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Horse Creek Stewardship Program
2003 Annual Report

Prepared for:

Mosaic

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EXECUTIVE SUMMARY

INTRODUCTION

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

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

The PRMRWSA requested that Mosaic also prepare a compilation of available historical water quality and biological data on the Horse Creek system. Since that request was made subsequent to the initiation of work on this report, and since the historic information may be useful for comparative purposes in any given year during the monitoring program, it was decided that a separate Historical Report would be prepared. Finalization of this 2003 Annual Report precedes the completion of the Historical Report, so direct comparisons between 2003 data and historic data are not presented here. Because this report presents only data from the first year of monitoring, discussion of that data in light of historic information would have limited value. Such comparisons will be a regular component of future annual reports and will have greater utility as the data record grows.

MINING AND RECLAMATION

About 330 acres were mined in the Horse Creek Basin at the Mosaic Fort Green Mine in 2003. All of the mining in the first quarter (35 acres) was done in January 2003; 60 acres were mined in May and June, and the remaining 235 acres were mined in the latter half of the year. Mining rates varied by month from a low of 30 acres in May 2003 to a maximum of 52 acres in December 2003. Mosaic is not aware of any phosphate mining by other parties in the Horse Creek Basin in the year 2003.

There are two clay settling areas in the Horse Creek Basin at the Fort Green Mine. The FGH-3 clay settling area, completed in 1999, is located predominantly in Sections 5, 8, and 9, T33S, R23E. The FGH-4 clay settling area, completed in 2001, is located predominantly in Section 31, T33S, R23E. Both settling areas have real-time monitoring of the liquid level in the ponds, with monitoring level data relayed to the PRMRWSA.

About 270 acres were reclaimed through earthmoving and initial revegetation in 2003 at the Fort Green Mine. Sand was used to backfill about 450 acres in the Basin as the initial step in land reclamation. Earthwork, included spreading of overburden of land backfilled with tailings and final contouring of the ground surface, was completed on 350 acres.

MONITORING PROGRAM COMPONENTS

Monitoring for the HCSP began in April 2003, and this report, which is the first of a series of Annual Reports, presents the results of the first year of monitoring. Approximately 12,000 acres of land in the Upper Horse Creek Basin had been mined at the time the HCSP was initiated; about 10,000 acres are located upstream of all HCSP monitoring stations on land controlled by Mosaic, with the remaining mined area on other parties' lands lying upstream of all but the northernmost monitoring location. In 2003, 332 acres of land located upstream of the northernmost Horse Creek monitoring location were mined. 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; rainfall data were collected daily from one USGS gauging station and three Mosaic rain gauges located in the Horse Creek Basin; water quality data were collected during monthly sampling events, continuously from one Horse Creek location, and during biological sampling events. Biological (fish and benthic macroinvertebrates) sampling events were conducted in April, July, and November.

WATER QUANTITY

Temporal patterns of average daily stream flow and stage were similar at both USGS gauging stations in Horse Creek, with highest flows and stages occurring during the rainy season (June through September) in 2003. A similar pattern was observed for Mosaic's National Pollutant Discharge Elimination System (NPDES)-permitted discharges upstream of northernmost monitoring location. As indicated by the 2003 rainfall data, an unusually high rainfall event occurred in late June. The effects of this event were apparent in all the water quantity data, and negatively affected the biological sampling effort in July.

WATER QUALITY

Reported water quality constituents were compared with HCSP trigger levels. Water quality parameters were almost always well within the desirable range relative to trigger levels, with trigger levels exceeded only for two parameters at two stations. Dissolved oxygen concentrations were consistently below the trigger level of 5 mg/l at HCSW-2, the station located on Horse Creek at County Road 663A/Goose Pond Road. HCSW-2 is located downstream of a segment of the creek known as Horse Creek Prairie, an area of very slow-moving water known to contain low dissolved oxygen levels (BRA 2005). During most of 2003, dissolved iron concentrations at HCSW-4, Horse Creek at State Road 72, exceeded the trigger value of 0.3 mg/l. Preliminary assessments were conducted for both dissolved oxygen and iron during 2003. Results of these assessments are provided in the appendices. Since this is the first annual report and only one year of data was available, temporal trends in water quality parameters relative to the established trigger levels were not evaluated. Several parameters (e.g., specific conductance, sulfate, and calcium) were consistently higher at the lower end of the study area than in the upper segment; this is attributed to contributions of groundwater entering the stream as runoff or seepage from irrigated agricultural areas.

BENTHIC MACROINVERTEBRATES

Optimal benthic macroinvertebrate habitat conditions, as determined through the DEP Habitat Assessment Procedure were present during all sampling events at all locations, and total Stream Condition Index (SCI) scores indicated that the benthic community was Fair or Poor. The Habitat Assessment Procedure and SCI protocol are independent measures of a stream segment, and it is common to find a discrepancy in the classification of a given segment. This discrepancy indicates that the sampled segments of Horse Creek were comparable in quality, as determined via the SCI, to other reference streams in Florida. Three of the four occasions when the benthic community was found to be in the Poor category occurred in July, almost certainly the result of poor sampling conditions during high water from the large amount of rainfall received in late June. During future monitoring events, we expect to collect additional species of benthic macroinvertebrates.

FISH

Thirty species of fish were collected in 2003. We expect to add more species during future monitoring events, because the species accumulation curves have not leveled off, based on the three samples collected in 2003. Many native species almost certainly occur in Horse Creek but were not collected in 2003. These include species such as the American eel (*Anguilla rostrata*), bowfin (*Amia calva*), white catfish (*Ameiurus catus*), pirate perch (*Aphredoderus sayanus*), and black crappie (*Pomoxis nigromaculatus*). The thirty species collected included four introduced species: walking catfish (*Clarias batrachus*), African jewelfish (*Hemichromis letourneauxi*), oriental weatherfish (*Misgurnus anguillicaudatus*), and sailfin catfish (*Pterygoplichthys multirandians*). Over 30 species of introduced fish have established reproducing populations in Florida, so we expect to continue to collect additional introduced species in Horse Creek during future monitoring events as new introductions occur and as introduced species continue to expand their ranges in Florida. High flows during the July sampling event resulted in the fewest number of species and individual fish collected relative to the other two sampling events. This trend was similar to what was observed for benthic macroinvertebrates. The lowest number of fish species was collected and lowest diversity was calculated for the most upstream Horse Creek station (HCSW-1), while the most species were collected and the highest diversity calculated for the station farthest downstream (HCSW-4). The presence of more fish species downstream than upstream is likely the result of several factors: (1) the closer proximity to the Peace River which presumably provides opportunity for movement of species upstream from the river, (2) the overall larger size of the stream channel which provides more room for various types of fish habitat, and (3) the fact that the lower reaches of Horse Creek are not as prone to very low discharge (or going dry) as the more upstream segments of the channel. Aside from the several introduced species which have not been documented in Horse Creek in the scientific literature, no unexpected fish taxa were found during the 2003 sampling, and no reduction was indicated in fish diversity or abundance as a result of mining activities in the watershed.

RELATED WORK

Pursuant to an agreement between Mosaic and the PRMRWSA, a separate report containing a review and summary of all available historical water quality and biological information for Horse Creek is in preparation. The compilation and electronic conversion of historic information is still in progress, so this report includes no comparisons with historical data as discussed in the HCSP plan document; however, such analyses will be included in the second Annual Report. This will not diminish the value of this report with respect to the overall intent of the HCSP. In addition, the structure and format of the electronic databases for data collected through the HCSP monitoring are still being refined; therefore, electronic files for both 2003 and 2004 monitoring will be provided as a component of the 2004 Annual Report in early 2005.

CONCLUSIONS

Although this report presents only one year of data, some general conclusions can be drawn. Expected relationships between rainfall, runoff and stream flow were observed in the 2003 water quantity data. With the exception of two cases which are not related to mining activities, water quality data were within established HCSP trigger levels. The benthic macroinvertebrate and fish communities found in Horse Creek in 2003 were typical of those found in a Southwest Florida stream, and no impacts from mining were apparent.

RECOMMENDATIONS

Water quantity and water quality monitoring should proceed in the same manner. Based upon the biological sampling events that were conducted in 2003, we recommend that biological sampling not be undertaken during times when the stream stage is above 10 feet at HCSW-1 (Horse Creek at State Road 64) and 5 feet at HCSW-4 (Horse Creek at State Road 72). Because USGS stage data is available in real time via the Internet, sampling conditions on a given day can be easily determined remotely. Based upon the observed distribution of Horse Creek flows in the 2003 (and 2004) wet season, it appears likely that biological sampling could be restricted to only a few days in the July/August time window specified in the HCSP plan document. In 2004, conducting the summer sampling event was not possible, although three hurricanes in peninsular Florida were largely responsible for the high flows. The summer sampling window should be extended to July/August/September to allow additional time for the biological sampling event when summer rains keep the stream stage high. If such a change is made, the fall window for biological sampling should be extended to include December, so that samples are relatively evenly spaced through the year.

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1.0 INTRODUCTION

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

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

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

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

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

HCSP monitoring began in April 2003. At the time the HCSP was initiated, some 12,000 acres of land in the Upper Horse Creek Basin had been mined, about 10,000 acres of which lies upstream of all HCSP monitoring stations on land controlled by Mosaic, with the remaining mined area on other parties' lands lying upstream of all but the northernmost monitoring location. In 2003, 332 acres were mined in the Horse Creek Basin upstream of the northernmost monitoring location (Figure 1). 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 or April, July or August, and October or November). Specific months when biological sampling occurs may change from year to year to avoid very low or very high flows which would impede representative sampling.

This report, which is the first of a series of Annual Reports, presents the results of monitoring conducted in 2003. A separate report contains a review and summary of all available historical water quality and biological information for Horse Creek (BRA 2005). An important component of the Historical Report is, to the extent feasible, a compilation of quantitative data on Horse Creek into electronic form. Because the compilation and electronic conversion of historic information was still in progress at the preparation time of this report, this first Annual Report includes no comparisons with historical data as discussed in the HCSP plan document; however, such analyses will be included in the second Annual Report to be prepared in 2005. In addition, the structure and format of the electronic databases for data collected through the HCSP monitoring are still being refined; therefore, electronic files for both 2003 and 2004 monitoring will be provided as a component of the 2004 Annual Report in 2005. This does not diminish the value of this report with respect to the overall intent of the HCSP.

During 2003, in accordance with the HCSP, two preliminary impact assessments were conducted, one for dissolved oxygen and one for iron. Copies of the assessment reports are provided as Appendices B and C. The conclusion of both assessments was that existing iron and dissolved oxygen levels are the results of natural biogeochemical conditions and are not the result of mining activities.

2.0 DESCRIPTION OF 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 (Figure 1). Horse Creek is a major tributary of the Peace River that drains the south-western 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 as an elongated basin with a north-to-south drainage that is influenced by the general topography of the area. Six sub-basins and five tributaries make up the Horse Creek Basin. West Fork Horse Creek and Brushy Creek, two northern tributaries in the Polk Uplands, are generally straight, 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 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 - 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).

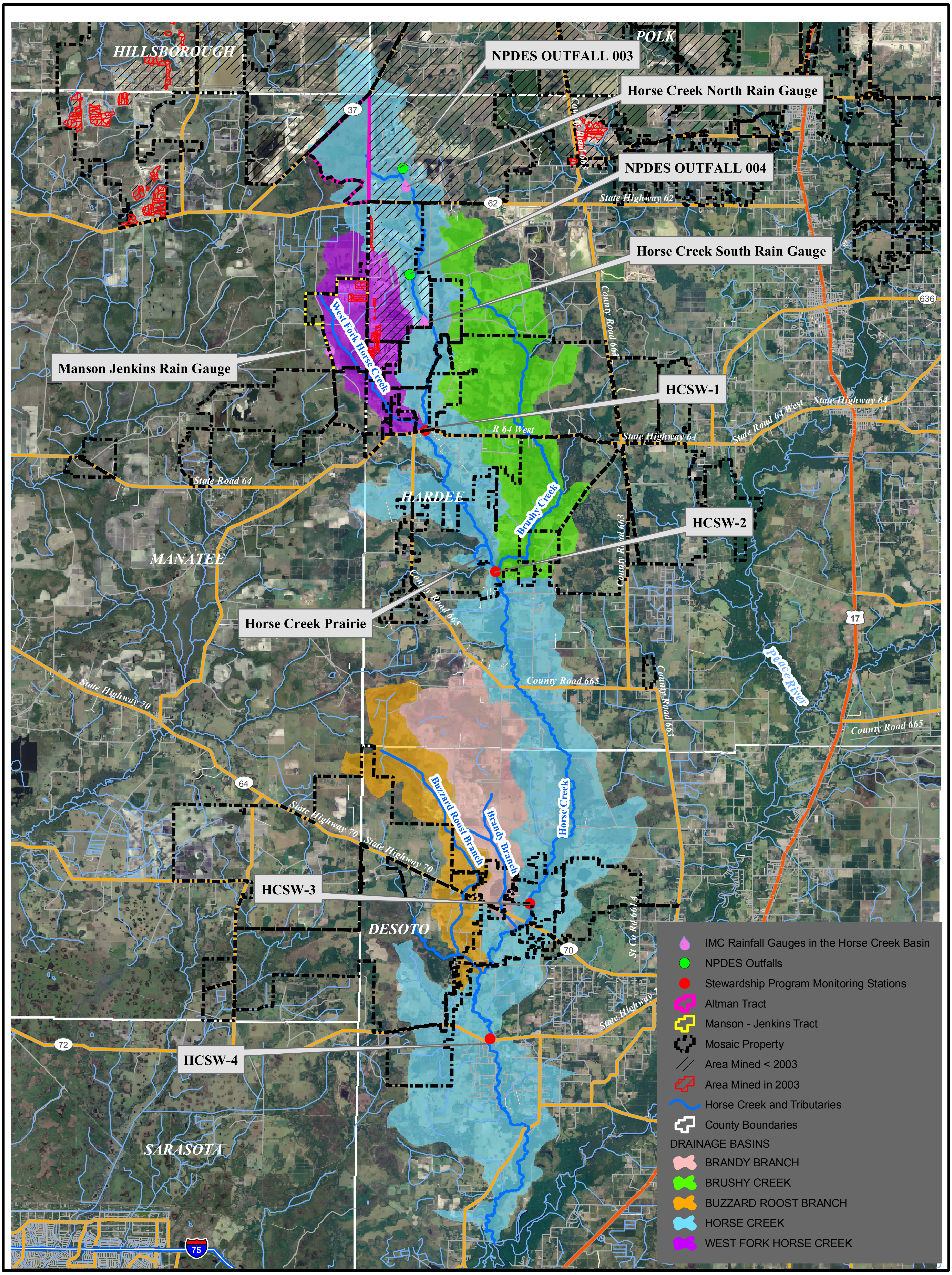
The climate of Horse Creek Basin is subtropical and humid with an average temperature of about 72 º F. Summer temperatures average 80 ºF, and winter temperatures average 60 ºF (Hammett, 1990). The average daily temperatures in Hardee County, in the northern Horse Creek Basin, range from is 52 º F to 91 º F (Robbins et al. 1984). The average daily temperatures in DeSoto County, in the southern Horse Creek Basin, range from 49 º F to 92 º F. 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 52 in, with more than half of that falling during localized thundershowers in the wet season (June - September) (Hammett, 1990). Rain during fall, winter, and spring is usually the result of large, broad frontal systems instead of local storms (Hammett, 1990). November is typically the driest month of the year, averaging 1.77 inches over the historic period from 1915 to 2004. The months of April and May are also characteristically dry, averaging 2.56 and 3.95 inches respectively. Dry conditions coincide with high evaporation rates and generally result in the lowest streamflows, lake stages, and ground-water levels of the year (Hammett, 1990). The wettest month of the year is typically June, averaging 8.27 inches.

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. These 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, 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 Nokatee 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. Mining is the primary land use above State Road 64, but the percentage of land devoted to mining decreases rapidly downstream. Agricultural land use, on the other hand, more than doubles in acreage from above County Road 663 (HCSW-2) to above SR 72 (HCSW-4). Rangeland covers a greater percentage of land in the northern part of the basin than in the southern portion. Upland forest and wetland area increase substantially from above SR 64 (HCSW-1) to above CR 663 (HCSW-2), but the percent forest and wetland cover remains relatively constant between CR 663 and further downstream (BRA 2005).



0 3 6 Miles

Imagery: 2004 SWFWMD DOQQs
1 inch equals 3 miles

Preparation Date:	Revision Date:	Project Number:
20 May 2005	01 June 2005	2476-065-b21
Project Manager:	GIS Operator:	GIS QA/ QC:
KYC	LBS	
ArcMap Name:	Plot File:	
horsecreek_aerial.mxd	horsecreek_aerial.pdf	

Figure 1. Overview of drainage basins, HCSP sampling locations and phosphate mining ownership in the Horse Creek Basin.

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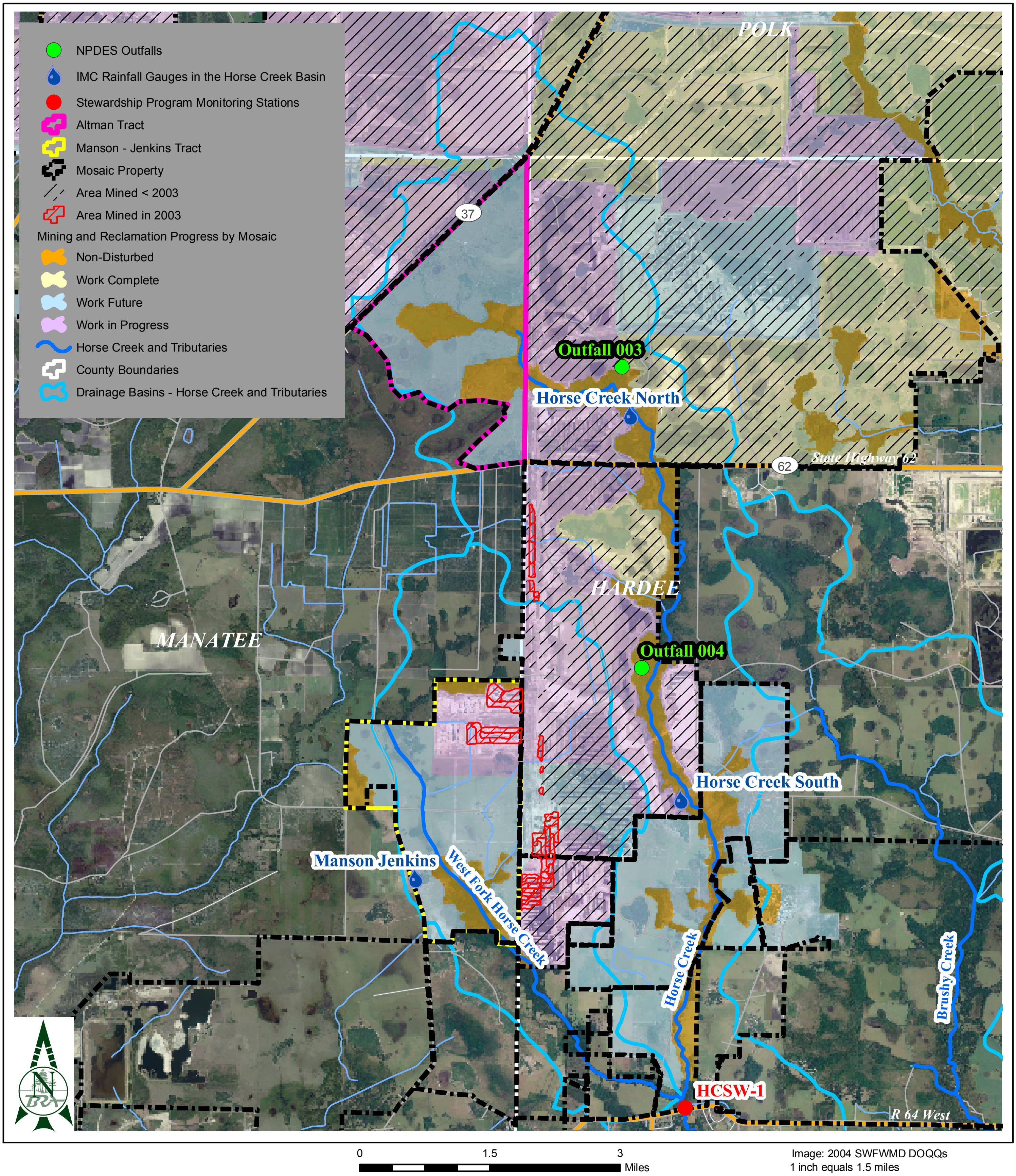
3.0 SUMMARY OF MINING AND RECLAMATION ACTIVITIES

3.1 MINING

About 330 acres were mined in the Horse Creek Basin at the Mosaic Fort Green Mine in 2003 (Figure 2). There was a period of three months (February – April) with no mining in the basin. All of the mining showing in the first quarter (35 acres) was done in January 2003. The 60 acres mined in the second quarter were all in May and June. Mining rates varied by month from a low of 30 acres in May 2003 to a maximum of 52 acres in December 2003. During the first half of the year, all mining took place in the South Fort Green Tract. During the second half of the year, mining was split between the South Fort Green Tract (200 acres mined in Hardee County) and the Manson Jenkins Tract (130 acres mined in Manatee County). There have been, and will be in the future, mining activities in the Horse Creek Basin outside of those performed by the Mosaic Corporation. Mosaic is not aware of any phosphate mining by other parties in the Horse Creek Basin in the year 2003. Information on pre-mining conditions in the Horse Creek Basin may be found in a 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).

There are two clay settling areas in the Horse Creek Basin at the Fort Green Mine. 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 crest elevation of 151.0 ft. NGVD, and a final pool elevation of 146.0 ft. NGVD. The effective area of the dam is approximately 933 acres. 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, to the 003 outfall, through spillways located in the return water ditch near the southwest corner of FGH-3. Clays are introduced into the settling area approximately midway on the east wall. Pond elevations in 2003 have ranged from a low of approximately 143.3 ft. NGVD in April to a high of approximately 145.3 ft. NGVD in September. No repairs have been required on the settling area, with the exception of routine maintenance.

The FGH-4 clay settling area is located predominantly in Section 31, T33S, R23E. Construction of the clay settling area was completed in 2001, and was put into service a shortly thereafter. The settling area was designed by Ardaman & Associates with a crest elevation of 164.0 ft. NGVD, and a final pool elevation of 159.0 ft. NGVD. The effective area of the dam 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. Decant spillways located in the south return water ditch also have the capability of discharging water to the 004 outfall. Clays are introduced into the settling area at the southwest corner, and at a point approximately midway on the west wall the dam. The settling area is also used to store mine pit water, which is pumped into the settling area at the northwest corner and at approximately the center of the south wall. Pond elevations in 2003 ranged from a low of approximately 134.8 ft. NGVD in December, to a high of approximately 139.8 ft. NGVD in June. No repairs have been required on the settling area, with the exception of routine maintenance. Both settling areas have real-time monitoring of the pond level, which is relayed to the PRMRWSA. Any sudden drop in pond level elevations, suggesting a substantial release of wastewater from the settling areas, would be detected promptly, allowing for an expedited response to the problem.



Preparation Date: 20 May 2005	Revision Date: 23 June 2005	Project Number: 2476-065-b21
Project Manager: DJD	GIS Operator: LBS	GIS QA/ QC:
ArcMap Name: horsecreek-mined.mxd	Plot File: horsecreek-mined.pdf	

Figure 2. Mining and reclamation areas in the Horse Creek Basin.

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3.2 RECLAMATION

Reclamation of lands that have been mined is an ongoing process at Mosaic's Fort Green Mine including lands in the Horse Creek Basin. The reclamation process consists of backfilling of the mined excavations with sand "tailings" produced as a by-product of the phosphate production process or shaping existing deposits of overburden material to bring the ground surface up to rough grade. Overburden material is spread over the backfilled areas and the areas are brought to the required final contours. Planting of both upland and wetland communities is done with appropriate species. Reclaimed areas are monitored, and supplemental plantings are done as necessary until the revegetation of the land is successful.

About 270 acres were reclaimed through earthmoving and initial revegetation in 2003 at the Fort Green Mine (Figure 2). Sand was used to backfill about 450 acres in the Basin as the initial step in land reclamation. Earthwork, which included spreading of overburden onto land backfilled with tailings and final contouring of the ground surface, was completed on 350 acres. Over 276,000 herbaceous plants and 415,000 trees were planted in reclamation projects within the Horse Creek Basin at the Fort Green Mine. Supplemental planting of grass, tree, and herbaceous plants was done as a supplement to more than 800 reclaimed acres in the basin.

4.0 METHODS

4.1 STATION LOCATIONS AND SAMPLING SCHEDULE

Four locations on Horse Creek, as shown in Figure 1, are 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, HCSW-1 and HCSW-4 are also long-term US Geological Survey (USGS) gauging stations, with essentially continuous stage and discharge records since 1977 and 1950, respectively. Water quality sampling was conducted monthly beginning in April, while biological sampling events were conducted three times in 2003 (Table 1).

Table 1. Schedule of Water Quality and Biological Sampling Events

Date	Water Quality Sampling Events	Macroinvertebrate and Fish Sampling Events
25 April 2003		X
30 April 2003	X	
27 May 2003	X	
19 June 2003	X	
14 July 2003	X	
29 July 2003		X
28 August 2003	X	
25 September 2003	X	
29 October 2003	X	
20 November 2003	X	X
16 December 2003	X	

4.2 WATER QUANTITY

Provisional discharge data for 2003 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. Discharge data were obtained for Mosaic's National Pollutant Discharge Elimination System (NPDES)-permitted discharges into Horse Creek (Outfalls 003 and 004) for 2003 (Figure 1). Daily rainfall data for 2003 were obtained from the USGS for HCSW-1, as well as from Mosaic's rain gauges in the Horse Creek Basin (Figure 1). The general relationship between rainfall and streamflow was graphically evaluated. All rainfall gauges are located in the upper portion of the Horse Creek basin, so longitudinal comparisons along the basin are not possible. The HCSP Historical Report (BRA 2005) will address long-term rainfall patterns in the area.

4.3 WATER QUALITY

A continuous monitoring unit was installed approximately 25 m upstream from HCSW-1 to record pH, specific conductivity, dissolved oxygen, and turbidity. Beginning in April 2003, data were recorded hourly and downloaded at least monthly. These data provide for the characterization of natural background fluctuations and allow 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 upstream to downstream. 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 sample 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, 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 2). All calibration activities were documented and records checked for completeness and accuracy. Field measurements by BRA in association with the three biological sampling events employed a HydroLab Quanta multiparameter unit with the same measuring methods and acceptance limits listed in Table 2. BRA also employed a Hack 2100P unit for turbidity measurement.

Table 2. HCSP Water Quality Sampling Field Methods and Acceptance Limits Associated with Monthly Sampling by Mosaic Staff.

Analyte	Meter Used	Method	Minimum Detection Limit	Acceptance Limit
pH	Hach Sension 2	150.1	1 su	+/- 0.2 standards units of the
Temperature	All	170.1		1 degree Centigrade
Specific Conductivity	Hach CO150	120.1	10 uS/cm	+/- 5% of the calibration
Dissolved Oxygen	YS1 Model 52	360.1	0.5 mg/l	+/- 0.2 mg/l of the correct
Turbidity	Hach 2100P	180.1	0.1 NTU	+/- 8% of the calibration

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 and their pH levels checked. Hydrochloric acid was added in the field to unpreserved samples for petroleum range organics analysis. 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 3. Table 3 also includes the laboratory analysis methods.

Table 3. Parameters Analyzed and Laboratory Methods for HCSP 2003 Monthly Water Quality Samples

Parameter	Method	Hold Time	Preservation	Minimum Detection Limit	Container
Color	110.2	48 hours	Unpreserved	2.5 PCU	Clear HDPE bottle
Total Kjeldahl Nitrogen	351.2	28 days	Sulfuric Acid, pH < 2	0.1 mg/l	Clear HDPE bottle
Nitrate-Nitrite Nitrogen	353.2	28 days	Sulfuric Acid, pH < 2	0.02 mg/l	Clear HDPE bottle
Nitrate Nitrogen	SM 4500E	48 hours	Unpreserved	0.02 mg/l	Clear HDPE bottle
Total Ammonia Nitrogen	350.1	28 days	Sulfuric Acid, pH < 2	0.03 mg/l	Clear HDPE bottle
Orthophosphate	365.1	48 hours	Unpreserved	0.05 mg/l	Clear HDPE bottle
Chlorophyll *a*	SM 10200H	48 hours	Unpreserved	1 mg/l	Opaque plastic bottle
Specific Conductivity	120.1	28 days	Unpreserved	10 uS/cm	Clear HDPE bottle
Total Alkalinity	310.1	14 days	Unpreserved	mg/l CaCO3	Clear HDPE bottle
Dissolved Calcium*	200.7	28 days	Unpreserved	0.1 mg/l	Clear HDPE bottle
Dissolved Iron*	200.7	28 days	Unpreserved	0.1 mg/l	Clear HDPE bottle
Chloride	300.0	28 days	Unpreserved	1 mg/l	Clear HDPE bottle
Fluoride	300.0	28 days	Unpreserved	0.1 mg/l	Clear HDPE bottle
Total Radium (Radium 226+228)	903.0	6 months	Nitric Acid, pH < 2	1 pCi/l	Clear HDPE bottle
Sulfate	300.0	28 days	Unpreserved	1 mg/l	Clear HDPE bottle
Total Dissolved Solids	160.1	7 days	Unpreserved	5 mg/l	Clear HDPE bottle
Petroleum Range Organics	FL-PRO	7 days	Hydrochloric Acid, pH < 2	0.1 mg/l	Amber Glass Bottle
Fatty Amido -amines	8270	7 days	Unpreserved	0.2 mg/l	Amber Glass Bottle
Total Fatty Acids	8270C	7 days	Unpreserved	0.5 mg/l	Amber Glass Bottle

- If a field conductivity measurement exceeded 1,400 umhos/cm, the laboratory performed an analysis of specific conductivity.
- All water samples were preserved at 4C while awaiting analysis.
- Ortho-phosphate samples were 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 will be field-filtered.
- * - The analytical method for iron and calcium was changed during the 2003 monitoring period; see results section for details.

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 on 25 April, 29 July, and 20 November 2003 using a Hydrolab Quanta. All sampling was conducted according to the Florida Department of Environmental Protection's (DEP's) Standard Operating Procedures (SOPs) for field sampling. Laboratory analyses were performed by experienced personnel according to National Environmental Laboratory Accreditation Council (NELAC) protocols, including quality assurance/quality control (QA/QC) considerations contained in the QA/QC plan developed for this program (currently in review). There were no substantial problems during water quality sampling events or laboratory analysis of samples during the 2003 monitoring.

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). In addition, results were compared with applicable Florida surface water quality standards (which in many cases are the same as the trigger values).

Table 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 from trigger level minimum or maximum.
	Dissolved Oxygen	Calibrated Meter	mg/L[1]	Monthly	<5.0	Excursions below trigger level or statistically significant trend line predicting concentrations below trigger level.
	Turbidity	Calibrated Meter	NTU[2]	Monthly	>29	Exceedance of, or statistically significant trend line predicting concentrations in excess of, trigger level.
	Color	EPA 110-2	PCU	Monthly	<25	Excursions below trigger level or statistically significant trend line predicting concentrations below trigger level.
Nutrients	Total Nitrogen	EPA 351 + 353	mg/l	Monthly	>3.0	Exceedance of, or statistically significant trend line predicting concentrations in excess of, trigger level.
	Total Ammonia	EPA 350.1	mg/l	Monthly	>0.3	Exceedance of, or statistically significant trend line predicting concentrations in excess of, trigger level.
	Ortho Phosphate	EPA 365	mg/l	Monthly	>2.5	Exceedance of, or statistically significant trend line predicting concentrations in excess of, trigger level.
	Chlorophyll *a*	EPA 445	mg/l	Monthly	>15	Exceedance of, or statistically significant trend line predicting concentrations in excess of, trigger level.
Dissolved Minerals	Specific Conductance	Calibrated Meter	µs/cm[3]	Monthly	>1,275	Exceedance of, or statistically significant trend line predicting concentrations in excess of, trigger level.
	Total Alkalinity	EPA 310.1	mg/l	Monthly	>100	Exceedance of, or statistically significant trend line predicting concentrations in excess of, trigger level.
	Calcium	EPA 200.7	mg/l	Monthly	>100	Exceedance of, or statistically significant trend line predicting concentrations in excess of, trigger level.
	Iron	EPA 200.7	mg/l	Monthly	>0.3 [6]; >1.0[7]	Exceedance of, or statistically significant trend line predicting concentrations in excess of, trigger level.
	Chloride	EPA 325	mg/l	Monthly	>250	Exceedance of, or statistically significant trend line predicting concentrations in excess of, trigger level.
	Fluoride	EPA 300	mg/l	Monthly	>1.5[6]; >4[7]	Exceedance of, or statistically significant trend line predicting concentrations in excess of, trigger level.
	Radium 226+228	EPA 903	pCi/l[4]	Quarterly	>5	Exceedance of, or statistically significant trend line predicting concentrations in excess of, trigger level.
	Sulfate	EPA 375	mg/l	Monthly	>250	Exceedance of, or statistically significant trend line predicting concentrations in excess of, trigger level.
	Total Dissolved Solids	EPA 160	mg/l	Monthly	>500	Exceedance of, or statistically significant trend line predicting concentrations in excess of, trigger level.
Mining Reagents	Petroleum Range Organics	EPA 8015 (FL-PRO)	mg/l	Monthly [5]	>5.0	Exceedance of, or statistically significant trend line predicting concentrations in excess of, trigger level.
	Total Fatty Acids, Incl.Oleic, Linoleic, and Linolenic Acid	EPA/600/4-91/002	mg/l	Monthly [5]	>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 [5]	>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: Macroinvertebrates	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]					
Biological Indices: Fish	Total Number of Taxa	Various appropriate standard sampling methods, taxonomic analysis, calculation of indices using published formulas	Units vary based upon metric or index	3 times per year	N/A	Statistically significant declining trend with respect to presence, abundance or distribution of native species
	Abundance					
	Shannon-Wiener Diversity [a]					
	Species Turnover (Morisita Similarity Index[a]					
	Species Accumulation Curves[b]					

Notes:

(1) Milligrams per liter.
(2) Nephelometric turbidity units.
(3) Microsiemens per centimeter.
(4) PicoCuries per liter.
(5) If reagents are not detected after two years, sampling frequency will be reduced to quarterly - if subsequent data indicate the
(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.
(8) Some metrics have been revised from original HCSP plan document due to revision of DEP SCI Protocol.

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.,
(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 each of the four sampling stations on 25 April, 29 July, and 20 November 2003. At each station, a Stream Habitat Assessment (DEP-SOP-001/01 FT 3100) was performed. This assessment results in a numerical rating for a stream segment that is presumed to be proportional to the quality of the stream for native macroinvertebrates. It also results in a partitioning of the various microhabitats in the stream into categories to allow for sample of such microhabitats in general proportion to their abundance.

Qualitative macroinvertebrate sampling was performed according to the Florida Stream Condition Index (SCI) protocol developed by the DEP (DEP-SOP-002/01 LT 7200) by personnel with training and experience in the SCI protocol and who have successfully passed DEP 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-m segment of stream. Utilizing this methodology, 20 0.5-m D-frame dip net sweeps are performed within a 100-m 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 DEP 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 5). The general interpretation for SCI score ranges are provided in Table 6. The calculation methodology for the SCI was revised by DEP in June 2004, and this report uses the new methodology. This change requires a departure from the various metrics listed for benthic macroinvertebrates in the HCSP plan; however, the plan itself anticipated such changes in methodology and the use of the revised protocol is consistent with the plan.

Fortunately, the revisions to the SCI protocol were implemented before the previous methodology was used to calculate SCI values for the HCSP, so there is no need to retroactively adjust SCI values from previous years' sampling results. Changes made to the calculation protocol are 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). Table 5 provides the new list of metrics used in calculating SCI scores, while the parameter table from the HCSP methodology document (copied as Table 4 above) includes the metrics used in the original SCI protocol.

The Shannon-Wiener Diversity Index was calculated using Ecological Methodology Software, Version 6.1 (www.exetersoftware.com). In the future, when more than one year of data will be available, the focus of the analyses will be to screen for statistically significant declining trends with respect to presence, abundance, and distribution of native species, as well as SCI values.

Table 5. Equations for Calculating SCI Metrics for Peninsular Florida (Range from Zero to Ten).

SCI Metric	Peninsula Score (*)
Total Taxa	10(X-16)/25
Ephemeropteran Taxa	10X/5
Trichopteran Taxa	10X/7
Percent Collector-Filterer Taxa	10(X-1)/39
Long-lived Taxa	10X/4
Clinger Taxa	10X/8
Percent Dominant Taxon	10-(10[(X-10)/44])
Percent Tanytarsini	10[ln(X+1)/3.3]
Sensitive Taxa	10X/9
Percent Very Tolerant Taxa	10-(10[ln(X+1)/4.1])

* 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.

Table 6. Ecological Interpretation of SCI Scores Calculated for Benthic Macroinvertebrate Samples Collected for the HCSP

SCI Category	Range	Typical Description for Range
Good	73-100	Similar to natural conditions, up to 10% loss of taxa expected
Fair	46-73	Significantly different from natural conditions; 20-30% loss of Ephemeroptera, Trichoptera and long-lived taxa; 40% loss of clinger and sensitive taxa; percentage of very tolerant individuals doubles
Poor	19-46	Very different from natural conditions; 30% loss of total taxa; Ephemeroptera, Trichoptera, long-lived, clinger and sensitive taxa uncommon or rare; Collector-Filterer and Tanytarsini individuals decline by half; 25% of individuals are very tolerant
Very Poor	0-19	Extremely degraded; 50% loss of expected taxa; Ephemeroptera, Trichoptera, long-lived, clinger, and sensitive taxa missing or rare; 60% of individuals are very tolerant

4.5 FISH

Fish sampling was conducted concurrently with the benthic macroinvertebrate sampling at each station on 25 April, 29 July, and 20 November 2003. Fish were collected with a 4-foot x 8-foot seine (3 mm mesh size) and by electrofishing, using a generator-powered Smith-Root, Inc. backpack electrofishing unit (Model 15-B Electrofisher). Electrofishing was timed (typically 4 to 6 minutes), and the number of seine hauls (typically 3 or 4) was recorded to standardize the sampling efforts among stations and between events. Future annual reports will compare catch per unit effort information among stations and over time.

Some fish, including the majority of large fish, were identified, weighed, measured, and released in the field, while some large and most small fish (<10 cm) were preserved in the field for later 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 1991). Total length (mm) and weight (g) were determined and 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 8 to 10) were measured for length and weight, while the remaining individuals were counted and then weighed *en masse*. All fish retained as voucher specimens were submitted to the Ichthyology Collection at the Florida Museum of Natural History in Gainesville. Future annual reports will compare fish lengths and weights among stations and over time.

Taxa richness (number of species) and abundance were determined for each station and each 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. The focus of these analyses will be to screen for statistically significant declining trends with respect to presence, abundance, and distribution of native species in future annual reports, when more than one year of data is available.

The presence of more fish species downstream in Horse Creek than upstream is assumed to be the combined result of several factors: (1) the closer proximity to the Peace River which presumably provides opportunity for movement of species upstream from the river, (2) the overall larger size of the stream channel which provides more room for various types of fish habitat, and (3) the fact that the lower reaches of Horse Creek are not as prone to very low discharge (or going dry) as the more upstream segments of the channel.

4.6 General Habitat Configuration at Monitoring Stations

The sampling segment at HCSW-1 is a deeply incised, narrow valley with very steep banks of rock-like outcroppings (Figure 3). The substrate is also rocky with little sand accumulation except in deeper holes. There is little woody/herbaceous structure at the water level. There are few undercut banks, but some eroded holes are available for fish and macroinvertebrates in the rocky substrate. The canopy cover along the sampling zone is heavy (>75 percent); thus the area receives a minimal amount of direct sunlight.

At HCSW-2, the sampling segment is essentially an oxbow of the main Horse Creek channel (Figure 3). The substrate is generally sandy. There are numerous holes, snags, and undercut banks and roots present. Canopy cover along the sampling zone is moderate (approximately 25 to 50 percent).

The sampling segment at HCSW-3 is more sinuous than the other three stations, with some shallow, sandy areas and several deep holes (Figure 3). There are numerous snags, undercut banks/roots, and occasional organic debris. Sand is the primary substrate component. During periods of low flow, portions of the sandy bottom are exposed, creating large sand bars. The canopy cover is low (approximately 25 percent); so, the area receives considerable direct sunlight.

At HCSW-4, the sampling segment is less sinuous (Figure 3). Submerged habitats include holes, undercut banks/roots, snags, and small amounts of emergent aquatic vegetation. The substrate is primarily sand, with occasional areas of small gravel. Several sand bars are located along the sampling zone and are exposed during periods of low flow. Canopy cover is moderate (approximately 50 percent).

HCSW-1 Horse Creek above SR 64

HCSW-2 Horse Creek above CR 663

HCSW-3 Horse Creek above SR 70

HCSW-4 Horse Creek above SR 72

Figure 3. Panoramic Photographs of the HCSP Sampling Locations, Photos taken on 25 April 2003.

5.0 RESULTS AND DISCUSSION

Below we present a summary of water quantity and quality data collected as part of the HCSP in 2003. In addition, results of the benthic macroinvertebrate and fish sampling that occurred in April, July, and November 2003 are presented.

5.1 WATER QUANTITY

5.1.1 Rainfall

Continuous rainfall data are collected by the USGS at HCSW-1 (USGS Station 2297155). Figure 4 includes 2003 daily rainfall data for HCSW-1, as well as data from the three Mosaic rain gauges located in the Horse Creek watershed (see Figure 1 for locations). Rainfall was variable at the different locations; however, heavy rainfall was observed on the same days at all four locations. Seasonality of daily rainfall was also similar among locations (Figure 5), with all stations showing highest daily rainfall during the wet season (June – September). During other months, daily rainfall was usually near zero at all locations.

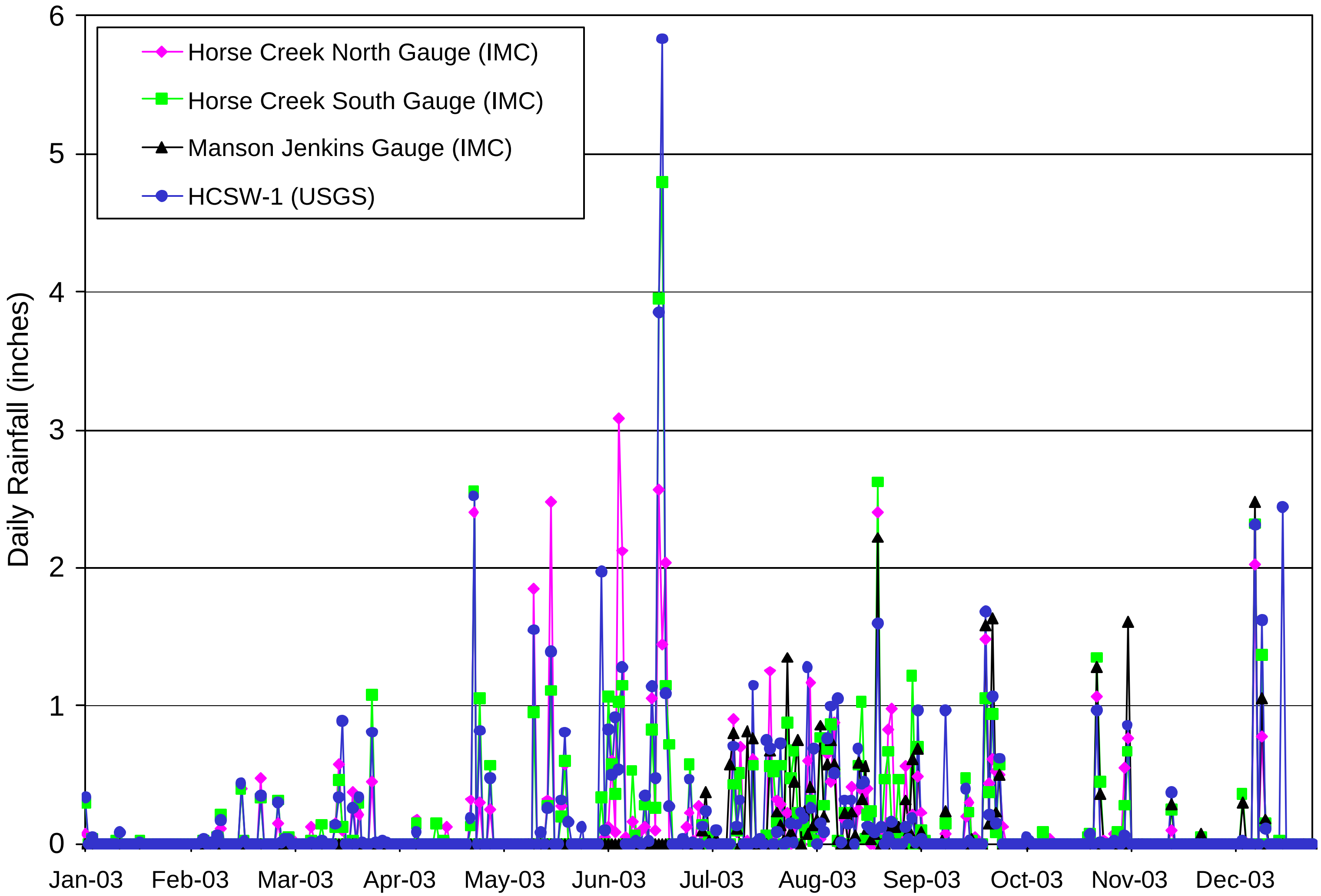


Figure 4. Daily Rainfall From Gauges in the Horse Creek Watershed in 2003 (Figure uses provisional data from USGS website).

