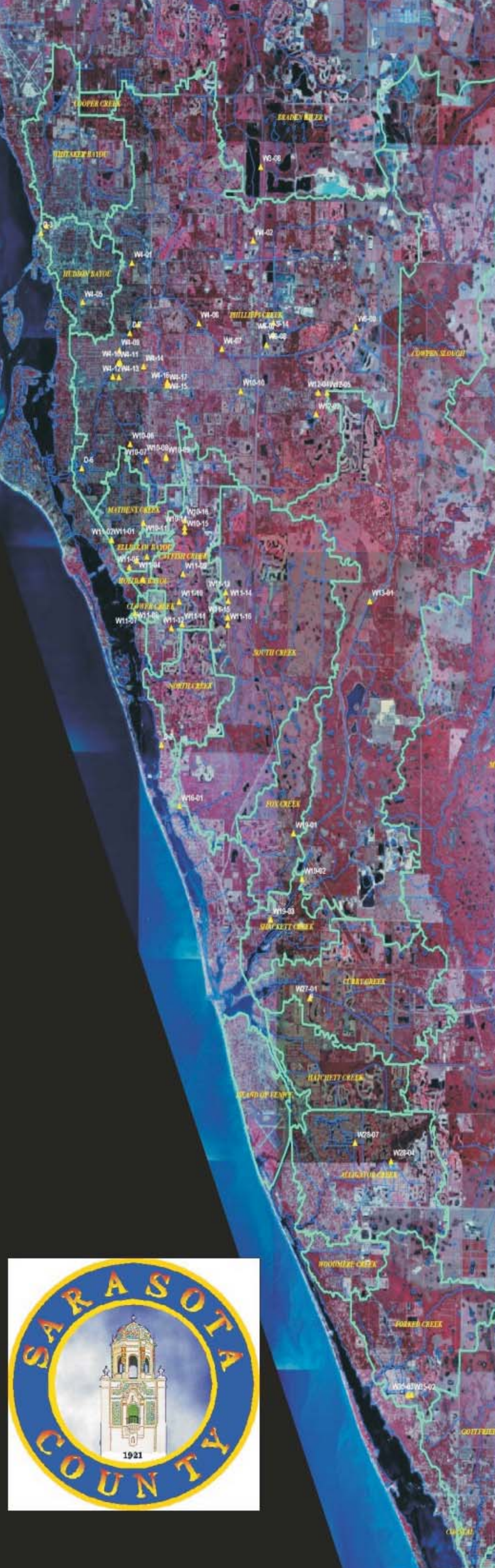

County-Wide Survey of Sediment Quality at Weir Structures

Final Report
August 2003

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Forward and Acknowledgments

Forward

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Executive Summary

This study involved the collection of sediment samples at multiple locations throughout Sarasota County, Florida. Samples were taken upstream of weir structures located at the downstream extents of several drainage basins to evaluate heavy metals and nutrient concentrations. In addition, several stormwater outfalls were sampled to evaluate sediment quality at discharge points which receive little or no water quality treatment.

This report includes the sediment chemistry and grain size analysis results of 64 different locations within the County and a discussion of contaminant concentrations within the various drainage basins represented in the sampling effort. One of the first applications of the results of this study is to prioritize future channel/waterways maintenance activities which may include sediment removal so that the most heavily polluted sites can be addressed effectively and efficiently and to provide the greatest protection to the sensitive receiving waters of Sarasota Bay and Lemon Bay. This analysis may also assist in identifying potential sources of pollution so that stormwater best management practices (such as street sweeping, stormwater treatment facilities) can be implemented to improve sediment and surface water quality.

Considering the extent of urban development within Sarasota County, sediment concentrations for most metals upstream of weirs were relatively low, in general, compared to FDEP guidelines and soil cleanup standards. However, heavy metals concentrations at some locations were above the FDEP's Threshold Effects Levels (TEL) and Probable Effects Levels (PEL) and Soil Cleanup Target Levels (SCTL). Interestingly, arsenic exceeded the FDEP SCTL concentration in 66% of all samples taken, while only 3 sites were determined to be anthropogenically enriched when normalized against Al concentrations (Carvalho et al., 2002). This suggests that arsenic may naturally occur at somewhat elevated concentrations throughout Sarasota County.

A comparison of upstream versus downstream samples at a limited number of weir sites showed sediment concentrations were higher for arsenic, chromium, copper, zinc, and total nitrogen than downstream. Silt/clay fractions and percent organic material were also higher upstream of weirs versus downstream, and metals and nutrient concentrations were correlated with silt/clay fractions. Based on these relationships, it appears that fine-grained sediments are detained by weirs along with elevated concentrations of metals and total nitrogen. The weirs appear to be acting as in-line sediment sumps or traps and prevent metals-enriched sediments from being transported downstream to the lower reaches of major creek systems and adjacent estuaries. Similar trends were observed where several weirs were constructed in series - greater concentrations of heavy metals were observed at the most upstream sites versus weirs located several hundred feet downstream.

Using a ranking system developed to prioritize channel maintenance at weir locations, the highest priority watersheds for removal of the most enriched sediments (for metals) are in Phillippi Creek, Catfish Creek, Elligraw Bayou, Holiday Bayou, Clower Creek, Hog Creek (City of Sarasota), and one Coastal drainage basin. Removal of heavy metal-enriched sediments would reduce the potential for contamination downstream in sensitive estuarine systems.

There are a number of different weir designs used throughout Sarasota County. The original function of many of these structures was for maintaining groundwater levels or for flood control and not for sediment management or control. At sites exhibiting elevated heavy metals or nutrient concentrations, improvements in weir design could be implemented to increase the potential for sediment trapping and storage (e.g., higher control elevations to increase freeboard for sediment accumulation). In addition, future weir construction should take into account a site's location with respect to various stream and estuarine habitats and salinity zones (e.g., used by juvenile fisheries species). Use of fish ladders or avoidance of weir installation at sites near the mouths of tributaries should be considered to avoid the disruption of fish/shellfish migration upstream into tidal and freshwater reaches.

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1.0 Introduction

Figure 1-1. Satellite image of Sarasota County and major watersheds draining to Sarasota Bay and Lemon Bay.

Sarasota County has recently begun several initiatives to address water resource issues using an integrated watershed management approach. The integration of water quality, water quantity, flood protection, and natural systems is a common theme among the County's and other watershed management programs in the region. Protection and management of the County's numerous creeks and two nationally recognized bays (Sarasota Bay and Lemon Bay) are key priorities for this initiative.

Although the coastal areas of the Sarasota Bay and Lemon Bay watersheds are highly developed, over the past two decades water quality in Sarasota Bay has gradually improved as a result of advances in wastewater treatment and disposal while Lemon Bay water quality has remained relatively stable (Tomasko *et al*., 2000). However, the effects of non-point source pollution (i.e., stormwater runoff) is still a significant issue, since a number of water quality indicators in several creeks and bay segments within the County often exceed standards set by the state for Class III waters (recreational and wildlife use). In addition, shellfish harvesting is currently prohibited along the entire eastern shorelines of both Sarasota and Lemon Bays (Florida Department of Agriculture and Consumer Services, 1993) since these areas receive runoff from urbanized areas and tidally-influenced creeks.

Between 1992 and 1993, several studies were completed for the Sarasota Bay National Estuary Program (SBNEP) to evaluate pollutant loads, water quality trends, and the spatial distribution of sediment contamination. The findings of these reports are summarized as follows (Lowery, 1993):

> "In Sarasota Bay, non-point sources of pollution, in particular stormwater, apparently influence many areas. Tributaries to the bay act as pipelines for dispensing stormwater and suspended matter into the estuary. Although the overall Trophic State Index for Sarasota Bay is "good", the segments that receive water from the tributaries have the poorest water quality. Toxic contaminants such as chlorinated pesticides, PAH, and metals were found in tributary sediments, as opposed to sediments from open water. Tributaries with the highest levels of these contaminants are Hudson Bayou, Cedar Hammock Creek, and Whitaker Bayou. These areas also are contaminated by more than one of these classes of toxic compounds. While the percentage of contaminated sediments is comparatively small with respect to the Bay bottom of the entire study area, the tributaries are vital low salinity habitats for larval and juvenile life stages of many fish. Adverse biological impacts attributed to these contaminants would be directed against these more sensitive life stages."

