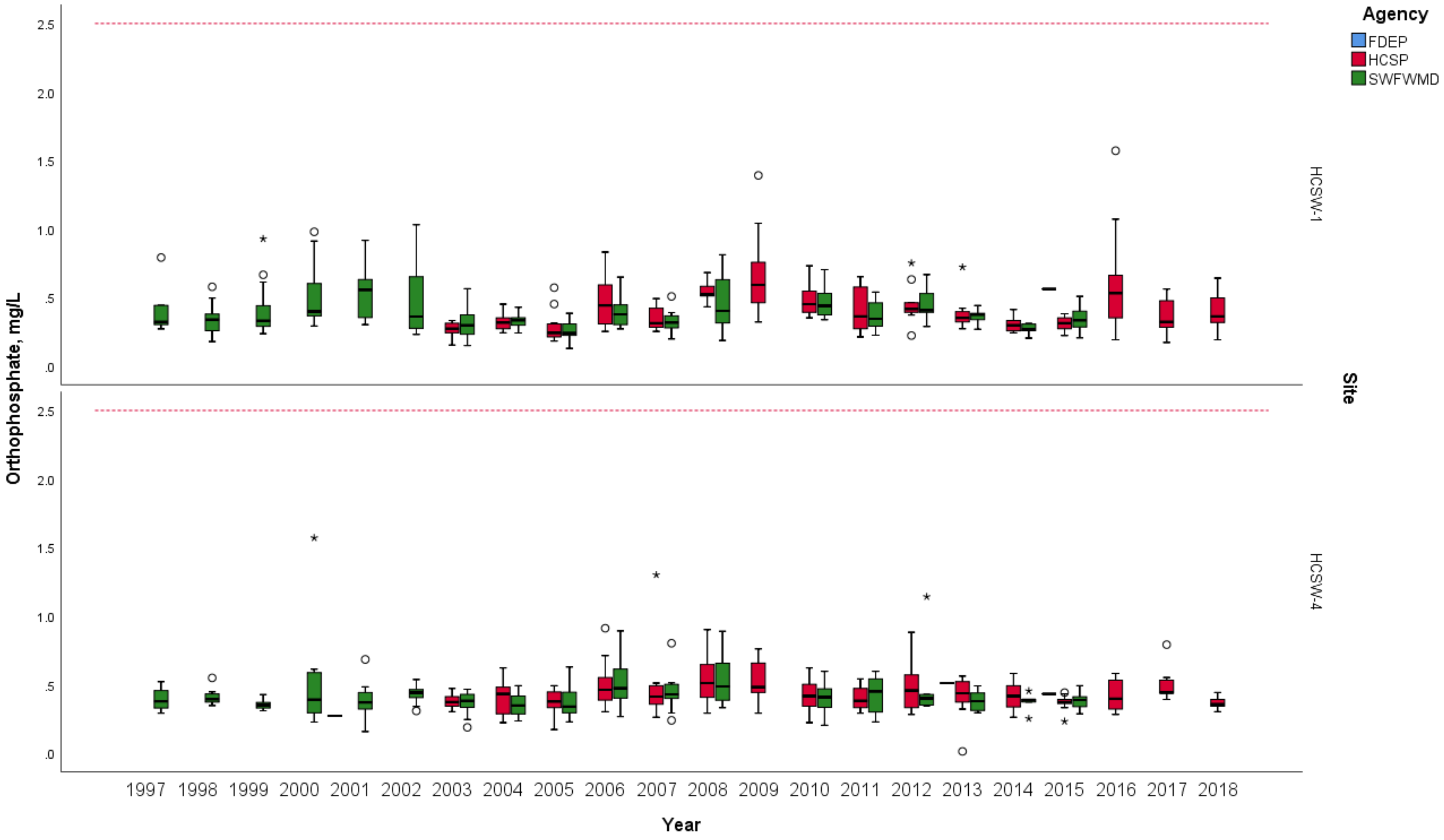


Figure C-30 HCSW-1 and HCSW-4 orthophosphate concentrations obtained from various data sources (FDEP, SWFWMD, and USGS Data from EPA STORET and HCSP) from 1990 to 2018. Analyte trigger level represented by dotted red line.

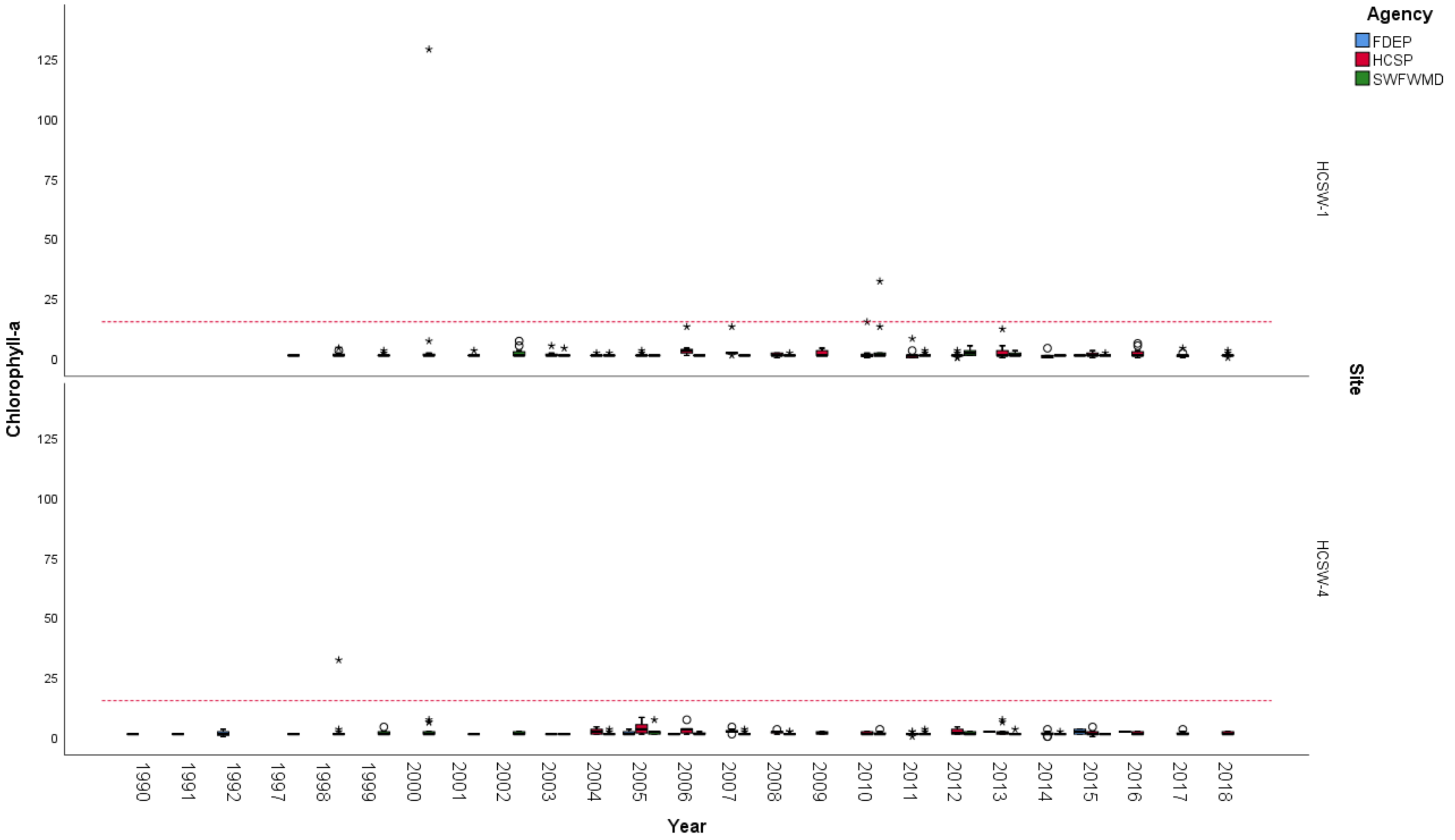


Figure C-31 HCSW-1 and HCSW-4 chlorophyll-a concentrations obtained from various data sources (FDEP, SWFWMD, and USGS Data from EPA STORET and HCSP) from 1990 to 2018. Analyte trigger level represented by dotted red line.

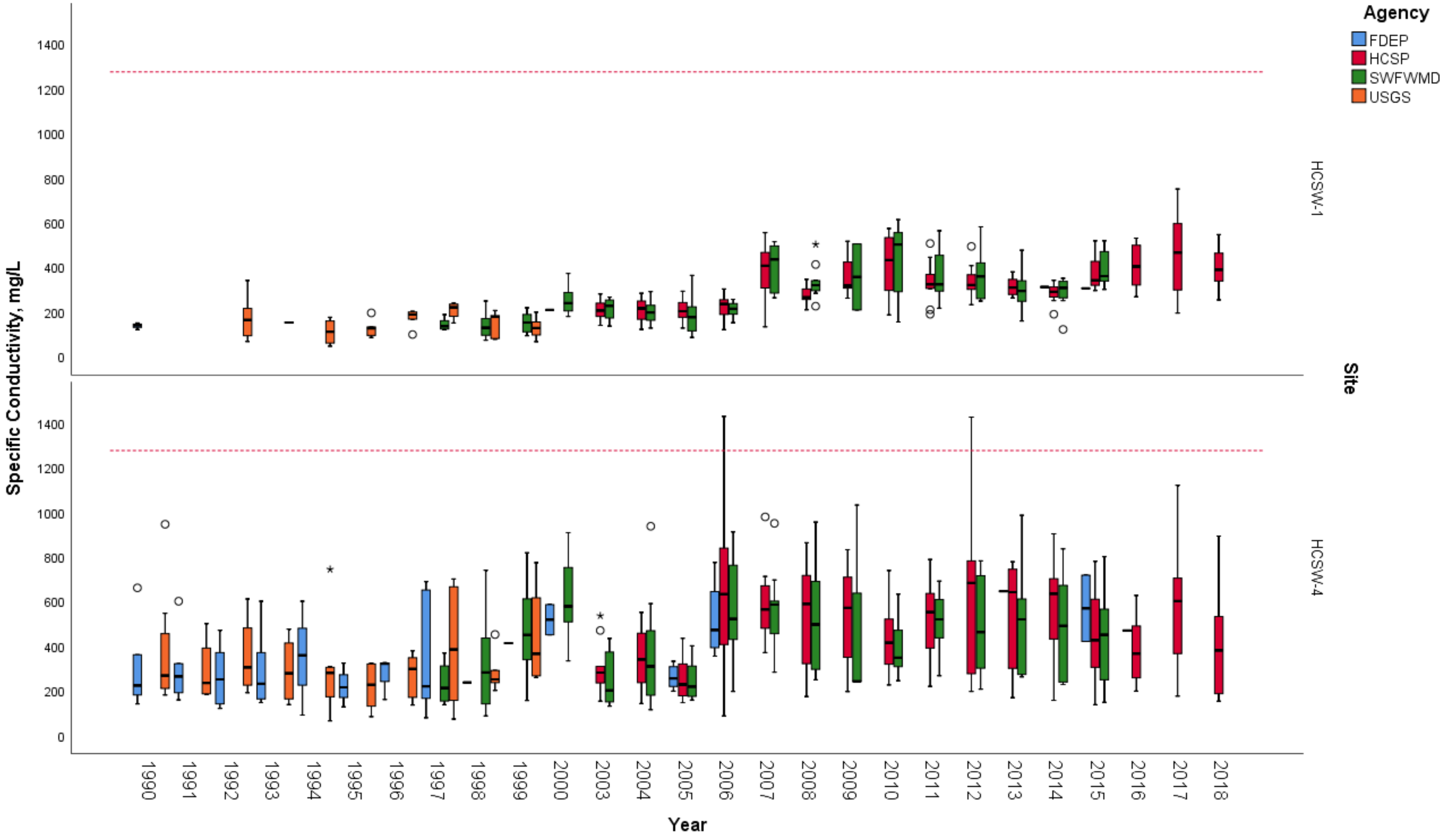


Figure C-32 HCSW-1 and HCSW-4 values of specific conductivity obtained from various data sources (FDEP, SWFWMD, and USGS Data from EPA STORET and HCSP) from 1990 to 2018. Analyte trigger level represented by dotted red line.

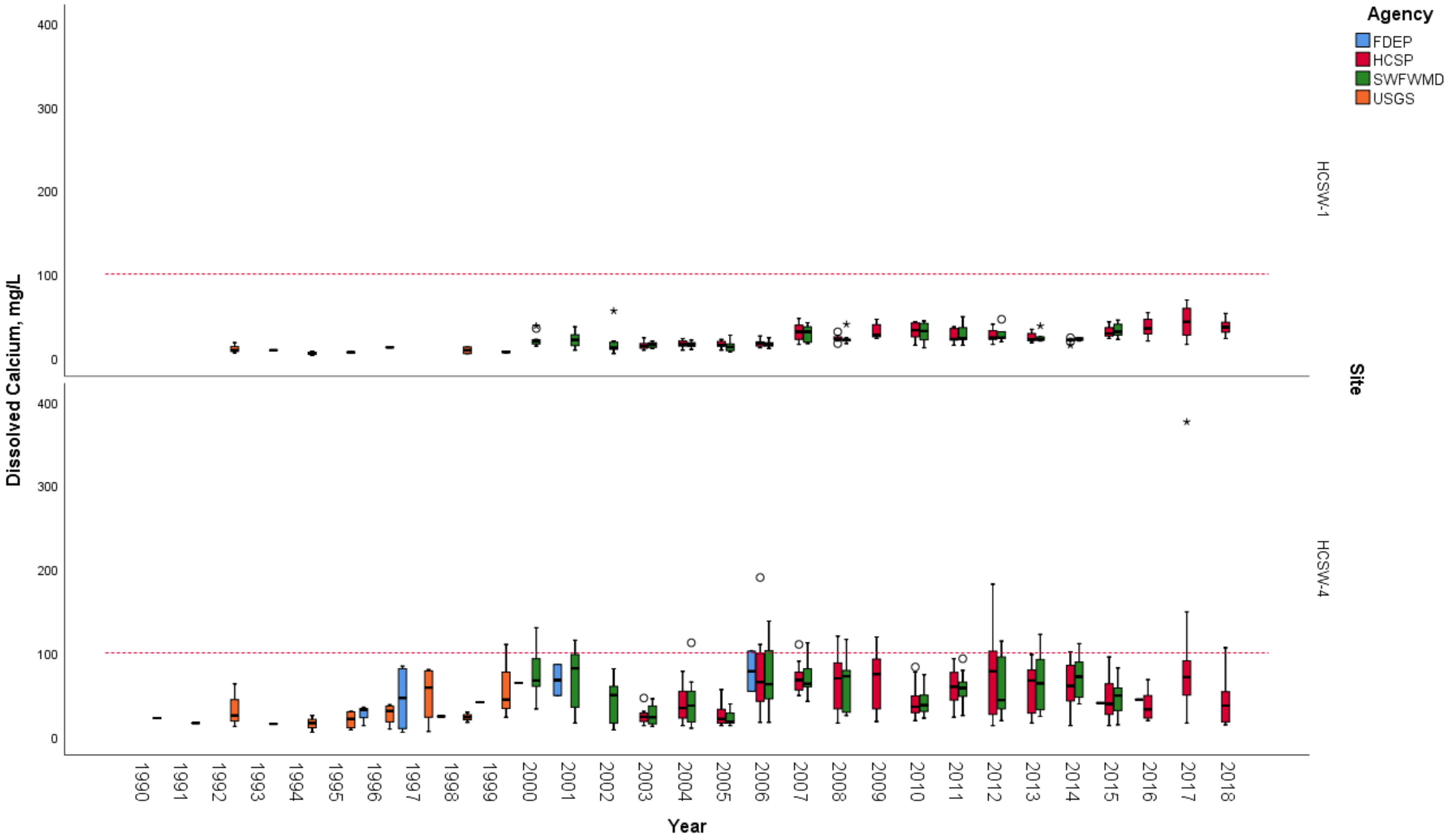


Figure C-33 HCSW-1 and HCSW-4 calcium concentrations obtained from various data sources (FDEP, SWFWMD, and USGS Data from EPA STORET and HCSP) from 1990 to 2018. Analyte trigger level represented by dotted red line.

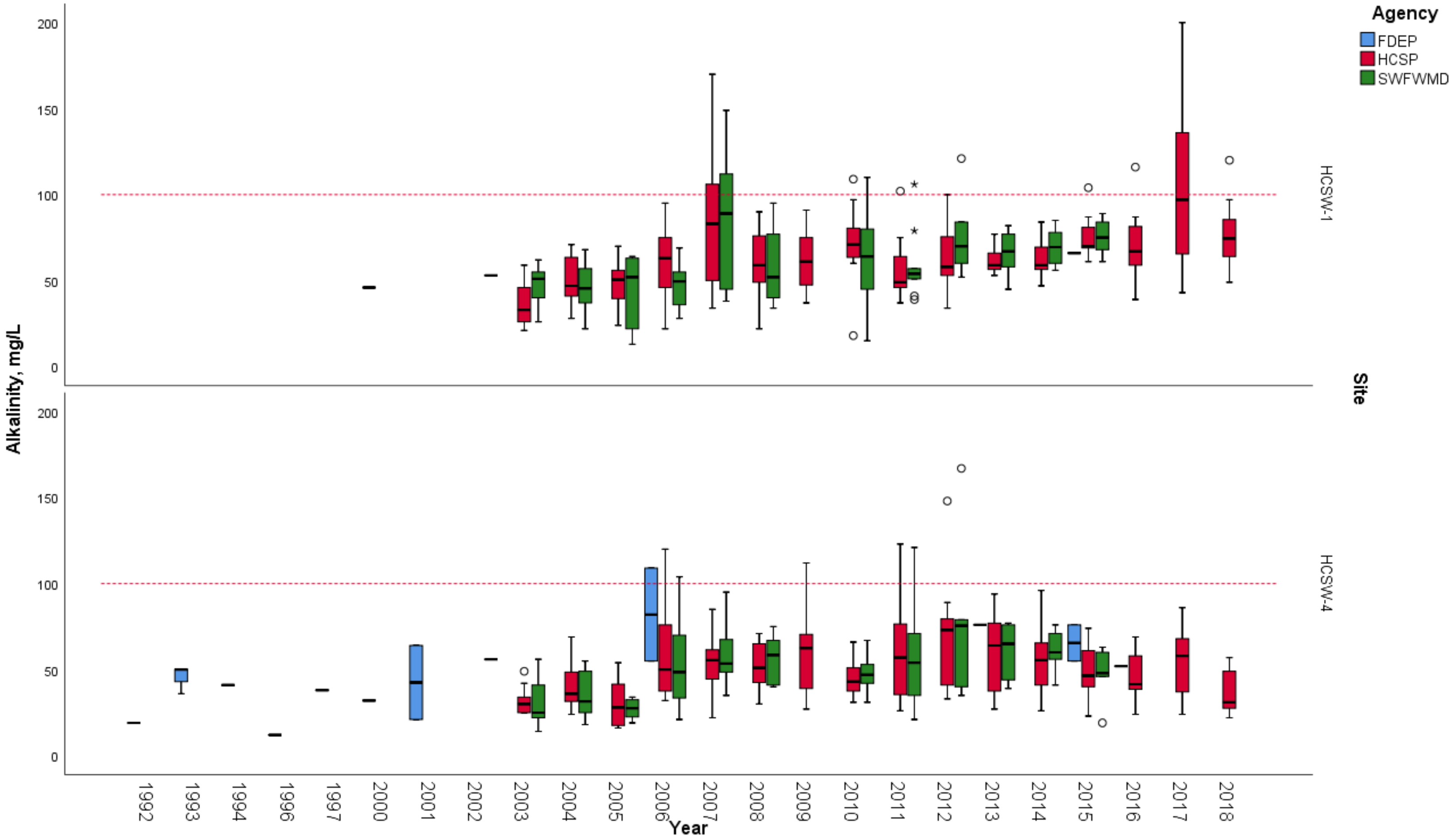


Figure C-34 **HCSW-1 and HCSW-4 alkalinity concentrations obtained from various data sources (FDEP, SWFWMD, and USGS Data from EPA STORET and HCSP) from 1990 to 2018. Analyte trigger level represented by dotted red line.**

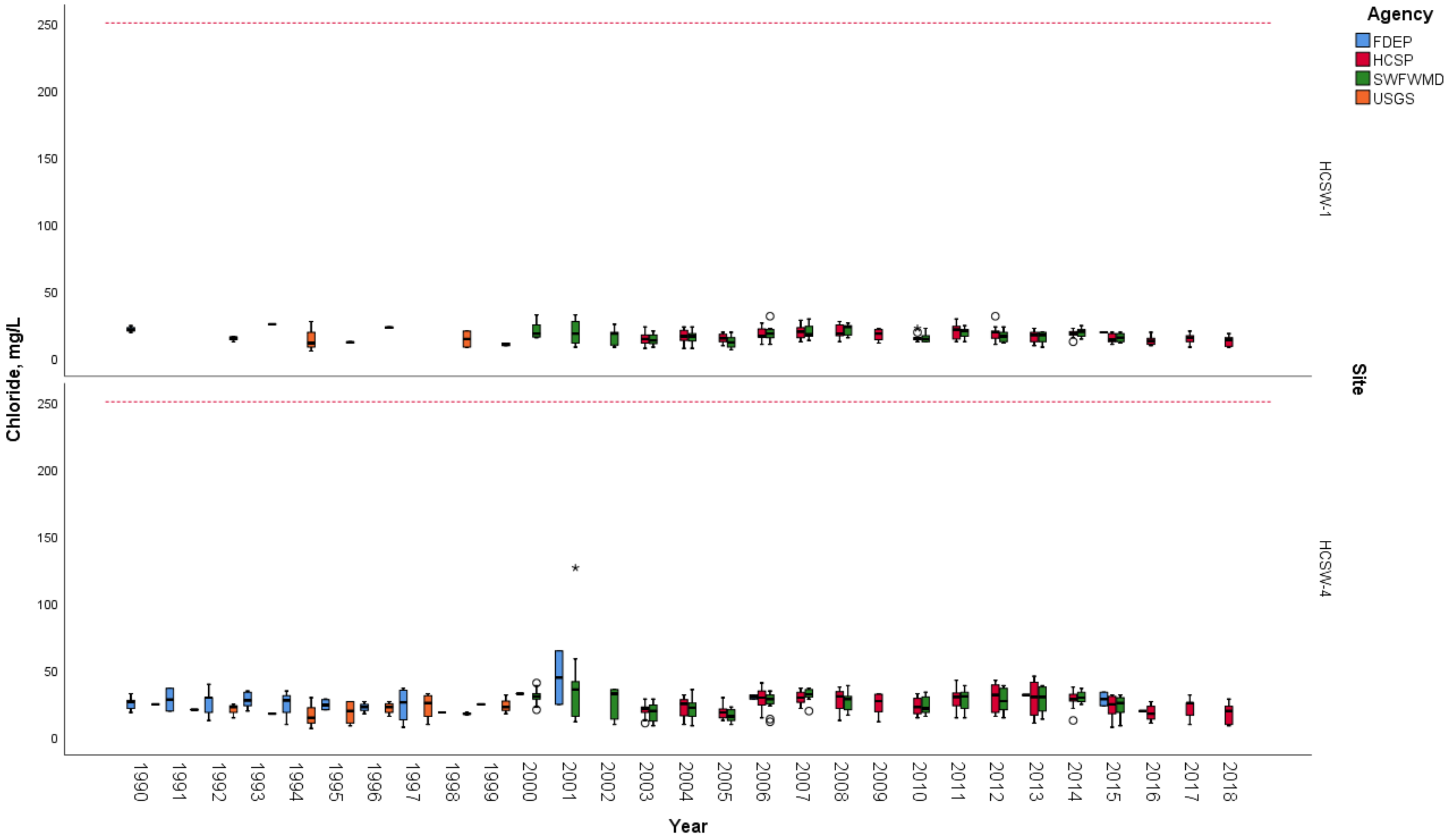


Figure C-35 HCSW-1 and HCSW-4 chloride concentrations obtained from various data sources (FDEP, SWFWMD, and USGS Data from EPA STORET and HCSP) from 1990 to 2018. Analyte trigger level represented by dotted red line.

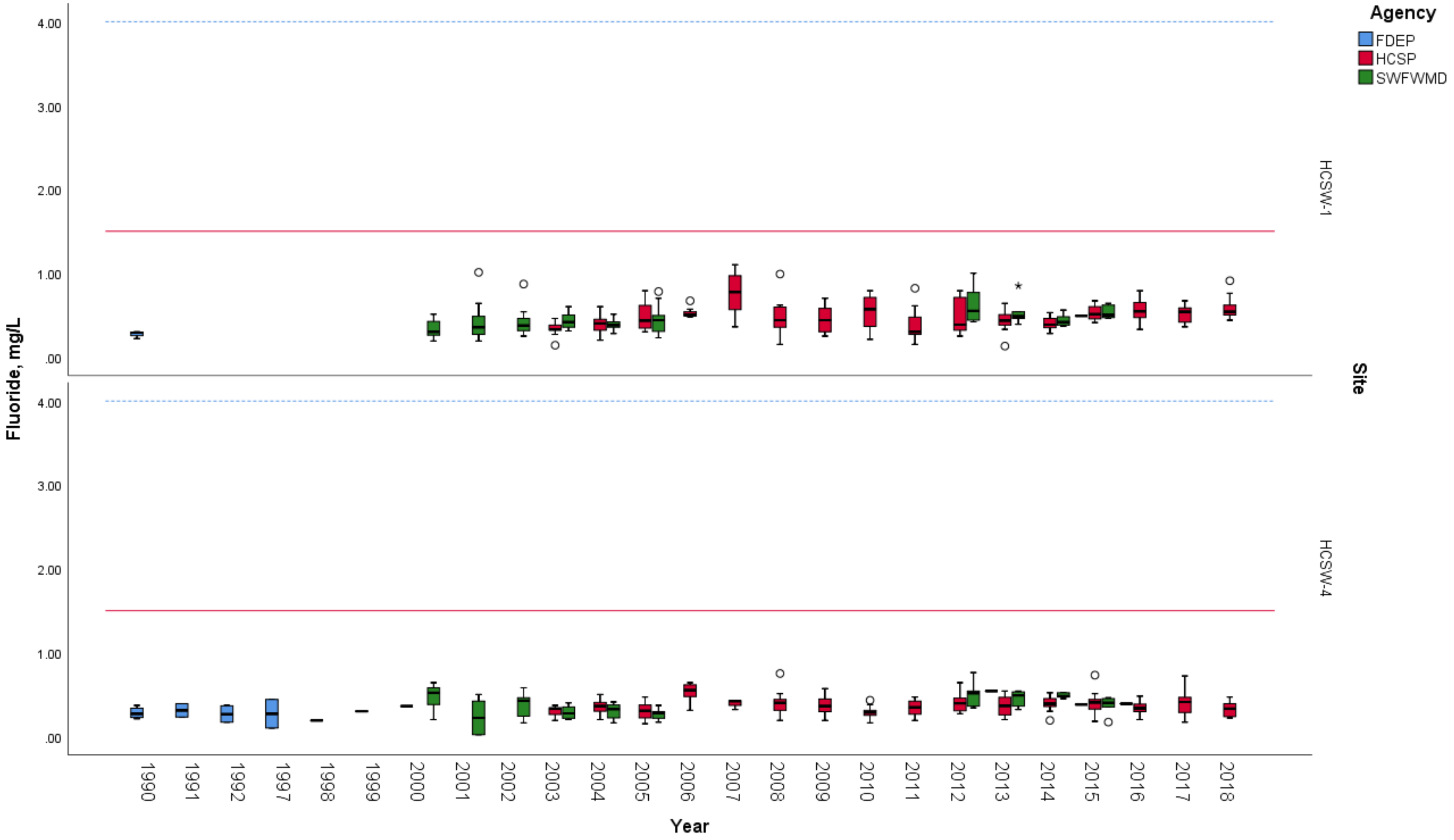


Figure C-36 HCSW-1 and HCSW-4 fluoride concentrations obtained from various data sources (FDEP, SWFWMD, and USGS Data from EPA STORET and HCSP) from 1990 to 2018. Analyte trigger level for HCSW-4 represented by solid red line; analyte trigger level for HSCW-1, HCSW-2, and HSCW-3 represented by dotted blue line.

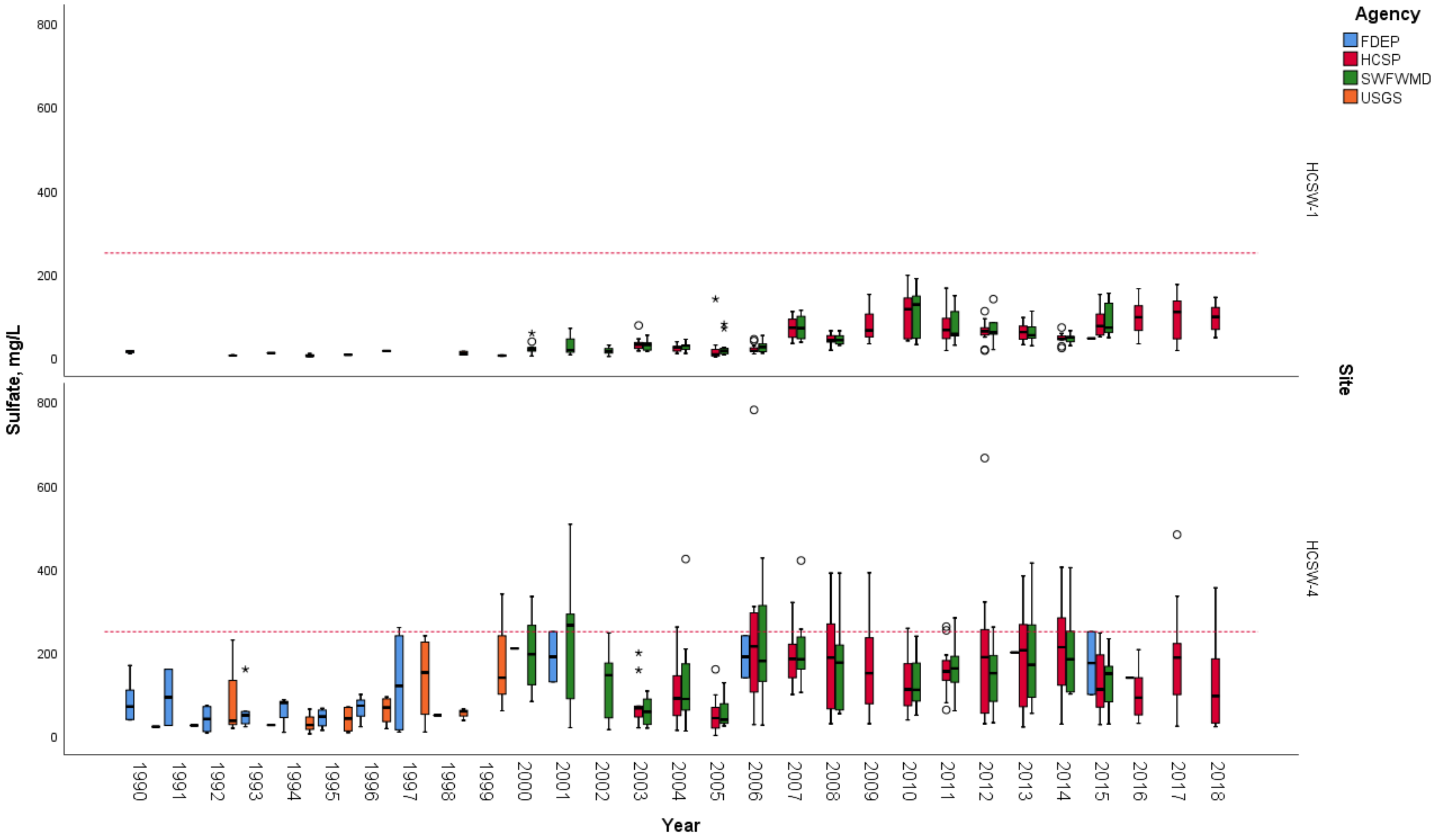


Figure C-37 HCSW-1 and HCSW-4 sulfate concentrations obtained from various data sources (FDEP, SWFWMD, and USGS Data from EPA STORET and HCSP) from 1990 to 2018. Analyte trigger level represented by dotted red line.

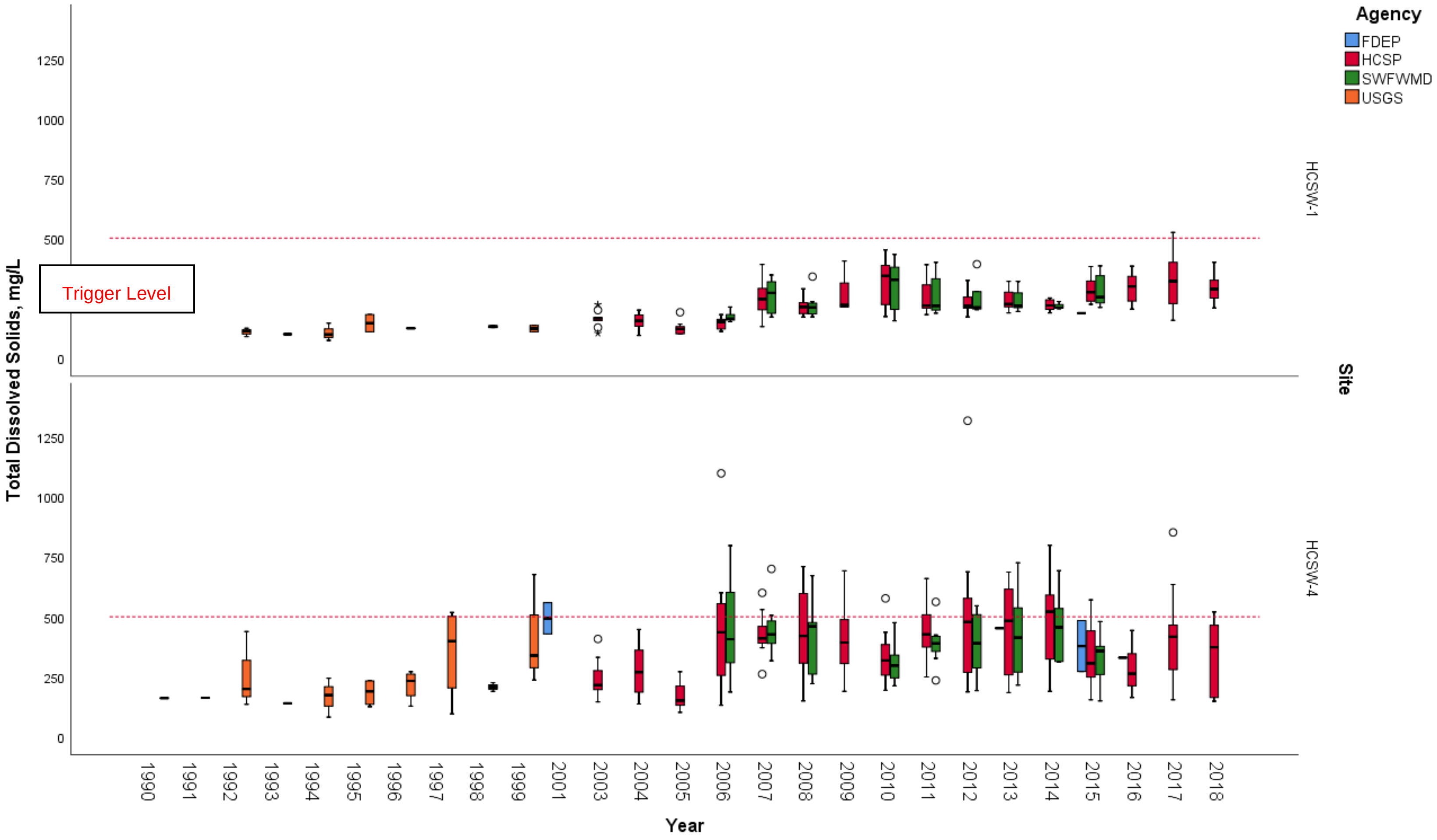


Figure C-38 HCSW-1 and HCSW-4 TDS concentrations obtained from various data sources (FDEP, SWFWMD, and USGS Data from EPA STORET and HCSP) from 1990 to 2018. Analyte trigger level represented by dotted red line.

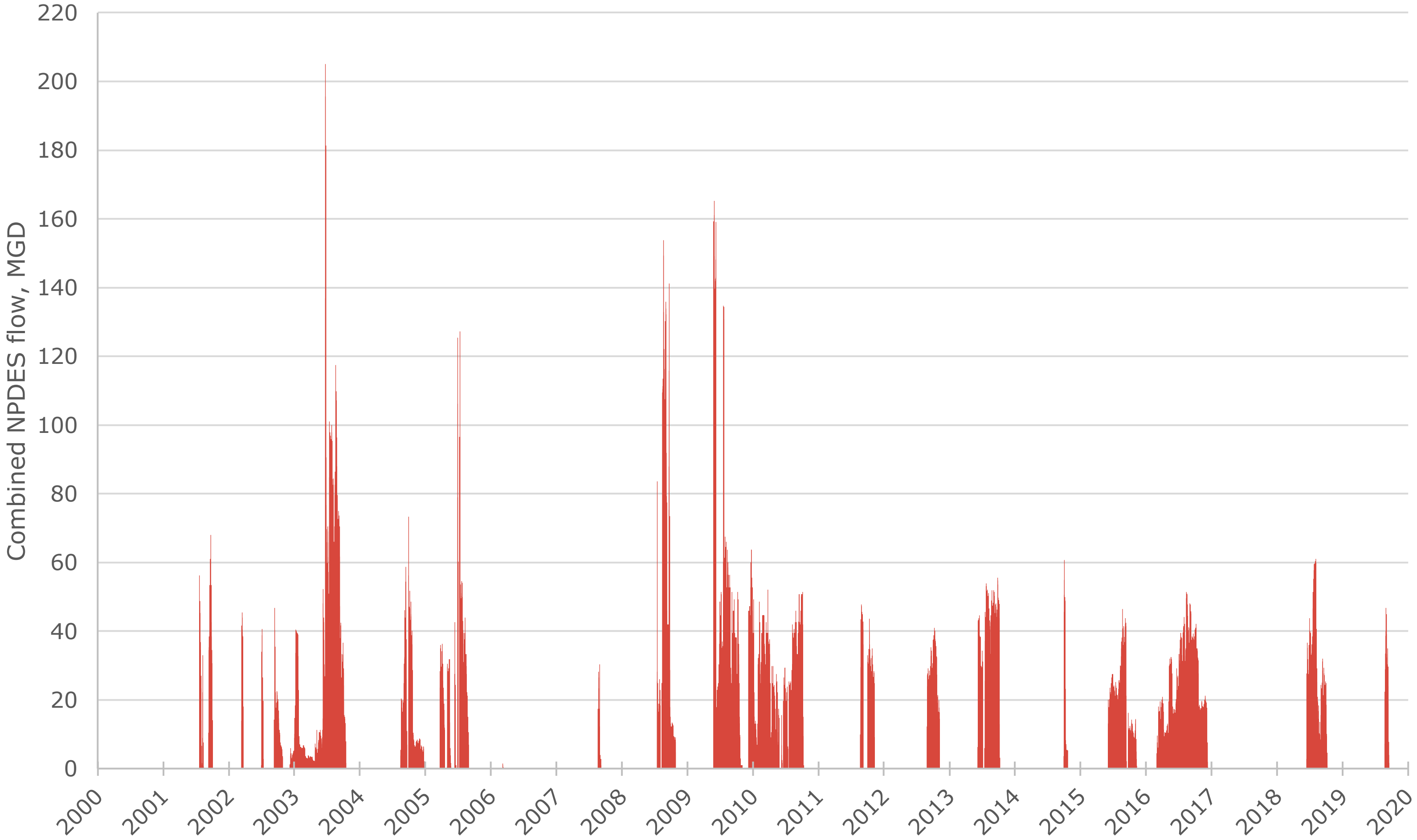


Figure C-39 Combined NPDES flow (FTG-003 & WIN-004) to Horse Creek, Period of Record.

Appendix D

Literature Review of Statistical Trend Analysis Methods

The following is a literature review of water quality data trend detection tests, intended to identify the best monotonic trend detection method for use in the Horse Creek Stewardship Program (HCSP). Based on information gleaned from a variety of sources, including the USGS (United States Geological Survey), the Seasonal Kendall test was determined to be the best method for use in the HCSP. Because the method needs a minimum of five years of data collection, the 2008 HCSP Annual Report will be the first report to include this analysis. In this (2007) and previous annual reports (2003–2006), a variation of this test, the annual median Mann-Kendall, was used on the combined data from several data sources (HCSP, Southwest Florida Water Management District (SWFWMD), USGS) for the period 1990 through 2007 to detect possible changes over time. Any changes over time detected using either method may result from a variety of causes, including changes in analytical methods, climatic variation, or anthropogenic causes; an impact assessment may be conducted to determine if the trend is caused by Mosaic mining activities. The following review describes both trend methods that have been or will be used in the HCSP.

Water quality monitoring data exhibits several characteristics that make trend analysis with traditional parametric statistics methods difficult. Water quality datasets often violate the assumptions of parametric statistics, such as the need for independent observations, normal distributions, and constant variance (Berryman et al. 1988, Lettenmaier 1988). In addition, water quality data may be seasonally cyclical or flow-dependent, and datasets may contain missing, censored, or truncated data. Although many methods have been proposed for trend detection, nonparametric methods are the most recommended for detecting trends in water quality data (Berryman et al. 1988, Lettenmaier 1988, Hirsch et al. 1982).

Trend detection methods include graphical methods, time series analysis, parametric statistical tests, and nonparametric statistical tests (Berryman et al. 1988). Graphical methods of trend analysis involve visual interpretation of the data, with no explicit test for trends. This method is often used for exploratory data analysis before other trend detection methods are applied. In time series analysis, a time series is broken down into components (base level, trend, cycle, etc.) using equations. These equations can be combined into a predictive model that can be used to estimate future water quality. Although trends can be modeled using time series analysis, the method does not determine the trend significance, or the chance that the trend is not random. Statistical tests may be used on the results of the time series analysis to detect trends, but it is considered more appropriate and efficient to use other statistical methods directly. In addition, time series analysis is not appropriate for datasets with irregularly spaced observations or truncated data (observations below method detection limit) (Berryman et al. 1988).

Statistical tests detect trends by applying a rule that the magnitude of the trend is large compared to the variance. Statistical tests may be parametric (based on a normal distribution) or nonparametric. Parametric methods assume that the data is normally distributed, independent, and of constant variance. Although parametric methods are robust against data that violates these assumptions, the power of the test to detect trends is reduced. When these assumptions are violated, as with most water quality data, nonparametric methods are preferred. Because nonparametric methods are based on ranks of observations rather than magnitudes, they can be used on datasets with non-normal distributions or truncated data (Berryman et al. 1988, Lettenmaier 1988, Hirsch et al. 1982). Nonparametric methods can also be adapted for data that is not independent with corrections for seasonality or serial autocorrelation (Berryman et al. 1988, Hirsch et al. 1982, Harcum et al. 1992).

Nonparametric tests may be used to detect monotonic trends, step trends, or multi-step trends (Berryman et al. 1988). Monotonic trends are gradual and unidirectional, but step trends may occur suddenly, be restricted to a limited time period, and may reverse direction over time. Nonparametric methods used to detect step trends include the Mann-Whitney (single step), Kolmogorov-Smirov (single step), and Kruskal-Wallis (multi-step) tests. For each of these tests, the mean ranks before and after a designated time-step are compared, similar to parametric t-tests or ANOVA.

In the absence of *a priori* knowledge of a time-specific potential impact that could affect water quality, monotonic trends are typically the most common trends examined. Nonparametric methods that detect monotonic trends include the Mann-Kendall, Spearman, Cox-Stuart, and Friedman's tests. The Spearman and Kendall are considered the most powerful; these methods detect trends by a significant correlation between the parameter values and time (Berryman et al. 1988). Several of these methods have been adapted for use with seasonally cyclic data; the most commonly used seasonally adjusted method for water quality trend analysis is the Seasonal Kendall method (Lettenmaier 1988, Hirsch et al. 1982, Harcum et al. 1992, Helsel et al. 2006).

The Seasonal Kendall method is a frequently recommended method for detecting trends in water quality data (Lettenmaier 1988, Hirsch et al. 1982, Harcum et al. 1992, Helsel et al. 2006). The Seasonal Kendall was developed by and is now the method of choice for the United States Geological Survey (USGS) (Hirsch et al. 1982, Helsel et al. 2006). Other agencies that have used the Seasonal Kendall include the United States Environmental Protection Agency (EPA), South Florida Water Management District (SFWMD), Departments of Environmental Protection in Virginia and Oregon, Charlotte Harbor National Estuary Program (CHNEP), National Institute of Water and Atmospheric Research (NIWA), and many universities.

The Seasonal Kendall test determines water quality trends after correcting for seasonality by only comparing values between similar seasons over time (Schertz et al. 1991). The Seasonal Kendall test selects one value for each season (average, median, or subsample) and makes all pair-wise comparisons between time-ordered seasonal values (Harcum et al. 1992). A test statistic (Tau) 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). Results for the Seasonal Kendall include the magnitude of the statistic Tau, its significance (p), its slope (Sen slope estimator), and the direction of significant trends. The trend (Sen) slope is the median slope of all pairwise comparisons. The direction of this slope (positive or negative) is more resistant to the effects of observations below minimum detection limits and missing data than the magnitude of the slope. The slope is a measure of the monotonic trend; the actual temporal variation may include step trends or trend reversals. If alternate seasons exhibit trends in opposite directions, the Seasonal Kendall test will not detect an overall trend (Lettenmaier 1988).

The power of the Seasonal Kendall test to detect trends in water quality data depends on sample size, season size, significance level, and the magnitude of trend to be detected (Harcum et al. 1992, Hirsch et al. 1982). Collapsing monthly data into quarters or years will reduce the power of the test to detect trends. If monthly data exhibits serial autocorrelation (dependence between adjacent months), however, collapsing is necessary to preserve an accurate significance level (p). Serial autocorrelation may make the actual p value much higher than expected (i.e. $p = 0.15$ instead of $p = 0.05$), leading to a very liberal interpretation of the significance level of potential trends. The loss of power caused by collapsing the data into quarters ceases to matter as sample size increases or the desired trend magnitude increases (Table 1, Harcum et al. 1992). The power difference between monthly and quarterly data disappears in 10-year datasets when the desired trend magnitude is 0.02 units/year, and in 5-year datasets when the trend magnitude is between 0.05 and 0.20 units/year.

Table D-1 **Power comparison for monthly and quarterly (median) data for five and ten years of data (adapted from figures in Harcum et al. 1992).**

Years of Data	Trend slope (units/yr)	Power (Monthly Data)	Power (Quarterly Data)
5	0.002	0.05	0.05
5	0.005	0.09	0.06
5	0.02	0.6	0.31
5	0.05	0.97	0.83
5	0.2	1	1
5	0.5	1	1
10	0.002	0.12	0.1
10	0.005	0.45	0.32
10	0.02	0.98	0.95
10	0.05	0.99	0.99
10	0.2	1	1
10	0.5	1	1

The USGS recommends at least five years of data with less than five percent truncated observations for the Seasonal Kendall test. Trends detected in datasets with more than five percent of the observations below the method detection limit will have an accurate direction, but the slope magnitude will be a poor estimate (Schertz et al. 1991).

Based on this literature review on tests for water quality data trend detection, the best monotonic trend detection method for use in the Horse Creek Stewardship Program (HCSP) is the Seasonal Kendall. Because the USGS recommends a minimum of five years of data collection before applying the Seasonal Kendall test (Schertz et al. 1991), the 2008 Annual Report will be the first report to include this analysis.

When the Seasonal Kendall test is applied to data in the 2008 HCSP Annual Report, trend detection will be limited by several factors. With only five years of data, the power of the test to detect trends of small magnitude will be limited (Table 1, Harcum et al. 1992, Hirsch et al. 1982). In addition, the monthly data collected as part of the HCSP exhibits serial autocorrelation, meaning that adjacent monthly observations are not independent. Because the dependence in data for some parameters extends to observations made two months apart, collapsing the data into quarterly values is recommended (Harcum et al. 1992). This will reduce the power of the test by an additional margin (Table 1). Finally, data for parameters whose method detection limits have changed several times over the HCSP (fluoride, nitrate+nitrite) will have to be truncated to the highest detection limit, thereby reducing the available data for the test. As a result, trends will be harder to detect, and only the direction of the trend, not the magnitude of the trend, will be valid (Schertz et al. 1991). Despite these limitations, the Seasonal Kendall test is still the most appropriate to detect monotonic trends in HCSP water quality data, once five years of measurements have been collected.

In this (2007) and previous annual reports (2003–2006), the dataset collected by the HCSP was not of sufficient length for the Seasonal Kendall analysis. Instead, those reports included a variation of this test, the Mann-Kendall, where the data from several data sources (HCSP, SWFWMD, USGS) were collapsed into annual median values to detect possible changes over time for years 1990 to the present. Although collapsing the data into annual medians results in a loss of power to detect changes, it is a valid method for water quality trend detection (Harcum et al. 1992). The combined data set used in the HCSP reports includes data collected from 1990 to 2007 by the Florida Department of Environmental Protection (FDEP), USGS, SWFWMD, and HCSP with various analytical methods, sampling frequencies, and method detection limits that may bias the results. The annual median Mann-Kendall was chosen over the Seasonal Kendall as a more conservative approach. All trend analysis methods are heavily influenced by the observations at the beginning and end of a dataset, so the effects of the recent drought years should also be considered when examining potential changes.

Because of all the potential sources of bias in the combined dataset (changes in methods, different agency sources, different sampling frequencies, climatic variation, etc.), a statistically significant Mann-Kendall test may be caused by factors other than anthropogenic sources. Any changes over time detected using either the annual median Mann-Kendall or Seasonal Kendall test should be further examined to determine if the perceived change is caused by a data bias, if its magnitude is ecologically significant, and if the cause of the trend is related to Mosaic mining activities. If warranted, an impact analysis can be performed on statistically significant trends to determine if trends are caused by Mosaic mining activities and if a corrective action by Mosaic is necessary.

D.0 REFERENCES

Berryman, D., B. Bobee, D. Cluis, and J. Haemmerli. 1988. Nonparametric tests for trend detection in water quality time series. Water Resources Bulletin of American Water Resources Association. 24(3): 545 – 556.

Harcum, J. B., J. C. Loftis, and R. C. Ward. 1992. Selecting trend tests for water quality series with serial correlation and missing values. Water Resources Bulletin of American Water Resources Association. 28(3): 469 – 478.

Helsel, D. R., D. K. Mueller, and J. R. Slack. 2006. Computer program for the Kendall family of trend tests. U.S. Geological Survey Scientific Investigations Report: 2005-5275. 4 p.