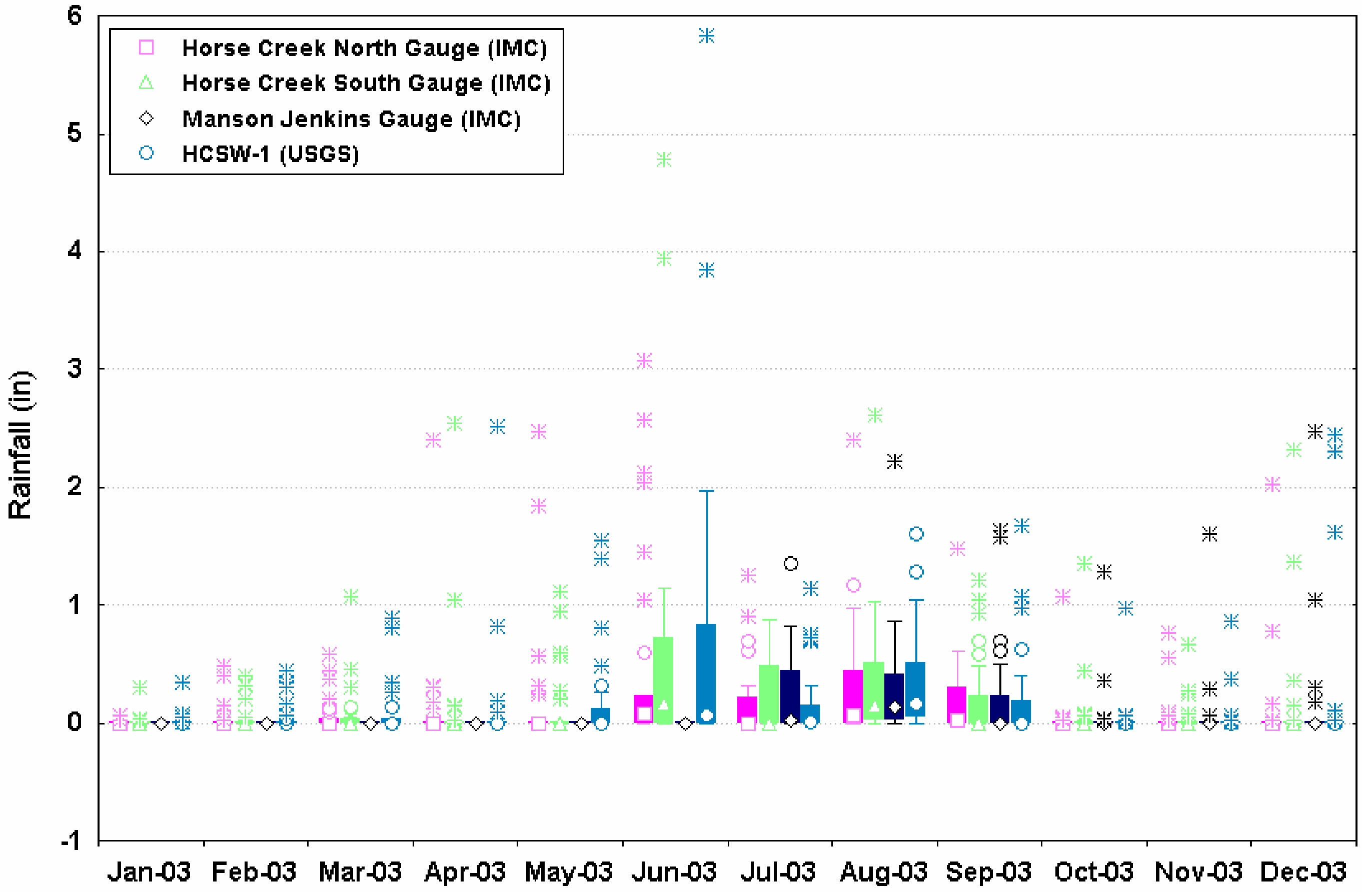
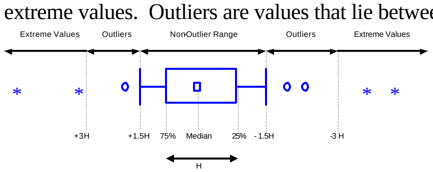


Figure 5. Median box-and-whisker plots[1] showing monthly Rainfall Summaries From Gauges in the Horse Creek Watershed in 2003 (Figure uses provisional data from USGS website).

[1] In median box-and-whisker plots, the small center square is the median of the distribution, and the large box is bounded by the 25% (mean – standard error) and 75% (mean + standard error) quartiles of the distribution. The length of the large box is designated H, and the "whiskers" represent the range of values between the box limits and 1.5H above and below the box limits. Outside the whiskers lie outliers and extreme values. Outliers are values that lie between 1.5H and 3H from the box limits, and extreme values lie beyond 3H from the box limits (StatSoft, Inc 2005).



5.1.2 Stream Stage

Figure 6 illustrates the relationship between the staff gauge readings made during each 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 (after adjustment to NGVD datum). The correlation of stage values among the stations is fairly close, as indicated in Table 7.

Patterns of daily stage levels, based upon monthly readings by Mosaic and data collected continuously by the USGS, were clearly related temporally among the four stations (Figure 6). Stage height (NGVD) collected monthly by Mosaic at four sites and continuously by the USGS at two sites was examined using Spearman's rank correlations (Zar 1999). Spearman's rank correlation procedure, a nonparametric procedure, was used because three of the six stations (HCSW-1 (IMC) and both USGS stations) had gage heights that were not distributed normally (Shapiro-Wilk test for normality, $p < 0.05$). Gage heights showed a strong and significant correlation between Mosaic stations HCSW-2 and HCSW-3 and between HCSW-2 and HCSW-4 (Table 7). The USGS stations HCSW-1 and HCSW-4 were strongly correlated with each other, and as well as the Mosaic stations. The upstream USGS station, HCSW-1, covaried strongly with Mosaic stations HCSW-1, HCSW-2, and HCSW-3, but not HCSW-4, the farthest station downstream. Similarly, the USGS station farthest downstream, HCSW-4, covaried with all but the most upstream Mosaic station. Non-significant correlation coefficients between stations may be explained by small sample sizes and the reduced power of the Spearman's rank correlation procedure to detect significance compared to parametric measures; as more data is collected, the statistical power to detect correlations between locations will increase. Such close correspondence is not unexpected for a fairly small watershed in a low gradient setting like peninsular Florida.

Mean daily stage levels were highest on 22 and 23 June, immediately after stream flows reached their highest levels for the year as a result of an extremely large rainfall event. Stage duration curves for 2003 were developed for HCSW-1 and HCSW-4 (Figure 7) to indicate the percentage of time stream stage was above particular elevations. Stage at HCSW-4 varied only three feet between the curve's P10 and P90, indicating that stream height is relatively constant over 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). Stages reached above the P10 show that a few rain events caused the stream at HCWS-4 to rise several feet higher for short periods of time in 2003. Stream stage at HCSW-1 is more variable than at HCSW-4 between the P10 and P 90 (about nine feet), but that station still showed considerable rises in stage beyond the P90 level as a result of large rain events.

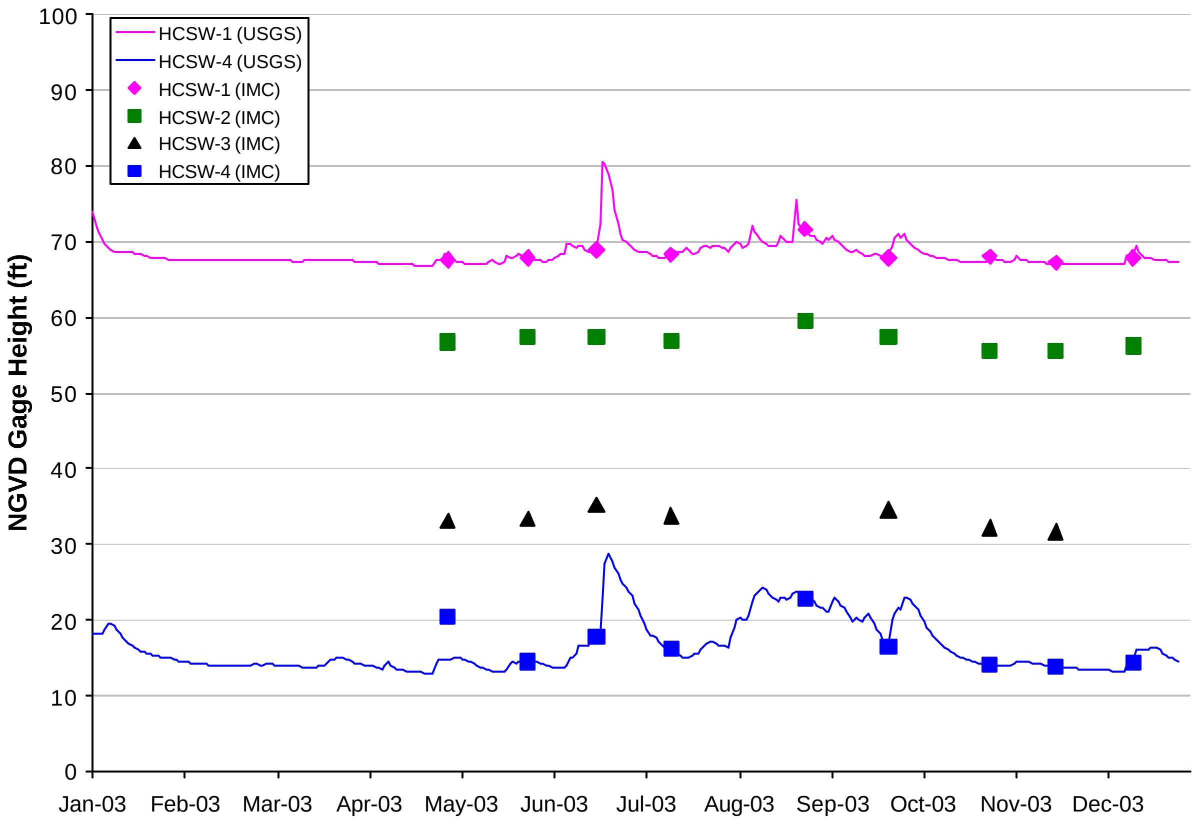


Figure 6. Stream Stage at HCSP Monitoring Stations in 2003. Individual data points are from Mosaic's monthly monitoring; continuous lines are average daily stage from USGS (Stations 02297155 and 02297310). HCSW-3 is missing two gage heights; water was above the gage in August 2003 and below the limits of detection in December 2003 (Figure uses provisional data from USGS website).

Table 7. Coefficients of Rank Correlation (r_s) for Spearman's Rank Correlations of Monthly Gage Height (NGVD) (significance at the $p < 0.05$ and $p < 0.005$ levels are indicated by (*) and (**), respectively -- sample size (N) was 9, except for station HCSW-3 (N = 7), which had two events above or below the gage range).

	HCSW-2 (IMC)	HCSW-3 (IMC)	HCSW-4 (IMC)	HCSW-1 (USGS)	HCSW-4 (USGS)
HCSW-1 (IMC)	0.5588	0.6429	0.4268	0.8703**	0.6276
HCSW-2 (IMC)		0.9009*	0.7866*	0.7113*	0.9121**
HCSW-3 (IMC)			0.6429	0.8571*	0.9643**
HCSW-4 (IMC)				0.5833	0.9000**
HCSW-1 (USGS)					0.8333*

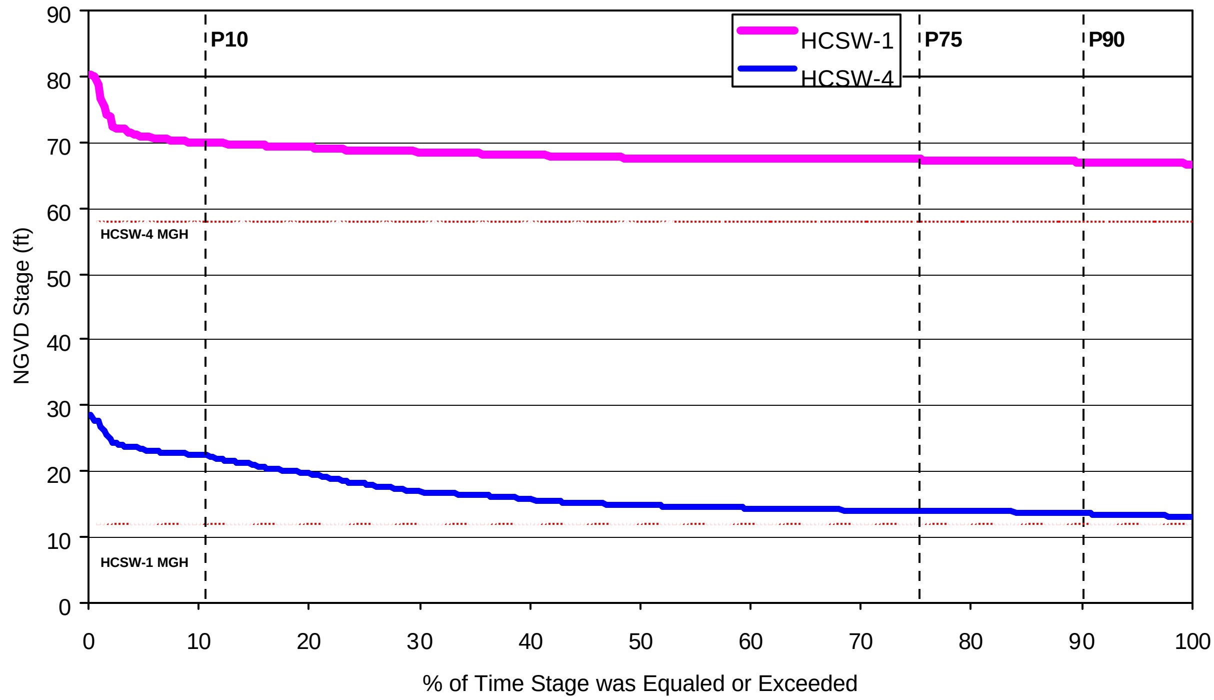


Figure 7. Stage Duration Curves for HCSW-1 and HCSW-4 in 2003, showing percent of year water levels were at or above a given stage. Typical reference points of 10% (P10), 90% (P90), and 75% (P75) are indicated on the graph, as well as the minimum gage heights of HCSW-1 (10.96 ft, NGVD) and HCSW-4 (58.12 ft NGVD). (Figure uses provisional data from USGS website, USGS Stations 02297155 and 02297310).

5.1.3 Discharge

The HCSP requires that staff gauges be installed at HCSW-2 and HCSW-3, but does not mandate that discharge be measured at those stations. Thus, all discharge results and discussion are based upon USGS data from HCSW-1 and HCSW-4. The average daily stream flow, calculated from the USGS continuous recorder data for HCSW-1 and HCSW-4, is presented in Figure 8 and Table 8. The highest flows occurred during the wet-season months of June through September, with extremely high flows occurring in late June 2003, following an unusually large rainfall event. Average daily stream flows exhibited a similar pattern at both HCSW-1 and HCSW-4 (Figure 8); stream discharge, however, was much higher at HCSW-4 than at HCSW-1 as a logical consequence of HCSW-4's lower position in the basin.

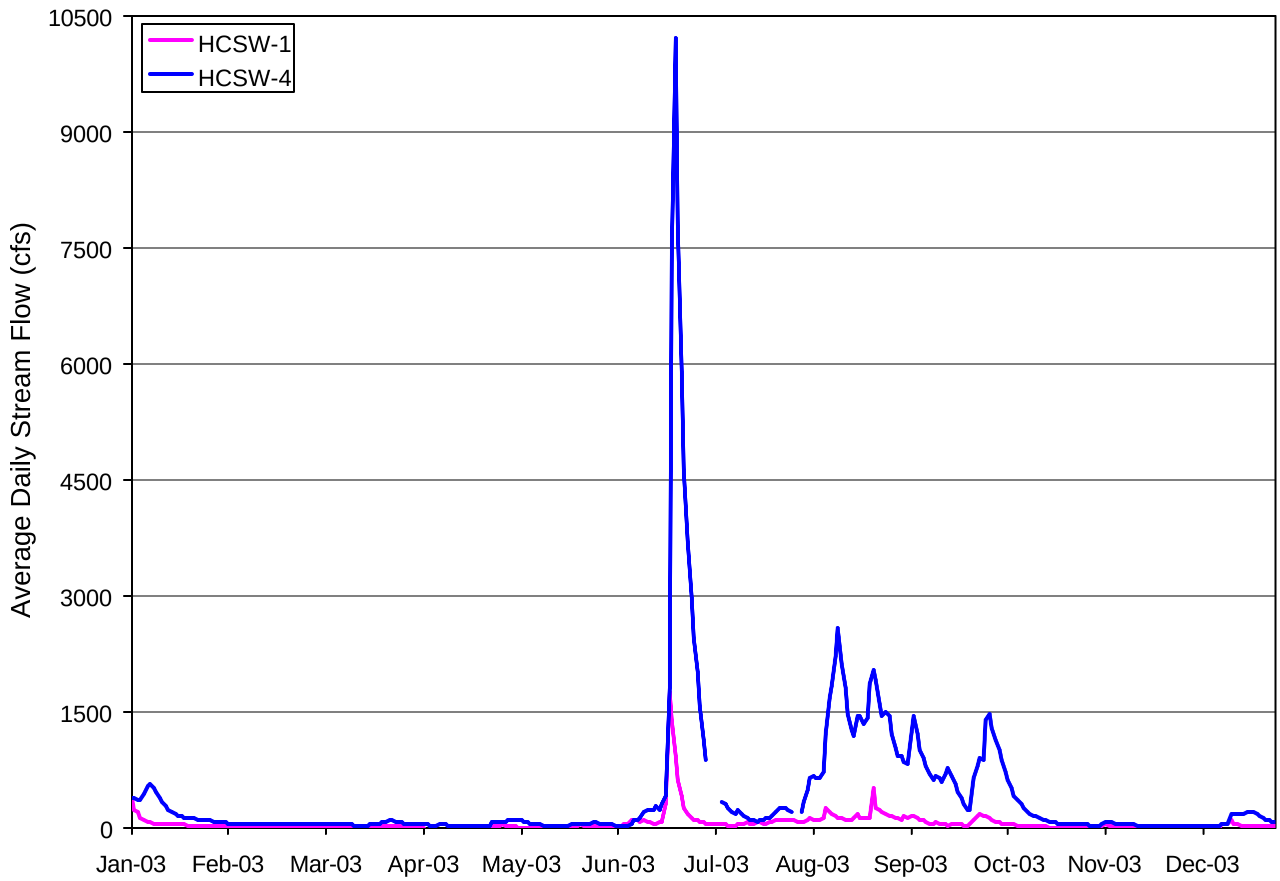


Figure 8. Average Daily Stream Flow for HCSW-1 and HCSW-4 in 2003 (Figure uses provisional data from USGS website).

Table 8. Median, 10th Percentile, and 90th Percentile of Stream Discharge at HCSW-1 and HCSW-4 in 2003, Based upon Provisional Data from USGS Website.

	HCSW-1	HCSW-4
10th percentile	3.7 cfs	21 cfs
Median	21 cfs	75 cfs
90th percentile	128 cfs	1220 cfs

5.1.4 Rainfall-Runoff Relationship

Stream discharge at HCSW-1 and the average daily rainfall for 2003 (average of daily rainfall at HCSW-1 (USGS) and three Mosaic rain gauges upstream of Highway 64) were compared in Figure 9. Higher stream discharge was usually associated with high rainfall, especially during the wet season; the pattern, however, was not consistent, because rainfall events of one inch or more often corresponded in little or no change in stream discharge at HCSW-1.

To further examine the strength of covariation between daily stream discharge and rainfall, Spearman's rank correlation procedure was used (Zar 1999). Stream discharge at HCSW-1 was compared to rainfall at HCSW-1 (USGS) and the three Mosaic rain gauges, as well the average of all rainfall gauges. Spearman's rank correlation procedure, a nonparametric procedure, was used because stream discharge and rainfall at Horse Creek were not distributed normally (Shapiro-Wilk test for normality, $p < 0.0001$ for all data). The correlation between stream discharge at HCSW-1 and rainfall was statistically significant for each rainfall gauge (Table 9). Although these results suggest that stream discharge and rainfall in Horse Creek covary more than would be expected by chance alone, the correlation coefficients are low ($0.30 > r < 0.44$), indicating that the relationship between the two variables is not very strong.

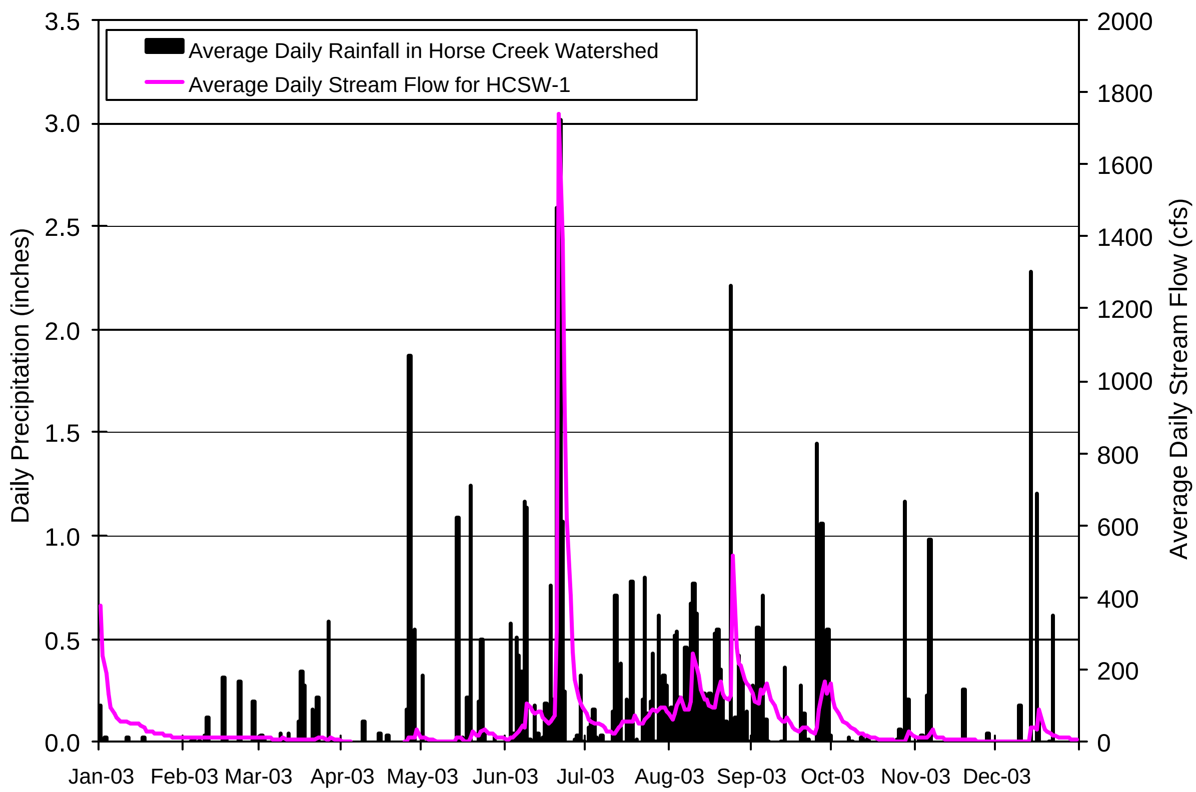


Figure 9. Average Daily Stream Flow and Average Daily Rainfall in the Horse Creek Watershed in 2003 (Figure uses provisional data from USGS website).

Table 9. Coefficients of Rank Correlation (r_s) for Spearman's Rank Correlations of HCSW-1 Daily Stream Discharge and Daily Rainfall at USGS Gauge and Three Mosaic Gauges.

Rainfall Gauge	r_s (with HCSW-1 Streamflow)	p value	N (Sample Size)
Horse Creek North	0.3136	< 0.0001	346
Horse Creek South	0.3426	< 0.0001	346
Manson Jenkins	0.4209	< 0.0001	346
HCSW-1 (USGS)	0.3387	< 0.0001	346
Average Rainfall	0.4352	< 0.0001	346

To make stream discharge and rainfall more comparable, HCSW-1 discharge was converted from cubic feet per second (cfs) to equivalent inches of runoff for the 42-square mile area of the watershed lying upstream of the gauging station (USGS website). Figure 10 illustrates the relationship between monthly total discharge at HGSW-1 and monthly rainfall totals from the gauges at HCSW-1 and the average of all gauges in the Horse Creek Basin upstream of Highway 64. Monthly runoff was substantially less than monthly rainfall as measured either at the HCSW-1 USGS gauge or as the average of all four rain gauges, with the exception of January. This is the typical situation in this portion of Florida, where evaporation is the primary sink for precipitation. Runoff was higher in January because of heavy rainfall in late December 2002. The total runoff at HCSW-1 was 18.5 inches, which corresponds fairly well with the long-term annual average of 10 to 15 inches reported by Heath and Conover (1981) for the Peace River Basin.

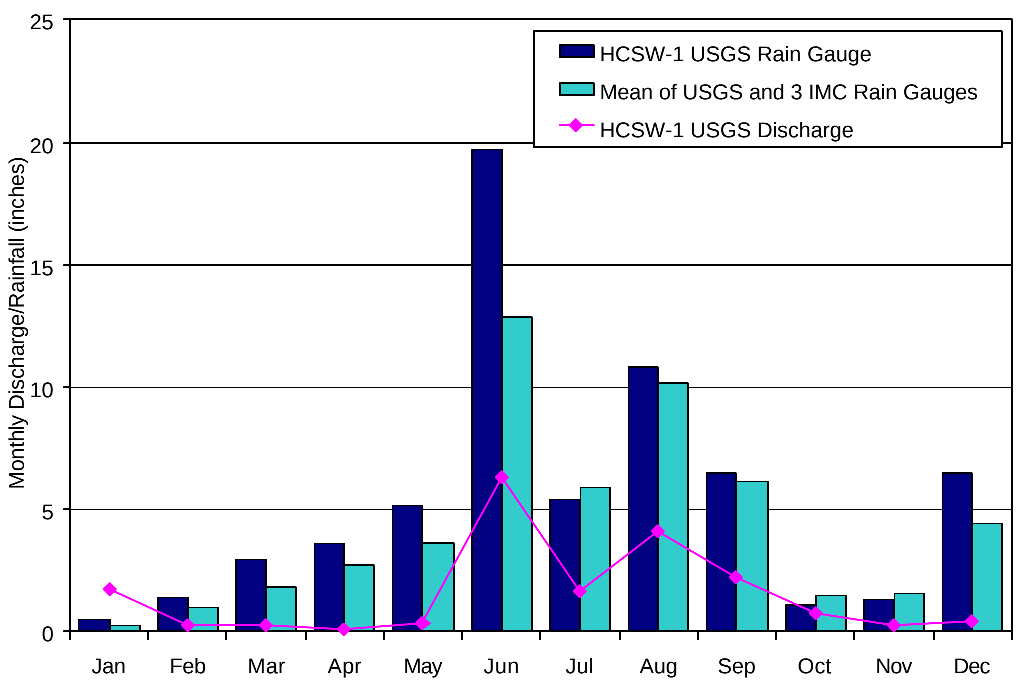


Figure 10. Comparison of Monthly Runoff and Rainfall in the Horse Creek Watershed in 2003 (Figure uses provisional data from USGS website).

5.1.5 NPDES Discharges

Industrial wastewater is discharged to Horse Creek through two outfalls located at the Fort Green Mine (Outfalls 003 and 004 on NPDES Permits FL0027600, Figure 1). Both outfalls are twenty-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. This general relationship is illustrated in the rainfall and NPDES discharge data for 2003 (Figure 11). The Horse Creek outfalls, however, are not the major discharge points of the mine, so this data represents only a portion of the mine's rainfall-discharge relationship (Table 10). In addition, Outfalls 003 and 004 are new, so it is not possible to compare 2003 outfall to "historical" levels. The Horse Creek portion of the Fort Green Mine is not a distinct entity on the ground; the mine property is continuous and covers portions of several basins. Mosaic has no other discharges to Horse Creek, and no other known industrial wastewater discharges to Horse Creek or any tributary by any other firm are known.

Because they potentially affect stream discharge, the combined 2003 daily discharge of two Mosaic NPDES outfalls (Outfalls 003 and 004) located upstream of HCSW-1 was plotted against the 2003 daily flow for HCSW-1 (Figure 12). The peak NPDES discharge in late June corresponded with the highest flows in Horse Creek, but although the total flow at HCSW-1 commonly included water discharged from the NPDES outfalls, there was no consistent relationship between the NPDES discharge and streamflow at HCSW-1 evident from Figure 12. Comparing HCSW-1 stream discharge and NPDES discharge in 2003 using a Spearman's rank correlation procedure (Zar 1999), however, indicates they covary strongly ($r_s = 0.8153$, $p < 0.0001$, $N = 346$). Thus, an increase in one parameter will correspond to an increase in the other. This does not necessarily suggest a causal relationship between NPDES discharge and stream discharge. Just as stream discharge at HCSW-1 was weakly correlated with rainfall (Table 9), so too is NPDES discharge (Table 11).

As indicated in Figure 12, during July 2003, NPDES outfall discharge is larger than streamflow at HCSW-1. Although this reduction in stream volume as the water moved downstream could indicate that Horse Creek is a "losing stream" in this area, it is more likely that the equipment at the USGS gage malfunctioned. Discharge volume at Mosaic's NPDES outfalls is manually checked for accuracy every week and represents a constant cross-section flowing over a smooth surface. The USGS discharge gauge at HCSW-1 is not checked manually and represents open channel flow, which is much harder to accurately measure. If the cross section of the stream at or near the gage changed during the period in question (e.g., debris became lodged or dislodged near the gage) the cross-sectional area could have changed sufficiently to give erroneous readings.

Table 10. 2003 Average monthly Mosaic Industrial Wastewater Discharge (NPDES) to Horse Creek (Outfalls 003 and 004) and Payne Creek from the Ft. Green Mine.

Month	Discharge to Payne Creek	Discharge to Horse Creek
	(MGD)	(MGD)
January	107.2	24.4
February	28.0	6.1
March	37.4	3.2
April	8.3	3.2
May	23.9	7.6
June	171.5	53.7
July	123.0	74.9
August	133.1	79.2
September	71.3	43.5
October	33.5	6.7
November	32.4	0.0
December	31.3	0.0

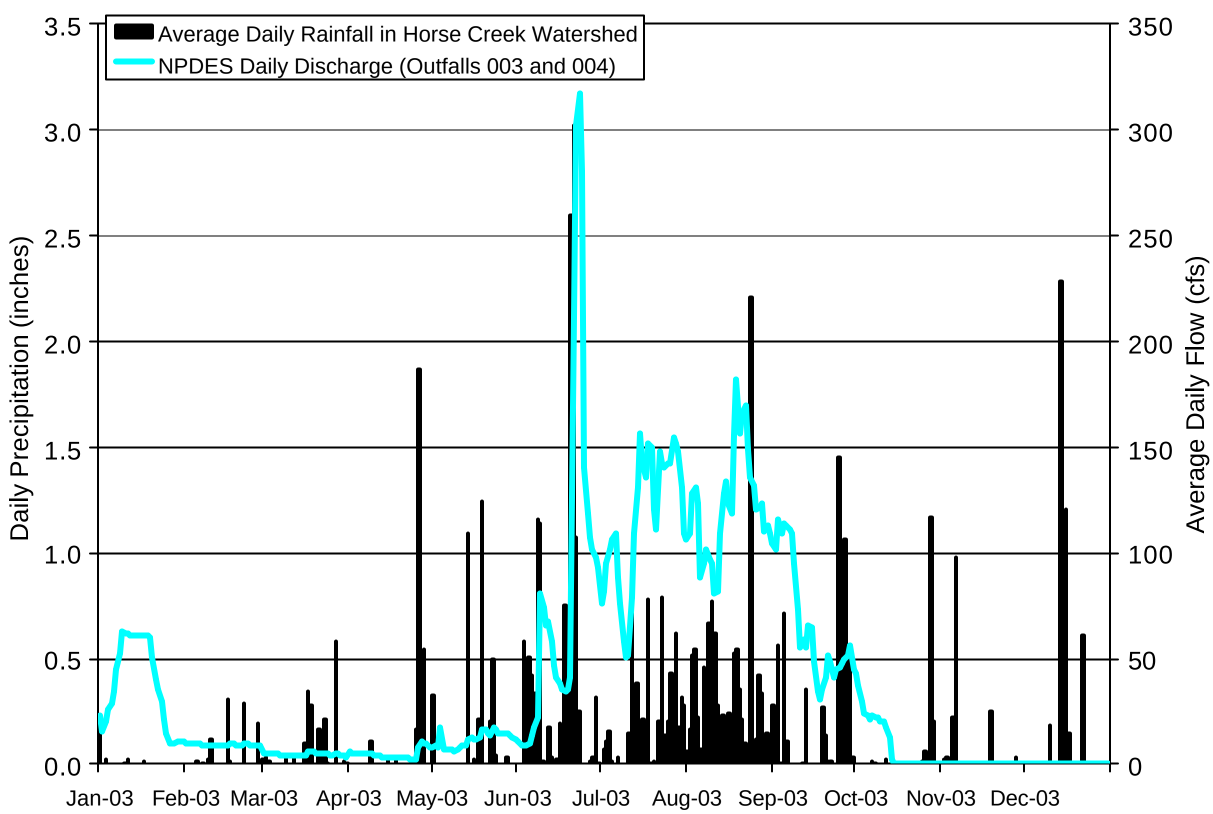


Figure 11. Combined Mosaic NPDES Discharge and Average Daily Rainfall in the Horse Creek Watershed in 2003 (Figure uses provisional data from USGS website).

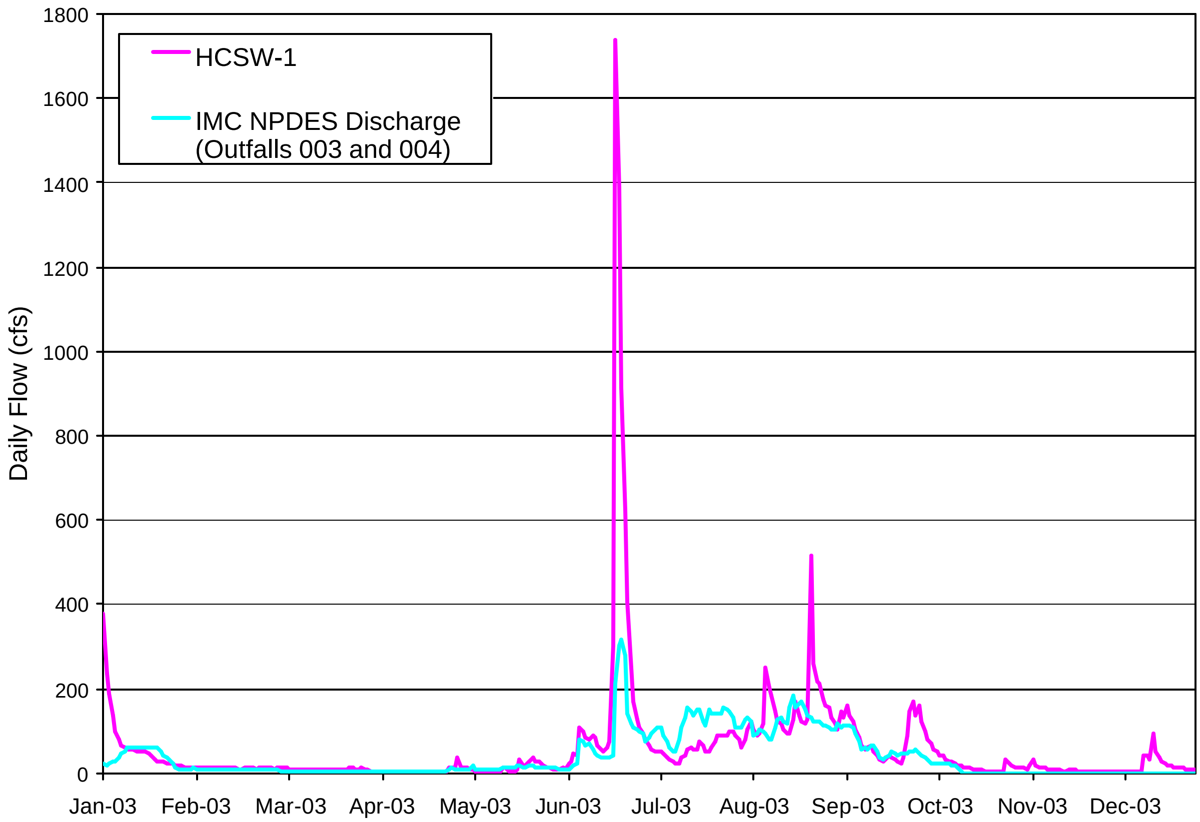


Figure 12. Daily Flow at HCSW-1 and Combined Mosaic NPDES Discharge for 2003 (Figure uses provisional data from USGS website).

Table 11. Coefficients of Rank Correlation (r_s) for Spearman's Rank Correlations of NPDES Daily Discharge and Daily Rainfall at USGS Gauge and Three Mosaic Gauges.

Rainfall Gauge	r_s (with NPDES Outfall)	p value	N (Sample Size)
Horse Creek North	0.3012	< 0.0001	365
Horse Creek South	0.3248	< 0.0001	365
Manson Jenkins	0.4055	< 0.0001	365
HCSW-1 (USGS)	0.3459	< 0.0001	365
Average Rainfall	0.4200	< 0.0001	365

5.1.6 Summary of Water Quantity Results

For 2003, temporal patterns of average daily stream flow and stage were similar across all stations, with highest flows and stages occurring during the rainy season (June through September). Mosaic's NPDES-permitted discharges upstream of HCSW-1 exhibited a similar pattern, contributing more water to Horse Creek during wet periods than dry. An unusually high rainfall event occurred in late June. The effects of this rainfall event were apparent in all the water quantity data.

5.2 WATER QUALITY

The results of field measurements and laboratory analyses of water samples obtained monthly from April through December 2003 at each HCSP monitoring station are presented below. 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 25 April, 29 July, and 20 November 2003. Water quality data are presented in tabular form in Appendix E.

Water quality of NPDES discharge was obtained periodically when water was discharged from Outfalls 003 and 004. A summary of water quality for these outfalls during 2003 is presented in Table 12. Water quality at the outfalls reached or exceeded the HCSP trigger values for only two parameters: dissolved oxygen at Outfall 004 and chlorophyll a at Outfall 003. However, water quality at HCSW-1, the HCSP station just downstream of the outfalls, did not exceed the trigger values for either of these parameters.

Table 12. Water quality summary of NPDES discharge into Horse Creek during 2003 at Outfalls 003 and 004.

	Outfall 003				**Outfall 004**			
Constituent	Avg	Count	Min	Max	Avg	Count	Min	Max
pH	7.39	5	6.78	8.00	6.80	28	6.40	7.22
Conductivity	353.50	2	244.00	463.00	447.29	7	364.00	571.00
Temperature	29.95	2	29.90	30.00	27.61	7	26.00	29.20
Turbidity	13.60	1	13.60	13.60	1.70	1	1.70	1.70
Dissolved Oxygen	6.15	2	5.70	6.60	5.21	7	**5.00**	5.60
TSS	15.40	5	11.00	20.00	2.36	28	1.00	6.00
Fixed Suspended Solids	3.40	5	1.00	9.00	1.29	28	1.00	3.00
Total Phosphorus	1.00	5	0.62	1.36	0.12	28	0.05	0.32
Total Kjeldahl Nitrogen	2.50	5	1.80	2.70	0.49	28	0.30	0.90
Nitrate-Nitrite	0.08	5	0.05	0.10	0.08	28	0.05	0.11
Total Nitrogen	2.58	5	1.88	2.80	0.56	28	0.36	0.99
Fluoride	1.15	2	0.80	1.49	0.64	3	0.42	0.86
Sulfate	25.50	2	24.00	27.00	145.67	3	93.00	216.00
Chlorophyll a	69.50	2	**25.00**	**114.00**	2.33	3	1.00	5.00

5.2.1 Physio-Chemical Parameters

Levels of pH, dissolved oxygen, and turbidity 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 sampling events at all stations (Figure 14). The upper and lower ranges of pH values established as trigger levels are identical to those for Florida Class III Surface Water Quality Standards. Values obtained during biological sampling events were consistent with pH levels determined during the monthly water quality sampling events (Figure 14). Continuous pH data obtained daily at HCSW-1 was within a range similar to that obtained during monthly water quality sampling (Figures 15). In addition, continuous pH values at HCSW-1 were always within the range of the trigger levels [6.0 to 8.5 standard units (SUs)] (Figure 14).

Levels of pH were significantly different among stations (Kruskal-Wallis ANOVA by ranks test, $H = 24.7$, $p < 0.0001$), with HCSW-2 significantly lower and HCSW-1 significantly higher than other stations (Mann-Whitney U test, $p < 0.05$). Station HCSW-2 lies just downstream of a large swamp complex (Figures 13 and 16) that has the potential to add substantial organic acids from plant decomposition that will tend to decrease the pH. Additional inflows from wetland areas further downstream may serve to maintain the lower pH regime at HCSW-3 and HCSW-4.

Figure 13. 2005 photograph of Horse Creek Prairie, a 160-acre swamp lying 1.5 km upstream of HCSW-2 on Horse Creek.