Since 1992, several stormwater improvement projects have been implemented within the Sarasota Bay watershed. However, a large number of man-made canals and channels were constructed throughout the County over the past century which still provide "pipelines" for transporting urban runoff and suspended sediments to the bay. Water levels in many of these channels/canals are controlled by weir structures and these features have recently been located and mapped by the County's Stormwater Division.

1.0 Introduction

Sediments are often transported in stormwater runoff either through erosion of existing uplands or stream banks or through wash-off from roads, parking lots, and residential developments. Heavy metals and nutrients are often bound to fine grained sediments impervious surfaces and are easily transported in runoff to receiving waters during rainfall events (Sansalone, 2002). The sources and potential effects of heavy metals on human and ecological health are presented in Table 1-1.

While there are no specific State standards for sediment trace metals, guidance concentrations for Florida coastal areas have been developed by the FDEP (MacDonald 1994 and 2003). These guidance concentrations are based on two levels:

- The "Threshold Effect Level" (TEL), which represents the upper limit of the range of sediment contamination that has no measurable effect on associated organisms.
- The "Probable Effects Level" (PEL), which is the estimated lower level on the range of contaminant concentration that almost always is associated with adverse biological effects.

The currently recommended TEL and PEL sediment concentrations for several trace metals are presented in Table 1-2. In addition, FDEP has developed Target Cleanup Levels for anthropogenically contaminated soils in Florida to protect human health in both residential and commercial settings. These upper limits are also presented in Table 1-2.

Table 1-1. Potential effects and sources of heavy metals in the environment.

Chemicals of Concern	Potential Effects	Possible Sources
Cadmium	Acute toxicity	Electroplating, plastics, batteries, and sewage
Chromium	Acute toxicity Mammalian carcinogen	Atmospheric, alloys, coal combustion, electroplating/ metal finishing, wastewater, urban runoff, and phosphate fertilizers
Copper	Acute toxicity	Oil/fuel combustion, antifouling paints, metal cleaning, plating, pigments and dyes, copper pipes, wood preservatives, and sewage
Lead (Banned in US gasoline)	Acute toxicity Chronic effects Human health hazard	Atmospheric (from gasoline additive), paints, batteries, and sewage
Mercury	Acute toxicity Bioaccumulates in biota Behavioral toxin Growth and development reduction	Atmospheric/incinerators, paints, batteries, and electrical switches
Zinc	Acute toxicity	Metals coatings, batteries, tires, municipal wastewater, sludge, brake linings, industrial discharges, and urban runoff

**from Long and Greening (1999)*

Table 1-2. Target soil cleanup levels (SCTL) for residential and commercial sites in Florida (62-777, F.A.C.) and Threshold Effects Levels and Probable Effects Levels for heavy metals (MacDonald, 2003).

Metal	SCTL Residential	SCTL Commercial	TEL	PEL
Aluminum (mg/kg)	72000	n/a	n/a	n/a
Arsenic (mg/kg)	0.8	3.7	5.9	17
Cadmium (mg/kg)	75	1300	0.596	3.53
Chromium (mg/kg)	210	420	37.3	90
Copper (mg/kg)	110	76000	35.7	197
Iron (mg/kg)	23000	480000	n/a	n/a
Lead (mg/kg)	400	920	35	91.3
Zinc (mg/kg)	23000	560000	123	271

This project was conducted to evaluate the effects of urban development on sediment quality throughout the most heavily developed areas within Sarasota County. The objectives of this project were as follows:

- Characterize sediment quality at weir/water control structures located throughout the County;
- Evaluate sediment quality with respect to existing sediment quality guidance levels and regulations developed to protect human health and ecological resources;
- Rank potential sediment removal areas throughout the County based on the sediment quality evaluation; and
- Recommend future activities to reduce sediment contamination or transport to downstream receiving waters.

The contents of this report include a description of the methods used to collect sediment samples, presentation of the results, discussion and comparison of the results to other similar studies, and a conclusions and recommendations section.

2.0 Methods and Materials

This study involved the collection and analysis of sediment samples at multiple locations throughout Sarasota County, Florida. Samples were taken upstream of weir structures located at the downstream extents of several drainage basins to evaluate heavy metals and nutrient concentrations. Composite sediment samples were collected at 64 sites from 17 different watersheds and coastal drainage areas which discharge to the Sarasota Bay and Lemon Bay estuaries (Figures 2-1 and 2-2). Sampling was conducted during daylight hours between February 14, 2003 and July 17, 2003. Samples were collected immediately upstream of existing water control structures (weirs or stormwater outfalls) at 61 of the sites, and immediately downstream of existing control structures at 3 of the sites (all of which had corresponding upstream sites). Control structures varied from large adjustable water control structures to shallow, low-flow concrete weirs. Descriptions of each of the sites are presented in the results section below and photographs of each sampling location are presented in **Appendix A**. The following is a list of the different watersheds that were included in the study area (arranged from north to south): Braden River, Hog Creek, Hudson Bayou, Phillippi Creek, Matheny Creek, Elligraw Bayou, Holiday Bayou, Clower Creek, Catfish Creek, South Creek, Cow Pen Slough, Fox Creek, Shakett Creek, Curry Creek, Alligator Creek, and Forked Creek.

At each site, three sediment cores were collected using a 5.5 cm diameter polycarbonate corer. The coring device was comprised of an elongated handle attached to a one-way valve manifold. The coring tube was attached to the manifold which created suction when the coring tube was extracted from the sediment layer. Cores were capped underwater, brought to the surface, and then disassembled from the coring handle. In the field, an average sediment thickness was recorded in centimeters and a photograph was taken of one of the three cores. Subsequently, the upper organic (top) and lower sandy (bottom) layers of the three cores were separated and placed into two stainless steel trays. Samples were homogenized using stainless steel spoons and carefully transferred to glass jars; one for sediment grain size analysis and one for metals and nutrients analyses. Samples at stations W4-01, W4-05, W4-09, W4-10, W4-15, W4-16, W27-01, W28-07, and D-2 had only one discernable sediment layer and so only one sample was analyzed in these cases. All samples were placed on ice (4 deg. C) and transported to the laboratory. The following parameters were analyzed for all samples:

- Aluminum(mg/kg)
- Arsenic(mg/kg)
- Cadmium(mg/kg)
- Chromium(mg/kg)
- Copper (mg/kg)
- Iron (mg/kg)
- Lead (mg/kg)
- Zinc (mg/kg)
- Total Nitrogen (g/g N)
- Total Phosphorus (g/g P)
- Total Organic Carbon (%)
- Grain Size (%)
- Organic Content (%)

The following in-situ water quality parameters were also collected at each site using a Hydrolab: dissolved oxygen (mg/L), temperature (deg.C), pH (SU), specific conductivity (Micromhos/cm), and salinity (ppt). Stratified (top, mid, bottom) data was collected if the total water depth was greater than one meter. Notations on sediment color, odors, oils, and deposition were made at each site as well as water odor, oil sheen, clarity, and color. Other field measurements were recorded as required by the FDEP physical/chemical characterization field sheet (DEP-SOP-001/01: Form FD 9000-3). Sketches of each core are presented in **Appendix B**.

2.0 Methods and Materials

All field collection and laboratory analysis were conducted in compliance with Florida Department of Environmental Protection Standard Operating Procedures. The laboratory analyses were subcontracted to Southern Analytical Laboratories (NELAC # E84129), located at 110 Bayview Boulevard, Oldsmar, FL 34877. Analyses were performed using EPA methods 6010, 7060, 7420, 351.2, and 365.2. The total digestion of sediments method (EPA Method 3052) was used to increase the accuracy of metals analyses and to allow metal concentrations to be normalized with aluminum concentrations. The grain size analyses were performed on the coarse fraction or plus 200 sieve portion of the samples in general accordance with ASTM D422-90 "Standard Test Method for Particle Size Analysis of Soils". Samples that contained a significant amount of organic matter were analyzed for organic content determination by the loss on ignition method (ASTM D2974/87). The samples were also visually classified using the Unified Soil Classification system.