Hirsch, R. M., J. R. Slack, and R. A. Smith. 1982. Techniques of trend analysis for monthly water quality data. Water Resources Research 18(1): 107 – 121.

Lettenmaier, D. P. 1988. Multivariate nonparametric tests for trend in water quality. Water Resources Bulletin of American Water Resources Association. 24(3): 505 – 512.

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.

Appendix E

TAG Meeting Summary

Horse Creek Stewardship Program (HCSP) TAG Meeting
Presentation on 2018 HCSP Annual Report Findings
Peace River Manasota Regional Water Supply Authority (PRMRWSA)
9415 Town Center Parkway, Lakewood Ranch, FL 34202
December 12, 2019 9:00 AM – 1:00 PM
Minutes - Recorded by Michael Grzywacz

ATTENDANTS
- Sam Stone (PRMRWSA)
- Daniel Roberts (PRMRWSA)
- Terri Holcomb (PRMRWSA)
- Alissa Powers (Parks and Natural Resources Dept.)
- Rob Brown (Manatee County Environmental)
- Ashlee Edwards (Sarasota County Public Works Dept.)
- John Ryan (Sarasota County Water Resources)
- Ruta Vardys (Charlotte County Utilities)
- Jeff Clark (Earth Balance)
- Ryan Tickles (Mosaic)
- Bethany Niec (Mosaic)
- Shannon Gonzalez (Flatwoods)
- Eesa Ali (Flatwoods)
- Michael Grzywacz (Flatwoods)

INTRODUCTION
Sam Stone and Shannon Gonzalez each gave a brief introduction of the Horse Creek Stewardship Program. Before the presentation began, John Ryan asked what the reason was for adding sampling at Brushy Creek into the program. Terri Holcomb asked how Brushy Creek (as a stream) compared to Horse Creek. Eesa Ali began the presentation after these questions.

WATER QUALITY
Ashlee Edwards asked how the turbidity trigger level for the continuous monitoring was chosen. John Ryan asked if the authority could investigate and/or report to the proper agencies other (non-mining) causes of stream degradation that are discovered throughout the study.

STREAM CONDITION INDEX SCORES
Rob Brown asked if the Florida Department of Environmental Protection (FDEP) has investigated the impairment of HCSW-2. In addition, he asked if any of this data was publicly available and noted if there was an agricultural related impairment, we (the Technical Advisory Group (TAG)) need to take steps to address it.

SHANNON-WIENER DIVERSITY INDEX FOR FISH SPECIES DIVERSITY AT EACH STATION BY YEAR

Jeff Clark asked if there were any explanations for the ups and downs at HCSW-2 and if there are any noted impediments downstream of HCSW-2.

RAINFALL

It was noted on the 2018 Monthly Rainfall graph the asterisk denoting no data in March needed to be defined. It was explained that the Horse Creek South rain gauge (HCS) was down for >10 days in March. John Ryan asked if daily rainfall data is checked since high rainfall events can affect averages.

STREAMFLOW AND DISCHARGE

Daniel Roberts asked if there was a limit on the discharge from the Mosaic outfalls. When looking at the Analysis of Variance (ANOVA) water quality results, John Ryan asked what the nitrate/nitrite data was showing. Sam Stone asked if the graph showing correlations with water quantity at HCSW-1 and HCSW-4 could be included in the report since the color coding helped with understanding.

SEASONAL TRENDS OVER TIME (2003-2018)

Daniel Roberts asked if the conductivity at HCSW-1 was still lower than HCSW-4 even though the increasing trend is larger. In addition, Rob Brown noted that we need to start looking at temperature.

TRIGGER LEVEL EXCEEDANCES

Sam Stone asked if the TAG should change the iron trigger level. It was discussed that the current trigger level was too low, and the TAG all seemed to agree during the meeting that it should be changed. Additionally, the TAG also agreed to accept changes in the way Seasonal Kendall Tau was calculated to use real-time data, rather than daily averages.

ANNUAL REPORT SUMMARY PRESENTATION

Around 12:30 P.M., Eesa Ali finished the annual report summary presentation. A short break was taken before going over the 2018 impact assessment. During this time Jeff Clark, John Ryan, Rob Brown, and Ashlee Edwards left. When discussing the impact assessment, Daniel Roberts asked how long the sod farm near Brandy Branch and Buzzard Roost has been active. The presentation and meeting ending shortly after 1 P.M.

FLATWOODS
Consulting Group

February 19, 2020

Sam Stone
Peace River Manasota Regional Water Supply Authority
C/O Peace River Regional Water Supply Facility
8998 SW County Road 769
Arcadia, Florida 34269

RE: Horse Creek Stewardship Program 2018 Annual Report Comments and Questions

Dear Sam:

This letter is in response to requests for additional information following the December 12, 2019 Technical Advisory Group (TAG) meeting for the 2018 Annual Report for the Horse Creek Stewardship Program (HCSP) Project. For clarity, this letter was separated into sections based on the TAG member that submitted the set of questions. Questions included in the letter are shown first in bold followed by our responses in regular type.

The questions below were submitted by Ashlee Edwards, Environmental Data Scientist representing Stormwater Environmental Utility, Sarasota County Public Works Department.

General Comments:

1. **I do agree with the sentiment expressed by both John and Rob that continuing to proactively engage state agencies may significantly improve the future water quality of Horse Creek as a lot of issues appear to be beyond the control of Mosaic and the Peace River Manasota Regional Water Supply Authority (PRMRWSA).**

The HCSP annual reports are public documents once finalized. A requirement of the HCSP agreement requires that the final annual reports be transmitted to DEP (mining department) and the Southwest Florida Water Management District. The PRMRWSA routinely transmits the final reports to the parties listed above. The TAG stakeholders are welcomed at any time to use those finding to engage the state on water quality degradation.

2. **It may increase state involvement and transparency to have the results stored in WIN as well.**

Flatwoods has initiated the process of becoming a data provider for Watershed Information Network (WIN) following the November 7, 2019 Florida Department of Environmental Protection (FDEP) Biocriteria meeting. The process of potentially uploading HCSP data to WIN can be discussed at the next TAG meeting.

3. **I believe it would be extremely useful to explain the trigger levels utilized. This may already be described in a section I did not get to, but if it is not, it may be important for a document that will be available to the general public and environmental activists to have these levels explained as they are typically higher than the values for water quality monitoring for other land uses. (i.e. 150 NTU; the explanation of historic data (including background data), industry specific turbidity ranges, truer indication of failure, timing of flow, and eliminating frequent false alarms was extremely useful and logical). Whether it's in this annual report or recorded elsewhere, it will be important that, as new eyes review these reports, it is clear how critical choices like trigger levels were made.**

For clarity there exists two sets of water quality data and two sets of trigger levels. The first set of water quality data and trigger level s is related to the replacement of a previously required clay settling area (CSA) water level monitoring system, with a new and improved continuous recorder located at HCSW-1. This new recorder, like the previous monitoring system, serves as an early warning system to alert the PRMRWSA in the event of a mining spill upstream, however the new recorder system is more accurate, and more reliable than the previous water level system. The 12 consecutive turbidity readings of 150 Nephelometric Turbidity Units (NTU) at 15-minute intervals is the established trigger levels for this continuous recorder. The 150 NTU criterion was established by both the PRMRWSA and Mosaic outside of the HCSP Agreement to distinguish a berm failure from false alarms generated by the in-situ turbidity sensor located at HCSW-1. The second set of water quality data and trigger levels were a part of the original HCSP agreement between the PRMRWSA and International Minerals and Chemicals (IMC) Global. Most of these trigger levels are at or below (more sensitive) Class III surface water standards while other trigger levels are based on potable water secondary standards. When no standard existed, IMC and the PRMRWSA agreed on project specific trigger-levels. Finally, these discussions on the trigger levels are in more detail and are already found in the annual reports.

4. **To clarify, HCSW-2 would be classified as a segment with impaired waters based upon state criteria and the increasing presence and abundance of invasives may lead to initiating the corrective action process should a significant declining trend be identified in the future; is this interpretation correct?**

We do not believe HCSW-2 is representative of most of Horse Creek. There are invasive fish and plants at all sites regardless of water chemistry. HCSW-2 is located between two wetland systems with episodic flow, whereas the rest of Horse Creek is lotic and perennial. HCSW-2's water chemistry is representative of a wetland system and it probably would qualify for a Site-Specific Alternative Criteria (SSAC), regardless of any upstream mining activity. SSACs are outside of the current scope of the HCSP. The site does serve as a control for water quality under different land use type and flow regime.

5. **I did read about and hear the discussion on the removal of FL-PRO, total fatty acids, and total amines based on TAG recommendations. As it was noted, they are not a cause for concern at this time, are there safeguards that would indicate testing one or more of those parameters may need to resume should levels increase in frequency or concentration?**

The mining reagents (Florida Petroleum-Range Organics (FL-PRO), total fatty acids, and total amines) were dropped by the TAG in September of 2009 in lieu of sampling Brushy Creek. See Change #10 in Appendix B of the 2018 Annual Report which gives dates and explanations of these parameter changes. These parameters were found to not remain in water since biodegradation and adsorption removes most of these parameters from the water column. These biodegradable and adsorptive conditions remain a part of the mining water circulation and storage system today. Nothing has changed in the Mosaic operations since that decision was made. The Wingate NPDES permit does require quarterly monitoring for oil and grease during discharges. Any future proposed changes should be addressed at subsequent TAG meetings

6. **This is likely addressed somewhere, but it appears specific conductance was measured both in situ and from a grab sample. How were the values reconciled?**

All specific conductivity values are in-situ. There is an unattended meter located at HCSW-1 that logs a value every 15 minutes; Mosaic collects meter readings during the monthly water quality sampling, and Flatwoods takes a measurement during the triannual biological monitoring events. All those data points are presented in the annual reports. We have not compared the values to each other because they occur at different times and not in the exact same locations. All specific conductivity meter readings are verified and qualified according to FDEP Standard Operating Procedure (SOP) 1200, Field Specific Conductance.

Specific Comments:

7. **Table 4.1 on page 27; For August, was Brushy Creek sampled? There’s a blank where typically there’s an explanation (i.e. sampled, no access, no flow, dry, etc.).**

The table has been updated to read, “No Access”. Samplers were precluded from entering the area due to flooding.

8. **Figure 5-1 on page 39; As noted during the meeting, August and December lack indicators for missing gauge data.**

The Horse Creek North rain gauge was functional all year but recorded 0” of rainfall for the months of August and December.

9. Page 83, the end of paragraph two; *only one exceedance of TDS at HCSW -1 during the period of record: 524 mg/L on …* . Is this continued elsewhere?

The sentence included a non-sequitur and has been replaced with, "There has been only one exceedance of [Total Dissolved Solids (TDS)] at HCSW-1 during the period of record: 524 mg/L on 4/11/2017-100 days after the last discharge."

10. Figure 7-9 on page 107; HCSW-2 2017; was the data for this station not summarized?

No samples were collected in March or December 2017. The October 2017 sample contained one taxa-233 mosquito fish; therefore, the Shannon-Wiener index value is 0.

The questions below were submitted by John Ryan, Interim Senior Manager representing Stormwater Environmental Utility, Sarasota County Public Works Department.

General Comments:

11. **How can we share this data with the USF Water Atlas?**

The final draft of the 2018 annual report and the accompanying database are public documents. The PRMRWA has been sharing the annual report with the University of South Florida (USF) Water Atlas.

Specific Comments:

12. **P. iv, NPDES discharge. This seems like a lot. Wasn't there little or no discharge in recent years?**

The commenter was referring to the following sentence: "National Pollutant Discharge Elimination System (NPDES) discharge occurred for 115 days uninterrupted in 2018, between June 14th and October 6th." 2018 was the 9th largest discharge over 18 years. There was no discharge in 2017.

13. **P. v. Can we give SWFWMD a heads up? Maybe they can help alleviate the saltiness coming to the creek before it becomes a problem for the ecosystem and water plant.**

Based on recent discussion with Sam Stone, we understand the PRMRWSA has passed on the HCSP report to the Southwest Florida Water Management District (SWFWMD). The PRMRWSA also meets with the District staff working in the FARMS program to discuss annual updates on progress made in the Horse Creek watershed.

14. **P. v. This is a good description that is helpful to the reader. All that's missing is an explanation of why they are monitored.**

This comment was made in the executive summary. We describe the purpose and method in great detail in the Biological Results and Discussion, Section 7.1 Benthic Macroinvertebrates (Page 90) of the report.

15. **P. vi. Is the property publicly owned? If so, the property owner should be contacted about bank stabilization, maybe with wetland trees. Sediment will continue to move and degrade the creek downstream.**

Based on a review of the DeSoto County Property Appraiser's website, HCSW-3 is located on private property. Potential contact with the landowner should be a TAG and/or stakeholder initiative.

16. **P. 17. Runoff is an interesting word. Does the contribution include baseflow?**

Yes, the term runoff in this context is inclusive of surface water flow and baseflow.

17. P. 18. It would be interesting to see a trend of land use in the basin.

It could be done using the Landscape Development Index (LDI) scores of individual or grouped land use classes. This can be discussed further in the next TAG meeting.

18. P. 26. Please date these photos.

Please see the footnote on page 26 of the report for the requested photo dates.

19. P. 30. The floral metrics, although in rule, are goofy. It is informative to use the NNC thresholds to illustrate water quality in Horse Creek.

We have added the Total Nitrogen (TN) Numeric Nutrient Criteria (NNC) threshold (1.65 mg/L TN) to the respective figures in the 2018 report. Also, please see the response to question 27 below.

20. P. 38 Table 5-1. Pretty unreliable data set if 21 of 80 years have data gaps: 26%.

The asterisks indicated that the gauge was down for parts of the year, not the entire year. Four gauges (not including the average of the mosaic gauges) over 16 years would be 64 data years or 23,376 days. There were 583, 231, 381, and 51 days of missing data at HC North, HC South, Manson Jenkins, and SWFWMD Flatford, respectively, which amounts to 1,246 days or 5.3%.

21. P. 39 Fig 5-1. Sometimes daily rainfall is very informative because a few large events drive the annual or monthly high values. Variation from average or median is informative.

Daily rainfall was presented in Figures 5-7 and 5-10 against stream flow and National Pollutant Discharge Elimination System (NPDES), respectively.

22. P. 42 Fig 5-3. Uptick in May and Dec. is steep.

Yes, the steep uptick corresponds to major rainfall events. See Figure 5-7, Average daily streamflow at HCSW-1 and average daily rainfall in the Horse Creek watershed in 2018.

23. P. 52 Fig 5-11. I would like to see a long-term graph of NPDES discharge volumes.

The requested figure was included in the 2018 TAG presentation. We added the figure to Appendix C of the report- figure C39 Combined NPDES discharge (FTG-003 & WiIN-004) to Horse Creek, Period of Record.

24. P. 53 NOAA annual rankings. Is there a graph of this somewhere?

We used ranks in the 2018 report to describe 2018 rainfall with respect to the Mosaic, SWFWMD, and National Oceanic and Atmospheric Administration (NOAA) data sets. We thought that it was sufficient to say that this was the third wettest year since 2003 (when the HCSP began) based on the NOAA dataset. The Period of Record (POR) NOAA data set, which goes back to 1908, is available in the HCSP database or on NOAA’s website.

25. P.58 ANOVA result for NOx. Is this significant? I hope this is explained later in the report.

The Analysis of Variance (ANOVA) result for Nitrate-Nitrite (NOx) was significant, $p<0.001$. The report says that the four sites are different with respect to NOx. The Duncan's Multiple Range Test (DMRT) ranked sites HCSW-2, HCSW-1, HCSW-3, and HCSW-4 for NOx from low to high, respectively. We added the DMRT to the NOx discussion, page 69. Additional discussion on nitrogen species can be found in the TN section on page 67.

26. P.59 Table 6-3 WQ correlations with rainfall, streamflow and NPDES. I need more explanation of what this is telling me.

Correlations between each water quality analyte and rainfall, NPDES discharge, and streamflow were discussed in the water quality section of the report for each individual analyte, pages 59-87. We also made an infographic in the TAG report that described the correlations without the mathematics.

Using alkalinity at HCSW-1 as an example, alkalinity is negatively correlated to rainfall but not NPDES or streamflow at an alpha of <0.5. This means alkalinity concentrations go down when rainfall increases, and there is a less than 5% chance that this is association is due to random chance.

27. P.65 Fig. 6-6 Real-time turbidity at HCSW-1. What is the turbidity of the NPDES discharge?

This information was included in the TAG presentation. All Discharge Monitoring Report (DMR) turbidity values at D-003 and D-004 were <29 NTUs over the POR.

28. P.67. 1.65 mg/L Nitrogen is NNC

We added the 1.65 mg/L NNC on the TN Figures 6-8 and C-6. The report contained the following NNC interpretation:

> *In addition to the trigger level for TN, HCSW-1, the station with the highest percent of upstream mined lands, was evaluated against the recently approved state numeric nutrient standards. Under those standards, in order to avoid being listed as impaired for nutrients, a stream must pass a combination of biological and/or numerical criteria. According to 62-302 and 62-303 F.A.C., biological and nutrient data collected during the HCSP at HCSW-1 indicate no nutrient impairment (Appendix I, 2017 Annual Report). As of December 2017, HCSW-1 meets the nutrient criteria set in 62-302.351(2)(c), because it shows no imbalance of flora and fauna (chlorophyll, RPS, and LVS) and has healthy benthic macroinvertebrate conditions (SCI). HCSW-1 shows no evidence of persistent algal blooms, has annual geometric mean concentrations of chlorophyll < 3.2 µg/L, and has 11 passing Rapid Periphyton Surveys (RPS) and Linear Vegetation Surveys (LVS) from 2012 to 2017. The HCSW-1 average of SCI scores is > 40, with neither of the two most recent scores < 35. HCSW-1 also meets the SCI portion of the Biological Heath Assessment in 62-303.330 with the two most recent SCI scores > 35 and within 20 points of the historic maximum (if the historic maximum is above 64).*

29. P.67. Fig. 6-8 Total nitrogen in 2018. Is total nitrogen increasing when comparing upstream to downstream?

Yes, the downstream sites are showing elevated TN concentrations. "Total nitrogen concentrations were different among stations from 2003 to 2018 (ANOVA, Table 6-2), with lower concentrations at HCSW-1 than other stations (DMRT, $p < 0.05$)," page 67.

30. P. 70 Fig 6-10 2018 NOx. The y-axis is too large for NOx depiction. Please change the axis to 1.0 as maximum concentration, trending up as we go downstream.

The figure has been rescaled. The lower basin NOx is elevated compared to the upper basin.

31. P.71 Fig. 6-11 Total ammonia. What's the MDL?

The ammonia Minimum Detection Limits (MDLs) have been between 0.008 - 0.05 mg/L through 2018. A trade-off was made with paneling the graphs, distinguishing when a discharge occurred and displaying fluctuating MDLs. All the historical MDLs may be found in the database. The markers could be changed to indicate non-detects instead of outfall status, but then no patterns associated with the outfall would be apparent.

32. P. 72 Fig 6-12. OP may be a little higher upstream.

The POR Ortho-Phosphate (OP) means were 0.2992, 0.3975, 0.4103, and 0.4370 mg/L at sites HCSW-2, HCSW-3, HCSW-1 and HCSW-4, respectively. Please see Fig. C10 in Appendix C.

33. P. 79 Fig. 6-18 Alkalinity. What is the upstream cause (of exceedance at HCSW-1 only)?

HCSW-1 is the only site with a limestone streambed. These excursions above the trigger level occur during low flow events. This is supported by the following statement, "Alkalinity at HCSW-1 was negatively correlated with rainfall and streamflow and not correlated to NPDES discharge" (Section 6.4.4 on page 79).

34. P.83 Fig 6-21 Sulfate. What's downstream? Agriculture?

Yes, HCSW-3 and HCSW-4 are heavily influenced by citrus and sod operations along the banks of Horse Creek and its tributaries.

35. P. 90 Stream Habitat Assessment. Do regulations exist to require fencing of cattle out of streams? If so, who should be contacted?

Livestock are not typically excluded from streams, lakes, and wetlands unless required by a conservation easement. Farmers and ranchers often rely on natural waterbodies to provide water for their animals.

36. P.91 Table 7-1. Please explain maximum score and other ranges for each category. For example, what is the maximum score for substrate diversity?

The figure has been updated to include maximum scores.

37. P. 100 Fig 7-4 Shannon-Wiener macroinvertebrate diversity. Is there a trend at HCSW-3? Maybe HCSW-4?

Yes, a trend is evident at stations HCSW-2, HCSW-3, and HCSW-4. Page 98 states the following, "When considered over time from 2007 to 2018, diversity increased at each station except at HCSW-1 and increased over time at all stations combined at 0.06 units/year (Seasonal Kendall-tau, $p > 0.001$)".

38. P.100 Fig 7-5. Lumping may obscure information. 2016 looks like a rough year.

Over the period of record, annual Shannon-Wiener diversity collapsed across sites was the highest in 2017 at 5.0 and the lowest in 2016 at 4.32, i.e. the lowest score was 13.6 % lower than the highest score. The FDEP criteria for determining impairment using a Shannon-Wiener metric is a reduction of >25% between the site and an established baseline score for the site. There was no baseline score established for Horse Creek because mining preceded the HCSP. Regarding lumping, this data was expressed in various ways with and without lumping in the annual report. Figure 7-4 "Shannon-Wiener diversity indices for benthic macroinvertebrate genera from all HCSP locations from 2003 to 2018" shows the data without lumping.

39. P. C6 Fig C-5, POR color. The y-axis should be made smaller with a maximum around 600 so we can see the results better.

The figure has been rescaled, as requested.

40. P. C7 Fig C-6 POR TN. Reduce the y-axis to a maximum of 4. Show the 1.65 NNC as a line. (HCSW-)4 may be showing some ag influences?

The data range does not permit rescaling because there are values >4. The NNC line has been added, as requested.

41. P. C9 Fig C-8 POR NO_x. Change y-axis to a max of 1. Is site HCSW-4 showing agricultural influence?

Figure C-8 has been updated, as requested. See the NOx discussion on page 71 of the annual report.

42. P. C10 Fig. C9 POR NH_3. Reduce the y-axis. Show the MDL.

A tradeoff was made by displaying the outfall status. The POR MDL for Ammonia can be found in the database. There is also an MDL slide in the TAG presentation.

43. P. C11 Fig C-10, POR OP. Reduce the y-axis.

The data range does not permit rescaling because there are values approaching 5 mg/L OP.

44. P. C30 Fig C29. Rescale the y-axis.

The data range does not permit rescaling because there are values > 1 mg/L NH_3.

45. P. I310 LDI Maps. I would like to see a FLUCCS map with categories lumped together.

The maps in Appendix I are based on Florida Land Use, Cover, and Forms Classification System (FLUCCS) data. Level 3 FLUCCS codes were combined to generate LDI scores and used to calculate the overall LDI score to aid the stream physical-chemical site characterization. Below we provide a copy of the table used to generate LDI scores.

Table 1 FLUCCS Code – LDI Score Relationship

FLUCCS CODE	LDI SCORE	FLUCCS CODE	LDI SCORE
110 - 119	6.8	230-232	5.2
120 - 129	7.6	240-250	4.1
130	8.7	251-255	5.2
131-132	8	260-330	2.1
133	8.7	410-414	1
134	9.2	419	1.6
135-140	8	420-437	1
141 - 142	9.2	440-443	1.6
145	4.1	510-525	1
146	8	530	4.1
148	4.1	540-653	1
149	8	660	1.6
150-167	8.3	710-730	1
170-179	8.1	740-743	4.1
180-181	4.1	745	1
182-184	6.9	747	4.1
185-186	4.1	750	1
187	6.9	810	7.8
189	4.1	811	8.3
190-192	1.9	812	7.8
210-211	3.5	813-830	8.3
212-213	2.1	831	10
214-219	4.6	832	1.9
220-224	4.1	833-839	8.3

The questions below were submitted by Sam Stone, Land and Environmental Services Manager representing Peace River Manasota Regional Water Supply Authority.

46. **P. 15. Thus far in talking about rainfall data sources, Mosaic has been stated as a source, NOAA, and WMD. The report needs to be consistent on rainfall data sources. Figure 1 is the first to show WMD as source.**

The 2018 report follows previous annual reports. We show SWFWMD and Mosaic rainfall data side by side. We used the NOAA data when we were looking at larger time spans where the SWFWMD and Mosaic datasets are limited. The only difference is we supplemented the discussion with rank of the years for each dataset and compared to 2018.

47. **P. 19, Land Use. Maybe we need to update this HC basin section for the 2019 report or 2020 report.**

Agreed. Flatwoods uses the most recent Water Management District land use shapefiles. The 2014 and 2017 Southwest Florida Water Management District datasets were published after the drafting of the 2018 report.

48. **P. 25. Is this accurate today (that there is no outfall to Brushy Creek). since Mosaic bought out CF Industries (CFI)?**

There are no NPDES outfalls to Brushy Creek.

49. **P. 57. "Because these three water quantity variables are correlated to each other (Table 5-6), a statistically significant correlation between NPDES discharge and water quality does not prove a causal relationship between water quality and mining discharge." I do not understand this sentence. I understand rainfall flow and NPDES is related. However, water quality is causal related?**

The Spearman Rank Correlation was used to compare correlations between the NPDES discharge and rainfall and streamflow. The NPDES discharge was more correlated to the United States Geological Survey (USGS) gauge at HCSW-1 than any of the rain gauges (Table 5-5), but they are all correlated. Spearman Rank Correlation was also applied to compare NPDES discharge, rainfall, and streamflow with each water chemistry parameter in Table 6-3. So, a correlation between an analyte and the NPDES discharge is more likely related to streamflow (specifically wet season streamflow) than specifically the NPDES discharge, and you can see that relationship in Table 6-3.

50. The question is what is the pH of the water during the wet season above the NPDES discharge location?

HC @ SR62	pH, su				
	Average	Max	Min	Sample Size	Data Date Range
Rainy season	6.96	7.48	6.41	37	7/2009 - 9/2019
All seasons	7.04	8.43	5.95	79	7/2009 - 11/2019

Data source: Mosaic

51. P. 66. Where is flow vs color graph?

The 2016 and 2017 format was followed when preparing the 2018 Draft Report. Because this graph was not included in the previous reports, it also does not appear in the 2018 version; The 2018 Water Quality Trend Impact Assessment, in Appendix I of the 2018 Annual Report does contain flow vs analyte graphs for TDS, calcium, and sulfate, perhaps this is what the commenter was thinking about. This answer is repeated for questions 55-59.

52. P. 67. Where is flow vs TN graph?

Please see the response to question 54, above.

53. P.69. Where is flow vs TKN graph?

Please see the response to question 54, above.

54. P. 70. Where is flow vs total ammonia graph?

Please see the response to question 54, above.

55. P.71. Where is flow vs O Phosphorus graph?

Please see the response to question 54, above.

56. P. 72. Where is flow vs chlorophyll graph?

Please see the response to question 54, above.

57. P. 90. Increased rainfall and stream flow equals NPDES discharge, so connecting water velocity and habitat smothering is not very solid

The stream habitat assessment component consists of eight metrics:

1 Substrate diversity
2 Substrate availability
3 Water velocity
4 Habitat smothering
5 Artificial channelization
6 Bank stability
7 Riparian buffer width
8 Riparian buffer vegetation quality

The commenter was referring to the following line on page 90 of the annual report: "*Parameters that might be hypothesized to have some linkage to mining are water velocity and habitat smothering, primarily as a result of NPDES discharges to a stream*". This line is saying that, of all habitat assessment metrics, a permitted discharge is most likely to affect water velocity and habitat smothering and is less likely to affect the other habitat assessment metrics.

58. P. 120. Where is the NPDES water quality data and graphs?

The 2016 and 2017 format was followed when preparing the 2018 Draft Report. Because this data was not included in the previous reports, it also does not appear in the 2018 version. The annual report format is being overhauled in 2019, and Flatwoods will discuss the inclusion of an NPDES water quality summary with Mosaic.

59. P. 121 "Mosaic will get in touch with USGS to determine if moving the flow/water level gauge at SR64 is feasible." When was this completed, and what did we learn?

USGS informed Mosaic that they are not going to move the location of the gauge. USGS will periodically verify and clean out the sedimentation that builds up at the base of the stilling well, as needed.

The questions below were submitted by Jeff Clark, M.S., PMP, Vice President of Business Development representing EarthBalance.

60. P. iv. "NPDES paragraph states, "It appears that a wet 2017 and early 2018 contributed to (a relatively shorter lag in summer of 2018)…". Was this caused by the early 2018 rainy season?

An early rainy season does not appear to be the cause of the reduced lag. We were stating that lag between rainfall and discharge was relatively short because storage (wetlands, in-ground, and clay settling areas) was already saturated.

61. P. 21. In the sentence "Beginning in 2015, …", in the parentheses it appears that the number of mined acres added when CFI became part of Mosaic is missing.

The sentence has been updated to read: "Beginning in 2015, annual reports contained revised information when legacy CF Industries holdings became part of Mosaic (table updated starting in 2015 with acres mined at South Pasture added to both the Horse Creek and Brushy Creek basins from 2004 to 2015)."

62. Table 3-1. It would be helpful to have the acreages summed up at the bottom of the table unless there's some reason not to.

The sum for each column in Table 3-1 has been added, as requested.

63. Section 3.0. Summary of Mining and Reclamation Activities; I'd like to get a sense of where we are in the life of the 2 mines (Fort Green and South Pasture). For example, how many acres of permitted land has yet to be mined? Figure 3-1 shows all of Mosaic's holdings but no indication of the extent of the current permitted minable area. Along this line of questioning, I ask if the HCSP agreement pertains to all future Mosaic mining activities within the Horse Creek basin or just these 2 mines. The introduction reads like the program would be inclusive of any new mines. Not looking to open a can of worms, just looking to get a sense of where we're at.

As of February 2020, there are 0 acres left to mine in the Fort Green Mine, ~3,700 acres left in the South Pasture mine, and ~3,100 acres left in the South Pasture Extension mine.

64. P. 25. It's mentioned that Brushy Creek was "added for comparison purposes". What does information from this station intend to tell us? It's a mined tributary just like the West Fork, I believe, and there were only 4 samples taken in 2018. Just want to understand any significance of this Creek. I may be missing since it's not clear to me.

Mining occurs in the watershed of Brushy Creek, but there is no outfall to Brushy Creek; therefore, mining activities are hydrologically disconnected from Brushy Creek. The Brushy Creek system is ephemeral, and sampling is often interrupted due to intermittent, low or no flow in the creek. Brushy Creek was added for comparison purposes when the mining reagents were removed from the program, so it is not quite a control site.

65. P. 67. In the last sentence, check spelling on Biological Health Assessment.

The word “heath” was revised to “health”.

The questions below were submitted by Ruta Vardys, PE, Engineer III representing Charlotte County Utilities.

66. **Iron trigger level – add that a detailed explanation for establishing the lower limit initially and rationale for changing to a higher limit is provided in the annual report along with a statement that it will not adversely affect the potable water supply if not triggered at the lower limit.**

We will include this in the 2019 report, Appendix B “Cumulative Chronological List of Procedural Changes to the HCSP”.

67. **Add that the Meeting Minutes reflect that the 2018 Annual Report was the document that was under review during the meeting.**

The meeting minutes will reflect that the meeting was about the draft 2018 HCSP Annual Report that occurred on December 12, 2019.

68. **Include an educational appendix or diagram to explain the mining processes and possible infrastructure failures that could occur to affect water quality in the Horse Creek as a tributary to Peace River and/or a copy of the NPDES permit in the appendix.**

Mosaic has offered the TAG an educational tour of the facilities. The current NPDES permit for the Wingate Mine is attached.

Sincerely,

Eesa Ali
Senior Water Resource Analyst

Shannon M. Gonzalez
Senior Ecologist/Principal

EGA/srw

Appendix F

Summary of Trigger Exceedances from 2013 to 2018

Table F-1 List of exceedances for monitored parameters from 2003 to present for current trigger levels.

Sampling Location	Station ID	Date	Analyte	Concentration	Trigger Level
Horse Creek at State Road 64	HCSW-1	1/23/2007	pH (SU)	8.83	8.5
Horse Creek at State Road 64	HCSW-1	1/4/2011	pH (SU)	4.8	6
Horse Creek at Goose Pond Road	HCSW-2	7/27/2006	pH (SU)	5.95	6
Horse Creek at Goose Pond Road	HCSW-2	10/19/2006	pH (SU)	5.99	6
Horse Creek at Goose Pond Road	HCSW-2	10/10/2012	pH (SU)	5.96	6
Horse Creek at State Road 70	HCSW-3	7/27/2005	pH (SU)	5.9	6
Horse Creek at State Road 72	HCSW-4	1/23/2007	pH (SU)	8.85	8.5
Horse Creek at State Road 72	HCSW-4	12/3/2015	pH (SU)	5.95	6
Horse Creek at State Road 72	HCSW-4	6/5/2012	Specific Conductance (µmhos/cm)	1,425	1,275
Horse Creek at Goose Pond Road	HCSW-2	7/2/2013	Dissolved Oxygen (%Saturation)	24.8	41.7
Horse Creek at Goose Pond Road	HCSW-2	8/1/2013	Dissolved Oxygen (%Saturation)	25.9	41.1
Horse Creek at Goose Pond Road	HCSW-2	9/4/2013	Dissolved Oxygen (%Saturation)	31.1	40.7
Horse Creek at Goose Pond Road	HCSW-2	10/1/2013	Dissolved Oxygen (%Saturation)	36.7	36.9
Horse Creek at Goose Pond Road	HCSW-2	2/3/2014	Dissolved Oxygen (%Saturation)	30.8	42.4
Horse Creek at Goose Pond Road	HCSW-2	8/6/2014	Dissolved Oxygen (%Saturation)	18.1	41.8
Horse Creek at Goose Pond Road	HCSW-2	9/3/2014	Dissolved Oxygen (%Saturation)	25.8	38.8
Horse Creek at Goose Pond Road	HCSW-2	10/6/2014	Dissolved Oxygen (%Saturation)	20.2	38.6
Horse Creek at Goose Pond Road	HCSW-2	11/4/2014	Dissolved Oxygen (%Saturation)	30.4	39.8
Horse Creek at Goose Pond Road	HCSW-2	12/2/2014	Dissolved Oxygen (%Saturation)	35.3	40.1
Horse Creek at Goose Pond Road	HCSW-2	3/5/2015	Dissolved Oxygen (%Saturation)	26	38.3
Horse Creek at Goose Pond Road	HCSW-2	7/6/2015	Dissolved Oxygen (%Saturation)	11.3	40.4
Horse Creek at Goose Pond Road	HCSW-2	8/6/2015	Dissolved Oxygen (%Saturation)	11.7	40.9

Sampling Location	Station ID	Date	Analyte	Concentration	Trigger Level
Horse Creek at Goose Pond Road	HCSW-2	9/22/2015	Dissolved Oxygen (%Saturation)	20.4	38.8
Horse Creek at Goose Pond Road	HCSW-2	10/5/2015	Dissolved Oxygen (%Saturation)	18.9	40.9
Horse Creek at Goose Pond Road	HCSW-2	11/3/2015	Dissolved Oxygen (%Saturation)	20.5	38.6
Horse Creek at Goose Pond Road	HCSW-2	2/23/2016	Dissolved Oxygen (%Saturation)	37.0	43.0
Horse Creek at Goose Pond Road	HCSW-2	3/7/2016	Dissolved Oxygen (%Saturation)	34.8	39.7
Horse Creek at Goose Pond Road	HCSW-2	4/6/2016	Dissolved Oxygen (%Saturation)	34.2	42.5
Horse Creek at Goose Pond Road	HCSW-2	5/5/2016	Dissolved Oxygen (%Saturation)	23.6	43.0
Horse Creek at Goose Pond Road	HCSW-2	6/7/2016	Dissolved Oxygen (%Saturation)	20.6	42.0
Horse Creek at Goose Pond Road	HCSW-2	7/7/2016	Dissolved Oxygen (%Saturation)	13.6	42.0
Horse Creek at Goose Pond Road	HCSW-2	8/4/2016	Dissolved Oxygen (%Saturation)	26.8	40.9
Horse Creek at Goose Pond Road	HCSW-2	9/8/2016	Dissolved Oxygen (%Saturation)	20.8	39.2
Horse Creek at Goose Pond Road	HCSW-2	10/18/2016	Dissolved Oxygen (%Saturation)	19.1	39.2
Horse Creek at Goose Pond Road	HCSW-2	11/7/2016	Dissolved Oxygen (%Saturation)	25.0	42.0
Horse Creek at Goose Pond Road	HCSW-2	12/13/2016	Dissolved Oxygen (%Saturation)	24.8	41.3
Horse Creek at Goose Pond Road	HCSW-2	6/19/2017	Dissolved Oxygen (%Saturation)	13.0	37.5
Horse Creek at Goose Pond Road	HCSW-2	7/17/2017	Dissolved Oxygen (%Saturation)	6.7	39.8
Horse Creek at Goose Pond Road	HCSW-2	8/14/2017	Dissolved Oxygen (%Saturation)	20.9	40.9
Horse Creek at Goose Pond Road	HCSW-2	9/25/2017	Dissolved Oxygen (%Saturation)	8.7	39.8
Horse Creek at Goose Pond Road	HCSW-2	10/12/2017	Dissolved Oxygen (%Saturation)	26.4	38.6
Horse Creek at Goose Pond Road	HCSW-2	11/15/2017	Dissolved Oxygen (%Saturation)	38.4	38.6
Horse Creek at State Road 70	HCSW-3	8/1/2013	Dissolved Oxygen (%Saturation)	38.4	39.9
Horse Creek at State Road 70	HCSW-3	8/6/2015	Dissolved Oxygen (%Saturation)	39.1	39.2
Horse Creek at Goose Pond Road	HCSW-2	5/24/2018	Dissolved Oxygen (%Saturation)	10.8	37.5
Horse Creek at Goose Pond Road	HCSW-2	6/20/2018	Dissolved Oxygen (%Saturation)	13.1	42.7
Horse Creek at Goose Pond Road	HCSW-2	7/11/2018	Dissolved Oxygen (%Saturation)	27	38.5

Sampling Location	Station ID	Date	Analyte	Concentration	Trigger Level
Horse Creek at Goose Pond Road	HCSW-2	10/2/2018	Dissolved Oxygen (%Saturation)	39.5	39.8
Horse Creek at Goose Pond Road	HCSW-2	11/8/2018	Dissolved Oxygen (%Saturation)	39.1	40.6
Horse Creek at State Road 70	HCSW-3	5/24/2018	Dissolved Oxygen (%Saturation)	32.7	35.9
Horse Creek at State Road 70	HCSW-3	6/20/2018	Dissolved Oxygen (%Saturation)	31.5	36.4
Horse Creek at State Road 64	HCSW-1	4/27/2006	Color (PCU)	20	25
Horse Creek at State Road 70	HCSW-3	4/27/2006	Color (PCU)	15	25
Horse Creek at State Road 70	HCSW-3	6/29/2006	Color (PCU)	15	25
Horse Creek at Goose Pond Road	HCSW-2	1/30/2008	Total Nitrogen (mg/L)	4.8	3.0
Horse Creek at State Road 70	HCSW-3	9/27/2006	Total Nitrogen (mg/L)	6.7	3.0
Horse Creek at State Road 70	HCSW-3	6/20/2007	Total Nitrogen (mg/L)	9.68	3.0
Horse Creek at State Road 70	HCSW-3	2/23/2016	Total Nitrogen (mg/L)	3.5	3.0
Horse Creek at State Road 72	HCSW-4	6/19/2017	Total Nitrogen (mg/L)	4.63	3.0
Horse Creek at Goose Pond Road	HCSW-2	7/31/2008	Total Ammonia (mg/L)	0.41	0.3
Horse Creek at State Road 70	HCSW-3	7/31/2008	Total Ammonia (mg/L)	0.32	0.3
Horse Creek at State Road 70	HCSW-3	5/3/2011	Total Ammonia (mg/L)	0.31	0.3
Horse Creek at State Road 72	HCSW-4	7/31/2008	Total Ammonia (mg/L)	0.31	0.3
Horse Creek at Goose Pond Road	HCSW-2	7/11/2018	Nitrogen, Ammonia (mg/L)	0.77F[1]	0.3
Horse Creek at State Road 70	HCSW-3	7/11/2018	Nitrogen, Ammonia (mg/L)	0.38F[1]	0.3

---

[1] F- Indicates that the analyte was detected in the sample as well as the field blank.

Sampling Location	Station ID	Date	Analyte	Concentration	Trigger Level
Horse Creek at State Road 72	HCSW-4	7/11/2018	Nitrogen, Ammonia (mg/L)	0.54F[1]	0.3
Horse Creek at State Road 64	HCSW-1	2/2/2010	Chlorophyll a (mg/m3)	15.4	15
Horse Creek at Goose Pond Road	HCSW-2	4/14/2004	Chlorophyll a (mg/m3)	16	15
Horse Creek at Goose Pond Road	HCSW-2	5/26/2004	Chlorophyll a (mg/m3)	21	15
Horse Creek at Goose Pond Road	HCSW-2	8/30/2004	Chlorophyll a (mg/m3)	35	15
Horse Creek at Goose Pond Road	HCSW-2	5/27/2005	Chlorophyll a (mg/m3)	17	15
Horse Creek at Goose Pond Road	HCSW-2	11/17/2005	Chlorophyll a (mg/m3)	17	15
Horse Creek at Goose Pond Road	HCSW-2	2/23/2006	Chlorophyll a (mg/m3)	23	15
Horse Creek at Goose Pond Road	HCSW-2	3/28/2006	Chlorophyll a (mg/m3)	30	15
Horse Creek at Goose Pond Road	HCSW-2	5/25/2006	Chlorophyll a (mg/m3)	32	15
Horse Creek at Goose Pond Road	HCSW-2	6/29/2006	Chlorophyll a (mg/m3)	45	15
Horse Creek at Goose Pond Road	HCSW-2	8/21/2006	Chlorophyll a (mg/m3)	20	15
Horse Creek at Goose Pond Road	HCSW-2	5/16/2007	Chlorophyll a (mg/m3)	25	15
Horse Creek at Goose Pond Road	HCSW-2	6/20/2007	Chlorophyll a (mg/m3)	110	15
Horse Creek at Goose Pond Road	HCSW-2	7/18/2007	Chlorophyll a (mg/m3)	17	15
Horse Creek at Goose Pond Road	HCSW-2	7/31/2008	Chlorophyll a (mg/m3)	22.6	15
Horse Creek at Goose Pond Road	HCSW-2	1/5/2009	Chlorophyll a (mg/m3)	24.9	15
Horse Creek at Goose Pond Road	HCSW-2	4/1/2009	Chlorophyll a (mg/m3)	21.7	15
Horse Creek at Goose Pond Road	HCSW-2	5/3/2011	Chlorophyll a (mg/m3)	17.5	15
Horse Creek at Goose Pond Road	HCSW-2	2/2/2012	Chlorophyll a (mg/m3)	75.1	15
Horse Creek at Goose Pond Road	HCSW-2	4/2/2012	Chlorophyll a (mg/m3)	35.9	15
Horse Creek at Goose Pond Road	HCSW-2	5/2/2012	Chlorophyll a (mg/m3)	34.1	15
Horse Creek at Goose Pond Road	HCSW-2	12/5/2012	Chlorophyll a (mg/m3)	17.9	15
Horse Creek at Goose Pond Road	HCSW-2	5/1/2013	Chlorophyll a (mg/m3)	53.2	15

Sampling Location	Station ID	Date	Analyte	Concentration	Trigger Level
Horse Creek at Goose Pond Road	HCSW-2	11/4/2013	Chlorophyll a (mg/m3)	17	15
Horse Creek at Goose Pond Road	HCSW-2	4/8/2015	Chlorophyll a (mg/m3)	28.6	15
Horse Creek at Goose Pond Road	HCSW-2	5/11/2015	Chlorophyll a (mg/m3)	26.7	15
Horse Creek at Goose Pond Road	HCSW-2	10/12/2017	Chlorophyll a (mg/m3)	15.5	15
Horse Creek at State Road 70	HCSW-3	8/30/2004	Chlorophyll a (mg/m3)	38	15
Horse Creek at State Road 70	HCSW-3	4/27/2006	Dissolved Calcium (mg/L)	110	100
Horse Creek at State Road 70	HCSW-3	6/29/2006	Dissolved Calcium (mg/L)	110	100
Horse Creek at State Road 70	HCSW-3	4/25/2007	Dissolved Calcium (mg/L)	110	100
Horse Creek at State Road 70	HCSW-3	5/16/2007	Dissolved Calcium (mg/L)	110	100
Horse Creek at State Road 70	HCSW-3	6/20/2007	Dissolved Calcium (mg/L)	140	100
Horse Creek at State Road 70	HCSW-3	4/2/2012	Dissolved Calcium (mg/L)	114	100
Horse Creek at State Road 70	HCSW-3	4/2/2013	Dissolved Calcium (mg/L)	123	100
Horse Creek at State Road 70	HCSW-3	5/1/2013	Dissolved Calcium (mg/L)	105	100
Horse Creek at State Road 72	HCSW-4	5/25/2006	Dissolved Calcium (mg/L)	110	100
Horse Creek at State Road 72	HCSW-4	6/29/2006	Dissolved Calcium (mg/L)	190	100
Horse Creek at State Road 72	HCSW-4	12/13/2006	Dissolved Calcium (mg/L)	110	100
Horse Creek at State Road 72	HCSW-4	6/20/2007	Dissolved Calcium (mg/L)	110	100
Horse Creek at State Road 72	HCSW-4	3/27/2008	Dissolved Calcium (mg/L)	120	100
Horse Creek at State Road 72	HCSW-4	5/29/2008	Dissolved Calcium (mg/L)	110	100
Horse Creek at State Road 72	HCSW-4	2/2/2009	Dissolved Calcium (mg/L)	106	100
Horse Creek at State Road 72	HCSW-4	6/3/2009	Dissolved Calcium (mg/L)	119	100
Horse Creek at State Road 72	HCSW-4	4/2/2012	Dissolved Calcium (mg/L)	117	100
Horse Creek at State Road 72	HCSW-4	5/2/2012	Dissolved Calcium (mg/L)	109	100
Horse Creek at State Road 72	HCSW-4	6/5/2012	Dissolved Calcium (mg/L)	182	100

Sampling Location	Station ID	Date	Analyte	Concentration	Trigger Level
Horse Creek at State Road 72	HCSW-4	2/3/2014	Dissolved Calcium (mg/L)	101	100
Horse Creek at State Road 72	HCSW-4	3/7/2017	Dissolved Calcium (mg/L)	105	100
Horse Creek at State Road 72	HCSW-4	4/11/2017	Dissolved Calcium (mg/L)	149	100
Horse Creek at State Road 72	HCSW-4	3/21/2018	Calcium, Dissolved (mg/L)	106	100
Horse Creek at Goose Pond Road	HCSW-2	7/27/2006	Dissolved Iron (mg/L)	1.2	1
Horse Creek at Goose Pond Road	HCSW-2	6/3/2009	Dissolved Iron (mg/L)	1.03	1
Horse Creek at State Road 72	HCSW-4	5/27/2003	Dissolved Iron (mg/L)	0.4	0.3
Horse Creek at State Road 72	HCSW-4	6/19/2003	Dissolved Iron (mg/L)	0.6	0.3
Horse Creek at State Road 72	HCSW-4	7/14/2003	Dissolved Iron (mg/L)	0.7	0.3
Horse Creek at State Road 72	HCSW-4	8/28/2003	Dissolved Iron (mg/L)	0.7	0.3
Horse Creek at State Road 72	HCSW-4	9/25/2003	Dissolved Iron (mg/L)	0.6	0.3
Horse Creek at State Road 72	HCSW-4	10/29/2003	Dissolved Iron (mg/L)	0.4	0.3
Horse Creek at State Road 72	HCSW-4	12/16/2003	Dissolved Iron (mg/L)	0.32	0.3
Horse Creek at State Road 72	HCSW-4	7/27/2004	Dissolved Iron (mg/L)	0.5	0.3
Horse Creek at State Road 72	HCSW-4	8/30/2004	Dissolved Iron (mg/L)	0.7	0.3
Horse Creek at State Road 72	HCSW-4	9/29/2004	Dissolved Iron (mg/L)	0.4	0.3
Horse Creek at State Road 72	HCSW-4	10/27/2004	Dissolved Iron (mg/L)	0.4	0.3
Horse Creek at State Road 72	HCSW-4	3/30/2005	Dissolved Iron (mg/L)	0.45	0.3
Horse Creek at State Road 72	HCSW-4	4/27/2005	Dissolved Iron (mg/L)	0.4	0.3
Horse Creek at State Road 72	HCSW-4	5/25/2005	Dissolved Iron (mg/L)	0.45	0.3
Horse Creek at State Road 72	HCSW-4	6/22/2005	Dissolved Iron (mg/L)	0.77	0.3
Horse Creek at State Road 72	HCSW-4	7/27/2005	Dissolved Iron (mg/L)	0.74	0.3
Horse Creek at State Road 72	HCSW-4	8/23/2005	Dissolved Iron (mg/L)	0.58	0.3
Horse Creek at State Road 72	HCSW-4	9/29/2005	Dissolved Iron (mg/L)	0.44	0.3