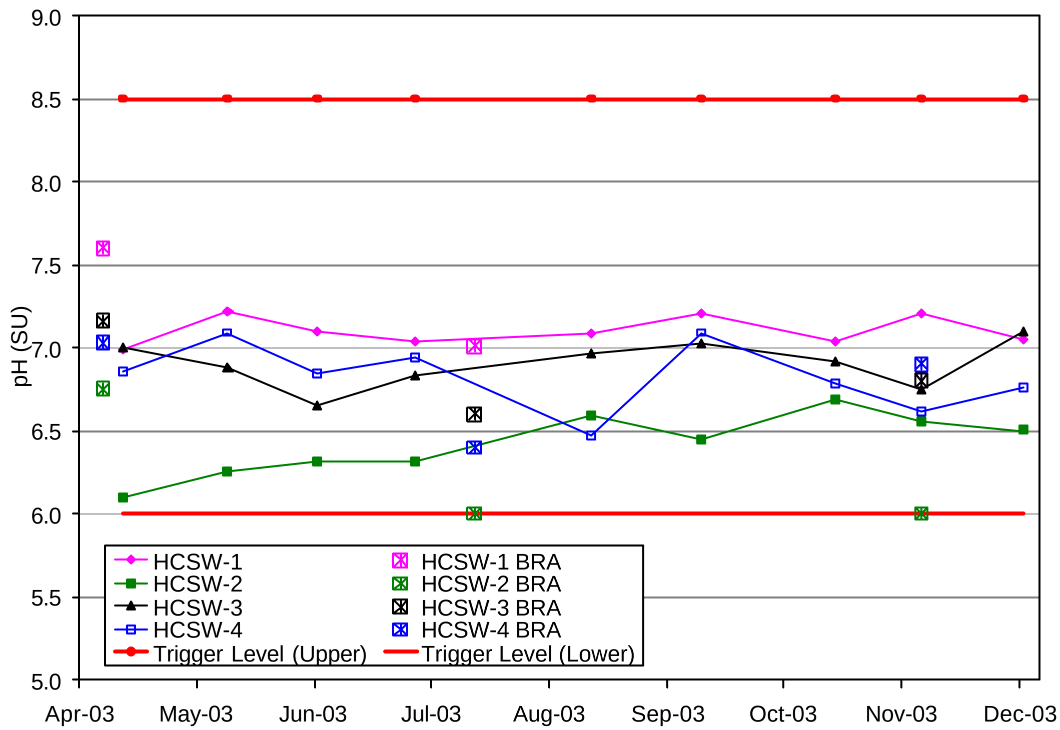


Figure 14. Values of pH Obtained During Monthly HCSP Water Quality Sampling and Biological Sampling Events in 2003. Minimum Detection Limit = 1 su.

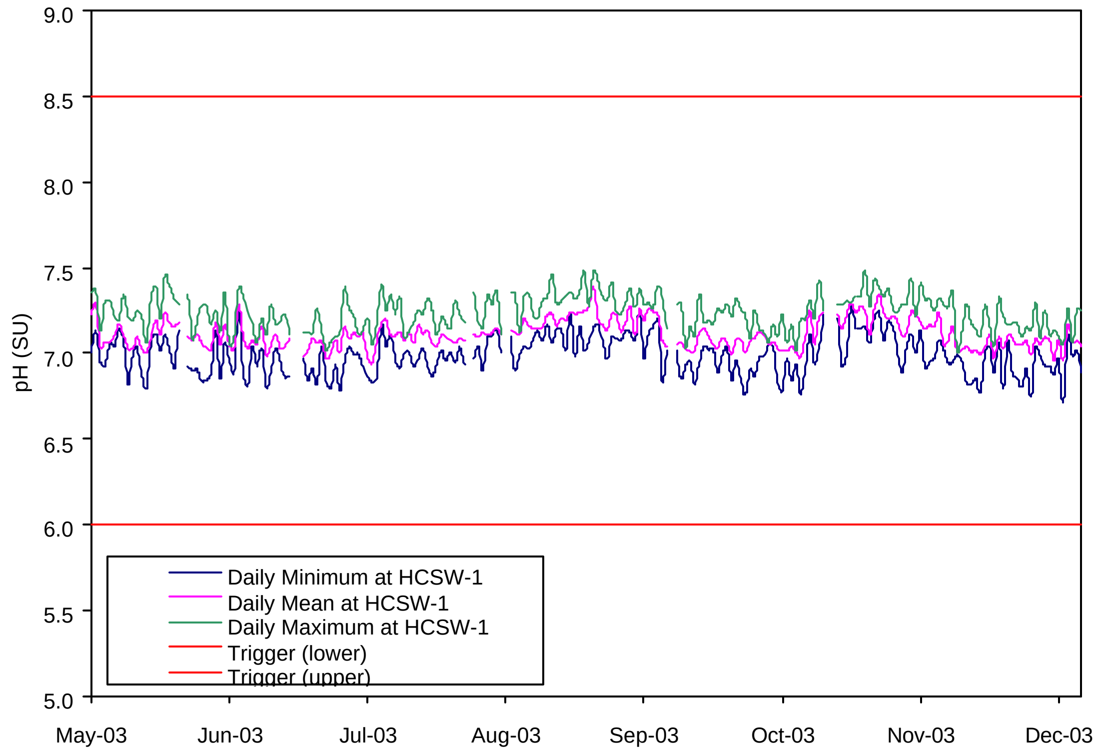
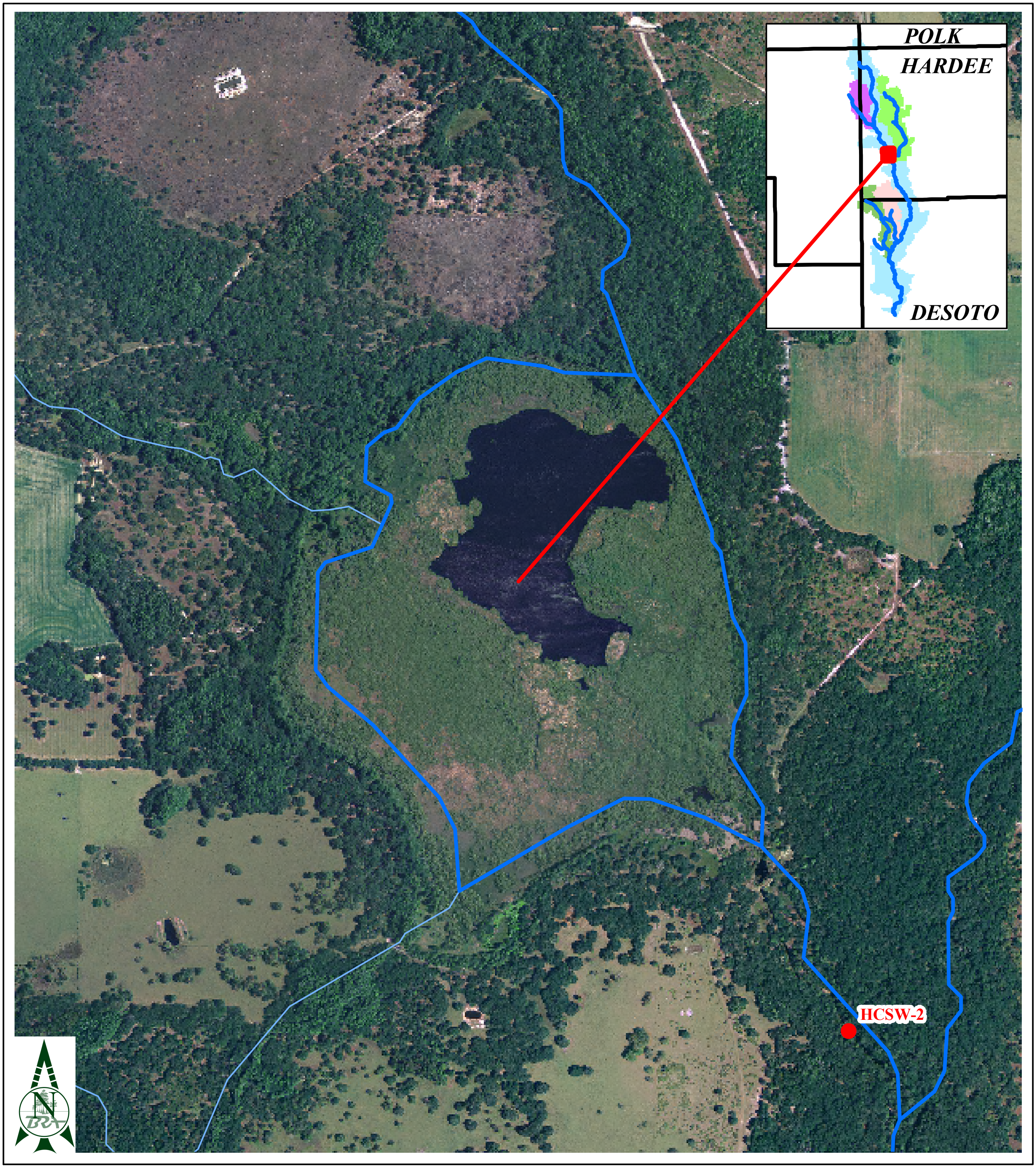


Figure 15. Values of pH Obtained From the Continuous Recorder at HCSW-1. Minimum Detection Limit = 1 su.



0 900 1800 Feet

Image: 2004 SWFWMD DOQQs
1 inch equals 900 feet

Preparation Date: 20 May 2005
Revision Date: 07 June 2005
Project Number: 2476-065-b21
Project Manager: DJD
GIS Operator: LBS
GIS QA/ QC:
ArcMap Name: horsecreek-prairie.mxd
Plot File: horsecreek_prairie.pdf

Figure 16. 2004 aerial photography of Horse Creek Prairie, a 160-acre swamp lying 1.5 km upstream of HCSW-2 on Horse Creek.

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Dissolved oxygen concentrations were above the trigger level and Class III Standard of 5.0 mg/l (indicating desirable conditions) during all sampling events at HCSW-1, HCSW-3, and HCSW-4 (Figure 17). However, levels of dissolved oxygen were consistently below 5.0 mg/l at HCSW-2; this station receives water from the Horse Creek Prairie (Figures 13 and 16), a blackwater swamp that typically has low dissolved oxygen concentrations. Levels of dissolved oxygen were significantly different among stations (Kruskal-Wallis ANOVA by ranks test, $H = 21.3$, $p < 0.0001$), with HCSW-2 significantly lower than other stations (Mann-Whitney U test, $p < 0.05$).

Dissolved oxygen concentrations at HCSW-1, HCSW-3, and HCSW-4 obtained during biological sampling events were consistent with those found during the monthly water quality sampling. Because biological sampling occurs upstream of water sampling in a more channelized, faster flowing reach, concentrations of dissolved oxygen determined at HCSW-2 during the biological sampling events in April and November were higher than levels found during Mosaic's monthly water quality sampling events (Figure 17). While the dissolved oxygen concentrations obtained at HCSW-1 during the monthly water quality sampling events were always above the trigger level of 5.0 mg/l, the continuous dissolved oxygen data obtained for HCSW-1 revealed that dissolved oxygen levels occasionally fell below the trigger level during the summer months when the water's potential for holding dissolved oxygen is low, which is not unexpected for a stream of this type in peninsular Florida (Figures 18). The reason for the higher variability in the continuously-measured oxygen levels late in 2003 is unclear.

Turbidity levels as measured monthly were not significantly different among stations in 2003 (one factor-ANOVA on log turbidity, $F = 0.511$, $p = 0.678$) (Figure 19). With the exception of HCSW-3 during July, turbidity levels obtained during biological sampling events were similar to those found during monthly water quality sampling events. Turbidity levels at all stations in 2003 were well below the trigger level and Class III Surface Water Quality Standard of 29 nephelometric turbidity units (NTUs).

The continuous turbidity data for HCSW-1 indicated that turbidity levels occasionally were higher than those obtained during the monthly water quality sampling events; however, the trigger level was never exceeded (Figure 20). Turbidity data from the continuous recorder was compared to rainfall, streamflow, gage height, and NPDES discharge using Spearman's rank correlations (Zar 1999). A statistically significant, but very weak, negative correlation was seen between HCSW-1 continuous turbidity (mean and minimum) and rainfall at Mosaic's Horse Creek South rain gauge ($r = -0.187$, $p = 0.007$; $r = -0.167$, $p = 0.0162$), but the other three rain gauges in the Horse Creek Basin did not correlate with turbidity at the $p < 0.05$ level. Daily maximum turbidity did not significantly covary with any of the four rain gauges. The highest values for continuous turbidity were measured when rainfall was at zero inches, suggesting that dry conditions increase the turbidity or the stream (Figure 21). Perhaps during dry spells, cattle and wildlife are more prone to use the stream as a source of water, thereby making it more turbid (Figure 22). Mean, minimum, and maximum turbidity at HCSW-1 were not significantly correlated with HCSW-1 streamflow, HCSW-1 gage height, or NPDES discharge. There were only ten days in the 2003 continuous recorder dataset with turbidity greater than 10 NTU.

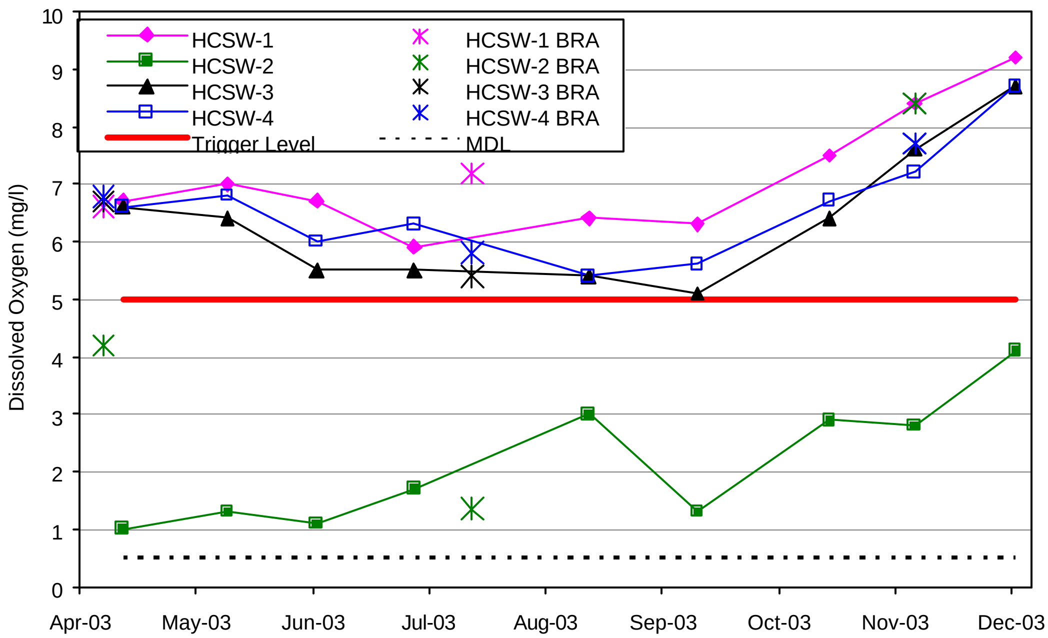

Figure 17. Dissolved Oxygen Levels Obtained During Monthly HCSP Water Quality Sampling and Biological Sampling Events in 2003.

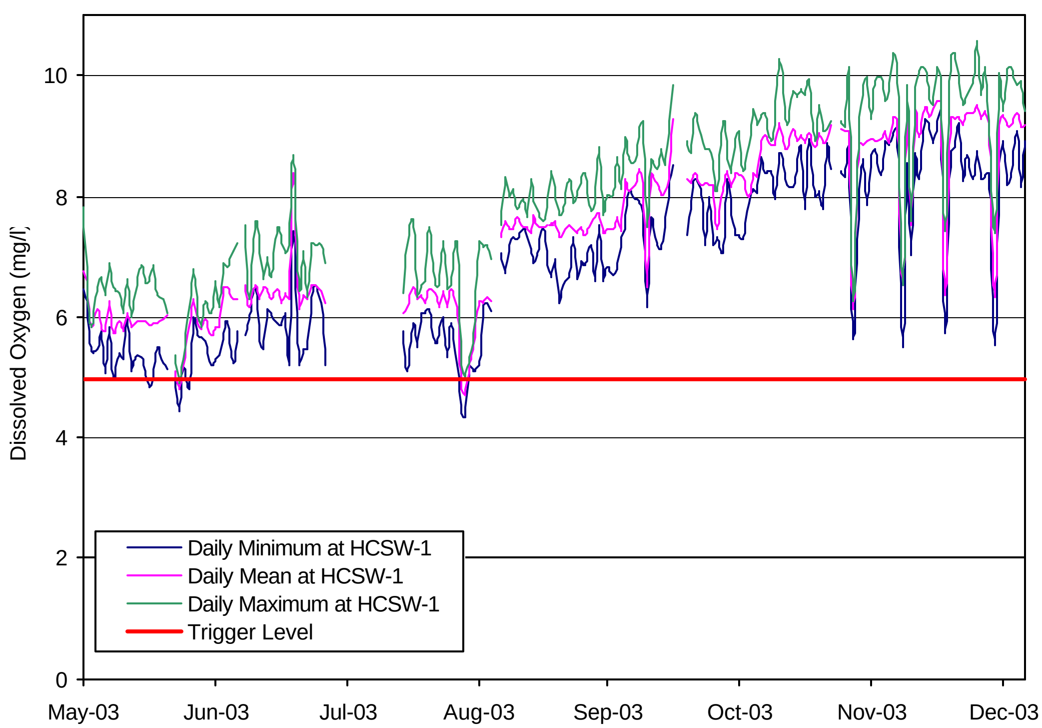

Figure 18. Dissolved Oxygen Levels Obtained From the Continuous Recorder at HCSW-1. Minimum Detection Limit = 0.5 mg/l.

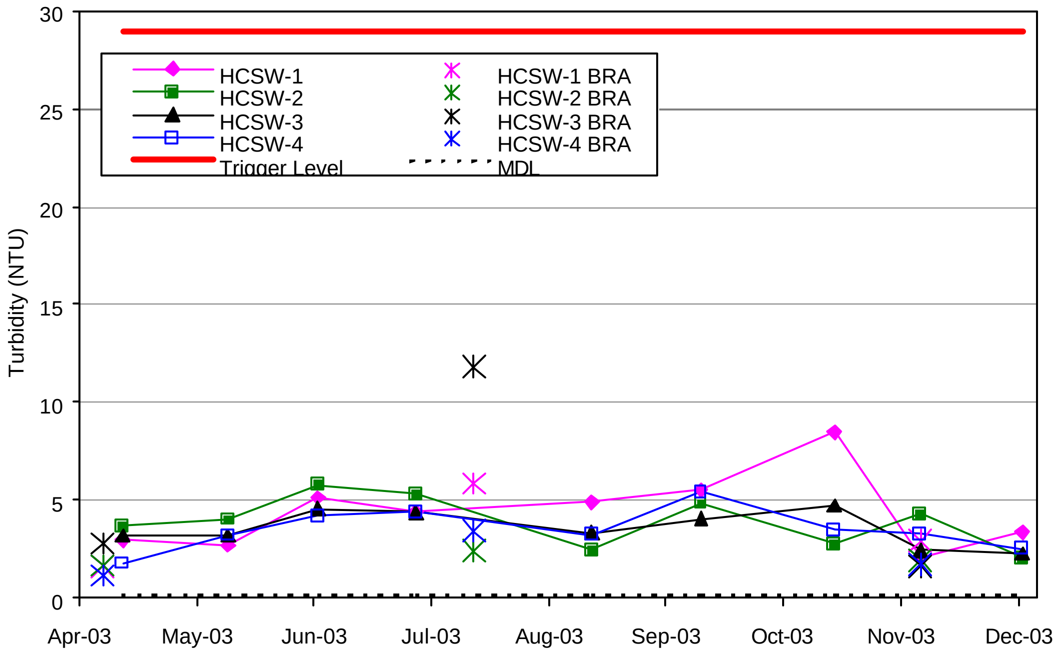

Figure 19. Turbidity Levels Obtained During Monthly HCSP Water Quality Sampling and Biological Sampling Events in 2003

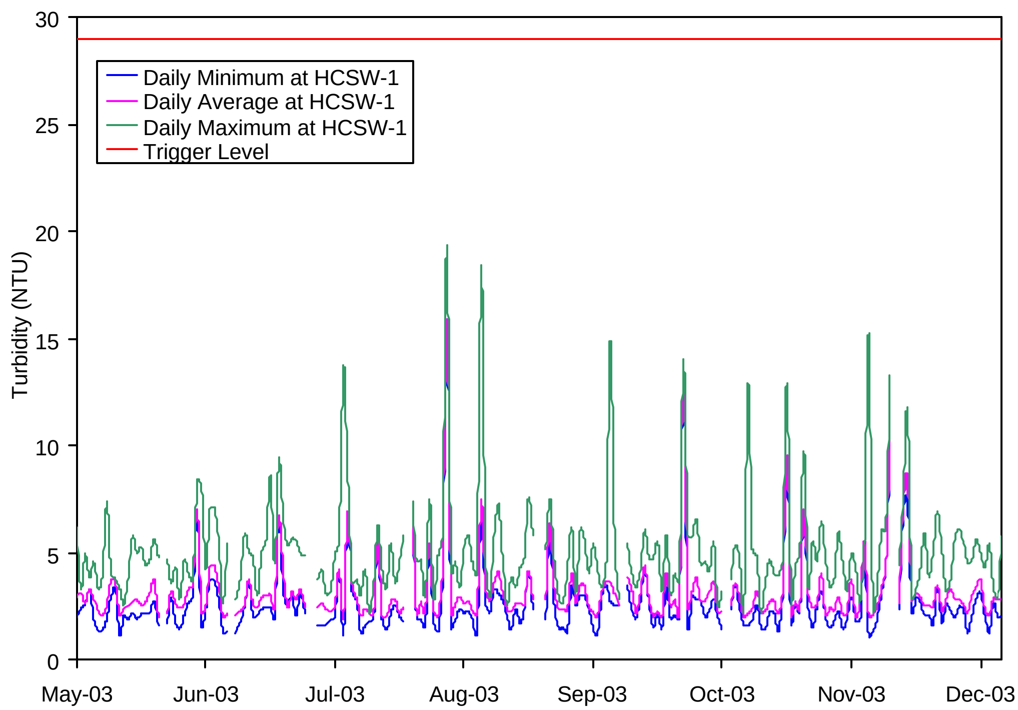

Figure 20. Turbidity Levels Obtained From the Continuous Recorder at HCSW-1. Minimum Detection Limit = 0.1 NTU.

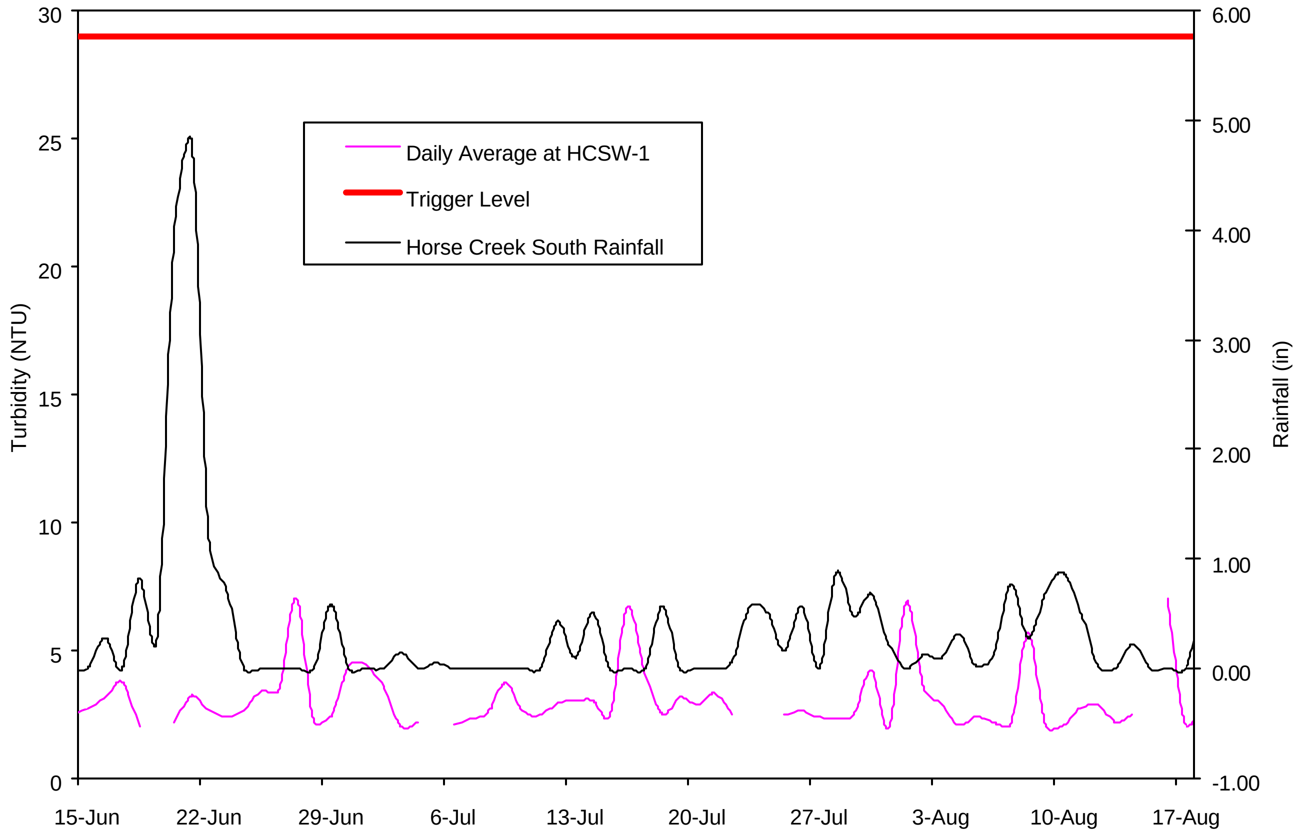

Figure 21. Relationship between Turbidity Levels Obtained From the Continuous Recorder at HCSW-1 and Rainfall at the Horse Creek South Rainfall gauge for two summer months in 2003.

Figure 22. Cattle crossing located less than 5 m upstream of HCSW-1 continuous turbidity meter.

All color levels were above the trigger level of 25 Platinum-Cobalt units (PCU) (indicating desirable conditions) during all events at all stations (Figure 23). Color levels were not significantly different among stations in 2003 (one-factor-ANOVA, $F = 1.451$, $p = 0.246$). The similar pattern among the stations, with higher color in the summer months and lower levels in the 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. As the dry season begins, groundwater seepage provides a proportionally higher contribution and contributes much clearer water to Horse Creek, thereby decreasing the color of the water. It is also likely that agricultural irrigation return flows also have some impact on color in the stream by introducing much clearer water during the drier parts of the year. This agricultural factor is also noted below with respect to several other parameters.

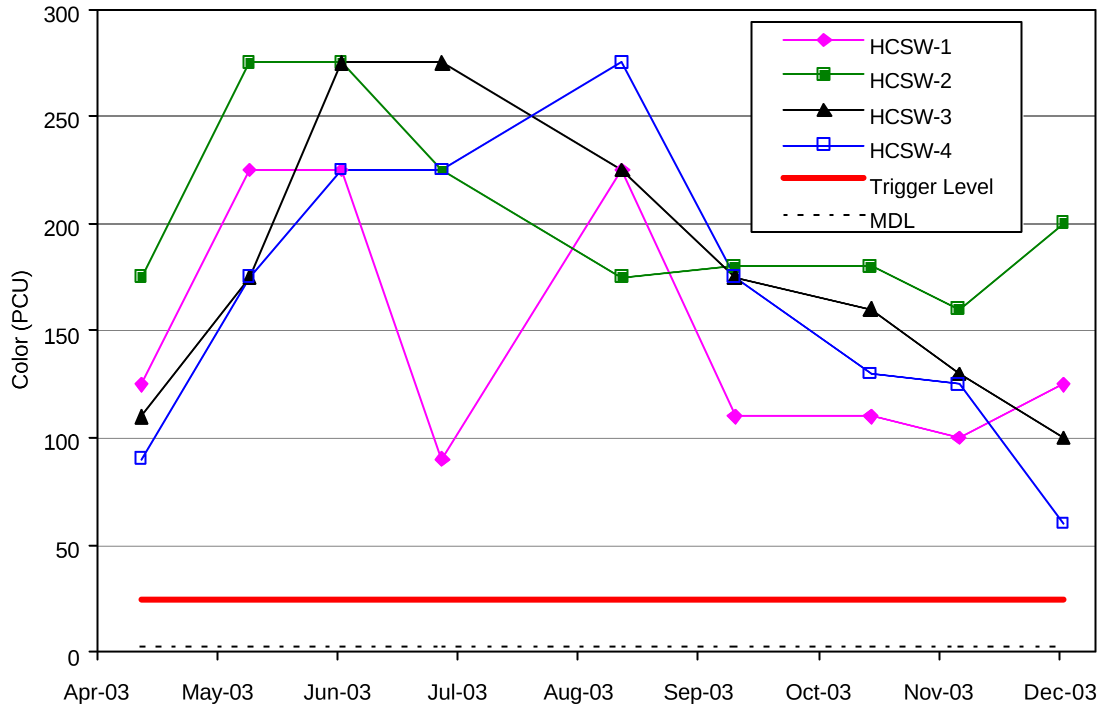

Figure 23. Color Levels Obtained During Monthly HCSP Water Quality Sampling in 2003

5.2.2 Nutrients

Total Nitrogen concentrations ranged between 1 and 2 mg/l during all sampling events at all stations except HCSW-1 in November and HCSW-4 in December (Figure 24). During 2003, total nitrogen was consistently below the trigger value of 3.0 mg/l. Total nitrogen concentrations were significantly different among stations (ANOVA, $F = 4.969$, $p = 0.006$), with a general pattern of increasing total nitrogen levels from upstream to downstream stations (Duncan's post hoc test, $p < 0.05$). Without extensive further investigation, this can only be tentatively attributed to inputs of agricultural fertilizers or biosolids application along the waterway.

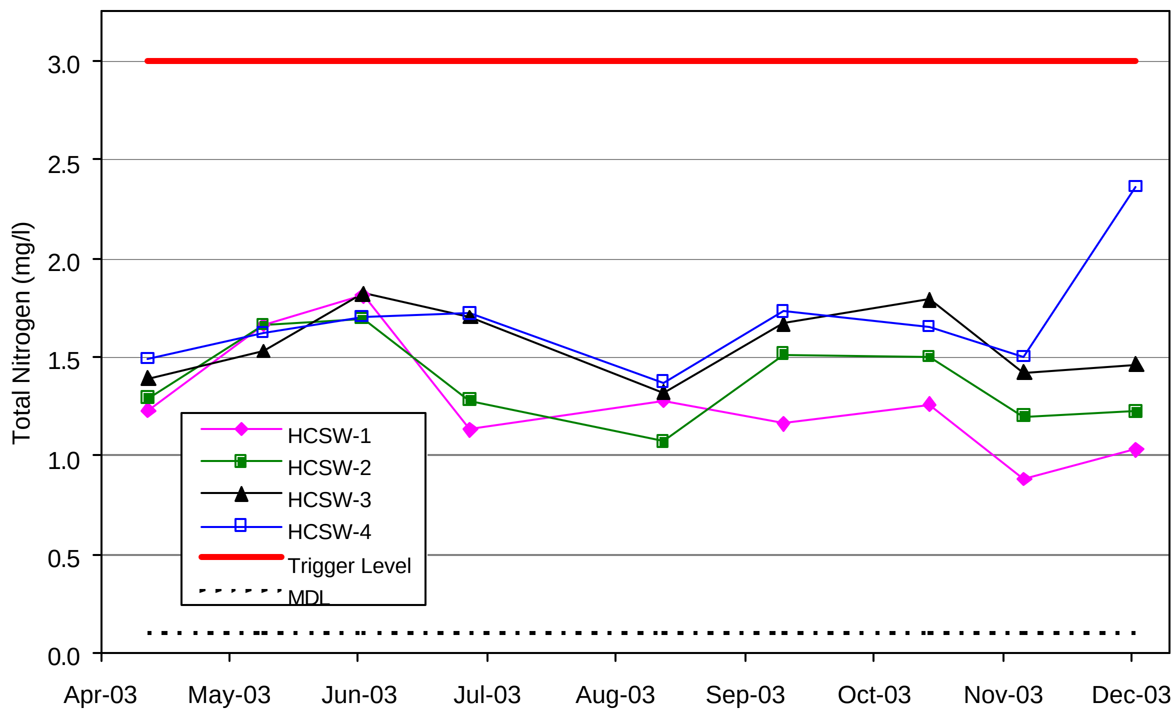

Figure 24. Total Nitrogen Concentrations Obtained During Monthly HCSP Water Quality Sampling in 2003

Total Kjeldahl Nitrogen (TKN) comprised the majority of total nitrogen in most samples (Figure 25, compare with Figure 24). An independent trigger value was not established for TKN. Concentrations of TKN were not significantly different among stations (ANOVA, F = 0.629, p = 0.602).

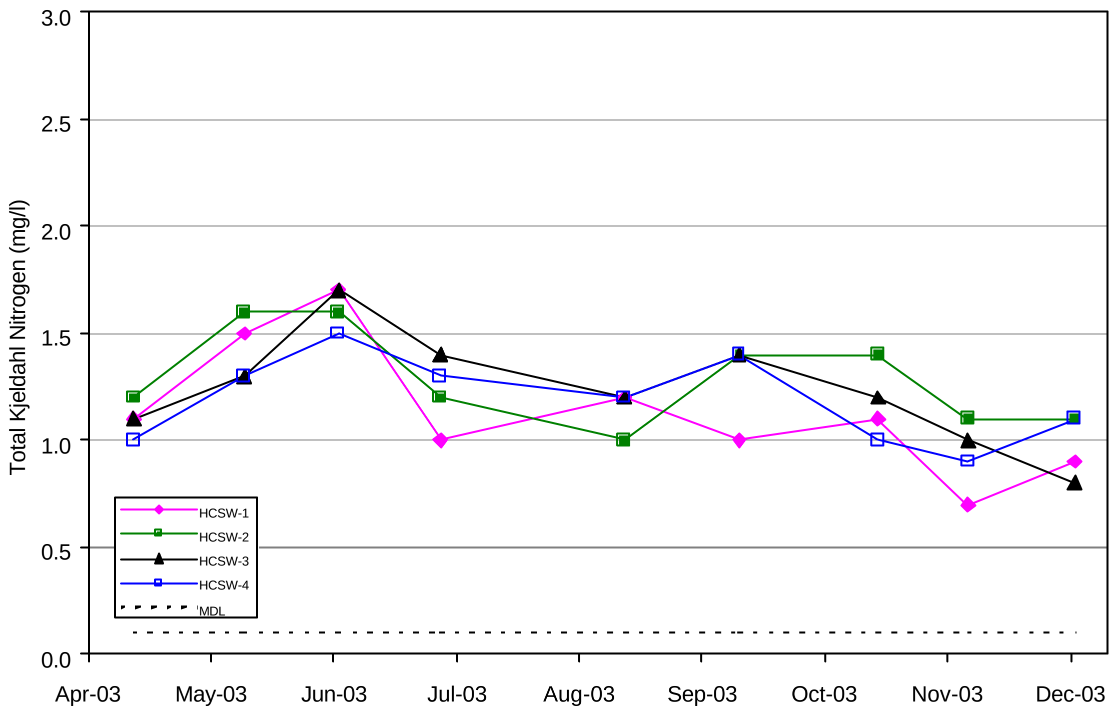

Figure 25. Total Kjeldahl Nitrogen Concentrations Obtained During Monthly HCSP Water Quality Sampling in 2003.

Nitrate-nitrite nitrogen levels were significantly different among stations (Kruskal-Wallis ANOVA by ranks test, $H = 25.39$, $p < 0.0001$), with concentrations lower at HCSW-1 and HCSW-2 and higher at HCSW-3 and HCSW-4 (Mann-Whitney U test, $p < 0.05$) (Figure 26). Nitrate-nitrite nitrogen levels increased at HCSW-3 and HCSW-4 through the latter part of the year, probably because of fertilizer inputs from irrigation runoff during the dry season. An independent trigger value was not established for nitrate-nitrite nitrogen.

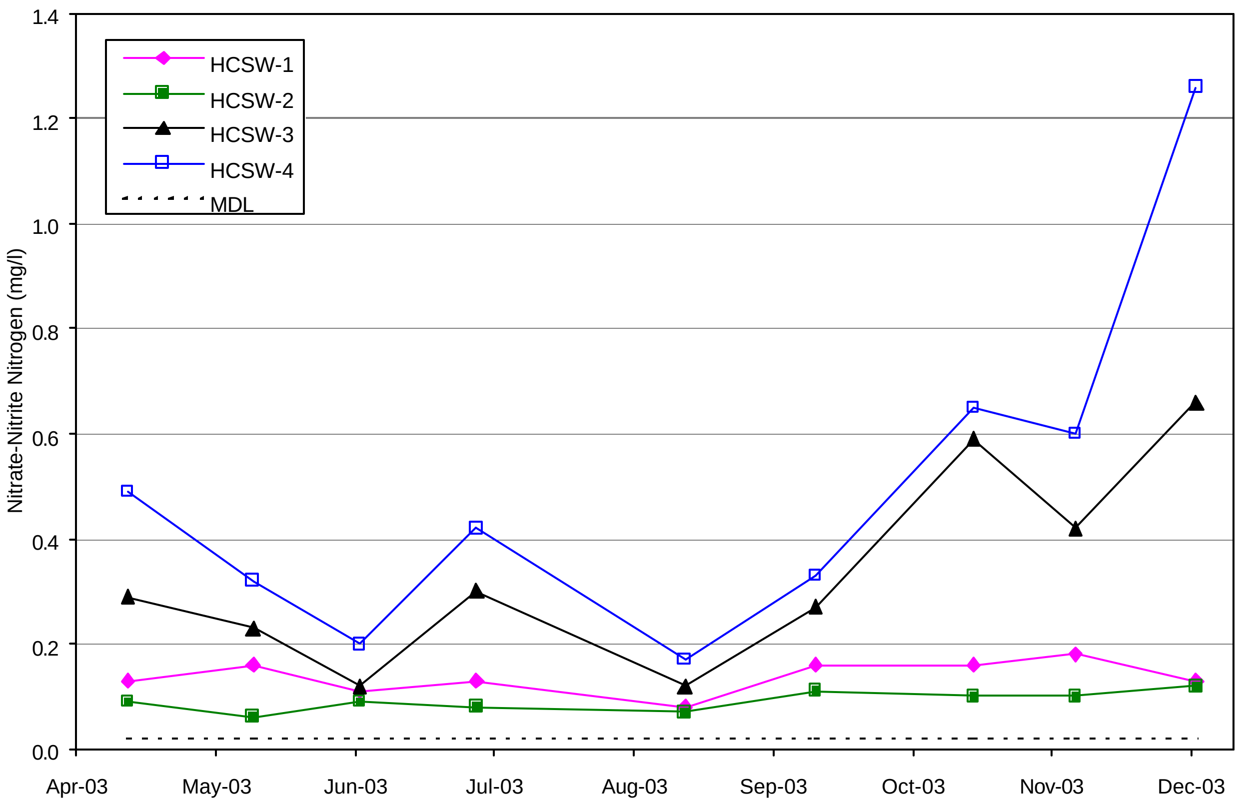

Figure 26. Nitrate-Nitrite Nitrogen Concentrations Obtained During Monthly HCSP Water Quality Sampling in 2003.

With the anomalous exception of HCSW-4 during December, total ammonia nitrogen levels were low and were within a similar range during all sampling events at all stations (Kruskal-Wallis ANOVA by ranks test, H = 3.78, p = 0.28) (Figure 27). An independent trigger value was not established for total ammonia nitrogen.

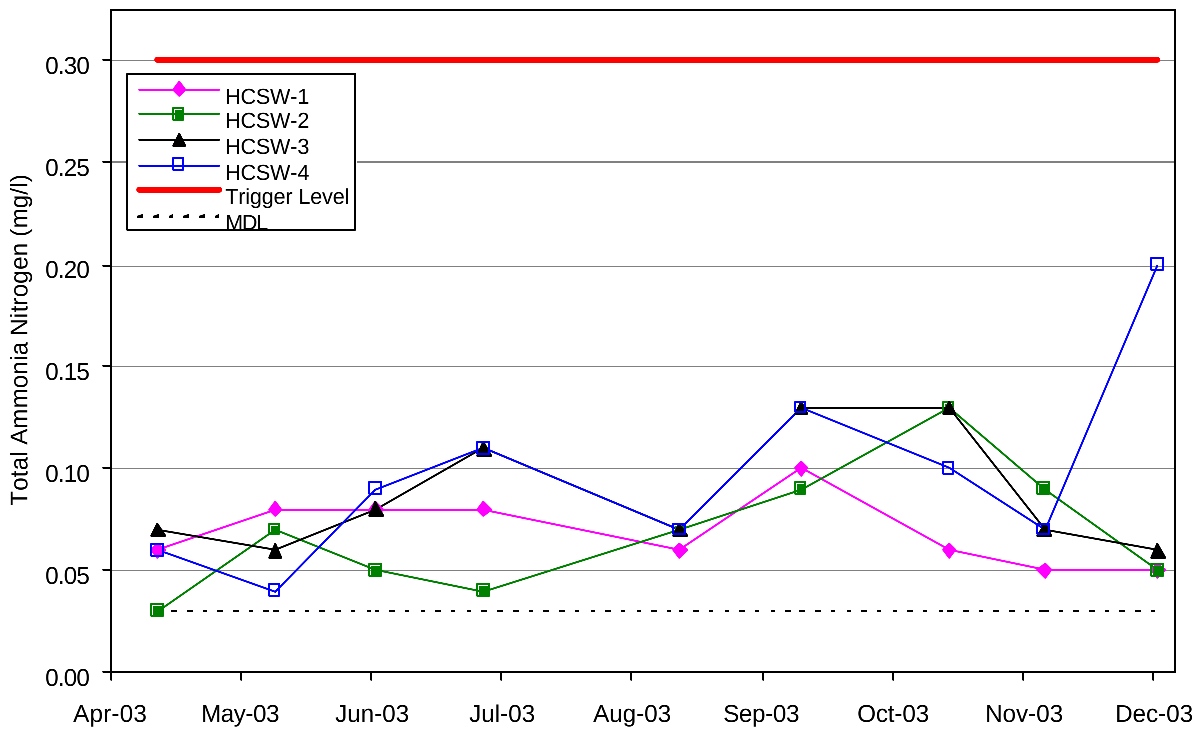

Figure 27. Total Ammonia Nitrogen Concentrations Obtained During Monthly HCSP Water Quality Sampling in 2003.

Levels of orthophosphate were well below the trigger level of 2.5 mg/l (Figure 28). Orthophosphate concentrations were significantly different among stations (one-factor-ANOVA, $F = 9.922$, $p < 0.0001$), with concentrations at HCSW-1 and HCSW-2 (closer to mines) significantly lower and HCSW-4 significantly higher than other stations (Duncan's post hoc test, $p < 0.05$). While the observed phosphorus levels would be considered quite high in some portions of the state, they are well within the expected range for streams in the Bone Valley Phosphate Region.

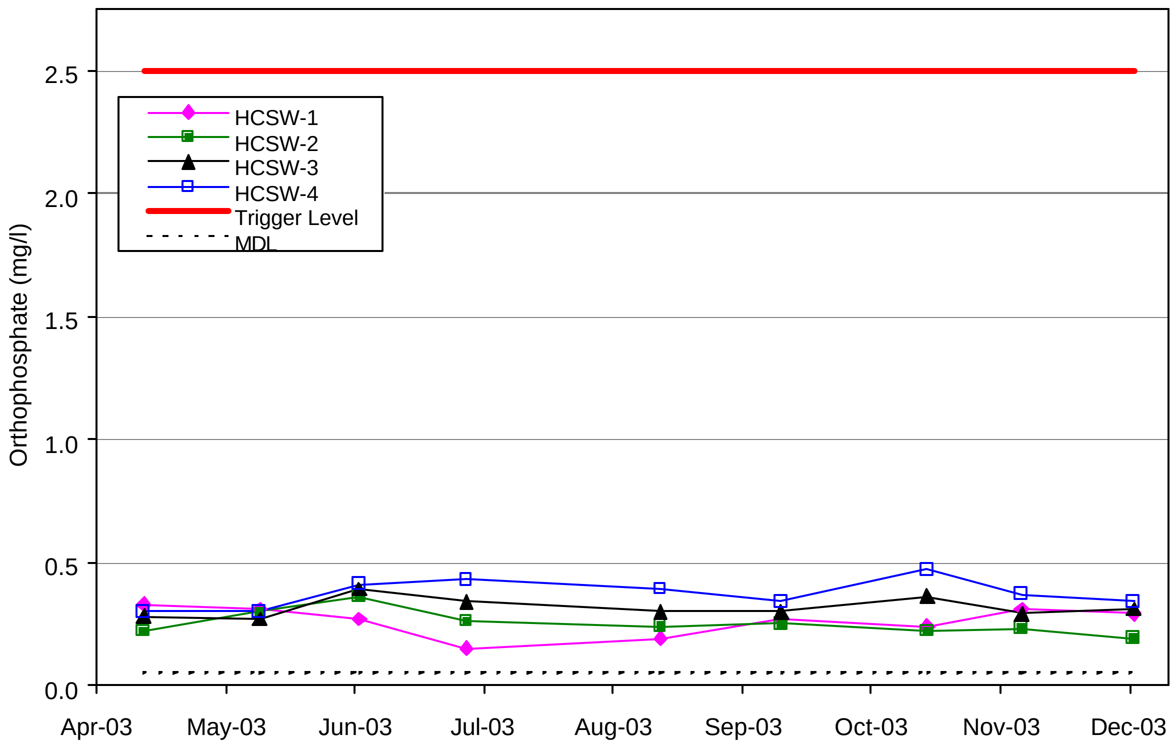

Figure 28. Orthophosphate Concentrations Obtained During Monthly HCSP Water Quality Sampling in 2003.