Previous studies of trace metals in Florida freshwater and marine sediments have suggested calculating metals ratios with naturally occurring aluminum sediment concentrations in order to provide relative estimates of anthropogenic enrichment (Schropp and Windom 1988, and Schropp et al. 1990). Analyses and plots of metals concentrations with respect to aluminum are presented in the following section based on a spreadsheet developed by FDEP for analyzing sediment metal enrichment (Carvalho et al., 2002).

Statistical summaries and comparisons of sediment metals and nutrient concentrations were performed using the data analysis function in Microsoft Excel. Concentrations were compared among watersheds, top versus bottom samples, and upstream versus downstream sites. Regression analyses were also performed for sediment metals and nutrient concentrations and silt/clay fractions. Statistical significance was considered to be at the $p \leq 0.05$ level.

2.0 Methods and Materials

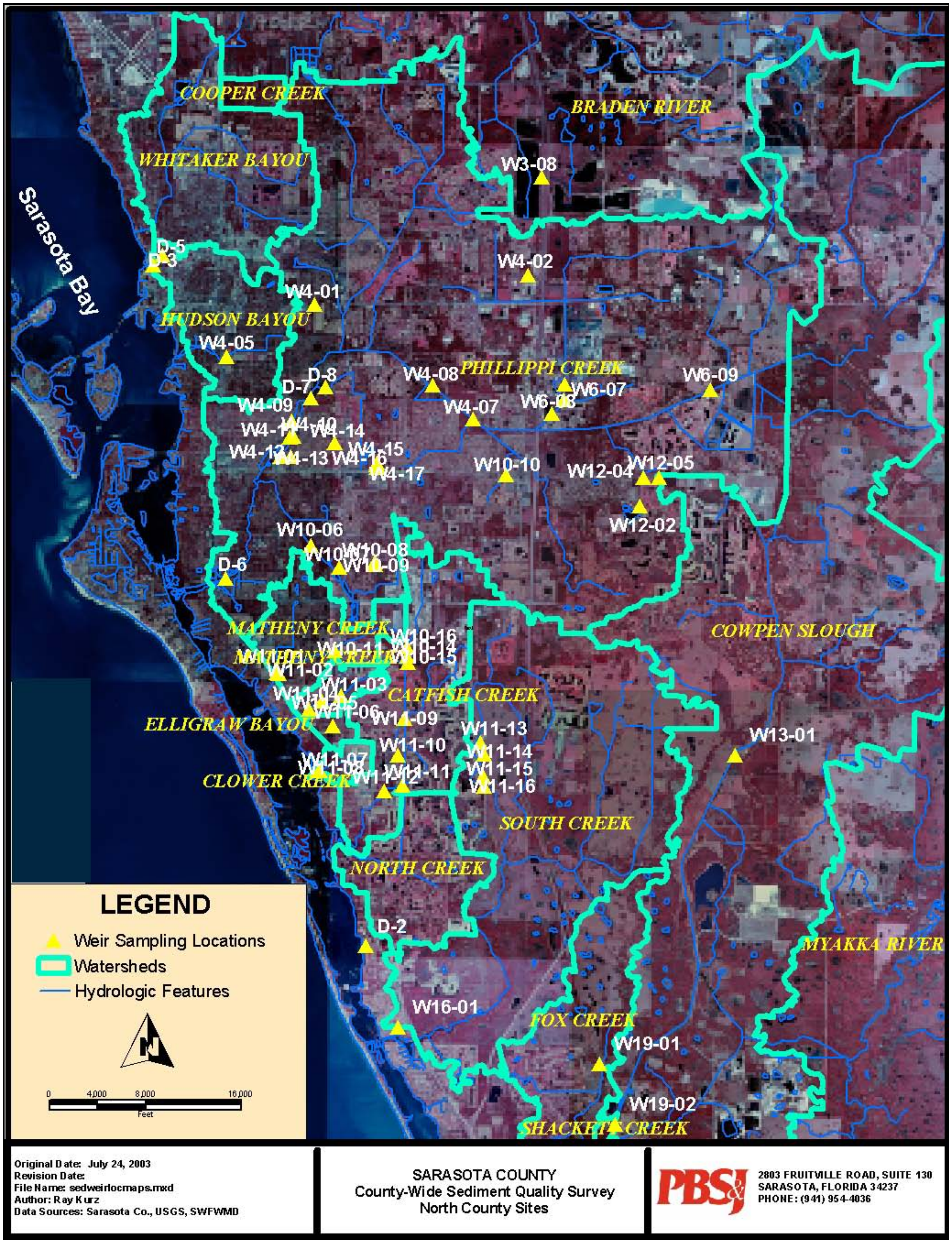


Figure 2-1. Map of sediment sampling locations in northern Sarasota County, Florida.

2.0 Methods and Materials

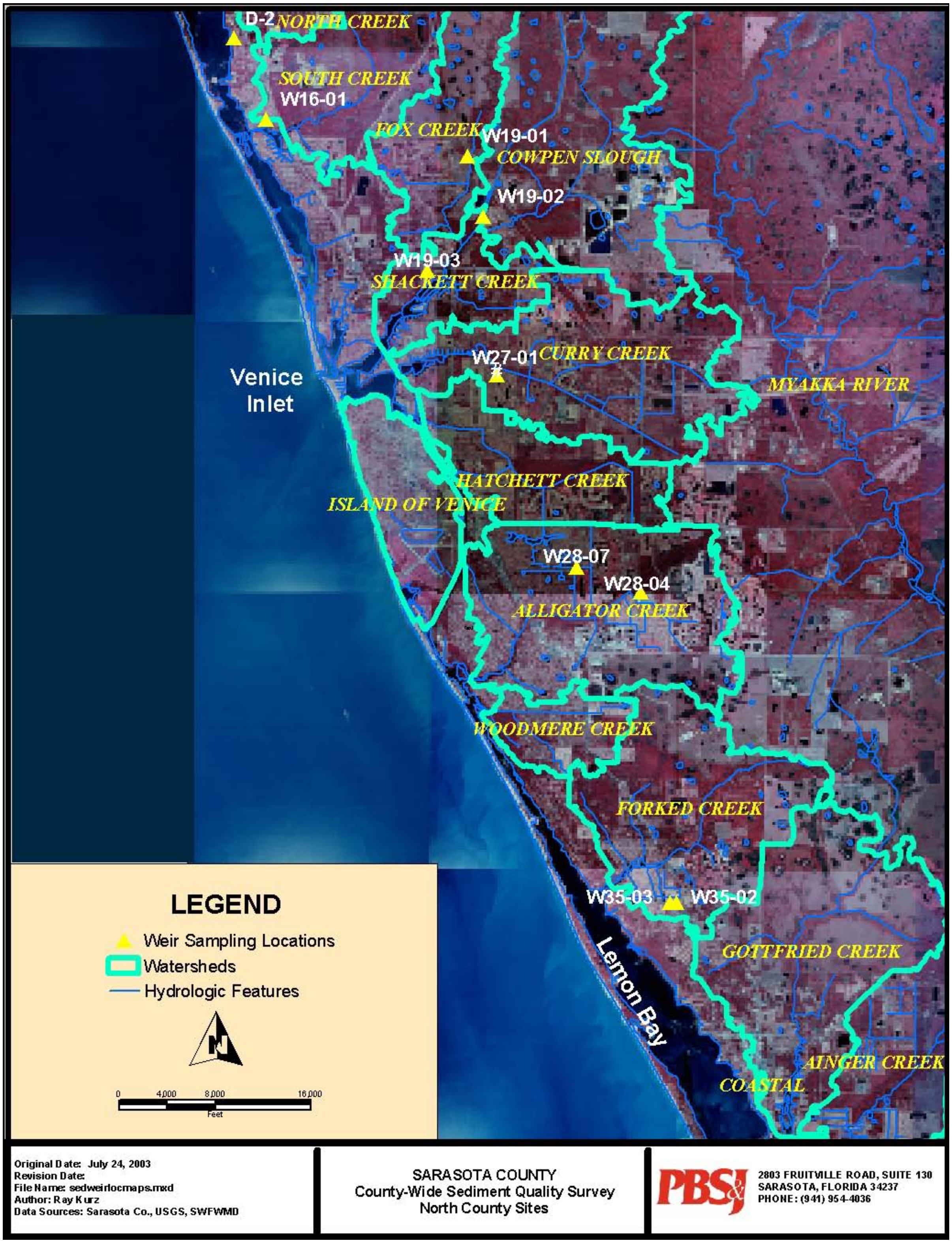


Figure 2-2. Map of sediment sampling locations in southern Sarasota County, Florida.