Sampling Location	Station ID	Date	Analyte	Concentration	Trigger Level
Horse Creek at State Road 72	HCSW-4	11/17/2005	Dissolved Iron (mg/L)	0.49	0.3
Horse Creek at State Road 72	HCSW-4	7/27/2006	Dissolved Iron (mg/L)	0.5	0.3
Horse Creek at State Road 72	HCSW-4	8/21/2006	Dissolved Iron (mg/L)	0.7	0.3
Horse Creek at State Road 72	HCSW-4	9/27/2006	Dissolved Iron (mg/L)	1	0.3
Horse Creek at State Road 72	HCSW-4	10/19/2006	Dissolved Iron (mg/L)	0.6	0.3
Horse Creek at State Road 72	HCSW-4	7/18/2007	Dissolved Iron (mg/L)	0.42	0.3
Horse Creek at State Road 72	HCSW-4	7/31/2008	Dissolved Iron (mg/L)	0.81	0.3
Horse Creek at State Road 72	HCSW-4	8/26/2008	Dissolved Iron (mg/L)	0.96	0.3
Horse Creek at State Road 72	HCSW-4	9/30/2008	Dissolved Iron (mg/L)	0.59	0.3
Horse Creek at State Road 72	HCSW-4	10/16/2008	Dissolved Iron (mg/L)	0.64	0.3
Horse Creek at State Road 72	HCSW-4	7/8/2009	Dissolved Iron (mg/L)	0.483	0.3
Horse Creek at State Road 72	HCSW-4	8/5/2009	Dissolved Iron (mg/L)	0.567	0.3
Horse Creek at State Road 72	HCSW-4	9/2/2009	Dissolved Iron (mg/L)	0.603	0.3
Horse Creek at State Road 72	HCSW-4	10/7/2009	Dissolved Iron (mg/L)	0.527	0.3
Horse Creek at State Road 72	HCSW-4	4/6/2010	Dissolved Iron (mg/L)	0.615	0.3
Horse Creek at State Road 72	HCSW-4	7/12/2010	Dissolved Iron (mg/L)	0.719	0.3
Horse Creek at State Road 72	HCSW-4	8/3/2010	Dissolved Iron (mg/L)	0.321	0.3
Horse Creek at State Road 72	HCSW-4	9/8/2010	Dissolved Iron (mg/L)	0.421	0.3
Horse Creek at State Road 72	HCSW-4	8/16/2011	Dissolved Iron (mg/L)	0.325	0.3
Horse Creek at State Road 72	HCSW-4	9/7/2011	Dissolved Iron (mg/L)	0.506	0.3
Horse Creek at State Road 72	HCSW-4	10/24/2011	Dissolved Iron (mg/L)	0.36	0.3
Horse Creek at State Road 72	HCSW-4	7/5/2012	Dissolved Iron (mg/L)	0.779	0.3
Horse Creek at State Road 72	HCSW-4	8/2/2012	Dissolved Iron (mg/L)	0.531	0.3
Horse Creek at State Road 72	HCSW-4	9/5/2012	Dissolved Iron (mg/L)	0.604	0.3
Horse Creek at State Road 72	HCSW-4	10/10/2012	Dissolved Iron (mg/L)	0.508	0.3

Sampling Location	Station ID	Date	Analyte	Concentration	Trigger Level
Horse Creek at State Road 72	HCSW-4	7/2/2013	Dissolved Iron (mg/L)	0.433	0.3
Horse Creek at State Road 72	HCSW-4	8/1/2013	Dissolved Iron (mg/L)	0.378	0.3
Horse Creek at State Road 72	HCSW-4	9/4/2013	Dissolved Iron (mg/L)	0.351	0.3
Horse Creek at State Road 72	HCSW-4	10/1/2013	Dissolved Iron (mg/L)	0.569	0.3
Horse Creek at State Road 72	HCSW-4	10/6/2014	Dissolved Iron (mg/L)	0.592	0.3
Horse Creek at State Road 72	HCSW-4	8/6/2015	Dissolved Iron (mg/L)	0.5	0.3
Horse Creek at State Road 72	HCSW-4	9/2/2015	Dissolved Iron (mg/L)	0.495	0.3
Horse Creek at State Road 72	HCSW-4	10/5/2015	Dissolved Iron (mg/L)	0.345	0.3
Horse Creek at State Road 72	HCSW-4	7/7/2016	Dissolved Iron (mg/L)	0.318	0.3
Horse Creek at State Road 72	HCSW-4	8/4/2016	Dissolved Iron (mg/L)	0.354	0.3
Horse Creek at State Road 72	HCSW-4	9/8/2016	Dissolved Iron (mg/L)	0.439	0.3
Horse Creek at State Road 72	HCSW-4	6/19/2017	Dissolved Iron (mg/L)	0.514	0.3
Horse Creek at State Road 72	HCSW-4	7/17/2017	Dissolved Iron (mg/L)	0.641	0.3
Horse Creek at State Road 72	HCSW-4	8/14/2017	Dissolved Iron (mg/L)	0.715	0.3
Horse Creek at State Road 72	HCSW-4	9/25/2017	Dissolved Iron (mg/L)	0.596	0.3
Horse Creek at State Road 72	HCSW-4	10/12/2017	Dissolved Iron (mg/L)	0.409	0.3
Horse Creek at State Road 72	HCSW-4	5/24/2018	Dissolved Iron (mg/L)	0.651	0.3
Horse Creek at State Road 72	HCSW-4	6/20/2018	Dissolved Iron (mg/L)	0.581	0.3
Horse Creek at State Road 72	HCSW-4	7/11/2018	Dissolved Iron (mg/L)	0.518	0.3
Horse Creek at State Road 72	HCSW-4	8/2/2018	Dissolved Iron (mg/L)	0.461	0.3
Horse Creek at State Road 72	HCSW-4	9/6/2018	Dissolved Iron (mg/L)	0.460	0.3
Horse Creek at State Road 72	HCSW-4	10/2/2018	Dissolved Iron (mg/L)	0.309	0.3
Horse Creek at State Road 64	HCSW-1	4/25/2007	Alkalinity (mg/L)	120	100
Horse Creek at State Road 64	HCSW-1	5/16/2007	Alkalinity (mg/L)	170	100

Sampling Location	Station ID	Date	Analyte	Concentration	Trigger Level
Horse Creek at State Road 64	HCSW-1	6/20/2007	Alkalinity (mg/L)	140	100
Horse Creek at State Road 64	HCSW-1	1/5/2010	Alkalinity (mg/L)	109	100
Horse Creek at State Road 64	HCSW-1	10/24/2011	Alkalinity (mg/L)	102	100
Horse Creek at State Road 64	HCSW-1	11/6/2012	Alkalinity (mg/L)	100.3	100
Horse Creek at State Road 64	HCSW-1	12/3/2015	Alkalinity (mg/L)	104	100
Horse Creek at State Road 64	HCSW-1	12/13/2016	Alkalinity (mg/L)	116	100
Horse Creek at State Road 64	HCSW-1	2/15/2017	Alkalinity (mg/L)	152	100
Horse Creek at State Road 64	HCSW-1	3/7/2017	Alkalinity (mg/L)	161	100
Horse Creek at State Road 64	HCSW-1	4/11/2017	Alkalinity (mg/L)	200	100
Horse Creek at State Road 64	HCSW-1	12/6/2017	Alkalinity (mg/L)	120	100
Horse Creek at State Road 72	HCSW-4	5/25/2006	Alkalinity (mg/L)	120	100
Horse Creek at State Road 72	HCSW-4	5/4/2009	Alkalinity (mg/L)	112	100
Horse Creek at State Road 72	HCSW-4	6/8/2011	Alkalinity (mg/L)	1223	100
Horse Creek at State Road 72	HCSW-4	5/2/2012	Alkalinity (mg/L)	147.5	100
Horse Creek at State Road 64	HCSW-1	4/18/2018	Alkalinity (mg/L)	120	100
Horse Creek at State Road 72	HCSW-4	1/23/2007	Fluoride (mg/L)	2.5	1.5
Horse Creek at State Road 72	HCSW-4	2/14/2007	Fluoride (mg/L)	2.5	1.5
Horse Creek at State Road 72	HCSW-4	3/14/2007	Fluoride (mg/L)	5	1.5
Horse Creek at State Road 70	HCSW-3	3/28/2006	Sulfate (mg/L)	300	250
Horse Creek at State Road 70	HCSW-3	4/27/2006	Sulfate (mg/L)	420	250
Horse Creek at State Road 70	HCSW-3	6/29/2006	Sulfate (mg/L)	430	250
Horse Creek at State Road 70	HCSW-3	5/16/2007	Sulfate (mg/L)	360	250
Horse Creek at State Road 70	HCSW-3	6/20/2007	Sulfate (mg/L)	440	250
Horse Creek at State Road 70	HCSW-3	6/26/2008	Sulfate (mg/L)	251	250

Sampling Location	Station ID	Date	Analyte	Concentration	Trigger Level
Horse Creek at State Road 70	HCSW-3	2/2/2009	Sulfate (mg/L)	280	250
Horse Creek at State Road 70	HCSW-3	4/1/2009	Sulfate (mg/L)	293	250
Horse Creek at State Road 70	HCSW-3	6/3/2009	Sulfate (mg/L)	251	250
Horse Creek at State Road 70	HCSW-3	2/2/2012	Sulfate (mg/L)	254	250
Horse Creek at State Road 70	HCSW-3	3/5/2012	Sulfate (mg/L)	287	250
Horse Creek at State Road 70	HCSW-3	4/2/2012	Sulfate (mg/L)	365	250
Horse Creek at State Road 70	HCSW-3	6/5/2012	Sulfate (mg/L)	304	250
Horse Creek at State Road 70	HCSW-3	3/6/2013	Sulfate (mg/L)	319	250
Horse Creek at State Road 70	HCSW-3	4/2/2013	Sulfate (mg/L)	400	250
Horse Creek at State Road 70	HCSW-3	5/1/2013	Sulfate (mg/L)	373	250
Horse Creek at State Road 70	HCSW-3	6/4/2013	Sulfate (mg/L)	363	250
Horse Creek at State Road 70	HCSW-3	1/2/2014	Sulfate (mg/L)	282	250
Horse Creek at State Road 70	HCSW-3	6/3/2015	Sulfate (mg/L)	316	250
Horse Creek at State Road 70	HCSW-3	3/7/2017	Sulfate (mg/L)	266	250
Horse Creek at State Road 70	HCSW-3	4/11/2017	Sulfate (mg/L)	278	250
Horse Creek at State Road 72	HCSW-4	6/29/2004	Sulfate (mg/l)	261	250
Horse Creek at State Road 72	HCSW-4	3/28/2006	Sulfate (mg/L)	300	250
Horse Creek at State Road 72	HCSW-4	5/25/2006	Sulfate (mg/L)	310	250
Horse Creek at State Road 72	HCSW-4	6/29/2006	Sulfate (mg/L)	780	250
Horse Creek at State Road 72	HCSW-4	12/13/2006	Sulfate (mg/L)	290	250
Horse Creek at State Road 72	HCSW-4	6/20/2007	Sulfate (mg/L)	320	250
Horse Creek at State Road 72	HCSW-4	3/27/2008	Sulfate (mg/L)	390	250
Horse Creek at State Road 72	HCSW-4	5/29/2008	Sulfate (mg/L)	290	250
Horse Creek at State Road 72	HCSW-4	6/26/2008	Sulfate (mg/L)	287	250
Horse Creek at State Road 72	HCSW-4	2/2/2009	Sulfate (mg/L)	290	250

Sampling Location	Station ID	Date	Analyte	Concentration	Trigger Level
Horse Creek at State Road 72	HCSW-4	6/3/2009	Sulfate (mg/L)	391	250
Horse Creek at State Road 72	HCSW-4	12/2/2009	Sulfate (mg/L)	279	250
Horse Creek at State Road 72	HCSW-4	11/3/2010	Sulfate (mg/L)	258	250
Horse Creek at State Road 72	HCSW-4	1/4/2011	Sulfate (mg/L)	262	250
Horse Creek at State Road 72	HCSW-4	7/5/2011	Sulfate (mg/L)	253	250
Horse Creek at State Road 72	HCSW-4	3/5/2012	Sulfate (mg/L)	267	250
Horse Creek at State Road 72	HCSW-4	4/2/2012	Sulfate (mg/L)	321	250
Horse Creek at State Road 72	HCSW-4	6/5/2012	Sulfate (mg/L)	665	250
Horse Creek at State Road 72	HCSW-4	2/7/2013	Sulfate (mg/L)	251	250
Horse Creek at State Road 72	HCSW-4	3/6/2013	Sulfate (mg/L)	267	250
Horse Creek at State Road 72	HCSW-4	5/1/2013	Sulfate (mg/L)	292	250
Horse Creek at State Road 72	HCSW-4	6/4/2013	Sulfate (mg/L)	383	250
Horse Creek at State Road 72	HCSW-4	12/3/2013	Sulfate (mg/L)	267	250
Horse Creek at State Road 72	HCSW-4	1/2/2014	Sulfate (mg/L)	333	250
Horse Creek at State Road 72	HCSW-4	2/3/2014	Sulfate (mg/L)	404	250
Horse Creek at State Road 72	HCSW-4	6/3/2014	Sulfate (mg/L)	389	250
Horse Creek at State Road 72	HCSW-4	3/7/2017	Sulfate (mg/L)	335	250
Horse Creek at State Road 72	HCSW-4	4/11/2017	Sulfate (mg/L)	482	250
Horse Creek at State Road 70	HCSW-3	4/18/2018	Sulfate (mg/L)	290	250
Horse Creek at State Road 72	HCSW-4	3/21/2018	Sulfate (mg/L)	355	250
Horse Creek at State Road 64	HCSW-1	4/11/2017	TDS (mg/L)	524	500
Horse Creek at State Road 70	HCSW-3	4/27/2006	TDS (mg/L)	580	500
Horse Creek at State Road 70	HCSW-3	6/29/2006	TDS (mg/L)	590	500
Horse Creek at State Road 70	HCSW-3	4/25/2007	TDS (mg/L)	590	500

Sampling Location	Station ID	Date	Analyte	Concentration	Trigger Level
Horse Creek at State Road 70	HCSW-3	5/16/2007	TDS (mg/L)	530	500
Horse Creek at State Road 70	HCSW-3	6/20/2007	TDS (mg/L)	700	500
Horse Creek at State Road 70	HCSW-3	7/18/2007	TDS (mg/L)	520	500
Horse Creek at State Road 70	HCSW-3	6/26/2008	TDS (mg/L)	580	500
Horse Creek at State Road 70	HCSW-3	2/2/2009	TDS (mg/L)	520	500
Horse Creek at State Road 70	HCSW-3	4/1/2009	TDS (mg/L)	568	500
Horse Creek at State Road 70	HCSW-3	6/3/2009	TDS (mg/L)	540	500
Horse Creek at State Road 70	HCSW-3	12/2/2009	TDS (mg/L)	524	500
Horse Creek at State Road 70	HCSW-3	1/4/2011	TDS (mg/L)	513	500
Horse Creek at State Road 70	HCSW-3	12/21/2011	TDS (mg/L)	543	500
Horse Creek at State Road 70	HCSW-3	1/12/2012	TDS (mg/L)	571	500
Horse Creek at State Road 70	HCSW-3	2/2/2012	TDS (mg/L)	532	500
Horse Creek at State Road 70	HCSW-3	3/5/2012	TDS (mg/L)	603	500
Horse Creek at State Road 70	HCSW-3	4/2/2012	TDS (mg/L)	714	500
Horse Creek at State Road 70	HCSW-3	6/5/2012	TDS (mg/L)	646	500
Horse Creek at State Road 70	HCSW-3	3/6/2013	TDS (mg/L)	643	500
Horse Creek at State Road 70	HCSW-3	4/2/2013	TDS (mg/L)	818	500
Horse Creek at State Road 70	HCSW-3	5/1/2013	TDS (mg/L)	648	500
Horse Creek at State Road 70	HCSW-3	6/4/2013	TDS (mg/L)	675	500
Horse Creek at State Road 70	HCSW-3	12/3/2013	TDS (mg/L)	528	500
Horse Creek at State Road 70	HCSW-3	6/3/2014	TDS (mg/L)	548	500
Horse Creek at State Road 70	HCSW-3	7/1/2014	TDS (mg/L)	518	500
Horse Creek at State Road 70	HCSW-3	3/7/2017	TDS (mg/L)	536	500
Horse Creek at State Road 70	HCSW-3	4/11/2017	TDS (mg/L)	527	500
Horse Creek at State Road 72	HCSW-4	3/28/2006	TDS (mg/L)	600	500

Sampling Location	Station ID	Date	Analyte	Concentration	Trigger Level
Horse Creek at State Road 72	HCSW-4	5/25/2006	TDS (mg/L)	560	500
Horse Creek at State Road 72	HCSW-4	6/29/2006	TDS (mg/L)	1100	500
Horse Creek at State Road 72	HCSW-4	11/9/2006	TDS (mg/L)	510	500
Horse Creek at State Road 72	HCSW-4	12/13/2006	TDS (mg/L)	550	500
Horse Creek at State Road 72	HCSW-4	6/20/2007	TDS (mg/L)	600	500
Horse Creek at State Road 72	HCSW-4	7/18/2007	TDS (mg/L)	530	500
Horse Creek at State Road 72	HCSW-4	1/30/2008	TDS (mg/L)	550	500
Horse Creek at State Road 72	HCSW-4	3/27/2008	TDS (mg/L)	660	500
Horse Creek at State Road 72	HCSW-4	5/29/2008	TDS (mg/L)	710	500
Horse Creek at State Road 72	HCSW-4	6/26/2008	TDS (mg/L)	644	500
Horse Creek at State Road 72	HCSW-4	2/2/2009	TDS (mg/L)	536	500
Horse Creek at State Road 72	HCSW-4	6/3/2009	TDS (mg/L)	692	500
Horse Creek at State Road 72	HCSW-4	12/2/2009	TDS (mg/L)	604	500
Horse Creek at State Road 72	HCSW-4	11/3/2010	TDS (mg/L)	577	500
Horse Creek at State Road 72	HCSW-4	1/4/2011	TDS (mg/L)	574	500
Horse Creek at State Road 72	HCSW-4	7/5/2011	TDS (mg/L)	660	500
Horse Creek at State Road 72	HCSW-4	12/21/2011	TDS (mg/L)	543	500
Horse Creek at State Road 72	HCSW-4	1/12/2012	TDS (mg/L)	569	500
Horse Creek at State Road 72	HCSW-4	2/2/2012	TDS (mg/L)	512	500
Horse Creek at State Road 72	HCSW-4	3/5/2012	TDS (mg/L)	585	500
Horse Creek at State Road 72	HCSW-4	4/2/2012	TDS (mg/L)	688	500
Horse Creek at State Road 72	HCSW-4	5/2/2012	TDS (mg/L)	536	500
Horse Creek at State Road 72	HCSW-4	6/5/2012	TDS (mg/L)	1,320	500
Horse Creek at State Road 72	HCSW-4	3/6/2013	TDS (mg/L)	660	500
Horse Creek at State Road 72	HCSW-4	4/2/2013	TDS (mg/L)	595	500

Sampling Location	Station ID	Date	Analyte	Concentration	Trigger Level
Horse Creek at State Road 72	HCSW-4	5/1/2013	TDS (mg/L)	614	500
Horse Creek at State Road 72	HCSW-4	6/4/2013	TDS (mg/L)	687	500
Horse Creek at State Road 72	HCSW-4	12/3/2013	TDS (mg/L)	617	500
Horse Creek at State Road 72	HCSW-4	1/2/2014	TDS (mg/L)	601	500
Horse Creek at State Road 72	HCSW-4	2/3/2014	TDS (mg/L)	799	500
Horse Creek at State Road 72	HCSW-4	4/1/2014	TDS (mg/L)	555	500
Horse Creek at State Road 72	HCSW-4	5/1/2014	TDS (mg/L)	544	500
Horse Creek at State Road 72	HCSW-4	6/3/2014	TDS (mg/L)	715	500
Horse Creek at State Road 72	HCSW-4	7/1/2014	TDS (mg/L)	580	500
Horse Creek at State Road 72	HCSW-4	4/8/2015	TDS (mg/L)	521	500
Horse Creek at State Road 72	HCSW-4	5/11/2015	TDS (mg/L)	571	500
Horse Creek at State Road 72	HCSW-4	6/3/2015	TDS (mg/L)	504	500
Horse Creek at State Road 72	HCSW-4	3/7/2017	TDS (mg/L)	635	500
Horse Creek at State Road 72	HCSW-4	4/11/2017	TDS (mg/L)	853	500
Horse Creek at State Road 70	HCSW-3	1/17/2018	TDS (mg/L)	742	500
Horse Creek at State Road 70	HCSW-3	4/18/2018	TDS (mg/L)	604	500
Horse Creek at State Road 72	HCSW-4	1/17/2018	TDS (mg/L)	520	500
Horse Creek at State Road 72	HCSW-4	3/21/2018	TDS (mg/L)	697F[1]	500
Horse Creek at Goose Pond Road	HCSW-2	7/27/2004	Radium (pCi/l)	5.1	5

Note: Dissolved oxygen (% Saturation) is the new Horse Creek Stewardship Program (HCSP)trigger parameter and it is the Class III water quality standard as of 2013. The standard listed for percent saturation in this table is adjusted for time-of-day.

[1] F- Indicates that the analyte was detected in the sample as well as the field blank.

Table F-2 List of exceedances for parameters no longer monitored or trigger levels no longer used for HCSP evaluation.

Sampling Location	Station ID	Date	Analyte	Concentration	Trigger Level
Horse Creek at State Road 64	HCSW-1	8/30/2004	Dissolved Oxygen (mg/l)	4.3	5
Horse Creek at State Road 64	HCSW-1	9/29/2004	Dissolved Oxygen (mg/l)	4.5	5
Horse Creek at State Road 64	HCSW-1	4/27/2006	Dissolved Oxygen (mg/l)	3.1	5
Horse Creek at State Road 64	HCSW-1	8/1/2013	Dissolved Oxygen (mg/l)	4.56	5
Horse Creek at Goose Pond Road	HCSW-2	4/30/2003	Dissolved Oxygen (mg/l)	1	5
Horse Creek at Goose Pond Road	HCSW-2	5/27/2003	Dissolved Oxygen (mg/l)	1.3	5
Horse Creek at Goose Pond Road	HCSW-2	6/19/2003	Dissolved Oxygen (mg/l)	1.1	5
Horse Creek at Goose Pond Road	HCSW-2	7/14/2003	Dissolved Oxygen (mg/l)	1.7	5
Horse Creek at Goose Pond Road	HCSW-2	8/28/2003	Dissolved Oxygen (mg/l)	3	5
Horse Creek at Goose Pond Road	HCSW-2	9/25/2003	Dissolved Oxygen (mg/l)	1.3	5
Horse Creek at Goose Pond Road	HCSW-2	10/29/2003	Dissolved Oxygen (mg/l)	2.9	5
Horse Creek at Goose Pond Road	HCSW-2	11/20/2003	Dissolved Oxygen (mg/l)	2.8	5
Horse Creek at Goose Pond Road	HCSW-2	12/16/2003	Dissolved Oxygen (mg/l)	4.1	5
Horse Creek at Goose Pond Road	HCSW-2	1/29/2004	Dissolved Oxygen (mg/l)	5	5
Horse Creek at Goose Pond Road	HCSW-2	2/24/2004	Dissolved Oxygen (mg/l)	3.6	5
Horse Creek at Goose Pond Road	HCSW-2	3/16/2004	Dissolved Oxygen (mg/l)	3.7	5
Horse Creek at Goose Pond Road	HCSW-2	5/26/2004	Dissolved Oxygen (mg/l)	3.1	5
Horse Creek at Goose Pond Road	HCSW-2	6/29/2004	Dissolved Oxygen (mg/l)	1.6	5
Horse Creek at Goose Pond Road	HCSW-2	7/27/2004	Dissolved Oxygen (mg/l)	0.3	5
Horse Creek at Goose Pond Road	HCSW-2	8/30/2004	Dissolved Oxygen (mg/l)	0.14	5
Horse Creek at Goose Pond Road	HCSW-2	9/29/2004	Dissolved Oxygen (mg/l)	1.4	5
Horse Creek at Goose Pond Road	HCSW-2	10/27/2004	Dissolved Oxygen (mg/l)	0.7	5
Horse Creek at Goose Pond Road	HCSW-2	11/18/2004	Dissolved Oxygen (mg/l)	2.8	5

Sampling Location	Station ID	Date	Analyte	Concentration	Trigger Level
Horse Creek at Goose Pond Road	HCSW-2	12/15/2004	Dissolved Oxygen (mg/l)	4.7	5
Horse Creek at Goose Pond Road	HCSW-2	1/26/2005	Dissolved Oxygen (mg/l)	4.1	5
Horse Creek at Goose Pond Road	HCSW-2	2/24/2005	Dissolved Oxygen (mg/l)	3.5	5
Horse Creek at Goose Pond Road	HCSW-2	3/30/2005	Dissolved Oxygen (mg/l)	2.6	5
Horse Creek at Goose Pond Road	HCSW-2	5/27/2005	Dissolved Oxygen (mg/l)	2	5
Horse Creek at Goose Pond Road	HCSW-2	6/22/2005	Dissolved Oxygen (mg/l)	1.4	5
Horse Creek at Goose Pond Road	HCSW-2	7/27/2005	Dissolved Oxygen (mg/l)	1.1	5
Horse Creek at Goose Pond Road	HCSW-2	8/23/2005	Dissolved Oxygen (mg/l)	1.7	5
Horse Creek at Goose Pond Road	HCSW-2	9/29/2005	Dissolved Oxygen (mg/l)	2.3	5
Horse Creek at Goose Pond Road	HCSW-2	10/27/2005	Dissolved Oxygen (mg/l)	4.6	5
Horse Creek at Goose Pond Road	HCSW-2	11/17/2005	Dissolved Oxygen (mg/l)	2.8	5
Horse Creek at Goose Pond Road	HCSW-2	12/20/2005	Dissolved Oxygen (mg/l)	4.4	5
Horse Creek at Goose Pond Road	HCSW-2	2/23/2006	Dissolved Oxygen (mg/l)	3.4	5
Horse Creek at Goose Pond Road	HCSW-2	5/25/2006	Dissolved Oxygen (mg/l)	4.9	5
Horse Creek at Goose Pond Road	HCSW-2	7/27/2006	Dissolved Oxygen (mg/l)	0.5	5
Horse Creek at Goose Pond Road	HCSW-2	9/27/2006	Dissolved Oxygen (mg/l)	1.3	5
Horse Creek at Goose Pond Road	HCSW-2	10/19/2006	Dissolved Oxygen (mg/l)	1.6	5
Horse Creek at Goose Pond Road	HCSW-2	11/9/2006	Dissolved Oxygen (mg/l)	2.9	5
Horse Creek at Goose Pond Road	HCSW-2	12/13/2006	Dissolved Oxygen (mg/l)	3.8	5
Horse Creek at Goose Pond Road	HCSW-2	1/23/2007	Dissolved Oxygen (mg/l)	3.38	5
Horse Creek at Goose Pond Road	HCSW-2	3/14/2007	Dissolved Oxygen (mg/l)	4.06	5
Horse Creek at Goose Pond Road	HCSW-2	4/25/2007	Dissolved Oxygen (mg/l)	4.6	5
Horse Creek at Goose Pond Road	HCSW-2	8/27/2007	Dissolved Oxygen (mg/l)	2.03	5
Horse Creek at Goose Pond Road	HCSW-2	9/26/2007	Dissolved Oxygen (mg/l)	0.86	5

Sampling Location	Station ID	Date	Analyte	Concentration	Trigger Level
Horse Creek at Goose Pond Road	HCSW-2	10/29/2007	Dissolved Oxygen (mg/l)	1.08	5
Horse Creek at Goose Pond Road	HCSW-2	11/29/2007	Dissolved Oxygen (mg/l)	1.53	5
Horse Creek at Goose Pond Road	HCSW-2	12/17/2007	Dissolved Oxygen (mg/l)	2.13	5
Horse Creek at Goose Pond Road	HCSW-2	1/30/2008	Dissolved Oxygen (mg/l)	3.34	5
Horse Creek at Goose Pond Road	HCSW-2	2/26/2008	Dissolved Oxygen (mg/l)	1.65	5
Horse Creek at Goose Pond Road	HCSW-2	3/27/2008	Dissolved Oxygen (mg/l)	4.21	5
Horse Creek at Goose Pond Road	HCSW-2	4/23/2008	Dissolved Oxygen (mg/l)	1.77	5
Horse Creek at Goose Pond Road	HCSW-2	5/29/2008	Dissolved Oxygen (mg/l)	2.33	5
Horse Creek at Goose Pond Road	HCSW-2	6/26/2008	Dissolved Oxygen (mg/l)	1.41	5
Horse Creek at Goose Pond Road	HCSW-2	7/31/2008	Dissolved Oxygen (mg/l)	0.74	5
Horse Creek at Goose Pond Road	HCSW-2	8/26/2008	Dissolved Oxygen (mg/l)	0.13	5
Horse Creek at Goose Pond Road	HCSW-2	9/30/2008	Dissolved Oxygen (mg/l)	1.27	5
Horse Creek at Goose Pond Road	HCSW-2	10/16/2008	Dissolved Oxygen (mg/l)	0.19	5
Horse Creek at Goose Pond Road	HCSW-2	11/12/2008	Dissolved Oxygen (mg/l)	1.29	5
Horse Creek at Goose Pond Road	HCSW-2	12/4/2008	Dissolved Oxygen (mg/l)	3.04	5
Horse Creek at Goose Pond Road	HCSW-2	1/5/2009	Dissolved Oxygen (mg/l)	2.29	5
Horse Creek at Goose Pond Road	HCSW-2	2/2/2009	Dissolved Oxygen (mg/l)	2.38	5
Horse Creek at Goose Pond Road	HCSW-2	3/4/2009	Dissolved Oxygen (mg/l)	3.35	5
Horse Creek at Goose Pond Road	HCSW-2	4/1/2009	Dissolved Oxygen (mg/l)	2.49	5
Horse Creek at Goose Pond Road	HCSW-2	7/8/2009	Dissolved Oxygen (mg/l)	0.61	5
Horse Creek at Goose Pond Road	HCSW-2	8/5/2009	Dissolved Oxygen (mg/l)	1.21	5
Horse Creek at Goose Pond Road	HCSW-2	9/2/2009	Dissolved Oxygen (mg/l)	1.5	5
Horse Creek at Goose Pond Road	HCSW-2	10/7/2009	Dissolved Oxygen (mg/l)	0.34	5
Horse Creek at Goose Pond Road	HCSW-2	11/3/2009	Dissolved Oxygen (mg/l)	1.78	5

Sampling Location	Station ID	Date	Analyte	Concentration	Trigger Level
Horse Creek at Goose Pond Road	HCSW-2	12/2/2009	Dissolved Oxygen (mg/l)	1.98	5
Horse Creek at Goose Pond Road	HCSW-2	2/2/2010	Dissolved Oxygen (mg/l)	2.67	5
Horse Creek at Goose Pond Road	HCSW-2	3/3/2010	Dissolved Oxygen (mg/l)	3.75	5
Horse Creek at Goose Pond Road	HCSW-2	4/6/2010	Dissolved Oxygen (mg/l)	1.42	5
Horse Creek at Goose Pond Road	HCSW-2	5/5/2010	Dissolved Oxygen (mg/l)	0.56	5
Horse Creek at Goose Pond Road	HCSW-2	6/2/2010	Dissolved Oxygen (mg/l)	0.6	5
Horse Creek at Goose Pond Road	HCSW-2	7/12/2010	Dissolved Oxygen (mg/l)	0.62	5
Horse Creek at Goose Pond Road	HCSW-2	8/3/2010	Dissolved Oxygen (mg/l)	0.56	5
Horse Creek at Goose Pond Road	HCSW-2	9/8/2010	Dissolved Oxygen (mg/l)	0.72	5
Horse Creek at Goose Pond Road	HCSW-2	10/6/2010	Dissolved Oxygen (mg/l)	0.93	5
Horse Creek at Goose Pond Road	HCSW-2	11/3/2010	Dissolved Oxygen (mg/l)	1.28	5
Horse Creek at Goose Pond Road	HCSW-2	1/4/2011	Dissolved Oxygen (mg/l)	3.02	5
Horse Creek at Goose Pond Road	HCSW-2	2/3/2011	Dissolved Oxygen (mg/l)	1.47	5
Horse Creek at Goose Pond Road	HCSW-2	3/2/2001	Dissolved Oxygen (mg/l)	1.95	5
Horse Creek at Goose Pond Road	HCSW-2	4/5/2011	Dissolved Oxygen (mg/l)	0.14	5
Horse Creek at Goose Pond Road	HCSW-2	5/3/2011	Dissolved Oxygen (mg/l)	1.78	5
Horse Creek at Goose Pond Road	HCSW-2	7/5/2011	Dissolved Oxygen (mg/l)	0.89	5
Horse Creek at Goose Pond Road	HCSW-2	8/16/2011	Dissolved Oxygen (mg/l)	0.59	5
Horse Creek at Goose Pond Road	HCSW-2	9/7/2011	Dissolved Oxygen (mg/l)	0.45	5
Horse Creek at Goose Pond Road	HCSW-2	10/24/2011	Dissolved Oxygen (mg/l)	1.11	5
Horse Creek at Goose Pond Road	HCSW-2	11/29/2011	Dissolved Oxygen (mg/l)	2.7	5
Horse Creek at Goose Pond Road	HCSW-2	3/5/2012	Dissolved Oxygen (mg/l)	4.55	5
Horse Creek at Goose Pond Road	HCSW-2	5/2/2012	Dissolved Oxygen (mg/l)	3.32	5
Horse Creek at Goose Pond Road	HCSW-2	10/10/2012	Dissolved Oxygen (mg/l)	2.92	5

Sampling Location	Station ID	Date	Analyte	Concentration	Trigger Level
Horse Creek at Goose Pond Road	HCSW-2	11/6/2012	Dissolved Oxygen (mg/l)	3.95	5
Horse Creek at Goose Pond Road	HCSW-2	12/5/2012	Dissolved Oxygen (mg/l)	4.74	5
Horse Creek at Goose Pond Road	HCSW-2	1/9/2013	Dissolved Oxygen (mg/l)	4.15	5
Horse Creek at Goose Pond Road	HCSW-2	6/4/2013	Dissolved Oxygen (mg/l)	4.21	5
Horse Creek at Goose Pond Road	HCSW-2	7/2/2013	Dissolved Oxygen (mg/l)	2.01	5
Horse Creek at Goose Pond Road	HCSW-2	8/1/2013	Dissolved Oxygen (mg/l)	2	5
Horse Creek at Goose Pond Road	HCSW-2	9/4/2013	Dissolved Oxygen (mg/l)	2.48	5
Horse Creek at Goose Pond Road	HCSW-2	10/1/2013	Dissolved Oxygen (mg/l)	2.56	5
Horse Creek at Goose Pond Road	HCSW-2	11/4/2013	Dissolved Oxygen (mg/l)	3.97	5
Horse Creek at Goose Pond Road	HCSW-2	12/3/2013	Dissolved Oxygen (mg/l)	3.8	5
Horse Creek at State Road 70	HCSW-3	7/27/2004	Dissolved Oxygen (mg/l)	4.7	5
Horse Creek at State Road 70	HCSW-3	8/30/2004	Dissolved Oxygen (mg/l)	0.27	5
Horse Creek at State Road 70	HCSW-3	9/29/2004	Dissolved Oxygen (mg/l)	2.4	5
Horse Creek at State Road 70	HCSW-3	6/22/2005	Dissolved Oxygen (mg/l)	3.9	5
Horse Creek at State Road 70	HCSW-3	7/27/2005	Dissolved Oxygen (mg/l)	3.5	5
Horse Creek at State Road 70	HCSW-3	8/23/2005	Dissolved Oxygen (mg/l)	4.4	5
Horse Creek at State Road 70	HCSW-3	7/27/2006	Dissolved Oxygen (mg/l)	4.5	5
Horse Creek at State Road 70	HCSW-3	8/21/2006	Dissolved Oxygen (mg/l)	3.7	5
Horse Creek at State Road 70	HCSW-3	9/27/2006	Dissolved Oxygen (mg/l)	1.8	5
Horse Creek at State Road 70	HCSW-3	10/19/2006	Dissolved Oxygen (mg/l)	4.5	5
Horse Creek at State Road 70	HCSW-3	7/18/2007	Dissolved Oxygen (mg/l)	3.93	5
Horse Creek at State Road 70	HCSW-3	8/27/2007	Dissolved Oxygen (mg/l)	2.8	5
Horse Creek at State Road 70	HCSW-3	9/26/2007	Dissolved Oxygen (mg/l)	2.88	5
Horse Creek at State Road 70	HCSW-3	10/29/2007	Dissolved Oxygen (mg/l)	3.06	5

Sampling Location	Station ID	Date	Analyte	Concentration	Trigger Level
Horse Creek at State Road 70	HCSW-3	11/29/2007	Dissolved Oxygen (mg/l)	4.3	5
Horse Creek at State Road 70	HCSW-3	2/26/2008	Dissolved Oxygen (mg/l)	3.64	5
Horse Creek at State Road 70	HCSW-3	3/27/2008	Dissolved Oxygen (mg/l)	4.75	5
Horse Creek at State Road 70	HCSW-3	4/23/2008	Dissolved Oxygen (mg/l)	3.27	5
Horse Creek at State Road 70	HCSW-3	5/29/2008	Dissolved Oxygen (mg/l)	2.9	5
Horse Creek at State Road 70	HCSW-3	6/26/2008	Dissolved Oxygen (mg/l)	4.78	5
Horse Creek at State Road 70	HCSW-3	7/31/2008	Dissolved Oxygen (mg/l)	0.99	5
Horse Creek at State Road 70	HCSW-3	8/26/2008	Dissolved Oxygen (mg/l)	1.62	5
Horse Creek at State Road 70	HCSW-3	9/30/2008	Dissolved Oxygen (mg/l)	3.28	5
Horse Creek at State Road 70	HCSW-3	10/16/2008	Dissolved Oxygen (mg/l)	2.73	5
Horse Creek at State Road 70	HCSW-3	6/3/2009	Dissolved Oxygen (mg/l)	3.89	5
Horse Creek at State Road 70	HCSW-3	7/8/2009	Dissolved Oxygen (mg/l)	3.38	5
Horse Creek at State Road 70	HCSW-3	8/5/2009	Dissolved Oxygen (mg/l)	3.33	5
Horse Creek at State Road 70	HCSW-3	9/2/2009	Dissolved Oxygen (mg/l)	3.87	5
Horse Creek at State Road 70	HCSW-3	10/7/2009	Dissolved Oxygen (mg/l)	3.13	5
Horse Creek at State Road 70	HCSW-3	4/6/2010	Dissolved Oxygen (mg/l)	4.74	5
Horse Creek at State Road 70	HCSW-3	7/12/2010	Dissolved Oxygen (mg/l)	3.67	5
Horse Creek at State Road 70	HCSW-3	8/3/2010	Dissolved Oxygen (mg/l)	4.61	5
Horse Creek at State Road 70	HCSW-3	9/8/2010	Dissolved Oxygen (mg/l)	4.09	5
Horse Creek at State Road 70	HCSW-3	8/16/2011	Dissolved Oxygen (mg/l)	4.14	5
Horse Creek at State Road 70	HCSW-3	9/7/2011	Dissolved Oxygen (mg/l)	3.32	5
Horse Creek at State Road 70	HCSW-3	6/5/2012	Dissolved Oxygen (mg/l)	4.64	5
Horse Creek at State Road 70	HCSW-3	7/5/2012	Dissolved Oxygen (mg/l)	3.28	5
Horse Creek at State Road 70	HCSW-3	8/2/2012	Dissolved Oxygen (mg/l)	3.05	5

Sampling Location	Station ID	Date	Analyte	Concentration	Trigger Level
Horse Creek at State Road 70	HCSW-3	9/5/2012	Dissolved Oxygen (mg/l)	3.8	5
Horse Creek at State Road 70	HCSW-3	10/10/2012	Dissolved Oxygen (mg/l)	4.66	5
Horse Creek at State Road 70	HCSW-3	7/2/2013	Dissolved Oxygen (mg/l)	4.65	5
Horse Creek at State Road 70	HCSW-3	8/1/2013	Dissolved Oxygen (mg/l)	3	5
Horse Creek at State Road 70	HCSW-3	9/4/2013	Dissolved Oxygen (mg/l)	4.4	5
Horse Creek at State Road 70	HCSW-3	10/1/2013	Dissolved Oxygen (mg/l)	4.5	5
Horse Creek at State Road 72	HCSW-4	8/30/2004	Dissolved Oxygen (mg/l)	0.58	5
Horse Creek at State Road 72	HCSW-4	9/29/2004	Dissolved Oxygen (mg/l)	2.9	5
Horse Creek at State Road 72	HCSW-4	6/22/2005	Dissolved Oxygen (mg/l)	4	5
Horse Creek at State Road 72	HCSW-4	7/27/2005	Dissolved Oxygen (mg/l)	4.1	5
Horse Creek at State Road 72	HCSW-4	9/24/2006	Dissolved Oxygen (mg/l)	4.1	5
Horse Creek at State Road 72	HCSW-4	7/31/2008	Dissolved Oxygen (mg/l)	3.1	5
Horse Creek at State Road 72	HCSW-4	8/26/2008	Dissolved Oxygen (mg/l)	2.2	5
Horse Creek at State Road 72	HCSW-4	9/30/2008	Dissolved Oxygen (mg/l)	4.77	5
Horse Creek at State Road 72	HCSW-4	7/8/2009	Dissolved Oxygen (mg/l)	4.2	5
Horse Creek at State Road 72	HCSW-4	8/5/2009	Dissolved Oxygen (mg/l)	3.36	5
Horse Creek at State Road 72	HCSW-4	9/2/2009	Dissolved Oxygen (mg/l)	4.89	5
Horse Creek at State Road 72	HCSW-4	10/7/2009	Dissolved Oxygen (mg/l)	4.48	5
Horse Creek at State Road 72	HCSW-4	7/12/2010	Dissolved Oxygen (mg/l)	4.31	5
Horse Creek at State Road 72	HCSW-4	4/5/2011	Dissolved Oxygen (mg/l)	4.89	5
Horse Creek at State Road 72	HCSW-4	9/7/2011	Dissolved Oxygen (mg/l)	4.29	5
Horse Creek at State Road 72	HCSW-4	7/5/2012	Dissolved Oxygen (mg/l)	2.23	5
Horse Creek at State Road 72	HCSW-4	9/5/2012	Dissolved Oxygen (mg/l)	4.12	5
Horse Creek at State Road 72	HCSW-4	7/2/2013	Dissolved Oxygen (mg/l)	4.16	5

Sampling Location	Station ID	Date	Analyte	Concentration	Trigger Level
Horse Creek at State Road 72	HCSW-4	8/1/2013	Dissolved Oxygen (mg/l)	4.46	5
Horse Creek at State Road 72	HCSW-4	9/4/2013	Dissolved Oxygen (mg/l)	4.74	5
Horse Creek at State Road 72	HCSW-4	10/1/2013	Dissolved Oxygen (mg/l)	4.3	5
Horse Creek at State Road 64	HCSW-1	6/20/2007	Total Fatty Acids (mg/L)	1.5	0.5
Horse Creek at Goose Pond Road	HCSW-2	11/18/2004	Total Fatty Acids (mg/L)	1.1	0.5
Horse Creek at Goose Pond Road	HCSW-2	3/30/2005	Total Fatty Acids (mg/L)	0.56	0.5
Horse Creek at Goose Pond Road	HCSW-2	4/27/2005	Total Fatty Acids (mg/L)	0.53	0.5
Horse Creek at Goose Pond Road	HCSW-2	12/13/2006	Total Fatty Acids (mg/L)	1.6	0.5
Horse Creek at Goose Pond Road	HCSW-2	6/20/2007	Total Fatty Acids (mg/L)	1.6	0.5
Horse Creek at Goose Pond Road	HCSW-2	7/18/2007	Total Fatty Acids (mg/L)	0.87	0.5
Horse Creek at Goose Pond Road	HCSW-2	12/17/2007	Total Fatty Acids (mg/L)	0.88	0.5
Horse Creek at Goose Pond Road	HCSW-2	12/4/2008	Total Fatty Acids (mg/L)	0.97	0.5

Note: Dissolved oxygen (mg/L) is listed for comparison purposes because it was the trigger level from 2003-2013. Total fatty acid monitoring stopped in September 2009 when the new Brushy Creek (BCSW-1) monitoring location was added.

Appendix G

Summary of Impact Assessments from 2003 to 2018

Station	Date	Exceedance	Action Taken	Conclusions
HCSW-4	7/14/2003	Dissolved Iron	A special sampling program was carried out in August 2003 where samples were collected from three locations on Horse Creek and two tributaries, but flow conditions were very high. In October 2003, eleven stations were sampled while flow was closer to normal.	Readings appear normal for the basin, the lower trigger level at this location caused the exceedance due to differences in water class. The trigger value may be set too low at this location.
HCSW-2	8/28/2003	Dissolved Oxygen	A sampling program was attempted in August 2003 in the northern portion of the stream, but flow conditions were very high. Instead six locations including tributaries were sampled at the end of October 2003.	Low DO levels persisted at HCSW-2 due to generally low streamflow levels and a greater amount of organics than the other stations. The low levels are not due to mining upstream.
HCSW-2	4/14/2004	Chlorophyll a	A special sampling program was carried out in May 2004 where samples were taken from four upstream locations in Horse Creek (due to dry conditions of tributaries).	Elevated chlorophyll a concentrations were caused by low streamflow and the physical nature of the stream channel and not mining activities.

Station	Date	Exceedance	Action Taken	Conclusions
HCSW-4	6/29/2004	Sulfate	A special sampling program was carried out where samples were taken from nearby tributaries as well as the Horse Creek Stewardship Program (HCSP) stations during July 2004.	Nearby tributary basins have high amounts of agricultural activity (requiring irrigation) and streamflow was very low at this time which led to the elevated sulfate concentration in June 2004.
HCSW-2	7/27/2004	Total Radium	None	Blank sample results had high values, making other values suspect. No impact assessment required for July 2004, but future results should be monitored.
HCSW-1	8/30/2004	Dissolved Oxygen	None	Impact assessment deferred until the streamflow in Horse Creek are near normal for the time period the exceedance occurred (multiple hurricanes passing through region dramatically increased streamflow).
HCSW-2	8/30/2004	Dissolved Oxygen	None	Impact assessment deferred until the streamflow in Horse Creek are near normal for the time period the exceedance occurred (multiple hurricanes passing through region dramatically increased streamflow).

Station	Date	Exceedance	Action Taken	Conclusions
HCSW-3	8/30/2004	Dissolved Oxygen	None	Impact assessment deferred until the streamflow in Horse Creek are near normal for the time period the exceedance occurred (multiple hurricanes passing through region dramatically increased streamflow).
HCSW-4	8/30/2004	Dissolved Oxygen	None	Impact assessment deferred until the streamflow in Horse Creek are near normal for the time period the exceedance occurred (multiple hurricanes passing through region dramatically increased streamflow).
HCSW-2	8/30/2004	Chlorophyll a	None	Impact assessment deferred until the streamflow in Horse Creek are near normal for the time period the exceedance occurred (multiple hurricanes passing through region dramatically increased streamflow).
HCSW-3	8/30/2004	Chlorophyll a	None	Impact assessment deferred until the streamflow in Horse Creek are near normal for the time period the exceedance occurred (multiple hurricanes passing through region dramatically increased streamflow).

Station	Date	Exceedance	Action Taken	Conclusions
HCSW-2	11/18/2004	Total Fatty Acids	A special sampling program was carried out in January 2005, where three Horse Creek locations and a tributary (Brushy Creek) were sampled.	Nearby Horse Creek Prairie is likely to contribute to the elevated levels since all other stations had undetected values for fatty acids. Low streamflow and high organics in this region, not mining, were likely contributing factors.
HCSW-2	4/27/2005	Total Fatty Acids	A special sampling program was carried out in June 2005, where three Horse Creek locations and a tributary were sampled.	The exceedance is most likely caused by the surrounding habitat conditions and not impacted by mining.
HCSW-2	7/27/2006	Iron	None	Nearby Horse Creek Prairie is likely to contribute to the elevated levels since all other stations had lower iron concentrations.
HCSW-1	1/23/2007	pH	Compared measurement to Southwest Florida Water Management District (SWFWMD) measurements for the months of January and February.	Not an actual exceedance but equipment malfunction
HCSW-4	1/23/2007	pH	Compared measurement to SWFWMD measurements for the months of January and February.	Not an actual exceedance but equipment malfunction

Station	Date	Exceedance	Action Taken	Conclusions
HCSW-1	4/25/2007	Alkalinity	Statistical analysis of HCSP alkalinity and SWFWMD measurements. When alkalinity compared to streamflow, there was a weak negative correlation between the two (high alkalinity during low flow).	No evidence that high alkalinity was caused by mining but was rather a seasonal pattern caused by lower water levels and flow. Once those recovered during the wet season, the alkalinity values decreased.
HCSW-1	6/20/2007	Total Fatty Acids	Used conclusions from the FIPR on the rate of biodegradation and soil leaching of organic compounds in a controlled environment.	It was unlikely that fatty acids from mining process water are responsible for the elevated levels seen. Instead it represents the variation in naturally occurring fatty acids in Horse Creek.
HCSW-2	6/20/2007	Total Fatty Acids	Used conclusions from the FIPR on the rate of biodegradation and soil leaching of organic compounds in a controlled environment.	It was unlikely that fatty acids from mining process water are responsible for the elevated levels seen. Instead it represents the variation in naturally occurring fatty acids in Horse Creek.
HCSW-2-FD	6/20/2007	Total Nitrogen	Compared to nitrate+nitrate and TKN values from April 2003 through August at HCSP.	Elevated measurements most likely due to lab analyst or instrument error. The total nitrogen levels recorded are not corroborated by measurements taken before or after the exceedance.

Station	Date	Exceedance	Action Taken	Conclusions
HCSW-3	6/20/2007	Total Nitrogen	Compared to nitrate+nitrate and TKN values from April 2003 through August at HCSP.	Elevated measurements most likely due to lab analyst or instrument error. The total nitrogen levels recorded are not corroborated by measurements taken before or after the exceedance.
HCSW-2	7/31/2008	Ammonia	None	Elevated concentrations are either due to laboratory method change or a seasonal fluctuation in the nitrogen cycle.
HCSW-3	7/31/2008	Ammonia	None	Elevated concentrations are either due to laboratory method change or a seasonal fluctuation in the nitrogen cycle.
HCSW-4	7/31/2008	Ammonia	None	Elevated concentrations are either due to laboratory method change or a seasonal fluctuation in the nitrogen cycle.
HCSW-4	5/4/2009	Alkalinity	Statistical analysis of HCSP alkalinity and SWFWMD measurements. When alkalinity compared to rainfall, there was a strong negative correlation between the two (high alkalinity during low flow).	No evidence that high alkalinity was caused by mining but was rather a seasonal pattern caused by lower water levels, flow, and rainfall. Once those recovered during the wet season, the alkalinity values decreased.

Station	Date	Exceedance	Action Taken	Conclusions
HCSW-1	2/2/2010	Chlorophyll a	None	No connection with mining. May have been a sampling error since color, pH, and DO do not indicate a significant algal bloom causing an elevated chlorophyll a reading.
HCSW-1	1/4/2011	pH	Compared to SWFWMD measurements from December 2010 through March 2011.	Not an actual exceedance but equipment malfunction.
HCSW-3	5/3/2011	Ammonia	None	No connection with mining. Lab analyzing the data was getting back results that were ten-times higher than other labs. Split sampling conducted in October 2011, verified that it was lab error.
HCSW-1	11/6/2012	Alkalinity	None	Although National Pollutant Discharge Elimination System (NPDES) discharge occurred prior to the November 2012 alkalinity exceedance, HCSW-1 alkalinity does not show a consistent pattern of exceeding the trigger level during periods of NPDES discharge.