Chlorophyll *a* values were well below the trigger level of 15 mg/m^3, ranging from below the limits of detection (1 mg/m^3) to 7 mg/m^3 during all sampling events at all stations (Figure 29). These low values are expected, given the lotic nature of the system and the degree of riparian shading along much of the watercourse. Chlorophyll a concentrations were significantly higher at the most lentic station, HCSW-2, than at other stations (Kruskal-Wallis ANOVA by ranks test, $H = 18.864$, $p < 0.0001$; Mann-Whitney U, $p < 0.05$).

Horse Creek Prairie, upstream of HCSW-2 (Figure 16), produces natural conditions that may encourage algae growth, such as slow-moving waters and decaying plant material. Chlorophyll a may be an important indicator of water quality in the future as mined lands are reclaimed, reconnecting wetlands to Horse Creek. A sharp increase in chlorophyll-a levels at HCSW-1 after reclamation may indicate that the wetlands are impounded and not functioning properly.

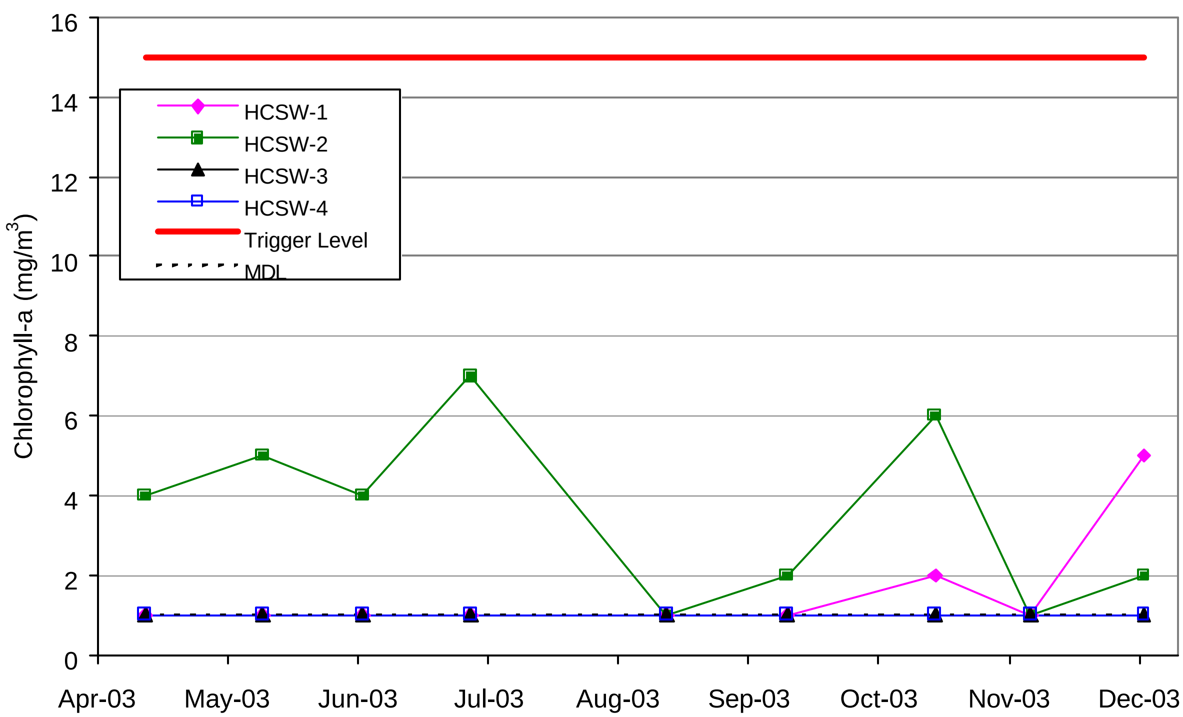

Figure 29. Chlorophyll-a Concentrations Obtained During Monthly HCSP Water Quality Sampling in 2003. Minimum Detection Limit = 1 mg/m^3.

5.2.3 Dissolved Minerals, Mining Reagents, and Radionuclides

During all sampling events and at all stations, specific conductivity levels were well below the trigger level of >1275 µmhos/cm^2 (Figure 30). Specific conductivity was significantly different among stations (one-factor ANOVA of log specific conductance, $F = 5.77$, $p = 0.003$), with a general trend of increasing levels downstream (Duncan's post hoc test, $p < 0.05$). Levels of specific conductivity determined during each biological sampling event were consistent with those obtained during monthly water quality sampling events (Figure 30). Specific conductivity values obtained from the recorder at HCSW-1 were within the range obtained during the monthly water quality sampling events (Figures 30 and 31). The fact that conductivity was usually higher at HCSW-4 than at the other stations is probably the cumulative result of contributions of groundwater that has either seeped into Horse Creek directly or has run off from agricultural irrigation water pumped from the aquifer. This pattern has been present for many years and will be more apparent in the review of the long-term data in the HCSP Historical Report (BRA 2005). It is also possible that some of the conductivity differential may simply be the result of spatial changes in geology of the watershed from the upper part of the basin toward the Peace River.

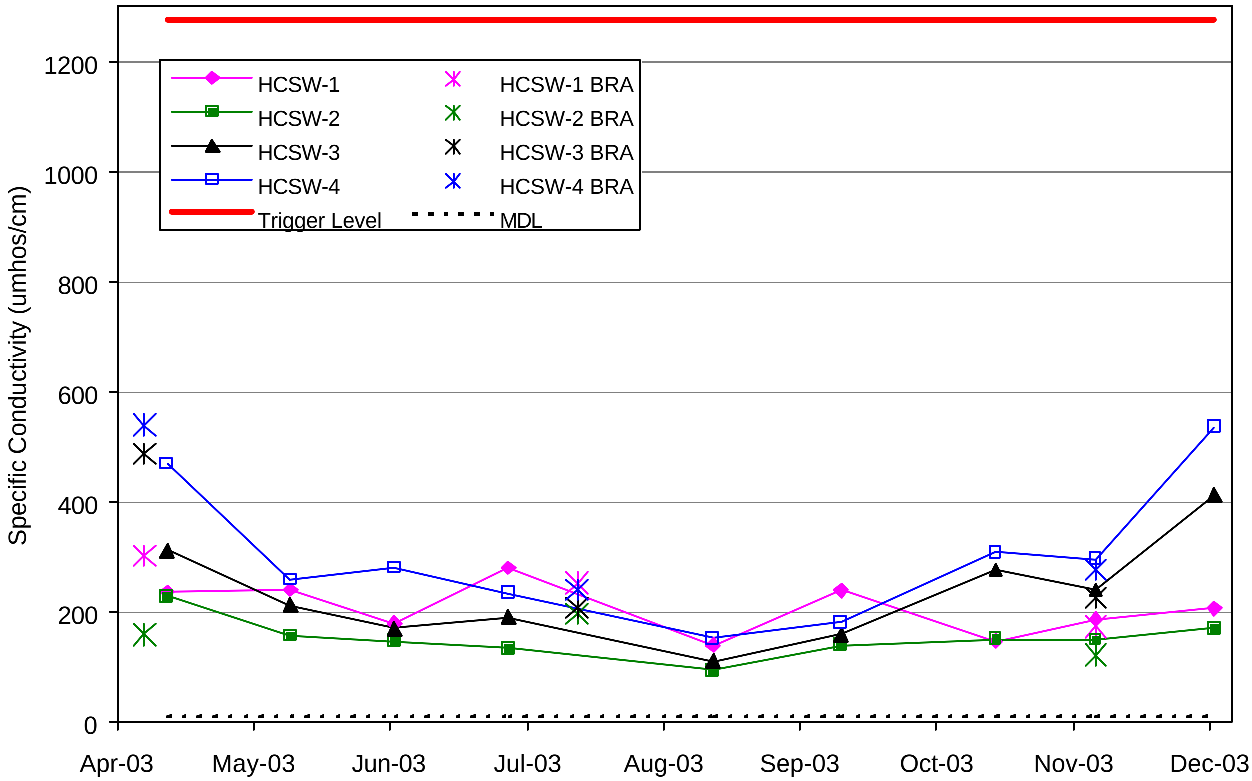

Figure 30. Levels of Specific Conductivity Obtained During Monthly HCSP Water Quality Sampling and Biological Sampling Events in 2003.

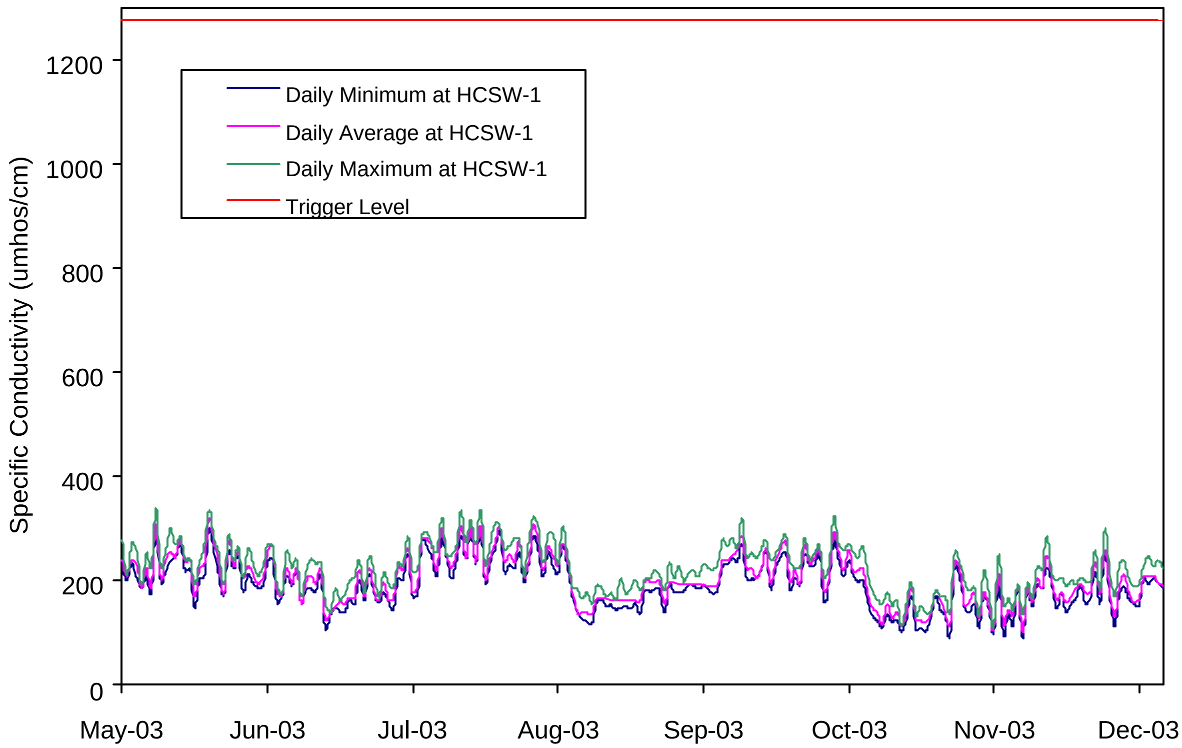

Figure 31. Specific Conductivity Levels Obtained From the Continuous Recorder at HCSW-1. Minimum Detection Limit = 10 umhos/cm.

Concentrations of calcium were significantly different between stations (one-factor ANOVA of log dissolved calcium, $F = 11.19$, $p < 0.0001$), with significantly lower levels at HCSW-2 and higher levels at HCSW-4 (Duncan's post hoc test, $p < 0.05$) (Figure 32). As with specific conductivity, calcium levels were higher downstream where the groundwater contribution to baseflow is higher. Calcium levels were much lower than the trigger value of 100 mg/l at all stations during all sampling events. The analytical procedure for calcium and iron changed during the 2003 monitoring period, although the change did not affect the general magnitude or interpretation of the results.[2]

[2] The Program began with sampling of dissolved iron and calcium (April – November 2003). At a meeting with the PRMRWSA and EarthBalance, it was requested that Mosaic begin sampling for total metals since the text in the body of the HCSP methodology specifies only "Calcium" and "Iron" so sub-samples for iron and calcium were not filtered before analysis in November and December 2003 and February to April 2004. Later the PRMRWSA noted that Table 1 of the Agreement has "Iron" and "Calcium" listed with a row heading of "Dissolved Minerals" and requested that the analysis be switched back to dissolved iron and calcium. Samples from January 2004 and May 2004 to the present have been analyzed for dissolved iron and calcium. All iron and calcium data (both total and dissolved) is included in Appendix E. As total iron and total calcium should by definition be equal or greater than the dissolved fractions alone, the months with total iron and calcium represent a conservative determination of the iron and calcium concentrations and in no way are any less protective than measuring dissolved concentrations. As For the 20 November 2003 sampling event, during which measurements of both Total and Dissolved Calcium and Iron were made, the measurements for each mineral were very similar, regardless of the method used (12.9 mg/l calcium, both methods; 0.3 mg/l dissolved iron and 0.297 mg/l total iron).

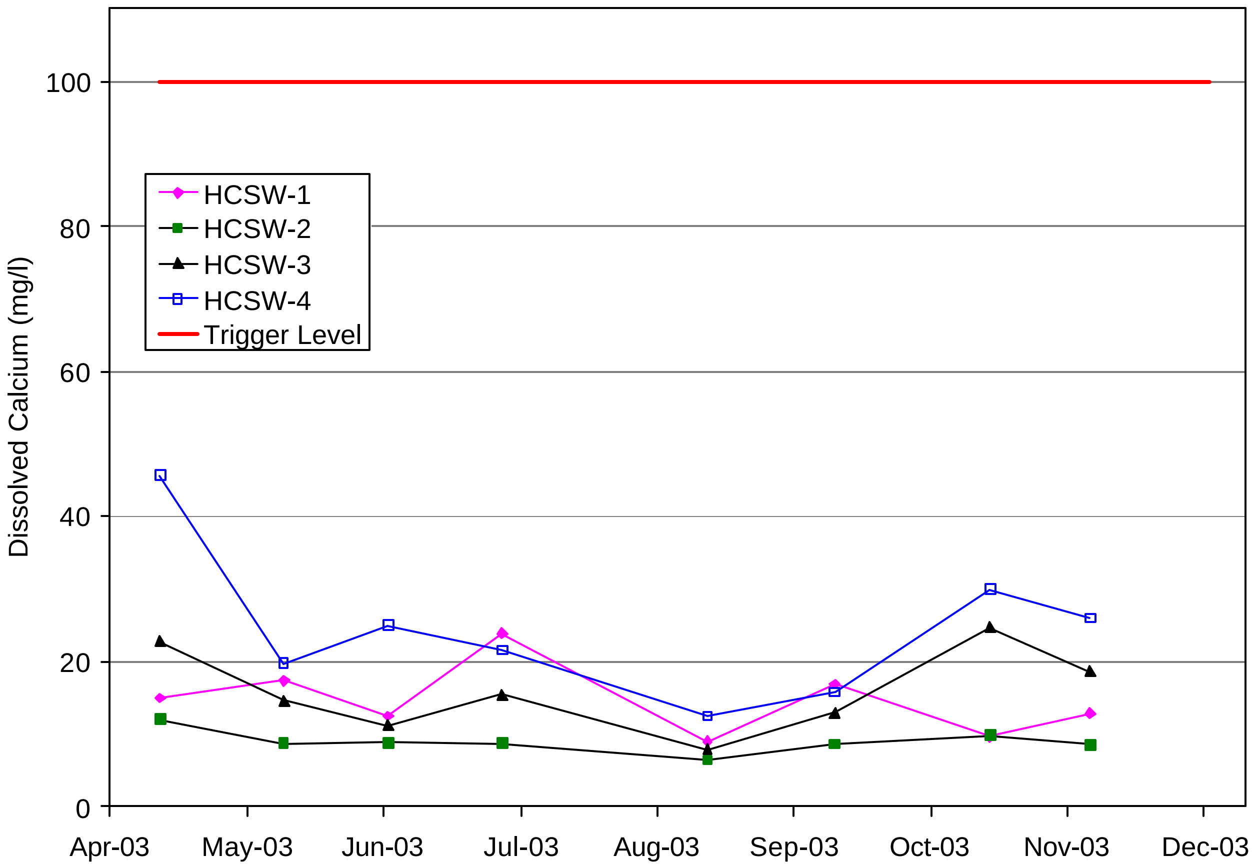

Figure 32. Dissolved Calcium Concentrations Obtained During Monthly HCSP Water Quality Sampling in 2003. Minimum Detection Limit = 0.1 mg/l.

Levels of dissolved iron at HCSW-1, HCSW-2, and HCSW-3 were below the trigger level of 1 mg/l established for those sampling locations during all sampling events (Figure 33). Dissolved iron concentrations were not significantly different among stations (Kruskal-Wallis ANOVA by ranks, H = 2.128, p = 0.546). With the exception of April, dissolved iron concentrations at HCSW-4 exceeded the trigger value of 0.3 mg/l established for that sampling station. HCSW-4 has a different trigger level for iron because it is located upstream of a segment of Horse Creek that is designated as Class I waters, which carry a lower standard value for iron (0.3 mg/l) than Class III waters (1.0 mg/l).

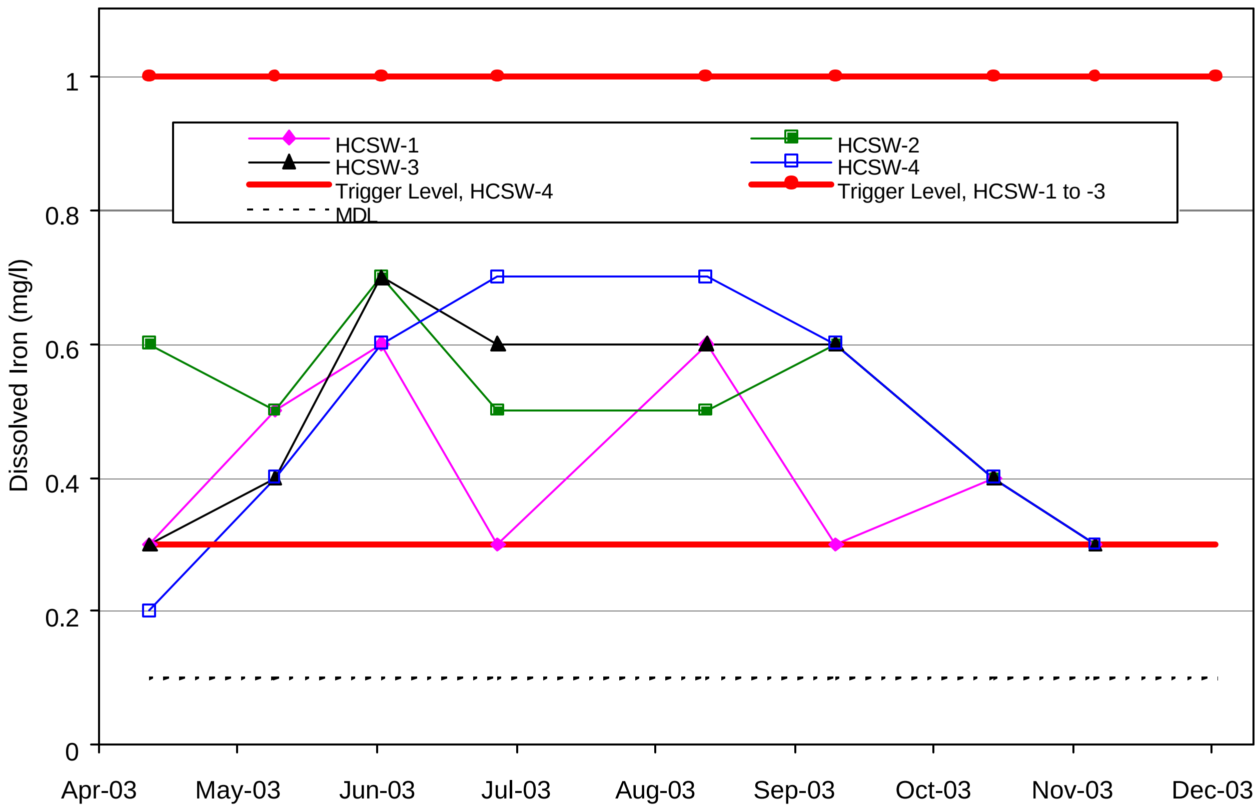

Figure 33. Dissolved Iron Concentrations Obtained During Monthly HCSP Water Quality Sampling in 2003.

Total alkalinity was significantly different among stations (one-factor ANOVA of log alkalinity, F = 3.602, p = 0.024), with highest levels at HCSW-1 and HCSW-4 (Duncan's post hoc test) (Figure 34). Levels of total alkalinity were well below the trigger value of 100 mg/l during 2003.

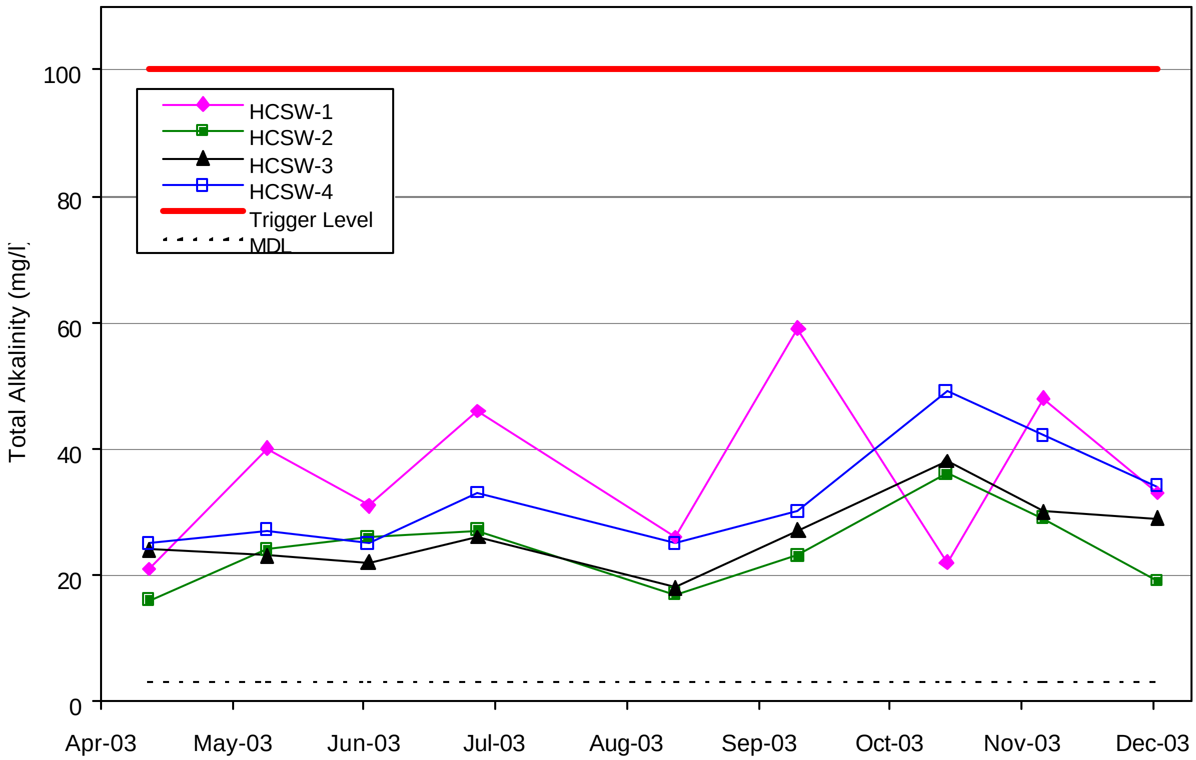

Figure 34. Levels of Total Alkalinity Obtained During Monthly HCSP Water Quality Sampling in 2003.

Chloride concentrations were not significantly different among stations during all sampling events (one-factor ANOVA, $F = 2.00$, $p = 0.13$) (Figure 35). Levels of chloride were below 30 mg/l during 2003, considerably lower than the trigger level of 250 mg/l.

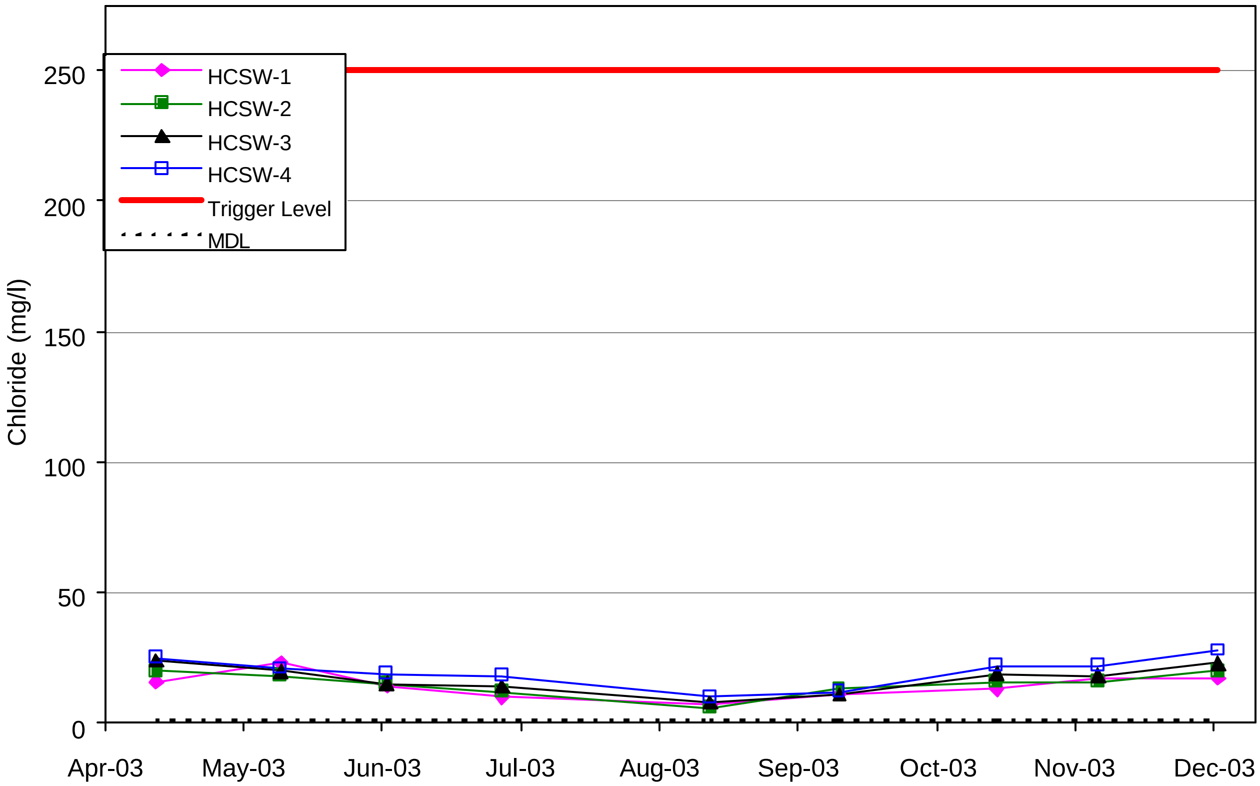

Figure 35. Chloride Concentrations Obtained During Monthly HCSP Water Quality Sampling in 2003.

Fluoride levels were below 0.5 mg/l during all sampling events at all stations and were not significantly different among sites (one-factor ANOVA, $F = 2.05$, $p = 0.125$) (Figure 36). Concentrations of fluoride were well below the trigger levels of 4.0 and 1.5 mg/l, established for HCSW-1, HCSW-2, and HCSW-3 and HCSW-4, respectively. As with iron, HCSW-4 has a different trigger level for fluoride than the other stations because of its proximity to Class I waters.

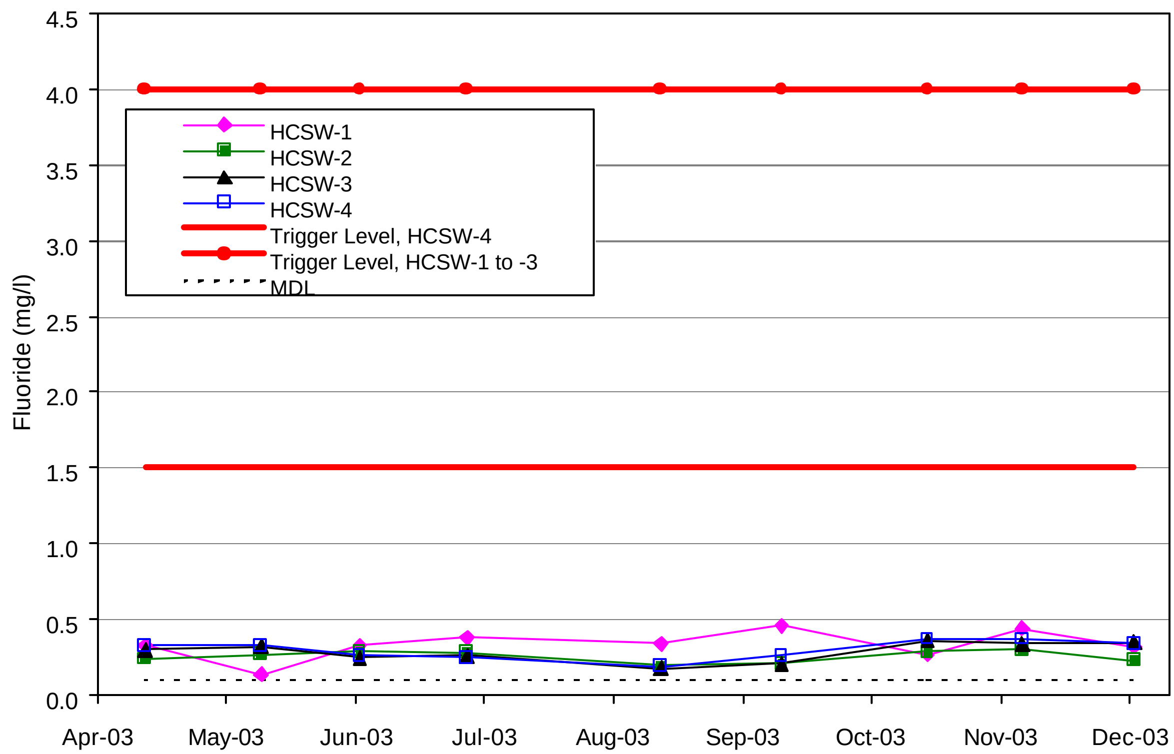

Figure 36. Fluoride Concentrations Obtained During Monthly HCSP Water Quality Sampling in 2003.

Sulfate concentrations were below the trigger level of 250 mg/l at all sampling stations during all sampling events (Figure 37). In 2003, levels of sulfate were significantly different among stations (one-factor ANOVA of log sulfate, $F = 11.10$, $p < 0.0001$), with lowest levels at HCSW-2 and highest at HCSW-3 and HCSW-4 (Duncan's post hoc test, $p < 0.05$). As with specific conductivity and calcium, sulfate concentrations may be higher downstream because of increased groundwater seepage or irrigation runoff.

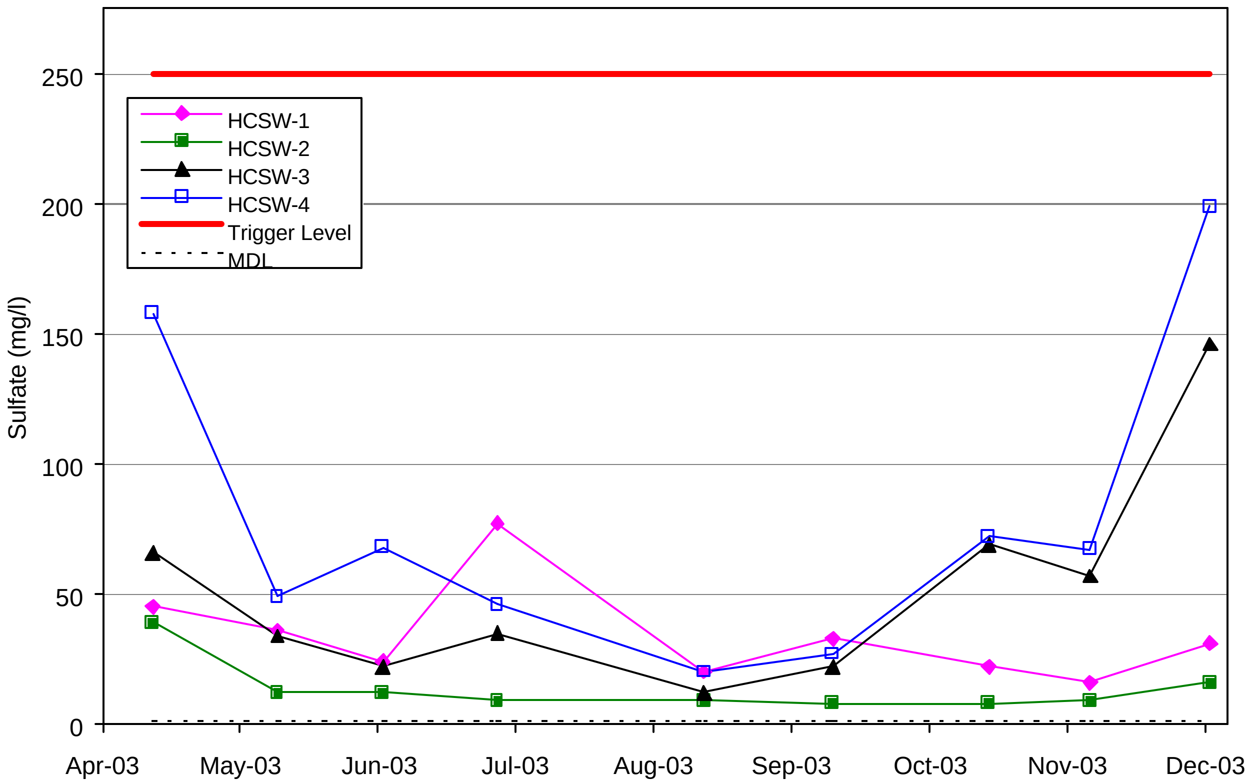

Figure 37. Sulfate Concentrations Obtained During Monthly HCSP Water Quality Sampling in 2003.

As with sulfate concentrations, total dissolved solids levels were lowest at HCSW-2 and highest at HCSW-3 and HCSW-4 (one-factor ANOVA of log TDS, $F = 5.59$, $p = 0.003$; Duncan's post hoc test, $p < 0.05$) (Figure 38). Total dissolved solids levels were below the trigger level of 500 mg/l during 2003. Both sulfate and total dissolved solids are probably affected by agricultural irrigation return flows in the same manner as discussed above for conductivity and calcium.

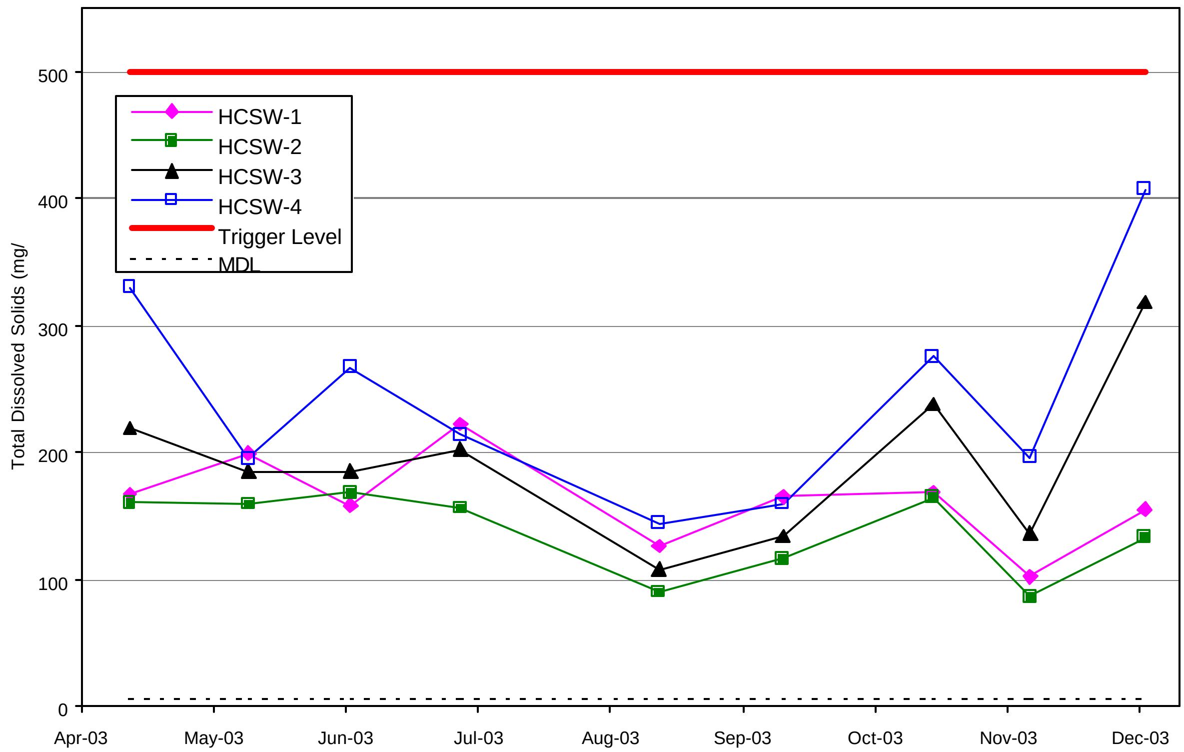

Figure 38. Levels of Total Dissolved Solids Obtained During Monthly HCSP Water Quality Sampling in 2003.

The phosphate benefication process that refines the mined phosphate ore uses several chemicals as reagents in the physio-chemical separation process. Three of these chemicals (fuel oil, fatty acids, and fatty amines) were selected for testing in the water-quality sampling program as potential indicator parameters of specific mining wastewater impacts. The FDEP Petroleum Range Organics (FL-PRO) test was selected as a test for fuel oil. Specific test methods were developed for fatty acids (obtained by Mosaic as a by-product of the paper industry and largely composed of oleic and linoleic acids) and fatty amines (fatty acids reacted with ammonia). PRO, fatty acid and amines all degrade biologically and/or photochemically within mine recirculation waters and clay settling areas. These organic parameters were added to the HCSP monitoring list as an extra safeguard, although it was Mosaic's position that they would never be present at detectable limits in any waters discharged from mining areas. Petroleum range organics, total fatty acids, and total amines were not detected at any sampling station in 2003.

Phosphate ore is a source of radioactivity as naturally occurring uranium-238 disintegrates into isotopes of radium and radon, which emit alpha waves in water. A water quality study of unmined and reclaimed basins in phosphate-mining areas found that radium concentrations of surface waters were higher in unmined areas than in reclaimed basins, probably because of undisturbed phosphate deposits on 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 2003, total radium levels were 2 pCi/1 or less during all sampling events at all stations (Figure 39) and were thus below the trigger level of 5 pCi/1 during 2003[3]. Total radium levels were not significantly different among stations (Kruskal-Wallis ANOVA by ranks test, $H = 3.974$, $p = 0.264$).

[3] 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. The data in Appendix E reflects these changes. Starting in December 2003 and continuing through the present, the data has been analyzed and reported as Radium 226 and Radium 228 separately. The PRMRWSA has recently requested that the data be reported as a sum of Radium 226 and Radium 228. The individual analysis of Radium 226 and 228 will continue. An arithmetic sum of the two numbers will be reported as "Radium 226 + 228" as well.

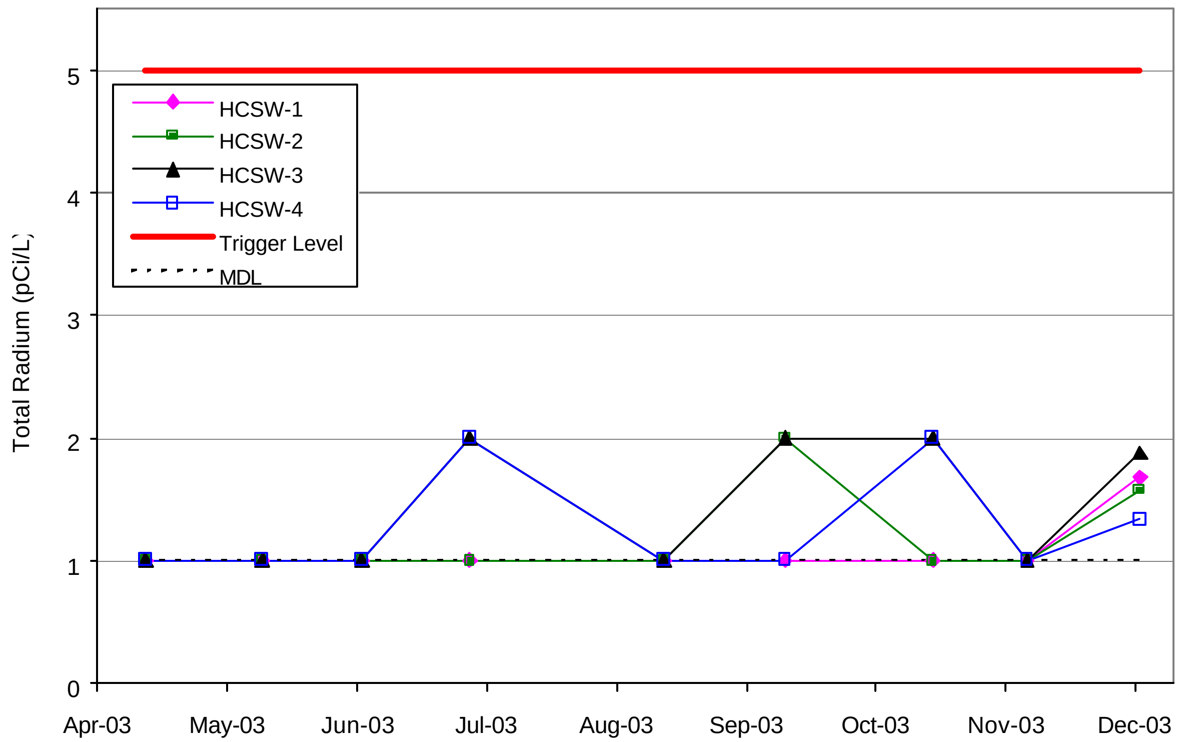

Figure 39. Levels of Total Radium Obtained During Monthly HCSP Water Quality Sampling in 2003.