3.0 Results and Discussion

3.0 Results and Discussion

The distribution of metals in sediments are controlled by several factors. These factors include overlying water quality, grain size distribution, organic carbon content, water velocity (for transport), and proximity to contaminant sources. Physicochemical parameters and sediment concentrations for both metals and nutrients were measured and evaluated for each site and watershed within the study area. Detailed site descriptions of each sampling location are presented below, followed by the results of the water quality and sediment chemistry analyses.

3.1 Site Descriptions

Individual site descriptions for each sampling location are provided below and are arranged by watershed, from north to south, within Sarasota County. These descriptions include the site location, surrounding land use, a general summary of the site conditions during the time of sampling, sediment characteristics, and flow. The greatest number of samples/sites was in the Phillippi Creek watershed (n = 24), followed by Catfish Creek (n=7) and South Creek (n=4). The remaining watersheds had three or fewer sampling locations. The number of sampling locations was related to the number of weirs within a watershed and also the extent of development (and resulting drainage improvements) within an area. Relatively dense urbanization occurs in the Phillippi Creek and Catfish Creek drainage areas.

3.1.2 BRADEN RIVER BASIN

SITE # W3-08

This station is located in North Metro Park, within the Braden River basin. The sample was taken directly upstream of a large concrete structure that extends across the waterbody. This structure separates the large pond within North Metro Park from the Braden River tributary that flows under I-75. The banks of the creek are naturally vegetated but steep with no vegetative buffer adjacent to the structure. Due to the lack of buffer, percent canopy cover was determined to be open (0-10%). The major land use within the immediate area is recreational. At the time of sample collection, February 14, 2003, water was slowly flowing through the notch of the structure though not over the entire structure. Two clearly defined sediment layers were observed within the samples, as depicted in the core photograph. The average sediment thickness was 12 cm.

3.1.3 HOG CREEK BASIN

SITE # D-5

This station is located within Hog Creek just upstream of the City of Sarasota reverse osmosis reject water outfall and immediately west of Cocoanut Avenue. The banks are relatively steep and lined with riprap though a vegetated buffer exists at the waters edge. The major land uses within the immediate area are residential and commercial. Percent canopy cover was determined to be open (0%-10%). At the time of sample collection, April 21, 2003, low flow was observed. Two clearly defined sediment layers were observed within the samples, as depicted in the core photograph. The average sediment thickness was 30 cm.

3.1.4 HUDSON BAYOU BASIN

SITE # W4-05

This site is located in a canal behind Sarasota High School, within the Hudson Bayou basin. Samples were collected immediately upstream of a concrete structure that extends across the entire waterbody. Both banks of the canal are sodded and frequently mowed and exhibit significant signs of erosion. The major land use within the immediate area is commercial. Percent canopy cover was determined to be lightly shaded (11-45%). At the time of sample collection, March 13, 2003, water was flowing through the notch of the structure though not over the complete structure. Only one sediment layer was identified in the samples and the average sediment thickness was 6 cm.

3.1.5 PHILLIPPI CREEK BASIN

SITE # D-6

This station is located within Phillippi Creek, immediately downstream of an outfall at the intersection of Montclair and Lucitania. Samples were collected at the end of a large stormwater pipe (outfall structure) in an area of significant sedimentation. The banks are relatively steep and lined with riprap though a vegetated buffer exists at the waters edge. The major land use within the immediate area is residential. Percent canopy cover was determined to be open (0%-10%). At the time of sample collection, April 21, 2003, low flow was observed. Two clearly defined sediment layers were observed within the samples, as depicted in the core photograph. The average sediment thickness was 30 cm.

SITE # D-7

This station is located at the end of Tanglewood Drive within the right of way, within the Phillippi Creek basin. Samples were collected within a ditch located in close proximity to the Creek, downstream of a concrete control structure. The banks are relatively steep though vegetated. The major land uses within the immediate area are residential and commercial (WWTP just upstream of the site). Percent canopy cover was determined to be open (0%-10%). At the time of sample collection, May 6, 2003, low flow was observed within the ditch. Two clearly defined sediment layers were observed within the samples, as depicted in the core photograph. The average sediment thickness was 15 cm.

SITE # D-8

This station is located at the intersection (west of) of Brookhaven Drive and Sea View Street, within the Phillippi Creek basin. Samples were collected within a ditch contiguous to the Creek, downstream of concrete control structure in an area of significant sedimentation. The banks are relatively steep though vegetated. The major land use within the immediate area is residential. Percent canopy cover was determined to be moderately shaded (46%-80%). At the time of sample collection, May 8, 2003, low flow was observed within the ditch. Two clearly defined sediment layers were observed within the samples, as depicted in the core photograph. The average sediment thickness was 18 cm.

3.0 Results and Discussion

SITE # W4-01

This site is located on Lockwood Ridge Road south of Fruitville Road, within the Phillippi Creek basin. Samples were collected immediately upstream of a concrete sill that extended across the entire waterway. Immediately upstream of this structure, water flows out of a culvert that pipes the water into the creek from an area further upstream. The area where the samples were taken and the adjacent banks are lined by concrete although over time they have become covered with soil, organic matter and upland grass species. There is no riparian vegetation adjacent to the site therefore the percent canopy was recorded as open. The land use within the immediate area is primarily residential. At the time of sample collection, water was not flowing over the sill and the water depth was 22 cm. Due to the concrete lining only one layer was identified in the sample and the average sediment thickness was 11 cm.

SITE # W4-02

This station is located on Richardson Road just north of Cattlemen Road, within the Phillippi Creek basin. Samples were collected immediately upstream of a large concrete control structure. The banks are relatively steep and lined with riprap and vegetation. The major land uses within the immediate area are residential, commercial, agricultural, and slight industrial. Percent canopy cover was determined to be open (0%-10%). At the time of sample collection, February 14, 2003, low flow was observed. Two clearly defined sediment layers were observed within the samples, as depicted in the core photograph. The average sediment thickness was 16 cm.

SITE # W4-07

This site is located on the Main A canal, south of Bahia Vista, within the Phillippi creek basin. Samples were collected immediately upstream of a concrete sill that extended across the entire waterway. This is one of several concrete sills that traverse the canal. The banks of the canal are sodded and frequently maintained. There is no riparian vegetation therefore the canopy cover was determined to open (0-10%). A maintenance road runs adjacent to the canal. At the time of sample collection, March 6, 2003, water was flowing steadily over the sill and the water depth was 0.48 m. Two clearly defined sediment layers were observed within the samples as depicted in the core photograph. The average sediment thickness was 36 cm.

SITE # W4-08

This site is located on the Main A canal, south of Bahia Vista, within the Phillippi Creek basin. Samples were collected immediately upstream of a concrete sill that extended across the entire waterway. This is one of several concrete sills that traverse the canal. The banks of the canal are sodded and frequently maintained. There is no riparian vegetation therefore the canopy cover was determined to open (0-10%). A maintenance road runs adjacent to the canal. At the time of sample collection, March 4, 2003, water was flowing steadily over the sill and the water depth was 0.40 m. Two clearly defined sediment layers were observed within the samples, as depicted in the core photograph. The average sediment thickness was 35 cm.

SITE # W4-10

This site is located near the intersection of Tangelwood Drive and Rose Road, within the Phillippi Creek basin. Samples were collected approximately 50 feet upstream of a concrete control structure that extends across the entire waterway. The bottom of the creek was lined with large boulders located immediately upstream of the structure. The banks at this site are slightly sloped and covered by herbaceous plants. The major land use within the immediate area is residential. Percent canopy cover was determined to be lightly shaded (11-45%). At the time of sample collection, March 14, 2003, water was flowing steadily over the structure. Due to the underlying rocks, only one sediment layer was identified in the sample. The average sediment thickness was 9 cm.