Station	Date	Exceedance	Action Taken	Conclusions
HCSW-4	6/19/2017	Total Nitrogen	Looked at nitrate-nitrite and TKN results as well as rainfall and streamflow prior to sampling event (no SWFWMD data available for May or July 2017).	In June 2017 there was a heavy rainfall event immediately preceding the sampling event, which increased runoff and streamflow in Horse Creek. This rainfall event, which followed an extended period of dry conditions most likely caused the much higher than normal TN concentrations at all stations, and the trigger exceedance at HCSW-4.
HCSW-1, HCSW-3, and HCSW-4	1/30/2019	TDS, Sulfate, Calcium	I. Historical analysis of TDS, calcium, and sulfate. II. Water quality field study measuring the same three parameters in neighboring streams not affected by mining vs flow. In progress. Due in fall 2019.	Historical analysis indicates TDS, sulfate, and calcium values have approached and exceeded HCSP trigger levels before levels were established and before Mosaic's outfalls were online. These exceedances also often occur when there is no discharge, long after there has been a discharge, or low stream flow conditions.

Appendix H

Summary of Trends from the 2005 to 2018 HCSP Annual Reports

Station	Year	Parameter	Trend Noted	Addressing of Trend
HCSW-1	2008	Alkalinity	increasing trend with slope of 4.58	Alkalinity was higher in the dry season and lower during times of National Pollutant Discharge Elimination System (NPDES) discharge. The trend was not shown to be linked to mining discharge. The trend is more likely linked to climate factors not completely accounted for in the Locally Estimated Scatterplot Smoothing (LOESS) smoothing with streamflow.
HCSW-1	2008	Specific Conductance	increasing trend with slope of 15.31	Specific conductivity was higher in the dry season and lower (or equal) during times of NDPES discharge. The trend was not shown to be linked to mining discharge. The trend is more likely linked to climate factors not completely accounted for in the LOESS smoothing with streamflow.
HCSW-1	2009	Alkalinity	increasing trend with slope of 4.71	As with specific conductivity, it is likely that this trend is strongly influenced by the dry conditions in 2006 to 2007, given that most of the highest alkalinity measurements are associated with periods without NPDES discharge. The estimated slopes for both stations are small compared to the historic Horse Creek Stewardship Program (HCSP) Minimum Detection Level (MDL) (≤ 1 mg/L) and/or the differences between primary and field duplicate samples (≤ 17 mg/L).
HCSW-1	2009	Dissolved Calcium	increasing trend with slope of 1.56	As with specific conductivity, it is likely that this trend is strongly influenced by the dry conditions in 2006 to 2007, given that most of the highest calcium measurements are associated with periods without NPDES discharge. The estimated slope of the trend for HCSW-1 is small compared to historic HCSP differences between primary and field duplicate samples (≤ 8.0 mg/L).
HCSW-1	2009	Chloride	slight increasing trend with slope of 0.50	As with the other dissolved ion parameters, the trend for HCSW-1 is small compared to the historic HCSP MDL (≤ 4.06 mg/L) and differences between primary and field duplicate samples (≤ 5.0 mg/L). The observed changes in chloride over time are probably related to the differences in rainfall over the course of the HCSP.
HCSW-1	2009	Orthophosphate	slight increasing trend with slope of 0.03	The slope is very small compared to historic HCSP values for laboratory Minimum Detection Limits (≤ 0.075 mg/L) or differences between primary and field duplicate samples (≤ 0.034 mg/L). Therefore, the trends at both stations are not of concern at this time and could be related to extreme differences in rainfall and streamflow within the sampling period.
HCSW-1	2009	Specific Conductance	increasing trend with slope of 16.73	It is likely that this trend is strongly influenced by the dry conditions and subsequent higher than average specific conductivity in 2006 to 2007, given that specific conductivity is greatly influenced by rainfall and most of the highest specific conductivity measurements are associated with dryer years. The estimated slope of the trend for HCSW-1 is not of concern currently because of the substantial variability in rainfall over the course of the HCSP.

Station	Year	Parameter	Trend Noted	Addressing of Trend
HCSW-1	2009	Total Dissolved Solids	increasing trend with slope of 9.46	As with the other dissolved ion parameters, the trend for HCSW-1 is small compared to differences between primary and field duplicate samples (≤ 44 mg/L). The observed changes in TDS over time are probably related to the differences in rainfall over the course of the HCSP.
HCSW-1	2010	pH	slight increasing trend with slope of 0.06	2010 Impact Assessment concluded that estimated slope was too small to be ecologically significant.
HCSW-1	2010	Fluoride	slight increasing trend with slope of 0.01	
HCSW-1	2010	Ammonia	slight decreasing trend with slope of -0.002	2010 Impact Assessment concluded that estimated slope was in the opposite direction of adverse change.
HCSW-1	2010	Orthophosphate	slight increasing trend with slope of 0.27	2010 Impact Assessment found that the evident trend was caused by a data bias and extending the period of record before 2003 caused the trend to no longer be valid. Concentrations in 2008-2010 were similar to those before 2003.
HCSW-1	2010	Specific Conductance	increasing trend with slope of 16.68	2010 Impact Assessment found step-change in specific conductivity and dissolved ions likely caused by increased groundwater contributions from 2006-2008 drought and subsequent influence from Wingate dredge mining outfall discharge. Concentrations after 2008 remain relatively steady, with no evidence of biological impact.
HCSW-1	2010	Alkalinity	increasing trend with slope of 4.19	
HCSW-1	2010	Dissolved Calcium	increasing trend with slope of 1.60	
HCSW-1	2010	TDS	increasing trend with slope of 10.66	
HCSW-1	2011	pH	slight increasing trend with slope of 0.05	2011 Impact Assessment concluded that estimated slope was too small to be ecologically significant.
HCSW-1	2011	Fluoride	slight increasing trend with slope of 0.01	
HCSW-1	2011	Ammonia	slight decreasing trend with slope of -0.002	2011 Impact Assessment concluded that estimated slope was in the opposite direction of adverse change.
HCSW-1	2011	Dissolved Iron	slight decreasing trend with slope of -0.02	
HCSW-1	2011	Orthophosphate	slight increasing trend with slope of 0.02	2011 Impact Assessment found that the evident trend was caused by a data bias and extending the period of record before 2003 caused the trend to no longer be valid. Concentrations in 2008-2011 were similar to those before 2003.

Station	Year	Parameter	Trend Noted	Addressing of Trend
HCSW-1	2011	Specific Conductance	increasing trend with slope of 14.57	2011 Impact Assessment found step-change in specific conductivity and dissolved ions likely caused by increased groundwater contributions from 2006-2008 drought and subsequent influence from Wingate dredge mining outfall discharge. Concentrations after 2008 remain relatively steady, with no evidence of biological impact.
HCSW-1	2011	Alkalinity	increasing trend with slope of 3.91	
HCSW-1	2011	Dissolved Calcium	increasing trend with slope of 1.37	
HCSW-1	2011	Sulfate	Increasing trend with slope of 2.82	
HCSW-1	2011	Total Dissolved Solids	increasing trend with slope of 9.65	
HCSW-1	2012	pH	slight increasing trend with slope of 0.05	2012 Impact Assessment concluded that estimated slope was too small to be ecologically significant.
HCSW-1	2012	Color	slight increasing trend with slope of 5.25	
HCSW-1	2012	Ammonia	slight decreasing trend with slope of -0.0003	2012 Impact Assessment concluded that estimated slope was in the opposite direction of adverse change.
HCSW-1	2012	Dissolved Iron	slight decreasing trend with slope of -0.02	
HCSW-1	2012	Orthophosphate	slight increasing trend with slope of 0.02	2012 Impact Assessment found that the evident trend was caused by a data bias and extending the period of record before 2003 caused the trend to no longer be valid. Concentrations in 2008-2012 were similar to those before 2003.

Station	Year	Parameter	Trend Noted	Addressing of Trend
HCSW-1	2012	Specific Conductance	increasing trend with slope of 10.6	2012 Impact Assessment found step-change in specific conductivity and dissolved ions likely caused by increased groundwater contributions from 2006-2008 drought and subsequent influence from Wingate dredge mining outfall discharge. Concentrations after 2008 remain relatively steady, with no evidence of biological impact.
HCSW-1	2012	Alkalinity	increasing trend with slope of 2.96	
HCSW-1	2012	Dissolved Calcium	increasing trend with slope of 1.05	
HCSW-1	2012	Sulfate	Increasing trend with slope of 2.27	
HCSW-1	2012	Total Dissolved Solids	increasing trend with slope of 6.64	
HCSW-1	2013	pH	slight increasing trend with slope of 0.05	Although the HCSP HCSW-1 pH data does show a step-change increase in 2007 during the drought period (which probably causes the statistically significant Seasonal Kendall Tau trend), there is no evidence that NPDES discharge is raising pH at HCSW-1. It is more likely that the step-change increase in pH may partially originate at stations upstream of HCSW-1 with no NPDES influence.
HCSW-1	2013	Fluoride	slight increasing trend with slope of 0.02	2013 Impact Assessment concluded that estimated slope was too small to be ecologically significant.
HCSW-1	2013	Ammonia	slight decreasing trend with slope of -0.002	2013 Impact Assessment concluded that estimated slope was in the opposite direction of adverse change.
HCSW-1	2013	Dissolved Iron	slight decreasing trend with slope of -0.01	

Station	Year	Parameter	Trend Noted	Addressing of Trend
HCSW-1	2013	Specific Conductance	increasing trend with slope of 11.2	The specific conductivity increases in recent years were influenced by regional factors unrelated to mining activities, drought-period baseflow contributions, upstream conditions, and increased influence of groundwater in current mining activities. Any small portion of the change in specific conductivity that may have been affected by changes in NPDES water quality is likely to stay relatively constant at HCSW-1 in the near future given planned mining practices and the stable range of concentrations shown since Wingate mine began discharging to Horse Creek in 2008.
HCSW-1	2013	Alkalinity	increasing trend with slope of 2.50	
HCSW-1	2013	Dissolved Calcium	increasing trend with slope of 0.99	
HCSW-1	2013	Sulfate	Increasing trend with slope of 4.19	
HCSW-1	2013	Total Dissolved Solids	increasing trend with slope of 10.3	
HCSW-1	2014	pH	slight increasing trend with slope of 0.04	Although the HCSP HCSW-1 pH data does show a step-change increase in 2007 during the drought period (which probably causes the statistically significant Seasonal Kendall Tau trend), there is no evidence that NPDES discharge is raising pH at HCSW-1. It is more likely that the step-change increase in pH may partially originate at stations upstream of HCSW-1 with no NPDES influence.
HCSW-1	2014	Fluoride	slight increasing trend with slope of 0.01	2014 Impact Assessment concluded that estimated slope was too small to be ecologically significant.
HCSW-1	2014	DO Saturation	slight increasing trend with slope of 1.43	2014 Impact Assessment concluded that estimated slope was in the opposite direction of adverse change.
HCSW-1	2014	Ammonia	slight decreasing trend with slope of -0.001	
HCSW-1	2014	Dissolved Iron	slight decreasing trend with slope of -0.01	
HCSW-1	2014	Specific Conductance	increasing trend with slope of 9.46	The specific conductivity increases in recent years were influenced by regional factors unrelated to mining activities, drought-period baseflow contributions, upstream conditions, and increased influence of groundwater in current mining activities. Any small portion of
HCSW-1	2014	Alkalinity	increasing trend with slope of 2.28	

Station	Year	Parameter	Trend Noted	Addressing of Trend
HCSW-1	2014	Dissolved Calcium	increasing trend with slope of 0.71	the change in specific conductivity that may have been affected by changes in NPDES water quality is likely to stay relatively constant at HCSW-1 in the near future given planned mining practices and the stable range of concentrations shown since Wingate mine began discharging to Horse Creek in 2008.
HCSW-1	2014	Sulfate	Increasing trend with slope of 2.85	
HCSW-1	2014	Total Dissolved Solids	increasing trend with slope of 7.07	
HCSW-1	2015	pH	increasing trend with slope of 0.04	Although the HCSP HCSW-1 pH data does show a step-change increase in 2007 during the drought period (which probably causes the statistically significant Seasonal Kendall Tau trend), there is no evidence that NPDES discharge is raising pH at HCSW-1. It is more likely that the step-change increase in pH may partially originate at stations upstream of HCSW-1 with no NPDES influence.
HCSW-1	2015	Dissolved Oxygen-%Sat	increasing trend with slope of 1.29	2015 Impact Assessment concluded that estimated slope was in the opposite direction of adverse change.
HCSW-1	2015	Ammonia	slight decreasing trend with slope of -0.001	
HCSW-1	2015	Dissolved Iron	slight decreasing trend with slope of -0.01	

Station	Year	Parameter	Trend Noted	Addressing of Trend
HCSW-1	2015	Specific Conductance	increasing trend with slope of 10.2	The specific conductivity increases in recent years were influenced by regional factors unrelated to mining activities, drought-period baseflow contributions, upstream conditions, and increased influence of groundwater in current mining activities. Any small portion of the change in specific conductivity that may have been affected by changes in NPDES water quality is likely to stay relatively constant at HCSW-1 in the near future given planned mining practices and the stable range of concentrations shown since Wingate mine began discharging to Horse Creek in 2008.
HCSW-1	2015	Alkalinity	increasing trend with slope of 2.42	
HCSW-1	2015	Dissolved Calcium	increasing trend with slope of 0.86	
HCSW-1	2015	Fluoride	slight increasing trend with slope of 0.01	
HCSW-1	2015	Sulfate	Increasing trend with slope of 2.92	
HCSW-1	2015	Total Dissolved Solids	increasing trend with slope of 8.31	
HCSW-1	2016	pH	increasing trend with slope of 0.05	Although the HCSP HCSW-1 pH data does show a step-change increase in 2007 during the drought period (which probably causes the statistically significant Seasonal Kendall Tau trend), there is no evidence that NPDES discharge is raising pH at HCSW-1. It is more likely that the step-change increase in pH may partially originate at stations upstream of HCSW-1 with no NPDES influence.

Station	Year	Parameter	Trend Noted	Addressing of Trend
HCSW-1	2016	Dissolved Oxygen-mg/L	increasing trend with slope of 0.06	The specific conductivity increases in recent years were influenced by regional factors unrelated to mining activities, drought-period baseflow contributions, upstream conditions, and increased influence of groundwater in current mining activities. Any small portion of the change in specific conductivity that may have been affected by changes in NPDES water quality is likely to stay relatively constant at HCSW-1 in the near future given planned mining practices and the stable range of concentrations shown since Wingate mine began discharging to Horse Creek in 2008.
HCSW-1	2016	Dissolved Oxygen-%Sat	increasing trend with slope of 0.74	
HCSW-1	2016	Ammonia	slight decreasing trend with slope of -0.001	
HCSW-1	2016	Dissolved Iron	slight decreasing trend with slope of -0.02	
HCSW-1	2016	Specific Conductance	increasing trend with slope of 10.4	
HCSW-1	2016	Alkalinity	increasing trend with slope of 2.39	
HCSW-1	2016	Dissolved Calcium	increasing trend with slope of 1.05	
HCSW-1	2016	Fluoride	slight increasing trend with slope of 0.01	
HCSW-1	2016	Sulfate	Increasing trend with slope of 3.67	
HCSW-1	2016	Total Dissolved Solids	increasing trend with slope of 8.56	
HCSW-1	2018	pH	Slight increasing trend with slope of 0.04 SU/yr	Slope very small in magnitude. Isolated step change. Not of concern.

Station	Year	Parameter	Trend Noted	Addressing of Trend
HCSW-1	2018	Alkalinity	Increasing trend with slope of 2.32 mg/L/yr	The specific conductivity increases in recent years were influenced by regional factors unrelated to mining activities, drought-period baseflow contributions, upstream conditions, and increased influence of groundwater in current mining activities. Any small portion of the change in specific conductivity that may have been affected by changes in NPDES water quality is likely to stay relatively constant at HCSW-1 in the near future given planned mining practices and the stable range of concentrations shown since Wingate mine began discharging to Horse Creek in 2008.
HCSW-1	2018	Chlorophyll-a	Slight decreasing trend with slope of -0.03	
HCSW-1	2018	DO (mg/L)	Slight increasing trend with slope of 0.04 mg/L/yr	
HCSW-1	2018	Fluoride	Slight increasing trend with slope of 0.01 mg/L/yr	
HCSW-1	2018	Iron	Slight decreasing trend with slope of -0.01 mg/L/yr	
HCSW-1	2018	Specific Conductance	Increasing trend with slope of 12.1 µS/yr	
HCSW-1	2018	Sulfate	Increasing trend with slope of 12.1 µS/yr	2018 Impact Assessment historical analysis indicated TDS, sulfate, and calcium values have approached and exceeded HCSP trigger levels before levels were established and before Mosaic's outfalls were online. These exceedances also often occur when there is no discharge, long after there has been a discharge, or low stream flow conditions.
HCSW-1	2018	Calcium	Increasing trend with slope of 1.1 mg/L/yr	
HCSW-1	2018	TDS	Increasing trend with slope of 4.24 mg/L/yr	
HCSW-4	2008	Dissolved Oxygen	slight decreasing trend with slope of -0.40	May be influenced by climate or other land use in southern basin.
HCSW-4	2008	Orthophosphate	slight increasing trend with slope of 0.02 (data not correlated with streamflow)	Magnitude of trend not ecologically significant. May be influenced by climate or other land use in southern basin.

Station	Year	Parameter	Trend Noted	Addressing of Trend
HCSW-4	2009	Alkalinity	increasing trend with slope of 1.90	As with specific conductivity, it is likely that this trend is strongly influenced by the dry conditions in 2006 to 2007, given that most of the highest alkalinity measurements are associated with periods without NPDES discharge. The estimated slopes for both stations are small compared to the historic HCSP MDL (≤ 1 mg/L) and/or the differences between primary and field duplicate samples (≤ 17 mg/L).
HCSW-4	2009	Dissolved Oxygen	slight decreasing trend with slope of -0.42	It appears the declining trend stems from the difference between DO concentrations in 2006-2007 (dry years) compared to 2008-2009. When comparing DO overall annual and seasonal medians, DO concentrations in 2008-2009 are consistent with those in 2003-2005. Given this information and the fact that HCSW-1 does not show a significant trend, it is unlikely that mining activities are contributing to a perceived trend in dissolved oxygen concentrations at HCSW-4.
HCSW-4	2009	Orthophosphate	slight increasing trend with slope of 0.02 (data not correlated with streamflow)	The slope is very small compared to historic HCSP values for laboratory Minimum Detection Limits (≤ 0.075 mg/L) or differences between primary and field duplicate samples (≤ 0.034 mg/L). Therefore, the trends at both stations are not of concern at this time and could be related to extreme differences in rainfall and streamflow within the sampling period.
HCSW-4	2010	Color	increasing trend with slope of 12.07	2010 Impact Assessment concluded that estimated slope was in the opposite direction of adverse change.
HCSW-4	2010	Orthophosphate	slight increasing trend with slope of 0.02	2010 Impact Assessment found that the evident trend was caused by a data bias and extending the period of record before 2003 caused the trend to no longer be valid. Concentrations in 2008-2010 were similar to those before 2003.

Station	Year	Parameter	Trend Noted	Addressing of Trend
HCSW-4	2010	Alkalinity	Increasing trend with slope of 1.62	2010 Impact Assessment found step-change in specific conductivity and dissolved ions likely caused by increased groundwater contributions from 2006-2008 drought and subsequent influence from Wingate dredge mining outfall discharge. Concentrations after 2008 remain relatively steady, with no evidence of biological impact.
HCSW-4	2011	Color	increasing trend with slope of 11.47	2011 Impact Assessment concluded that estimated slope was in the opposite direction of adverse change.
HCSW-4	2011	Dissolved Iron	slight decreasing trend with slope of -0.01	
HCSW-4	2011	Alkalinity	increasing trend with slope of 1.31	2011 Impact Assessment found step-change in specific conductivity and dissolved ions likely caused by increased groundwater contributions from 2006-2008 drought and subsequent influence from Wingate dredge mining outfall discharge. Concentrations after 2008 remain relatively steady, with no evidence of biological impact.
HCSW-4	2012	Color	increasing trend with slope of 10.6	2012 Impact Assessment concluded that estimated slope was in the opposite direction of adverse change.
HCSW-4	2012	Dissolved Iron	slight decreasing trend with slope of -0.01	
HCSW-4	2012	Alkalinity	increasing trend with slope of 1.66	2012 Impact Assessment found step-change in specific conductivity and dissolved ions likely caused by increased groundwater contributions from 2006-2008 drought and subsequent influence from Wingate dredge mining outfall discharge. Concentrations after 2008 remain relatively steady, with no evidence of biological impact.
HCSW-4	2013	Color	increasing trend with slope of 7.29	2013 Impact Assessment concluded that estimated slope was in the opposite direction of adverse change.
HCSW-4	2013	Dissolved Iron	slight decreasing trend with slope of -0.01	

Station	Year	Parameter	Trend Noted	Addressing of Trend
HCSW-4	2013	Alkalinity	increasing trend with slope of 1.37	The specific conductivity increases in recent years were influenced by regional factors unrelated to mining activities, drought-period baseflow contributions, upstream conditions, and increased influence of groundwater in current mining activities. Any small portion of the change in specific conductivity that may have been affected by changes in NPDES water quality is likely to stay relatively constant at HCSW-1 in the near future given planned mining practices and the stable range of concentrations shown since Wingate mine began discharging to Horse Creek in 2008.
HCSW-4	2013	Chloride	slight increasing trend with slope of 0.36	
HCSW-4	2013	Fluoride	Slight increasing trend with slope of 0.01	
HCSW-4	2014	Color	increasing trend with slope of 6.61	2014 Impact Assessment concluded that estimated slope was in the opposite direction of adverse change.
HCSW-4	2014	Dissolved Iron	slight decreasing trend with slope of -0.01	
HCSW-4	2014	Specific Conductance	increasing trend with slope of 9.01	The specific conductivity increases in recent years were influenced by regional factors unrelated to mining activities, drought-period baseflow contributions, upstream conditions, and increased influence of groundwater in current mining activities. Any small portion of the change in specific conductivity that may have been affected by changes in NPDES water quality is likely to stay relatively constant at HCSW-1 in the near future given planned mining practices and the stable range of concentrations shown since Wingate mine began discharging to Horse Creek in 2008.
HCSW-4	2014	Alkalinity	increasing trend with slope of 1.40	
HCSW-4	2014	Chloride	slight increasing trend with slope of 0.33	
HCSW-4	2014	Fluoride	slight increasing trend with slope of 0.01	
HCSW-4	2014	Sulfate	increasing trend with slope of 3.21	
HCSW-4	2014	TDS	increasing trend with slope of 12.2	
HCSW-4	2015	Color	increasing trend with slope of 6.32	2015 Impact Assessment concluded that estimated slope was in the opposite direction of adverse change.
HCSW-4	2015	Dissolved Iron	slight decreasing trend with slope of -0.01	

Station	Year	Parameter	Trend Noted	Addressing of Trend
HCSW-4	2015	Specific Conductivity	increasing trend with slope of 7.47	The specific conductivity increases in recent years were influenced by regional factors unrelated to mining activities, drought-period baseflow contributions, upstream conditions, and increased influence of groundwater in current mining activities. Any small portion of the change in specific conductivity that may have been affected by changes in NPDES water quality is likely to stay relatively constant at HCSW-1 in the near future given planned mining practices and the stable range of concentrations shown since Wingate mine began discharging to Horse Creek in 2008.
HCSW-4	2015	Alkalinity	increasing trend with slope of 1.18	
HCSW-4	2015	Fluoride	Slight increasing trend with slope of 0.01	
HCSW-4	2015	Total Dissolved Solids	increasing trend with slope of 9.26	
HCSW-4	2016	Color	increasing trend with slope of 4.31	2016 Impact Assessment concluded that estimated slope was in the opposite direction of adverse change.
HCSW-4	2016	Dissolved Iron	slight decreasing trend with slope of -0.01	
HCSW-4	2016	Specific Conductivity	increasing trend with slope of 7.94	The specific conductivity increases in recent years were influenced by regional factors unrelated to mining activities, drought-period baseflow contributions, upstream conditions, and increased influence of groundwater in current mining activities. Any small portion of the change in specific conductivity that may have been affected by changes in NPDES water quality is likely to stay relatively constant at HCSW-1 in the near future given planned mining practices and the stable range of concentrations shown since Wingate mine began discharging to Horse Creek in 2008.
HCSW-4	2016	Alkalinity	increasing trend with slope of 1.08	
HCSW-4	2016	Fluoride	Slight increasing trend with slope of 0.01	
HCSW-4	2016	Total Dissolved Solids	increasing trend with slope of 6.02	
HCSW-4	2018	pH	Slight increasing trend with slope of 0.02 mg/L/yr	Slope very small in magnitude. Isolated step change. Not of concern.

Station	Year	Parameter	Trend Noted	Addressing of Trend
HCSW-4	2018	Alkalinity	Increasing trend with slope of 0.54 mg/L/yr	The specific conductivity increases in recent years were influenced by regional factors unrelated to mining activities, drought-period baseflow contributions, upstream conditions, and increased influence of groundwater in current mining activities. Any small portion of the change in specific conductivity that may have been affected by changes in NPDES water quality is likely to stay relatively constant at HCSW-1 in the near future given planned mining practices and the stable range of concentrations shown since Wingate mine began discharging to Horse Creek in 2008.
HCSW-4	2018	Chlorophyll-a	Slight decreasing trend with slope of -0.05	
HCSW-4	2018	Color	Increasing trend with slope of 2.82 PCU/yr	
HCSW-4	2018	Iron	Slight decreasing trend with slope of -0.01 mg/L/yr	
HCSW-4	2018	Nitrogen, Total Kjeldahl	Slight increasing trend with slope of 0.02 mg/L/yr	
HCSW-4	2018	Radium, Combined	Slight decreasing trend with slope of -0.02 pCi/L/yr	
HCSW-4	2018	Specific Conductance	Increasing trend with slope of 5.7 µS/yr	
HCSW-4	2018	Turbidity	Slight increasing trend with slope of 0.09 NTU/yr	

Appendix I

2018 Water Quality Impact Assessment

HORSE CREEK STEWARDSHIP PROGRAM
HARDEE AND DESOTO COUNTIES, FLORIDA
TDS, SULFATE AND CALCIUM HISTORICAL ANALYSIS

Prepared for:

Mr. Ryan Tickles
Mosaic Fertilizer, LLC
13830 Circa Crossing Drive
Lithia, Florida 33547

May 14, 2020

Prepared by:

8306 Laurel Fair Circle•Suite 120
Tampa, FL 33610•813-600-5747

Eesa G. Ali
Senior Water Resource Analyst

Shannon M. Gonzalez
Senior Ecologist/Principal

CONTENTS

TABLES

FIGURES

MAPS

1.0 SUMMARY

Below are the findings from an Impact Assessment of Total Dissolved Solids (TDS), calcium, and sulfate in Horse Creek, its tributaries, and two control sites in adjacent watersheds. This study was done in two phases, the first was a historical analysis of all available surface water and groundwater data available for Horse Creek and its tributaries and the second phase involved sampling at two control sites outside of the Horse Creek watershed. Because the headwater of Horse Creek occurs on the Mosaic mine, the two control sites that were selected occurred within the Conceptual Phosphate Area but had not been mined.

The objective of this report is to determine if Mosaic Fertilizer, LLC's (Mosaic) activities in the Upper Horse Creek Basin are contributing to the TDS, dissolved calcium and sulfate exceedances documented within the Horse Creek Stewardship Program (HCSP).

Mosaic has two outfalls that intermittently discharge to Horse Creek. The Wingate D-004 outfall is approximately 4.2 miles downstream of the Fort Green D-003 outfall. The HCSP established four sample sites along Horse Creek: HCSW-1, HCSW-2, HCSW-3 and HCSW-4. HCSW-1 is closest to and approximately 5.5 miles downstream of the Wingate Mine outfall and HCSW-2, HCSW-3 and HCSW-4 are 12, 25.8 and 32.2 miles further downstream, respectively. All TDS, sulfate, and calcium exceedances but one, have occurred downstream of station HCSW-2 at sites in the Lower Horse Creek Basin (Figures 1, 4-1 through 4-3, Table 2).

Site	HCSW-1	HCSW-2	HCSW-3	HCSW-4
Number of combined (TDS, calcium and sulfate) exceedances, period of record*	1	0	60	144
Date of first recorded exceedance	4/11/2017	NA	3/28/2006	3/6/1997**

*Period of record: HCSW-1 8/82- 2/18, HCSW-2 4/03-2/18, HCSW-3 4/03-2/18, HCSW-4 6/62-2/18. Period of record for Upper and Lower Horse Creek basins began in 1975 (sulfate) and 1962 (TDS, Ca and sulfate) respectively. TDS and calcium data collection began in 1982 for the Upper Horse Creek Basin.

**Date of first recorded Mosaic discharge- 9/30/2001

Historical data from the Lower Horse Creek Basin indicates TDS, sulfate and calcium values have approached and exceeded the HCSP trigger levels before the levels were established and before Mosaic's outfalls were online (Figure 4-1). These exceedances often occur when there is no discharge or long after there has been a discharge through either outfall. These exceedances also often occur when the stream is at low flow and dominated by base flow (i.e. consisting mostly of groundwater seepage) which suggests a non-point source input (Figure 4-1, Table 2, Table 3, Table 4).

Groundwater data collected near the Wingate Mine (located in the Upper Horse Creek Basin) suggests that surficial groundwater from the mine is not contributing to elevated TDS, sulfate or calcium in Horse Creek (Figures 8-1 through 8-3).

Other than phosphate mining, the dominant land use in the Upper Horse Creek Basin, according to the most recent Landscape Development Index (LDI) maps (2011), is agriculture (38.71% by area, Map 2). Agriculture dominates the lower Horse Creek Basin at 59.71% (Map 3). Four tributaries of Horse Creek, Unnamed Creek at Barrow Road and Unnamed Creek at County Road 665, Brandy Branch and Buzzard Roost Branch, all located in the lower basin, have documented elevated TDS, sulfate and calcium values (Table 2, Table 4, Figures 7-1 through 7-3). No mining has occurred in any of these watersheds.

Water quality and stream flow sampling was conducted in Charlie Creek and Limestone Creek, two nearby tributaries of the Peace River that are within the Conceptual Phosphate Area but have not been mined. Both systems showed TDS, calcium, and sulfates concentration increased approaching HCSP trigger levels during low-flow conditions only- much like Horse Creek.

2.0 INTRODUCTION

This Impact Assessment was conducted in response to exceedances of trigger levels for dissolved calcium, sulfate and TDS during HCSP monthly monitoring activities. As part of the HCSP plan, Mosaic must initiate impact assessments to determine if Mosaic's activities are a contributing factor to exceedances or deleterious water quality trends in Horse Creek.

The Upper Basin (WBID 1787B) and part of the Lower Basin (WBID 1787A) of Horse Creek is a Class III (Fish Consumption; Recreation, Propagation and Maintenance of a Healthy, Well-Balanced Population of Fish and Wildlife) surface water. Approximately 1.6 miles downstream of HCSW-4, Horse Creek becomes a Class I surface water to the confluence with the Peace River. The Peace River, from the confluence with Horse Creek to the southern line of section 15, Township 39 South, Range 23 East is proposed as a Class I-treated (potable water supply with treatment) surface water, pending EPA approval, *62-302.400.17.b.14, F.A.C.* Because of the downstream Class I designation and the settlement with the Peace River Manasota River Water Authority (PRMRWA), the HCSP adopted trigger levels are based on secondary potable water quality standards and water treatment needs. The constituents included in this Impact Assessment (dissolved calcium, sulfate and TDS) do not have Class III water quality standard thresholds, pursuant to Ch. *62-302.530, F.A.C.*

This report focuses on existing historical groundwater data collected through Mosaic's Hydrogeologic Investigation and Monitoring Plan of Study (HIMPOS), wastewater data from Mosaic's National Pollutant Discharge Elimination System (NPDES) Discharge Monitoring Report (DMR) data, flow data collected by United States Geological Survey (USGS) gauging stations, and, surface water data from the HCSP and the State of Florida's Impaired Waters Rule (IWR) database- Run 54. A copy of the past and current run of the IWR dataset can be downloaded here http://publicfiles.dep.state.fl.us/dear/IWR/

HCSP sites (Map 1) were lumped into waterbody IDs (WBIDs). HCSW-1 and HCSW-2 data were associated with IWR data corresponding to the Upper Horse Creek Basin (WBID 1787B), while HCSW-3 and HCSW-4 were associated with IWR data corresponding to the Lower Horse Creek Basin (WBID 1787A). HCSW-2 is located downstream of the Horse Creek/Brushy Creek confluence, on the border between the Lower Horse Creek Basin and the Upper Horse Creek Basin. The data presented below demonstrates more similarity between HCSW-2 and the HCSW-1/Brushy Creek sites than the sites in Lower Horse Creek Basin.

Estimated base flow and surface runoff for Horse Creek (expressed at percent base flow) was calculated in this report using the Purdue Web-based Hydrograph Analysis Tool. USGS gauging station number 02297310 (near HCSW-4) period of record data was input in to the application and a recursive digital filter + "perennial streams with porous aquifers" default settings were selected. The modeling application can be found here: https://engineering.purdue.edu/mapserve/WHAT/

Both the Upper and Lower Horse Creek basins were characterized and scored using the Landscape Development Index (Maps 2 and 3). The LDI is a tool utilized by the Florida Department of Environmental Protection (FDEP) to estimate potential impacts of changes in land use on surface waters (Florida Department of Environmental Protection, 2005). LDI scores range from 1-10 with a score of ≤2 considered "minimally disturbed". This assessment calculates the LDI across the entire watershed instead of the more typical 100m buffer x ≤ 10km of upstream reach.

$$LDI = \sum(LDI_i \times \% LU_i)$$

Where,

LDI_i = LDI coefficient for a given land use *I* (see table below).

$\%LU_i$ = The percentage of land area in a basin with land use *i*

Land Use	LDI Value
Natural Open water	1
Pine Plantation	1.58
Woodland Pasture	2.02
Pasture	2.77
Recreational / Open Space (Low-intensity)	2.77
Low Intensity Pasture (with livestock)	3.41
Citrus	3.68
High Intensity Pasture (with livestock)	3.74
Row crops	4.54
Single Family Residential (Low-density)	6.79
Recreational / Open Space (High-intensity)	6.92
High Intensity Agriculture 7.00	7
Single Family Residential (Med-density)	7.47
Single Family Residential (High-density)	7.55
Low Intensity Highway	7.81
Low Intensity Commercial	8
Institutional	8.07
High Intensity Highway	8.28
Industrial	8.32
Low Intensity Multi-family residential	8.66
High intensity commercial	9.18
High Intensity Multi-family residential	9.19
Low Intensity Central Business District	9.42
High Intensity Central Business District	10

3.0 TOTAL DISSOLVED SOLIDS, CALCIUM AND SULFATE

TDS measurements do not differentiate between cations, anions or dissolved organic material. The gravimetric analytical method (SM2540-C) requires the water sample be run through a 2.0 µm filter, the filtrate evaporated at 180°C, and the leftover solids weighed (Rice, Baird, & Eaton, 2017). The two other parameters under review, dissolved calcium and sulfate, are the most ubiquitous and dominant ions (behind bicarbonate) found in rivers worldwide and are therefore inherently tied to TDS values (Wetzel, 1983).

Looking at the average molar concentrations of each ion in the upper and lower Horse Creek basins, $CaCO_3$, Na^+ and Ca^{2+} are the most abundant ions in the upper basin and $CaCO_3$, SO_4^{2-} and Ca^{2+} are the most abundant ions in the lower basin (Table 1). Also, average ionic concentrations are elevated in the lower basin relative to the upper basin, with the exception of Na^+. These two facts suggest that there are different processes and/or contributions driving water chemistry in the two basins.

Table 1 Dominant Ion Ratio for Upper and Lower Horse Creek Calculated with IWR Data (2000 – 2015)

Ion	M.W.	Upper Horse Creek			Lower Horse Creek			RPD
		mean $mg\cdot L^{-1}$	moles	ratio	mean $mg\cdot L^{-1}$	moles	ratio	
K^+	39.09	4.37	0.1118	1:	6.58	0.1683	1:	40.3
SO_4^{2-}	96.06	45.87	0.4775	**4:**	160.37	1.6695	**10:**	111.0
Cl^-	35.45	16.99	0.4793	4:	25.79	0.7275	4:	41.1
Mg^{2+}	24.3	11.69	0.4809	**4:**	20.31	0.8358	**5:**	53.9
Ca^{2+}	40.08	21.69	0.5412	**5:**	52.51	1.3101	**8:**	83.1
Na^+	22.99	16.56	0.7203	**6:**	13.80	0.6003	**4:**	-18.2
Hardness, $CaCO_3$	100	102.26	1.0226	**9**	214.73	2.1473	**13**	71.0

"Ratio" column indicates the relative abundance of respective ions that comprise TDS values.
Bolded values indicate a difference in ion ratio between the Upper and Lower Horse Creek Basins.
M.W. = molecular weight.
RPD= relative percent difference of moles for each ion between basins.

Hard water (water with high TDS, calcium, and sulfate) is of great concern to potable water production and distribution. High levels of sulfate will negatively affect the taste of water and hard water creates limescale which fouls equipment and water distribution systems. Additionally, high cationic concentrations consume residual free chlorine: lowering disinfection efficiency.

TDS values in freshwater can be affected by surface mining, industrial effluents, precipitation, river flow, evapotranspiration, geology (Weber-Scannell & Duffy, 2007), agricultural irrigation return flows, stormwater from urban areas and salt water intrusion (Jenke, 1974). Horse Creek is located in the Bone Valley Region which consists of an apatite/phosphatized karst formation (Page et al, 1955), and surface and ground water in the region is slightly hard (>17.1 $mg\cdot L^{-1}$) to very hard (>180 $mg\cdot L^{-1}$) (Jones, DeHaven, Clark, Rauch, Mulroney, & Ramirez, 1990) using the Water Quality Association's hardness classification system.

4.0 HISTORICAL OVERVIEW OF TDS, SULFATE AND CALCIUM EXCEEDANCES IN HORSE CREEK

State of Florida records show water quality data collection in the Horse Creek Basin began in 1962 in the Lower Basin (WBID 1787A, Horse Creek above Peace River) and in 1972 in the Upper Horse Creek Basin (WBID 1787B, Horse Creek above Brushy Creek). The IWR TDS, calcium, and sulfate period of record are shown in the table below:

	TDS	n	Ca	n	SO_4	n
1787A	6/1962 - 5/2017	323	6/1962 - 5/2016	320	6/1962 - 6/2016	427
SR72	6/1962 - 5/2016	142	6/1962 - 5/2016	299	6/1962 - 5/2016	347
SR70	6/1970 - 9/2008	10	6/1970 - 9/2008	7	6/1970 - 9/2008	27
HCSP	4/2003 - present	682	4/2003 - present	690	4/2003 - present	682
1787B	8/1982 – 11/2015	94	5/1972 - 11/2015	165	6/1975 - 11/2015	180
Goose Pond	NA	--	NA	--	NA	--
SR64	8/1982 - 11/2015	93	5/1972 - 11/2015	164	6/1975 - 11/2015	179

Values prior to the year 2000 (collected by SWFWMD and USGS) were disconnected from quality assurance/quality control metadata in the IWR database- specifically, method detection limits, practical quantitation limits, and occasionally, analytical method. Using data with unknown precision and multiple available analytical methods is unavoidable in a historical analysis. Values prior to 2000 (14% of all data used) should therefore be viewed as estimates.

The Wingate and Fort Green Mines and their respective outfalls occur in and upstream of the Upper Horse Creek Basin. The Wingate D-004 outfall is approximately 4.2 miles downstream of the Fort Green D-003 outfall. The HCSP established four sample sites along Horse Creek: HCSW-1, HCSW-2, HCSW-3 and HCSW-4. HCSW-1 is closest to and approximately 5.5 miles downstream of the Wingate Mine outfall and HCSW-2, HCSW-3 and HCSW-4 are 12, 25.8 and 32.2 miles further downstream, respectively (Map 1).

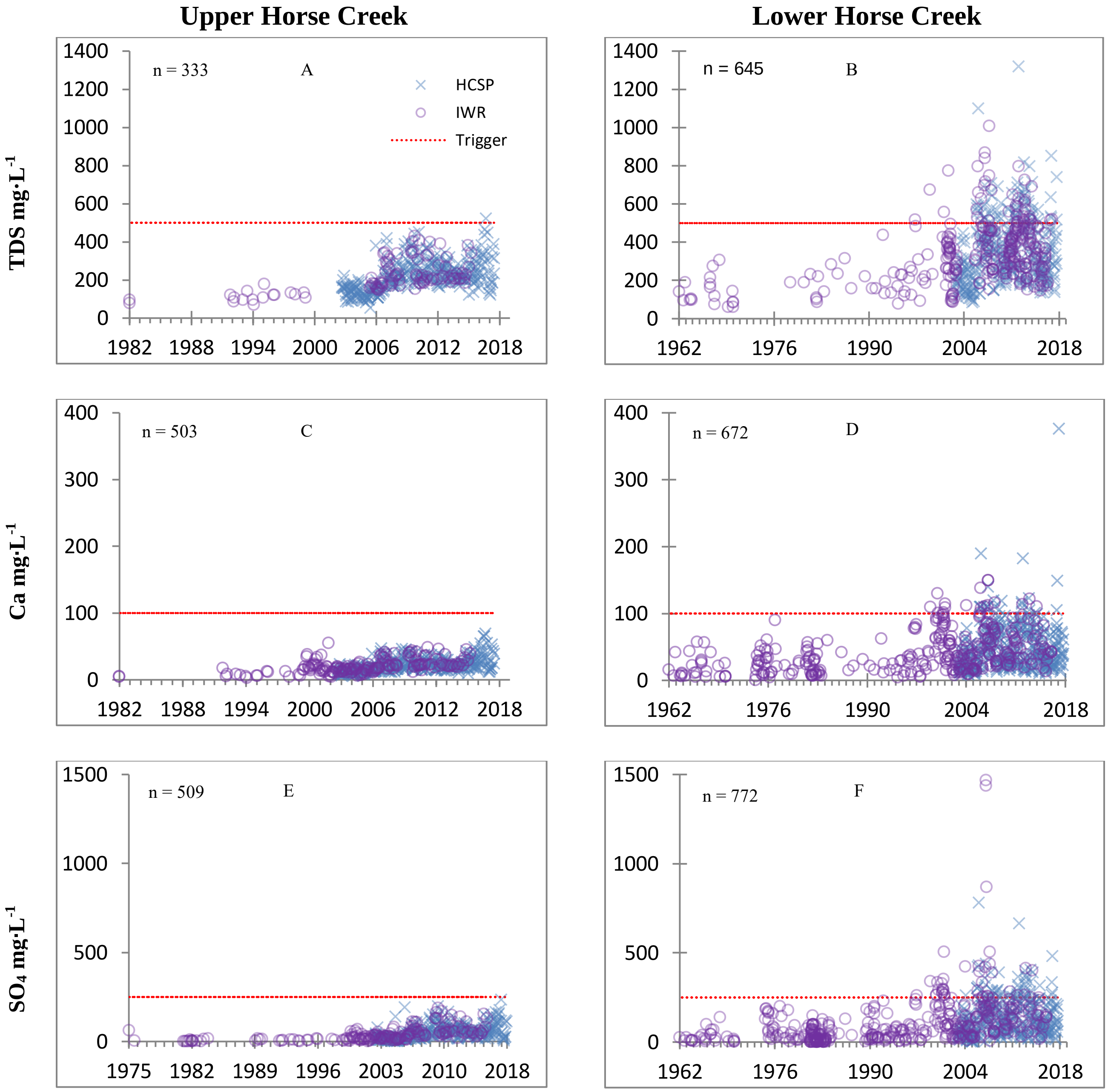
Water passing through HCSW-1 in the Upper Basin is from a 42 square mile drainage area. The HCSW-4 drainage area in the Lower Horse Creek is 218 square miles (USGS NWIS). This means that the HCSW-1 site represents the full impact of Fort Green and Wingate NPDES outfalls both in proximity and concentration.

The first recorded TDS, calcium, and sulfate values above the HCSP thresholds occurred before mining began in the Horse Creek basin, in 1997 and 1999 (Figure 4-1) and were all in the Lower Basin. The first recorded discharge through the Fort Green Mine outfall D-003 occurred on July 19, of 2001 and the first recorded discharge through the Wingate Mine outfall D-004 occurred on September 10, 2002. These pre-mining exceedances all occurred in the Lower Horse Creek Basin. Occurrences of trigger value exceedances in the Lower Basin have become more frequent since the mid-2000s.

The first and only exceedance measured in the Upper Horse Creek Basin (HCSW-1) was a TDS value of 524 mg·L^{-1} on April 11, 2017 when the creek at HCSW-4 was discharging at 2.54 cfs and 100% base flow. The USGS station near HCSW-1 was down that day but the USGS subsequently estimated the flow rate to ~0.5 cfs. HCSW-2 was not sampled because there was no flow, HCSW-3 exceeded sulfate and TDS trigger levels, and HCSW-4 exceeded calcium, sulfate and TDS trigger levels.

Prior to April 11, 2017, the most recent NPDES discharge through outfalls D-003 or D-004 occurred 124 days earlier (Table 2). In other words, on April 11, 2017, the constituents of the stream flow consisted of no effluent, no surface runoff and 100% groundwater seepage.

113 of 114 TDS exceedances (Figure 4-2), all 89 sulfate exceedances (Figure 4-4) and all 30 calcium exceedances (Figure 4-3) occurred in the Lower Basin. 1/233 exceedances occurred in the Upper Basin. No TDS, calcium or sulfate exceedances occurred at station HCSW-2. While it appears that the exceedances in the Lower Basin coincide with mining activity in the Upper Basin, and the Upper Basin appears to be showing larger swings in data albeit below the trigger values, the stream conditions present when an exceedance occurs (i.e. low flow, high groundwater input) appears to suggest non-point sources tied to other land use activities in the Horse Creek watershed. A combination of water withdrawals, fertilizer application, and irrigation runoff alone can produce elevated concentrations of dissolved ions in freshwater systems.



Historical TDS values in **A**, upper Horse Creek basin (WBID 1787B), n=333; and **B**, Lower Horse Creek basin (WBID 1787A), n=645.
Historical calcium values in **C**, upper Horse Creek basin, n=503; and **D**, Lower Horse Creek basin, n=672.
Historical sulfate values in **E**, upper Horse Creek Basin, n=509; and **F**, lower Horse Creek Basin, n=772.

Figure 4-1 Period of record TDS, calcium and sulfate values for the Upper and Lower Horse Creek basins. IWR calcium values are reported as "total calcium" and 682 out of 694 HCSP calcium values are reported as "dissolved calcium". It can be assumed that dissolved calcium values are ≤ a given total calcium value.