5.2.4 Summary of Water Quality Results

Trends in water quality parameters toward the established trigger levels were not evaluated because this is the first annual report and only one year of data was available. However, we did evaluate whether HCSP trigger levels were exceeded. Water quality parameters were usually within the desirable range relative to trigger levels and water quality standards. Trigger levels were exceeded for dissolved oxygen at HCSW-2 and for iron at HCSW-4 (Table 13). Based upon the preliminary assessments provided in Appendices B and C, the reported values for iron and dissolved oxygen are the result of natural conditions and are not related to mining activities. From the limited data available after only nine months of sampling, there was no evidence of temporal trends that could be attributed to anything other than general wet season/dry season fluctuations, including the effect of irrigation water inflows, as just mentioned for color at HCSW-2. Significant differences between stations were evident for several parameters. Overall, HCSW-2 was the most dissimilar from the other three stations, especially in pH, dissolved oxygen, and some dissolved ions. Some nutrients (nitrate + nitrite and orthophosphate) and dissolved ions (specific conductivity, calcium, sulfate) had higher concentrations downstream in Horse Creek, probably because of increased groundwater seepage and agricultural runoff in the lower Horse Creek basin. Differences in topology, geology, and land use that could account for these trends in Horse Creek are examined in the Horse Creek Stewardship Program Historical Report (BRA 2005).

Table 13. Instances of Trigger Level Exceedance Observed in 2003 HCSP Monitoring.

Sampling Location	Station_ID	Date	Analyte	Concentration
Horse Creek at Goose Pond Road	HCSW-2	04/30/03	Dissolved Oxygen (mg/l)	1
Horse Creek at Goose Pond Road	HCSW-2	05/27/03	Dissolved Oxygen (mg/l)	1.3
Horse Creek at Goose Pond Road	HCSW-2	06/19/03	Dissolved Oxygen (mg/l)	1.1
Horse Creek at Goose Pond Road	HCSW-2	07/14/03	Dissolved Oxygen (mg/l)	1.7
Horse Creek at Goose Pond Road	HCSW-2	08/28/03	Dissolved Oxygen (mg/l)	3
Horse Creek at Goose Pond Road	HCSW-2	09/25/03	Dissolved Oxygen (mg/l)	1.3
Horse Creek at Goose Pond Road	HCSW-2	10/29/03	Dissolved Oxygen (mg/l)	2.9
Horse Creek at Goose Pond Road	HCSW-2	11/20/03	Dissolved Oxygen (mg/l)	2.8
Horse Creek at Goose Pond Road	HCSW-2	12/16/03	Dissolved Oxygen (mg/l)	4.1
Horse Creek at State Road 72	HCSW-4	05/27/03	Iron (mg/l)	0.40
Horse Creek at State Road 72	HCSW-4	06/19/03	Iron (mg/l)	0.60
Horse Creek at State Road 72	HCSW-4	07/14/03	Iron (mg/l)	0.70
Horse Creek at State Road 72	HCSW-4	08/28/03	Iron (mg/l)	0.70
Horse Creek at State Road 72	HCSW-4	09/25/03	Iron (mg/l)	0.60
Horse Creek at State Road 72	HCSW-4	10/29/03	Iron (mg/l)	0.40
Horse Creek at State Road 72	HCSW-4	12/16/03	Iron (mg/l)	0.32

5.3 BENTHIC MACROINVERTEBRATES

5.3.1 Stream Habitat Assessment

During all sampling events and for all stations, the habitat quality was within the optimal range (Table 14). The minor variation among the sampling events for a given station primarily reflects differences in habitat quality caused by changes in stream stage, which affects the availability and ratios of in-stream habitats. The majority of the habitat assessment parameters 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. Although water velocity and habitat smothering were slightly higher when NPDES discharge was elevated (July 2003), this also coincides with heavy rainfall and overall high discharge in Horse Creek (Figures 8 and 9).

Table 14. Habitat Scores Obtained During HCSP Biological Sampling Events

	HCSW-1			HCSW-2			HCSW-3			HCSW-4		
	25 Apr 2003	29 Jul 2003	20 Nov 2003	25 Apr 2003	29 Jul 2003	20 Nov 2003	25 Apr 2003	29 Jul 2003	20 Nov 2003	25 Apr 2003	29 Jul 2003	20 Nov 2003
Substrate Diversity	15	10	10	18	15	15	15	18	10	20	15	15
Substrate Availability	18	20	13	20	20	14	20	20	18	20	20	18
Water Velocity	10	20	17	10	18	13	13	18	17	15	18	17
Habitat Smothering	18	18	15	15	15	7	18	19	10	17	18	10
Artificial Channelization	15	15	5	16	16	18	18	18	18	15	15	15
Bank Stability												
Right Bank	8	8	9	8	8	9	8	8	8	8	8	8
Left Bank	8	8	9	8	8	8	8	8	8	8	8	8
Riparian Buffer Zone Width												
Right Bank	9	9	10	10	10	10	10	10	10	10	10	10
Left Bank	8	8	10	10	10	10	10	10	10	10	10	10
Riparian Zone Vegetation Quality												
Right Bank	9	9	10	10	10	10	10	10	10	10	10	10
Left Bank	8	8	10	10	10	10	10	10	10	10	10	10
Total Score*	**126**	**133**	**118**	**135**	**140**	**124**	**140**	**149**	**129**	**145**	**144**	**131**
Habitat Descriptor	Optimal	Optimal	Optimal	Optimal	Optimal	Optimal	Optimal	Optimal	Optimal	Optimal	Optimal	Optimal

* The maximum possible score under this protocol is 160.

5.3.2 Stream Condition Index

A listing of the benthic macroinvertebrate taxa collected during 2003 is presented in Table F1 in Appendix F. Table 15 provides the SCI metrics, resulting SCI values, and total SCI scores calculated for the benthic macroinvertebrates collected at the four stations during each sampling event. Please note that the number of individuals included in Table 15 represents the number extrapolated for the entire sample (i.e., all 20 dipnet sweeps), while numbers of individuals listed in Table F1 are the actual number of individuals in the subsample analyzed by the taxonomist (only a portion of each sample is sorted and processed, per the SOP). The various components of the SCI calculations are briefly described in the subsections below.

5.3.2.1 Total Taxa

In general, a healthy stream system will support colonization by a diverse number of taxa. Therefore, the more taxa a station is shown to have, the healthier that system is regarded. Figure 40 illustrates the number of taxa collected at each of the proposed receiving-waters stations during the quarterly events. For HCSW-1, HCSW-3, and HCSW-4, the highest number of individual benthic macroinvertebrates was collected during April, but often only by a small margin. The fewest individuals were collected in July at all stations but HCSW-2 as a result of very high water levels from the large amount of rainfall received in late June. Low sample size in July is largely a sampling artifact and does not reflect lessened habitat quality in the stream. Differences in taxa numbers among samples are expected, both spatially and temporally, as a result of natural variability, as well as differences in sampling conditions and sample processing, even when the invertebrate communities are very similar.

Table 15. SCI Metrics Calculated for Benthic Macroinvertebrates Collected at Four Locations on Horse Creek for the HCSP During 2003

SCI Metric	**HCSW-1**						**HCSW-2**					
	25 April 2003		**29 July 2003**		**20 November 2003**		**25 April 2003**		**29 July 2003**		**20 November 2003**	
	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	28	**4.8**	22	**2.4**	27	**4.4**	34	**7.2**	22	**2.4**	31	**6.0**
Ephemeropteran Taxa	4	**8.0**	2	**4.0**	2	**4.0**	3	**6.0**	0	**0.0**	1	**0.0**
Trichopteran Taxa	2	**2.9**	2	**2.9**	3	**4.3**	3	**4.3**	0	**0.0**	0	**0.0**
Percent Collector-Filterer Taxa	34.3	**8.5**	78.2	**10**	34.6	**8.6**	44	**10**	68.2	**10**	20.7	**5.0**
Long-lived Taxa	4	**10**	5	**10**	4	**10**	4	**10**	2	**5.0**	3	**7.5**
Clinger Taxa	3	**3.8**	7	**8.8**	5	**6.3**	2	**2.5**	0	**0.0**	0	**0.0**
Percent Dominant Taxon	28.6	**5.8**	71.4	**0.0**	29	**5.7**	25.7	**6.4**	66.2	**0.0**	17.9	**8.2**
Percent Tanytarsini	8.6	**6.8**	0	**0.0**	2.8	**4.0**	4.2	**5.0**	0	**0.0**	6.8	**6.2**
Sensitive Taxa	4	**4.4**	6	**6.7**	3	**3.3**	1.0	**1.1**	0	**0.0**	0	**0.0**
Percent Very Tolerant Taxa	0.7	**8.7**	2	**7.3**	0.0	**10**	5.4	**5.5**	17.1	**2.9**	21.0	**2.5**
Total SCI Score	**70.8**		**57.7**		**67.4**		**64.4**		**22.6**		**37.4**	
Interpretation	**Fair**		**Fair**		**Fair**		**Fair**		**Poor**		**Poor**	
Total Number of Individuals	1,120		147		214		668		1,332		972	

SCI Metric	**HCSW-3**						**HCSW-4**					
	25 April 2003		**29 July 2003**		**20 November 2003**		**25 April 2003**		**29 July 2003**		**20 November 2003**	
	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	30	**5.6**	13	**0**	29	**5.2**	34	**7.2**	28	**4.8**	27	**4.4**
Ephemeropteran Taxa	3	**6.0**	0	**0**	3	**6.0**	4	**8.0**	5	**10**	4	**8.0**
Trichopteran Taxa	3	**4.3**	0	**0**	2	**2.9**	2	**2.9**	3	**4.3**	2	**2.9**
Percent Collector-Filterer Taxa	71.5	**10**	77.1	**10**	14.7	**3.5**	34.2	**8.5**	13.3	**3.2**	17.5	**4.2**
Long-lived Taxa	2	**5.0**	3	**7.5**	4	**10**	4	**10**	2	**5.0**	4	**10**
Clinger Taxa	4	**5.0**	1	**1.3**	6	**7.5**	3	**3.8**	5	**6.3**	5	**6.3**
Percent Dominant Taxon	61.1	**0.0**	77.1	**0**	23.9	**6.9**	30.8	**5.3**	15.2	**8.8**	25.8	**6.4**
Percent Tanytarsini	1.4	**2.6**	0	**0**	0.0	**2.0**	2.3	**3.6**	5.1	**5.5**	1.7	**3.0**
Sensitive Taxa	2	**2.2**	0	**0**	4	**4.4**	2	**2.2**	5	**5.6**	4	**4.4**
Percent Very Tolerant Taxa	10.1	**4.1**	2.4	**7**	1.8	**7.5**	0.8	**8.6**	15.2	**3.2**	1.7	**7.6**
Total SCI Score	**49.8**		**28.6**		**62.0**		**66.7**		**62.8**		**63.5**	
Interpretation	**Fair**		**Poor**		**Fair**		**Fair**		**Fair**		**Fair**	
Total Number of Individuals	2,368		83		327		1,064		79		720	

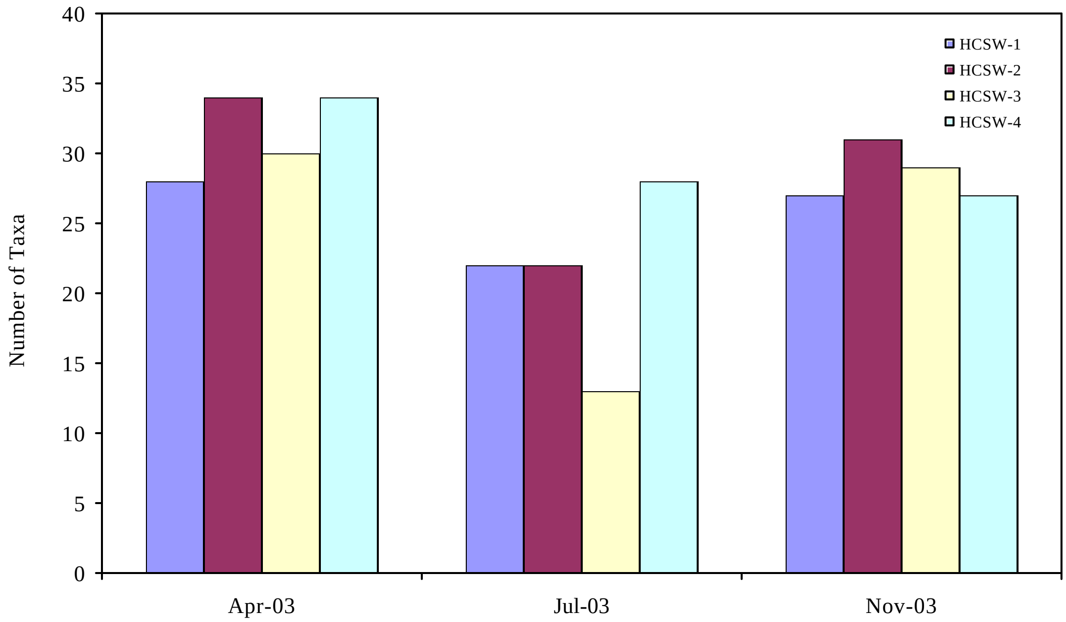

Figure 40. Number of Invertebrate Taxa Collected from the Horse Creek Stewardship Project in 2003.

5.3.2.2 Ephemeroptera Taxa

Ephemeropterans (mayflies) are typically associated with more pristine waters and better habitat conditions. A higher taxa count for this group is associated with better habitat value. At least one mayfly taxon must be present to score a SCI metric above zero. None were collected during the July event at HCSW-3 and HCSW-3, therefore, those stations received a zero for the metric on that date. The greatest number of mayfly taxa collected at any station during any event was five. Although the number of Ephemeroptera taxa was as high as six at some sites used in developing the SCI calculation protocols, typical samples produce only 0-2 taxa (Fore 2004). This is consistent with the findings from the Horse Creek stations (Table 15).

5.3.2.3 Trichoptera Taxa

Trichopterans (caddisflies) are also associated with more pristine waters and better habitats, so higher counts of caddisflies are associated with better ecological conditions. At least one taxon must be collected in order for the SCI metric to be above zero. This metric was zero for HCSW-2 in both July and December, and for HCSW-3 in July. The greatest number of caddisfly taxa in any sample was three (in each of four samples representing all three sampling events). According to Fore (2004), caddisfly taxa ranged from zero to eight in samples used for calibrating the SCI protocol, with most samples having four or fewer taxa. This is quite comparable to the observed pattern from Horse Creek in 2003 (Table 15).

5.3.2.4 Percent Collector-Filterer Taxa

Taxa whose functional feeding group is "collector-filterer" are often more prolific in pristine natural waters. A reduction in the collector-filterer community can indicate a water quality problem. The SCI metric increases as the percentage of a sample comprised by these taxa increases. To score above zero for this metric, more than one percent of the sample must be composed of collector-filterers. Samples at each station during each 2003 event were composed of at least 15 percent collector-filterers, with a maximum of 78 percent (Table 15). This is within the range reported by Fore (2004) in developing the SCI calculation protocol. For all stations except HCSW-4, the highest percentage of filter-collectors was found in the July samples; the basis for this difference is unclear.

5.3.2.5 Long-lived Taxa

Long-lived taxa are those that require more than one year to complete their life cycles (Fore, 2004), so they would not be expected in great numbers in intermittent streams or tributaries that go dry before their life cycle can be completed. Some long-lived taxa might also be less frequently encountered in less pristine waters, where these taxa could be exposed to potential contaminants for longer than their short-lived counterparts. To score above zero for this SCI metric, at least one long-lived taxon must be present in a sample; each station met this threshold during each event. The observed range of long-lived taxa (2 - 5 taxa) in samples collected from Horse Creek in 2003 (Table 15) corresponds with the range used to develop the SCI methodology (Fore 2004). Overall, the greatest number of long-lived taxa was collected from HCSW-1, but the small number of taxa collected and small sample size make it difficult to show differences among the stations for this group.

5.3.2.6 Clinger Taxa

Taxa whose mode of existence is identified as clinging by Merritt and Cummins (1996) are defined as "having behavioral (e.g., fixed retreat construction) and morphological adaptations for attachment to surfaces in stream riffles." The SCI 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. No clinger taxa were found at HCSW-2 during the July or November events, and only two species were found there during April (Table 15). This is presumed to be the result of more sluggish flow conditions at that station, which yields conditions not generally suited for clingers that prefer riffles. Clinger taxa were found at the other three stations at all sampling events, with the most in any sample being seven (Table 15). While Fore (2004) reported more than ten clinger taxa in some cases, most samples used to develop the SCI protocol had less than five taxa.

5.3.2.7 Percent Dominant Taxon

As the contribution of the dominant taxon increases, the diversity of taxa within a system generally decreases. Therefore, higher percent contribution by one taxon is interpreted as less ecologically desirable, and lowers the numerical value associated with this metric. The SCI score is zero if the percentage contribution of the dominant taxon is at or above 54 percent, which was the case at three of the four stations in July 2003. Overall, nine of the 12 samples had a single taxon representing more than one fourth of the invertebrate community (Table 15). For eight of the 12 samples, a mollusk dominated the sample; the exotic clam *Corbicula fluminea* was dominant at three stations during at least one sampling event, and the snail *Pisidium* sp. and fingernail clam *Musculium lacustre* were dominant at HCSW-2 during the April and July events, respectively. Beetles (Coleoptera) dominated the November samples from HCSW-2, 3 and 4, and the mayfly *Stenonema exiguum* dominated the relatively small sample from HCSW-4 in July (see Appendix F).

5.3.2.8 Percent Tanytarsini

Species in the chironomid tribe Tanytarsini (comprising several genera found in Florida) are commonly associated with less disturbed sites. Therefore, as the percentage of Tanytarsini increases for a sampling site, the SCI metric score also increases. If no Tanytarsini individuals are collected in a sample, this SCI metric score is zero; this occurred at three of the four stations in July 2003. The contribution by Tanytarsini was less than ten percent in all 2003 samples (Table 15).

5.3.2.9 Sensitive Taxa

Sensitive taxa are those that have been identified as sensitive to human disturbance (Fore, 2004). Using this definition, one would expect to find more sensitive taxa in undeveloped "natural" areas as opposed to developed watersheds. At least one sensitive taxon must be collected to raise this SCI metric score above zero. The number of sensitive taxa collected at Horse Creek stations in 2003 ranged from zero (in three samples) to six (Table 15). That only one sensitive taxon was collected from HCSW-2 corroborates well with the lower dissolved oxygen regime at that station and the sluggish nature of the stream segment there, as caused by its proximity to the Horse Creek Prairie.

5.3.2.10 Percent Very Tolerant Taxa

Fore (2004), classified a number of taxa as "very tolerant", meaning they are commonly present in areas with marked human disturbance (although they may also be found in undisturbed sites). More disturbed and/or developed areas, therefore, would be expected to have a higher percentage of tolerant taxa in comparison to areas that have not experienced human disturbance. This SCI metric is similar to the percent contribution of dominant taxa in that, as the fraction of a sample comprised by tolerant taxa increases, the calculated metric decreases. If the percentage of very tolerant taxa reaches or surpasses fifty-nine percent, the SCI metric is zero. This did not occur during the 2003 sampling period at any station, with the highest value being 21 % (Table 15).

5.3.2.11 SCI Overall Score

Final SCI scores for the samples ranged from about 23 to 71 (Table 15 and Figure 41). As reflected in Figure 37, nine of the samples are thus interpreted as indicating "Fair" conditions, and the other three as "Poor" (see Table 6 for interpretation of scores). Simply taking the mean of the SCI scores for each station would imply that HCSW-1 (65.3) and HCSW-4 (64.3) harbor more desirable communities than HCSW-2 (41.5) or HCSW-3 (46.8). However, the poor sampling conditions during the July event make such a comparison unreliable. Future sampling will improve the relevance of comparisons across the stations to allow for more robust conclusions.

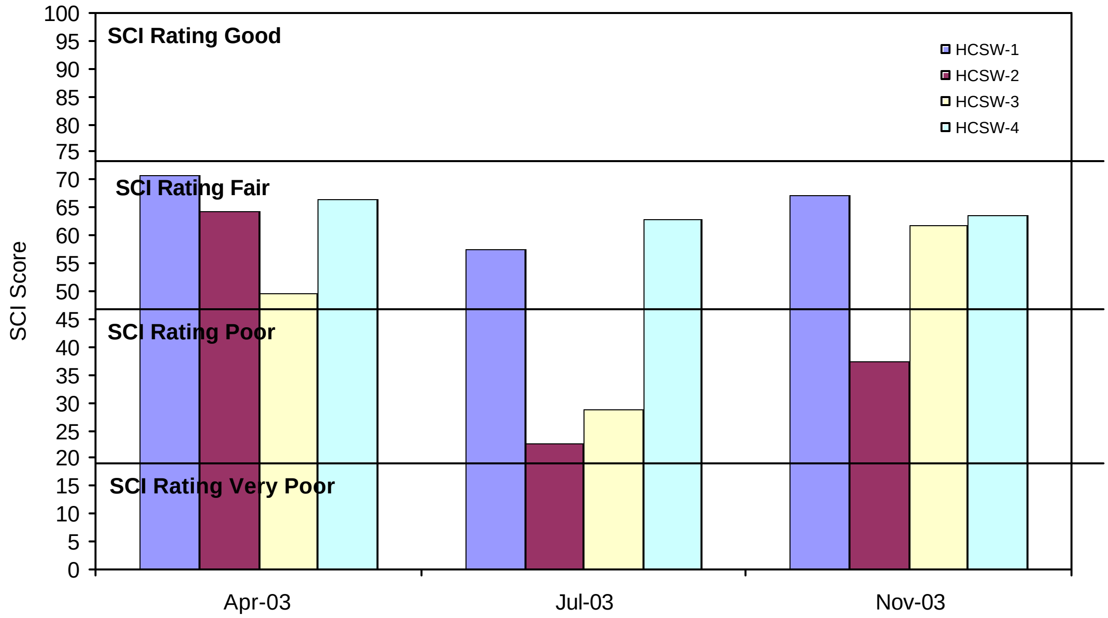

Figure 41. SCI Scores for Samples Collected from Horse Creek, 2003.

5.3.3 Shannon-Wiener Diversity Index

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

$$H' = \overset{S}{\underset{i=1}{?}} (p_i)(\log_2 p_i)$$

where, H' = Information content of sample (bits/individual), index of species diversity,
S = Number of species, and
p_i = Proportion of total sample belonging to ith species.

The Shannon-Wiener Index, H', increases with the number of species 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 species and their relative abundance; a greater number of species and a more even distribution of individuals across species both increase diversity as measured by H'. For example, consider two communities, each with 100 individuals of 10 species captured. Community A is dominated by one species (91 of 100 individuals), while only one individual was captured for each of the other nine species. Community B, however, is even, with 10 individuals captured for each of the ten species. 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 species.

In Horse Creek in 2003, the Shannon-Wiener Diversity Index ranged from 1.4 to 3.9, with higher diversity values occurring for the April and November events than for July (because of high water inhibiting the July sample collection) (Table 16). When results from all events were combined by station, HCSW-3 showed the highest benthic macroinvertebrate diversity (3.9) and HCSW-4 the lowest (3.0).

Table 16. Summary of Shannon-Wiener Diversity Indices for Benthic Macroinvertebrates from Four Stations on Horse Creek on 25 April, 29 July, and 20 November 2003

Event	HCSW-1		HCSW-2		HCSW-3		HCSW-4		All Stations Combined	
	Estimate	***90% Confidence Limits****	***Estimate***	***90% Confidence Limits***	***Estimate***	***90% Confidence Limits***	***Estimate***	***90% Confidence Limits***	***Estimate***	***90% Confidence Limits***
25 April 2003	3.5	3.2-3.7	3.7	3.4-3.9	2.3	2.1-2.5	3.8	3.5-4.1	3.9	3.8-4.0
29 July 2003	1.9	1.6-2.2	1.9	1.7-2.2	1.4	0.9-1.7	3.9	3.7-4.2	3.5	3.3-3.7
20 November 2003	3.5	3.2-3.7	3.8	3.6-3.9	3.7	3.5-3.9	3.6	3.3-3.9	4.6	4.5-4.7
All Dates Combined	3.5	3.2-3.7	3.5	3.2-3.7	3.9	3.7-4.0	3.0	2.8-3.2		

* - 90% confidence limits are automatically provided by the software used to calculate the index values (Ecological Methods v 6.1.1, Exeter Software 2003)

5.3.4 Taxa Abundance

Although it is not a component of the SCI protocol, the total number of specimens from each station was also evaluated as a supplemental ecological measure (Figure 42 and Table 15). From Figure 42, the wide variation in sample size is evident, and reviewing this figure along with data in Appendix F indicates the manner in which one or two taxa can dramatically increase the overall sample size (e.g., 181 of the 296 specimens picked from the April HCSW-3 sample were *Corbicula fluminea*.

It is important to keep in mind that the SCI metric calculations were developed for samples that contain at least 100 to 125 individuals, and samples with fewer individuals are not expected to yield valid SCI results. If the target range of 100 to 125 individuals was not reached in a given sample, as occurred at HCSW-3 and HCSW-4 during July of 2003, the SCI results cannot be considered to be comparable to those for larger samples. This may explain why HCSW-3 was evaluated as "Poor" by the SCI index in July 2003.

5.3.5 Summary of Benthic Macroinvertebrate Results

The SCI value calculated for each individual metric, as well as the total SCI scores, was always lowest during the July sampling event. High water levels present as a result of the unusually large rainfall received in late June probably lowered SCI scores and benthic macroinvertebrate species diversity. Macroinvertebrates may be washed from the stream during high streamflow, resulting in lower invertebrate diversity during and after high rainfall events.

The brief discussion of each of the SCI parameters above implies two important aspects of this particular ecological metric. First, there can be a large degree of variability among stations and among samples from the same station for a given calculated metric. Second, the actual range over which many of the measured parameters fluctuates can be very small, particularly for the parameters relying on integer counts of taxa (e.g., Ephemeroptera taxa generally ranging between 0 and about 4 across the various stream types evaluated in developing the SCI). These considerations suggest that care should be exercised in using any individual metric of the SCI as a separate indicator of stream habitat quality. This is the justification for combining all the parameters into a composite index that presumably has a stronger correlation to stream conditions than the separate metrics themselves.

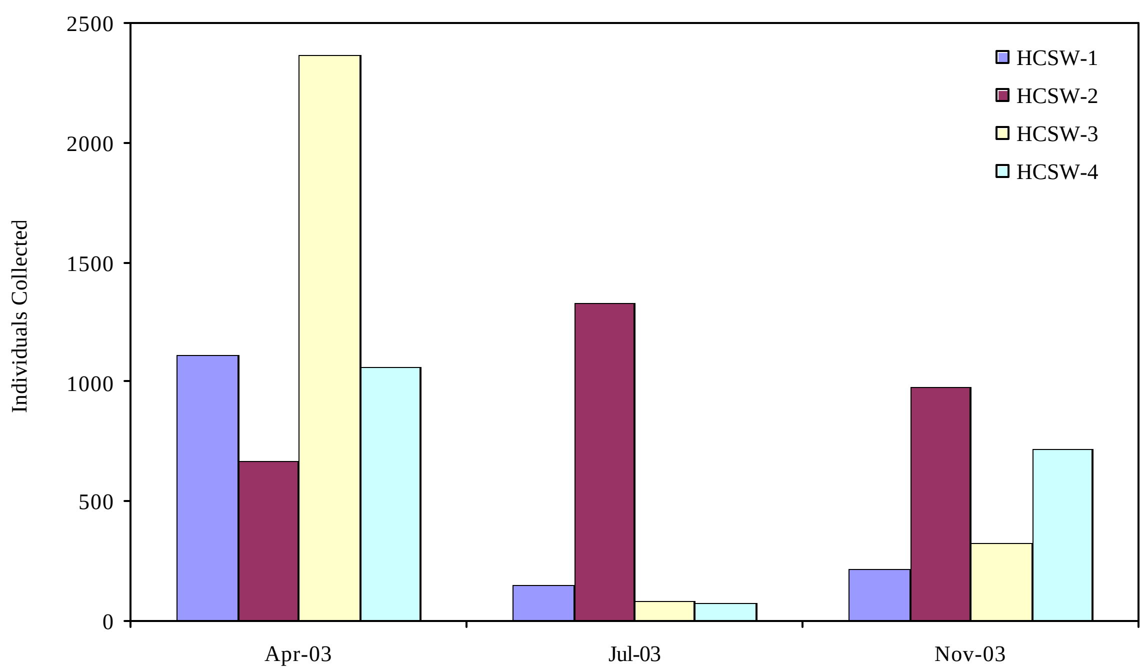

Figure 42. Invertebrate Abundances in Samples Collected from Horse Creek in 2003 (values are extrapolated based upon numbers of individuals sorted from known proportions of samples).

The general quality of the macroinvertebrate community at the Horse Creek stations was within the range commonly observed by BRA in similarly-sized natural streams in this region of Florida. It may appear inconsistent that the Habitat Assessment scores all indicated optimal conditions at all locations during all sampling events, while the total SCI scores indicated that the benthic communities were Fair or Poor. However, this is essentially a matter of semantics resulting from the assignment of qualitative categories under the two different assessment protocols (which were developed independently and not necessarily designed to provide matching qualitative assignments for a given location). Following the adoption of the revised SCI calculation procedure, DEP found that the majority of the reference/background stations it had sampled fell into the Fair category when calculated under the new SCI (R. Frydenbourg, pers. comm.). This indicates that the sampled segments of Horse Creek are comparable in quality (as determined via the SCI) to other reference streams in Florida, particularly given that two of the three occasions when the benthic community was found to be in the Poor category occurred in July, almost certainly the result of poor sampling conditions during high water.

5.4 FISH

During 2003, thirty species of fish were collected from the four Horse Creek sampling stations; they are listed in Table 17 (Appendix G provides the same listing with scientific nomenclature for the species). Of the native species collected, most were quite common regionally and none were unexpected for this portion of Florida. Catfishes, killifishes and sunfishes were the most commonly collected groups.

Four of the 30 species are not native to Florida: the walking catfish (*Clarias batrachus*), African jewelfish (*Hemichromis letourneauxi*), oriental weatherfish (*Misgurnus anguillicaudatus*), and sailfin catfish (*Pterygoplichthys multirandians*). Walking catfish were collected at HCSW-1 and HCSW-2 on 29 July and 20 November 2003 (Table 17). African jewelfish were only collected during the November sampling event, and only from HCSW-3 and HCSW-4. Oriental weatherfish were only found at HCSW-2, on 25 April and 20 November (Table 17). Two sailfin catfish were collected at HCSW-1 and HCSW-4, during the July and November sampling events.

5.4.1 Taxa Richness and Abundance

The greatest numbers of individual fish were collected on 25 April 2003, followed by 20 November 2003 (Table 17), and more species of fish were collected during November as compared to the other two sampling events. Compared to the other sampling events, the least number of individuals and species were collected on 29 July 2003 (Table 17), primarily because of poor sampling conditions.

Usually, most of the individuals collected at a sampling station consisted of eastern mosquitofish. This can generally be attributed to site conditions that are very conducive to seining for small species. The fewest fish species were collected at HCSW-1 during all sampling events (Table 17). In April and July, more species were found at HCSW-4 as compared to the other stations, while in November, more species were collected at HCSW-3. When combining sampling events, the most species of fish were collected at HCSW-4 (Table 17).

Small numbers (as few as one) of individual fish were collected for most of the species found in 2003 (Table 17). Warmouth (*Lepomis gulosus*), bluegill (*Lepomis macrochirus*), spotted sunfish (*Lepomis punctatus*), and coastal shiners (*Notropis petersoni*) were collected at all four sampling stations the majority of the time. Eastern mosquitofish were the only species of fish collected at all sampling stations during all 2003 sampling events.

Table 17. Fish Collected from Horse Creek on 25 April, 29 July, and 20 November 2003.

	HCSW-1				***HCSW-2***				***HCSW-3***				***HCSW-4***			
Common Name	***4/25/2003***	***7/29/2003***	***11/20/2003***	***All Dates***	***4/25/2003***	***7/29/2003***	***11/20/2003***	***All Dates***	***4/25/2003***	***7/29/2003***	***11/20/2003***	***All Dates***	***4/25/2003***	***7/29/2003***	***11/20/2003***	***All Dates***
longnose gar	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1
Florida gar	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1
taillight shiner	0	0	0	0	0	0	0	0	0	0	5	5	0	1	0	1
coastal shiner	19	1	2	22	1	0	0	1	79	5	25	109	11	9	11	31
lake chubsucker	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0
oriental weatherfish	0	0	0	0	1	0	2	3	0	0	0	0	0	0	0	0
brown bullhead	3	0	0	3	0	1	0	1	0	0	0	0	1	0	1	2
yellow bullhead	0	0	1	1	0	0	0	0	0	0	0	0	1	0	0	1
channel catfish	0	0	0	0	0	0	0	0	0	0	1	1	0	0	2	2
tadpole madtom	0	0	1	1	0	0	0	0	0	0	0	0	1	0	0	1
walking catfish	0	0	1	1	0	1	0	1	0	0	0	0	0	0	0	0
sailfin catfish	0	0	1	1	0	0	0	0	0	0	0	0	0	1	0	1
Seminole killifish	0	0	0	0	0	0	0	0	12	3	9	24	3	12	0	15
golden topminnow	0	0	0	0	0	0	3	3	0	1	0	1	0	3	0	3
flagfish	0	0	0	0	0	0	7	7	0	0	0	0	0	0	2	2
bluefin killifish	0	0	0	0	0	4	0	4	0	1	1	2	0	3	0	3
eastern mosquitofish	170	2	9	181	116	86	83	285	112	171	239	522	10	57	59	126
least killifish	0	0	0	0	18	28	12	58	80	15	2	97	1	6	1	8
sailfin molly	0	0	0	0	3	0	17	20	36	1	13	50	10	21	7	38
brook silverside	0	0	2	2	0	0	0	0	5	10	9	24	2	4	6	12
Everglades pygmy sunfish	0	0	0	0	0	0	0	0	0	1	0	1	0	1	0	1
bluespotted sunfish	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0
warmouth	3	0	2	5	6	12	10	28	0	0	1	1	0	1	8	9
spotted sunfish	26	0	7	33	5	1	1	7	27	2	6	35	11	10	12	33
bluegill	7	0	0	7	2	2	0	4	2	2	3	7	5	1	0	6
redear sunfish	0	0	0	0	1	0	0	1	0	0	0	0	0	0	2	2
largemouth bass	0	1	0	1	0	0	0	0	2	3	1	6	1	0	1	2
swamp darter	1	0	0	1	1	2	2	5	1	0	2	3	2	1	0	3
African jewelfish	0	0	0	0	0	0	0	0	0	0	1	1	0	0	14	14
hogchoker	0	0	0	0	0	0	0	0	4	0	7	11	1	2	1	4
Total	229	4	26	259	155	137	138	430	360	215	325	900	62	133	127	322

5.4.2 Shannon-Wiener Diversity Index

Diversity of individual fish samples ranged from 0.7 (HCSW-1, July) to 3.1 (HCSW-4, April) (Table 18). When fish samples were combined across all sampling events, the highest species diversity was calculated for HCSW-4, and HCSW-1 had the lowest diversity (Table 18). When all stations were combined across sampling dates, Shannon-Wiener Diversity Index values were fairly similar for all sampling events. Diversity generally increased as the distance between the station and the confluence of Horse Creek and Peace River decreased.

Table 18. Summary of Shannon-Wiener Diversity Indices and 90% Confidence Limits for Fish Collected from Four Stations on Horse Creek on 25 April, 29 July, and 20 November 2003

Event	HCSW-1		HCSW-2		HCSW-3		HCSW-4		All Stations Combined	
	Estimate	*90% Confidence Limits**	*Estimate*	*90% Confidence Limits*	*Estimate*	*90% Confidence Limits*	*Estimate*	*90% Confidence Limits*	*Estimate*	*90% Confidence Limits*
25 April 2003	1.3	1.1-1.5	1.4	1.1-1.6	2.5	2.4-2.6	3.1	2.8-3.3	2.4	2.3-2.5
29 July 2003	0.7	0.0-1.0	1.6	1.4-1.8	1.2	1.0-1.5	2.7	2.4-2.9	2.1	1.9-2.3
20 November 2003	2.3	1.8-2.7	1.9	1.7-2.2	1.6	1.4-1.8	2.6	2.3-2.8	2.3	2.1-2.5
All Dates Combined	1.5	1.4-1.7	1.8	1.7-1.9	2.2	2.1-2.3	3.1	2.9-3.3		

* - 90% confidence limits are automatically provided by the software used to calculate the index values (Ecological Methods v 6.1.1, Exeter Software 2003)

5.4.3 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:

$$C_l = \frac{2\sum X_{ij} X_{ik}}{(l_1 + l_2) N_j N_k}$$

Where C_l = 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 = ΣX_{ij} = Total number of individuals in sample *j*

N_k = ΣX_{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). The index was formulated for counts of individuals and not for other abundance estimates based on biomass, productivity, or cover.

Table 19 includes Morisita's Indices calculated for each station, as well as all stations combined, by sampling event. Values ranged from 0.64 (HCSW-3, comparing April and July) to 0.99 (HCSW-3, comparing July and November). When combining all sampling locations, fish communities were similar for all sampling events. The fish community at HCSW-2 was similar throughout 2003, while at other stations the communities in July and November were more similar to each other than to the April community.

Although Morisita's Index is robust to differences in sample size, the number of individuals at HCSW-1 in July 2003 was four, thereby inflating similarity measures of this sample with other dates or stations.

Values of Morisita's Index were also calculated for each sampling event, as well as all events combined, for each station (Table 20). The lowest value of 0.39 was calculated when comparing HCSW-2 to HCSW-4 during April, while the highest reasonable value of 0.98 was calculated comparing HCSW-1 to HCSW-2 in April. Fish communities were fairly similar at all stations when sampling events were combined. Stations were most dissimilar in April 2003.

Table 19. Morisita's Similarity Index Values Comparing Sampling Dates within Stations for 2003 Samples.

Event	HCSW-1		HCSW-2		HCSW-3		HCSW-4		All Stations Combined	
	29 July 2003	20 November 2003	29 July 2003	20 November 2003	29 July 2003	20 November 2003	29 July 2003	20 November 2003	29 July 2003	20 November 2003
25 April 2003	1.06	0.78	0.98	0.97	0.64	0.67	0.75	0.65	0.95	0.95
29 July 2003		1.20		0.97		0.99		0.94		0.99

Table 20. Morisita's Similarity Index Values Comparing Stations within Sampling Dates for 2003 Samples.

Station	25 April 2003			29 July 2003			20 November 2003			All Dates Combined		
	HCSW-2	HCSW-3	HCSW-4	HCSW-2	HCSW-3	HCSW-4	HCSW-2	HCSW-3	HCSW-4	HCSW-2	HCSW-3	HCSW-4
HCSW-1	0.98	0.66	0.46	1.03	1.01	1.18	0.75	0.73	0.93	0.96	0.96	0.84
HCSW-2		0.68	0.39		0.95	0.84		0.96	0.92		0.97	0.83
HCSW-3			0.77			0.81			0.89			0.91

5.4.4 Species Accumulation Curves

One way to determine when enough individuals in a community have been sampled for calculating species diversity with some level of confidence is to plot the cumulative number of species collected across the sampling events. The result should be a curve that increases steeply at first when new species are continually being found, then gradually levels off when new species become very rare. The asymptote of the curve indicates the point at which additional sampling will provide no additional species. The total number of species in a community, as well as the number of rare species, strongly influences how many species must be collected to offer some certainty that most species have been reported. As indicated by the curves plotted for each of the sampling locations, as well as that for all stations combined, we continue to add species with each sampling event and the curve has not leveled off (Figure 43). This suggests that additional species will likely be collected in the future.

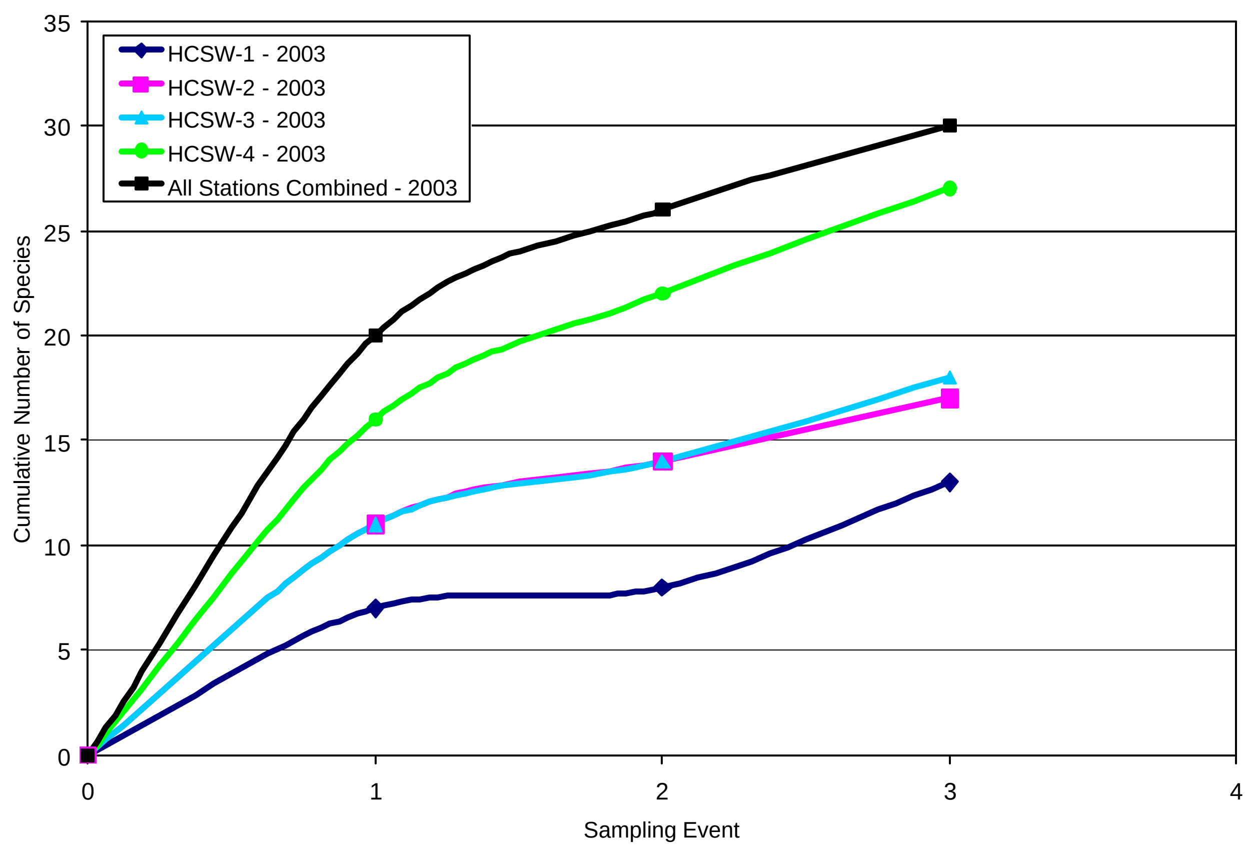

Figure 43. Cumulative Numbers of Fish Species Collected at Horse Creek Stations During 2003.

5.4.5 Summary of Fish Results

Thirty species of fish were collected in 2003. We expect to add more species during future monitoring events, because the species accumulation curves based on the three samples collected in 2003 have not leveled off. Several native species are almost certainly present in Horse Creek but were not collected in 2003. These include species such as the American eel (*Anguilla rostrata*), bowfin (*Amia calva*), white catfish (*Ameiurus catus*), pirate perch (*Aphredoderus sayanus*), and black crappie (*Pomoxis nigromaculatus*). The thirty species of fish that were collected included four introduced species: walking catfish, African jewelfish, oriental weatherfish, and sailfin catfish. Introduced species rank second only to habitat destruction in their effects on native species, communities, and ecosystems (Wilson 1992, Parker et al. 1999). Over 30 species of introduced 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. Because of this, we expect to continue to collect additional introduced species in Horse Creek during future monitoring events as new introductions occur and as introduced species continue to expand their ranges in Florida.

Because of high flows during the July sampling event resulting from the heavy rains in late June, the fewest number of species and individual fish were collected on 29 July 2003, as compared to the other two sampling events. This trend was similar to what was observed for benthic macroinvertebrates. Fish species number and diversity were lowest at the most upstream Horse Creek station and highest at the most downstream station. This pattern of longitudinal zonation of increasing species diversity with increasing stream order is typical of stream systems (Harrel et al. 1967, Whiteside and McNatt 1972, Sheldon 1988). Fish communities were similar for all sampling events when locations were combined and for all locations when events were combined.