SITE # W4-11

This site is located off Southgate Circle, within the Phillippi Creek basin. Samples were collected immediately upstream of a concrete structure that extended across the entire waterway. One bank is occupied entirely by a concrete bulkhead and the other consists of herbaceous grass species and Brazilian pepper (*S. terebinthifolius*). The width of the riparian vegetation, on the least buffered side, is 1 m. The canopy cover was determined to be open (0-10%). The major land use within the immediate area is residential. One half of this structure is a solid aluminum wall and the other half is composed of several short concrete walls that run parallel to the stream. Therefore, the structure never completely blocks the flow of the water. Two clearly defined sediment layers were observed within the samples, as depicted in the core photograph. This sample appeared to have high clay content. The average sediment thickness was 18 cm.

SITE # W4-12

This site is located adjacent to Tuttle Avenue near the intersection of Homossasa Boulevard, within the Phillippi Creek Basin. Samples were collected immediately upstream of a concrete structure that diverts water beneath Tuttle Ave. Both banks of this site are sodded and frequently mowed. The canal is abutted by two commercial businesses and and runs parallel to Tuttle Avenue, therefore there is very little vegetated buffer. The percent canopy cover was determined to be open (0-10%). At the time of the collection, March 14, 2003 water was flowing steadily over the structure, and the water depth was 0.55 m. Two clearly defined sediment layers were observed within the samples, as depicted in the core photograph. The average sediment thickness was 30 cm.

SITE # W4-13

This site is located behind a single-family residence, located at 2919 Homosassa Road, within the Phillippi Creek basin. Samples were collected immediately upstream of a concrete structure that extends across the entire waterway. Both banks are sodded and frequently mowed. There are several large oak trees on the adjacent uplands therefore the percent cover was determined to be lightly shaded (11-45%). The major land use within the immediate area is residential. At the time of sample collection, March 14, 2003, water was flowing steadily over the structure and the water depth was 0.48 m. Two clearly defined sediment layers were observed within the samples as depicted in the core photograph. The average sediment thickness was 19 cm.

SITE # W4-14

This site is located near the intersection of Medford Lane and Village Green Drive, within the Phillippi creek basin. Samples were taken immediately upstream of a concrete culvert that diverts water beneath Medford lane. The banks of this site are sodded and maintained as part of a golf course. The major land uses within the immediate area are residential and recreational (golf course). Percent canopy cover was determined to be open (0-10%). Water is never completely constrained by this structure as it was designed to allow flow beneath the road. At the time of sample collection, the water depth was 0.22 m. Two clearly defined sediment layers were observed within the samples, as depicted in the core photograph. The average sediment thickness was 15 cm.

3.0 Results and Discussion

SITE # W4-15

This station is located at the intersection of Bee Ridge Road and Sawyer Road (north), within the Phillippi Creek basin. Samples were collected upstream of a concrete sill (and debris) that extends across the width of a narrow ditch (approximately 4 feet wide). Debris, including a fallen fence, concrete rubble, and vegetation, covered the area immediately upstream of the structure. The banks are not artificially impounded though relatively steep. Aquatic macrophytes were abundant within the ditch at the time of sample collection, June 10, 2003. The major land uses within the immediate area are residential and commercial, with a gas station located immediately west of the sample location. Percent canopy cover was determined to be lightly shaded (11%-45%). At the time of collection, little flow was observed. Only one layer of sediment was present within the samples, as depicted in the core photograph. The average sediment thickness was 10 cm.

SITE # W4-16

This station is located at the intersection of Bee Ridge Road and Sawyer Road (north), within the Phillippi Creek basin. Samples were collected immediately upstream of a concrete sill that extends across the width of a narrow ditch (approximately 4 feet wide). The banks are artificially impounded with concrete slopes. Aquatic macrophytes were abundant within the ditch at the time of sample collection, March 6, 2003. The major land uses within the immediate area are residential and commercial, with a gas station located immediately west of the sample location. Percent canopy cover was determined to be open (0%-10%). At the time of collection, little flow was observed. Only one layer of sediment was present within the samples, as depicted in the core photograph. The average sediment thickness was 12 cm.

SITE # W4-17

This station is located at the intersection of Bee Ridge Road and Sawyer Road (north), within the Phillippi Creek basin. Samples were collected immediately upstream of a concrete underdrain that is beneath Bee Ridge Road. The banks are not artificially impounded though relatively steep. Aquatic macrophytes were abundant within the ditch at the time of sample collection, June 10, 2003. The major land uses within the immediate area are residential and commercial, with a gas station located immediately west of the sample location. Percent canopy cover was determined to be lightly shaded (11%-45%). At the time of collection, not much flow was observed. Two clearly defined sediment layers were observed within the samples, as depicted in the core photograph. The average sediment thickness was 15 cm.

SITE # W6-09

This station is located near the intersection of Palmer Boulevard and Debrecan Street within a tributary of Phillippi Creek. Samples were collected immediately upstream of a large concrete bridge structure that traversed across the waterbody. The banks of the creek are naturally vegetated but very steep and there is no vegetative buffer adjacent to the structure. Due to the lack of buffer percent canopy cover was determined to be open (0-10%) at this location. This structure is constructed similar to a bridge with several large pilings within the creek therefore it never completely blocks the flow of water. At the time of collection the water level was measured at 0.50 m and the high water mark was recorded 1.5 meters above the current level. Two clearly defined sediment layers were observed within the samples as depicted in the core photograph. The average sediment thickness was 18 cm.

Samples were also collected downstream of the structure. In this area the banks were naturally vegetated and very steep. There is no vegetated buffer adjacent to the downstream portion and the percent canopy cover was determined to be open (0-10%). The structure never completely blocked the water flow therefore conditions were similar both downstream and upstream. Two clearly defined sediment layers were observed within the samples as depicted in the core photograph. The average sediment thickness was 25 cm.

SITE # W6-07

This site is located west of Raymond Road and is a tributary to Phillippi creek. Samples were collected immediately upstream of a large concrete bridge structure that traversed the waterbody. The banks of the creek are naturally vegetated but steep. A four foot wide vegetative buffer exists on either side. Percent cover was determined to be lightly shaded (11-45%). The major land uses within the immediate area are residential and agricultural. This structure is constructed similar to a bridge with several large pilings within the creek; therefore it never completely blocks the flow of the water. At the time of sample collection the water level was measured at 0.25 m and the high water mark was recorded at 0.25 meters above the current level. Only one sediment layer was identified within the sample. The average sediment thickness was 15 cm.

Samples were also collected downstream of the previously mentioned structure. In this area, the banks were also naturally vegetated and very steep. The percent cover was determined to be lightly shaded (11%-45%). Samples were also collected downstream of the structure. The structure never completely blocked the water flow therefore conditions were similar at both the downstream and upstream sites. Two clearly defined sediment layers were observed within the samples as depicted in the core photograph. The average sediment thickness was 18 cm.

SITE # W6-08

This site is located south of Porter Road and is the Main C weir, within the Phillippi Creek basin. Samples were collected immediately upstream of a large concrete bridge structure that traversed across the waterbody. The banks immediately adjacent to the structure are covered with a concrete mesh but further upstream the banks were covered with herbaceous grass species. Due to the lack of buffer, percent canopy cover was determined to be open (0-10%) at this location. The land use within the immediate area is primarily residential. This structure is constructed similar to a bridge with several large pilings within the creek; therefore it never completely blocks the flow of the water. Two clearly defined sediment layers were observed within the samples as depicted in the core photograph. The average sediment thickness was 33 cm.