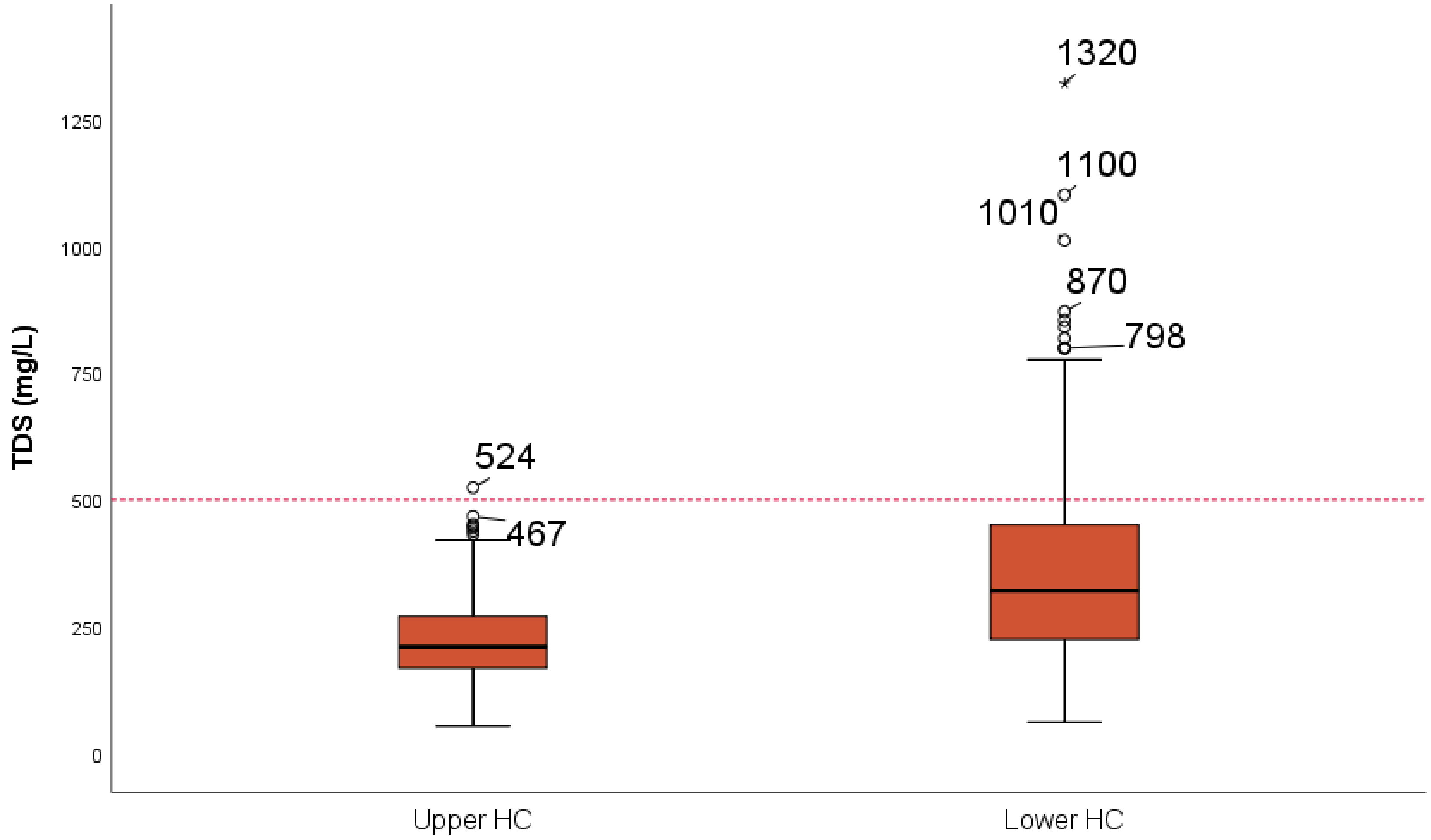


Figure 4-2 **Boxplot of TDS data split between the Upper and Lower Horse Creek Basins, period of record (1982- 2018, Upper Basin; 1962- 2018, Lower Basin). Circles indicate 1.5x the interquartile (IQ) range, asterisks indicate values >3x the IQ range, and the line across the box indicates the median. The red line denotes the TDS trigger level.**

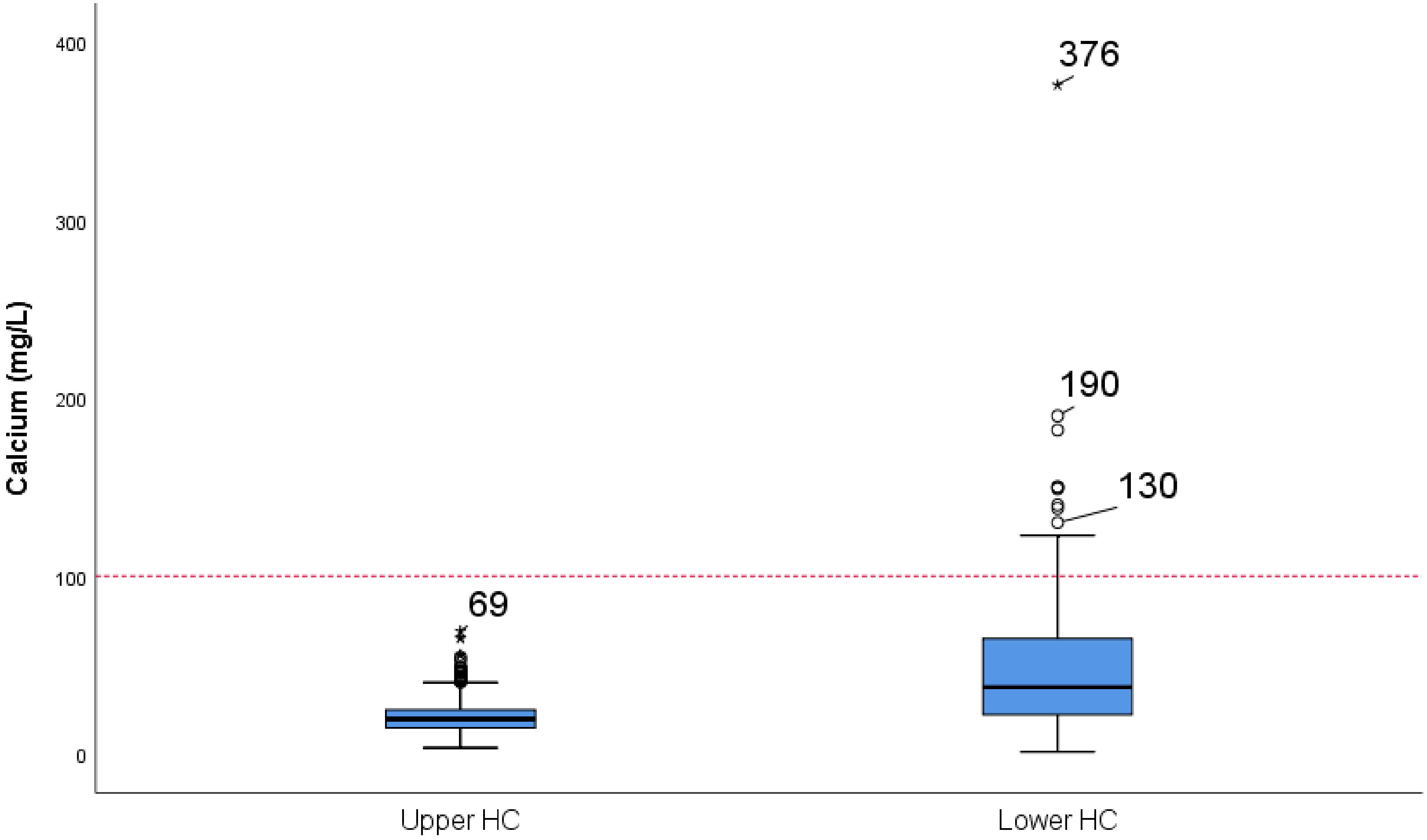


Figure 4-3 **Boxplot of Calcium data split between the Upper and Lower Horse Creek Basins, period of record (1972- 2018, Upper Basin; 1962- 2018, Lower Basin). Circles indicate 1.5x the interquartile (IQ) range, asterisks indicate values >3x the IQ range, and the line across the box indicates the median. The red line denotes the calcium trigger level.**

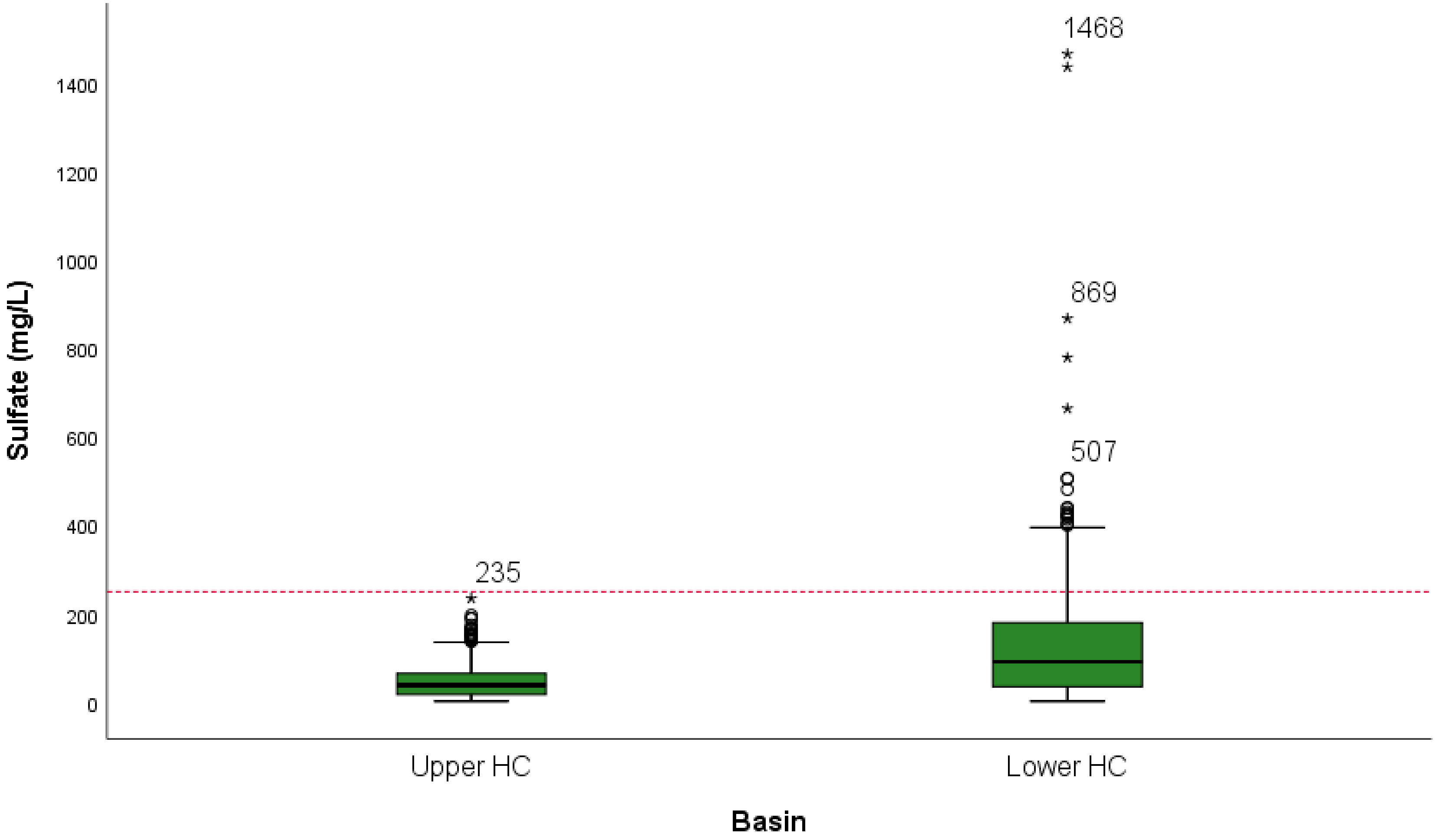


Figure 4-4 **Boxplot Sulfate data split between the Upper and Lower Horse Creek Basins, period of record (1976- 2018, Upper Basin; 1962- 2018, Lower Basin). Circles indicate 1.5x the interquartile (IQ) range, asterisks indicate values >3x the IQ range, and the line across the box indicates the median. The red line denotes the sulfate trigger level.**

5.0 WINGATE AND FORT GREEN NPDES DISCHARGE

The Wingate and Fort Green NPDES wastewater permits do not require reporting of TDS, calcium or sulfate. The permits do require specific conductivity, which can be used to estimate TDS concentration. Two effluent TDS estimates are presented in Figure 5-1 and compared against the Upper Horse Creek, Lower Horse Creek, and Brushy Creek basin values. A typical TDS sensor calculates TDS concentration by applying a 0.65 coefficient to in-situ specific conductivity. This coefficient can be adjusted to factor in components of TDS that are not detectable by the probe like dissolved organic material. Since the mining process displaces the organic overburden, it is assumed that the TDS is largely comprised of inorganic, and therefore, probe-detectable material.

Not having TDS values for the NPDES discharge to model the true coefficient, we utilized a regression of the TDS vs specific conductivity of the receiving waters at HCSW-1 (Figure 5-2), assuming that the discharge is generally a fraction of the creek flow and the creek flow contains more organic material than the effluent. That regression was then applied to the effluent specific conductivity to generate an estimated TDS value of the effluent (denoted at “lin” in Figure 5-1).

What the two TDS estimates show in Figure 5-1 is that the effluent data distribution is less variable than the Upper and Lower Basins (narrower spread), the effluent mean is more similar to the Lower Basin’s mean. However, the effluent record as well as the receiving waters in the Upper Basin cannot explain the frequent and extreme TDS values in the Lower Basin.

One notable exception to the effluent making up a fraction of the creek flow occurred on June 3, 2009 when the discharge through Wingate D-004 was flowing at 219.85 cfs and the stream flow rate was 40 cfs at HCSW-1 and 27.3 cfs at HCSW-4 (Table 2). Both outfalls had been discharging for 8 days. TDS exceedances on that day were modest and occurred only at HCSW-3 and HCSW-4 (540 and 692 $mg \cdot L^{-1}$ respectively). The TDS value at HCSW-1 that day was 388 $mg \cdot L^{-1}$ when the streamflow consisted mostly effluent, the specific conductivity was 513 µS which would be 333.45 $mg \cdot L^{-1}$ and 269.68 $mg \cdot L^{-1}$ using the 0.65 coefficient and the HCSW-1 calibrated regression respectively. This appears to support the assumption that the NPDES discharge TDS is low in organic material. It also suggests that the discharge contained relatively low TDS.

Calcium in the effluent is not monitored through the NPDES permit. The Upper Basin and Brushy Creek calcium values are less concentrated than the values in the Lower Basin (Figure 5-3). There have been no calcium exceedances in Brushy Creek or any of the sites in the Upper Basin.

Sulfate was collected between 2010 and 2013 as part of the Wingate NPDES permit renewal 2CS submittal. Effluent sulfate concentrations at the outfall D-004 ranged from 44.91 $mg \cdot L^{-1}$ - 199.8 $mg \cdot L^{-1}$ (Figure 5-4). There have been no sulfate exceedances at any of the Upper Horse Creek Basin monitoring sites to date. Neither the limited effluent sulfate data nor the extensive Upper Basin data explain the extremes seen in the Lower Basin. Some other unaccounted phenomenon appears to be pulling the Lower Basin values to the right (higher concentrations).

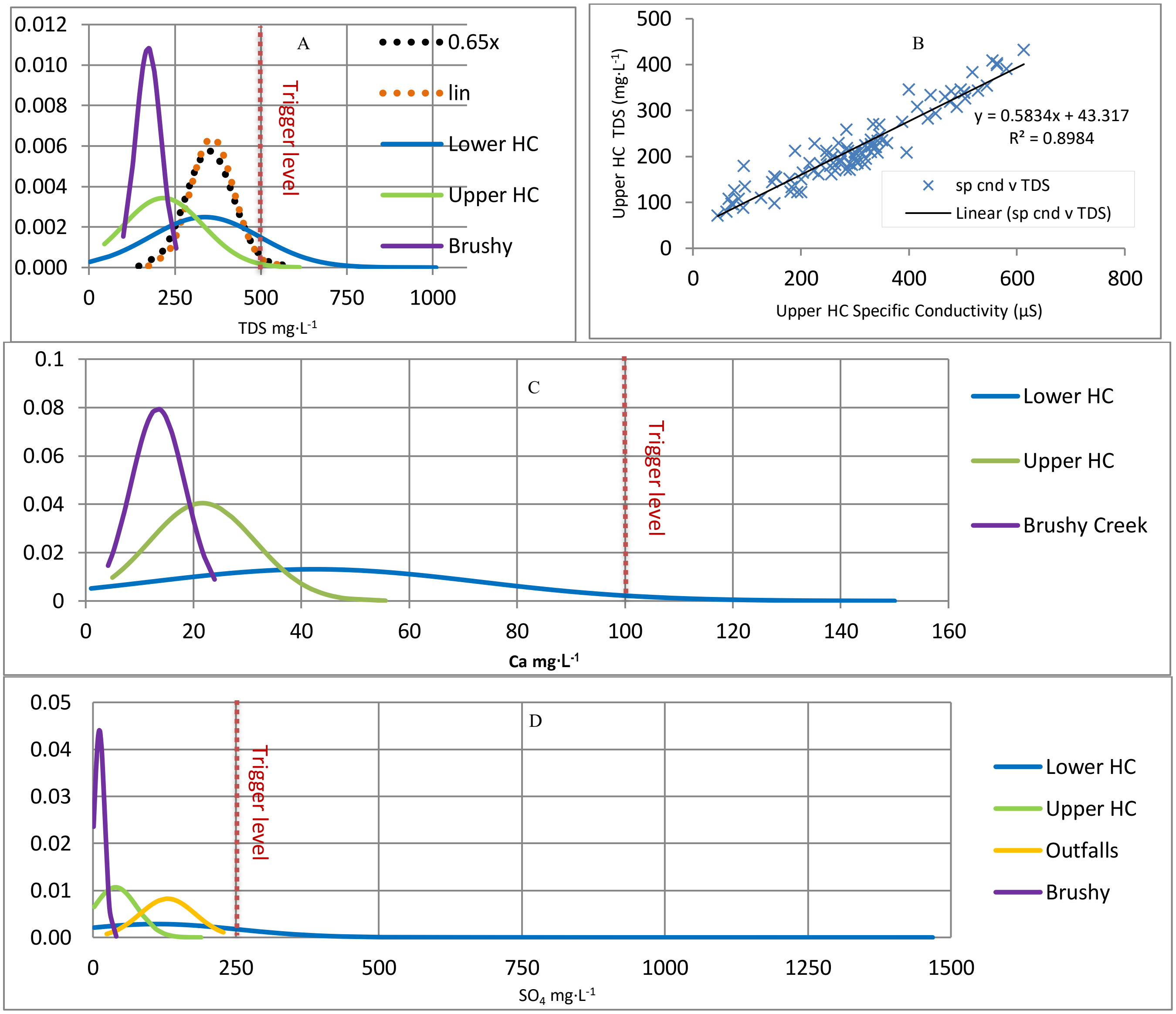


Figure 5-1 **Normal distribution charts comparing spread of values for each parameter between sample sites. Y-axes (Figures 5-1A, 5-1B, 5-1C, & 5-1D) are probability densities**

$$f(x;\mu,\sigma) = \frac{1}{\sigma\sqrt{2\pi}} e^{-\left(\frac{(x-\mu)^2}{\sigma^2}\right)}$$

(**A**) TDS was estimated for the combined outfalls to compare with Horse and Brushy Creek. The estimates were calculated two ways: The first was the standard conversion coefficient, 0.65 x outfall specific conductivity= estimated TDS. And the second was using outfall specific conductivity with a (**B**) regression derived from HCSW-1 specific conductivity vs. HCSW-1 TDS. Specific conductivity accounts for inorganic components of TDS. It can be assumed that the effluent from D-004 is lower in organic components than HCSW-1 because the organic overburden is displaced before production.

(**C**) Calcium samples are not a required component of the NPDES permit but to date there has not been a single calcium exceedance at any site in the Upper Horse Creek Basin. (**D**) Sulfate samples were required under the NPDES permit renewal application form 2CS. The outfall data used spans 2001-2015 and comprises both the Fort Green D-003, n = 11; and Wingate D-004, n = 40 outfalls.

6.0 CREEK FLOW

TDS, sulfate and calcium concentrations in Horse Creek tended to be lower when there was a discharge through either outfall than when there was no discharge (Figures 6-1 through 6-3). This is because the Fort Green and Wingate Mine wastewater discharges are driven by stormwater as opposed to process demand. If either outfall is discharging, Horse Creek is either at an elevated stream flow or coming off a state of elevated stream flow.

With the exception of the June 3, 2009 (discussed above) and the June 3, 2015 events, all TDS, sulfate and calcium exceedances occurred at times when the outfalls were inactive (Table 2), often long inactive (9-503 days), and Horse Creek was under very low flow conditions. Tables 3 and 4 below show that mean and median stream flow during times of exceedances are an order of magnitude lower than the overall mean and median streamflow. That is to say, the stream condition when exceedances can be predicted is low flow conditions in the Lower Basin with some groundwater input.

When considered together, the elevated TDS, calcium and sulfate concentrations between the Lower and Upper Horse Creek basins; the exceedances occurring outside of periods of wastewater discharge; and, the exceedances occurring during periods of high base flow/ low stream flow, it appears that these exceedances are tied to land use practices downstream of HCSW-2 and unrelated to the Wingate or Fort Green Mine outfalls.

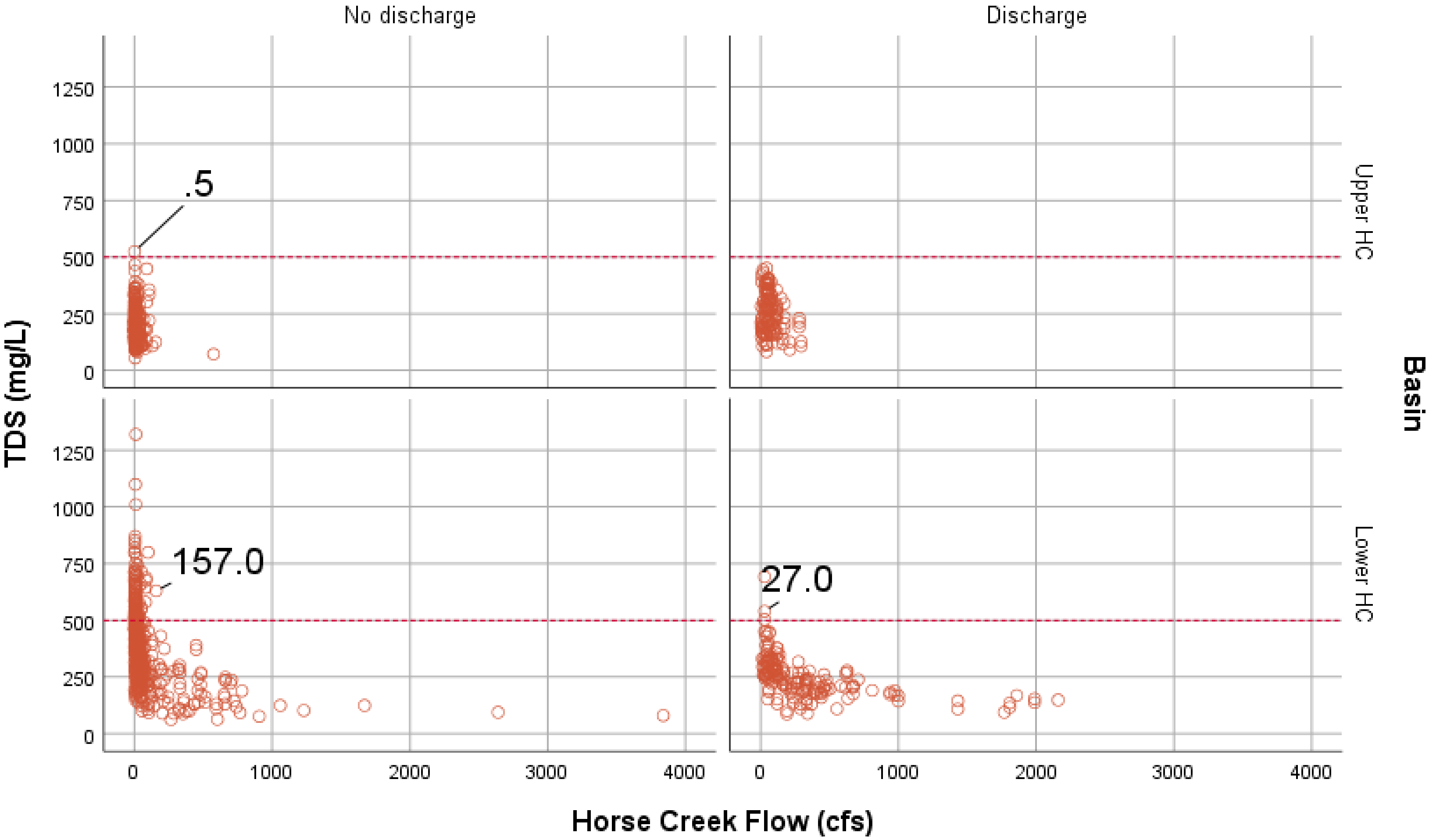


Figure 6-1 Horse Creek Flow vs TDS. Values separated by NPDES Discharge Status and Basin location. Greatest stream flow value associated with an exceedance labeled. Upper and Lower Horse Creek Basin flow values are from USGS stations 02297155 and 02297310, respectively. Mean and median flow in Horse Creek during the HCSP period was 36.7 and 8.9 cfs in Upper Basin and 201.6 and 46 cfs in the Lower Basin.

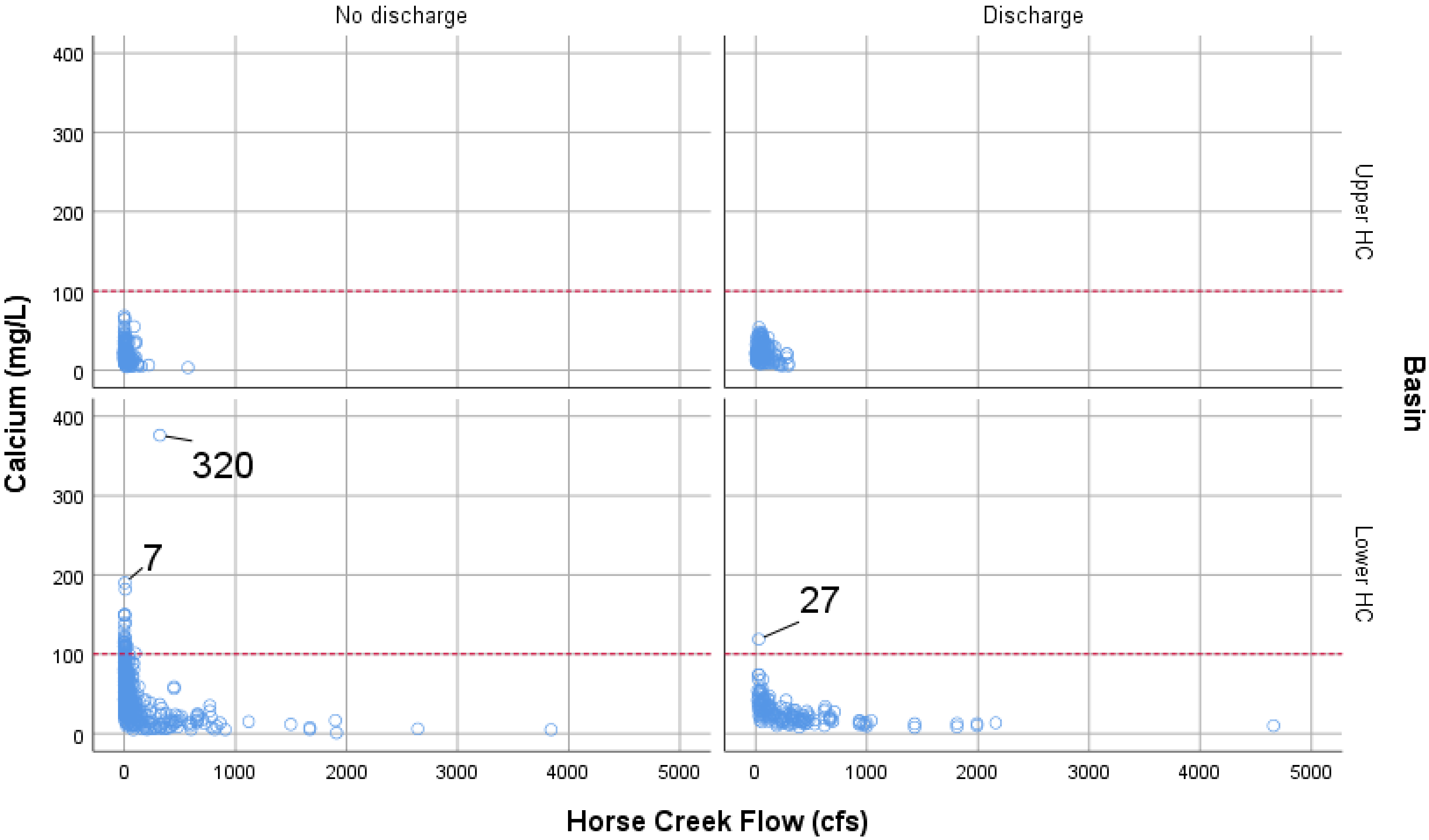


Figure 6-2 **Horse Creek Flow vs Calcium. Values separated by NPDES Discharge Status and Basin location. Greatest stream flow value associated with an exceedance labeled. Upper and Lower Horse Creek Basin flow values are from USGS stations 02297155 and 02297310, respectively. Mean and median flow in Horse Creek during the HCSP period was 36.7 and 8.9 cfs in Upper Basin and 201.6 and 46 cfs in the Lower Basin.**

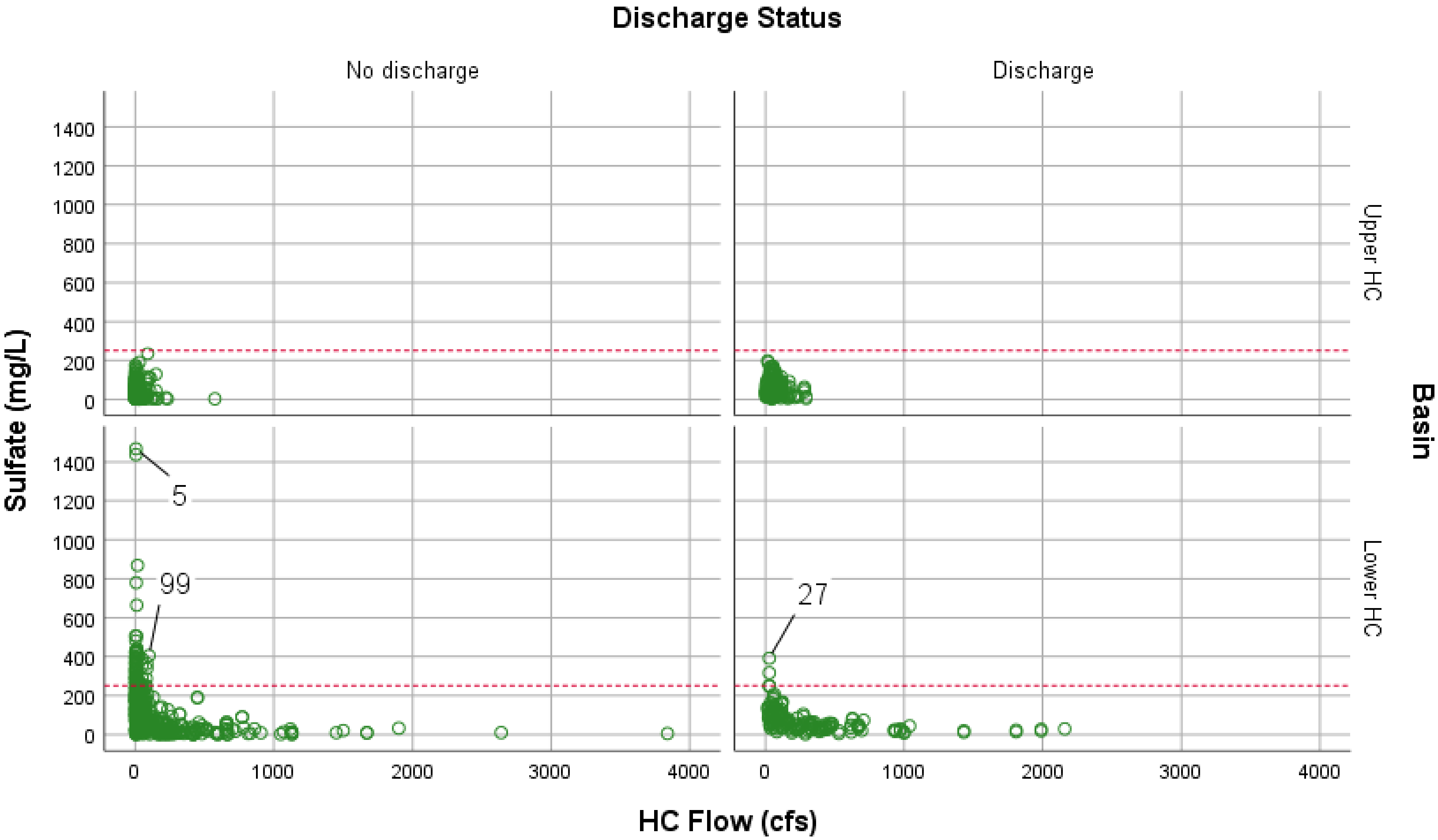


Figure 6-3 Horse Creek Flow vs Sulfate. Values separated by NPDES Discharge Status and Basin location. Greatest stream flow value associated with an exceedance labeled. Upper and Lower Horse Creek Basin flow values are from USGS stations 02297155 and 02297310, respectively. Mean and median flow in Horse Creek during the HCSP period was 36.7 and 8.9 cfs in Upper Basin and 201.6 and 46 cfs in the Lower Basin

Table 2 **Historical List of All Exceedances (TDS, Ca & SO_4) and Elapsed Days Between the Exceedance and Last NPDES Discharge (D-003 or D-004), n= 232, 101 Unique Dates.**

Data Source	Site	Date	Ca	SO_4	TDS	Date of Recent Discharge	Elapsed Time	NPDES Flow D-003 & 004	HCSW-4 Flow	% Baseflow
			$mg \cdot L^{-1}$				Days	cfs		
IWR	SR72	3/6/97	--	--	518	--	--	--	3	100
IWR	SR72	4/24/97	--	260		--	--	--	14	24
IWR	SR72	5/3/99	110	340	677	--	--	--	2.9	44
IWR	SR72	5/3/99	--	--	--	--	--	--	2.9	44
IWR	SR72	5/3/99	--	--	--	--	--	--	2.9	44
IWR	SR72	3/14/00		266	--	--	--	--	3.7	100
IWR	SR72	5/8/00	130	334	--	--	--	--	0.28	39
IWR	SR72	6/7/00	101	--	--	--	--	--	no flow	no flow
IWR	SR72	7/10/00	--	292	--	--	--	--	16	61
IWR	SR72	1/11/01	--	328	--	--	--	--	8.2	75
IWR	SR72	2/6/01	--	280	--	--	--	--	5.2	90
IWR	SR72	3/8/01	102	297	--	--	--	--	6.1	68
IWR	SR72	4/5/01	--	353	--	--	--	--	49	54
IWR	SR72	5/9/01	--	507	--	--	--	--	0.82	82
IWR	SR72	6/4/01	115	266	559	--	--	--	2.7	23

Data Source	Site	Date	Ca	SO_4	TDS	Date of Recent Discharge	Elapsed Time	NPDES Flow D-003 & 004	HCSW-4 Flow	% Baseflow
			$mg \cdot L^{-1}$				Days	cfs		
IWR	SR761	2/4/02	--	--	776	9/30/01	127	21.83	14.6	100
IWR	SR72	6/9/04	112	424	--	10/14/03	239	2.57	10.5	70
HCSP	HCSW-4	6/29/04	--	261	--	10/14/03	259	2.57	40.7	48
HCSP	HCSW-3	3/28/06	--	300	--	3/9/06	19	0.51	10.5	98
HCSP	HCSW-4	3/28/06	--	300	600	3/9/06	19	0.51	10.5	98
IWR	SR72	4/11/06	--	289	573	3/9/06	33	0.51	5.81	88
HCSP	HCSW-3	4/27/06	110	420	580	3/9/06	49	0.51	2.96	100
IWR	SR72	5/3/06	--	--	531	3/9/06	55	0.51	2.31	100
IWR	SR72	5/4/06	102	--	--	3/9/06	56	0.51	2.27	100
HCSP	HCSW-4	5/25/06	110	310	560	3/9/06	77	0.51	1.92	96
IWR	SR72	6/8/06	138	426	798	3/9/06	91	0.51	2.12	100
HCSP	HCSW-3	6/29/06	110	430	590	3/9/06	112	0.51	6.95	54
HCSP	HCSW-4	6/29/06	190	780	1100	3/9/06	112	0.51	6.95	54
IWR	SR72	7/6/06	108	395	662	3/9/06	119	0.51	3.63	100
HCSP	HCSW-4	11/9/06	--	--	510	3/9/06	245	0.51	15	100
IWR	SR72	12/6/06	111	336	631	3/9/06	272	0.51	7.51	100

Data Source	Site	Date	Ca	SO_4	TDS	Date of Recent Discharge	Elapsed Time	NPDES Flow D-003 & 004	HCSW-4 Flow	% Baseflow
			$mg \cdot L^{-1}$				Days	cfs		
HCSP	HCSW-4	12/13/06	110	290	550	3/9/06	279	0.51	6.69	98
IWR	SR72	1/2/07	--	256	506	3/9/06	299	0.51	29.2	57
IWR	SR72	2/8/07	--	252	--	3/9/06	336	0.51	50.7	62
IWR	SR761	3/22/07	--	--	506	3/9/06	378	0.51	7.24	100
HCSP	HCSW-3	4/25/07	110	--	590	3/9/06	412	0.51	3.65	100
HCSP	HCSW-3	5/16/07	110	360	530	3/9/06	433	0.51	3.3	69
IWR	SR72	6/5/07	112	420	700	3/9/06	453	0.51	8.59	31
HCSP	HCSW-3	6/20/07	140	440	700	3/9/06	468	0.51	11.5	52
HCSP	HCSW-4	6/20/07	110	320	600	3/9/06	468	0.51	11.5	52
IWR	Pine Level Rd	6/28/07	150	1468	870	3/9/06	476	0.51	4.86	84
HCSP	HCSW-3	7/18/07	--	--	520	3/9/06	496	0.51	30.9	87
HCSP	HCSW-4	7/18/07	--	--	530	3/9/06	496	0.51	30.9	87
IWR	Pine Level Rd	7/25/07	--	869	720	3/9/06	503	0.51	15.6	100
IWR	**SR70**	**9/14/07**	**--**	**255**	**--**	**9/5/07**	**9**	**1.54**	**26.1**	**100**
IWR	SR761	12/20/07	--	--	535	9/5/07	106	1.54	10.2	52
IWR	SR72	1/9/08	--	--	513	9/5/07	126	1.54	6.57	97

Data Source	Site	Date	Ca	SO$_4$	TDS	Date of Recent Discharge	Elapsed Time	NPDES Flow D-003 & 004	HCSW-4 Flow	% Baseflow
			mg·L^{-1}				Days	cfs		
IWR	SR70	1/29/08	--	506	1010	9/5/07	146	1.54	9.48	70
IWR	Unnamed Creek @ CR665	1/30/08	--	438	750	9/5/07	147	1.5	8.54	78
HCSP	HCSW-4	1/30/08	--	--	550	9/5/07	147	1.54	8.54	78
HCSP	HCSW-4	3/27/08	120	390	660	9/5/07	204	1.54	7.98	60
HCSP	HCSW-4	5/29/08	110	290	710	9/5/07	267	1.54	0.13	100
IWR	SR72	6/2/08	116	390	672	9/5/07	271	1.54	1.21	29
HCSP	HCSW-3	6/26/08	--	251	580	9/5/07	295	1.54	79.7	56
HCSP	HCSW-4	6/26/08	--	287	644	9/5/07	295	1.54	79.7	56
HCSP	HCSW-3	2/2/09	--	280	520	10/26/08	99	7.52	6.66	73
HCSP	HCSW-4	2/2/09	106	290	536	10/26/08	99	7.52	6.66	73
HCSP	HCSW-3	4/1/09	--	293	568	10/26/08	157	7.52	3.48	89
HCSP	**HCSW-3**	**6/3/09**	**--**	**251**	**540**	**6/3/09**	**0**	**219.85**	**27.3**	**63**
HCSP	**HCSW-4**	**6/3/09**	**119**	**391**	**692**	**6/3/09**	**0**	**219.85**	**27.3**	**63**
HCSP	HCSW-3	12/2/09	--	--	524	10/31/09	32	1.54	7.32	89
HCSP	HCSW-4	12/2/09	--	279	604	10/31/09	32	1.54	7.32	89
HCSP	HCSW-4	11/3/10	--	258	577	10/10/10	24	0.68	34.6	44

Data Source	Site	Date	Ca	SO_4	TDS	Date of Recent Discharge	Elapsed Time	NPDES Flow D-003 & 004	HCSW-4 Flow	% Baseflow
			mg·L^{-1}				Days	cfs		
IWR	SR72	1/3/11	--	283	562	10/10/10	85	0.68	17.6	93
HCSP	HCSW-3	1/4/11	--	--	513	10/10/10	86	0.68	17.2	94
HCSP	HCSW-4	1/4/11	--	262	574	10/10/10	86	0.68	17.2	94
HCSP	HCSW-4	7/5/11	--	253	660	10/10/10	268	0.68	45.9	23
IWR	SR761	7/14/11	--	--	650	10/10/10	277	0.68	32.8	70
HCSP	HCSW-3	12/21/11	--	--	543	11/8/11	43	14.09	8.7	100
HCSP	HCSW-4	12/21/11	--	--	543	11/8/11	43	14.09	8.7	100
HCSP	HCSW-3	1/12/12	--	--	571	11/8/11	65	14.09	8.75	69
IWR	SR761	1/12/12	--	--	590	11/8/11	65	14.09	8.75	69
HCSP	HCSW-4	1/12/12	--	--	569	11/8/11	65	14.09	8.75	69
HCSP	HCSW-3	2/2/12	--	254	532	11/8/11	86	14.09	5.95	95
HCSP	HCSW-4	2/2/12	--	--	512	11/8/11	86	14.09	5.95	95
HCSP	HCSW-3	3/5/12	--	287	603	11/8/11	118	14.09	2.76	100
IWR	SR72	3/5/12	--	261	546	11/8/11	118	14.09	2.76	100
HCSP	HCSW-4	3/5/12	--	267	585	11/8/11	118	14.09	2.76	100
IWR	SR761	3/22/12	--	--	506	11/8/11	135	14.09	1.1	92

Data Source	Site	Date	Ca	$\mathrm{SO_4}$	TDS	Date of Recent Discharge	Elapsed Time	NPDES Flow D-003 & 004	HCSW-4 Flow	% Baseflow
			mg·L^{-1}				Days	cfs		
HCSP	HCSW-3	4/2/12	114	365	714	11/8/11	146	14.09	1.1	95
HCSP	HCSW-4	4/2/12	117	321	688	11/8/11	146	14.09	1.1	95
IWR	SR761	4/5/12	--	--	588	11/8/11	149	14.09	0.95	100
IWR	SR761	4/19/12	--	--	511	11/8/11	163	14.09	0.31	94
HCSP	HCSW-4	5/2/12	109	--	536	11/8/11	176	14.09	0.21	100
IWR	SR72	5/7/12	114	--	509	11/8/11	181	14.09	0.18	94
IWR	SR761	5/31/12	--	--	798	11/8/11	205	14.09	0.25	100
HCSP	HCSW-3	6/5/12	--	304	646	11/8/11	210	14.09	10.3	50
HCSP	HCSW-4	6/5/12	182	665	1320	11/8/11	210	14.09	10.3	50
IWR	SR761	6/14/12	--	--	630	11/8/11	219	14.09	157	34
HCSP	HCSW-4	2/7/13	--	251	--	11/5/12	94	14.91	8.34	100
HCSP	HCSW-3	3/6/13	--	319	643	11/5/12	121	14.91	5.93	85
HCSP	HCSW-4	3/6/13	--	267	660	11/5/12	121	14.91	5.93	85
IWR	SR761	3/7/13	--	--	520	11/5/12	122	14.91	5.81	86
IWR	SR72	3/7/13	--	266	537	11/5/12	122	14.91	5.81	86
HCSP	HCSW-3	4/2/13	123	400	818	11/5/12	148	14.91	2.23	100

Data Source	Site	Date	Ca	SO_4	TDS	Date of Recent Discharge	Elapsed Time	NPDES Flow D-003 & 004	HCSW-4 Flow	% Baseflow
			mg·L^{-1}				Days	cfs		
HCSP	HCSW-4	4/2/13	--	--	595	11/5/12	148	14.91	2.23	100
IWR	SR761	4/4/13	--	--	512	11/5/12	150	14.91	5.39	44
IWR	SR761	4/18/13	--	--	610	11/5/12	164	14.91	4.17	100
HCSP	HCSW-3	5/1/13	105	373	648	11/5/12	177	14.91	3.38	73
HCSP	HCSW-4	5/1/13	--	292	614	11/5/12	177	14.91	3.38	73
IWR	SR761	5/2/13	--	--	504	11/5/12	178	14.91	8.13	35
IWR	SR72	5/8/13	122	414	726	11/5/12	184	14.91	4.36	98
IWR	SR761	5/16/13	--	--	621	11/5/12	192	14.91	2.52	100
IWR	SR761	5/30/13	--	--	572	11/5/12	206	14.91	6.91	100
HCSP	HCSW-3	6/4/13	--	363	675	11/5/12	211	14.91	84	26
HCSP	HCSW-4	6/4/13	--	338	687	11/5/12	211	14.91	84	26
HCSP	HCSW-3	12/3/13	--	--	528	10/6/13	58	4.72	14.7	85
HCSP	HCSW-4	12/3/13	--	267	617	10/6/13	58	4.72	14.7	85
HCSP	HCSW-3	1/2/14	--	282	--	10/6/13	88	4.72	6.51	88
HCSP	HCSW-4	1/2/14	--	333	601	10/6/13	88	4.72	6.51	88
IWR	SR72	1/9/14	--	251	535	10/6/13	95	4.72	6.5	84

Data Source	Site	Date	Ca	SO_4	TDS	Date of Recent Discharge	Elapsed Time	NPDES Flow D-003 & 004	HCSW-4 Flow	% Baseflow
			$mg{\cdot}L^{-1}$				Days	cfs		
IWR	SR761	1/22/14	--	--	523	10/6/13	108	4.72	11.1	58
HCSP	HCSW-4	2/3/14	101	404	799	10/6/13	120	4.72	99.2	41
IWR	SR761	3/20/14	--	--	516	10/6/13	165	4.72	33	64
HCSP	HCSW-4	4/1/14	--	--	555	10/6/13	177	4.72	50.9	65
HCSP	HCSW-4	5/1/14	--	--	544	10/6/13	207	4.72	7.8	100
IWR	SR72	5/7/14	111	403	693	10/6/13	213	4.72	24.1	56
HCSP	HCSW-3	6/3/14	--	--	548	10/6/13	240	4.72	49.5	49
HCSP	HCSW-4	6/3/14	--	389	715	10/6/13	240	4.72	49.5	49
HCSP	HCSW-3	7/1/14	--	--	518	10/6/13	268	4.72	18.1	100
HCSP	HCSW-4	7/1/14	--	--	580	10/6/13	268	4.72	18.1	100
HCSP	HCSW-4	4/8/15	--	--	521	10/19/14	171	8.08	8.76	100
HCSP	HCSW-4	5/11/15	--	--	571	10/19/14	204	8.08	10.5	91
HCSP	**HCSW-3**	**6/3/15**	**--**	**316**	**--**	**6/3/15**	**0**	**20.22**	**27.4**	**19**
HCSP	**HCSW-4**	**6/3/15**	**--**	**--**	**504**	**6/3/15**	**0**	**20.22**	**27.4**	**19**
IWR	SR761	1/26/17	--	--	517	12/8/16	49	0.67	12	79
HCSP	HCSW-3	3/7/17	--	266	536	12/8/16	89	0.67	5.87	97

Data Source	Site	Date	Ca	SO_4	TDS	Date of Recent Discharge	Elapsed Time	NPDES Flow D-003 & 004	HCSW-4 Flow	% Baseflow
			$mg \cdot L^{-1}$				Days	cfs		
HCSP	HCSW-4	3/7/17	105	335	635	12/8/16	89	0.67	5.87	97
HCSP	HCSW-3	4/11/17	--	278	527	12/8/16	124	0.67	2.54	100
HCSP	HCSW-4	4/11/17	149	482	853	12/8/16	124	0.67	2.54	100
HCSP	**HCSW-1** [†]	**4/11/17**	**--**	**--**	**524**	**12/8/16**	**124**	**0.67**	**2.54**	**100**
IWR	SR761	5/10/17	--	--	521	12/8/16	153	0.67	0.36	100
HCSP	HCSW-4	7/17/17	376	--	--	12/8/16	221	0.67	320	58
HCSP	HCSW-3	1/17/18	--	--	742	12/8/16	405	0.67	23.4	78
HCSP	HCSW-4	1/17/18	--	--	520	12/8/16	405	0.67	23.4	78

Red text indicates events occurring within 10-days of NPDES discharge

[†] HCSW-1 gauging station was down on 12/8/2016. USGS subsequently estimated the flow to ~0.5cfs. This was the sole exceedance in the Upper Horse Creek basin.

Table 3 Summary Statistics of Flow Events through Outfalls D-003 and D-004 and Horse Creek Flow during the Same Time Period of NPDES Discharge to Horse Creek (7/19/2001- 12/8/2016)

	NPDES Combined Flow (cfs)	HCSW-1 Flow (cfs)	HCSW-1 % Baseflow	HCSW-4 Flow (cfs)	HCSW-4 % Baseflow
Mean	**14.5**	**36.9**	**75.8**	**182.8**	**79.5**
Median	**0**	**9.2**	**86.4**	**44.7**	**90.4**
Mode	0	0	100	11.7	100
Minimum	0	0	0	0	0
Maximum	317.8	1740	100	6520	100
Count	5318	5620	5620	5257	5257

Table 4 Summary Statistics of Horse Creek Stream Flow Conditions at the Time of Recorded Exceedance (TDS, Ca & SO_4) and Elapsed Days between the Exceedance (7/19/2001- 12/8/2016).

	Elapsed Days since NPDES Discharge	Combined NPDES Flow (cfs)*	HCSW-1 Flow (cfs)	% Baseflow HCSW-1	HCSW-4 Flow (cfs)	% Baseflow HCSW-4
Mean	180.5	1.99	**4.4**	64.4	**18.1**	76.4
Median	160	0	**2**	75.1	**7.3**	86.2
Mode	49	0	0	100	10.5	100
Minimum	0	20.1	0	0	0	0.0
Maximum	503	219	56.2	100	320	100
Count	88	101*	101	101	101	101

This is a Subset of Table 3. The mean and median stream flow during times of exceedance is an order of magnitude lower than the mean and median under normal conditions. NPDES outfalls are usually not discharging when there was an exceedance.

*There were only two occasions when an exceedance (TDS, calcium, or sulfate) occurred on the same day as an NPDES discharge 6/3/2009 (219.8 cfs average daily flow) and 6/3/2015 (120 cfs average daily flow).

7.0 MAJOR TRIBUTARIES TO HORSE CREEK

Between the confluence of West Fork Horse Creek (North of HCSW-1 at State Road 64) and HCSW-4 at State Road 72, there are approximately 40 tributaries that drain into Horse Creek. Most of these waterbodies are unnamed 1st order streams. Six of the forty tributaries are named systems, with designated WBIDs. Of those six WBIDs, four have some historical TDS, sulfate, and total calcium data in the IWR database (Figures 7-1 through 7-3, Table 5).

Cypress Branch and Brushy Creek Drain into the Upper Horse Creek Basin, between HCSW-1 and HCSW-2. Brandy Branch and Buzzard Roost Branch both drain into the Lower Horse Creek Basin between HCSW-3 and HCSW-4. Only Brandy Branch and Buzzard Roost Branch show excursions above the trigger levels set for TDS, calcium and sulfate in Horse Creek, which is consistent with what has been observed in the lower basin at HCSW-3 and HCSW-4 throughout the HCSP.

Both Brandy Branch and Buzzard Roost Branch have exhibited values above Horse Creek's trigger values for TDS, calcium, and sulfate from the start of their respective periods of record (Figure 7-4 A-C), across their reaches. Both streams cross sod fields along Lily County Line Road. Neither watershed has been mined or has a permitted wastewater discharge.