Table 21. Percentage of individual fish captured for three fish families in Horse Creek during 2003 as part of the Horse Creek Stewardship Program.

Fish Family	HCSW-1	HCSW-2	HCSW-3	HCSW-4	Total
Poeciliidae	69 %	84 %	74 %	53 %	72 %
Cyprinodontidae	0 %	6 %	3 %	7 %	3 %
Centrarchidae	18 %	10 %	5 %	16 %	10 %

Fish play an integral role in freshwater ecosystems, serving as both predators and prey in the food web. In Florida, fish belonging to families Cyprinodontidae (killifishes and topminnows) and Centrarchidae (sunfishes and basses) are some of the most important (ES&E, 1982). A 1978-1979 study of fish populations in Horse Creek and Big Slough found that the open and fast moving streams of the Horse Creek Basin have more species but fewer individuals than the more lentic Big Slough (ES&E, 1982). More than 23,000 individuals from 9 families were collected in Horse Creek, with over 80 percent of individuals from family Poeciliidae (mosquitofish and least killifish) (ES&E, 1982). Although Centrarchids (largemouth bass and pygmy sunfish) comprised a small percentage of individuals captured during the study, Centrarchid biomass was estimated to comprise the highest percentage of the total fish biomass (ES&E, 1982). The relative abundance of fish from Poeciliidae and Centrarchidae is affected by the hydrological regime, density of macrophytic vegetation, and dominant substrate (ES&E, 1982). Centrarchids, which are egg layers, are most abundant in open, flowing regions of Horse Creek, like HCSW-4, where scoured sand is the dominant substrate (Table 21). Poeciliids, on the other hand, are favored in low flow, densely vegetated areas (like HCSW-2) where marcophytic vegetation and the plant remains substrate give shelter (Table 21); poeciliids are live bearers, making them less affected by the low dissolved oxygen of these stream regions (ES&E 1982).

6.0 CONCLUSIONS

During 2003, rainfall, streamflow, gage height, and NPDES discharge showed expected relationships within the Horse Creek Basin. Rainfall varied between gauges, but showed similar seasonality at all sites. Stream stage height was also similar among sites, with the highest stage levels maintained for only 10 to 20 percent of 2003. Logically, stream discharge was higher at the downstream USGS gauging station than the upstream station, but streamflow patterns were similar at both sites. Streamflow, NPDES discharge, and rainfall were significantly correlated, preventing the relative magnitude of the effects of each on water quality and biological parameters from being clearly determined.

Water quality parameters were all within established HCSP trigger levels, with the exception of two cases (dissolved oxygen and iron). Neither exceedance is related to mining, but instead is caused by (1) the monitoring station's proximity to a hypoxic swamp (dissolved oxygen at HCSW-2), and (2) a difference in the trigger level applied at a station, but not to the actual observed levels (iron at HCSW-4) compared to other stations. Some seasonal patterns in water quality parameters were evident, and further investigation will be made into historical patterns in water quality within the HCSP Historical Report (BRA 2005). Other landscape factors, such as the proximity of agriculture, biosolid application, prairies, or larger river systems, may also have an effect on such water quality parameters as pH, nutrients (nitrogen oxides and orthophosphate), and dissolved ions (calcium and sulfate). Land use analysis in the HCSP Historical Report (BRA 2005) may provide a means of gaging the effect of these landscape factors on water quality in Horse Creek, but an extensive investigation to precisely quantify the effects of non-mining land use is beyond the scope of the Horse Creek Stewardship Program.

Benthic invertebrate habitat scores were "Optimal" and SCI scores were "Fair" or "Poor" at all stations on all dates; these scores are typical of southwestern Florida streams, including those used to develop the Habitat Assessment and SCI indices. Macroinvertebrate diversity was similar among stations, but was lower at most locations when rainfall was heavy during the summer, primarily as a result of poor sampling conditions in July.

Fish species richness and diversity was higher in the more downstream locations, primarily because of their proximity to the species-rich Peace River. In July, fish diversity was lower than on other sampling dates, again because of high stream stage that complicated sampling efforts. Fish diversity at the most downstream station (HCSW-4) was least affected by the increase in rainfall because its stage height and discharge rates were already higher than upstream locations. Fish communities were fairly similar between stations and between dates at each station, although similarity was lower between stations and dates in April 2003, when fish diversity was highest. Although the lowest fish and macroinvertebrate diversity (July 2003) corresponded with peaks in NPDES discharge, the covariation of NPDES discharge and rainfall supports the conclusion that diversity is more affected by precipitation than mining activities.

As monitoring continues and sufficient data accumulates to allow for interpretation of apparent temporal patterns, it will become possible, in at least some cases, to address specific changes within certain parameters. In addition, the incorporation of historical water quality and hydrologic data from the HCSP Historical Report (BRA 2005) will allow for comparisons of current conditions with those reported in past years using trend analysis. Sampling for benthic macroinvertebrates and fish parameters may take longer to show trends, especially with the limited amount of historical biological data available for Horse Creek.

For the purposes of this first annual report, it is merely possible to report that the water quality, hydrologic patterns, and aquatic biota of Horse Creek do not display evidence of adverse impacts associated with phosphate mining operations in the watershed.

7.0 RECOMMENDATIONS FOR FUTURE SAMPLING

During "typical" flow conditions at the four stations utilized for this monitoring program, Horse Creek ranges from about three to six m in width, and about one-half to 1.5 m in depth. During periods of high rainfall, however, the stream can rise until the depth is at least one meter deeper (more than two meters in some cases). Where the banks are low (HCSW-2, HCSW-3 and HCSW-4), water overflows the banks and can extend many meters into the floodplain. During such times, wading access to the stream channel for sampling is not possible. At HCSW-1, the stream is in a deeply incised channel where even relatively small changes in discharge can result in a substantial change in depth, and wading access is infeasible.

Because the monthly water quality sampling is conducted from bridge crossings over Horse Creek, stream stage has little effect on the ability to collect the grab samples. Under most flow conditions, water quality samples can be collected at the edge of the stream or by wading. Under very high flow conditions when immediate access to the stream is impractical or impossible, samples can be collected from the bridges using a dipper or sampling vessel that can be lowered on a rope.

In contrast, biological sampling requires that the stream be accessible by wading. Although some limited sampling for invertebrates may be possible by using D-frame dipnets from the edge of the water, this generally yields few invertebrates when stream stage is high. At the very least, such sampling does not provide a representative sample of the overall invertebrate community because all of the in-stream habitats are not available for sampling. Likewise, fish sampling is compromised by high stream stage. Use of seines is impractical if the stream cannot be waded, and the efficacy of backpack electrofishing equipment from the shoreline is limited in the same way as dipnetting for invertebrates.

During 2003, the April and November biological events were conducted when the stream presented quite favorable conditions for both invertebrate and fish sampling (see Figure 6). The July event, however, presented conditions that were not conducive to the biological collections. Based upon our experience during these three events, as well as considerable additional biological sampling on Horse Creek during the last ten years, biological sampling becomes hindered, with commensurate reductions in data quality, as the stream stage rises above about 10 feet (68.12 ft NGVD) at HCSW-1 and about 5 feet at HCSW-4 (15.96 ft NGVD). It is still generally possible to conduct sampling when the stage at these two stations is up to one foot higher than these elevations (as was the case in the July 2003 event), but the sample quality is almost certainly impaired (as was discussed above). Therefore, we recommend that biological sampling not be undertaken during times when the stream stage is above 10 feet at HCSW-1 and 5 feet at HCSW-4. Because USGS stage data is available in real time via the Internet, sampling conditions on a given day can be easily determined from the office.

In light of this sampling restriction, and based upon the observed distribution of Horse Creek flows in the 2003 and 2004 wet seasons, it appears likely that biological sampling could be restricted to only a few days in the July/August time window specified in the HCSP plan document. While sampling could probably be conducted early in July before water levels rise with the onset of the wet season, such scheduling would not necessarily be reflective of wet season ecological conditions. As of the time of this report (early September 2004), it has not been possible to conduct the summer 2004 biological event (although three hurricanes in peninsular Florida are largely responsible for the high flows this year). Based upon the observed flow conditions for the remainder of 2004, the summer sampling window should be extended to all of July/August/September to allow additional time for the biological sampling when summer rains keep the stream stage high. In light of such an adjustment, it would also be prudent to extend the fall window for biological sampling to include December so that samples are relatively evenly spaced through the year.

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APPENDICES

Appendix A

Horse Creek Stewardship Program

Horse Creek
Stewardship Program

Intent

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

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

There are three basic components to this stewardship program:

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

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

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

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

Program Implementation and Oversight

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

Historical, Background and Contemporaneous Data

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

Monitoring Period

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

1.0 Surface Water Monitoring Stations

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

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

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

2.0 Water Quantity Monitoring and Analysis

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

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

3.0 Surface Water Quality Monitoring and Analysis

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

Nitrate + Nitrite
Total Kjeldahl Nitrogen
Total Nitrogen
Total Ammonia Nitrogen
Ortho Phosphate
Chlorophyll *a*
Calcium
Iron

Color
Total Alkalinity
Chloride
Fluoride
Radium 226 + 228
Sulfate
Mining Reagents (petroleum-based organics, fatty acids, fatty amido amines).

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

Table 1 presents the analytical schedules and procedures. All sampling will be conducted according to DEP's Standard Operating Procedures (SOP) for field sampling. Laboratory analyses will be performed by experienced personnel according to National Environmental Laboratory Accreditation Council

(NELAC) protocols, including quality assurance/quality control considerations. Invertebrate sampling will be conducted by personnel with training and experience in the DEP's SOP for such sampling.

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

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

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

4.0 Aquatic Macroinvertebrate Sampling and Analysis

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

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

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

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

5.0 Fish Sampling and Analysis

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

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

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

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

6.0 Reporting

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

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

Monitoring Program Evaluation

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

Protocol for Addressing Potential Problems Identified Through Monitoring

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

Impact Assessment/Characterization

In the event the annual data evaluation identifies trigger value exceedences or statistically significant trends in Horse Creek, IMC will conduct an impact assessment to identify the cause of the adverse trend. The impact assessment may include more intensive monitoring of water quality in terms of frequency of sampling, laboratory analyses conducted, or locations monitored. In all cases, however, the impact assessment will include supplemental quantitative and qualitative data evaluations and consultation with Authority scientists, as well as perhaps other investigations within the basin (e.g., examination of land use changes, discharge monitoring records reviews of others, water use permit reports of others, etc.).

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

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

Corrective Action Alternatives Evaluation and Implementation

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

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

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

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

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

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

References:

(a) Brower, J. E., Zar, J. H., von Ende, C. N. Field and Laboratory Methods for General Ecology. 3rd Edition. Wm. C. Brown Co., Dubuque, IA. pp. 237; 1
(b) Gotelli, N.J., and G.R. Graves. 1996. Null Models in Ecology. Smithsonian Institution Press, Washington, DC.

Appendix B

Dissolved Oxygen at CR 663 (Goose Pond Road)
Preliminary Impact Assessment
2003

From 1972 to 1991, the Florida Department of Environmental Regulation (the precursor to the Florida Department of Environmental Protection) collected 140 ambient water quality samples for dissolved oxygen in Horse Creek at the bridge on State Road 64, at the crossing under Goose Pond Road, and at the bridge on State Road 70. This time period begins before mining in any part of the basin and ends after the initiation of mining in the very upper part of the basin by W. R. Grace but before large-scale mining at the Fort Green Mine.

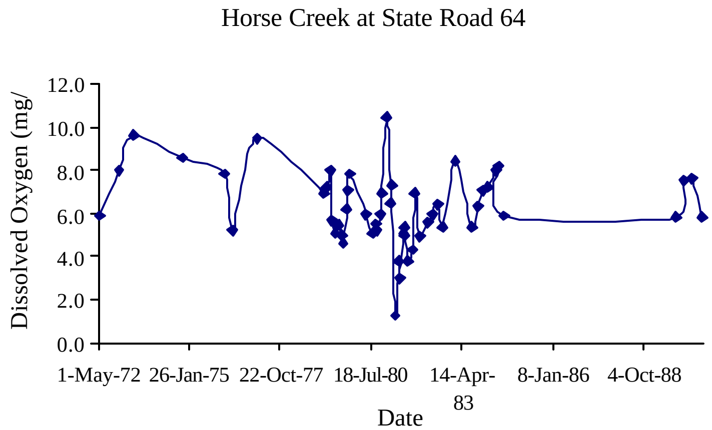
Horse Creek at State Road 64
Fifty-three dissolved oxygen samples were collected between May 15, 1972 and July 10, 1990.

Count:	53
Minimum:	1.3
25th percentile:	5.2
Median:	6
Mean:	6.3
75th percentile:	7.3
Maximum:	10.4

A stem and leaf plot of the dissolved oxygen data shows a fairly bell-shaped distribution with the median and mean close together.

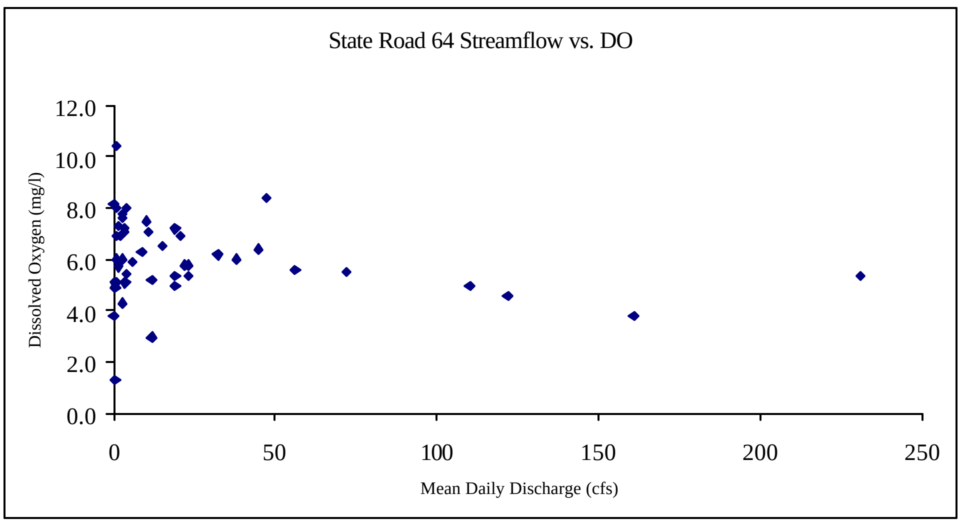
1 | 3 = 1.3 mg/l	1	3
	2	
	3	0 8 8
	4	3 6 9
	5	0 0 1 1 1 2 2 4 4 4 5 5 6 7 8 8 9 9
	6	0 0 0 2 3 4 5 9 9 9
	7	1 1 2 2 3 5 6 8 8
	8	0 0 0 2 4 6
	9	5 6
10 | 4 = 10.4 mg/l	10	4

There appears to be no overall trend over the period of record. A time series plot of the data:



Within the year there appears to be no strong summer/winter effect in the data. The winter mean dissolved oxygen concentration was 5.9 mg/l (15 events) and the mean summer dissolved oxygen concentration was 7.0 mg/l (18 events). There was no significant difference between these means at a 95% confidence interval.

There is no strong correlation between dissolved oxygen and streamflow:



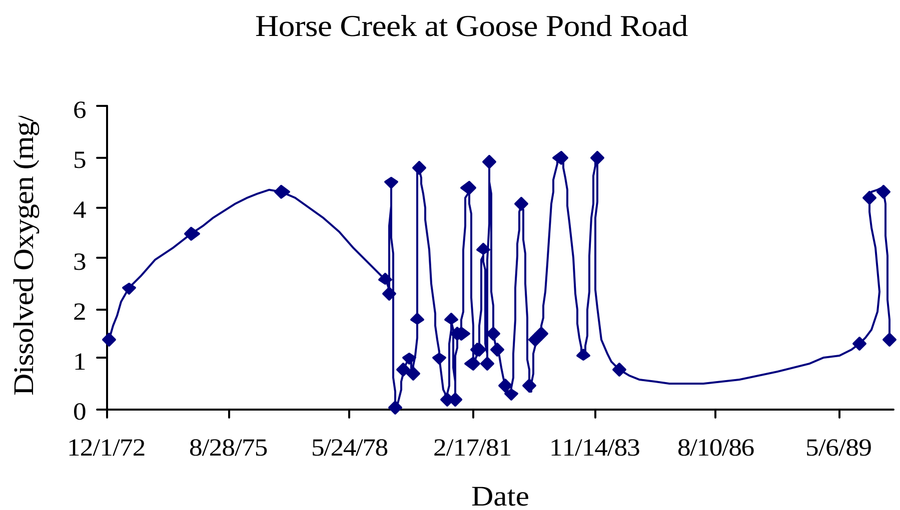
Horse Creek at Goose Pond Road
Forty-three dissolved oxygen readings were recorded between December 12, 1972 and July 5, 1990.

Count:	43
Minimum:	0.05
25th percentile:	0.9
Median:	1.4
Mean:	2.0
75th percentile:	3.4
Maximum:	5

A stem-and-leaf plot of the data shows a somewhat skewed distribution with then median value less than the mean.

0 | 1 = 0.1 mg/l	0	1 2 2 2 3 5 5 7 8 8 9 9
	1	0 0 1 2 2 2 3 4 4 4 5 5 5 5 8 8
	2	3 4 6
	3	2 5
	4	1 2 3 3 4 5 8 9
5 | 0 = 5.0 mg/l	5	0 0

A time series plot shows no overall trend in the data over time.



There is a significant summer/winter effect in the data with the summer dissolved oxygen concentration (1.9 mg/l mean based on 14 values) significantly lower than the mean winter value of 2.9 mg/l (based on 14 values).

Horse Creek at State Road 70
Forty-four dissolved oxygen readings were recorded between May 15, 1972 and August 21, 1991.

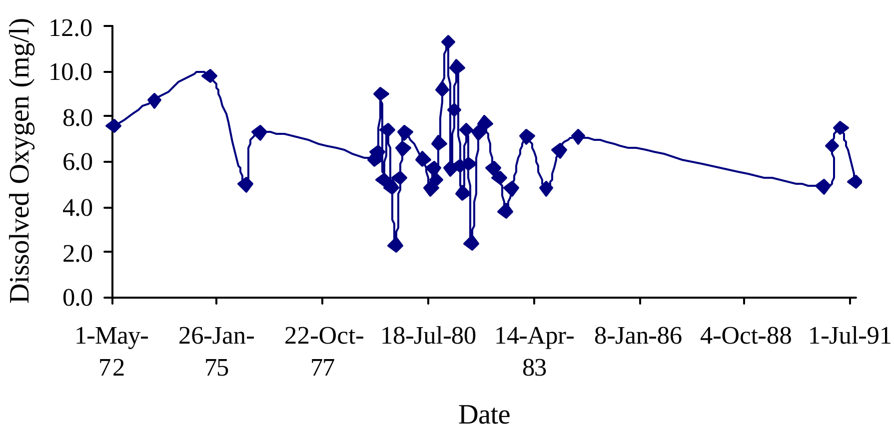
Count:	44
Minimum:	2.3
25th percentile:	5.2
Median:	6.3
Mean:	6.4
75th percentile:	7.4
Maximum:	11.3

A stem-and-leaf plot of the data shows a mound-shaped distribution with the median and mean values being essentially the same.

2 | 3 = 2.3 mg/l	2	3 4
	3	8
	4	6 8 8 8 9 9
	5	0 1 2 2 3 3 7 7 8 9
	6	1 1 4 5 6 7 8
	7	1 1 3 3 3 4 4 5 6 7
	8	3 7
	9	0 2 8
	10	2
11| 3 = 11.3 mg/l	11	3

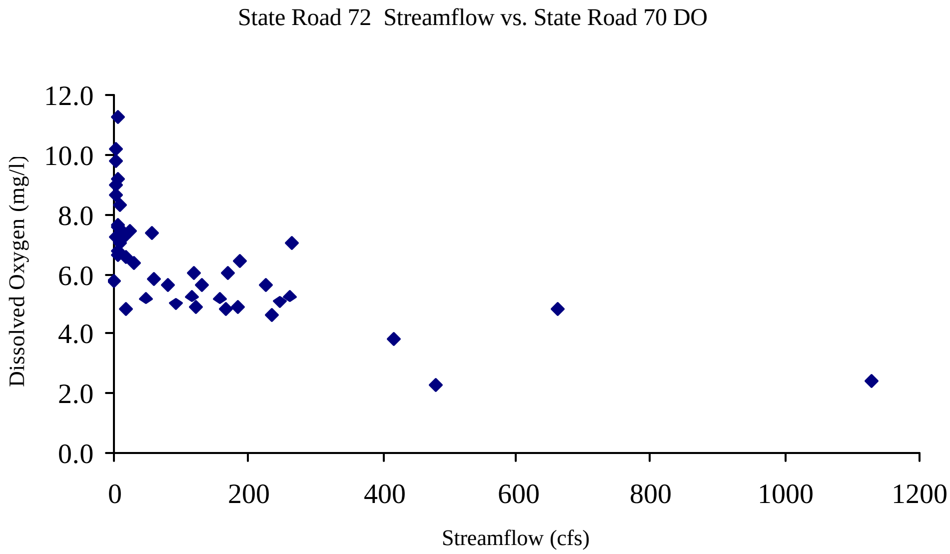
A time series plot shows no overall trend in the data over time.

Horse Creek at State Road 70



There is a significant summer/winter effect in the data with the summer dissolved oxygen concentration (5.9 mg/l mean based on 15 values) significantly lower than the mean winter value of 7.6 mg/l (based on 12 values).

There is no long-term flow measurement at State Road 70, but the State Road 70 dissolved oxygen data was plotted against the streamflow data from State Road 72. State Road 72 is about four miles south of State Road 70 and two tributaries (Brandy Branch and Buzzard Roost Branch) conflue with Horse Creek in that stretch. The State Road 72 data is being mentioned only because of the very strong inverse relationship between dissolved oxygen concentrations at State Road 70 and streamflow at State Road 72 (43% of the behavior in dissolved oxygen is "explained" by streamflow at State Road 72).



Summary

Dissolved oxygen concentrations in Florida streams are usually interpreted in light of the State Water quality standard of 5.0 mg/l. That is a anthropogenic standard and there is no guarantee that any stream even in its most pristine state in Florida has or will meet that standard at any given time. Looking synpotically at the data, the Horse Creek at State Road 64 and State Road 70 stations, dissolved oxygen concentrations are generally between 4.0 and 9.0 mg/l. There is some seasonality to the data, but no trend over the period of record. Each station has periods where dissolved oxygen concentrations have been below 5.0 mg/l and there is no reason to expect that to stop.

The Goose Pond Road station has much lower dissolved oxygen concentrations than the other stations. It is a rarity for the station to meet the State Water Quality standard. There was no overall trend in the data over the period of record, but there was a fairly strong seasonal component. The depressed dissolved oxygen concentrations at Goose Pond Road persist for some distance downstream (and though not considered in this report, Brushy Creek, a major tributary to Horse Creek in that part of the Basin also has lower concentrations in the historical FDER sampling). A significant portion of the Horse Creek Basin has not, is, not, and will not in the future, "meet" the Water Quality Standard. This portion of the basin is also usually held up as the most pristine, most aesthetic, and most ecologically valuable portion of the basin.

Appendix C

Iron Concentrations - Horse Creek at State Road 72
Preliminary Impact Assessment
2003

As part of the Horse Creek Stewardship Program, IMC Phosphates samples four locations once per month on Horse Creek in Hardee and Desoto Counties for a number of chemical and physical parameters. One of these parameters is iron. A "trigger level" of 0.3 mg/l was set for iron concentrations at State Road 72 in the Program. To date, seven months of sampling have been completed and iron concentrations determined.

Horse Creek at State Road 72	April 2003	0.2 mg/l
Horse Creek at State Road 72	May 2003	0.4 mg/l
Horse Creek at State Road 72	June 2003	0.6 mg/l
Horse Creek at State Road 72	July 2003	0.7 mg/l
Horse Creek at State Road 72	August 2003	0.7 mg/l
Horse Creek at State Road 72	September 2003	0.6 mg/l
Horse Creek at State Road 72	October 2003	0.4 mg/l

In six of the seven months, iron concentrations at State Road 72 have been greater than the trigger level.

Analysis

All iron concentrations recorded as part of the Program are included in Table 1 (attached). A trigger level of 1.0 mg/l is in effect for the State Road 64, Goose Pond Road, and State Road 70 stations. The differing trigger levels for the stations correspond to the Class I and Class III Surface Water Quality Standards for iron codified in 62-302.530, Florida Administrative Code. The lowest iron concentrations to date have been recorded at State Road 64, slightly below those recorded at State Road 70 and State Road 72. This is the most northern station in the sampling program, but is also downstream of all of IMC Phosphates mining activities in the Horse Creek basin. The iron concentrations recorded to date at State Road 72 seem representative of concentrations throughout the basin during this time period and do not appear elevated relative to the other Horse Creek locations (there is little difference between any of the stations with the means all lying between 0.12 mg/l of each other).

A special sampling program was carried out on August 4, 2003. Iron samples were taken from Horse Creek at State Road 70, at Pine Level Road, and at State Road 72. Also, iron samples were taken from the two large tributaries that enter Horse Creek between these two stations, Brandy Branch (at State Road 70) and Buzzard Roost Branch (at Pine Level Road). Iron concentrations were as follows (locations are on the attached map):

Horse Creek at State Road 70	0.4 mg/l
Brandy Branch at State Road 70	0.2 mg/l
Horse Creek at Pine Level Road	0.4 mg/l
Buzzard Roost Branch at Pine Level Road	0.6 mg/l

Horse Creek at State Road 72	0.4 mg/l

Stream conditions on this date (August 4, 2003) were extreme with water well out of the banks of Horse Creek and further sampling of other locations was not carried out.

Another round of iron sampling was performed on October 31, 2003. Stream flow was greatly reduced from the August sampling and the streams were well within their banks at the time of sampling.

West Fork of Horse Creek at Roberts Road	0.31 mg/l
Horse Creek at State Road 64	0.36 mg/l
Elder Branch at County Road 665	0.22 mg/l
Horse Creek at the exit from the Prairie	0.23 mg/l
Horse Creek at Goose Pond Road	0.40 mg/l
Horse Creek at County Road 665	0.46 mg/l
Horse Creek at State Road 70	0.51 mg/l
Brandy Branch at State Road 70	0.25 mg/l
Horse Creek at Pine Level Road	0.44 mg/l
Buzzard Roost Branch at Pine Level Road	0.23 mg/l
Horse Creek at State Road 72	0.46 mg/l

Given this is only two sampling events, it's probably wise not to read too much into the data. All mining activities are north of State Road 64. Aside from the Prairie, the Horse Creek floodplain south of State Road 64 is surrounded by fairly homogenous land uses (mostly pasture, some citrus, some row crops) and it seem unlikely that a cow-calf operation in Section 18, Township 37 South, Range 24 East will "cause" any more or less iron to run off into Horse Creek than a similar operation in Section 21, Township 34 South, Range 23 East. My assessment is that iron concentrations in the Horse Creek Basin have been and will continue to be relatively homogenous with none of the four stations sampled in the program differing greatly from the others. That any real long-term differences (say if Brandy Branch is always low relative to the other stations) will probably be reflections of the iron concentrations in the soil in that sub-basin area. The trigger level exceedances are solely a result of the lower limit at State Road 72 and do not reflect elevated iron concentrations at State Road 72 relative to the rest of the Horse Creek basin or to the upper end of the Basin that is currently host to mining activities.

Appendix D

HCSP 2003 Water Quantity Data

Continuous stage and discharge data for HCSW-1 and HCSW-4 for 2003 collected by the USGS are available at http://waterdata.usgs.gov/fl.

Table D1. HCSP Rainfall Data Collected by Mosaic and USGS in 2003

Date	Horse Creek North (Mosaic)	Horse Creek South (Mosaic)	Manson Jenkins (Mosaic)	HCSW-1 (USGS)	Average Rainfall
01/01/03	0.07	0.30	0.00	0.34	0.1775
01/02/03	0.00	0.00	0.00	0.00	0
01/03/03	0.00	0.04	0.00	0.05	0.0225
01/04/03	0.00	0.00	0.00	0.00	0
01/05/03	0.00	0.00	0.00	0.00	0
01/06/03	0.00	0.00	0.00	0.00	0
01/07/03	0.00	0.00	0.00	0.00	0
01/08/03	0.00	0.00	0.00	0.00	0
01/09/03	0.00	0.00	0.00	0.00	0
01/10/03	0.00	0.03	0.00	0.00	0.0075
01/11/03	0.00	0.00	0.00	0.08	0.02
01/12/03	0.00	0.00	0.00	0.00	0
01/13/03	0.00	0.00	0.00	0.00	0
01/14/03	0.00	0.00	0.00	0.00	0
01/15/03	0.00	0.00	0.00	0.00	0
01/16/03	0.00	0.00	0.00	0.00	0
01/17/03	0.03	0.03	0.00	0.01	0.0175
01/18/03	0.00	0.00	0.00	0.00	0
01/19/03	0.00	0.00	0.00	0.00	0
01/20/03	0.00	0.00	0.00	0.00	0
01/21/03	0.00	0.00	0.00	0.00	0
01/22/03	0.00	0.00	0.00	0.00	0
01/23/03	0.00	0.00	0.00	0.00	0
01/24/03	0.00	0.00	0.00	0.00	0
01/25/03	0.00	0.00	0.00	0.00	0
01/26/03	0.00	0.00	0.00	0.00	0
01/27/03	0.00	0.00	0.00	0.00	0
01/28/03	0.00	0.00	0.00	0.00	0
01/29/03	0.00	0.00	0.00	0.00	0
01/30/03	0.00	0.00	0.00	0.00	0
01/31/03	0.00	0.00	0.00	0.00	0
02/01/03	0.00	0.00	0.00	0.00	0
02/02/03	0.00	0.00	0.00	0.00	0
02/03/03	0.00	0.00	0.00	0.00	0
02/04/03	0.00	0.00	0.00	0.01	0.0025
02/05/03	0.00	0.02	0.00	0.04	0.015
02/06/03	0.00	0.00	0.00	0.00	0
02/07/03	0.00	0.00	0.00	0.01	0.0025
02/08/03	0.00	0.00	0.00	0.00	0
02/09/03	0.00	0.05	0.00	0.06	0.0275
02/10/03	0.11	0.21	0.00	0.17	0.1225
02/11/03	0.00	0.00	0.00	0.00	0
02/12/03	0.00	0.00	0.00	0.00	0
02/13/03	0.00	0.00	0.00	0.00	0
02/14/03	0.00	0.00	0.00	0.00	0
02/15/03	0.00	0.00	0.00	0.00	0
02/16/03	0.40	0.40	0.00	0.44	0.31
02/17/03	0.02	0.02	0.00	0.02	0.015
02/18/03	0.00	0.00	0.00	0.00	0
02/19/03	0.00	0.00	0.00	0.00	0
02/20/03	0.00	0.00	0.00	0.00	0
02/21/03	0.00	0.00	0.00	0.00	0
02/22/03	0.48	0.33	0.00	0.35	0.29
02/23/03	0.00	0.00	0.00	0.00	0
02/24/03	0.00	0.00	0.00	0.00	0
02/25/03	0.00	0.00	0.00	0.00	0
02/26/03	0.00	0.00	0.00	0.00	0
02/27/03	0.15	0.32	0.00	0.30	0.1925
02/28/03	0.00	0.00	0.00	0.01	0.0025
03/01/03	0.00	0.04	0.00	0.04	0.02
03/02/03	0.03	0.05	0.00	0.04	0.03
03/03/03	0.04	0.00	0.00	0.00	0.01
03/04/03	0.00	0.00	0.00	0.00	0
03/05/03	0.00	0.00	0.00	0.00	0
03/06/03	0.00	0.00	0.00	0.00	0
03/07/03	0.00	0.00	0.00	0.00	0
03/08/03	0.00	0.00	0.00	0.00	0
03/09/03	0.12	0.02	0.00	0.01	0.0375
03/10/03	0.02	0.00	0.00	0.00	0.005
03/11/03	0.00	0.00	0.00	0.00	0
03/12/03	0.00	0.14	0.00	0.03	0.0425
03/13/03	0.00	0.00	0.00	0.00	0
03/14/03	0.00	0.00	0.00	0.00	0
03/15/03	0.00	0.00	0.00	0.00	0
03/16/03	0.15	0.12	0.00	0.14	0.1025
03/17/03	0.58	0.46	0.00	0.34	0.345
03/18/03	0.10	0.12	0.00	0.89	0.2775
03/19/03	0.00	0.00	0.00	0.00	0
03/20/03	0.00	0.00	0.00	0.00	0
03/21/03	0.37	0.02	0.00	0.26	0.1625
03/22/03	0.00	0.00	0.00	0.00	0
03/23/03	0.21	0.30	0.00	0.34	0.2125
03/24/03	0.00	0.00	0.00	0.01	0.0025
03/25/03	0.00	0.00	0.00	0.00	0
03/26/03	0.00	0.00	0.00	0.00	0
03/27/03	0.45	1.08	0.00	0.81	0.585
03/28/03	0.00	0.00	0.00	0.01	0.0025
03/29/03	0.00	0.00	0.00	0.00	0
03/30/03	0.03	0.00	0.00	0.02	0.0125
03/31/03	0.00	0.00	0.00	0.01	0.0025
04/01/03	0.00	0.00	0.00	0.00	0
04/02/03	0.00	0.00	0.00	0.00	0
04/03/03	0.00	0.00	0.00	0.00	0
04/04/03	0.00	0.00	0.00	0.00	0
04/05/03	0.00	0.00	0.00	0.00	0
04/06/03	0.00	0.00	0.00	0.00	0
04/07/03	0.00	0.00	0.00	0.00	0
04/08/03	0.00	0.00	0.00	0.00	0
04/09/03	0.18	0.15	0.00	0.09	0.105
04/10/03	0.00	0.00	0.00	0.00	0
04/11/03	0.00	0.00	0.00	0.00	0
04/12/03	0.00	0.00	0.00	0.00	0
04/13/03	0.00	0.00	0.00	0.00	0
04/14/03	0.00	0.00	0.00	0.00	0
04/15/03	0.00	0.15	0.00	0.00	0.0375
04/16/03	0.00	0.00	0.00	0.00	0
04/17/03	0.00	0.02	0.00	0.00	0.005
04/18/03	0.12	0.00	0.00	0.00	0.03
04/19/03	0.00	0.00	0.00	0.00	0
04/20/03	0.00	0.00	0.00	0.00	0
04/21/03	0.00	0.00	0.00	0.00	0
04/22/03	0.00	0.00	0.00	0.00	0
04/23/03	0.00	0.00	0.00	0.00	0
04/24/03	0.00	0.00	0.00	0.00	0
04/25/03	0.32	0.13	0.00	0.19	0.16
04/26/03	2.40	2.55	0.00	2.52	1.8675
04/27/03	0.00	0.00	0.00	0.00	0
04/28/03	0.30	1.05	0.00	0.82	0.5425
04/29/03	0.00	0.00	0.00	0.00	0
04/30/03	0.00	0.00	0.00	0.00	0

Date	Horse Creek North (Mosaic)	Horse Creek South (Mosaic)	Manson Jenkins (Mosaic)	HCSW-1 (USGS)	Average Rainfall
05/01/03	0.25	0.57	0.00	0.48	0.325
05/02/03	0.00	0.00	0.00	0.00	0
05/03/03	0.00	0.00	0.00	0.00	0
05/04/03	0.00	0.00	0.00	0.00	0
05/05/03	0.00	0.00	0.00	0.00	0
05/06/03	0.00	0.00	0.00	0.00	0
05/07/03	0.00	0.00	0.00	0.00	0
05/08/03	0.00	0.00	0.00	0.00	0
05/09/03	0.00	0.00	0.00	0.00	0
05/10/03	0.00	0.00	0.00	0.00	0
05/11/03	0.00	0.00	0.00	0.00	0
05/12/03	0.00	0.00	0.00	0.00	0
05/13/03	0.00	0.00	0.00	0.00	0
05/14/03	1.85	0.95	0.00	1.55	1.0875
05/15/03	0.00	0.00	0.00	0.00	0
05/16/03	0.00	0.00	0.00	0.08	0.02
05/17/03	0.00	0.00	0.00	0.00	0
05/18/03	0.32	0.28	0.00	0.26	0.215
05/19/03	2.48	1.11	0.00	1.39	1.245
05/20/03	0.00	0.00	0.00	0.00	0
05/21/03	0.00	0.00	0.00	0.00	0
05/22/03	0.28	0.20	0.00	0.32	0.2
05/23/03	0.57	0.60	0.00	0.81	0.495
05/24/03	0.00	0.00	0.00	0.16	0.04
05/25/03	0.00	0.00	0.00	0.00	0
05/26/03	0.00	0.00	0.00	0.00	0
05/27/03	0.00	0.00	0.00	0.00	0
05/28/03	0.00	0.00	0.00	0.12	0.03
05/29/03	0.00	0.00	0.00	0.00	0
05/30/03	0.00	0.00	0.00	0.00	0
05/31/03	0.00	0.00	0.00	0.00	0
06/01/03	0.00	0.00	0.00	0.00	0
06/02/03	0.00	0.00	0.00	0.00	0
06/03/03	0.00	0.34	0.00	1.97	0.5775
06/04/03	0.05	0.00	0.00	0.10	0.0375
06/05/03	0.12	1.07	0.00	0.83	0.505
06/06/03	0.60	0.58	0.00	0.50	0.42
06/07/03	0.08	0.36	0.00	0.92	0.34
06/08/03	3.08	1.03	0.00	0.54	1.1625
06/09/03	2.12	1.15	0.00	1.28	1.1375
06/10/03	0.05	0.00	0.00	0.00	0.0125
06/11/03	0.00	0.00	0.00	0.00	0

Date	Horse Creek North (Mosaic)	Horse Creek South (Mosaic)	Manson Jenkins (Mosaic)	HCSW-1 (USGS)	Average Rainfall
06/12/03	0.16	0.53	0.00	0.00	0.1725
06/13/03	0.07	0.06	0.00	0.02	0.0375
06/14/03	0.00	0.00	0.00	0.01	0.0025
06/15/03	0.10	0.00	0.00	0.00	0.025
06/16/03	0.13	0.28	0.00	0.35	0.19
06/17/03	0.00	0.00	0.00	0.02	0.005
06/18/03	1.05	0.83	0.00	1.14	0.755
06/19/03	0.10	0.26	0.00	0.48	0.21
06/20/03	2.57	3.95	0.00	3.85	2.5925
06/21/03	1.45	4.79	0.00	5.83	3.0175
06/22/03	2.04	1.15	0.00	1.09	1.07
06/23/03	0.00	0.72	0.00	0.27	0.2475
06/24/03	0.00	0.00	0.00	0.00	0
06/25/03	0.00	0.00	0.00	0.00	0
06/26/03	0.00	0.00	0.00	0.00	0
06/27/03	0.00	0.00	0.00	0.04	0.01
06/28/03	0.12	0.00	0.00	0.00	0.03
06/29/03	0.23	0.58	0.00	0.47	0.32
06/30/03	0.02	0.00	0.00	0.01	0.0075
07/01/03	0.00	0.00	0.00	0.00	0
07/02/03	0.27	0.00	0.00	0.00	0.0675
07/03/03	0.07	0.14	0.10	0.13	0.11
07/04/03	0.00	0.00	0.38	0.24	0.155
07/05/03	0.00	0.05	0.02	0.00	0.0175
07/06/03	0.00	0.00	0.00	0.00	0
07/07/03	0.00	0.00	0.04	0.10	0.035
07/08/03	0.00	0.00	0.00	0.00	0
07/09/03	0.00	0.00	0.00	0.00	0
07/10/03	0.00	0.00	0.00	0.00	0
07/11/03	0.00	0.00	0.58	0.00	0.145
07/12/03	0.90	0.43	0.80	0.71	0.71
07/13/03	0.09	0.10	0.11	0.13	0.1075
07/14/03	0.70	0.51	0.00	0.32	0.3825
07/15/03	0.00	0.00	0.00	0.00	0
07/16/03	0.02	0.00	0.82	0.00	0.21
07/17/03	0.00	0.00	0.00	0.00	0
07/18/03	0.61	0.57	0.77	1.15	0.775
07/19/03	0.00	0.00	0.02	0.01	0.0075
07/20/03	0.00	0.00	0.00	0.04	0.01
07/21/03	0.00	0.00	0.00	0.00	0
07/22/03	0.02	0.06	0.00	0.75	0.2075
07/23/03	1.25	0.56	0.67	0.69	0.7925

Date	Horse Creek North (Mosaic)	Horse Creek South (Mosaic)	Manson Jenkins (Mosaic)	HCSW-1 (USGS)	Average Rainfall
07/24/03	0.02	0.52	0.00	0.00	0.135
07/25/03	0.32	0.16	0.23	0.09	0.2
07/26/03	0.29	0.57	0.14	0.73	0.4325
07/27/03	0.00	0.00	0.03	0.00	0.0075
07/28/03	0.22	0.88	1.35	0.01	0.615
07/29/03	0.00	0.48	0.08	0.15	0.1775
07/30/03	0.13	0.68	0.45	0.01	0.3175
07/31/03	0.00	0.22	0.75	0.14	0.2775
08/01/03	0.00	0.00	0.00	0.23	0.0575
08/02/03	0.12	0.13	0.24	0.19	0.17
08/03/03	0.60	0.10	0.07	1.28	0.5125
08/04/03	1.17	0.32	0.41	0.26	0.54
08/05/03	0.02	0.02	0.14	0.69	0.2175
08/06/03	0.00	0.12	0.17	0.00	0.0725
08/07/03	0.04	0.77	0.86	0.15	0.455
08/08/03	0.07	0.28	0.20	0.09	0.16
08/09/03	0.65	0.69	0.58	0.76	0.67
08/10/03	0.45	0.87	0.75	1.00	0.7675
08/11/03	0.88	0.52	0.58	0.51	0.6225
08/12/03	0.00	0.02	0.03	1.05	0.275
08/13/03	0.00	0.00	0.00	0.01	0.0025
08/14/03	0.17	0.22	0.22	0.32	0.2325
08/15/03	0.00	0.00	0.00	0.14	0.035
08/16/03	0.41	0.00	0.23	0.32	0.24
08/17/03	0.04	0.00	0.06	0.00	0.025
08/18/03	0.25	0.57	0.59	0.69	0.525
08/19/03	0.39	1.03	0.33	0.43	0.545
08/20/03	0.37	0.04	0.56	0.45	0.355
08/21/03	0.40	0.21	0.11	0.13	0.2125
08/22/03	0.00	0.24	0.03	0.11	0.095
08/23/03	0.00	0.08	0.07	0.08	0.0575
08/24/03	2.40	2.62	2.22	1.60	2.21
08/25/03	0.05	0.02	0.00	0.12	0.0475
08/26/03	0.00	0.47	0.00	0.00	0.1175
08/27/03	0.83	0.67	0.14	0.05	0.4225
08/28/03	0.98	0.15	0.04	0.16	0.3325
08/29/03	0.00	0.05	0.12	0.00	0.0425
08/30/03	0.00	0.47	0.13	0.00	0.15
08/31/03	0.02	0.00	0.00	0.00	0.005
09/01/03	0.56	0.10	0.32	0.12	0.275
09/02/03	0.07	0.00	0.10	0.04	0.0525
09/03/03	0.21	1.22	0.61	0.19	0.5575