SITE # W10-06

This site is located on Redbug Slough at the Lockwood Ridge right-of-way, within the Phillippi Creek basin. Samples were collected immediately upstream of a concrete sill that extended across the entire waterway. The banks are sodded and frequently maintained. There is no riparian vegetation therefore the canopy cover was determined to open (0-10%). On either side of the creek are the backyards of homes within a medium density housing development. Household debris was found within the creek bed upstream of the structure. At the time of sample collection, March 6, 2003, water was flowing steadily over the sill and the water depth was 0.45 m. Two clearly defined sediment layers were observed within the samples as depicted in the core photograph. The top layer consisted of darker organic matter and the bottom layer consisted of more compacted sand material. The average sediment thickness was 16 cm.

3.0 Results and Discussion

SITE # W10-07

This site is located on Ashton Road, west of Beneva Road, within the Phillippi creek basin. Samples were collected immediately upstream of a concrete structure that extended across the entire waterway. The banks of the creek are vegetated with herbaceous grass species but are very steep. No vegetative buffer exists adjacent to the structure. Due to the lack of buffer, percent canopy cover was determined to be open (0-10%). The major land use within the immediate area is residential. At the time sample collection, water was flowing through two small openings at the bottom of the structure. These openings have become clogged with debris and are currently only allowing a small amount of water to pass through. Two clearly defined sediment layers were observed within the samples, as depicted in the core photograph. The average sediment thickness was 18 cm.

Samples were also collected downstream of the previously mentioned structure. In this area the banks were also very steep and vegetated with herbaceous grass species. Samples were collected immediately downstream of a concrete platform that extends out from the structure. Two clearly defined sediment layers were observed within the samples, as depicted in the core photograph. The top layer of sediment was light gray in contrast to the bottom, which was a darker black/brown. The average sediment thickness was 23 cm.

SITE # W10-10

This site is located south of Bee Ridge Road and east of Centergate, within the Phillippi Creek basin. Samples were collected immediately upstream of a concrete sill that extends across the entire waterway. The banks are sodded and mowed frequently down to the water line. There is no riparian vegetation therefore the canopy cover was determined to open (0-10%). The major land use within the area is commercial. In addition, there was a lot of household debris found within the water behind the structure. At the time of sample collection, March 4, 2003, water was flowing through the notch of the structure but was too low to be flowing over the entire structure. Two clearly defined sediment layers were observed within the samples as depicted in the core photograph. The average sediment thickness was 23.5 cm.

SITE # W12-04

This site is located south of Bee Ridge Road and east of Hidden Glen Drive, within the Phillippi creek basin. Samples were collected immediately upstream of a concrete sill that extended across the entire waterway. The banks of the creek are vegetated by herbaceous grass species and there is no riparian buffer. Due to the lack of buffer, percent canopy cover was determined to be open (0-10%). On either side of the creek are backyards of homes within medium density housing developments. At the time of the inspection, February 28, 2003, water was flowing steadily over the sill. Two clearly defined sediment layers were observed within the samples as depicted in the core photograph. The average sediment thickness was 20 cm.

SITE # W12-02

This site is located east of Mauna Loa Blvd adjacent to a dead-end, within the Phillippi Creek basin. Samples were collected immediately upstream of a concrete sill that extends across the entire waterway. The banks of the creek are vegetated primarily by a herbaceous grass species and Brazilian pepper (*S. terebinthifolius*). There is no riparian vegetation therefore the canopy cover was determined to be open (0-10%). The land use within the immediate area is primarily residential. At the time of sample, March 4, 2003, water was flowing steadily over the sill and the total water depth was 0.67 m. Two clearly defined sediment layers were observed within the samples, as depicted in the core photograph. The average sediment thickness was 18 cm.

SITE # W12-05

This station is located at on Bee Ridge Road (south of) just east of Bent Tree Boulevard, within the Phillippi Creek basin. Samples were collected upstream of a concrete sill within a ditch contiguous to the Creek. The banks are relatively steep though vegetated. The major land use within the immediate area is residential. Percent canopy cover was determined to be lightly shaded (11%-45%). At the time of sample collection, May 8, 2003, low flow was observed within the ditch. Two clearly defined sediment layers were observed within the samples, as depicted in the core photograph. The average sediment thickness was 15 cm.

3.1.7 MATHENY CREEK BASIN

SITE #W10-11

This site is located west of Beneva Road and south of Markridge Road, within the Matheny creek basin. Samples were collected immediately upstream of a concrete structure that extends across the entire waterbody. Both banks are vegetated with herbaceous grass species and oaks located on the adjacent uplands. Residential homes are located adjacent to the Creek on both sides. Percent canopy cover was determined to be open (0-10%). At the time of sample collection, March 13, 2003, water was flowing steadily over the structure and the water depth was 0.49 m. Only one sediment layer was identified in the samples and the average sediment thickness was 15 cm.

SITE # W11-01

This station is located south of Bispham Road, East of US41 at the north weir, within the Matheny Creek basin. Samples were collected immediately upstream of a large concrete control structure. The banks are relatively steep though vegetated. The major land use within the immediate area is residential. Percent canopy cover was determined to be open (0%-10%). At the time of sample collection, April 21, 2003, steady flow was observed over the entire structure. Two clearly defined sediment layers were observed within the samples, as depicted in the core photograph. The average sediment thickness was 18 cm.

SITE # W11-02

This station is located south of Bispham Road, East of US41 at the south weir, within the Matheny Creek basin. Samples were collected immediately upstream of a large concrete control structure. The banks are relatively steep though vegetated. The major land use within the immediate area is residential. Percent canopy cover was determined to be open (0%-10%). At the time of sample collection, April 21, 2003, steady flow was observed over the entire structure. Two clearly defined sediment layers were observed within the samples, as depicted in the core photograph. The average sediment thickness was 18 cm.

3.1.8 ELLIGRAW BAYOU BASIN

SITE # W11-03

This station is located on Beneva Road (west of) just after Curtis, within the Elligraw Bayou basin. Samples were collected upstream of a large concrete control structure. The banks of the waterway are artificially impounded and lined with concrete. The major land uses within the immediate area are residential and commercial (gas station, office buildings). Percent canopy cover was determined to be open (0-10%). At the time of collection, June 10, 2003, water was flowing steadily over the control structure. Two clearly defined sediment layers were observed within the samples, as depicted in the core photograph. The average sediment thickness was 24 cm.

SITE # W11-04

This station is located at the intersection of Captiva Drive and Tuckerstown Drive (just west of Beneva), within the Elligraw Bayou basin. Samples were collected immediately upstream of a metal sheet pile that extends across the entire waterway that was approximately 50 feet wide. The banks of this site were not artificially impounded though were comprised of sod/ornamental plants up to the waters edge, with no defined vegetative buffer. The major land use within the immediate area is residential. Percent canopy cover was determined to be open (0-10%). At the time of collection, June 10, 2003, water was flowing steadily over the middle portion of the structure. Two clearly defined sediment layers were observed within the samples, as depicted in the core photograph. The average sediment thickness of all three cores was 18 cm.

SITE # W11-05

This station is located on Dale Avenue, just north of Pinehurst (access obtained from Coventry Way), within the Elligraw Bayou basin. Samples were collected immediately upstream of a concrete control structure (sill) that extended the entire width of the waterbody (approximately 50 feet). A significant drop occurred downstream of the sill with water continuing to flow through a large, divided concrete culvert. The banks were very steep and artificially impounded. The major land use within this area is residential. Percent canopy cover was determined to be open (0-10%). At the time of sample collection, June 16, 2003, water was flowing steadily over the length of the structure. Two clearly defined sediment layers were observed within the samples, as depicted in the core photograph. The average sediment thickness was 34 cm. A distinct blue/white/gray color was observed within the bottom layers of all three cores, which is difficult to discern from the photograph.

3.1.9 HOLIDAY BAYOU BASIN

SITE # W11-06

This site is located west of Beneva Road and south of Eugene Road, within the Holiday Bayou basin. Samples were collected immediately upstream of a concrete fish ladder that extends across the waterbody. The fish ladder is oriented parallel to the stream but encompasses the entire width. Water flows through the fish ladder and out several holes in the bottom of the ladder. Samples were collected just before the water exited the fish ladder. Both banks are covered with grass and frequently mowed. The major land use within the immediate area is low density commercial. Percent canopy cover was determined to be open (0-10%). At the time of sample collection, March 28, 2003, water was flowing slowly through the fish ladder and the water depth was 0.10 m. Only one sediment layer was identified in the sample and the average sediment thickness was 20 cm.