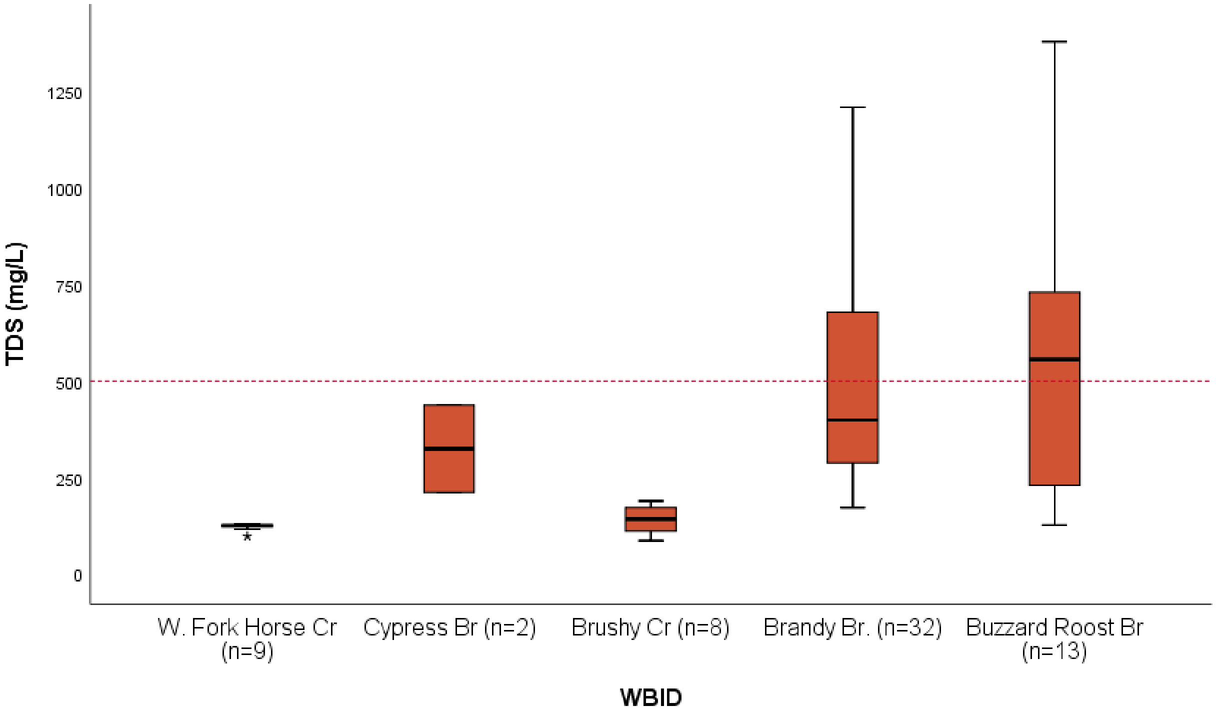


Figure 7-1 **Period of record IWR TDS data from West Fork Horse Creek (1993-1995), Cypress Branch (2013-2014), Brushy Creek (1982-2002), Brandy Branch (1993-2016), and Buzzard Roost Branch (1993-2002). Circles indicate 1.5x the interquartile (IQ) range, asterisks indicate values >3x the IQ range, and the line across the box indicates the median. The red line denotes the HCSP TDS trigger level for Horse Creek.**

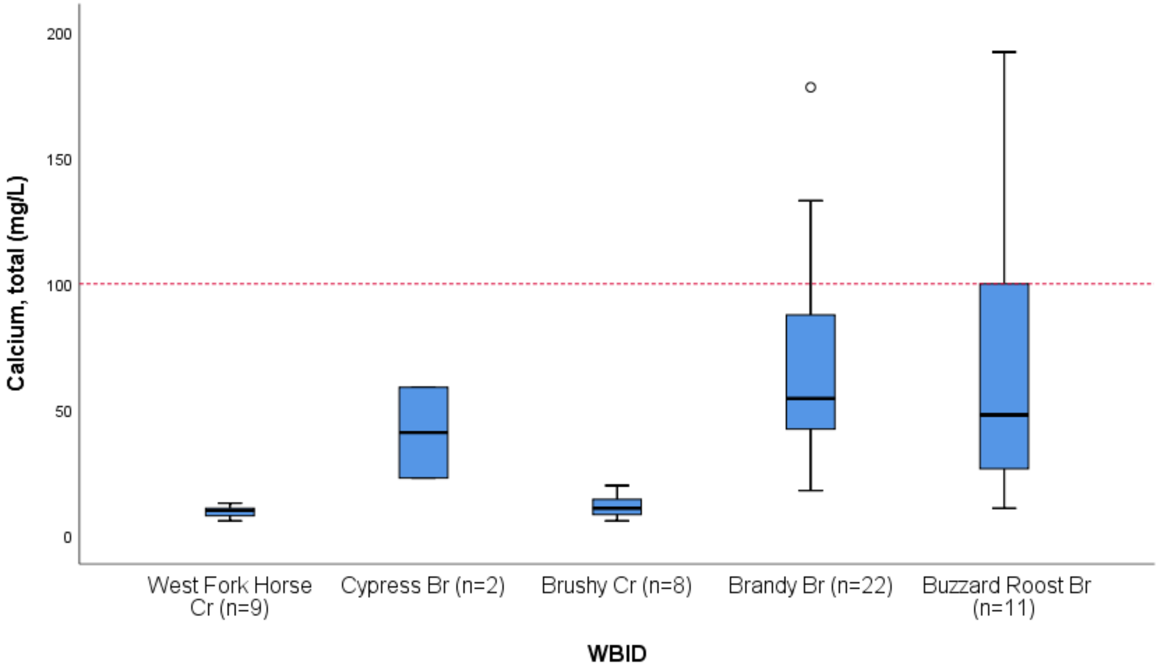


Figure 7-2 Period of record IWR total calcium data from West Fork Horse Creek (1993-1995), Cypress Branch (2013-2014), Brushy Creek (1982-2002), Brandy Branch (1993-2016), and Buzzard Roost Branch (1993-2002). Circles indicate 1.5x the interquartile (IQ) range, asterisks indicate values >3x the IQ range, and the line across the box indicates the median. The red line denotes the HCSP dissolved calcium trigger level for Horse Creek.

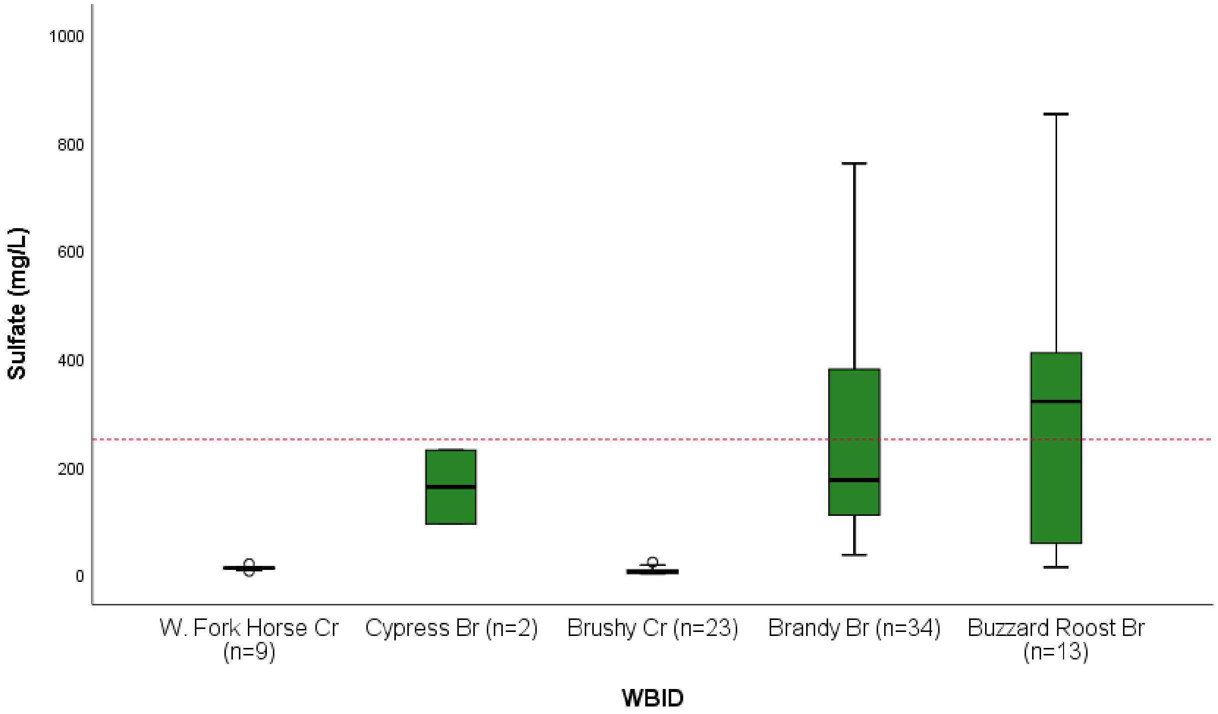


Figure 7-3 **Period of record IWR sulfate data from West Fork Horse Creek (1993-1995), Cypress Branch (2013-2014), Brushy Creek (1982-2002), Brandy Branch (1993-2016), and Buzzard Roost Branch (1993-2002). Circles indicate 1.5x the interquartile (IQ) range, asterisks indicate values >3x the IQ range, and the line across the box indicates the median. The red line denotes the HCSP sulfate trigger level for Horse Creek.**

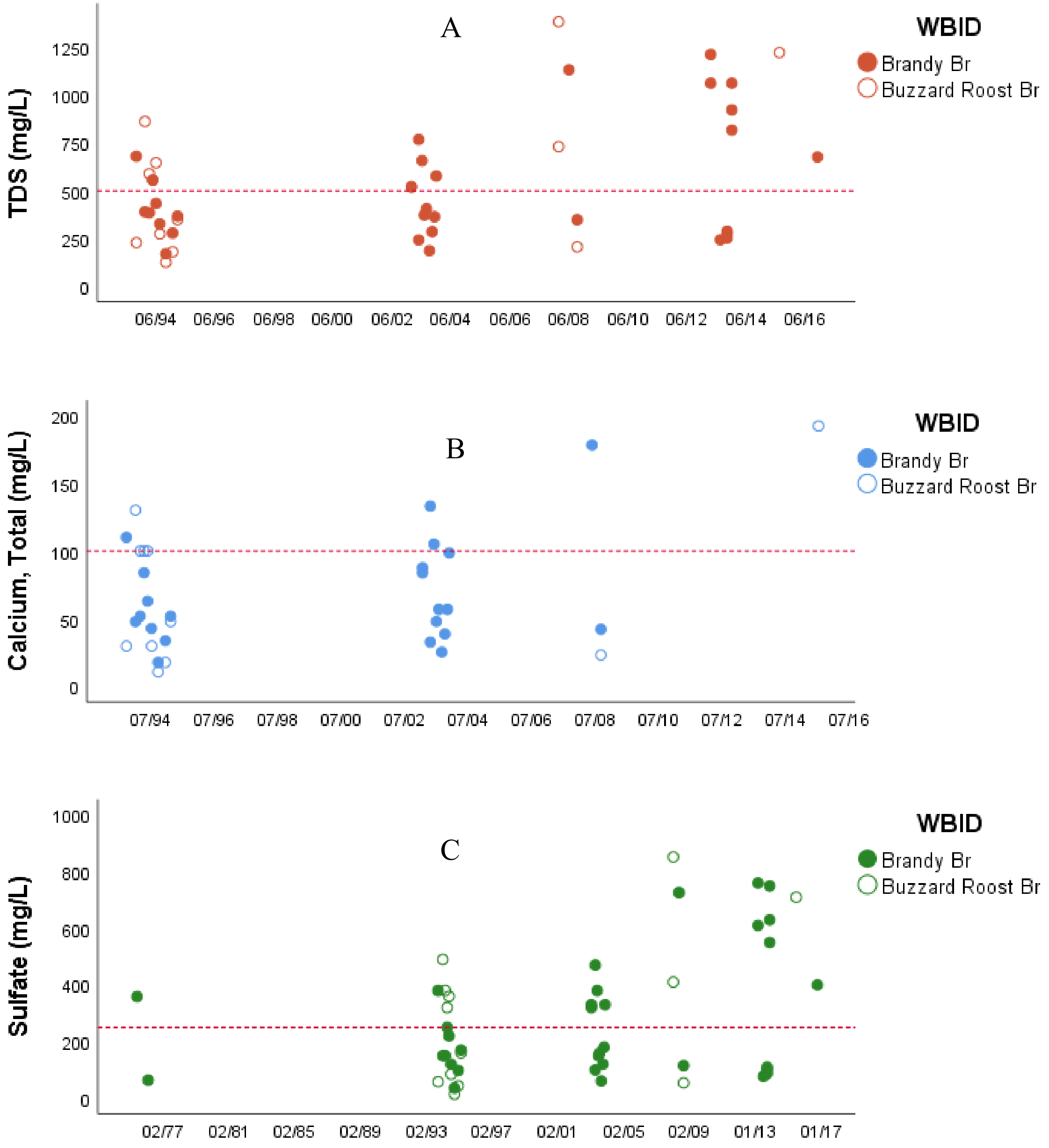


Figure 7-4 Period of record IWR TDS (A), sulfate (B), and total calcium (C) values from Brandy Branch and Buzzard Roost Branch. The red lines denote the HCSP trigger levels for Horse Creek.

Table 5 Period of Record TDS, Sulfate and Calcium Data for Tributaries of Horse Creek.

WBID	Site	Date	Parameter	Result (mg/L)
1826A	Brushy Creek Near Ona FL	8/24/1982	Ca	8
1826A	Brushy Creek Near Lilly FL	10/15/1993	Ca	10
1826A	Brushy Creek Near Lilly FL	1/27/1994	Ca	12
1826A	Brushy Creek Near Lilly FL	3/22/1994	Ca	14
1826A	Brushy Creek Near Lilly FL	7/27/1994	Ca	9
1826A	Brushy Creek Near Lilly FL	1/5/1995	Ca	15
1826A	Brushy Creek Near Lilly FL	3/7/1995	Ca	20
1826A	SWD-SS-1011 Brushy Creek	8/26/2002	Ca	6
1836	West Fork Horse Creek Near Myakka Head FL	10/13/1993	Ca	7
1836	West Fork Horse Creek Near Myakka Head FL	1/26/1994	Ca	8
1836	West Fork Horse Creek Near Myakka Head FL	3/21/1994	Ca	12
1836	West Fork Horse Creek Near Myakka Head FL	5/4/1994	Ca	13
1836	West Fork Horse Creek Near Myakka Head FL	6/16/1994	Ca	8
1836	West Fork Horse Creek Near Myakka Head FL	7/29/1994	Ca	10
1836	West Fork Horse Creek Near Myakka Head FL	10/14/1994	Ca	6
1836	West Fork Horse Creek Near Myakka Head FL	12/14/1994	Ca	11
1836	West Fork Horse Creek Near Myakka Head FL	3/7/1995	Ca	10
1915	Z4-SS-7019 Unnamed Small Stream	7/24/2013	Ca	59
1915	Z4-SS-8029 Unnamed Small Stream	7/29/2014	Ca	23
1939	Brandy Branch at Pine Level FL	10/14/1993	Ca	110
1939	Brandy Branch at Pine Level FL	1/27/1994	Ca	48
1939	Brandy Branch at Pine Level FL	3/22/1994	Ca	52
1939	Brandy Branch at Pine Level FL	5/5/1994	Ca	84
1939	Brandy Branch at Pine Level FL	6/15/1994	Ca	63
1939	Brandy Branch at Pine Level FL	7/29/1994	Ca	43

WBID	Site	Date	Parameter	Result (mg/L)
1939	Brandy Branch at Pine Level FL	10/14/1994	Ca	18
1939	Brandy Branch at Pine Level FL	1/5/1995	Ca	34
1939	Brandy Branch at Pine Level FL	3/7/1995	Ca	52
1939	TP165 - Brandy Branch	2/5/2003	Ca	84
1939	TP99 - Brandy Branch	2/5/2003	Ca	88
1939	TP165 - Brandy Branch	5/6/2003	Ca	133
1939	TP99 - Brandy Branch	5/6/2003	Ca	33
1939	TP99 - Brandy Branch	6/17/2003	Ca	105
1939	TP99 - Brandy Branch	7/15/2003	Ca	48
1939	TP99 - Brandy Branch	8/11/2003	Ca	57
1939	TP99 - Brandy Branch	9/15/2003	Ca	26
1939	TP99 - Brandy Branch	10/20/2003	Ca	39
1939	TP99 - Brandy Branch	11/18/2003	Ca	57
1939	TP99 - Brandy Branch	12/9/2003	Ca	99
1939	Brandy Branch SR 70	6/6/2008	Ca	178
1939	Brandy Branch SR 70	9/16/2008	Ca	42
1944	Buzzard Roost Branch Near Pine Level FL	10/15/1993	Ca	30
1944	Buzzard Roost Branch Near Pine Level FL	1/28/1994	Ca	130
1944	Buzzard Roost Branch Near Pine Level FL	3/22/1994	Ca	100
1944	Buzzard Roost Branch Near Pine Level FL	5/5/1994	Ca	100
1944	Buzzard Roost Branch Near Pine Level FL	6/15/1994	Ca	100
1944	Buzzard Roost Branch Near Pine Level FL	8/1/1994	Ca	30
1944	Buzzard Roost Branch Near Pine Level FL	10/14/1994	Ca	11
1944	Buzzard Roost Branch Near Pine Level FL	1/5/1995	Ca	18
1944	Buzzard Roost Branch Near Pine Level FL	3/7/1995	Ca	48
1944	Buzzard Roost Branch at Pine Level	9/16/2008	Ca	23

WBID	Site	Date	Parameter	Result (mg/L)
1944	Z4-SS-9029 Buzzard Roost Branch	7/21/2015	Ca	192
1826A	Brushy Creek at SR64	8/31/1981	SO_4	2
1826A	Brushy Creek at SR64	11/9/1981	SO_4	18
1826A	Brushy Creek at SR64	1/4/1982	SO_4	2
1826A	Brushy Creek at SR64	3/29/1982	SO_4	2
1826A	Brushy Creek at SR64	5/25/1982	SO_4	2
1826A	Brushy Creek at SR64	7/20/1982	SO_4	2
1826A	Brushy Creek Near Ona FL	8/24/1982	SO_4	9
1826A	Brushy Creek at SR64	9/13/1982	SO_4	2
1826A	Brushy Creek at SR64	2/8/1983	SO_4	14
1826A	Brushy Creek at SR64	8/9/1983	SO_4	2
1826A	Brushy Creek at SR64	12/12/1983	SO_4	2
1826A	Brushy Creek at SR64	6/4/1984	SO_4	2
1826A	Brushy Creek at SR64	10/3/1989	SO_4	13
1826A	Brushy Creek at SR64	1/4/1990	SO_4	23
1826A	Brushy Creek at SR64	4/4/1990	SO_4	8
1826A	Brushy Creek at SR64	7/10/1990	SO_4	5
1826A	Brushy Creek Near Lilly FL	10/15/1993	SO_4	8
1826A	Brushy Creek Near Lilly FL	1/27/1994	SO_4	7
1826A	Brushy Creek Near Lilly FL	3/22/1994	SO_4	6
1826A	Brushy Creek Near Lilly FL	7/27/1994	SO_4	4
1826A	Brushy Creek Near Lilly FL	1/5/1995	SO_4	8
1826A	Brushy Creek Near Lilly FL	3/7/1995	SO_4	9
1826A	SWD-SS-1011 Brushy Creek	8/26/2002	SO_4	1
1836	West Fork Horse Creek Near Myakka Head FL	10/13/1993	SO_4	11
1836	West Fork Horse Creek Near Myakka Head FL	1/26/1994	SO_4	12

WBID	Site	Date	Parameter	Result (mg/L)
1836	West Fork Horse Creek Near Myakka Head FL	3/21/1994	SO_4	12
1836	West Fork Horse Creek Near Myakka Head FL	5/4/1994	SO_4	11
1836	West Fork Horse Creek Near Myakka Head FL	6/16/1994	SO_4	20
1836	West Fork Horse Creek Near Myakka Head FL	7/29/1994	SO_4	7
1836	West Fork Horse Creek Near Myakka Head FL	10/14/1994	SO_4	6
1836	West Fork Horse Creek Near Myakka Head FL	12/14/1994	SO_4	15
1836	West Fork Horse Creek Near Myakka Head FL	3/7/1995	SO_4	14
1915	Z4-SS-7019 Unnamed Small Stream	7/24/2013	SO_4	230
1915	Z4-SS-8029 Unnamed Small Stream	7/29/2014	SO_4	94
1939	Brandy Branch at SR 70 Bridge	6/30/1975	SO_4	359
1939	Brandy Branch at SR 70 Bridge	3/1/1976	SO_4	64
1939	Brandy Branch at Pine Level FL	10/14/1993	SO_4	380
1939	Brandy Branch at Pine Level FL	1/27/1994	SO_4	150
1939	Brandy Branch at Pine Level FL	3/22/1994	SO_4	150
1939	Brandy Branch at Pine Level FL	5/5/1994	SO_4	250
1939	Brandy Branch at Pine Level FL	6/15/1994	SO_4	220
1939	Brandy Branch at Pine Level FL	7/29/1994	SO_4	120
1939	Brandy Branch at Pine Level FL	10/14/1994	SO_4	36
1939	Brandy Branch at Pine Level FL	1/5/1995	SO_4	98
1939	Brandy Branch at Pine Level FL	3/7/1995	SO_4	170
1939	TP165 - Brandy Branch	2/5/2003	SO_4	330
1939	TP99 - Brandy Branch	2/5/2003	SO_4	320
1939	TP165 - Brandy Branch	5/6/2003	SO_4	470
1939	TP99 - Brandy Branch	5/6/2003	SO_4	100
1939	TP99 - Brandy Branch	6/17/2003	SO_4	380
1939	TP99 - Brandy Branch	7/15/2003	SO_4	150

WBID	Site	Date	Parameter	Result (mg/L)
1939	TP99 - Brandy Branch	8/11/2003	SO_4	160
1939	TP99 - Brandy Branch	9/15/2003	SO_4	61
1939	TP99 - Brandy Branch	10/20/2003	SO_4	120
1939	TP99 - Brandy Branch	11/18/2003	SO_4	180
1939	TP99 - Brandy Branch	12/9/2003	SO_4	330
1939	Brandy Branch SR 70	6/6/2008	SO_4	726
1939	Brandy Branch SR 70	9/16/2008	SO_4	115
1939	Brandy Branch at Mosaic	3/25/2013	SO_4	760
1939	TP99 - Brandy Branch	3/25/2013	SO_4	610
1939	Brandy Branch at VCH Citrus	7/22/2013	SO_4	77
1939	Brandy Branch at Mosaic	10/14/2013	SO_4	87
1939	Brandy Branch at VCH Citrus	10/14/2013	SO_4	100
1939	TP99 - Brandy Branch	10/14/2013	SO_4	110
1939	Brandy Branch at Mosaic	12/10/2013	SO_4	630
1939	Brandy Branch at VCH Citrus	12/10/2013	SO_4	750
1939	TP99 - Brandy Branch	12/10/2013	SO_4	550
1939	Brandy Branch at SR 70 Bridge	11/3/2016	SO_4	400
1944	Buzzard Roost Branch Near Pine Level FL	10/15/1993	SO_4	58
1944	Buzzard Roost Branch Near Pine Level FL	1/28/1994	SO_4	490
1944	Buzzard Roost Branch Near Pine Level FL	3/22/1994	SO_4	380
1944	Buzzard Roost Branch Near Pine Level FL	5/5/1994	SO_4	320
1944	Buzzard Roost Branch Near Pine Level FL	6/15/1994	SO_4	360
1944	Buzzard Roost Branch Near Pine Level FL	8/1/1994	SO_4	85
1944	Buzzard Roost Branch Near Pine Level FL	10/14/1994	SO_4	14
1944	Buzzard Roost Branch Near Pine Level FL	1/5/1995	SO_4	44
1944	Buzzard Roost Branch Near Pine Level FL	3/7/1995	SO_4	160

WBID	Site	Date	Parameter	Result (mg/L)
1944	Buzzard Roost Branch at Pine Level	1/30/2008	SO_4	410
1944	Buzzard Roost Branch at SR 70	1/30/2008	SO_4	852
1944	Buzzard Roost Branch at Pine Level	9/16/2008	SO_4	54
1944	Z4-SS-9029 Buzzard Roost Branch	7/21/2015	SO_4	710
1826A	Brushy Creek Near Ona FL	8/24/1982	TDS	109
1826A	Brushy Creek Near Lilly FL	10/15/1993	TDS	118
1826A	Brushy Creek Near Lilly FL	1/27/1994	TDS	171
1826A	Brushy Creek Near Lilly FL	3/22/1994	TDS	173
1826A	Brushy Creek Near Lilly FL	7/27/1994	TDS	113
1826A	Brushy Creek Near Lilly FL	1/5/1995	TDS	168
1826A	Brushy Creek Near Lilly FL	3/7/1995	TDS	190
1826A	SWD-SS-1011 Brushy Creek	8/26/2002	TDS	87
1836	West Fork Horse Creek Near Myakka Head FL	10/13/1993	TDS	128
1836	West Fork Horse Creek Near Myakka Head FL	1/26/1994	TDS	130
1836	West Fork Horse Creek Near Myakka Head FL	3/21/1994	TDS	129
1836	West Fork Horse Creek Near Myakka Head FL	5/4/1994	TDS	131
1836	West Fork Horse Creek Near Myakka Head FL	6/16/1994	TDS	126
1836	West Fork Horse Creek Near Myakka Head FL	7/29/1994	TDS	122
1836	West Fork Horse Creek Near Myakka Head FL	10/14/1994	TDS	98
1836	West Fork Horse Creek Near Myakka Head FL	12/14/1994	TDS	122
1836	West Fork Horse Creek Near Myakka Head FL	3/7/1995	TDS	116
1915	Z4-SS-7019 Unnamed Small Stream	7/24/2013	TDS	438
1915	Z4-SS-8029 Unnamed Small Stream	7/29/2014	TDS	212
1939	Brandy Branch at Pine Level FL	10/14/1993	TDS	680
1939	Brandy Branch at Pine Level FL	1/27/1994	TDS	391
1939	Brandy Branch at Pine Level FL	3/22/1994	TDS	386

WBID	Site	Date	Parameter	Result (mg/L)
1939	Brandy Branch at Pine Level FL	5/5/1994	TDS	556
1939	Brandy Branch at Pine Level FL	6/15/1994	TDS	434
1939	Brandy Branch at Pine Level FL	7/29/1994	TDS	328
1939	Brandy Branch at Pine Level FL	10/14/1994	TDS	172
1939	Brandy Branch at Pine Level FL	1/5/1995	TDS	280
1939	Brandy Branch at Pine Level FL	3/7/1995	TDS	368
1939	TP165 - Brandy Branch	2/5/2003	TDS	522
1939	TP99 - Brandy Branch	2/5/2003	TDS	519
1939	TP165 - Brandy Branch	5/6/2003	TDS	767
1939	TP99 - Brandy Branch	5/6/2003	TDS	244
1939	TP99 - Brandy Branch	6/17/2003	TDS	657
1939	TP99 - Brandy Branch	7/15/2003	TDS	374
1939	TP99 - Brandy Branch	8/11/2003	TDS	407
1939	TP99 - Brandy Branch	9/15/2003	TDS	188
1939	TP99 - Brandy Branch	10/20/2003	TDS	287
1939	TP99 - Brandy Branch	11/18/2003	TDS	365
1939	TP99 - Brandy Branch	12/9/2003	TDS	577
1939	Brandy Branch SR 70	6/6/2008	TDS	1130
1939	Brandy Branch SR 70	9/16/2008	TDS	349
1939	Brandy Branch at Mosaic	3/25/2013	TDS	1210
1939	TP99 - Brandy Branch	3/25/2013	TDS	1060
1939	Brandy Branch at VCH Citrus	7/22/2013	TDS	245
1939	Brandy Branch at Mosaic	10/14/2013	TDS	254
1939	Brandy Branch at VCH Citrus	10/14/2013	TDS	277
1939	TP99 - Brandy Branch	10/14/2013	TDS	289
1939	Brandy Branch at Mosaic	12/10/2013	TDS	921

WBID	Site	Date	Parameter	Result (mg/L)
1939	Brandy Branch at VCH Citrus	12/10/2013	TDS	1060
1939	TP99 - Brandy Branch	12/10/2013	TDS	816
1939	Brandy Brnch at SR 70 Bridge	11/3/2016	TDS	676
1944	Buzzard Roost Branch Near Pine Level FL	10/15/1993	TDS	230
1944	Buzzard Roost Branch Near Pine Level FL	1/28/1994	TDS	861
1944	Buzzard Roost Branch Near Pine Level FL	3/22/1994	TDS	589
1944	Buzzard Roost Branch Near Pine Level FL	5/5/1994	TDS	556
1944	Buzzard Roost Branch Near Pine Level FL	6/15/1994	TDS	646
1944	Buzzard Roost Branch Near Pine Level FL	8/1/1994	TDS	276
1944	Buzzard Roost Branch Near Pine Level FL	10/14/1994	TDS	128
1944	Buzzard Roost Branch Near Pine Level FL	1/5/1995	TDS	182
1944	Buzzard Roost Branch Near Pine Level FL	3/7/1995	TDS	350
1944	Buzzard Roost Branch at Pine Level	1/30/2008	TDS	730
1944	Buzzard Roost Branch at SR 70	1/30/2008	TDS	1380
1944	Buzzard Roost Branch at Pine Level	9/16/2008	TDS	208
1944	Z4-SS-9029 Buzzard Roost Branch	7/21/2015	TDS	1220

Red text indicates values above respective trigger level.

8.0 GROUNDWATER

Mosaic maintains a number of monitoring wells as part of their Hydrogeological Investigation and Monitoring Plan of Study (HIMPOS). These wells are located within the Wingate Mine and drilled to depths from 18 feet to 356 feet (Figures 8-1 through 8-3) and the water quality data was collected between 1997 and 2014. All the median values across all three parameters and at all depths were below the respective trigger levels. All sulfate values, regardless of well depth, were below 100 $mg \cdot L^{-1}$ (sulfate trigger value: 250 $mg \cdot L^{-1}$).

The bulk of the TDS data was below the 500 $mg \cdot L^{-1}$ trigger level and the bulk of the >500 $mg \cdot L^{-1}$ TDS values occurred in the deepest well at 356 feet. This should be expected in Karst topography. With the exception of a single outlier in the 96 foot well, all calcium values in well depths <356 feet were below the 100 $mg \cdot L^{-1}$ trigger level. This data along with the entire historical record of the Upper Horse Creek surface water TDS, sulfate, and calcium water quality data suggests that surficial groundwater from the Wingate mine is not a contributor to elevated values seen in the Lower Horse Creek Basin.

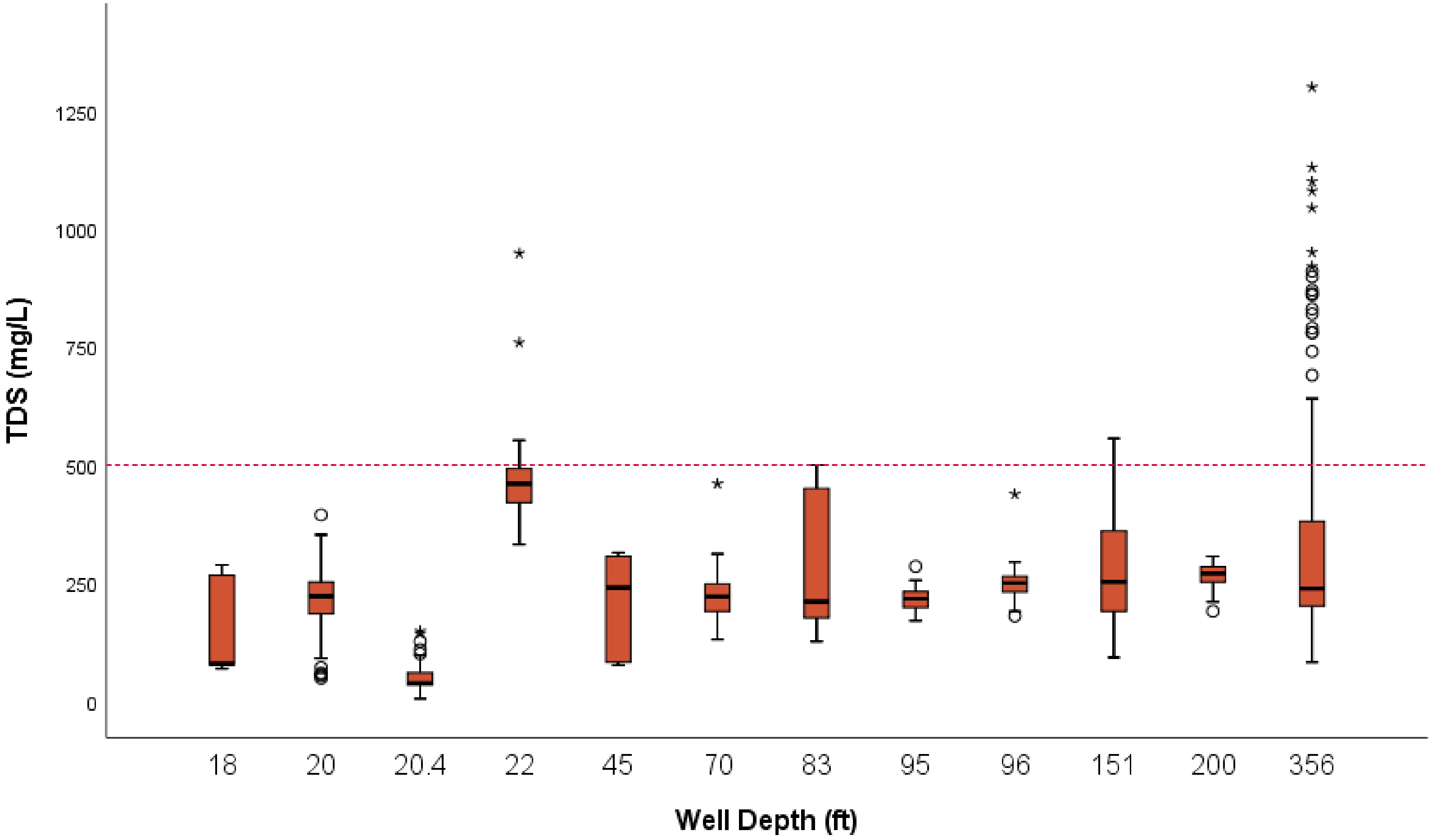


Figure 8-1 **HIMPOS TDS groundwater data across all well depths. All HIMPOS wells are located within the Wingate Mine in the Upper Horse Creek Basin.**

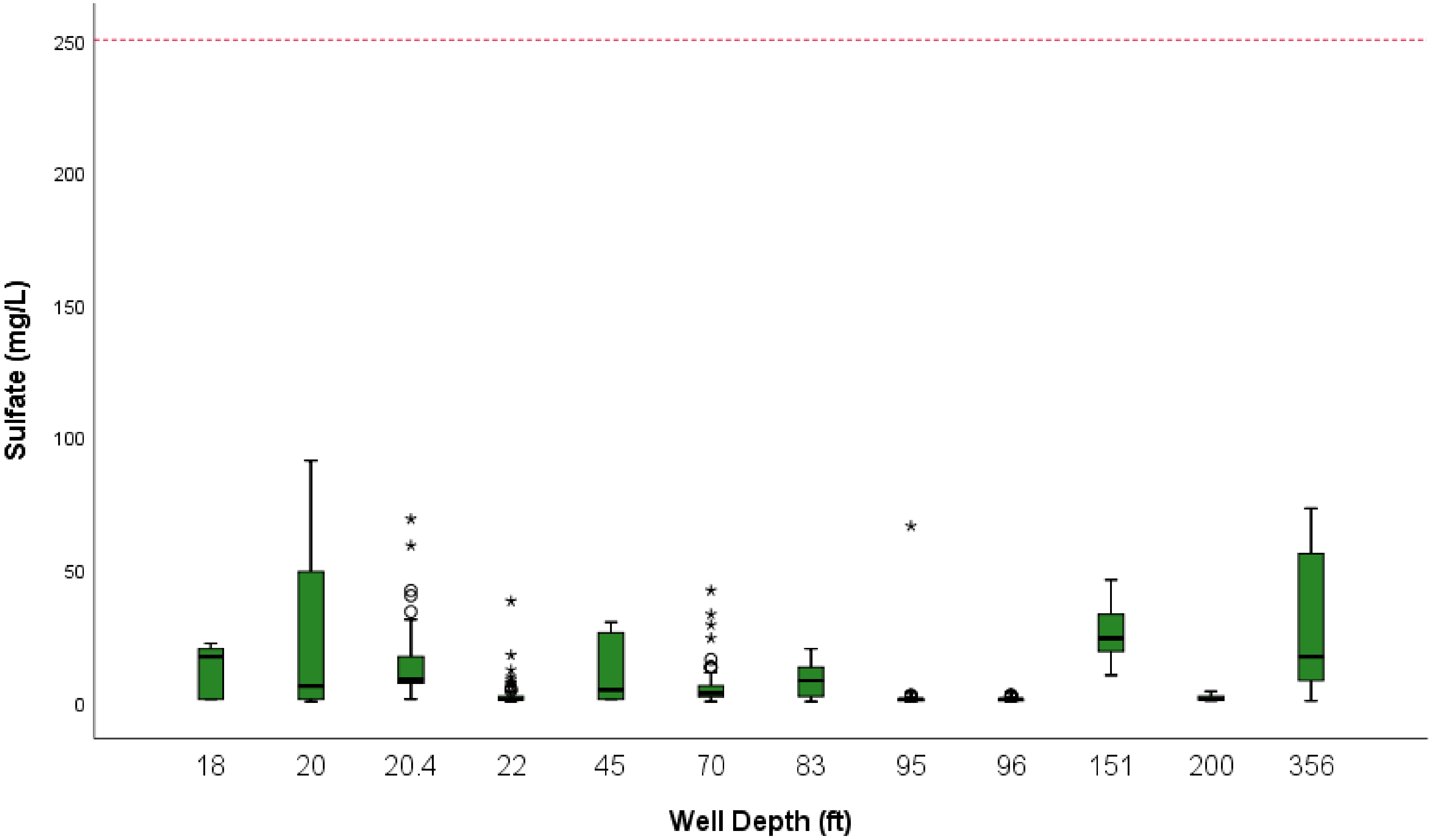


Figure 8-2 **HIMPOS Sulfate groundwater data across all well depths. All HIMPOS wells are located within the Wingate Mine in the Upper Horse Creek Basin.**

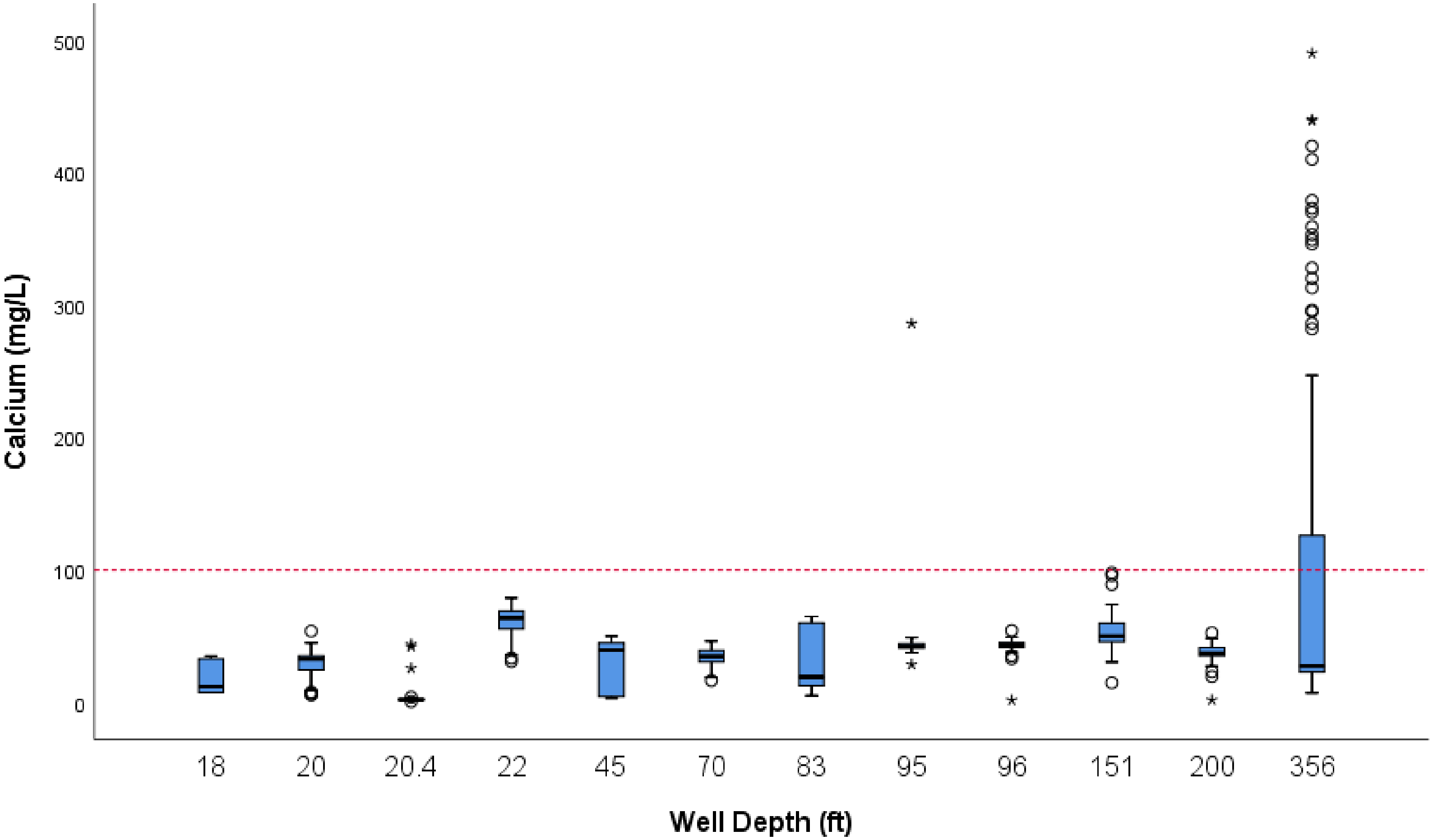


Figure 8-3 **HIMPOS Calcium groundwater data across all well depths. All HIMPOS wells are located within the Wingate Mine in the Upper Horse Creek Basin.**

Table 6 Period of Record Wingate Mine HIMPOS Groundwater Data.

Well	Date	Sulfate (mg/L)	TDS (mg/L)	Dissolved Ca (mg/L)	Depth (ft)
MW- 9	9/30/2009	0.4	352	44.9	20
MW- 9	12/29/2009	0.3	282	43.2	20
MW- 9	3/18/2010	6.1	248	45.0	20
MW- 9	5/6/2010	1.2	232	41.3	20
MW- 9	9/29/2010	0.4	229	31.4	20
MW- 9	12/16/2010	0.2	228	35.5	20
MW- 9	1/18/2011	0.0	205	33.5	20
MW- 9	6/23/2011	3.0	281	42.9	20
MW- 9	9/20/11	0.3	261	35.1	20
MW- 9	12/14/11	1.4	234	39.5	20
MW- 9	3/20/12	0.3	218	34.5	20
MW- 9	6/5/12	0.1	214	33.2	20
MW- 9	8/2/2012	2.9	199	32.7	20
MW- 9	12/3/2012	1.6	201	35.2	20
MW- 9	3/20/2013	0.1	213	33.4	20
MW- 9	6/12/2013	0.3	233	38.0	20
MW- 9	9/19/2013	1.3	285	39.6	20
MW- 9	12/12/2013	0.5	250	34.0	20
MW- 9	3/11/2014	0.4	224	33.6	20
MW- 9	6/24/2014	1.2	287	41.6	20
MW1-4	8/15/1997	1.0	250	43.0	96
MW1-4	3/10/1999	1.0	274	39.8	96
MW1-4	4/22/1999	1.0	254	40.4	96
MW1-6	8/15/1997	6.9	120	13.0	20
MW1-6	3/10/1999	2.0	102	11.5	20

Well	Date	Sulfate (mg/L)	TDS (mg/L)	Dissolved Ca (mg/L)	Depth (ft)
MW1-6	4/22/1999	3.0	101	8.9	20
MW2-1	8/3/1997	60.0	140	20.0	356
MW2-1	11/16/1997	62.0	160	23.0	356
MW2-1	2/19/1999	66.0	204	45.6	356
MW2-1	5/25/1999	66.0	173	21.8	356
MW2-1	9/28/1999	68.0	230	39.4	356
MW2-1	12/12/1999	65.0	194	30.2	356
MW2-1	3/19/2000	62.0	245	28.5	356
MW2-1	6/6/2000	58.0	207	21.1	356
MW2-1	8/30/2000	65.0	185	22.1	356
MW2-1	12/7/2000	65.0	200	38.1	356
MW2-1	3/22/2001	63.0	193	19.2	356
MW2-1	9/27/2001	64.0	225	19.6	356
MW2-1	12/6/2001	62.0	197	18.4	356
MW2-1	3/26/2002	60.0	350	36.6	356
MW2-1	6/11/2002	34.0	690	379	356
MW2-1	9/29/2002	64.0	201	26.9	356
MW2-1	12/5/2002	66.0	232	27.6	356
MW2-1	3/13/2003	62.0	168	19.0	356
MW2-1	6/27/2003	61.0	194	15.2	356
MW2-1	9/29/2003	65.0	211	20.5	356
MW2-1	12/28/2003	64.0	187	25.6	356
MW2-1	3/27/2004	52.0	863	174	356
MW2-1	6/20/2004	56.0	494	77.6	356
MW2-1	9/29/2004	32.0	1080	359	356
MW2-1	12/29/2004	25.0	1100	410	356

Well	Date	Sulfate (mg/L)	TDS (mg/L)	Dissolved Ca (mg/L)	Depth (ft)
MW2-1	3/29/2005	21.0	950	440	356
MW2-1	6/28/2005	28.0	820	320	356
MW2-1	9/29/2005	56.0	180	38.0	356
MW2-1	12/19/2005	66.0	150	33.0	356
MW2-1	3/30/2006	73.0	180	37.0	356
MW2-1	6/27/2006	2.7	82	370	356
MW2-1	9/28/2006	36.0	410	190	356
MW2-1	11/21/2006	7.0	1300	420	356
MW2-1	11/13/2007	2.0	190	35.0	356
MW2-1	3/18/2008	63.0	160	33.0	356
MW2-1	9/10/2008	48.6	528	346	356
MW2-1	12/16/2008	33.6	920	373	356
MW2-1	6/24/2009	23.4	1044	490	356
MW2-1	9/30/2009	53.7	296	34.0	356
MW2-1	11/16/2009	54.3	640	138	356
MW2-1	9/29/2010	20.2	1130	439	356
MW2-1	12/29/2010	57.0	190	19.7	356
MW2-1	1/19/2011	60.1	192	33.1	356
MW2-1	6/22/2011	61.3	233	30.0	356
MW2-1	9/20/11	60.2	233	33.6	356
MW2-1	12/14/11	64.4	176	30.8	356
MW2-1	3/20/12	39.4	550	209	356
MW2-1	6/5/12	33.5	740	282	356
MW2-1	8/7/2012	39.2	630	247	356
MW2-1	12/3/2012	33.1	780	286	356
MW2-1	3/18/2013	32.1	790	328	356

Well	Date	Sulfate (mg/L)	TDS (mg/L)	Dissolved Ca (mg/L)	Depth (ft)
MW2-1	6/11/2013	31.0	780	349	356
MW2-1	9/19/2013	32.3	860	353	356
MW2-1	12/11/2013	32.0	910	296	356
MW2-1	3/13/2014	29.3	830	295	356
MW2-1	6/24/2014	30.1	870	313	356
MW2-2	12/28/2003	2.0	211	19.5	200
MW2-2	9/26/2012	0.9	264	38.0	200
MW2-2	12/4/2012	1.2	241	1.8	200
MW2-2	3/19/2013	0.6	267	45.5	200
MW2-2	6/11/2013	0.9	300	48.5	200
MW2-2	9/19/2013	0.6	306	48.1	200
MW2-2	12/11/2013	0.8	290	42.6	200
MW2-2	3/13/2014	0.6	304	45.4	200
MW2-2	6/24/2014	0.7	296	46.9	200
MW2-3	8/3/1997	1.0	198	41.0	95
MW2-3	11/16/1997	1.0	210	41.0	95
MW2-3	2/19/1999	1.0	208	45.9	95
MW2-3	5/25/1999	1.0	236	41.4	95
MW2-3	9/28/1999	1.0	217	38.5	95
MW2-3	12/12/1999	1.0	218	40.1	95
MW2-3	3/19/2000	3.0	242	41.0	95
MW2-3	6/6/2000	1.0	251	42.0	95
MW2-3	8/30/2000	1.0	212	44.6	95
MW2-3	12/7/2000	1.0	211	42.6	95
MW2-3	3/22/2001	1.0	244	41.9	95
MW2-3	5/30/2001	1.0	236	41.5	95

Well	Date	Sulfate (mg/L)	TDS (mg/L)	Dissolved Ca (mg/L)	Depth (ft)
MW2-3	9/27/2001	1.0	254	40.5	95
MW2-3	12/6/2001	1.0	256	28.6	95
MW2-3	3/26/2002	1.0	213	39.9	95
MW2-3	6/11/2002	1.0	203	37.5	95
MW2-3	9/25/2002	1.0	235	40.9	95
MW2-3	12/5/2002	1.0	238	39.6	95
MW2-3	3/13/2003	1.0	241	42.1	95
MW2-3	6/27/2003	1.0	224	42.3	95
MW2-3	9/29/2003	1.0	243	40.6	95
MW2-3	12/28/2003	1.0	221	42.6	95
MW2-3	3/27/2004	1.0	232	42.0	95
MW2-3	6/20/2004	1.0	285	45.0	95
MW2-3	9/29/2004	1.0	216	43.7	95
MW2-3	12/29/2004	2.0	180	45.0	95
MW2-3	3/29/2005	2.5	180	45.0	95
MW2-3	6/28/2005	1.7	190	40.0	95
MW2-3	9/29/2005	1.7	200	44.0	95
MW2-3	12/19/2005	1.7	190	45.0	95
MW2-3	3/30/2006	1.7	190	41.0	95
MW2-3	6/27/2006	2.3	180	43.0	95
MW2-3	3/22/2007	2.0	180	42.0	95
MW2-3	6/20/2007	2.0	170	42.0	95
MW2-3	8/7/2007	2.0	180	44.0	95
MW2-3	11/13/2007	2.0	210	43.0	95
MW2-3	3/18/2008	0.1	190	43.0	95
MW2-3	6/12/2008	0.1	207	41.4	95

Well	Date	Sulfate (mg/L)	TDS (mg/L)	Dissolved Ca (mg/L)	Depth (ft)
MW2-3	9/10/2008	0.6	232	49.1	95
MW2-3	12/16/2008	0.3	184	44.1	95
MW2-3	3/24/2009	0.3	228	45.7	95
MW2-3	6/24/2009	0.3	232	46.1	95
MW2-3	9/30/2009	0.3	196	45.7	95
MW2-3	12/29/2009	0.3	227	46.7	95
MW2-3	3/18/2010	0.3	208	44.3	95
MW2-3	5/6/2010	0.3	212	46.9	95
MW2-3	9/29/2010	0.1	227	43.2	95
MW2-3	12/16/2010	0.1	225	42.2	95
MW2-3	1/19/2011	0.1	225	41.8	95
MW2-3	6/22/2011	0.2	245	38.5	95
MW2-3	9/19/11	0.1	220	41.0	95
MW2-3	12/15/11	0.1	197	42.6	95
MW2-3	3/14/12	0.1	220	41.3	95
MW2-3	6/1/12	0.0	231	43.7	95
MW2-3	8/7/2012	0.0	213	42.4	95
MW2-3	12/3/2012	66.4	216	286	95
MW2-3	3/19/2013	0.1	208	42.5	95
MW2-3	6/11/2013	0.2	224	45.3	95
MW2-3	9/19/2013	0.1	231	44.0	95
MW2-3	12/11/2013	0.5	225	45.5	95
MW2-3	3/13/2014	0.4	183	41.9	95
MW2-3	6/24/2014	0.5	184	43.6	95
MW2-4	8/3/1997	15.0	71	6.0	20
MW2-4	11/16/1997	13.0	56	5.6	20