Date	Horse Creek North (Mosaic)	Horse Creek South (Mosaic)	Manson Jenkins (Mosaic)	HCSW-1 (USGS)	Average Rainfall
09/04/03	0.00	0.00	0.01	0.01	0.005
09/05/03	0.49	0.70	0.69	0.97	0.7125
09/06/03	0.23	0.10	0.08	0.04	0.1125
09/07/03	0.00	0.03	0.00	0.00	0.0075
09/08/03	0.00	0.00	0.00	0.00	0
09/09/03	0.00	0.00	0.00	0.00	0
09/10/03	0.00	0.00	0.00	0.00	0
09/11/03	0.00	0.00	0.00	0.00	0
09/12/03	0.00	0.00	0.02	0.00	0.005
09/13/03	0.07	0.15	0.24	0.97	0.3575
09/14/03	0.00	0.00	0.00	0.00	0
09/15/03	0.00	0.00	0.00	0.00	0
09/16/03	0.00	0.00	0.00	0.00	0
09/17/03	0.00	0.00	0.00	0.00	0
09/18/03	0.00	0.00	0.00	0.00	0
09/19/03	0.20	0.48	0.00	0.40	0.27
09/20/03	0.30	0.23	0.00	0.02	0.1375
09/21/03	0.00	0.02	0.04	0.00	0.015
09/22/03	0.05	0.00	0.00	0.00	0.0125
09/23/03	0.00	0.00	0.00	0.00	0
09/24/03	0.00	0.00	0.00	0.00	0
09/25/03	1.48	1.05	1.58	1.68	1.4475
09/26/03	0.44	0.37	0.15	0.21	0.2925
09/27/03	0.61	0.94	1.63	1.07	1.0625
09/28/03	0.53	0.08	0.23	0.15	0.2475
09/29/03	0.50	0.58	0.50	0.62	0.55
09/30/03	0.13	0.00	0.00	0.00	0.0325
10/01/03	0.00	0.00	0.00	0.00	0
10/02/03	0.00	0.00	0.00	0.00	0
10/03/03	0.00	0.00	0.00	0.00	0
10/04/03	0.00	0.00	0.00	0.00	0
10/05/03	0.00	0.00	0.00	0.00	0
10/06/03	0.00	0.00	0.00	0.00	0
10/07/03	0.00	0.00	0.02	0.05	0.0175
10/08/03	0.00	0.00	0.00	0.02	0.005
10/09/03	0.00	0.00	0.00	0.00	0
10/10/03	0.00	0.00	0.00	0.00	0
10/11/03	0.00	0.00	0.00	0.00	0
10/12/03	0.00	0.08	0.00	0.00	0.02
10/13/03	0.00	0.00	0.00	0.00	0
10/14/03	0.04	0.00	0.00	0.00	0.01
10/15/03	0.00	0.00	0.00	0.00	0

Date	Horse Creek North (Mosaic)	Horse Creek South (Mosaic)	Manson Jenkins (Mosaic)	HCSW-1 (USGS)	Average Rainfall
10/16/03	0.00	0.00	0.00	0.00	0
10/17/03	0.00	0.00	0.00	0.00	0
10/18/03	0.00	0.00	0.00	0.00	0
10/19/03	0.00	0.00	0.00	0.00	0
10/20/03	0.00	0.00	0.00	0.00	0
10/21/03	0.00	0.00	0.00	0.00	0
10/22/03	0.00	0.00	0.00	0.00	0
10/23/03	0.00	0.00	0.00	0.00	0
10/24/03	0.00	0.00	0.00	0.00	0
10/25/03	0.00	0.05	0.00	0.00	0.0125
10/26/03	0.05	0.07	0.04	0.07	0.0575
10/27/03	0.00	0.00	0.00	0.00	0
10/28/03	1.07	1.35	1.28	0.97	1.1675
10/29/03	0.00	0.45	0.36	0.01	0.205
10/30/03	0.03	0.00	0.00	0.00	0.0075
10/31/03	0.00	0.00	0.00	0.00	0
11/01/03	0.00	0.00	0.00	0.00	0
11/02/03	0.07	0.00	0.00	0.02	0.0225
11/03/03	0.04	0.08	0.00	0.01	0.0325
11/04/03	0.00	0.00	0.00	0.00	0
11/05/03	0.55	0.28	0.00	0.06	0.2225
11/06/03	0.77	0.67	1.61	0.86	0.9775
11/07/03	0.00	0.00	0.00	0.00	0
11/08/03	0.00	0.00	0.00	0.00	0
11/09/03	0.00	0.00	0.00	0.00	0
11/10/03	0.00	0.00	0.00	0.00	0
11/11/03	0.00	0.00	0.00	0.00	0
11/12/03	0.00	0.00	0.00	0.00	0
11/13/03	0.00	0.00	0.00	0.00	0
11/14/03	0.00	0.00	0.00	0.00	0
11/15/03	0.00	0.00	0.00	0.00	0
11/16/03	0.00	0.00	0.00	0.00	0
11/17/03	0.00	0.00	0.00	0.00	0
11/18/03	0.00	0.00	0.00	0.00	0
11/19/03	0.10	0.25	0.29	0.37	0.2525
11/20/03	0.00	0.00	0.00	0.00	0
11/21/03	0.00	0.00	0.00	0.00	0
11/22/03	0.00	0.00	0.00	0.00	0
11/23/03	0.00	0.00	0.00	0.00	0
11/24/03	0.00	0.00	0.00	0.00	0
11/25/03	0.00	0.00	0.00	0.00	0
11/26/03	0.00	0.00	0.00	0.00	0

Date	Horse Creek North (Mosaic)	Horse Creek South (Mosaic)	Manson Jenkins (Mosaic)	HCSW-1 (USGS)	Average Rainfall
11/27/03	0.00	0.00	0.00	0.00	0
11/28/03	0.03	0.05	0.07	0.00	0.0375
11/29/03	0.00	0.00	0.00	0.00	0
11/30/03	0.00	0.00	0.00	0.00	0
12/01/03	0.00	0.00	0.00	0.00	0
12/02/03	0.00	0.00	0.00	0.00	0
12/03/03	0.00	0.00	0.00	0.00	0
12/04/03	0.00	0.00	0.00	0.00	0
12/05/03	0.00	0.00	0.00	0.00	0
12/06/03	0.00	0.00	0.00	0.00	0
12/07/03	0.00	0.00	0.00	0.00	0
12/08/03	0.00	0.00	0.00	0.00	0
12/09/03	0.00	0.00	0.00	0.00	0
12/10/03	0.03	0.36	0.30	0.03	0.18
12/11/03	0.00	0.00	0.00	0.00	0
12/12/03	0.00	0.00	0.00	0.00	0
12/13/03	0.00	0.00	0.00	0.00	0
12/14/03	2.02	2.32	2.48	2.31	2.2825
12/15/03	0.00	0.00	0.00	0.00	0
12/16/03	0.78	1.37	1.05	1.62	1.205
12/17/03	0.16	0.15	0.18	0.11	0.15
12/18/03	0.00	0.00	0.00	0.00	0
12/19/03	0.00	0.00	0.00	0.00	0
12/20/03	0.00	0.00	0.00	0.00	0
12/21/03	0.00	0.02	0.00	0.00	0.005
12/22/03	0.00	0.00	0.00	2.44	0.61
12/23/03	0.00	0.00	0.00	0.00	0
12/24/03	0.00	0.00	0.00	0.00	0
12/25/03	0.00	0.00	0.00	0.00	0
12/26/03	0.00	0.00	0.00	0.00	0
12/27/03	0.00	0.00	0.00	0.00	0
12/28/03	0.00	0.00	0.00	0.00	0
12/29/03	0.00	0.00	0.00	0.00	0
12/30/03	0.00	0.00	0.00	0.00	0
12/31/03	0.00	0.00	0.00	0.00	0

Appendix E

HCSP 2003 Water Quality Data

Table E1. HCSP Water Quality Data Collected by Mosaic in 2003

Station_ID	Date	Sampling Location	Time	Sample Type	Sample Depth	Water Elevation ft MSL	Width ft	Depth ft	Velocity ft/sec	pH Std Units		Specific Conductivity umhos/cm		Turbidity NTU		Dissolved Oxygen mg/l		Ammonia mg/l		Sulfate mg/l	Fluoride mg/l
HCSW-1	4/30/2003	Horse Creek at State Road 64	16:10	Grab	MD	67.57	12	2.0	0.9	7.0	d	237	d	2.9	d	6.7	d	0.06	P, J	45	0.33
HCSW-1	5/27/2003	Horse Creek at State Road 64	12:00	Grab	MD	67.87	20	2.0	0.9	7.2	d	240	d	2.7	d	7	d	0.08	P	36	0.14
HCSW-1	6/19/2003	Horse Creek at State Road 64	9:35	Grab	TOWC	68.92	20	3.5	0.8	7.1	d	179	d	5.1	d	6.7	d	0.08	P	24	0.33
HCSW-1	7/14/2003	Horse Creek at State Road 64	11:00	Grab	MD	68.29	20	2.5	0.5	7.0	d	280	d	4.4	d	5.9	d	0.08	P	77	0.38
HCSW-1	8/28/2003	Horse Creek at State Road 64	12:10	Grab	TOWC	71.57	25	5.0	1.0	7.1	d	139	d	4.9	d	6.4	d	0.06	P	20	0.34
HCSW-1	9/25/2003	Horse Creek at State Road 64	10:45	Grab	MD	67.82	15	3.0	0.3	7.2	d	239	d	5.5	d	6.3	d	0.1	P	33	0.46
HCSW-1	10/29/2003	Horse Creek at State Road 64	14:30	Grab	MD	68.02	20	2.5	0.9	7.0	d	146	d	8.5	d	7.5	d	0.06	P	22	0.27
HCSW-1	11/20/2003	Horse Creek at State Road 64	14:40	Grab	MD	67.23	20	0.6	0.4	7.2	d	187	d	2.1	d	8.4	d	0.05	P	16	0.44
HCSW-1	12/16/2003	Horse Creek at State Road 64	13:45	Grab	MD	67.87	18	2.5	0.6	7.1	d	206	d	3.3	d	9.2	d	0.05	P	31	0.32
HCSW-2	4/30/2003	Horse Creek at Goose Pond Road	15:00	Grab	MD	56.7	25	5.5	0.5	6.1	d	228	d	3.7	d	1	d	0.03	P, J	39	0.24
HCSW-2	5/27/2003	Horse Creek at Goose Pond Road	13:30	Grab	MD	57.3	25	5.0	0.4	6.3	d	156	d	4.0	d	1.3	d	0.07	P	12	0.27
HCSW-2	6/19/2003	Horse Creek at Goose Pond Road	10:30	Grab	TOWC	57.47	50	8.0	0.3	6.3	d	147	d	5.8	d	1.1	d	0.05	P	12	0.29
HCSW-2	7/14/2003	Horse Creek at Goose Pond Road	12:30	Grab	TOWC	56.85	30	5.0	0.3	6.3	d	133	d	5.3	d	1.7	d	0.04	P	9	0.28
HCSW-2	8/28/2003	Horse Creek at Goose Pond Road	11:25	Grab	TOWC	59.6	125	5.0	0.7	6.6	d	93	d	2.4	d	3	d	0.07	P	9	0.2
HCSW-2	9/25/2003	Horse Creek at Goose Pond Road	12:30	Grab	TOWC	57.3	35	5.0	0.3	6.5	d	139	d	4.8	d	1.3	d	0.09	P	8	0.21
HCSW-2	10/29/2003	Horse Creek at Goose Pond Road	13:45	Grab	TOWC	55.55	35	3.5	0.4	6.7	d	150	d	2.7	d	2.9	d	0.13	P	8	0.29
HCSW-2	11/20/2003	Horse Creek at Goose Pond Road	13:40	Grab	MD	55.6	35	3.5	0.9	6.6	d	149	d	4.3	d	2.8	d	0.09	P	9	0.3
HCSW-2	12/16/2003	Horse Creek at Goose Pond Road	12:55	Grab	TOWC	56.2	50	4.0	0.1	6.5	d	169	d	2.0	d	4.1	d	0.05	P	16	0.23
HCSW-3	4/30/2003	Horse Creek at State Road 70	13:00	Grab	MD	33.04	15	3.5	1.0	7.0	d	311	d	3.2	d	6.6	d	0.07	P, J	66	0.3
HCSW-3	5/27/2003	Horse Creek at State Road 70	15:15	Grab	MD	33.3	18	2.5	1.4	6.9	d	212	d	3.2	d	6.4	d	0.06	P	34	0.32
HCSW-3	6/19/2003	Horse Creek at State Road 70	11:45	Grab	TOWC	35.16	20	5.0	0.9	6.7	d	169	d	4.6	d	5.5	d	0.08	P	22	0.25
HCSW-3	7/14/2003	Horse Creek at State Road 70	14:30	Grab	TOWC	33.77	20	4.0	0.5	6.8	d	190	d	4.4	d	5.5	d	0.11	P	35	0.26
HCSW-3	8/28/2003	Horse Creek at State Road 70	10:30	Grab	TOWC	See Notes	300	6.0	0.7	7.0	d	110	d	3.3	d	5.4	d	0.07	P	12	0.18
HCSW-3	9/25/2003	Horse Creek at State Road 70	14:25	Grab	MD	34.56	35	4.0	0.5	7.0	d	159	d	4.0	d	5.1	d	0.13	P	22	0.21
HCSW-3	10/29/2003	Horse Creek at State Road 70	12:30	Grab	MD	32.19	15	2.5	1.1	6.9	d	276	d	4.7	d	6.4	d	0.13	P	69	0.36
HCSW-3	11/20/2003	Horse Creek at State Road 70	12:40	Grab	MD	31.62	22	1.2	1.1	6.8	d	240	d	2.4	d	7.6	d	0.07	P	57	0.34
HCSW-3	12/16/2003	Horse Creek at State Road 70	11:30	Grab	MD	< 31.6	20	2.5	0.4	7.1	d	412	d	2.3	d	8.7	d	0.06	P	146	0.35
HCSW-4	4/30/2003	Horse Creek at State Road 72	11:45	Grab	MD	20.41	25	3.5	0.8	6.9	d	469	d	1.7	d	6.6	d	0.06	P, J	158	0.33
HCSW-4	5/27/2003	Horse Creek at State Road 72	17:00	Grab	MD	14.44	25	3.0	1.0	7.1	d	258	d	3.2	d	6.8	d	0.04	P	49	0.33
HCSW-4	6/19/2003	Horse Creek at State Road 72	13:00	Grab	TOWC	17.71	50	5.0	0.5	6.8	d	280	d	4.2	d	6	d	0.09	P	68	0.26
HCSW-4	7/14/2003	Horse Creek at State Road 72	16:00	Grab	TOWC	16.21	45	4.0	0.6	6.9	d	234	d	4.4	d	6.3	d	0.11	P	46	0.25
HCSW-4	8/28/2003	Horse Creek at State Road 72	8:15	Grab	TOWC	22.84	300	10.0	0.7	6.5	d	152	d	3.2	d	5.4	d	0.07	P	20	0.19
HCSW-4	9/25/2003	Horse Creek at State Road 72	16:00	Grab	TOWC	16.46	50	5.0	0.8	7.1	d	181	d	5.4	d	5.6	d	0.13	P	27	0.26
HCSW-4	10/29/2003	Horse Creek at State Road 72	11:00	Grab	MD	14.14	30	3.0	14.1	6.8	d	308	d	3.5	d	6.7	d	0.1	P	72	0.37
HCSW-4	11/20/2003	Horse Creek at State Road 72	10:40	Grab	MD	13.85	31	1.2	1.0	6.6	d	296	d	3.3	d	7.2	d	0.07	P	67	0.37
HCSW-4	12/16/2003	Horse Creek at State Road 72	10:15	Grab	MD	14.3	40	2.5	0.5	6.8	d	535	d	2.5	d	8.7	d	0.2	P	199	0.34

Table E1. HCSP Water Quality Data Collected by Mosaic in 2003 (continued)																								
		Chlorophyll-A		Total Nitrogen	Ortho-phosphate	True Color	Total Dissolved Solids	Chloride	Dissolved Calcium	Total Radium		Alkalinity	Dissolved Iron		FL--PRO		Total Amines		Total Fatty Acids		Total Kjeldahl Nitrogen		Nitrate-Nitrite	Total Iron
Station_ID	Date	mg/m^3		mg/l	mg/l	CU	mg/l	mg/l	mg/l	pCi/L		mg/l Ca CO3	mg/l		mg/l		ug/l		ug/l		mg/l		mg/l	mg/l
HCSW-1	4/30/2003	1	U	1.23	0.33	125	167	16	15	1	U	21	0.3		0.3	U	500	U	500	U	1.1		0.13	
HCSW-1	5/27/2003	1	U	1.66	0.31	225	199	23	17.4	1		40	0.5		0.3	U	500	U	500	U	1.5		0.16	
HCSW-1	6/19/2003	1		1.81	0.27	225	158	14	12.5	1	U	31	0.6		0.3	U	500	U	500	U	1.7		0.11	
HCSW-1	7/14/2003	1	U	1.13	0.15	90	222	10	23.9	1	U	46	0.3		0.3	U	500	U	500	U	1		0.13	
HCSW-1	8/28/2003	1	UJ3	1.28	0.19	225	126	7	9	1		26	0.6		0.3	U	500	U	500	U	1.2	J3	0.08	
HCSW-1	9/25/2003	1	U	1.16	0.27	110	165	11	16.9	1	U	59	0.3		0.3	U	200	U	500	U	1		0.16	
HCSW-1	10/29/2003	2		1.26	0.24	110	168	13	9.7	1	U	22	0.4		0.3	U	100	U	200	U	1.1		0.16	
HCSW-1	11/20/2003	1	U	0.88	0.31	100	102	17	12.9	1	U	48	0.3	J	0.3	U	200	U	200	U	0.7		0.18	0.297
HCSW-1	12/16/2003	5		1.03	0.29	125	155	17		1.677		33			0.3	U	200	U	200	U	0.9		0.13	0.318
HCSW-2	4/30/2003	4		1.29	0.22	175	160	20	12.1	1	U	16	0.6		0.3	U	500	U	500	U	1.2		0.09	
HCSW-2	5/27/2003	5		1.66	0.3	275	159	18	8.7	1	U	24	0.5		0.3	U	500	U	500	U	1.6		0.06	
HCSW-2	6/19/2003	4		1.69	0.36	275	168	15	8.8	1		26	0.7		0.3	U	500	U	500	U	1.6		0.09	
HCSW-2	7/14/2003	7		1.28	0.26	225	156	12	8.7	1	U	27	0.5		0.3	U	500	U	500	U	1.2		0.08	
HCSW-2	8/28/2003	1	J3	1.07	0.24	175	90	6	6.4	1	U	17	0.5		0.3	U	500	U	500	U	1	J3	0.07	
HCSW-2	9/25/2003	2		1.51	0.25	180	116	13	8.6	2		23	0.6		0.3	U	200	U	500	U	1.4		0.11	
HCSW-2	10/29/2003	6		1.5	0.22	180	164	16	9.9	1	U	36	0.4		0.3	U	100	U	200	U	1.4		0.1	
HCSW-2	11/20/2003	1		1.2	0.23	160	86	16	8.5	1	U	29	0.3	J	0.3	U	200	U	200	U	1.1		0.1	0.326
HCSW-2	12/16/2003	2		1.22	0.19	20	133	20		1.574		19			0.3	U	200	U	200	U	1.1		0.12	0.208
HCSW-3	4/30/2003	1		1.39	0.28	110	219	24	22.8	1	U	24	0.3		0.3	U	500	U	500	U	1.1		0.29	
HCSW-3	5/27/2003	1	U	1.53	0.27	175	185	20	14.6	1	U	23	0.4		0.3	U	500	U	500	U	1.3		0.23	
HCSW-3	6/19/2003	1	U	1.82	0.39	275	185	15	11.2	1	U	22	0.7		0.3	U	500	U	500	U	1.7		0.12	
HCSW-3	7/14/2003	1	U	1.7	0.34	275	202	14	15.5	2		26	0.6		0.3	U	500	U	500	U	1.4		0.3	
HCSW-3	8/28/2003	1	UJ3	1.32	0.3	225	108	8	7.9	1	U	18	0.6		0.3	U	500	U	500	U	1.2	J3	0.12	
HCSW-3	9/25/2003	1	U	1.67	0.3	175	134	11	13	2		27	0.6		0.3	U	200	U	500	U	1.4		0.27	
HCSW-3	10/29/2003	1	U	1.79	0.36	160	238	19	24.7	2		38	0.4		0.3	U	100	U	200	U	1.2		0.59	
HCSW-3	11/20/2003	1	U	1.42	0.29	130	136	18	18.7	1		30	0.3	J	0.3	U	200	U	200	U	1		0.42	0.327
HCSW-3	12/16/2003	1	U	1.46	0.31	100	318	23		1.878		29			0.3	U	200	U	200	U	0.8		0.66	0.284
HCSW-4	4/30/2003	1		1.49	0.3	90	330	25	45.7	1	U	25	0.2		0.3	U	500	U	500	U	1		0.49	
HCSW-4	5/27/2003	1	U	1.62	0.3	175	195	21	19.7	1	U	27	0.4		0.3	U	500	U	500	U	1.3		0.32	
HCSW-4	6/19/2003	1	U	1.7	0.41	225	267	19	25	1	U	25	0.6		0.3	U	500	U	500	U	1.5		0.2	
HCSW-4	7/14/2003	1		1.72	0.43	225	214	18	21.6	2		33	0.7		0.3	U	500	U	500	U	1.3		0.42	
HCSW-4	8/28/2003	1	UJ3	1.37	0.39	275	144	10	12.5	1		25	0.7		0.3	U	500	U	500	U	1.2	J3	0.17	
HCSW-4	9/25/2003	1	U	1.73	0.34	175	159	12	15.8	1	U	30	0.6		0.3	U	200	U	500	U	1.4		0.33	
HCSW-4	10/29/2003	1	U	1.65	0.47	130	275	22	30	2		49	0.4		0.3	U	100	U	200	U	1		0.65	
HCSW-4	11/20/2003	1	U	1.5	0.37	125	196	22	26	1	U	42	0.3	J	0.3	U	200	U	500	U	0.9		0.6	0.359
HCSW-4	12/16/2003	1	U	2.36	0.34	60	407	28		1.335		34			0.3	U	200	U	200	U	1.1		1.26	0.317

Table E1. HCSP Water Quality Data Collected by Mosaic in 2003 (continued)

		Total Calcium	Radium 226	Radium 228						
		mg/l	pCi/L	pCi/L		Laboratory ID	Sampler	Weather	Sample Qualities	Notes
HCSW-1	4/30/2003					51593-4, AG01184	RMM	W, L, 30 C, S, C, R	Tannic, No Odor, No Sediment	Flow and elevation from USGS
HCSW-1	5/27/2003					AG01425, 51994-1	RMM	W, L, 30 C, S, C, H	Tannic, No Odor, No Sediment	
HCSW-1	6/19/2003					AG01669 52341-1	RMM	V, C, 26 C, O, C, H	Tannic, No Odor, Minor Sediment	Flow from USGS Website
HCSW-1	7/14/2003					AG01985	RMM	SE, L, 30.0C, S, C, H	Tannic, No Odor, Minor Sediment	
HCSW-1	8/28/2003					AG02534, 53323-4	RMM	E, L, 32 C, S, C, H	Tannic, No Odor, No Sediment	
HCSW-1	9/25/2003					AG02893, 53720-1	RMM	E, L, 28.5C, S, C, H	Tannic, No Odor, Minor Sediment	
HCSW-1	10/29/2003					AG03299; 54218-1	RMM	N/A, C, 29.0C, C, C, H	Tannic, No Odor, Minor Sediment	
HCSW-1	11/20/2003	12.9				54610-4, AG03600	RMM	N, L, 24.0C, C, C, D	Tannic, No Odor, No Sediment	
HCSW-1	12/16/2003	12.2	0.407	1.27		AG03825; 54942-4	RMM	E, L, 23 C, O, H, R	Tannic, No Odor, No Sediment	
HCSW-2	4/30/2003					51593-3, AG01185	RMM	W, L, 28 C, O, C, H	Tannic, No Odor, No Sediment	
HCSW-2	5/27/2003					AG01426, 51994-2	RMM	NW, L, 29 C, S, C, H	Tannic, No Odor, No Sediment	
HCSW-2	6/19/2003					AG01670 52341-2,	RMM	SW, L, 29 C, O, C, H	Tannic, No Odor, Minor Sediment	
HCSW-2	7/14/2003					AG01986	RMM	V, C, 30 C, S, C, H	Tannic, No Odor, Minor Sediment	
HCSW-2	8/28/2003					AG02535, 53323-3	RMM	E, L, 30 C, S, C, H	Tannic, No Odor, No Sediment	Flooded; River out of the banks
HCSW-2	9/25/2003					AG02894, 53720-2	RMM	SE, L, 27.0C, O, H, R	Tannic, No Odor, Minor Sediment	
HCSW-2	10/29/2003					AG03300; 54218-2	RMM	N, L, 29.0C, C, C, H	Tannic, No Odor, No Sediment	
HCSW-2	11/20/2003	9.1				54610-3, AG03601	RMM	NE, L, 24 C, C, C, D	Tannic, No Odor, No Sediment	
HCSW-2	12/16/2003	8.8	0.134	1.44		AG03824; 54942-3	RMM	SE, L, 23 C, O, C, H	Tannic, No Odor, No Sediment	
HCSW-3	4/30/2003					51593-2, AG01186	RMM	S, L, 26 C, O, H, H	Tannic, No Odor, No Sediment	
HCSW-3	5/27/2003					AG01427, 51994-3	RMM	NW, L, 32 C S, C, H	Tannic, No Odor, No Sediment	Blank and Duplicate Taken Here
HCSW-3	6/19/2003					AG01671 52341-3	RMM	SW, L, 29 C, O, C, H	Tannic, No Odor, Minor Sediment	River just starting to come out of the channel
HCSW-3	7/14/2003					AG01987	RMM	V, C, 32 C, S, C, H	Tannic, No Odor, No Sediment	
HCSW-3	8/28/2003					AG02536	RMM	E, L, 30 C, S, C, H	Tannic, No Odor, No Sediment	Flooded Conditions, Staff gauge under water
HCSW-3	9/25/2003					AG02895, 53720-3	RMM	Var., C, 31.0C, O, H, H	Tannic, No Odor, No Sediment	
HCSW-3	10/29/2003					AG03301; 54218-3	RMM	N, L, 28.5C, S, C, H	Tannic, No Odor, No Sediment	
HCSW-3	11/20/2003	20.7				AG03602, 54610-2	RMM	N, L, 23 C, C, C, D	Tannic, No Odor, No Sediment	
HCSW-3	12/16/2003	44.6	0.788	1.09		AG03823; 54942-2	RMM	SE, L, 23 C, O, C, H	Tannic, No Odor, No Sediment	Water level was below the lowest mark on the staff gauge
HCSW-4	4/30/2003					51593-1, AG01187	RMM	W, L, 26 C, O, C, H	Lightly Tannic, No Odor, No Sediment	Flow and elevation from USGS
HCSW-4	5/27/2003					AG01428, 51994-4	RMM	W, L, 32 C, S, C, H	Tannic, No Odor, No Sediment	
HCSW-4	6/19/2003					AG01672 52341-4	RMM	SW, L, 30 C, O, C, H	Tannic, No Odor, Minor Sediment	Flow from USGS Website
HCSW-4	7/14/2003					AG01988	RMM	SW, L, 26 C, O, H, H	Tannic, No Odor, Minor Sediment	Flow and water elevation from USGS
HCSW-4	8/28/2003					AG02537, 53323-1	RMM	E, L, 25 C, C, C, H	Tannic, No Odor, No Sediment	Blank and Duplicate Taken Here; Flow and Stage from USGS
HCSW-4	9/25/2003					AG02896, 53720-4	RMM	S, L, 26.0C, O, H, R	Tannic, No Odor, Minor Sediment	
HCSW-4	10/29/2003					AG03302; 54218-4	RMM	N, L, 26.0C, S, C, H	Tannic, No Odor, No Sediment	
HCSW-4	11/20/2003	28.7				54610-1, AG03603	RMM	N, L, 20 C, C, C, D	Lightly Tannic, No Odor, No Sediment	
HCSW-4	12/16/2003	57.9	0.646	0.689		AG03822; 54942-1	RMM	E, L, 21 C, O, C, D	Tannic, No Odor, No Sediment	

Table E1. HCSP Water Quality Data Collected by Mosaic in 2003 (continued)

Water Quality Monitoring Parameters and Trigger Levels

Specific Conductance	uS/cm	> 1,275
Total Alkalinity	mg/l Ca CO3	> 100
Calcium	mg/l	> 100
Iron	mg/l	> 0.3, > 1.0
Chloride	mg/l	> 250
Fluoride	mg/l	> 1.5, > 4.0
Radium 226 + 228	pCi/L	> 5.0
Sulfate	mg/l	> 250
Total Dissolved Solids	mg/l	> 500
Petroleum Range Organics	mg/l	> 5.0
Parameter	Reporting Units	Trigger Level
pH	Std Units	< 6.0 or > 8.5
Dissolved Oxygen	mg/l	< 5.0
Turbidity	NTU	> 29
Color	PCU	< 25
Total Nitrogen	mg/l	> 3.0
Total Ammonia	mg/l	> 0.3
Otho-Phosphorous	mg/l	> 2.5
Chlorophyll-A	mg/m^3	> 15
Fatty Amido-amines	ug/l	200
Total Fatty Acids	ug/l	500

Total Kjehdahl Nitrogen and Nitrate/Nitrite are performed as part of the Total Nitrogen analysis.

The iron trigger of 1.0 applies at Stations HCSW-1, HCSW-2, and HCSW-3. The iron trigger of 0.3 mg/l applies at the HCSW-4 station.

The fluoride trigger of 4.0 applies at Stations HCSW-1, HCSW-2, and HCSW-3. The fluoride trigger of 1.5 mg/l applies at the HCSW-4 station.

The total fatty acids trigger level is the "No Observed Effects" concentration for *Ceriodaphnia dubia* reproduction and *Pimephales promelas* growth

The Fatty Amido-amines trigger level is the "No Observed Effects" concentration for *Ceriodaphnia dubia*

Sampling Abbreviations

U	Data Qualifier (analyte not detected at the method detection limit)
P	Sample was analyzed without manual distillation
J	Estimated Value
D	Field Data

Weather Abbreviations

Wind Direction: NE, SW, S, or no direction if there are calm conditions

Wind Strength: Calm, Light, Medium, High

Temperature: 76 F, 27 C, etc.

Abbreviation	Meaning
mg/l	milligram per liter
pCi/l	picocuries per liter
Std Units	Standard Units
NTU	Nephelomteric Turbidity Units
PCU	Platinum Cobalt Color Units
uS/cm	microSiemens per centimeter
ug/l	micrograms per liter
mg/m^3	milligrams per cubic meter

Sky: Clear, Overcast, Scattered

Visibility: Clear, Hazy

Humidity: Dry, Humid, Raining

Example: SW, L, 20 C, S, C, D

A light wind out of the southwest.

The air temperature is 20 degrees C.

There are scattered clouds with clear visibility and dry conditions (low humidity).

Table E2. Field Water Quality Data Collected During Each HCSP Biological Sampling Event in 2003

Sample Date	*Station*	*Sample ID*	*Temperature* (C)	*pH* (SU)	*Conductivity* (µmhos/cm)	*Dissolved Oxygen* (mg/l)	*Turbidity* (NTU)
4/25/2003	HCSW-1	HCSW1-2003-1	23.3	7.6	302	6.6	1.6
4/25/2003	HCSW-2	HCSW2-2003-1	24.9	6.8	159	4.2	1.6
4/25/2003	HCSW-3	HCSW3-2003-1	24.5	7.2	487	6.7	2.8
4/25/2003	HCSW-4	HCSW4-2003-1	23.4	7.0	539	6.8	1.1
7/29/2003	HCSW-1	HCSW1-2003-2	27.4	7.0	252	7.2	5.8
7/29/2003	HCSW-2	HCSW2-2003-2	28.1	6.0	196	1.4	2.4
7/29/2003	HCSW-3	HCSW3-2003-2	28.5	6.6	207	5.4	11.8
7/29/2003	HCSW-4	HCSW4-2003-2	27.7	6.4	240	5.8	3.4
11/20/2003	HCSW-1	HCSW1-2003-3	19.7	6.8	173	8.4	2.9
11/20/2003	HCSW-2	HCSW2-2003-3	21.3	6.0	121	3.5	1.9
11/20/2003	HCSW-3	HCSW3-2003-3	20.5	6.8	225	7.7	1.6
11/20/2003	HCSW-4	HCSW4-2003-3	20.0	6.9	276	7.7	1.7

Table E3. Daily Mean, Maximum, and Minimum Water Quality Values Obtained from Continuous Recorder at HCSW-1 from May 2003 to December 2003 for HCSP.

	Dissolved Oxygen			pH			Specific Conductivity			Turbidity		
	Daily Minimum	Daily Mean	Daily Maximum	Daily Minimum	Daily Mean	Daily Maximum	Daily Minimum	Daily Mean	Daily Maximum	Daily Minimum	Daily Mean	Daily Maximum
Date	mg/l	mg/l	mg/l	SU	SU	SU	umhos/cm	umhos/cm	umhos/cm	NTU	NTU	NTU
5/30/2003	6.5	6.8	7.8	7.00	7.23	7.35	230.99	237.00	253.06	2.0	2.9	6.2
5/31/2003	6.2	6.5	6.6	7.13	7.29	7.37	196.07	210.05	238.01	2.4	3.2	3.3
6/1/2003	5.4	5.8	5.9	6.94	7.03	7.13	221.36	240.00	260.37	2.6	2.7	5.0
6/2/2003	5.5	6.1	6.5	6.93	7.07	7.30	216.81	227.62	272.14	3.3	3.3	3.9
6/3/2003	5.8	5.8	6.7	7.06	7.07	7.31	165.07	186.22	227.42	1.9	2.8	4.6
6/4/2003	5.1	5.8	6.4	7.04	7.10	7.22	220.85	223.67	249.21	1.4	2.3	3.3
6/5/2003	5.9	6.3	6.9	7.14	7.17	7.19	185.27	188.96	206.44	1.4	2.1	4.0
6/6/2003	5.0	5.7	6.5	7.07	7.11	7.34	304.20	306.22	329.73	2.0	2.5	7.4
6/7/2003	5.4	5.9	6.4	6.82	7.02	7.22	203.44	204.00	239.47	3.0	3.8	4.1
6/8/2003	5.3	5.8	6.1	6.99	7.03	7.19	229.81	239.15	242.00	3.4	3.7	3.8
6/9/2003	6.0	6.1	6.6	7.04	7.10	7.25	235.68	256.34	300.39	1.2	2.1	3.4
6/10/2003	5.1	5.9	6.0	6.86	7.02	7.20	234.38	245.18	245.63	2.1	2.4	2.6
6/11/2003	5.4	5.9	6.4	6.80	7.01	7.06	271.42	281.35	284.99	1.9	2.6	3.8
6/12/2003	5.3	5.9	6.9	7.06	7.08	7.33	219.12	235.01	276.60	2.2	2.7	5.8
6/13/2003	5.1	6.0	6.6	7.11	7.19	7.39	222.69	239.59	252.49	1.9	2.8	5.0
6/14/2003	4.8	5.9	6.6	7.01	7.10	7.20	144.10	168.00	179.82	2.2	2.6	5.3
6/15/2003	5.0	5.9	6.9	7.11	7.24	7.45	202.67	223.49	252.92	2.2	2.7	4.5
6/16/2003	5.5	5.9	6.4	7.02	7.18	7.39	217.78	232.96	248.76	2.2	3.1	4.7
6/17/2003	5.2	6.0	6.3	6.91	7.15	7.32	306.55	318.74	319.57	2.8	3.7	5.7
6/18/2003	5.1	6.0	6.1	7.13	7.18	7.29	252.25	271.44	279.33	1.7	2.0	4.8
6/19/2003	No Data	No Data	No Data	No Data	No Data	No Data	225.80	226.83	253.49	No Data	No Data	No Data
6/20/2003	5.0	5.1	5.4	6.92	7.10	7.34	164.76	175.68	196.17	1.8	2.2	4.7
6/21/2003	4.4	4.8	4.9	6.90	7.08	7.08	256.31	275.06	291.86	2.9	3.2	3.6
6/22/2003	5.2	5.2	5.3	6.90	7.11	7.18	207.21	227.00	266.68	1.7	2.6	4.4
6/23/2003	4.8	5.9	6.2	6.84	7.06	7.28	233.16	255.19	294.21	1.5	2.4	2.9
6/24/2003	6.0	6.3	6.8	6.85	7.03	7.27	196.27	203.22	211.22	2.1	2.7	4.7
6/25/2003	5.7	5.9	6.2	6.88	7.02	7.17	203.15	227.97	259.05	2.7	3.4	4.0
6/26/2003	5.7	5.8	5.9	7.13	7.18	7.25	197.82	213.87	222.57	3.0	3.4	3.7
6/27/2003	5.6	6.0	6.3	6.85	7.05	7.13	175.50	193.00	235.09	6.6	7.0	8.4
6/28/2003	5.2	5.7	6.1	7.06	7.16	7.35	195.71	203.59	213.16	1.6	2.2	8.2
6/29/2003	5.3	5.8	6.6	6.96	7.05	7.05	239.19	251.22	275.49	2.4	2.4	4.3
6/30/2003	5.4	5.8	6.2	6.88	7.02	7.08	256.06	266.89	297.62	3.7	4.4	7.1
7/1/2003	5.7	6.5	6.9	7.26	7.28	7.39	159.57	179.00	212.27	3.7	4.4	7.1
7/2/2003	5.9	6.5	6.9	6.89	7.10	7.33	160.78	172.12	199.09	2.9	3.6	5.8
7/3/2003	5.3	6.3	7.1	6.81	7.03	7.25	218.73	225.00	236.93	1.3	2.0	2.6
7/4/2003	5.8	6.3	7.2	7.04	7.08	7.16	189.09	194.61	206.67	1.4	2.2	5.5
7/5/2003	No Data	No Data	No Data	6.93	7.05	7.06	219.46	222.45	258.97	No Data	No Data	No Data
7/6/2003	5.7	6.6	7.5	7.03	7.15	7.21	140.36	156.41	167.57	1.3	2.1	2.8

	Dissolved Oxygen			pH			Specific Conductivity			Turbidity		
	Daily Minimum	Daily Mean	Daily Maximum	Daily Minimum	Daily Mean	Daily Maximum	Daily Minimum	Daily Mean	Daily Maximum	Daily Minimum	Daily Mean	Daily Maximum
Date	mg/l	mg/l	mg/l	SU	SU	SU	umhos/cm	umhos/cm	umhos/cm	NTU	NTU	NTU
7/7/2003	6.0	6.2	6.3	6.80	6.99	7.11	178.48	196.87	225.73	1.8	2.3	3.7
7/8/2003	6.5	6.5	7.6	6.88	7.04	7.28	202.00	209.40	218.44	2.5	2.6	5.9
7/9/2003	5.7	6.3	7.2	7.03	7.11	7.17	172.05	194.87	221.84	3.7	3.7	5.1
7/10/2003	5.5	6.5	6.6	6.95	7.03	7.18	197.66	220.87	227.02	2.1	2.6	4.8
7/11/2003	6.2	6.5	7.0	6.86	7.04	7.23	120.99	125.27	135.45	2.1	2.5	3.0
7/12/2003	6.1	6.3	6.7	6.86	7.09	7.11	115.90	138.30	142.01	2.4	2.9	5.0
7/13/2003	5.9	6.5	7.5	No Data	No Data	No Data	126.72	149.63	173.79	2.4	3.0	5.6
7/14/2003	5.9	6.2	7.3	No Data	No Data	No Data	156.79	160.46	184.40	2.5	3.1	8.6
7/15/2003	6.0	6.4	7.1	6.97	6.98	7.12	145.38	155.48	155.90	2.0	2.4	4.5
7/16/2003	5.3	6.3	7.2	6.84	7.02	7.12	153.47	167.46	203.80	6.5	6.7	9.4
7/17/2003	7.4	8.4	8.7	6.92	7.08	7.12	144.61	166.42	184.52	3.2	4.1	6.6
7/18/2003	5.3	6.2	6.5	6.82	7.06	7.26	220.61	221.33	246.68	2.5	2.5	5.4
7/19/2003	5.5	6.4	7.1	7.04	7.07	7.13	155.99	170.58	184.98	3.2	3.2	5.7
7/20/2003	5.5	6.3	6.3	6.84	6.97	7.02	214.96	223.41	236.11	2.1	2.9	5.6
7/21/2003	6.3	6.5	7.2	6.79	7.00	7.07	169.18	180.26	192.79	3.2	3.3	5.0
7/22/2003	6.5	6.5	7.2	6.93	7.08	7.10	149.87	160.63	182.11	2.2	2.5	4.9
7/23/2003	6.2	6.4	7.2	6.78	7.00	7.11	195.35	196.03	197.36	No Data	No Data	No Data
7/24/2003	5.2	6.2	6.9	6.96	7.16	7.38	156.45	163.19	177.74	No Data	No Data	No Data
7/25/2003	No Data	No Data	No Data	7.03	7.08	7.26	147.25	165.03	177.77	1.6	2.5	3.8
7/26/2003	No Data	No Data	No Data	6.99	7.12	7.21	213.41	226.03	254.70	1.6	2.6	4.2
7/27/2003	No Data	No Data	No Data	6.99	7.09	7.11	201.43	219.47	224.72	1.7	2.4	3.1
7/28/2003	No Data	No Data	No Data	6.92	7.11	7.13	259.45	261.00	278.77	1.9	2.3	3.2
7/29/2003	No Data	No Data	No Data	6.87	6.97	7.20	161.45	177.00	197.77	2.0	2.5	5.0
7/30/2003	No Data	No Data	No Data	6.83	6.94	7.05	175.71	194.17	204.78	4.1	4.2	5.6
7/31/2003	No Data	No Data	No Data	6.86	7.07	7.19	257.58	280.91	323.28	1.2	2.0	13.7
8/1/2003	No Data	No Data	No Data	7.16	7.18	7.40	277.72	280.00	299.18	6.9	6.9	8.7
8/2/2003	No Data	No Data	No Data	7.04	7.19	7.24	260.86	265.18	274.98	3.2	3.5	3.6
8/3/2003	No Data	No Data	No Data	7.10	7.11	7.34	208.83	220.00	221.26	2.9	2.9	3.7
8/4/2003	No Data	No Data	No Data	6.96	7.10	7.23	281.58	299.79	337.68	1.3	2.1	3.0
8/5/2003	No Data	No Data	No Data	6.91	7.12	7.33	227.66	246.00	252.85	1.6	2.4	4.2
8/6/2003	No Data	No Data	No Data	7.00	7.07	7.09	207.85	225.31	240.23	1.8	2.2	2.2
8/7/2003	No Data	No Data	No Data	7.00	7.11	7.13	246.16	249.74	258.21	1.9	2.1	3.5
8/8/2003	No Data	No Data	No Data	6.92	7.06	7.18	284.71	305.19	319.95	5.5	5.7	6.3
8/9/2003	No Data	No Data	No Data	6.97	7.16	7.26	220.04	243.99	269.22	1.9	2.0	4.1
8/10/2003	No Data	No Data	No Data	7.03	7.11	7.23	291.42	299.51	306.24	1.5	2.1	3.4
8/11/2003	5.8	6.1	6.4	6.92	7.13	7.32	232.54	235.77	239.19	2.2	2.8	5.5
8/12/2003	5.1	6.2	7.2	6.87	7.06	7.25	285.07	303.09	313.25	2.6	2.9	3.6
8/13/2003	5.9	6.5	7.6	6.94	7.04	7.10	195.75	202.00	218.30	2.0	2.2	4.6
8/14/2003	5.5	6.3	6.4	7.02	7.11	7.21	219.64	242.45	278.51	1.8	2.5	5.9
8/15/2003	6.1	6.4	6.5	6.95	7.09	7.17	248.34	268.28	309.51	No Data	No Data	No Data