3.1.10 CLOWER CREEK BASIN

SITE # W11-07

This station is located on Clower Creek Drive (Pelican Bay subdivision) west of Vamo Road, within the Clower Creek basin. Samples were collected immediately upstream of a concrete sill that extended across the entire width of the waterway (approximately 50 feet). The banks of the creek are relatively steep though a vegetative buffer exists, primarily composed of mangroves. The major land use within the immediate area is residential. Percent canopy cover was determined to be lightly shaded (11-45%). At the time of sample collection, June 9, 2003, water was flowing steadily over the middle portion of the concrete structure. Two clearly defined sediment layers were observed within the samples, as depicted in the core photograph. The average sediment thickness was 18 cm.

SITE # W11-08

This station is located just downstream of Site #W11-07. Samples were collected immediately upstream of a concrete sill that extended the entire width of the waterway (approximately 50 feet). The banks of the creek were relatively steep though occupied by a vegetative buffer, primarily composed of mangroves. The major land use within the immediate area is residential. Percent canopy cover was determined to be lightly shaded (11-45%). At the time of collection, June 9, 2003, water was flowing steadily over the entire concrete sill. Two clearly defined sediment layers were observed within the samples, as depicted in the core photograph. The average sediment thickness was 14 cm.

3.1.11 CATFISH CREEK BASIN

SITE # W10-14

This station is located on McIntosh Road (east of) south of Sawyer Loop, within the Catfish Creek basin. Samples were collected immediately upstream of a concrete control structure that extends across the width of the waterbody (approximately 40 feet) and up the sides of both banks. The banks upstream of the structure are not artificially impounded and have a narrow vegetative buffer of vegetation. The major land use within the immediate area is residential with some agricultural use (both historic and present). Percent canopy cover was determined to be open (0-10%). At the time of sample collection, March 13, 2003, water was flowing steadily over the control structure. Two clearly defined sediment layers were observed within the samples as depicted in the core photograph. The average sediment thickness was 14 cm.

SITE # W10-15

This station is located on McIntosh Road north of Palmer Ranch Parkway, within the Catfish Creek basin. Samples were collected immediately upstream of a concrete structure (sill) that extends across the width of the trunk ditch (approximately 30 feet) and up the sides of both banks. The banks are not artificially impounded and have a narrow vegetative buffer of wetland vegetation. The major land use within the immediate area is currently residential with some agricultural use (both historic and present). Percent canopy cover was determined to be open (0-10%). At the time of sample collection, June 16, 2003, water was flowing steadily over the entire sill. Concrete rubble exists downstream of the control structure. Two clearly defined sediment layers were observed within the samples, as depicted in the core photograph. The average sediment thickness was 25 cm.

SITE # W10-16

This station is located on McIntosh Road at the corner of Sawyer Loop, within the Catfish Creek basin. Samples were collected upstream of a large, divided concrete culvert beneath Sawyer Loop Road. Also, the samples were collected upstream of the concrete lined bottom that occurred approximately 25 upstream of the culvert. The banks are not artificially impounded and are lined with isolated clumps of wetland vegetation. The major land use within the immediate area is residential with some agricultural (both historic and present) and commercial use. Percent canopy cover was determined to be open (0-10%). At the time of sample collection, June 16, 2003, water was flowing through the culvert. Two clearly defined sediment layers were observed within the samples as depicted in the core photograph. The average sediment thickness was 22 cm.

SITE # W11-09

This site is located between Prestancia and Country Club Road, within the Catfish Creek basin. Samples were collected immediately upstream of a concrete sill that extends across the entire ditch. The banks of this site are covered with grass and frequently maintained. The primary land use within the immediate area is residential. Percent canopy cover was determined to be open (0-10%). At the time of sample collection, March 28, 2003, water was flowing steadily over the sill and the water depth was 0.75 m. Two clearly defined sediment layers were observed within the samples, as depicted in the core photograph. The average sediment thickness was 20 cm.

SITE # W11-10

This site is located east of McIntosh Road and south of Sarasota Square Boulevard, within the Catfish Creek basin. Samples were collected immediately upstream of a concrete sill that extends across the entire ditch. Both banks are sodded and frequently mowed. The primary land use in the immediate area is residential. Percent canopy cover was determined to be open (0-10%). At the time of sample collection, March 28, 2003, water was flowing steadily over the sill and the water depth was 0.05 m. Two clearly defined sediment layers were observed within the samples, as depicted in the core photograph. The average sediment thickness was 30 cm.

SITE # W11-11

This station is located at the McIntosh Bridge immediately north of Central Sarasota Parkway, within the Catfish Creek basin. Samples were collected within a ditch contiguous to the Creek, upstream of a concrete control structure. The banks are not artificially impounded and are vegetated. The major land use within the immediate area is residential. Percent canopy cover was determined to be open (0%-10%). At the time of sample collection, May 6, 2003, low flow was observed within the ditch. Two clearly defined sediment layers were observed within the samples, as depicted in the core photograph. The average sediment thickness was 22 cm.

SITE # W11-12

This site is located north of Central Sarasota Parkway and west of McInstosh Road, within the Catfish Creek basin. Samples were collected immediately upstream of a concrete sill that extends across the entire waterway. Both banks are sodded and frequently mowed. Several large trees were observed within the adjacent uplands and the percent canopy cover was determined to be lightly shaded (11-45%). The major land use within the immediate area is residential. At the time of sample collection, March 28, 2003, water was flowing steadily over the sill and the water depth was 1.0 m. Two clearly defined sediment layers were observed within the samples as depicted in the core photograph. The top layer was composed of dark organic matter and the bottom layer was composed primarily of compacted sand. The average sediment thickness was 28 cm.

3.1.12 SOUTH CREEK BASIN

SITE # W11-13

This station is located west of McIntosh Road at the Turtle Rock subdivision. Samples were collected upstream of a large concrete control structure that extends across the width of the waterbody (approximately 50 feet) and up the sides of both banks. The banks are relatively steep with no vegetative buffer. The major land use within the immediate area is residential with some agricultural use (both historic and present). Percent canopy cover was determined to be open (0-10%). At the time of sample collection, March 28, 2003, water was flowing steadily over the entire structure. Two clearly defined sediment layers were observed within the samples, as depicted in the core photograph. The average sediment thickness was 45 cm.

SITE # W11-14

This station is located on Honore Avenue east of the Turtle Rock subdivision within a trunk ditch. Samples were collected upstream of a concrete weir structure that extends across the width of the trunk ditch (approximately 50 feet) and drains water through a concrete culvert underground. The banks are not artificially impounded and have a narrow vegetative buffer of obligate vegetation. The major land use within the immediate area is currently residential with some agricultural use (both historic and present). Percent canopy cover was determined to be open (0-10%). At the time of sample collection, June 9, 2003, water was flowing steadily into the culvert. Two clearly defined sediment layers were observed within the samples, as depicted in the core photograph. The average sediment thickness was 22 cm. Significant stratification was observed in the dissolved oxygen readings between the bottom (1.0m), mid and top (0.5m and 0.1m) depths, of 1.0 mg/L, 3.09 mg/L, and 4.41 mg/L, respectively.

SITE # W11-15

This station is located on Honore Avenue east of the Turtle Rock subdivision within a trunk ditch (south W11-14). Samples were collected upstream of a concrete sill that extends across the width of the trunk ditch (approximately 30 feet) and up the sides of both banks. The banks are not artificially impounded and have a narrow vegetative buffer of wetland vegetation and aquatic macrophytes. The major land use within the immediate area is currently residential with some agricultural use (both historic and present). Percent canopy cover was determined to be open (0-10%). At the time of collection, June 10, 2003, water was flowing steadily over the sill. Two clearly defined sediment layers were observed within the samples as depicted in the core photograph. The average sediment thickness was 42 cm. Significant stratification was observed in the dissolved oxygen readings between the bottom (1.0m), mid and top (0.5m and 0.1m) depths, of 1.0 mg/L, 3.39 mg/L, and 3.50 mg/L, respectively.