Well	Date	Sulfate (mg/L)	TDS (mg/L)	Dissolved Ca (mg/L)	Depth (ft)
MW2-4	2/19/1999	71.0	167	20.4	20
MW2-4	5/25/1999	64.0	180	17.7	20
MW2-4	9/28/1999	59.0	170	14.3	20
MW2-4	12/12/1999	60.0	183	16.4	20
MW2-4	3/19/2000	63.0	173	15.9	20
MW2-4	6/6/2000	66.0	116	20.1	20
MW2-4	8/30/2000	49.0	157	19.5	20
MW2-4	12/7/2000	50.0	181	19.6	20
MW2-4	3/22/2001	54.0	187	21.8	20
MW2-4	5/30/2001	53.0	145	22.4	20
MW2-4	9/27/2001	38.0	158	15.5	20
MW2-4	12/6/2001	57.0	278	31.3	20
MW2-4	3/13/2002	40.0	147	17.7	20
MW2-4	3/26/2002	46.0	242	31.1	20
MW2-4	6/11/2002	51.0	274	31.5	20
MW2-4	9/25/2002	14.0	59	10.5	20
MW2-4	12/5/2002	27.0	146	16.0	20
MW2-4	6/26/2003	10.0	53	7.8	20
MW2-4	9/28/2003	8.0	48	7.1	20
MW2-4	12/28/2003	44.0	274	34.3	20
MW2-4	3/27/2004	61.0	221	29.0	20
MW2-4	6/20/2004	61.0	267	28.1	20
MW2-4	9/29/2004	25.0	94	13.1	20
MW2-4	12/29/2004	68.0	160	27.0	20
MW2-4	3/29/2005	14.0	90	22.0	20
MW2-4	9/29/2005	39.0	190	33.0	20

Well	Date	Sulfate (mg/L)	TDS (mg/L)	Dissolved Ca (mg/L)	Depth (ft)
MW2-4	12/19/2005	67.0	160	25.0	20
MW2-4	6/27/2006	52.0	190	27.0	20
MW2-4	9/28/2006	46.0	140	25.0	20
MW2-4	3/18/2008	68.0	190	24.0	20
MW2-4	6/12/2008	68.5	212	22.4	20
MW2-4	9/10/2008	6.0	212	24.1	20
MW2-4	6/24/2009	56.0	228	26.2	20
MW2-4	9/30/2009	44.8	260	28.2	20
MW2-4	12/29/2009	43.1	254	32.0	20
MW2-4	3/18/2010	43.7	252	29.5	20
MW2-4	5/6/2010	49.2	192	25.2	20
MW2-4	9/29/2010	49.1	227	24.5	20
MW2-4	12/16/2010	48.1	266	29.2	20
MW2-4	1/19/2011	47.0	302	27.7	20
MW2-4	6/22/2011	54.0	341	25.4	20
MW2-4	9/19/11	44.7	222	20.9	20
MW2-4	12/13/11	48.2	243	24.2	20
MW2-4	3/20/12	58.0	271	26.2	20
MW2-4	6/1/12	63.2	273	28.0	20
MW2-4	8/7/2012	43.6	255	21.6	20
MW2-4	12/3/2012	91.1	234	41.6	20
MW2-4	3/19/2013	79.5	262	29.1	20
MW2-4	6/11/2013	71.8	268	28.6	20
MW2-4	9/19/2013	74.2	327	31.3	20
MW2-4	12/11/2013	85.7	261	30.4	20
MW2-4	3/13/2014	86.0	317	26.3	20

Well	Date	Sulfate (mg/L)	TDS (mg/L)	Dissolved Ca (mg/L)	Depth (ft)
MW2-4	6/24/2014	77.4	269	28.4	20
MW5-1	8/28/1997	11.0	260	25.0	356
MW5-1	12/6/1997	0.3	180	26.0	356
MW5-1	2/28/1999	9.0	198	24.0	356
MW5-1	5/26/1999	8.0	220	24.2	356
MW5-1	9/28/1999	10.0	229	22.0	356
MW5-1	12/12/1999	10.0	248	28.8	356
MW5-1	3/19/2000	10.0	228	20.9	356
MW5-1	6/6/2000	9.0	223	20.1	356
MW5-1	8/31/2000	8.0	239	26.5	356
MW5-1	12/7/2000	8.0	221	23.8	356
MW5-1	3/22/2001	8.0	232	24.3	356
MW5-1	5/30/2001	9.0	217	21.7	356
MW5-1	9/5/2001	8.0	271	22.9	356
MW5-1	12/6/2001	8.0	269	19.6	356
MW5-1	3/26/2002	9.0	208	21.4	356
MW5-1	6/19/2002	8.0	225	23.3	356
MW5-1	9/29/2002	8.0	248	22.0	356
MW5-1	12/4/2002	8.0	262	22.4	356
MW5-1	3/12/2003	9.0	251	23.4	356
MW5-1	6/27/2003	8.0	247	22.8	356
MW5-1	9/29/2003	8.0	271	24.3	356
MW5-1	12/29/2003	8.0	247	24.7	356
MW5-1	3/28/2004	8.0	197	7.1	356
MW5-1	6/20/2004	8.0	898	128	356
MW5-1	9/29/2004	8.0	237	8.8	356

Well	Date	Sulfate (mg/L)	TDS (mg/L)	Dissolved Ca (mg/L)	Depth (ft)
MW5-1	12/29/2004	9.9	270	92.0	356
MW5-1	3/29/2005	8.6	380	120	356
MW5-1	6/28/2005	6.8	120	10.0	356
MW5-1	9/29/2005	7.4	304	110	356
MW5-1	12/19/2005	7.9	200	24.0	356
MW5-1	3/30/2006	15.0	210	26.0	356
MW5-1	6/27/2006	7.9	180	24.0	356
MW5-1	9/28/2006	16.0	190	63.0	356
MW5-1	11/21/2006	17.0	270	69.0	356
MW5-1	3/22/2007	8.5	430	160	356
MW5-1	6/20/2007	17.0	110	26.0	356
MW5-1	8/7/2007	7.5	380	140	356
MW5-1	11/13/2007	8.8	280	100.0	356
MW5-1	3/18/2008	15.0	210	27.0	356
MW5-1	6/12/2008	14.4	359		356
MW5-1	9/10/2008	23.6	288	82.1	356
MW5-1	12/16/2008	30.1	376	126	356
MW5-1	3/24/2009	10.4	424	38.2	356
MW5-1	6/24/2009	34.9	456	165	356
MW5-1	11/16/2009	24.4	216	59.2	356
MW5-1	5/6/2010	18.0	452	173	356
MW5-1	9/29/2010	11.3	158	39.0	356
MW5-1	12/16/2010	7.6	221	21.4	356
MW5-1	1/18/2011	7.2	227	22.2	356
MW5-1	6/21/2011	6.9	232	27.4	356
MW5-1	9/20/11	6.9	232	22.0	356

Well	Date	Sulfate (mg/L)	TDS (mg/L)	Dissolved Ca (mg/L)	Depth (ft)
MW5-1	12/15/11	6.5	218	23.0	356
MW5-1	3/14/12	8.3	233	23.0	356
MW5-1	5/30/12	8.2	227	24.9	356
MW5-1	8/6/2012	8.6	241	22.8	356
MW5-1	12/4/2012	7.8	230	26.9	356
MW5-1	3/6/2013	8.0	255	24.2	356
MW5-1	6/10/2013	7.3	240	25.8	356
MW5-1	9/17/2013	8.1	239	23.7	356
MW5-1	12/10/2013	7.5	258	26.6	356
MW5-1	3/11/2014	9.0	243	23.0	356
MW5-1	6/18/2014	8.5	240	23.3	356
MW5-2	10/8/2002		279	41.2	200
MW5-2	12/4/2002	1.0	271	35.0	200
MW5-2	3/12/2003	1.0	273	35.0	200
MW5-2	6/27/2003	1.0	283	35.7	200
MW5-2	9/29/2003	1.0	288	36.2	200
MW5-2	12/29/2003	1.0	269	36.9	200
MW5-2	3/28/2004	2.0	233	27.4	200
MW5-2	6/20/2004	1.0	274	38.3	200
MW5-2	9/29/2004	1.0	278	33.2	200
MW5-2	12/29/2004	2.3	220	35.0	200
MW5-2	3/29/2005	3.9	250	44.0	200
MW5-2	6/28/2005	1.7	240	34.0	200
MW5-2	9/29/2005	2.9	240	48.0	200
MW5-2	12/19/2005	1.7	260	38.0	200
MW5-2	3/30/2006	1.7	240	36.0	200

Well	Date	Sulfate (mg/L)	TDS (mg/L)	Dissolved Ca (mg/L)	Depth (ft)
MW5-2	6/27/2006	2.7	230	37.0	200
MW5-2	9/28/2006	3.2	210	43.0	200
MW5-2	11/21/2006	2.0	280	45.0	200
MW5-2	3/22/2007	2.0	250	38.0	200
MW5-2	6/20/2007	2.0	190	33.0	200
MW5-2	8/7/2007	2.0	240	37.0	200
MW5-2	11/13/2007	2.3	270	38.0	200
MW5-2	3/18/2008	3.5	250	37.0	200
MW5-2	6/12/2008	1.0	258	36.1	200
MW5-2	9/10/2008	1.2	288	41.4	200
MW5-2	12/16/2008	0.3	264	36.7	200
MW5-2	3/24/2009	1.0	292	38.2	200
MW5-2	6/24/2009	1.4	256	28.1	200
MW5-2	9/30/2009	2.1	280	42.8	200
MW5-2	11/16/2009	1.2	256	41.5	200
MW5-2	3/18/2010	0.9	284	52.5	200
MW5-2	5/6/2010	2.4	268	45.4	200
MW5-2	9/29/2010	0.9	291	40.9	200
MW5-2	12/16/2010	0.6	294	35.6	200
MW5-2	1/18/2011	0.3	279	34.2	200
MW5-2	6/21/2011	0.3	290	32.9	200
MW5-2	9/19/11	0.6	278	34.7	200
MW5-2	12/13/11	0.6	270	35.3	200
MW5-2	3/14/12	0.3	254	36.3	200
MW5-2	5/30/12	0.4	252	37.2	200
MW5-2	8/6/2012	0.7	270	35.8	200

Well	Date	Sulfate (mg/L)	TDS (mg/L)	Dissolved Ca (mg/L)	Depth (ft)
MW5-2	12/4/2012	0.3	271	23.3	200
MW5-2	3/6/2013	0.6	282	35.8	200
MW5-2	6/10/2013	0.4	260	37.1	200
MW5-2	9/17/2013	0.6	289	37.2	200
MW5-2	12/10/2013	0.8	283	41.6	200
MW5-2	3/12/2014	0.7	302	35.4	200
MW5-2	6/18/2014	0.7	286	36.2	200
MW5-3	8/28/1997	1.0	268	47.0	96
MW5-3	12/6/1997	1.0	267	42.0	96
MW5-3	2/28/1999	1.0	266	40.8	96
MW5-3	5/26/1999	1.0	231	43.5	96
MW5-3	9/28/1999	1.0	241	38.2	96
MW5-3	12/12/1999	1.0	273	33.0	96
MW5-3	3/19/2000	1.0	247	40.8	96
MW5-3	6/6/2000	1.0	265	42.4	96
MW5-3	8/31/2000	1.0	248	46.7	96
MW5-3	12/7/2000	1.0	223	40.6	96
MW5-3	3/22/2001	1.0	282	43.2	96
MW5-3	5/30/2001	1.0	267	44.4	96
MW5-3	9/5/2001	1.0	258	40.5	96
MW5-3	12/6/2001	1.0	269	40.2	96
MW5-3	3/26/2002	1.0	207	38.0	96
MW5-3	6/19/2002	1.0	238	40.0	96
MW5-3	9/25/2002	1.0	234	41.8	96
MW5-3	12/4/2002	1.0	246	41.7	96
MW5-3	3/12/2003	1.0	243	42.6	96

Well	Date	Sulfate (mg/L)	TDS (mg/L)	Dissolved Ca (mg/L)	Depth (ft)
MW5-3	6/27/2003	1.0	231	42.8	96
MW5-3	9/29/2003	1.0	258	44.5	96
MW5-3	12/29/2003	1.0	232	1.7	96
MW5-3	3/28/2004	1.0	272	41.7	96
MW5-3	6/20/2004	1.0	438	44.0	96
MW5-3	9/29/2004	1.0	236	43.6	96
MW5-3	12/29/2004	2.3	200	44.0	96
MW5-3	3/29/2005	3.0	200	45.0	96
MW5-3	6/28/2005	1.7	260	41.0	96
MW5-3	9/29/2005	1.4	255	46.0	96
MW5-3	12/19/2005	1.7	230	45.0	96
MW5-3	3/30/2006	1.7	210	45.0	96
MW5-3	6/27/2006	2.7	200	44.0	96
MW5-3	9/28/2006	2.0	190	47.0	96
MW5-3	11/21/2006	2.0	250	47.0	96
MW5-3	3/22/2007	2.0	220	45.0	96
MW5-3	6/20/2007	2.0	180	43.0	96
MW5-3	8/7/2007	2.0	190	43.0	96
MW5-3	11/13/2007	2.0	220	43.0	96
MW5-3	3/18/2008	0.1	200	45.0	96
MW5-3	6/12/2008	0.1	244	40.8	96
MW5-3	9/10/2008	0.6	228	48.1	96
MW5-3	12/16/2008	0.5	220	41.6	96
MW5-3	3/24/2009	0.3	256	54.3	96
MW5-3	6/24/2009	0.6	260	44.4	96
MW5-3	9/30/2009	0.3	240	45.7	96

Well	Date	Sulfate (mg/L)	TDS (mg/L)	Dissolved Ca (mg/L)	Depth (ft)
MW5-3	11/16/2009	0.3	228	46.1	96
MW5-3	3/18/2010	0.3	260	46.6	96
MW5-3	5/6/2010	0.3	260	49.5	96
MW5-3	9/29/2010	0.7	262	43.8	96
MW5-3	12/16/2010	0.1	281	45.1	96
MW5-3	1/18/2011	0.1	256	43.6	96
MW5-3	6/21/2011	0.2	277	40.7	96
MW5-3	9/19/11	0.0	262	42.0	96
MW5-3	12/13/11	0.1	251	45.3	96
MW5-3	3/1/12	0.2	236	41.2	96
MW5-3	5/30/12	0.0	241	46.6	96
MW5-3	8/6/2012	0.0	256	44.7	96
MW5-3	12/4/2012	0.0	258	35.1	96
MW5-3	3/18/2013	0.1	254	44.5	96
MW5-3	6/10/2013	0.1	248	47.5	96
MW5-3	9/17/2013	0.7	282	46.5	96
MW5-3	12/10/2013	0.5	269	43.0	96
MW5-3	3/12/2014	0.4	294	45.2	96
MW5-3	6/18/2014	0.4	275	45.7	96
MW5-4	8/28/1997	1.0	46	1.1	20.4
MW5-4	12/6/1997	1.0	38	1.3	20.4
MW5-4	2/28/1999	5.0	36	1.0	20.4
MW5-4	5/26/1999	5.0	32	1.1	20.4
MW5-4	9/28/1999	6.0	37	1.1	20.4
MW5-4	12/12/1999	7.0	67	0.9	20.4
MW5-4	3/19/2000	6.0	29	0.8	20.4

Well	Date	Sulfate (mg/L)	TDS (mg/L)	Dissolved Ca (mg/L)	Depth (ft)
MW5-4	6/6/2000	42.0	126	2.0	20.4
MW5-4	8/31/2000	40.0	109	3.3	20.4
MW5-4	12/7/2000	29.0	64	2.4	20.4
MW5-4	3/22/2001	69.0	148	2.6	20.4
MW5-4	5/30/2001	59.0	143	2.1	20.4
MW5-4	9/5/2001	29.0	87	1.9	20.4
MW5-4	12/6/2001	30.0	93	1.8	20.4
MW5-4	3/26/2002	28.0	55	1.9	20.4
MW5-4	6/19/2002	31.0	60	2.0	20.4
MW5-4	9/25/2002	19.0	61	2.1	20.4
MW5-4	12/4/2002	17.0	91	3.5	20.4
MW5-4	3/12/2003	16.0	39	1.6	20.4
MW5-4	6/27/2003	12.0	43	3.1	20.4
MW5-4	9/28/2003	10.0	43	2.0	20.4
MW5-4	12/29/2003	11.0	34	42.1	20.4
MW5-4	3/28/2004	34.0	97	2.2	20.4
MW5-4	6/20/2004	29.0	100	1.6	20.4
MW5-4	9/29/2004	18.0	77	1.2	20.4
MW5-4	12/29/2004	18.0	28	1.6	20.4
MW5-4	3/29/2005	8.3	5	2.5	20.4
MW5-4	6/28/2005	6.8	26	2.0	20.4
MW5-4	9/29/2005	9.0	71	2.6	20.4
MW5-4	12/19/2005	7.9	36	2.5	20.4
MW5-4	3/30/2006	8.7	18	2.2	20.4
MW5-4	6/27/2006	2.3	5	2.1	20.4
MW5-4	9/28/2006	2.0	16	2.1	20.4

Well	Date	Sulfate (mg/L)	TDS (mg/L)	Dissolved Ca (mg/L)	Depth (ft)
MW5-4	11/21/2006	7.1	44	2.0	20.4
MW5-4	3/22/2007	7.6	26	2.0	20.4
MW5-4	3/18/2008	12.0	34	2.4	20.4
MW5-4	6/12/2008	11.8	45	2.5	20.4
MW5-4	9/10/2008	11.5	60	3.0	20.4
MW5-4	12/16/2008	9.5	36	2.4	20.4
MW5-4	3/24/2009	19.7	72	3.5	20.4
MW5-4	6/24/2009	11.0	60	2.3	20.4
MW5-4	9/30/2009	7.9	32	2.8	20.4
MW5-4	11/16/2009	9.1	12	2.8	20.4
MW5-4	3/18/2010	8.3	36	2.4	20.4
MW5-4	5/6/2010	7.3	32	2.5	20.4
MW5-4	9/29/2010	7.8	36	3.9	20.4
MW5-4	12/16/2010	7.5	37	2.2	20.4
MW5-4	1/18/2011	7.7	36	2.1	20.4
MW5-4	6/21/2011	8.2	42	1.1	20.4
MW5-4	9/19/11	7.9	38	1.3	20.4
MW5-4	12/13/11	7.8	35	1.9	20.4
MW5-4	3/14/12	9.2	35	1.9	20.4
MW5-4	5/30/12	9.1	31	2.6	20.4
MW5-4	8/7/2012	7.1	34	1.9	20.4
MW5-4	12/4/2012	6.7	41	43.8	20.4
MW5-4	3/18/2013	6.7	35	2.2	20.4
MW5-4	6/10/2013	7.7	30	25.8	20.4
MW5-4	9/17/2013	5.2	42	2.1	20.4
MW5-4	12/10/2013	5.8	46	2.6	20.4

Well	Date	Sulfate (mg/L)	TDS (mg/L)	Dissolved Ca (mg/L)	Depth (ft)
MW5-4	3/12/2014	4.5	60	2.6	20.4
MW5-4	6/18/2014	5.5	36	1.5	20.4
MW6	8/17/1997	1.0	288	35.0	18
MW6	8/17/1997	15.0	80	7.4	18
MW6	8/17/1997	20.0	77	12.0	18
MW6	11/16/1997	1.0	266	33.0	18
MW6	11/16/1997	19.0	68	7.5	18
MW6	11/16/1997	22.0	78	12.0	18
MW7	8/3/1997	1.0	230	39.0	45
MW7	8/3/1997	1.0	76	3.2	45
MW7	8/3/1997	26.0	314	45.0	45
MW7	11/15/1997	1.0	250	40.0	45
MW7	11/15/1997	8.0	82	4.5	45
MW7	11/15/1997	30.0	306	50.0	45
MW8-1	9/18/1997	46.0	204	36.0	151
MW8-1	2/18/1999	40.0	267	31.6	151
MW8-1	4/21/1999	37.0	259	30.8	151
MW8-1	8/8/1999	38.0	262	33.4	151
MW8-1	11/21/1999	32.0	224	30.5	151
MW8-1	3/5/2000	33.0	530	89.0	151
MW8-1	8/30/2000	39.0	492	97.8	151
MW8-1	11/2/2000	36.0	547	95.9	151
MW8-1	9/27/2001	20.0	556	64.2	151
MW8-1	12/5/2001	36.0	530	59.5	151
MW8-1	3/27/2002	20.0	193	61.4	151
MW8-1	6/11/2002	19.0	328	51.5	151

Well	Date	Sulfate (mg/L)	TDS (mg/L)	Dissolved Ca (mg/L)	Depth (ft)
MW8-1	9/29/2002	13.0	337	59.9	151
MW8-1	12/5/2002	13.0	212	14.9	151
MW8-1	3/13/2003	12.0	246	49.8	151
MW8-1	6/27/2003	10.0	402	45.8	151
MW8-1	9/29/2003	13.0	410	47.0	151
MW8-1	12/28/2003	34.0	306	46.2	151
MW8-1	3/24/2004	12.0	249	38.6	151
MW8-1	9/28/2004	16.0	398	49.5	151
MW8-1	12/29/2004	15.0	130	33.0	151
MW8-1	3/29/2005	24.0	150	58.0	151
MW8-1	6/28/2005	28.0	170	45.0	151
MW8-1	9/29/2005	24.0	140	74.0	151
MW8-1	12/19/2005	24.0	92	47.0	151
MW8-1	3/30/2006	30.0	170	50.0	151
MW8-1	6/27/2006	32.0	210	53.0	151
MW8-1	9/28/2006	18.0	150	56.0	151
MW8-1	11/21/2006	23.0	180	47.0	151
MW8-1	3/22/2007	20.0	120	46.0	151
MW8-1	8/7/2007	21.0	190	51.0	151
MW8-1	11/13/2007	26.0	210	46.0	151
MW8-1	9/10/2008	24.1	252	58.1	151
MW8-1	12/16/2008	21.4	268	62.0	151
MW8-1	6/24/2009	23.9	360	61.2	151
MW8-1	9/30/2009	39.6	556	55.0	151
MW8-1	9/29/2010	31.5	287	64.9	151
MW8-3	8/8/1999	16.0	314	22.0	83.17

Well	Date	Sulfate (mg/L)	TDS (mg/L)	Dissolved Ca (mg/L)	Depth (ft)
MW8-3	11/21/1999	17.0	246	20.4	83.17
MW8-3	3/5/2000	18.0	209	18.2	83.17
MW8-3	6/7/2000	10.0	225	15.2	83.17
MW8-3	8/30/2000	20.0	188	14.4	83.17
MW8-3	11/2/2000	16.0	257	12.9	83.17
MW8-3	3/8/2001	19.0	172	13.0	83.17
MW8-3	5/29/2001	8.0	173	12.5	83.17
MW8-3	5/29/2001	8.0	173	12.5	83.17
MW8-3	9/27/2001	11.0	180	13.8	83.17
MW8-3	12/5/2001	10.0	183	12.9	83.17
MW8-3	3/27/2002	13.0	126	10.7	83.17
MW8-3	6/11/2002	9.0	147	10.6	83.17
MW8-3	9/29/2002	13.0	180	22.1	83.17
MW8-3	12/5/2002	7.0	197	14.4	83.17
MW8-3	3/13/2003	10.0	190	6.6	83.17
MW8-3	6/27/2003	4.0	212	11.0	83.17
MW8-3	9/29/2003	4.0	176	5.2	83.17
MW8-3	12/28/2003	2.0	151	13.3	83.17
MW8-3	3/24/2004	7.0	195	11.5	83.17
MW8-3	6/18/2004	4.0	223	11.1	83.17
MW8-3	9/28/2004	2.0	176	29.5	83.17
MW8-3	12/29/2004	4.6	130	33.0	83.17
MW8-3	3/29/2005	20.0	140	51.0	83.17
MW8-3	6/28/2005	1.7	460	51.0	83.17
MW8-3	9/29/2005	1.7	450	54.0	83.17
MW8-3	12/19/2005	1.7	490	62.0	83.17

Well	Date	Sulfate (mg/L)	TDS (mg/L)	Dissolved Ca (mg/L)	Depth (ft)
MW8-3	3/30/2006	17.0	460	60.0	83.17
MW8-3	6/27/2006	7.2	450	62.0	83.17
MW8-3	9/28/2006		420	65.0	83.17
MW8-3	3/22/2007	2.0	460	63.0	83.17
MW8-3	6/20/2007	11.0	460	62.0	83.17
MW8-3	8/7/2007	2.0	500	63.0	83.17
MW8-3	11/13/2007	2.0	480	61.0	83.17
MW8-3	3/18/2008	0.1	470	60.0	83.17
MW8-3	9/26/2012	0.6	443	62.8	83.17
MW8-4	9/10/1997	9.4	422	36.0	22.06
MW8-4	2/18/1999	1.0	334	31.0	22.06
MW8-4	4/21/1999	2.0	331	33.5	22.06
MW8-4	8/8/1999	7.0	333	38.8	22.06
MW8-4	11/21/1999	5.0	360	39.5	22.06
MW8-4	3/5/2000	3.0	376	38.1	22.06
MW8-4	6/7/2000	4.0	420	45.0	22.06
MW8-4	8/29/2000	2.0	394	46.3	22.06
MW8-4	11/2/2000	1.0	759	45.6	22.06
MW8-4	3/8/2001	1.0	415	48.6	22.06
MW8-4	5/29/2001	1.0	438	54.7	22.06
MW8-4	5/29/2001	1.0	438	54.7	22.06
MW8-4	9/27/2001	1.0	541	46.8	22.06
MW8-4	12/5/2001	1.0	527	51.1	22.06
MW8-4	3/27/2002	1.0	409	72.7	22.06
MW8-4	6/11/2002	1.0	542	57.7	22.06
MW8-4	9/29/2002	1.0	514	64.8	22.06

Well	Date	Sulfate (mg/L)	TDS (mg/L)	Dissolved Ca (mg/L)	Depth (ft)
MW8-4	12/5/2002	1.0	551	38.5	22.06
MW8-4	3/13/2003	1.0	552	56.0	22.06
MW8-4	6/27/2003	1.0	518	64.0	22.06
MW8-4	9/28/2003	1.0	516	61.8	22.06
MW8-4	12/16/2003	1.0	455	68.7	22.06
MW8-4	3/24/2004	1.0	492	65.7	22.06
MW8-4	6/18/2004	1.0	503	69.5	22.06
MW8-4	9/28/2004	1.0	492	61.6	22.06
MW8-4	12/29/2004	2.3	440	61.0	22.06
MW8-4	3/29/2005	4.2	460	62.0	22.06
MW8-4	6/28/2005	1.7	470	60.0	22.06
MW8-4	9/29/2005	1.7	460	70.0	22.06
MW8-4	12/19/2005	6.1	480	72.0	22.06
MW8-4	3/30/2006	38.0	470	66.0	22.06
MW8-4	6/27/2006	12.0	460	70.0	22.06
MW8-4	9/28/2006	2.0	390	69.0	22.06
MW8-4	11/21/2006	2.0	450	65.0	22.06
MW8-4	3/22/2007	2.0	460	70.0	22.06
MW8-4	6/20/2007	2.0	400	69.0	22.06
MW8-4	8/7/2007	2.0	480	65.0	22.06
MW8-4	11/13/2007	2.0	470	67.0	22.06
MW8-4	3/18/2008	0.6	460	67.0	22.06
MW8-4	6/12/2008	0.2	472	60.3	22.06
MW8-4	9/10/2008	0.6	500	73.3	22.06
MW8-4	6/24/2009	7.2	528	74.0	22.06
MW8-4	9/30/2009	17.6	464	78.8	22.06

Well	**Date**	**Sulfate (mg/L)**	**TDS (mg/L)**	**Dissolved Ca (mg/L)**	**Depth (ft)**
MW8-4	12/29/2009	6.2	338	75.8	22.06
MW8-4	3/18/2010	8.3	452	76.9	22.06
MW8-4	5/6/2010	0.5	476	73.3	22.06
MW8-4	9/29/2010	1.0	478	71.0	22.06
MW8-4	12/28/2010	0.5	470	72.3	22.06
MW8-4	1/19/2011	0.4	948	65.6	22.06
MW8-4	6/22/2011	0.2	506	68.7	22.06
MW8-4	9/19/11	0.3	472	59.6	22.06
MW8-4	12/14/11	0.3	470	62.2	22.06
MW8-4	3/20/12	0.3	446	66.1	22.06
MW8-4	6/5/12	0.2	430	69.1	22.06
MW8-4	8/2/2012	0.2	447	63.6	22.06
MW8-4	12/5/2012	0.2	401	60.0	22.06
MW8-4	3/19/2013	0.3	391	59.4	22.06
MW8-4	6/12/2013	0.5	418	64.7	22.06
MW8-4	9/19/2013	1.3	469	66.8	22.06
MW8-4	12/12/2013	0.6	429	58.2	22.06
MW8-4	3/11/2014	0.4	416	55.4	22.06
MW8-4	6/24/2014	1.2	426	56.7	22.06
MW-9	9/30/2009	6.1	216	32.1	70
MW-9	12/29/2009	5.7	234	43.5	70
MW-9	3/18/2010	0.3	276	45.4	70
MW-9	5/6/2010	4.3	256	43.8	70
MW-9	9/29/2010	1.5	240	33.2	70
MW-9	12/16/2010	3.4	242	43.7	70
MW-9	1/18/2011	3.2	221	39.0	70

Well	Date	Sulfate (mg/L)	TDS (mg/L)	Dissolved Ca (mg/L)	Depth (ft)
MW-9	6/23/2011	0.2	227	30.4	70
MW-9	9/20/11	0.7	237	34.2	70
MW-9	12/14/11	0.1	225	34.1	70
MW-9	3/20/12	1.9	221	37.5	70
MW-9	6/5/12	3.6	215	40.4	70
MW-9	8/2/2012	0.3	258	34.3	70
MW-9	12/3/2012	0.1	217	33.1	70
MW-9	3/20/2013	2.3	208	35.3	70
MW-9	6/12/2013	3.4	184	39.9	70
MW-9	9/19/2013	3.1	201	33.7	70
MW-9	12/12/2013	3.3	234	38.7	70
MW-9	3/11/2014	1.9	241	39.3	70
MW-9	6/24/2014	5.8	257	46.3	70
MW9-O	2/19/1999	1.0	220	37.3	20
MW9-O	5/25/1999	1.0	237	33.4	20
MW9-O	8/8/1999	1.0	238	35.1	20
MW9-O	11/21/1999	1.0	232	36.6	20
MW9-O	3/5/2000	1.0	230	33.2	20
MW9-O	6/7/2000	1.0	227	43.3	20
MW9-O	8/29/2000	1.0	222	34.9	20
MW9-O	11/1/2000	1.0	394	34.4	20
MW9-O	3/8/2001	1.0	223	33.8	20
MW9-O	5/29/2001	27.0	330	39.7	20
MW9-O	5/29/2001	27.0	330	39.7	20
MW9-O	9/5/2001	1.0	209	32.7	20
MW9-O	12/5/2001	1.0	238	22.0	20

Well	Date	Sulfate (mg/L)	TDS (mg/L)	Dissolved Ca (mg/L)	Depth (ft)
MW9-O	3/27/2002	1.0	185	33.7	20
MW9-O	6/19/2002	1.0	237	34.6	20
MW9-O	9/25/2002	1.0	222	34.2	20
MW9-O	12/5/2002	1.0	262	32.4	20
MW9-O	3/13/2003	1.0	254	33.3	20
MW9-O	6/26/2003	1.0	232	37.9	20
MW9-O	9/28/2003	1.0	262	35.4	20
MW9-O	12/16/2003	1.0	193	34.7	20
MW9-O	3/24/2004	1.0	252	37.1	20
MW9-O	6/20/2004	1.0	240	38.9	20
MW9-O	9/29/2004	1.0	237	38.8	20
MW9-O	12/29/2004	2.3	180	35.0	20
MW9-O	3/29/2005	2.7	200	38.0	20
MW9-O	6/28/2005	1.7	210	34.0	20
MW9-O	9/29/2005	1.7	190	37.0	20
MW9-O	12/19/2005	1.7	220	36.0	20
MW9-O	3/30/2006	16.0	190	32.0	20
MW9-O	6/27/2006	6.8	200	39.0	20
MW9-O	9/28/2006	2.0	200	39.0	20
MW9-O	11/21/2006	2.0	210	36.0	20
MW9-O	3/22/2007	2.0	170	34.0	20
MW9-O	6/20/2007	2.0	150	34.0	20
MW9-O	8/7/2007	2.0	170	34.0	20
MW9-O	11/13/2007	2.0	190	35.0	20
MW9-O	3/18/2008	0.1	170	33.0	20
MW9-O	6/12/2008	0.2	237	34.6	20

Well	Date	Sulfate (mg/L)	TDS (mg/L)	Dissolved Ca (mg/L)	Depth (ft)
MW9-O	9/10/2008	0.8	248	41.2	20
MW9-O	12/16/2008	0.6	208	34.2	20
MW9-O	3/24/2009	0.4	232	53.9	20
MW9-O	6/24/2009	1.1	252	38.9	20
MW9-S	2/19/1999	7.0	181	28.2	70
MW9-S	5/25/1999	9.0	227	25.5	70
MW9-S	8/8/1999	10.0	154	16.6	70
MW9-S	11/21/1999	6.0	191	20.7	70
MW9-S	3/5/2000	6.0	278	19.0	70
MW9-S	6/7/2000	9.0	296	40.1	70
MW9-S	8/29/2000	6.0	275	28.2	70
MW9-S	11/2/2000	11.0	460	32.1	70
MW9-S	3/8/2001	10.0	254	34.8	70
MW9-S	5/29/2001	1.0	208	36.7	70
MW9-S	5/29/2001	1.0	208	36.7	70
MW9-S	9/5/2001	13.0	286	38.8	70
MW9-S	12/5/2001	16.0	311	38.9	70
MW9-S	3/27/2002	29.0	259	40.2	70
MW9-S	6/19/2002	42.0	279	40.8	70
MW9-S	9/25/2002	33.0	283	38.7	70
MW9-S	12/5/2002	24.0	268	30.9	70
MW9-S	3/13/2003	13.0	267	29.6	70
MW9-S	6/26/2003	13.0	207	27.1	70
MW9-S	9/28/2003	13.0	221	25.9	70
MW9-S	12/16/2003	4.0	168	29.1	70
MW9-S	3/24/2004	4.0	205	27.6	70

Well	Date	Sulfate (mg/L)	TDS (mg/L)	Dissolved Ca (mg/L)	Depth (ft)
MW9-S	6/20/2004	3.0	229	29.1	70
MW9-S	9/29/2004	5.0	186	31.5	70
MW9-S	12/29/2004	2.3	170	32.0	70
MW9-S	3/29/2005	3.0	140	31.0	70
MW9-S	6/28/2005	1.7	160	26.0	70
MW9-S	9/29/2005	1.7	140	30.0	70
MW9-S	12/19/2005	1.7	170	33.0	70
MW9-S	3/30/2006	1.7	160	28.0	70
MW9-S	6/27/2006	3.0	160	32.0	70
MW9-S	9/28/2006	2.0	140	38.0	70
MW9-S	11/21/2006	2.0	190	35.0	70
MW9-S	3/22/2007	2.0	170	35.0	70
MW9-S	6/20/2007	2.0	130	33.0	70
MW9-S	8/7/2007	2.0	200	39.0	70
MW9-S	11/13/2007	2.0	200	37.0	70
MW9-S	3/18/2008	4.0	190	40.0	70
MW9-S	6/12/2008	2.6	237	40.0	70
MW9-S	9/10/2008	2.8	224	39.6	70
MW9-S	12/16/2008	0.3	196	38.2	70
MW9-S	3/24/2009	0.4	240	43.2	70
MW9-S	6/24/2009	4.3	240	40.5	70

Red text indicates values above respective trigger level.

9.0 COMPARABLE STREAM SYSTEMS

To study the response of TDS, sulfate, and calcium to flow independent of mining, background (aka control) sites may be used for comparison to Horse Creek. Horse Creek and the HCSP lack a true background site since the headwaters of Horse Creek occur in the footprint of the mine. For this study, two control sites were chosen in neighboring stream systems within the Conceptual Phosphate Mining Area but with no history of mining. Limestone Creek is a smaller 3rd order stream while Charlie Creek is a larger 4th order stream. Both streams are in Hardee County, Florida, east of Horse Creek, and both are tributaries of the Peace River, like Horse Creek.

9.1 Methods

Flatwoods characterized the condition of each background site using the following approved FDEP methods: FT3001 Physical/Chemical Characterization, FT3100 Stream and River Habitat Assessment (HA), and Landscape Development Intensity Index (LDI). These characteristics are compared to HCSP sites in Table 7 below.

Water quality samples covering all HCSP parameters were taken concurrently with flow measurements at both control sites. Sampling consisted of fifteen grab samples collected at each site no less than a week apart across various flow conditions (Table 8). At the time of each sampling event, a multiparameter water quality meter was used to collect dissolved oxygen, specific conductivity, pH, depth, temperature, and salinity. Additionally, a water turbidity meter was used to collect turbidity. Water velocity and secchi depth were also recorded each time. Water quality instruments were calibrated before each use and data was validated post-sampling per DEP-SOP-001/01. The TDS, sulfate, calcium and flow data alone are presented in this report. The full suite of raw water quality data collected during this assessment is included with the attached access database CD-ROM.

Stream flow was collected at both sites during each sampling event. At Limestone Creek, flow was calculated using the USGS Midsection Method (USGS, 2015). A water velocity meter and wading rod was used to collect velocity readings at multiple points and depths at a cross section of the stream. Those readings were used to compute the stream's total discharge. At Charlie Creek, flow data was retrieved from the nearby USGS Gauge 02296500.

9.2 Results

Limestone Creek had an overall LDI score of 2.57. The largest percentage of land use was agriculture (LDI 3.5-4.6), followed by natural (LDI 1) and land clearing (LDI 1.6-2.1) (Map 4). Charlie Creek had an overall LDI score of 2.78. The largest percentage of land use again was agriculture, followed by natural and land clearing (Map 5). Both control sites LDI scores and LDI components (Land Clearing and Agriculture) were more similar to HCSW-4 than HCSW-1 (Low intensity Development and Mining) (Table 7).

Table 7 Comparative Stream Order, LDI and HA Scores of Impact Assessment Control and Test Sites.

Stream Name	Stream Order	Drainage Area (mi^2)	LDI Score	HA Score
Limestone Creek at Ranch Road	3	< 8.5†	2.57	107 / Suboptimal
Charlie Creek at US 17	4	330	2.78	118 / Suboptimal
HCSW-1	3	42	4.11	112 / Suboptimal
HCSW-4	4	218	2.66	111 / Suboptimal

† Total area of Limestone Creek WBID.

Table 8 Summary Data for Sampling Conducted at Limestone and Charlie Creek.

Event #	Site	Date	Time	Flow	TDS	SO_4	Total Ca
				cfs	mg/L	mg/L	mg/L
1	Oak at Murphy Road	10/31/18	12:01	1.3	363	136	55
	Charlie at US17	10/31/18	13:49	25	219	42	26
2	Limestone at Ranch Rd	11/12/18	11:53	2.1	209	58	34
	Charlie at US17	11/12/18	13:20	25	192	48	27
3	Limestone at Ranch Rd	12/18/18	10:10	3.6	363	156	59
	Charlie at US17	12/18/18	9:26	42	246	79	36
4	Limestone at Ranch Rd	01/08/19	10:55	11	230	72	32
	Charlie at US17	01/08/19	12:05	46	231	52	25
5	Limestone at Ranch Rd	01/25/19	10:08	12	281	111	42
	Charlie at US17	01/25/19	13:05	43	212	56	26
6	Limestone at Ranch Rd	02/21/19	11:00	8.8	243	65	34
	Charlie at US17	02/21/19	12:15	105	223	51	21
7	Limestone at Ranch Rd	03/26/19	9:40	6	274	71	37
	Charlie at US17	03/26/19	11:10	92	226	60	22
8	Limestone at Ranch Rd	05/23/19	9:30	0.0	246	39	37
	Charlie at US17	05/23/19	10:50	9.5	256	71	32
9	Limestone at Ranch Rd	06/11/19	9:42	0.3	224	21	34
	Charlie at US17	06/11/19	11:05	351	220	52	22
10	Limestone at Ranch Rd	08/07/19	12:00	90	243	60	27
	Charlie at US17	08/07/19	13:00	1210	164	17	14
11	Limestone at Ranch Rd	08/28/19	10:35	15	246	61	32
	Charlie at US17	08/28/19	12:20	773	153	13	13
12	Limestone at Ranch Rd	10/03/19	10:20	0.7	261	52	43
	Charlie at US17	10/03/19	13:00	28	203	33	23
13	Limestone at Ranch Rd	10/29/19	10:30	2.4	428	171	60
	Charlie at US17	10/29/19	12:15	54	244	43	22
14	Limestone at Ranch Rd	11/26/19	9:30	1.3	440	214	66
	Charlie at US17	11/26/19	12:00	26	229	76	29
15	Limestone at Ranch Rd	12/30/19	12:00	2.5	423	202	65
	Charlie at US17	12/30/19	13:21	75	214	59	23
	Field Blank	12/30/19	12:00	NA	10 U	0.2 I, V	0.22

TDS, sulfate and calcium concentrations showed the same pattern at both control sites as they did in Horse Creek- concentrations decreased with increased stream flow (Figures 9-1 through 9-3). Concentrations of TDS, sulfate, and calcium approached but did not exceed the respective HCSP trigger levels during low flow conditions further supporting the conclusion made in section 6.0, Creek Flow, of this report. Trigger level exceedances were observed in some of the additional parameters that were not in the scope of this impact assessment. These exceedances were also found to be during low flow conditions.

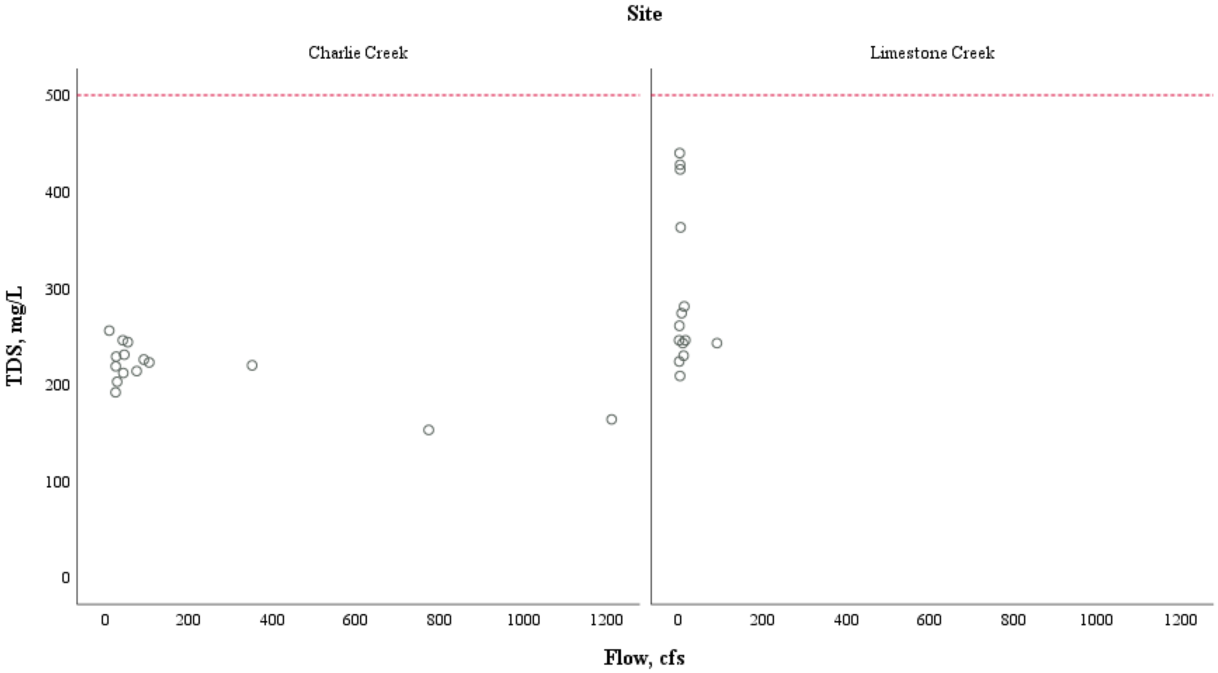


Figure 9-1 Total Dissolved Solids (TDS) vs. Flow at Limestone and Charlie Creeks. The red line denotes the TDS trigger level.

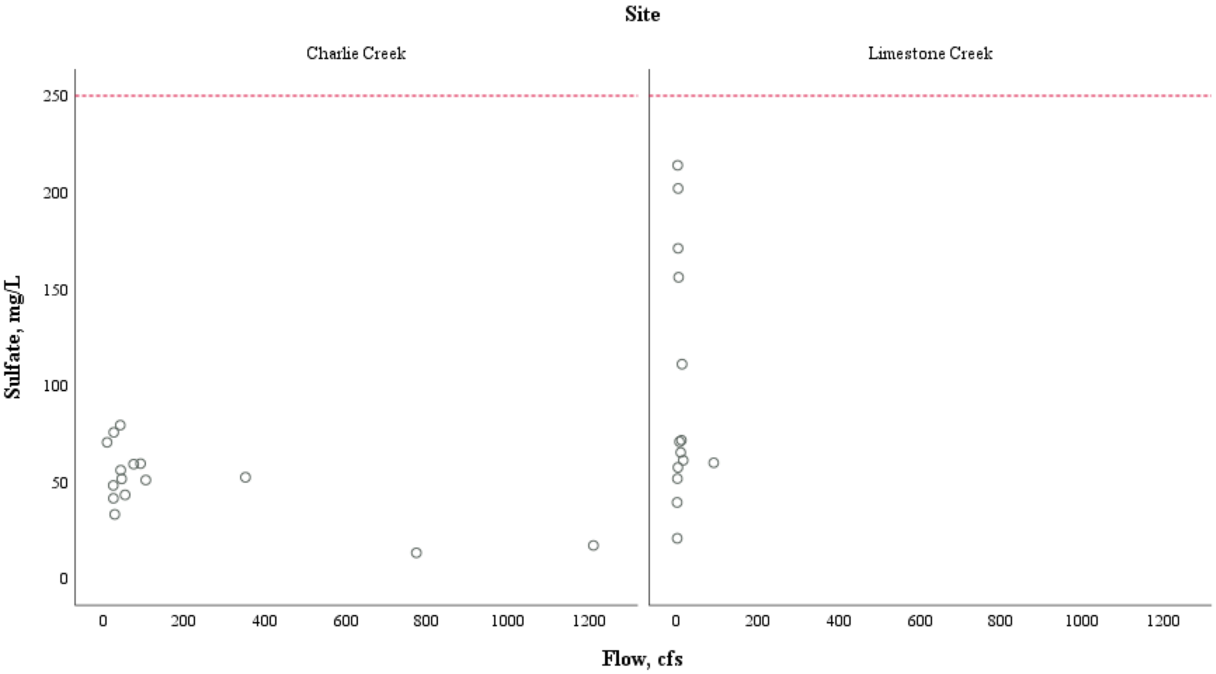


Figure 9-2 **Sulfate vs. Flow at Limestone and Charlie Creeks. The red line denotes the sulfate trigger level.**

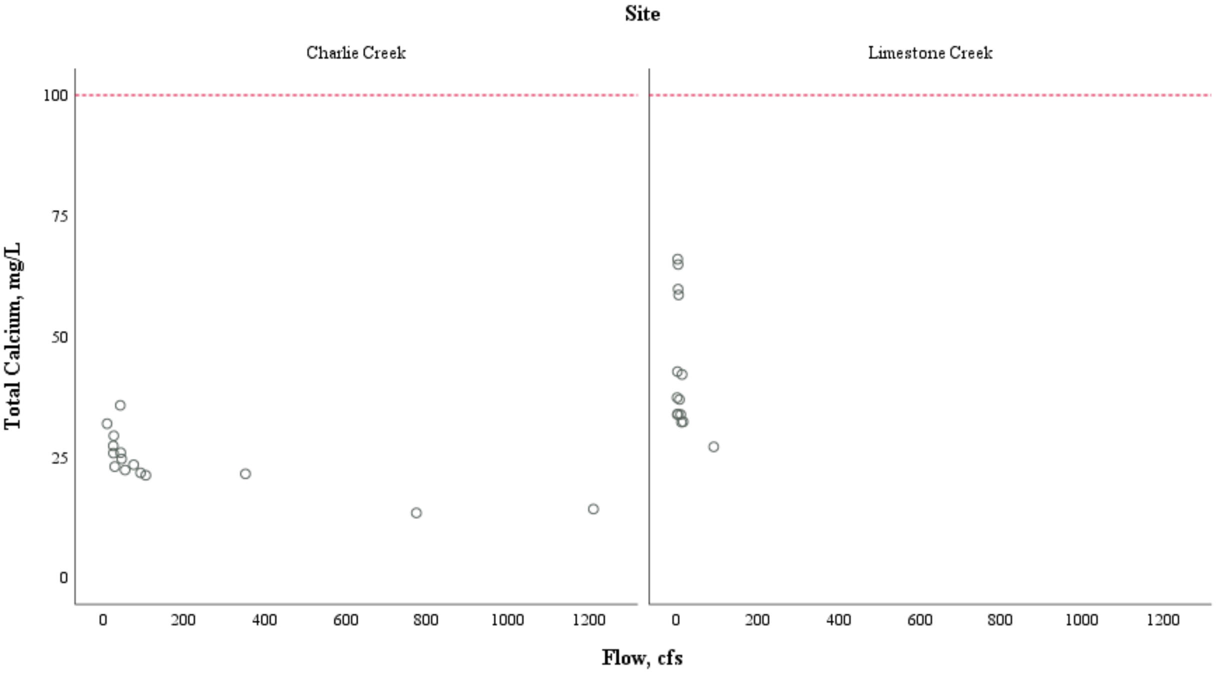


Figure 9-3 **Calcium vs. Flow at Limestone and Charlie Creeks. The red line denotes the sulfate trigger level.**

10.0 CONCLUSION

Based on our findings, 231 out of 232 TDS, sulfate, and dissolved calcium exceedances have occurred in the Lower Horse Basin. Trigger value exceedances in the Lower Basin occurred before the Mosaic outfalls to Horse Creek were online, though they do occur more regularly in recent times. On all days but two, exceedances have occurred when the outfalls were not discharging and had not been discharging for weeks – in most cases months – and Horse Creek was under low-flow conditions: which suggests a non-point source input.