	Dissolved Oxygen			pH			Specific Conductivity			Turbidity		
	Daily Minimum	Daily Mean	Daily Maximum	Daily Minimum	Daily Mean	Daily Maximum	Daily Minimum	Daily Mean	Daily Maximum	Daily Minimum	Daily Mean	Daily Maximum
Date	mg/l	mg/l	mg/l	SU	SU	SU	umhos/cm	umhos/cm	umhos/cm	NTU	NTU	NTU
8/16/2003	6.1	6.2	6.6	7.01	7.07	7.14	291.57	305.32	330.30	6.9	7.0	7.4
8/17/2003	6.1	6.5	7.5	6.95	7.06	7.31	211.50	236.42	264.88	2.0	2.1	4.6
8/18/2003	5.6	6.4	6.5	7.04	7.09	7.23	245.55	250.47	256.74	1.9	2.7	4.7
8/19/2003	5.8	6.2	6.5	6.94	7.07	7.18	224.38	236.19	256.85	1.6	2.2	3.1
8/20/2003	6.0	6.4	7.3	No Data	No Data	No Data	252.45	275.45	304.58	5.2	5.5	7.5
8/21/2003	5.3	6.2	6.5	6.97	7.11	7.36	198.05	207.00	226.46	1.7	2.3	2.9
8/22/2003	5.9	6.5	6.6	7.04	7.10	7.19	224.49	238.33	254.13	1.4	2.1	4.9
8/23/2003	5.2	6.2	7.2	6.89	7.12	7.15	287.28	306.04	344.49	3.8	4.2	5.9
8/24/2003	4.4	4.8	5.2	7.10	7.10	7.34	245.22	269.97	297.40	15.9	15.9	19.3
8/25/2003	4.3	4.7	5.0	7.10	7.12	7.28	216.65	220.60	237.70	1.5	2.2	4.1
8/26/2003	5.2	5.2	5.3	7.14	7.15	7.36	244.86	263.95	288.36	1.9	2.7	4.6
8/27/2003	5.1	5.5	5.6	7.00	7.10	7.11	238.02	245.81	286.02	2.4	3.0	3.4
8/28/2003	5.2	6.3	7.3	No Data	No Data	No Data	223.75	229.00	260.39	2.2	2.6	5.2
8/29/2003	6.2	6.2	7.2	7.09	7.13	7.35	261.65	269.81	308.31	2.3	2.8	5.8
8/30/2003	6.2	6.4	7.2	6.90	7.12	7.35	229.85	240.79	256.29	1.9	2.3	4.5
8/31/2003	6.1	6.3	7.0	6.99	7.12	7.12	164.75	182.00	182.24	1.2	2.1	4.0
9/1/2003	No Data	No Data	No Data	7.04	7.20	7.34	130.58	139.00	164.27	6.7	7.5	18.4
9/2/2003	7.1	7.3	7.5	7.03	7.15	7.35	134.46	138.35	159.94	2.7	3.4	4.7
9/3/2003	6.7	7.6	8.3	7.09	7.15	7.21	115.40	137.71	161.98	2.2	2.8	2.9
9/4/2003	7.2	7.5	8.0	7.13	7.14	7.21	132.15	137.06	175.65	3.3	3.6	5.8
9/5/2003	7.3	7.5	8.1	7.07	7.15	7.31	161.11	166.00	171.57	3.1	4.1	7.3
9/6/2003	7.3	7.7	7.8	7.17	7.22	7.33	150.53	165.35	209.15	2.8	3.2	4.8
9/7/2003	7.5	7.5	8.0	7.06	7.23	7.46	158.72	164.71	190.87	2.1	2.4	2.6
9/8/2003	7.3	7.5	7.7	7.14	7.16	7.28	150.40	164.06	172.38	1.4	2.3	3.9
9/9/2003	7.1	7.4	8.3	7.14	7.20	7.30	151.91	163.42	177.69	2.4	2.6	3.5
9/10/2003	6.9	7.7	7.9	7.01	7.19	7.33	141.27	162.77	187.81	1.7	2.6	4.3
9/11/2003	7.0	7.5	7.8	7.23	7.24	7.36	157.74	162.13	181.61	2.4	2.6	4.8
9/12/2003	7.5	7.5	7.6	6.98	7.23	7.31	154.93	161.48	174.44	4.2	4.2	7.6
9/13/2003	7.0	7.5	7.8	7.16	7.24	7.36	152.28	160.84	176.05	2.4	2.9	5.8
9/14/2003	6.7	7.5	8.4	7.02	7.25	7.48	143.10	160.19	187.65	No Data	No Data	No Data
9/15/2003	7.0	7.6	8.1	7.07	7.27	7.27	191.25	199.00	209.93	No Data	No Data	No Data
9/16/2003	6.2	7.3	7.7	7.15	7.38	7.48	182.09	198.35	220.02	1.9	2.8	5.2
9/17/2003	6.5	7.4	7.8	7.17	7.21	7.42	194.97	197.71	225.95	5.9	6.4	7.5
9/18/2003	6.7	7.5	8.3	7.07	7.16	7.33	180.64	197.06	202.51	2.5	3.3	4.7
9/19/2003	7.3	7.5	7.9	6.96	7.13	7.31	135.65	156.00	192.89	1.4	2.4	3.0
9/20/2003	6.6	7.4	8.0	7.09	7.23	7.42	171.86	195.77	228.29	1.5	2.4	2.7
9/21/2003	6.9	7.5	8.3	7.08	7.22	7.24	193.49	195.13	219.20	1.3	2.3	4.2
9/22/2003	6.9	7.4	8.4	7.07	7.13	7.23	175.57	194.48	201.45	3.5	4.1	6.2
9/23/2003	7.2	7.6	7.8	7.13	7.18	7.30	189.15	193.84	203.09	2.6	2.7	3.2
9/24/2003	6.6	7.7	8.0	7.12	7.28	7.38	180.09	193.19	213.98	3.0	3.5	6.1

	Dissolved Oxygen			pH			Specific Conductivity			Turbidity		
	Daily Minimum	Daily Mean	Daily Maximum	Daily Minimum	Daily Mean	Daily Maximum	Daily Minimum	Daily Mean	Daily Maximum	Daily Minimum	Daily Mean	Daily Maximum
Date	mg/l	mg/l	mg/l	SU	SU	SU	umhos/cm	umhos/cm	umhos/cm	NTU	NTU	NTU
9/25/2003	7.5	7.7	8.8	7.07	7.11	7.27	172.48	192.55	226.85	3.0	3.5	5.7
9/26/2003	6.6	7.4	7.7	7.24	7.26	7.38	190.95	191.90	213.95	2.4	2.5	4.1
9/27/2003	6.8	7.5	8.0	6.98	7.19	7.28	175.14	191.26	216.84	1.5	2.3	5.4
9/28/2003	6.7	7.5	8.0	7.12	7.26	7.29	170.06	190.61	217.45	1.2	2.1	4.3
9/29/2003	6.8	7.7	8.7	7.15	7.24	7.26	173.60	189.97	226.18	2.9	3.2	3.4
9/30/2003	7.3	7.5	8.1	7.19	7.23	7.39	169.07	189.32	219.92	3.5	3.7	4.4
10/1/2003	7.6	8.2	9.0	6.83	7.07	7.31	224.88	239.00	272.25	2.7	3.6	14.9
10/2/2003	8.1	8.1	8.6	7.02	7.04	7.15	225.60	238.66	239.85	2.6	3.1	5.4
10/3/2003	8.0	8.2	8.6	No Data	No Data	No Data	240.96	246.37	260.41	2.6	2.6	2.9
10/4/2003	7.9	8.5	9.1	7.01	7.05	7.29	241.58	259.59	287.69	No Data	No Data	No Data
10/5/2003	7.7	8.2	9.3	6.85	7.06	7.29	276.44	285.83	297.78	3.5	3.9	5.5
10/6/2003	6.2	6.5	7.5	6.92	7.02	7.03	209.99	222.41	266.61	2.4	3.3	4.1
10/7/2003	7.6	8.3	8.6	6.95	7.01	7.15	217.00	224.30	245.24	2.0	2.2	3.4
10/8/2003	7.2	8.2	8.5	6.82	7.01	7.11	184.76	204.66	223.55	2.8	3.1	4.2
10/9/2003	7.1	8.0	8.8	6.94	7.12	7.35	208.50	221.48	255.33	4.3	4.4	6.1
10/10/2003	7.5	8.1	8.5	7.04	7.14	7.18	258.09	260.11	273.46	2.6	2.8	4.7
10/11/2003	8.1	8.3	9.3	7.02	7.10	7.19	181.90	194.32	238.63	1.5	2.1	4.8
10/12/2003	8.5	9.3	9.8	7.03	7.05	7.17	240.49	240.91	284.79	2.2	2.3	5.5
10/13/2003	No Data	No Data	No Data	6.89	7.03	7.26	239.41	263.54	301.99	1.5	2.0	3.2
10/14/2003	No Data	No Data	No Data	6.99	7.09	7.24	262.69	274.66	298.28	3.4	4.1	5.8
10/15/2003	7.4	8.3	8.9	7.03	7.06	7.28	187.89	197.91	234.18	1.9	2.5	3.1
10/16/2003	7.9	8.2	8.7	6.84	7.00	7.21	220.50	220.80	226.26	2.1	2.8	4.1
10/17/2003	8.3	8.4	9.4	6.96	7.08	7.32	182.61	193.92	195.35	1.9	2.0	3.7
10/18/2003	8.1	8.2	9.0	6.84	7.08	7.26	260.65	266.90	309.02	12.5	12.8	14.0
10/19/2003	7.2	8.2	8.8	6.76	7.00	7.22	215.89	232.42	250.43	1.6	2.5	5.8
10/20/2003	8.0	8.2	8.8	6.91	7.08	7.08	238.37	244.16	250.53	3.0	3.2	5.8
10/21/2003	7.2	8.2	8.6	6.86	7.09	7.25	240.76	260.91	293.85	2.9	3.8	6.6
10/22/2003	7.3	7.5	8.1	6.97	7.12	7.15	165.76	179.75	209.97	2.8	2.8	4.5
10/23/2003	7.1	8.1	9.2	6.98	7.10	7.12	188.17	202.68	202.68	2.0	2.8	4.6
10/24/2003	8.2	8.4	8.8	7.05	7.05	7.06	280.15	290.53	308.39	2.3	3.2	4.1
10/25/2003	7.8	8.2	8.4	7.03	7.07	7.17	247.76	255.75	281.58	2.9	3.7	5.5
10/26/2003	7.4	8.4	9.0	6.83	7.03	7.10	216.35	219.00	247.69	2.0	2.2	2.6
10/27/2003	7.4	8.3	9.1	6.78	7.02	7.23	241.56	258.67	301.75	1.5	2.3	3.3
10/28/2003	7.3	8.3	8.4	6.96	7.01	7.06	205.40	215.77	244.72	No Data	No Data	No Data
10/29/2003	7.9	8.0	8.9	6.83	7.04	7.17	197.11	219.33	261.39	2.4	2.6	3.8
10/30/2003	8.1	8.4	9.5	6.94	7.01	7.02	215.77	222.00	237.07	3.5	3.6	5.4
10/31/2003	8.0	8.3	9.2	6.76	6.98	7.20	149.94	173.54	192.02	2.4	2.9	4.8
11/1/2003	8.7	8.9	9.4	6.90	7.08	7.20	121.85	146.00	182.55	1.7	2.1	2.5
11/2/2003	8.4	9.0	9.4	7.10	7.24	7.30	124.75	139.40	180.37	1.6	2.2	12.9
11/3/2003	8.4	8.8	8.9	6.94	7.05	7.20	108.46	116.66	154.82	1.9	2.4	5.1

	Dissolved Oxygen			pH			Specific Conductivity			Turbidity		
	Daily Minimum	Daily Mean	Daily Maximum	Daily Minimum	Daily Mean	Daily Maximum	Daily Minimum	Daily Mean	Daily Maximum	Daily Minimum	Daily Mean	Daily Maximum
Date	mg/l	mg/l	mg/l	SU	SU	SU	umhos/ cm	umhos/ cm	umhos/ cm	NTU	NTU	NTU
11/4/2003	8.0	8.8	9.4	7.03	7.20	7.43	132.97	156.00	157.52	2.6	3.3	4.9
11/5/2003	8.7	9.2	10.2	7.22	7.24	7.25	104.20	126.33	160.85	1.5	2.2	2.2
11/6/2003	8.6	8.9	9.9	No Data	No Data	No Data	128.56	140.23	185.10	1.5	2.3	3.7
11/7/2003	8.2	8.8	9.2	No Data	No Data	No Data	103.33	111.03	127.65	2.3	2.7	4.7
11/8/2003	8.1	9.1	9.8	7.21	7.22	7.28	125.57	140.31	173.93	2.2	2.8	4.0
11/9/2003	8.5	8.9	9.6	6.93	7.14	7.29	173.79	185.54	206.88	1.4	2.2	4.0
11/10/2003	8.8	9.0	9.8	7.00	7.23	7.31	113.88	126.90	133.37	2.9	3.1	4.7
11/11/2003	7.8	8.9	9.7	7.27	7.29	7.30	108.04	121.92	164.19	9.2	9.6	12.9
11/12/2003	8.9	9.1	9.9	7.15	7.23	7.33	99.83	120.95	146.90	1.7	2.1	2.8
11/13/2003	8.0	8.8	8.9	7.15	7.28	7.33	122.67	137.78	167.66	2.7	2.7	4.5
11/14/2003	8.1	9.1	9.5	7.15	7.25	7.48	170.13	180.89	193.20	2.2	2.4	4.9
11/15/2003	7.8	8.9	9.1	7.06	7.11	7.28	149.82	165.18	176.55	6.8	7.0	9.7
11/16/2003	8.8	8.9	9.1	7.20	7.26	7.43	123.59	137.95	142.33	2.5	3.1	3.5
11/17/2003	8.5	9.2	9.2	7.24	7.34	7.38	105.37	113.81	131.99	1.5	2.5	5.6
11/18/2003	No Data	No Data	No Data	7.08	7.24	7.33	218.93	235.26	255.55	2.5	2.6	4.7
11/19/2003	8.4	9.1	9.2	7.19	7.20	7.38	196.10	219.89	249.43	3.2	4.1	6.5
11/20/2003	8.3	9.1	9.2	7.15	7.22	7.26	137.49	151.02	194.75	2.0	2.1	4.7
11/21/2003	8.8	9.1	10.0	7.01	7.19	7.23	145.38	162.20	169.33	1.5	2.5	3.4
11/22/2003	5.6	6.1	6.3	6.89	7.10	7.29	173.51	175.26	210.05	1.8	2.3	3.8
11/23/2003	7.9	8.9	9.1	7.03	7.12	7.29	121.32	126.11	127.93	2.3	3.0	6.0
11/24/2003	8.6	8.9	9.8	7.11	7.24	7.44	162.81	176.89	186.20	1.5	2.2	4.5
11/25/2003	7.9	8.9	10.0	7.01	7.22	7.22	136.42	150.88	164.30	1.9	2.2	3.2
11/26/2003	8.7	9.0	9.3	7.13	7.18	7.41	83.76	104.72	109.77	3.0	3.8	5.0
11/27/2003	8.8	8.9	9.9	6.91	7.14	7.31	210.65	212.41	225.70	1.9	2.0	4.3
11/28/2003	8.4	8.9	10.0	6.95	7.16	7.32	113.05	115.00	154.66	1.8	2.7	2.7
11/29/2003	8.9	9.1	9.6	6.97	7.16	7.24	133.35	144.43	151.43	4.9	5.6	5.7
11/30/2003	8.9	8.9	9.7	7.08	7.24	7.32	122.82	134.55	155.71	1.1	2.1	15.2
12/1/2003	9.0	9.3	10.4	7.02	7.05	7.28	177.28	187.00	211.79	1.3	2.1	2.3
12/2/2003	9.1	9.3	10.2	6.94	7.07	7.27	101.71	102.35	120.19	1.9	2.5	3.4
12/3/2003	5.5	6.5	6.6	6.95	7.15	7.36	178.55	187.42	224.20	3.2	3.4	6.1
12/4/2003	8.5	9.3	9.8	6.99	7.01	7.02	150.98	159.70	171.44	4.2	4.2	6.1
12/5/2003	7.1	7.5	7.6	6.96	7.02	7.12	182.99	203.00	212.92	10.2	10.7	13.3
12/6/2003	8.7	9.4	9.7	6.83	7.04	7.29	181.31	185.15	196.79	No Data	No Data	No Data
12/7/2003	8.3	9.0	10.1	6.82	7.01	7.18	223.69	248.05	283.09	2.4	2.7	4.4
12/8/2003	9.3	9.5	10.1	6.85	7.02	7.14	183.40	201.51	229.77	6.9	7.2	7.6
12/9/2003	9.2	9.3	9.7	6.77	6.99	7.10	149.59	164.18	189.91	7.6	8.6	11.7
12/10/2003	8.9	9.5	9.5	7.00	7.04	7.28	152.07	177.04	205.48	2.3	2.8	2.9
12/11/2003	9.2	9.6	10.1	7.04	7.10	7.17	154.70	156.37	160.07	2.9	3.1	3.3
12/12/2003	9.4	9.6	9.9	6.88	6.98	7.04	148.28	170.47	185.93	2.7	3.0	4.2
12/13/2003	5.8	6.4	7.4	7.06	7.09	7.32	176.94	183.57	193.84	2.1	2.6	5.9

	Dissolved Oxygen			pH			Specific Conductivity			Turbidity		
	Daily Minimum	Daily Mean	Daily Maximum	Daily Minimum	Daily Mean	Daily Maximum	Daily Minimum	Daily Mean	Daily Maximum	Daily Minimum	Daily Mean	Daily Maximum
Date	mg/l	mg/l	mg/l	SU	SU	SU	umhos/cm	umhos/cm	umhos/cm	NTU	NTU	NTU
12/14/2003	8.8	9.3	10.3	6.79	7.03	7.21	178.73	193.70	212.44	2.1	2.6	3.9
12/15/2003	8.8	9.3	10.4	7.08	7.10	7.17	161.16	176.08	194.83	1.7	2.5	5.1
12/16/2003	9.2	9.3	9.9	6.87	7.09	7.18	165.35	179.61	213.31	3.4	3.5	7.0
12/17/2003	8.3	9.2	9.5	6.85	7.05	7.18	221.25	234.87	269.00	1.8	2.3	5.1
12/18/2003	8.7	9.4	9.7	6.80	7.05	7.09	155.90	174.69	208.86	2.7	2.9	3.2
12/19/2003	8.3	9.4	9.9	6.91	7.07	7.15	238.07	258.98	299.22	2.3	3.3	3.8
12/20/2003	8.8	9.5	10.6	6.74	6.99	7.14	154.14	173.59	191.82	2.0	2.9	5.7
12/21/2003	8.3	9.3	9.7	7.04	7.09	7.29	125.07	130.11	132.40	2.5	2.8	6.1
12/22/2003	8.3	9.4	10.1	6.98	7.05	7.09	192.52	193.06	199.31	2.4	2.6	5.5
12/23/2003	8.4	9.1	9.2	6.93	7.09	7.25	190.51	210.37	222.47	1.3	2.2	4.5
12/24/2003	5.5	6.3	7.4	6.92	7.07	7.11	171.07	173.90	200.96	2.1	3.0	4.7
12/25/2003	8.4	9.2	10.0	6.87	6.96	7.13	142.92	157.71	160.27	2.9	3.4	5.7
12/26/2003	8.9	9.4	9.4	6.97	7.08	7.10	150.52	164.12	168.21	3.1	3.8	5.0
12/27/2003	8.2	9.2	10.1	6.71	6.96	7.05	198.52	205.36	228.30	2.0	2.4	4.3
12/28/2003	8.3	9.2	10.1	7.10	7.16	7.26	208.86	209.47	213.02	1.3	2.1	5.4
12/29/2003	9.1	9.4	9.8	6.99	7.06	7.07	188.44	208.64	245.03	2.6	2.9	3.4
12/30/2003	8.2	9.2	9.9	7.01	7.07	7.26	185.50	195.40	202.20	2.0	2.8	3.0
12/31/2003	8.9	9.2	9.4	6.89	7.04	7.25	171.41	187.17	232.02	2.1	2.9	5.8

Appendix F

HCSP 2003 Benthic Macroinvertebrate Data

Table F1. Summary of HCSP Benthic Macroinvertebrates Collected at Each Station and for Each Sampling Event in 2003

Order	Family	Genus	Species	HCSW-1				HCSW-2				HCSW-3				HCSW-4			
				4/25/2003	7/29/2003	11/20/2003	All Dates	4/25/2003	7/29/2003	11/20/2003	All Dates	4/25/2003	7/29/2003	11/20/2003	All Dates	4/25/2003	7/29/2003	11/20/2003	All Dates
Amphipoda	Talitridae	Hyalella	azteca	0	0	0	0	26	1	13	40	0	1	10	11	0	3	1	4
Araneida	Lycosidae	Pirata	sp.	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0
Araneida	Pisauridae	Dolomedes	triton	0	0	0	0	0	1	0	1	0	1	2	3	0	0	0	0
Coleoptera	Dryopidae	Pelonomus	obscurus	0	2	0	2	0	1	0	1	0	0	0	0	0	0	1	1
Coleoptera	Dryopidae	unidentified	sp.	0	0	0	0	0	0	0	0	0	0	14	14	0	0	1	1
Coleoptera	Dytiscidae	Coptotomus	sp.	0	0	0	0	0	0	0	0	0	0	0	0	6	0	0	6
Coleoptera	Dytiscidae	Coptotomus	venustus	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0
Coleoptera	Elmidae	Dubiraphia	vittata	2	0	5	7	0	0	0	0	1	1	2	4	4	2	4	10
Coleoptera	Elmidae	Microcylloepus	pusillus	7	1	14	22	0	0	0	0	0	0	0	0	2	0	10	12
Coleoptera	Elmidae	Stenelmis	hungerfordi	0	2	0	2	0	0	0	0	0	0	0	0	0	0	0	0
Coleoptera	Elmidae	Stenelmis	sp.	22	1	0	23	0	0	0	0	0	1	3	4	0	2	17	19
Coleoptera	Gyrinidae	Dineutus	serralatus	0	0	0	0	0	0	29	29	0	4	0	4	0	3	31	34
Coleoptera	Gyrinidae	Dineutus	serralatus s erralatus	4	0	0	4	2	0	0	2	2	0	0	2	0	0	0	0
Coleoptera	Gyrinidae	Dineutus	sp.	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Coleoptera	Halipildae	Peltodytes	dietrichi	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0
Coleoptera	Helodidae	Scirtes	sp.	1	0	1	2	0	15	22	37	2	0	26	28	0	0	0	0
Coleoptera	Heptageniidae	Stenelmis	hungerfordi	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	4
Coleoptera	Heptageniidae	Stenelmis	sp.	0	0	12	12	0	0	0	0	11	0	0	11	13	0	0	13
Coleoptera	Hydrochidae	Hydrochus	sp.	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0
Coleoptera	Hydrophilidae	Helobata	larvalis	0	0	1	1	0	0	0	0	0	0	3	3	0	0	0	0
Coleoptera	Hydrophilidae	Tropisternus	sp.	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0
Coleoptera	Ictaluridae	Gyrinus	sp.	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1
Coleoptera	Noteridae	Hydrocanthus	oblongus	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Coleoptera	Noteridae	Hydrocanthus	sp.	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0
Coleoptera	Noteridae	Suphisellus	sp.	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0
Coleoptera	Scirtidae	Prionocyphon	sp.	0	0	0	0	0	0	5	5	0	0	11	11	0	0	0	0
Coleoptera	unidentified	Coleoptera	sp.	0	0	0	0	0	0	0	0	2	0	0	2	0	0	0	0
Decapoda	Astacidae	Procambarus	alleni	0	0	0	0	0	0	0	0	0	2	0	2	0	0	0	0
Decapoda	Cambaridae	unidentified	sp.	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	2
Decapoda	Palaemonidae	Palaemonetes	paludosus	0	3	2	5	12	0	14	26	0	4	3	7	2	0	1	3
Decapoda	Palaemonidae	palaemonetes	unidentified	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	2
Diptera	Ceratopogonidae	Bezzia/Johannsenomyia/Palpomyia	group	0	0	0	0	0	0	0	0	3	0	0	3	2	0	0	2
Diptera	Ceratopogonidae	Bezzia/Palpomyia	group sp.	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0
Diptera	Ceratopogonidae	unidentified	sp.	7	0	2	9	0	0	0	0	0	0	0	0	0	2	1	3
Diptera	Chironomidae	Ablabesmyia	rhamphe group	1	0	0	1	4	0	2	6	0	0	0	0	2	0	0	2
Diptera	Chironomidae	Chironomus	decorus group	0	0	0	0	0	23	0	23	0	0	0	0	0	0	0	0
Diptera	Chironomidae	Chironomus	stigmaterus	0	0	0	0	1	1	0	2	0	0	0	0	0	0	0	0
Diptera	Chironomidae	Cladotanytarsus	cf. daviesi	0	0	0	0	0	0	2	2	0	0	0	0	0	0	0	0
Diptera	Chironomidae	Cladotanytarsus	sp.	2	0	0	2	1	0	0	1	0	0	0	0	0	0	0	0
Diptera	Chironomidae	Cryptochironomus	sp.	0	2	0	2	1	0	0	1	0	0	0	0	0	0	0	0
Diptera	Chironomidae	Cryptotendipes	sp.	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Diptera	Chironomidae	Demicryptochironomous	sp.	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0
Diptera	Chironomidae	Dicrotendipes	simpsoni	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0

Table F1. Summary of HCSP Benthic Macroinvertebrates Collected at Each Station and for Each Sampling Event in 2003

Order	***Family***	***Genus***	***Species***	***HCSW-1***				***HCSW-2***				***HCSW-3***				***HCSW-4***			
				4/25/2003	*7/29/2003*	*11/20/2003*	*All Dates*	*4/25/2003*	*7/29/2003*	*11/20/2003*	*All Dates*	*4/25/2003*	*7/29/2003*	*11/20/2003*	*All Dates*	*4/25/2003*	*7/29/2003*	*11/20/2003*	*All Dates*
Diptera	Chironomidae	Goeldichironomus	amazonicus	0	0	0	0	0	0	13	13	0	0	0	0	0	0	0	0
Diptera	Chironomidae	Goeldichironomus	cf. natans	0	0	0	0	0	0	3	3	0	0	1	1	0	0	0	0
Diptera	Chironomidae	Goeldichironomus	holoprasinus	0	0	0	0	0	6	9	15	0	0	0	0	0	0	0	0
Diptera	Chironomidae	Goeldichironomus	natans	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0
Diptera	Chironomidae	Pentaneura	inconspicua	0	0	1	1	0	0	1	1	0	0	0	0	0	1	0	1
Diptera	Chironomidae	Pentaneura	inconspicua (=inculta)	0	0	0	0	0	0	0	0	1	0	2	3	1	0	0	1
Diptera	Chironomidae	Polypedilum	flavum	0	3	10	13	0	0	0	0	0	1	0	1	0	7	1	8
Diptera	Chironomidae	Polypedilum	halterale group	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	1
Diptera	Chironomidae	Polypedilum	illinoense group	0	0	0	0	2	1	0	3	30	1	0	31	1	10	0	11
Diptera	Chironomidae	Polypedilum	scalaenum group	0	0	0	0	0	0	0	0	4	0	0	4	7	0	0	7
Diptera	Chironomidae	Polypedilum	sp.	0	0	0	0	0	0	0	0	11	0	0	11	7	0	0	7
Diptera	Chironomidae	Polypedilum	trigonus	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0
Diptera	Chironomidae	Rheotanytarsus	exiguus group	0	0	1	1	0	0	0	0	1	0	1	2	1	3	2	6
Diptera	Chironomidae	Stenochironomus	sp.	9	0	0	9	3	0	0	3	1	0	1	2	0	0	2	2
Diptera	Chironomidae	Tanytarsus	sp.	2	0	1	3	1	0	0	1	2	0	0	2	1	0	0	1
Diptera	Chironomidae	Tanytarsus	sp. A	0	0	1	1	0	0	0	0	0	0	0	0	0	1	0	1
Diptera	Chironomidae	Tanytarsus	sp. A Epler	6	0	0	6	0	0	0	0	0	0	0	0	0	0	0	0
Diptera	Chironomidae	Tanytarsus	sp. F	0	0	0	0	0	0	7	7	0	0	0	0	0	0	0	0
Diptera	Chironomidae	Tanytarsus	sp. G Epler	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0
Diptera	Chironomidae	Tanytarsus	sp. L	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0
Diptera	Chironomidae	Tanytarsus	sp. L Epler	1	0	0	1	1	0	0	1	1	0	0	1	0	0	0	0
Diptera	Chironomidae	Tanytarsus	sp. O Epler	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Diptera	Chironomidae	Tanytarsus	sp. P Epler	0	0	0	0	2	0	0	2	0	0	0	0	0	0	0	0
Diptera	Chironomidae	Tanytarsus	sp. T Epler	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0
Diptera	Chironomidae	Tanytarsus	sp.O	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0
Diptera	Chironomidae	Thienemanniella	sp.	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0
Diptera	Chironominae	Stempellina	sp.	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1
Diptera	Chironominae	Tribelos	fuscicorne	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1
Diptera	Culicidae	Chaoborus	punctipennis	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0
Diptera	Simuliidae	Simulium	sp.	0	3	0	3	0	0	0	0	0	0	0	0	0	0	0	0
Diptera	Tipulaidae	Tipula	sp.	0	0	0	0	2	0	0	2	0	0	0	0	0	0	0	0
Diptera	Tipulidae	Megistocera	longipennis	0	0	0	0	0	0	7	7	0	0	6	6	0	0	0	0
Ephemeroptera	Baetidae	Callibaetis	floridanus	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0
Ephemeroptera	Baetidae	Procloeon	viridocularis	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0
Ephemeroptera	Baetidae	Pseudocloeon	propinquum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2
Ephemeroptera	Baetidae	Pseudocloeon	sp.	0	0	0	0	0	0	0	0	1	0	0	1	1	0	0	1
Ephemeroptera	Caenidae	Brachycercus	maculatus	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1
Ephemeroptera	Caenidae	Caenis	diminuta	16	0	0	16	15	0	0	15	0	0	1	1	0	2	1	3
Ephemeroptera	Caenidae	Caenis	hilaris	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1
Ephemeroptera	Caenidae	Caenis	sp.	0	0	0	0	0	0	0	0	1	0	0	1	1	0	0	1
Ephemeroptera	Heptageniidae	Choroterpes	sp.	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Ephemeroptera	Heptageniidae	Stenacron	sp.	2	4	1	7	5	0	0	5	0	0	1	1	0	2	0	2
Ephemeroptera	Heptageniidae	Stenonema	exiguum	1	3	4	8	0	0	0	0	1	0	3	4	5	12	9	26
Ephemeroptera	Leptohyphidae	Tricorythodes	albilineatus	0	0	0	0	0	0	0	0	0	0	0	0	4	0	3	7
Hemiptera	Belostomatidae	Belostoma	lutarium	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0

Table F1. Summary of HCSP Benthic Macroinvertebrates Collected at Each Station and for Each Sampling Event in 2003

Order	***Family***	***Genus***	***Species***	***HCSW-1***				***HCSW-2***				***HCSW-3***				***HCSW-4***			
				4/25/2003	***7/29/2003***	***11/20/2003***	***All Dates***	***4/25/2003***	***7/29/2003***	***11/20/2003***	***All Dates***	***4/25/2003***	***7/29/2003***	***11/20/2003***	***All Dates***	***4/25/2003***	***7/29/2003***	***11/20/2003***	***All Dates***
Hemiptera	Belostomatidae	Belostoma	sp.	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0
Hemiptera	Gerridae	Metrobates	anomalus	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	3
Hemiptera	Gerridae	unidentified	sp.	1	0	0	1	0	0	0	0	1	0	0	1	0	0	0	0
Hemiptera	Naucoridae	Pelocoris	sp.	0	0	0	0	1	0	1	2	0	0	0	0	0	0	0	0
Hemiptera	Nepidae	Ranatra	sp.	0	0	0	0	0	0	0	0	3	0	0	3	6	0	0	6
Heteroptera	Corixidae	Sigara	bradleyi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
Hirudinea	Glossiphoniida	Helobdella	stagnalis	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0
Hirudinea	Glossiphoniidae	Desserobdella	phalera	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1
Hirudinea	Glossiphoniidae	Gloiobdella	elongata	0	0	0	0	3	0	0	3	0	0	0	0	0	0	0	0
Hirudinea	Glossiphoniidae	Helobdella	stagnalis	0	0	0	0	0	7	0	7	0	0	0	0	0	0	0	0
Hirudinea	Glossiphoniidae	Helobdella	triserialis	0	0	0	0	2	0	0	2	0	0	0	0	0	0	0	0
Lepidoptera	Pyralidae	unidentified	sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2
Megaloptera	Coryadalidae	Corydalus	cornutus	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0
Mollusca	Amnicolidae	Amnicola	sp.	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1
Mollusca	Ancylidae	Hebetancylus	excentricus	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0
Mollusca	Ancylidae	Laevapex	sp.	0	0	0	0	0	2	0	2	0	0	0	0	0	0	0	0
Mollusca	Corbiculidae	Corbicula	fluminea	0	0	31	31	0	0	1	1	0	0	6	6	0	0	10	10
Mollusca	Corbiculidae	Corbicula	fluminea (=manilensis)	40	105	0	145	1	0	0	1	181	64	0	245	41	1	0	42
Mollusca	Hydrobiidae	Pyrogophorus	platyrachis	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0	6
Mollusca	Lymnaeidae	Pseudosuccinea	columella	0	0	0	0	1	0	0	1	1	0	1	2	1	0	0	1
Mollusca	Physidae	Physa	sp.	0	0	1	1	0	0	0	0	0	0	0	0	0	2	0	2
Mollusca	Planorbidae	Micromenetus	dilatatus	1	0	0	1	0	0	0	0	0	0	0	0	0	2	0	2
Mollusca	Planorbidae	Planorbella	trivolvis intertexta	0	0	0	0	1	2	0	3	0	0	0	0	0	0	0	0
Mollusca	Sphaeridae	Pisidium	sp.	0	3	1	4	43	0	17	60	0	0	0	0	2	5	0	7
Mollusca	Thiaridae	Melanoides	tuberculata	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Mollusca	Unionidae	Musculium	lacustre	0	0	0	0	0	147	0	147	0	0	0	0	0	0	0	0
Mollusca	Unionidae	Musculium	sp.	2	0	0	2	17	0	0	17	2	0	0	2	0	0	0	0
Mollusca	Unionidae	unidentified	sp.	0	0	0	0	8	4	2	14	0	0	0	0	0	0	0	0
Odonata	Aeshnidae	Nasiaeschna	pentacantha	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Odonata	Calopterygidae	Hetaerina	titia	0	0	3	3	0	0	0	0	0	0	0	0	0	0	0	0
Odonata	Coenagrionidae	Argia	moesta	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1
Odonata	Coenagrionidae	Argia	sedula	0	0	1	1	0	0	0	0	2	0	1	3	0	0	1	1
Odonata	Coenagrionidae	Argia	sp.	0	0	0	0	0	0	0	0	2	0	0	2	5	1	1	7
Odonata	Coenagrionidae	Enallagma	cardenium	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Odonata	Coenagrionidae	Enallagma	sp.	0	0	3	3	0	0	0	0	0	0	1	1	0	1	4	5
Odonata	Coenagrionidae	Ischnura	sp.	0	0	0	0	2	0	0	2	0	0	0	0	0	0	0	0
Odonata	Corduliidae	Macromia	illinoiensis georgina	0	4	0	4	0	0	0	0	0	0	0	0	0	0	0	0
Odonata	Corduliidae	Macromia	sp.	1	0	0	1	0	0	0	0	0	0	1	1	0	1	1	2
Odonata	Gomphidae	Gomphus	sp.	3	1	4	8	0	0	0	0	0	0	0	0	0	0	0	0
Odonata	Libellulidae	Erythemis	simplicicollis	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0
Odonata	Libellulidae	Libellula	sp.	0	0	0	0	0	1	1	2	0	0	1	1	0	0	0	0
Odonata	Libellulidae	Pachydiplax	longipennis	0	0	0	0	1	0	1	2	0	0	0	0	0	0	0	0
Odonata	Libellulidae	Tetragoneuria	sp.	0	1	0	1	0	0	0	0	0	0	2	2	0	0	2	2
Oligochaeta	Lumbriculidae	unidentified	sp.	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	2
Oligochaeta	Naididae	Dero	nivea	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0

Table F1. Summary of HCSP Benthic Macroinvertebrates Collected at Each Station and for Each Sampling Event in 2003

Order	Family	Genus	Species	HCSW-1 4/25/2003	HCSW-1 7/29/2003	HCSW-1 11/20/2003	HCSW-1 All Dates	HCSW-2 4/25/2003	HCSW-2 7/29/2003	HCSW-2 11/20/2003	HCSW-2 All Dates	HCSW-3 4/25/2003	HCSW-3 7/29/2003	HCSW-3 11/20/2003	HCSW-3 All Dates	HCSW-4 4/25/2003	HCSW-4 7/29/2003	HCSW-4 11/20/2003	HCSW-4 All Dates
Oligochaeta	Tubificidae	immature without capilliform chaetae	sp.	0	0	0	0	0	3	0	3	0	1	0	1	0	2	0	2
Oligochaeta	Tubificidae	Limnodrilus	hoffmeisteri	0	0	0	0	0	1	0	1	0	1	0	1	0	0	0	0
Oligochaeta	Tubificidae	unidentifiedsp. w/o hair setae	sp.	2	0	0	2	0	0	0	0	1	0	0	1	0	0	0	0
Oligochaeta	Tubificidae	w/o capilliform chaetae	sp.	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0
Oligochaeta	unidentified	unidentified	sp.	0	1	0	1	0	0	0	0	0	1	0	1	0	0	0	0
Rhynchobdellida	Glossiphoniidae	Gloiobdella	elongata	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0
Trichoptera	Hydropsychidae	Cheumatopsyche	sp.	0	0	2	2	1	0	0	1	24	0	2	26	1	0	6	7
Trichoptera	Hydropsychidae	Hydropsyche	rossi	0	3	0	3	0	0	0	0	0	0	1	1	0	1	3	4
Trichoptera	Hydropsychidae	Hydropsyche	sp.	0	0	0	0	0	0	0	0	2	0	0	2	0	0	0	0
Trichoptera	Leptoceridae	Nectopsyche	exquisita	0	0	0	0	0	0	0	0	1	0	0	1	1	1	0	2
Trichoptera	Leptoceridae	Nectropsyche	exquisita	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Trichoptera	Leptoceridae	Oeceitis	persimilis	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0
Trichoptera	Leptoceridae	Oecetis	inconspicua complex	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0
Trichoptera	Leptoceridae	Oecetis	sp.	2	0	0	2	2	0	0	2	0	0	0	0	0	0	0	0
Trichoptera	Leptoceridae	Triaenodes	sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1
Trichoptera	Philopotamidae	Chimarra	florida	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0
Trichoptera	Philopotamidae	Chimarra	sp.	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0
			Total	140	147	107	394	167	222	162	551	296	83	109	488	133	79	119	331

Appendix G

HCSP 2003 Fish Data

Summary of HCSP Fish Collected at Each Station and for Each Sampling Event in 2003

Order	***Family***	***Genus***	***Species***	***Common Name***	***HCSW-1***				***HCSW-2***				***HCSW-3***				***HCSW-4***			
					4/25/2003	*7/29/2003*	*11/20/2003*	*All Dates*	*4/25/2003*	*7/29/2003*	*11/20/2003*	*All Dates*	*4/25/2003*	*7/29/2003*	*11/20/2003*	*All Dates*	*4/25/2003*	*7/29/2003*	*11/20/2003*	*All Dates*
Semionotiformes	Lepisosteidae	*Lepisosteus*	*osseus*	longnose gar	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	
Semionotiformes	Lepisosteidae	*Lepisosteus*	*platyrhincus*	Florida gar	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	
Cypriniformes	Cyprinidae	*Notropis*	*maculatus*	taillight shiner	0	0	0	0	0	0	0	0	0	0	5	5	0	1	0	
Cypriniformes	Cyprinidae	*Notropis*	*petersoni*	coastal shiner	19	1	2	22	1	0	0	1	79	5	25	109	11	9	11	3
Cypriniformes	Catostomidae	*Erimyzon*	*sucetta*	lake chubsucker	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	
Cypriniformes	Cobititae	*Misgurnus*	*anguilllicaudatus*	oriental weatherfish	0	0	0	0	1	0	2	3	0	0	0	0	0	0	0	
Siluriformes	Ictaluridae	*Ameiurus*	*nebulosus*	brown bullhead	3	0	0	3	0	1	0	1	0	0	0	0	1	0	1	
Siluriformes	Ictaluridae	*Ameiurus*	*natalis*	yellow bullhead	0	0	1	1	0	0	0	0	0	0	0	0	1	0	0	
Siluriformes	Ictaluridae	*Ictalurus*	*punctatus*	channel catfish	0	0	0	0	0	0	0	0	0	0	1	1	0	0	2	
Siluriformes	Ictaluridae	*Noturus*	*gyrinus*	tadpole madtom	0	0	1	1	0	0	0	0	0	0	0	0	1	0	0	
Siluriformes	Clariidae	*Clarias*	*batrachus*	walking catfish	0	0	1	1	0	1	0	1	0	0	0	0	0	0	0	
Siluriformes	Loricariidae	*Pterygoplichthys*	*multirandians*	sailfin catfish	0	0	1	1	0	0	0	0	0	0	0	0	0	1	0	
Atheriniformes	Cyprinodontidae	*Fundulus*	*seminolis*	Seminole killifish	0	0	0	0	0	0	0	0	12	3	9	24	3	12	0	1
Atherinifomes	Cyprinodontidae	*Fundulus*	*chrysotus*	golden topminnow	0	0	0	0	0	0	3	3	0	1	0	1	0	3	0	
Atheriniformes	Cyprinodontidae	*Jordanella*	*floridae*	flagfish	0	0	0	0	0	0	7	7	0	0	0	0	0	0	2	
Atheriniformes	Cyprinodontidae	*Lucania*	*goodei*	bluefin killifish	0	0	0	0	0	4	0	4	0	1	1	2	0	3	0	
Atheriniformes	Poeciliidae	*Gambusia*	*holbrooki*	eastern mosquitofish	170	2	9	181	116	86	83	285	112	171	239	522	10	57	59	12
Atheriniformes	Poeciliidae	*Heterandria*	*formosa*	least killifish	0	0	0	0	18	28	12	58	80	15	2	97	1	6	1	
Atheriniformes	Poeciliidae	*Poecilia*	*latipinna*	sailfin molly	0	0	0	0	3	0	17	20	36	1	13	50	10	21	7	3
Atheriniformes	Atherinidae	*Labidesthes*	*sicculus*	brook silverside	0	0	2	2	0	0	0	0	5	10	9	24	2	4	6	1
Perciformes	Elassomatidae	*Elassoma*	*evergladei*	Everglades pygmy sunfish	0	0	0	0	0	0	0	0	0	1	0	1	0	1	0	
Perciformes	Centrarchidae	*Enneacanthus*	*gloriosus*	bluespotted sunfish	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	
Perciformes	Centrarchidae	*Lepomis*	*gulosus*	warmouth	3	0	2	5	6	12	10	28	0	0	1	1	0	1	8	
Perciformes	Centrarchidae	*Lepomis*	*punctatus*	spotted sunfish	26	0	7	33	5	1	1	7	27	2	6	35	11	10	12	3
Perciformes	Centrarchidae	*Lepomis*	*macrochirus*	bluegill	7	0	0	7	2	2	0	4	2	2	3	7	5	1	0	
Perciformes	Centrarchidae	*Lepomis*	*microlophus*	redear sunfish	0	0	0	0	1	0	0	1	0	0	0	0	0	0	2	
Perciformes	Centrarchidae	*Micropterus*	*salmoides*	largemouth bass	0	1	0	1	0	0	0	0	2	3	1	6	1	0	1	
Perciformes	Percidae	*Etheostoma*	*fusiforme*	swamp darter	1	0	0	1	1	2	2	5	1	0	2	3	2	1	0	
Perciformes	Cichlidae	*Hemichromis*	*letourneauxi*	African jewelfish	0	0	0	0	0	0	0	0	0	0	1	1	0	0	14	1
Pleuronectiformes	Soleidae	*Trinectes*	*maculatus*	hogchoker	0	0	0	0	0	0	0	0	4	0	7	11	1	2	1	
				Total	229	4	26	259	155	137	138	430	360	215	325	900	62	133	127	32