Neither the surficial groundwater data (collected within the Wingate Mine boundary), nor the outfall water quality data (collected from both the Wingate and Fort Green outfalls), demonstrate excessively high TDS, sulfate, or dissolved calcium values. This is particularly true for sulfate as the outfall and groundwater values consistently remain at very low concentrations.

The stations that have a record of surpassing the established TDS, sulfate, and dissolved calcium limits with regularity have been HCSW-4 and HCSW-3. These two sites' water chemistry, with respect to all three parameters, resembles the water chemistry signature of the two major nearby tributaries- Buzzard Roost Branch and Brandy Branch- more than they do water quality stations further upstream on Horse Creek. Additionally, there were a few samples collected from Horse Creek at Pine Level Road (n= 9), Unnamed Creek at Barrow Road (n= 2), and Unnamed Creek at County Road 665 (n = 2), all in the Lower Basin, with concentrations approaching or above the HCSP established trigger levels. Neither of the aforementioned creeks watersheds contained extractive industry of any kind. This may warrant some further study.

Across all three parameters, the values in the Lower Horse Creek Basin began to fluctuate more in the late 1990's. These were years when natural lands in Florida were rapidly being converted to intensive human uses (Stys, et al, 2007) that are often less regulated than NPDES discharges. Land being converted to agriculture and pasture use has increased consistently in Horse Creek, and Agriculture is the dominant land use in the Lower Basin (Table 9). Agriculture is linked to increased TDS and dissolved ions in adjacent freshwater systems and salinization of arable land through the application of fertilizer, water withdrawals and irrigation. The Lower Basin is more influenced by agriculture than the Upper Basin.

Table 9 Comparison of Landscape Development Scores Over Time and Basins with a Detailed Breakdown of the 2011 Land Use Components.

WBID	Whole-Basin Landscape Development Index			2011 Land Use Break Down				
	1990	1999	2011	Natural	Silviculture	Clearing/ Agriculture	Low Intensity Development	High Intensity Development
Upper Horse Creek	2.14	3.66	4.11	29.70%	0.12%	38.71%	1.34%	30.13%
Brushy Creek	2.04	2.06	2.81	40.51%	0.00%	48.42%	0.63%	10.45%
Lower Horse Creek	2.42	2.47	2.66	35.04%	0.47%	59.71%	4.53%	0.25%

Sampling results from the nearby Limestone and Charlie creeks do not show any trigger level exceedances for TDS, calcium, or sulfate across the various flow conditions. However, higher values for each of these parameters were reported during low flow conditions.

11.0 REFERENCES

Florida Department of Environmental Protection. (2005). *The Landscape Devlopment Intensity Index Technical Support Document.* Retrieved from https://floridadep.gov/dear/bioassessment/documents/landscape-development-intensity-index-ldi

Florida Department of Environmental Protection. (2019). *Watershed Assessment Section*. Retrieved from https://floridadep.gov/dear/watershed-assessment-section/content/basin-411-0

Jenke, A. L. (1974). *Evaluation of Salinity created by irrigation return flows.* Washington, D.C.: EPA, Office of Water Program Operations.

Jones, G., DeHaven, E., Clark, L., Rauch, J., Mulroney, T., & Ramirez, C. (1990). *Groundwater Quality of the Southwest Florida Water Management District: Southern Region.* Ambient Ground-Water Quality Monitoring Program & Florida Department of Environmental Regulation.

Lincoln R. Page, H. E. (1955). Contributions to the Geology of Uranium and Thorium: By the United States Geological Survey and Atomic Energy Commission . *United Nations International Conference on Peaceful Uses of Atomic Energy* (p. 496). Geneva, Switzerland: U.S. Government Printing Office.

Mount, D. R., Gulley, D. D., Hockett, R. J., Garrison, T. D., Evans, & M., J. (1997, October). Statistical models to predict the toxicity of major ions to C. dubia, Daphnia magna and Pimephales promelas. *Environmental Toxicology and Chemistry 16:10*, pp. 2009-2019.

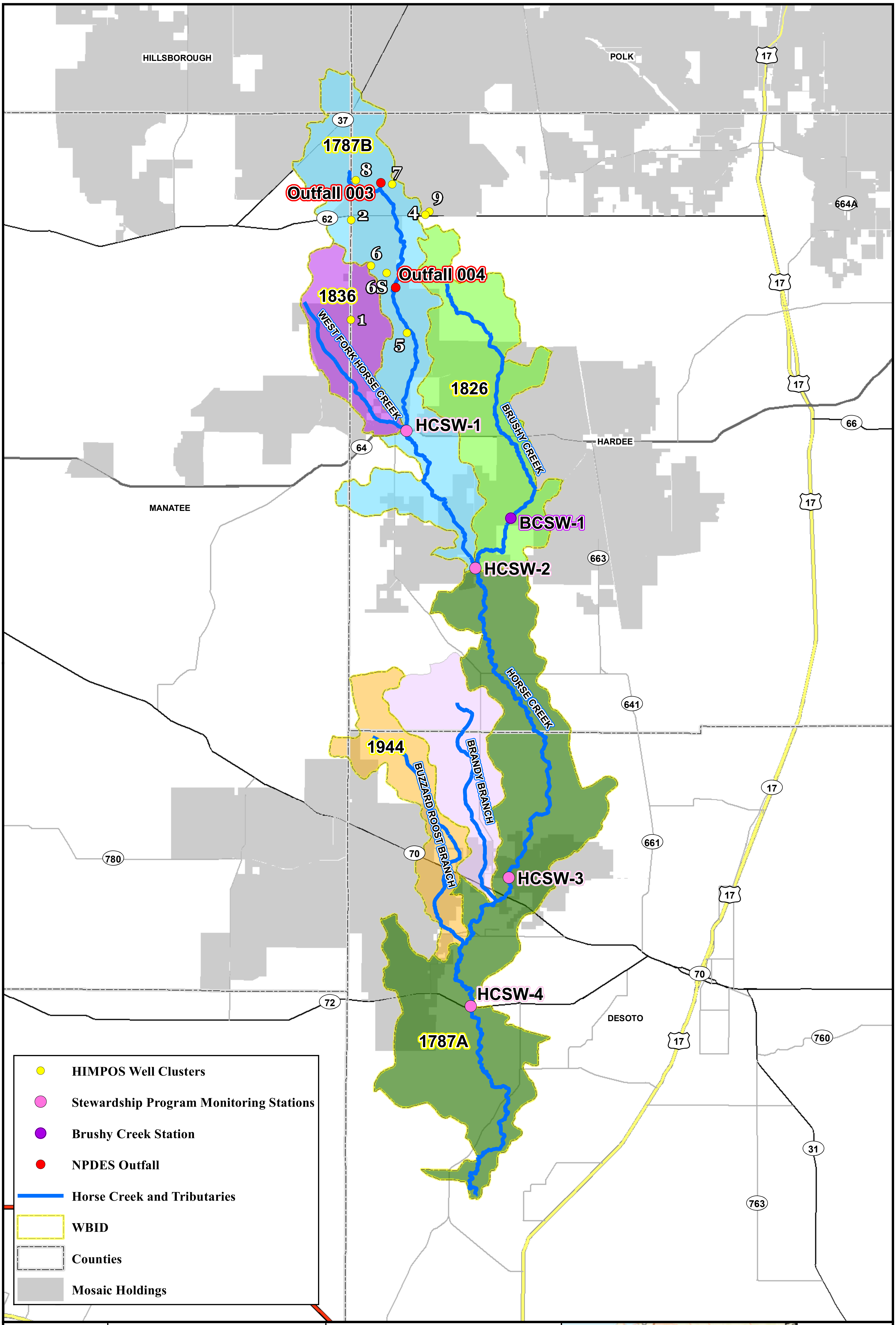
Rice, E. W., Baird, R. B., & Eaton, A. D. (2017). *Standard Methods for the Examination of Water and Wastewater, 23rd Edition.* Water Environment Federation.

Stys, B., Kautz, R., Reed, D., Kertis, M., Kawula, R., Keller, C., et al. (2007, November 1). FLORIDA VEGETATION 2003 AND LAND USE CHANGE. *Agricultural and Natural Resource Sciences*, pp. 12-23.

U.S. Geological Survey. (2015). *Mid-Section Measurements*. Retrieved from https://hydroacoustics.usgs.gov/midsection/index.shtml

Weber-Scannell, P. K., & Duffy, L. K. (2007). Effects of Total Dissolved Solids on Aquatic Organisms: A Review of Literature and Recommendation for Salmonid Species. *American Journal of Environmental Sciences*, 1-6.

Wetzel, R. (1983). *Limnology, second edition, pp. 767.* New York: Saunders College Publishing.



Miles
0 3
1 in = 3 miles

FLATWOODS Consulting Group

HORSE CREEK
STEWARDSHIP PROGRAM
MOSAIC FERTILIZER LLC.

HARDEE COUNTY, FLORIDA

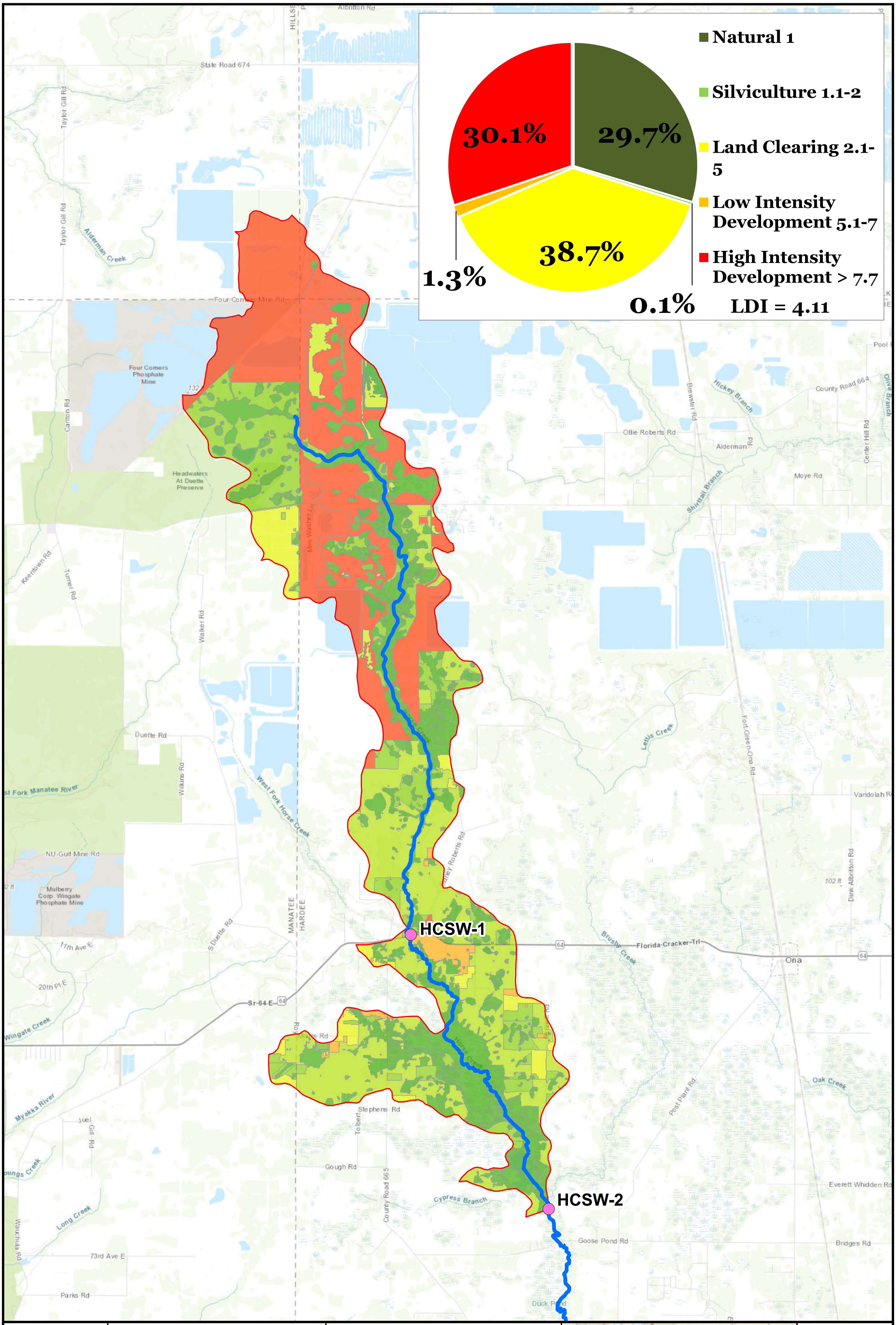
Drainage Basins

🟪	BRANDY BRANCH
🟩	BRUSHY CREEK
🟧	BUZZARD ROOST BRANCH
🟪	WEST FORK HORSE CREEK
🟦	UPPER HORSE CREEK
🟩	LOWER HORSE CREEK

N
W E
S

MAP 1
HCSP
MONITORING
LOCATIONS

P:\0003MOS\125-HCSP\GIS\HCSW STATIONS.mxd



Miles 0 — 1.5 1 in = 1.5 miles	HORSE CREEK STEWARDSHIP PROGRAM MOSAIC FERTILIZER, LLC
FLATWOODS Consulting Group	DESOTO COUNTY, FLORIDA

● Stewardship Program Monitoring Stations

▭ Upper Horse Creek WBID

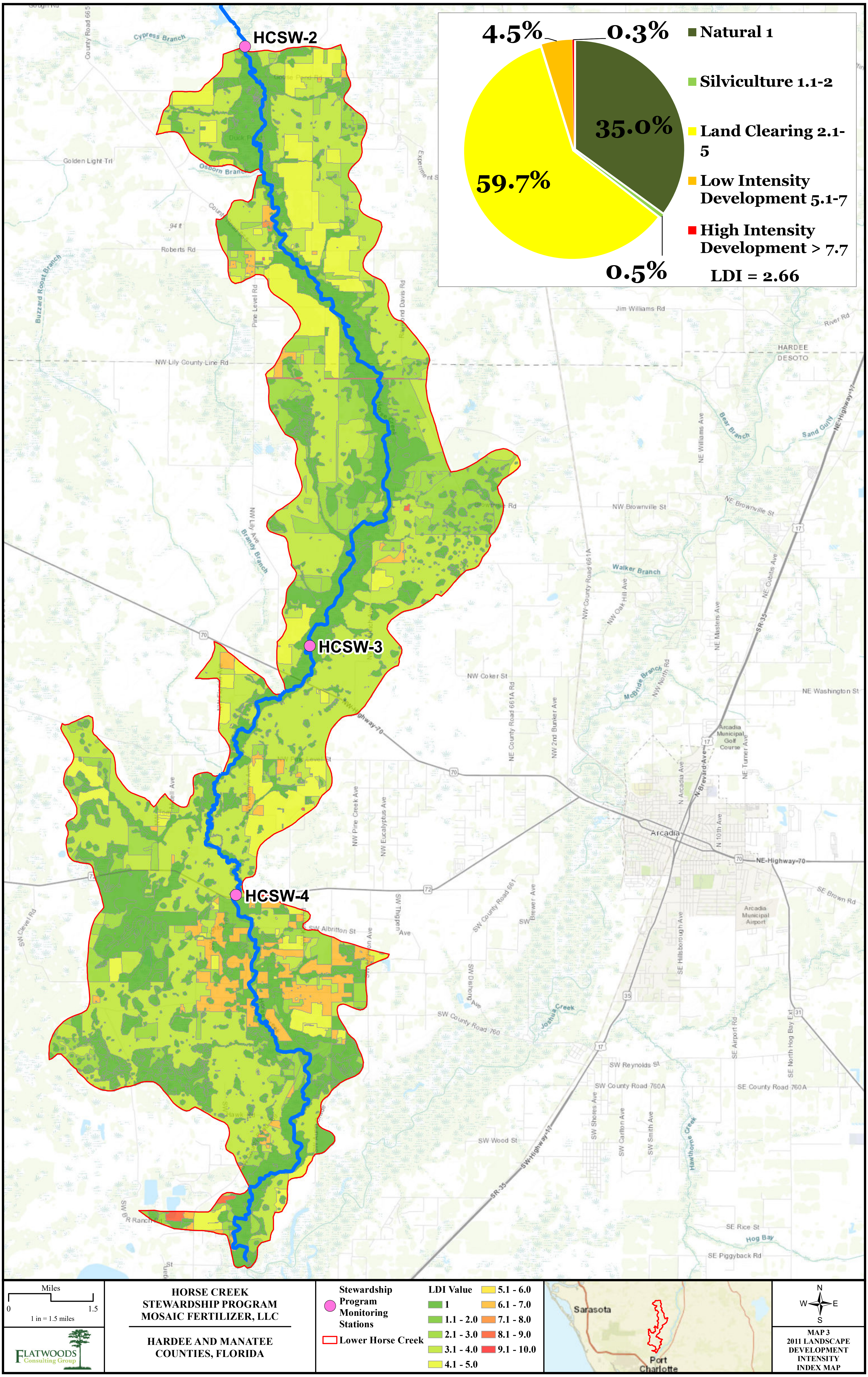
LDI Value

🟩 1	🟨 5.1 - 6.0
🟩 1.1 - 2.0	🟧 6.1 - 7.0
🟩 2.1 - 3.0	🟧 7.1 - 8.0
🟩 3.1 - 4.0	🟥 8.1 - 9.0
🟨 4.1 - 5.0	🟥 9.1 - 10.0

N
W E
S

MAP 2
2011 LANDSCAPE
DEVELOPMENT
INTENSITY
INDEX MAP

P:\0003MOS\125-HCSP\GIS\UPPER HORSE CREEK LDI.mxd



Miles
0 1.5
1 in = 1.5 miles

**HORSE CREEK
STEWARDSHIP PROGRAM
MOSAIC FERTILIZER, LLC**

**HARDEE AND MANATEE
COUNTIES, FLORIDA**

FLATWOODS Consulting Group

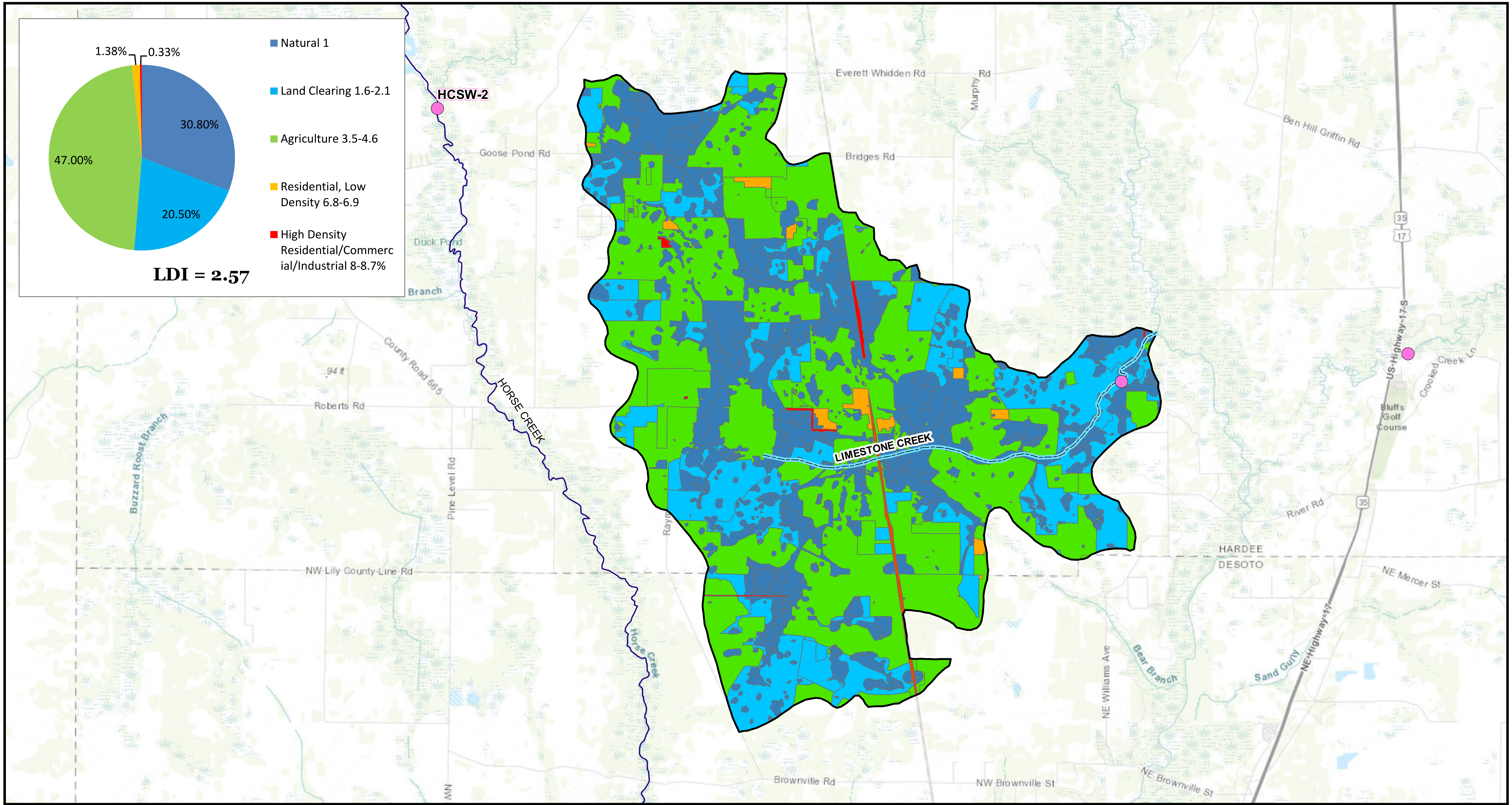
● Stewardship Program Monitoring Stations

▭ Lower Horse Creek

LDI Value			
🟩	1	🟨	5.1 - 6.0
🟩	1.1 - 2.0	🟧	6.1 - 7.0
🟩	2.1 - 3.0	🟧	7.1 - 8.0
🟩	3.1 - 4.0	🟥	8.1 - 9.0
🟨	4.1 - 5.0	🟥	9.1 - 10.0

**MAP 3
2011 LANDSCAPE
DEVELOPMENT
INTENSITY
INDEX MAP**

P:\0003MOS\125-HCSP\GIS\LOWER HORSE CREEK LDI.mxd



N
W E
S

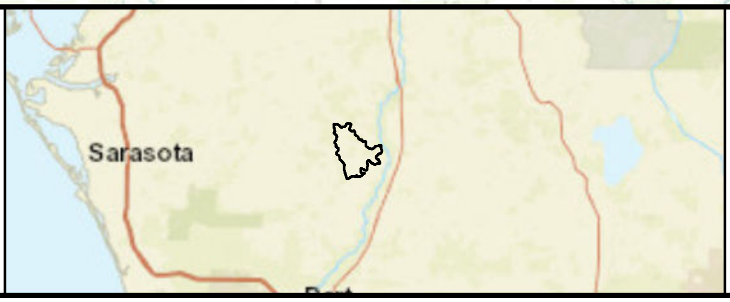
Feet
0 6,000
1 in = 6,000 feet

HORSE CREEK STEWARDSHIP PROGRAM MOSAIC FERTILIZER, LLC

DESOTO AND HARDEE COUNTIES, FLORIDA

● Stewardship Program Monitoring Stations
▭ Limestone Creek WBID

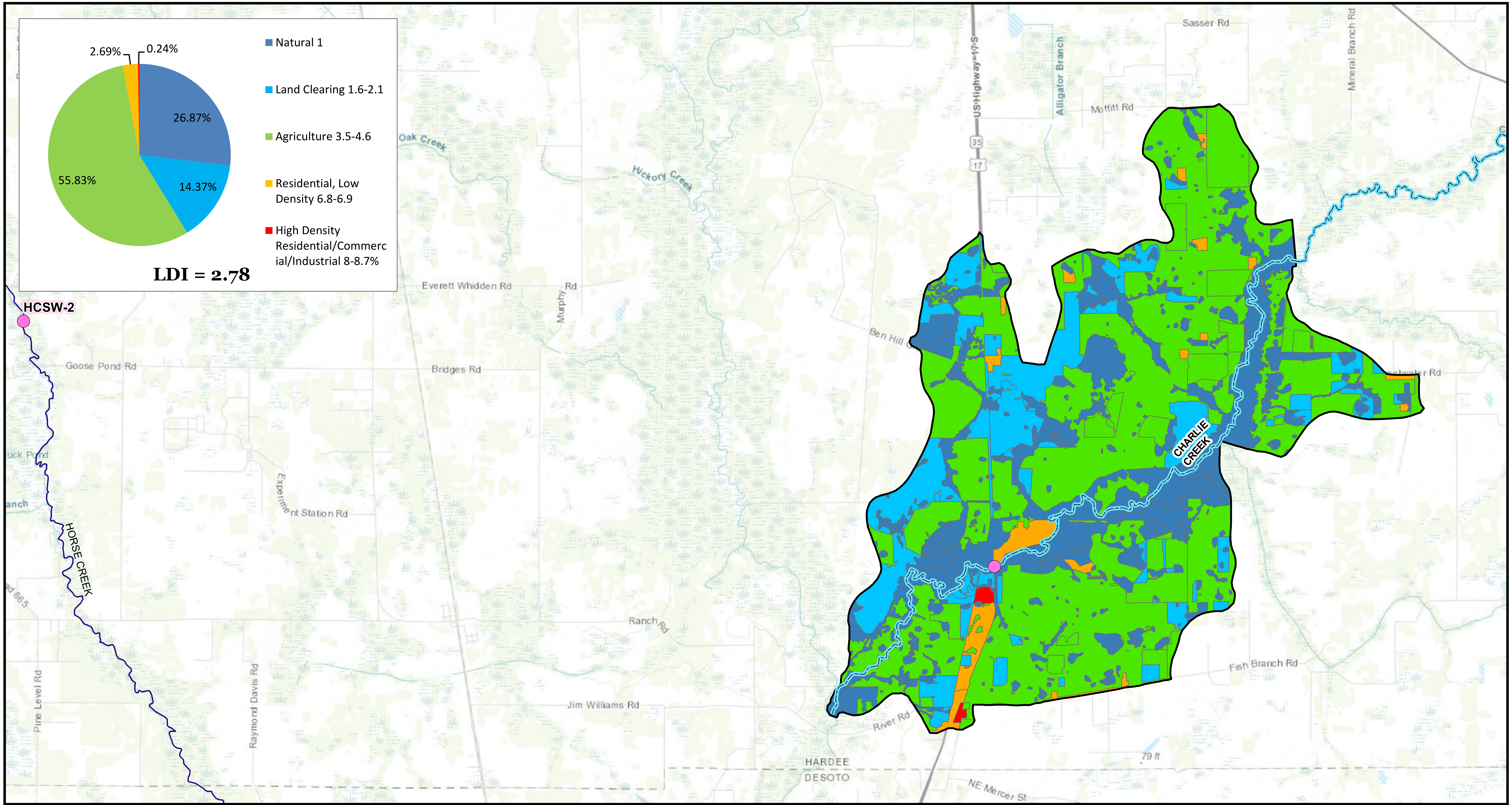
🟦 1	🟧 5.3-7.5
🟦 1-2.1	🟧 7.6-7.9
🟩 2.2-5.1	🟥 8-9.1
🟨 5.2	🟪 9.2-10



2011 LANDSCAPE DEVELOPMENT INTENSITY INDEX MAP

FLATWOODS Consulting Group

P:\0003MOS\125-HCSP\GIS\LIMESTONE CREEK WBID LDI 06262019.mxd



N
W E
S

Feet
0 6,000
1 in = 6,000 feet

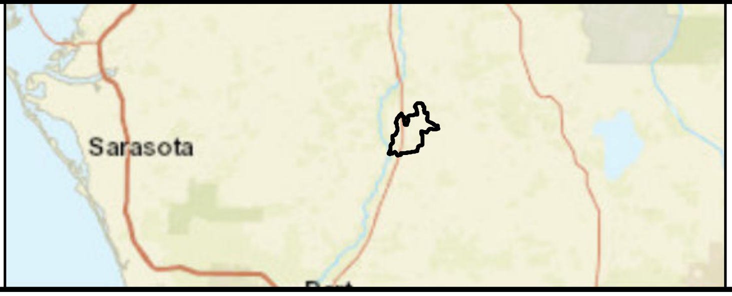
**HORSE CREEK
STEWARDSHIP PROGRAM
MOSAIC FERTILIZER, LLC**

HARDEE COUNTY, FLORIDA

● **Stewardship Program Monitoring Stations**

▭ **Charlie Creek WBID**

🟦 **1**	🟧 **5.3-7.5**
🟦 **1-2.1**	🟧 **7.6-7.9**
🟩 **2.2-5.1**	🟥 **8-9.1**
🟨 **5.2**	🟪 **9.2-10**



2011 LANDSCAPE DEVELOPMENT INTENSITY INDEX MAP

FLATWOODS
Consulting Group

P:\0003MOS\125-HCSP\GIS\CHARLIE CREEK WBID LDI.mxd

Appendix J

Comments on HCSP SCI Data

Comments on HCSP SCI Data

Beginning with the 2010 annual report, the Horse Creek Stewardship Program (HCSP) Stream Condition Index (SCI) data was reevaluated with strict interpretation of Florida Department of Environmental Protection (FDEP) Standard Operating Procedure (SOP) guidance, including the upper and lower limits of the SOP target number of individuals, the SOP target of a minimum velocity of 0.05 m/sec 28 days prior to sampling, the SOP target of waiting at least 90 days after abatement of a stream desiccation event (i.e. no refugia for organisms), and the SOP target of less than a 0.5 m water level increase in the previous 28 days. As a result of this evaluation, some SCI scores have been removed from the analysis (in red italics). In addition, some SCI results with more than the target number of individuals were randomly resampled to provide an unbiased result.

Date	HCSW-1					HCSW-2					HCSW-3					HCSW-4				
	HA Score	2004 SCI Score	2007 SCI Score	2012 SCI Score	Comments	HA Score	2004 SCI Score	2007 SCI Score	2012 SCI Score	Comments	HA Score	2004 SCI Score	2007 SCI Score	2012 SCI Score	Comments	HA Score	2004 SCI Score	2007 SCI Score	2012 SCI Score	Comments
4/25/2003	*134*	*64*	NA	NA	Stream presumed dry earlier in month with no refugia for organisms; sample taken less than 90 days from when dry conditions abated	134	52	NA	NA	Randomly subsampled because original sort had more than the recommended number of individuals from FDEP SOP	142	38	NA	NA	Randomly subsampled because original sort had more than the recommended number of individuals from FDEP SOP	147	62	NA	NA	
7/29/2003	*141*	*55*	NA	NA	Greater than 0.5m water level increase over previous 28 days	*139*	*14*	NA	NA	Greater than 0.5m water level increase over previous 28 days	*151*	*27*	NA	NA	Less than SOP target number of individuals; Greater than 0.5m water level increase over previous 28 days	*146*	*61*	NA	NA	Less than SOP target number of individuals; Greater than 0.5m water level increase over previous 28 days
11/20/2003	133	65	NA	NA		121	35	NA	NA	Randomly subsampled because original sort had more than the recommended number of individuals from FDEP SOP	131	60	NA	NA		135	61	NA	NA	
4/22/2004	138	37	NA	NA		134	27	NA	NA	Randomly subsampled because original sort had more than the recommended number of individuals from FDEP SOP	138	*34*	NA	NA	Less than SOP target number of individuals	141	*57*	NA	NA	Less than SOP target number of individuals
11/3/2004	NA	*58*	NA	NA	Less than SOP target number of individuals	117	5	NA	NA		99	*24*	NA	NA	Less than SOP target number of individuals	111	33	NA	NA	
2/15/2005	131	48	NA	NA	Randomly subsampled because original sort had more than the recommended number of individuals from FDEP SOP	117	62	NA	NA	Randomly subsampled because original sort had more than the recommended number of individuals from FDEP SOP	112	51	NA	NA	Randomly subsampled because original sort had more than the recommended number of individuals from FDEP SOP	113	54	NA	NA	Randomly subsampled because original sort had more than the recommended number of individuals from FDEP SOP

Date	HCSW-1					HCSW-2					HCSW-3					HCSW-4				
	HA Score	2004 SCI Score	2007 SCI Score	2012 SCI Score	Comments	HA Score	2004 SCI Score	2007 SCI Score	2012 SCI Score	Comments	HA Score	2004 SCI Score	2007 SCI Score	2012 SCI Score	Comments	HA Score	2004 SCI Score	2007 SCI Score	2012 SCI Score	Comments
4/20/2005	126	18	NA	NA	Randomly subsampled because original sort had more than the recommended number of individuals from FDEP SOP	117	40	NA	NA		124	59	NA	NA		121	67	NA	NA	Randomly subsampled because original sort had more than the recommended number of individuals from FDEP SOP
9/15/2005[1]	129	42	NA	NA	Randomly subsampled because original sort had more than the recommended number of individuals from FDEP SOP	124	21	NA	NA	Randomly subsampled because original sort had more than the recommended number of individuals from FDEP SOP	121	53	NA	NA	Randomly subsampled because original sort had more than the recommended number of individuals from FDEP SOP	114	53	NA	NA	Randomly subsampled because original sort had more than the recommended number of individuals from FDEP SOP
12/15/2005	130	48	NA	NA	Randomly subsampled because original sort had more than the recommended number of individuals from FDEP SOP	114	37	NA	NA	Randomly subsampled because original sort had more than the recommended number of individuals from FDEP SOP	115	41	NA	NA		115	36	NA	NA	
4/6/2006	110	46	NA	NA	Randomly subsampled because original sort had more than the recommended number of individuals from FDEP SOP	98	25	NA	NA		103	60	NA	NA		105	46	NA	NA	
7/27/2006	*115*	*59*	NA	NA	Stream presumed dry at end of May with no refugia for organisms; sample taken less than 90 days from when dry conditions abated	106	26	NA	NA	Stream presumed dry in May with no refugia for organisms; sample taken less than 90 days from when dry conditions abated; Less than SOP target number of individuals	118	32	NA	NA	Stream presumed dry in May with no refugia for organisms; sample taken less than 90 days from when dry conditions abated	127	50	NA	NA	
11/28/2006[2]	115		40	45		93		34	36		121		43	47		113		42	48	
3/28/2007	115		65	72	Randomly subsampled because original sort had more than the recommended number of individuals from FDEP SOP	100		32	37	Randomly subsampled because original sort had more than the recommended number of individuals from FDEP SOP	117		55	60	Randomly subsampled because original sort had more than the recommended number of individuals from FDEP SOP	113		50	56	

Date	HCSW-1					HCSW-2					HCSW-3					HCSW-4				
	HA Score	2004 SCI Score	2007 SCI Score	2012 SCI Score	Comments	HA Score	2004 SCI Score	2007 SCI Score	2012 SCI Score	Comments	HA Score	2004 SCI Score	2007 SCI Score	2012 SCI Score	Comments	HA Score	2004 SCI Score	2007 SCI Score	2012 SCI Score	Comments
8/9/2007	123		65	71		-		-	-	Does not meet SOP minimum velocity requirements - no sample	121		29	34	Randomly subsampled because original sort had more than the recommended number of individuals from FDEP SOP	130		41	48	
11/27/2007	116		65	73		108		22	25		116		65	72	Randomly subsampled because original sort had more than the recommended number of individuals from FDEP SOP	124		61	66	
4/24/2008	*101*		47	54	Did not meet SOP minimum velocity requirements	109		23	27		114		48	53		104		52	59	
9/12/2008	122		45	51	Randomly subsampled because original sort had more than the recommended number of individuals from FDEP SOP	104		9	11		121		7	10		119		33	40	
11/19/2008	115		48	55	Randomly subsampled because original sort had more than the recommended number of individuals from FDEP SOP	84		25	26		109		29	34		108		56	61	
4/22/2009	--		-	-	Does not meet SOP minimum velocity requirements - no sample	-		-	-	Does not meet SOP minimum velocity requirements - no sample	-		-	-	Does not meet SOP minimum velocity requirements - no sample	105		45	50	
10/22/2009	124		49	56		123		22	25		106		54	60		114		52	59	
4/20/2010	126		37	44		115		29	34		103		59	64		110		68	73	
9/28/2010	128		55	63		102		11	14		99		65	71		109		58	65	
11/4/2010 (or 11/11/10)	119		45	51		105		32	36		100		64	71		105		55	63	
4/18/2011	127		56	63		102		20	25		103		67	72		113		83	90	
8/9/2011	--		-		Severe thunderstorm with rising water levels – no sample	-		-	-	Suspected water level increase >0.5m and habitats less than 28 days inundated – no sample	112		-	-	Normal stream channel not accessible (flooded) according to SOP – no sample	122		26	29	

Date	HCSW-1					HCSW-2					HCSW-3					HCSW-4				
	HA Score	2004 SCI Score	2007 SCI Score	2012 SCI Score	Comments	HA Score	2004 SCI Score	2007 SCI Score	2012 SCI Score	Comments	HA Score	2004 SCI Score	2007 SCI Score	2012 SCI Score	Comments	HA Score	2004 SCI Score	2007 SCI Score	2012 SCI Score	Comments
10/26/2011	110		49	55		-		-	-	Normal stream channel not accessible (flooded) according to SOP - no sample	109		61	68		116		45	51	
3/30/2012	--		-	-	Low water levels - no samples collected	-		-	-	Dry - no samples collected	-		-	-	Does not meet SOP minimum velocity requirements - no sample	121		73	78	
10/26/2012	126		54	60		-		-	-	Normal stream channel not accessible (flooded) according to SOP – no sample	118		61	68		97		64	70	
12/12/2012	120		51	58		-		-	-	Does not meet SOP minimum velocity requirements - no sample	104		72	78		103		62	69	
3/20/2013	96		61	67		-		-	-	Does not meet SOP minimum velocity requirements - no sample	107		65	71		113		69	75	
10/28/2013	114		44	50		98		15	20		117		61	67		94		68	74	
12/16/2013	108		40	45		105		43	46		115		72	79		119		55	62	
3/18/2014	115		57	63		109		37	42		120		66	72		119		74	81	
9/3/2014	124		74	81		103		33	36		120		38	43		121		50	56	
11/10/2014	121		43	49		103		21	25		111		49	56		111		52	59	
4/3/2015	117		59	66		100		36	40		107		70	76		117		83	88	
10/27/2015	129		62	66		109		23	27		112		68	75		114		48	55	
12/15/2015	136		54	60		111		49	52		107		58	64		114		68	75	
3/17/2016	125		68	74		114		52	57		110		51	58		115		69	75	
11/16/2016	131		49	54		105		27	31		107		59	65		111		72	78	
3/23/2017	100		67	74		-		-	-	Does not meet SOP minimum velocity requirements - no sample	102		54	60		105		82	87	
10/19/2017	124		47	54		96		19	22		108		53	60		112		52	59	
12/4/2017	109		59	65		-		-	-	Does not meet SOP minimum velocity requirements - no sample	104		58	65		113		65	71	
4/30/18	109			81						Does not meet SOP minimum velocity requirements - no sample	74			65		111			58	
10/30/18						103			24		85			63		116			66	
10/31/18	114			66	Sample events less than 90 days apart, average SCI score = 60.5					Sample events less than 90 days apart, average SCI score = 23.5					Sample events less than 90 days apart, average SCI score = 63.5					Sample events less than 90 days apart, average SCI score = 67
12/17/18						108			23		86			63		111			68	
12/18/18	112			55																

[1] Sorting method change in FDEP SOP

[2] Sorting and calculation method change in FDEP SOP; two vial average

Appendix K

Summary of Major Events, Lab Changes, and Potentially Erroneous Data Recorded during the HCSP

K.1 EVENTS TIMELINE

April 2003 – Horse Creek Stewardship Program (HCSP) began.

August 2004 – Hurricane Charley moves up the Horse Creek Basin. A few days later, there were odor complaints in the Peace River. As a response, monthly water sampling was increased to weekly sampling to aid in determining problems with water quality data, primarily dissolved oxygen in the Peace River watershed (including estuary and lower tributaries)[2]. In Horse Creek near Myakka Head (HCSW-1) water levels did not drop to hypoxic levels; however, at Horse Creek near Arcadia (HCSW-4) a drop was observed (it did see the fastest recovery to pre-hurricane conditions of sites tested)[7].

September 2004 – Hurricane Frances moves up the Horse Creek Basin.

September 2004 – Hurricane Jeanne moves up the Horse Creek Basin. The combined effects of the three hurricanes appear to be related to hypoxic conditions recorded in the Peace River watershed with areas within 20 km of the eyewall experiencing hypoxic condtions[7]. Dissolved oxygen (DO) took approximately two to three months to recover to pre-hurricane levels at most locations.

August 2005 – Invertebrate sorting methodology change in Florida Department of Environmental Protection (FDEP) Stream Condition Index (SCI) Standard Operating Procedure (SOP). Target number of individuals between 100 and 120 per sample (SCI-2004).

October 2005 – U.S. Geological Survey (USGS) rain gauge discontinued at HCSW-1. Began using Southwest Florida Water Management District (SWFWMD) rain gauge 494 for annual reports.

June 2006 – The last clays from Fort Green beneficiation plant were sent to clay settling areas (CSAs) FGH3 and FGH4 which discharge to Horse Creek via FTG-003 and FTG-004.

November 2006 – Invertebrate sorting methodology change in FDEP SCI SOP. Two vials with a target number of individuals of 140-160 per sample are required. The average SCI score of the two vials is used for reporting purposes (SCI-2007).

2006 – 2008 – Time period with lower than average streamflow and rainfall for the Horse Creek Basin.

---

[2] Tomasko, D.A., C. Anastasiou, and C. Kovach. 2006. Dissolved oxygen dynamics in Charlotte Harbor and its contributing watershed, in response to Hurricanes Charley, Frances, and Jeanne – impacts and recovery. Estuaries and Coasts 29 (6A): 932-938.

July 2006 - September 2008 – Very little National Pollutant Discharge Elimination System (NPDES) discharge (stormwater and baseflow only) from FTG-003 and FTG-004 due to extremely dry conditions.

October 2008 – Clays mined via dredge from the Wingate Mine began to be transported to facilities and FM1 in the Horse Creek basin for processing and storage. NPDES discharge was comprised mostly of groundwater from the Wingate mining process.

March 2009 – Added CSA FM-1 to existing monitoring program.

September 2009 – discontinue monitoring Florida Petroleum Residual Organics (FL-PRO), fatty acids, and total amines at all four Horse Creek locations. Sampling began in Brushy Creek (BCSW-1) minus trigger levels and impact assessments.

Winter 2009/2010 – Florida experienced one of the coldest winters on record (December-February the 10th coldest period in Tampa since records started in 1890). In Hillsborough County, overnight lows in early January were at or below freezing for 12 consecutive nights. Cold temperatures led to large fish kill in the area as a result.

December 2010 – Coldest December for the Tampa Bay area in recorded history (the daily average [53.2°C] was 10°C lower for the month than normal). Several areas throughout west-central and southwest Florida also set record lows.

October 2011 – SWFWMD reduced sampling frequency at HCSW-1 and HCSW-4 to every other month from monthly sampling.

November 2011 – SWFWMD rain gaugue 494 discontinued. Began using NOAA gauges.

January 2013 – Supplemented SWFWMD Flatfort Swamp rain gauge in additoin to NOAA gauges and Mosaic gauges in annual report tables and graphics.

July 2014 – New FDEP SOP for the SCI (SCI 1000) calculations along with newly estabished bioregions (Panhandle West, Big Bend, Northeast, and Peninsula) went into effect with the approval of the new QA rule. This new methodology is referred to as the SCI-2012 method in the report.

September 2017- Hurricane Irma crosses both DeSoto and Hardee County as a Category 1 storm.

January 2018 – Flatwoods took over sampling of the HCSP.

K.2 LAB CHANGES TIMELINE

April 2003 – November 2004: Various labs

December 2004 – May 2008: STL/Test America (all but Radiologicals)

April 2006 – July 2008: KNL Labs (Radiologicals only)

July 2008 – July 2010: Benchmark Analytical (all parameters except Radiologicals)

July 2008 – November 2014: Benchmark Analytical (color and chlorophyll-a only)

August 2008 – Present: Florida Radiochemistry (Radiologicals only)

August 2010 – Present: Mosaic's Laboratory

December 2014 – Present: Mosaic's Laboratory started analyzing color and chlorophyll-a

January 2018 – Macroinvertebrate samples analyzed by Wood.

K.3 MAJOR MDL CHANGES

January 2006 – July 2008: Nitrate-Nitrite highly variable

April 2003 – December 2011: Ammonia (around 0.03 mg/L through October 2007, variable through July 2008, stable through July 2011, then variable)

December 2007: Orthophosphate abnormally high value (0.75 mg/L)

April 2003 – December 2011: Dissolved iron started at 0.1 mg/L, reduced in March 2006 to 0.022 mg/L, stable from August 2010 at around 0.01 mg/L

March 2006 – February 2008: Chloride numerous changes ranging from 0.022-30 mg/L; stable since March 2008

March 2006 – February 2008: Fluoride numerous changes ranging from 0.017-5 mg/L; relatively stable since March 2008

March 2006 – February 2008: Sulfate numerous changes; stable since March 2008

K.4 POSSIBLE OUTLIER DATA IDENTIFIED BUT REMAINING IN ANALYSIS

The data listed in the table below was identified in Decision Memo #1 as outlier data but remains in Appendix C graphs and data analysis.

Parameter	Date	HCSW-1	HCSW-2	HCSW-3	HCSW-4	Units	Explanation
TKN	9/27/2006			6.6		mg/L	Outlier based on adjacent sampling events and SWFWMD data from the same month. Likely lab error. Was not removed from analysis.
TN	9/27/2006			6.7		mg/L	Outlier based on TKN sample being higher than adjacent sampling events and SWFWMD data from the same month. Likely lab error. Was not removed from analysis.
TKN	1/30/2008		4.7			mg/L	Outlier based on adjacent sampling events and SWFWMD data from the same month. Likely lab error. Was not removed from analysis.

Parameter	Date	HCSW-1	HCSW-2	HCSW-3	HCSW-4	Units	Explanation
TN	1/30/2008		4.8			mg/L	TKN was an outlier based on adjacent sampling events and SWFWMD data from the same month. Likely lab error. Was not removed from analysis.

K.5 ERRONEOUS AND OUTLIER DATA REMOVED FROM ANALYSIS

The data listed in the table below was identified in Decision Memo #1 as erroneous or outlier data that should be removed from all graphs and analysis.

Parameter	Date	HCSW-1	HCSW-2	HCSW-3	HCSW-4	Units	Explanation
pH	1/23/2007	8.8	8	8.5	8.9	SU	Compared HCSW-1 and HCSW-4 to SWFWMD measurements for January and February 2007; not an actual exceedance but equipment malfunction. All measurements were elevated. Removed from analysis.
	1/4/2011	4.8				SU	When compared measurement to SWFWMD collected that month and to previous months was found to be much lower than other values; not exceedance but equipment malfunction. Removed from analysis.

Parameter	Date	HCSW-1	HCSW-2	HCSW-3	HCSW-4	Units	Explanation
Ammonia	7/31/2008	0.24	0.41	0.32	0.31	mg/L	Elevated concentrations are either due to laboratory method change or a seasonal fluctuation in the nitrogen cycle. Removed from analysis
	8/3/2010	0.06	0.1	0.07	0.05	mg/L	Lab analyzing the data was getting back results that were ten-times higher than other labs. Split sampling conducted in October 2011, verified that it was lab error. All results during time period of higher results (August 2010 to July 2011) removed from analysis.
	9/8/2010	0.1	0.12	0.16	0.12	mg/L	
	10/6/2010	0.01	0.24	0.01	0.2	mg/L	
	11/3/2010	0.01	0.01	0.05	0.01	mg/L	
	12/7/2010	0.08	0.11	0.1	0.1	mg/L	
	1/4/2011	0.03	0.08	0.14	0.08	mg/L	
	2/3/2011	0.18	0.13	0.16	0.2	mg/L	
	3/2/2011	0.11	0.13	0.2	0.15	mg/L	
	4/5/2011	0.13	0.13	0.13	0.17	mg/L	
	5/3/2011	0.12	0.22	0.31	0.19	mg/L	
	6/8/2011				0.27	mg/L	
	7/5/2011	0.02	0.02	0.1	0.02	mg/L	
Nitrate-Nitrite	6/20/2007			9.5		mg/L	Order of magnitude higher than adjacent sampling events and SWFWMD data from the same month. Likely lab error. Removed from data analysis as an outlier.
TN	6/20/2007			9.7		mg/L	Elevated measurements most likely due to lab analyst or instrument error in the nitrate-nitrite result. The total nitrogen levels recorded are not corroborated by measurements taken before or after the exceedance. Removed from data analysis as an outlier.

Parameter	Date	HCSW-1	HCSW-2	HCSW-3	HCSW-4	Units	Explanation
Fluoride	7/27/2006	2.6				mg/L	Value did not agree with the field duplicate and was an order of magnitude higher than previous values. It also occurred during the MDL elevated period. Removed from analysis.
	5/25/2006		0.5			mg/L	All values between May 2006 and Feb 2008 are suspect because the MDL was raised above the previously measured maximum; the lab diluted all samples subject to the U.S. Environmental Protection Agency's (EPA) 300.0 method because the chloride and sulfate concentrations during the drought period were very high. During this period, all fluoride measurements with a U code are removed from the analysis, and all those with I codes (almost all the non-U samples) should be considered estimates only.
	6/29/2006		0.5			mg/L	
	7/27/2006		0.5			mg/L	
	8/21/2006		0.5	0.5	0.5	mg/L	
	9/27/2006		0.5	0.5	0.5	mg/L	
	10/19/2006	1	0.5	1	1	mg/L	
	11/9/2006	1	0.5	2.5	2.5	mg/L	
	12/13/2006	0.5	0.5	1	2.5	mg/L	
	1/23/2007	1	1	2	2.5	mg/L	
	2/14/2007	1	0.5	2.5	2.5	mg/L	
	3/14/2007	1	1	2.5	5	mg/L	
	4/25/2007	1	0.5	0.5	1	mg/L	
	5/16/2007		0.5	1	0.5	mg/L	
	6/20/2007		0.5	2.5	1	mg/L	
	7/18/2007		0.5	1	1	mg/L	
	8/27/2007		0.5	0.5	0.5	mg/L	
	9/26/2007		0.5	0.5	0.5	mg/L	
	11/29/2007		0.26			mg/L	
	12/17/2007		0.25			mg/L	
	1/30/2008		0.25			mg/L	
	2/26/2008		0.25			mg/L	

Parameter	Date	HCSW-1	HCSW-2	HCSW-3	HCSW-4	Units	Explanation
Total Radium	7/27/2004	4.76	5.12	4.16	3.26	pCi/L	Blank sample results had high values (2.52 pCi/L) for Radium 228. The high blank measurement makes all other Radium 228 values suspect and most likely high by the same amount found in the blank. Removed from analysis.