SITE # W11-16

This station is located on Honore Avenue east of the Turtle Rock subdivision within a trunk ditch (south W11-14 & W11-15). Samples were collected upstream of a concrete weir structure that extends across the width of the trunk ditch (approximately 50 feet) and drains water through a concrete culvert under the road. The banks are not artificially impounded and have a narrow vegetative buffer of wetland vegetation and aquatic macrophytes. The major land use within the immediate area is currently residential with some agricultural use (both historic and present). Percent canopy cover was determined to be open (0-10%). At the time of collection, June 10, 2003, water was flowing steadily into the culvert. Two clearly defined sediment layers were observed within the samples as depicted in the core photograph. The average sediment thickness was 24 cm. Significant stratification was observed in the dissolved oxygen readings between the bottom (1.0m), mid and top (0.5m and 0.1m) depths, of 0.34 mg/L, 2.16 mg/L, and 2.39 mg/L, respectively.

3.1.13 COW PEN SLOUGH BASIN

SITE # W13-01

This station is located south of SR72, off of a private road that runs parallel to Cow Pen Slough. Samples were collected immediately upstream of a large adjustable control structure. The banks are relatively steep and partially lined with riprap. The major land uses within the immediate area are primarily residential and agricultural. Percent canopy cover was determined to be open (0%-10%). At the time of sample collection, June 18, 2003, the structure was fully open. Two clearly defined sediment layers were observed within the samples, as depicted in the core photograph. The average sediment thickness was 13 cm.

SITE # W19-02

This station is located just north of the King's Gate mobile home park within Cow Pen Slough. Samples were collected immediately upstream of the control structure. The banks are relatively steep, though vegetated. The major land use within the immediate area is residential. Percent canopy cover was determined to be open (0%-10%). At the time of sample collection, April 15, 2003, the control structure was fully open. Two clearly defined sediment layers were observed within the samples, as depicted in the core photograph. The average sediment thickness was 40 cm.

3.1.14 FOX CREEK BASIN

SITE # W19-01

This station is located immediately west of I-75 on Fox Creek, within the Fox Creek basin. Samples were collected immediately upstream of a large concrete control structure that extends across the width of the waterbody. The banks are relatively steep though vegetated. The major land use within the immediate area is residential. Percent canopy cover was determined to be open (0%-10%). At the time of sample collection, April 11, 2003, low flow was observed. Two clearly defined sediment layers were observed within the samples, as depicted in the core photograph. The average sediment thickness was 25 cm.

3.1.15 SHAKETT CREEK BASIN

SITE # W19-03

This station is located east of Laurel Road, at the intersection of Orange Avenue and Garland, within the Shakett Creek basin. Samples were collected upstream of a concrete box structure that extends across the width of a narrow ditch (approximately 4 feet wide). The bottom of the ditch was underlain by concrete until approximately five feet upstream of the structure. The banks are not artificially impounded though relatively steep. Aquatic macrophytes were abundant within the ditch at the time of sample collection, July 17, 2003. The major land use within the immediate area is primarily residential. Percent canopy cover was determined to be open (0-10%). At the time of sample collection, water was flowing steadily into the box structure. Only one layer of sediment was present within the samples, as depicted in the core photograph. The average sediment thickness was 14 cm.

3.1.16 CURRY CREEK BASIN

SITE # W27-01

This station is located north of Pinebrook Way and West of Featherbed Lane, within the Curry Creek Basin. Samples were collected immediately upstream of a wide riprap structure that extends across the waterbody. The banks are relatively steep and lined with riprap and vegetation. The major land use within the immediate area is residential. Percent canopy cover was determined to be open (0%-10%). At the time of collection, April 11, 2003, low flow was observed. Only one sediment layer was observed within the samples, as depicted in the core photograph. The average sediment thickness was 11 cm.

3.1.17 ALLIGATOR CREEK BASIN

SITE # W28-04

This station is located at the intersection of Sklar and Liesl Drive (behind the homes on Olga), within the Alligator Creek basin. Samples were collected immediately upstream of a concrete box structure that drains water under ground through a culvert. The bank on one side of the structure is colonized by Brazilian pepper (*Schinus terebinthifolius*), and the other by sod. The major land use within this area is residential, however there is a wastewater treatment plant located immediately downstream of the sampling site. Percent canopy cover was determined to be open (0-10%). At the time of sample collection, June 16, 2003, water was flowing steadily into the box structure. Two clearly defined sediment layers were observed within the samples, as depicted in the core photograph. The average sediment thickness was 20 cm.

SITE # W28-07

This station is located south of Venice Gardens at the east end of Briarwood, within the Alligator Creek basin. Samples were collected immediately upstream of a large concrete structure/sill than extends across the waterbody. A significant drop occurred downstream of the sill allowing water to continue through a road culvert. Numerous dead fish (Tilapia) were present along the top of the sill with live fish just downstream of the drop, upstream of the culvert. Both banks were heavily vegetated with Australian pines (*Casurina sp.*) and Brazilian pepper (*S. terebinthifolius*). The major land use within the immediate area is residential. Percent canopy cover was determined to be heavily shaded (81-100%). At the time of sample collection, June 16, 2003, water was flowing steadily over the concrete control structure. Only one sediment layer was present within the samples, as depicted in the core photograph. The average sediment thickness was 20 cm.

3.1.18 FORKED CREEK

SITE # W35-02

This station is located west of Old Englewood Road (Buchan Airport), within the Forked Creek basin. Samples were collected immediately downstream of concrete sill that extended across the width of the ditch. The banks are relatively steep though not artificially impounded. The major land use within the immediate area is primarily residential. Percent canopy cover was determined to be open (0%-10%). At the time of collection, May 6, 2003, low flow was observed within the ditch. Two clearly defined sediment layers were observed within the samples, as depicted in the core photograph. The average sediment thickness was 45 cm.

3.1.19 COASTAL SITES

SITE # D-2

This station is located just north of the intersection of Bayshore Road and Bay Avenue, within a ditch contiguous to Little Sarasota Bay. Samples were collected immediately upstream of a concrete weir/sill that extends across the width of the ditch (approximately 25 feet). The banks are artificially impounded and lined with large riprap. Aquatic macrophytes were abundant within the ditch at the time of sample collection, May 6, 2003. The major land use within the immediate area is residential. Percent canopy cover was determined to be open (0%-10%). At the time of collection low flow was observed within the ditch. Only one sediment layer was observed within the samples, as depicted in the core photograph. The average sediment thickness was 11 cm.

SITE # D-3

This station is located within Payne's terminal at the 10th Street Boat Ramp (Centenial Park), in an artificially created basin contiguous to Sarasota Bay. Samples were collected at an outfall near an area of significant sedimentation. The basin is occupied entirely by a concrete seawall. The major land uses within the immediate area are recreational and commercial. Percent canopy cover was determined to be open (0%-10%). Two clearly defined sediment layers were observed within the samples, as depicted in the core photograph. The average sediment thickness was 16 cm.

SITE # W16-01

This station is located within a roadside ditch just west of US-41 contiguous to Sarasota Bay. Samples were collected immediately upstream of a riprap control structure that extends across the width of the ditch (approximately 10 feet wide). One of the banks is occupied by a vertical concrete bulkhead and the other is a steep bank vegetated by sod. The major land use within the immediate area is residential. Percent canopy cover was determined to be moderately shaded (46-80%). At the time of sample collection, April 11, 2003, low flow was observed. Two clearly defined sediment layers were observed within the samples, as depicted in the core photograph. The average sediment thickness was 20 cm.

3.2 Water Quality

A summary table of physicochemical parameters measured at each sediment sampling location are presented in Table 3-1 below. Temperatures increased by approximately 10 deg. C from the start of the sampling period in spring 2003 to the completion of sampling in early summer (Figure 3-1). The pH was relatively neutral at most sites ranging from approximately 6 to 9 with a few values greater than 10. Dissolved oxygen values were highly variable among the sampling locations with a number of sites falling below the state's Class III waterbody standard (Figure 3-3). Water depths ranged between less than 0.5 m (upper tributaries) to approximately 2 m (Cow Pen Slough outfall structure).

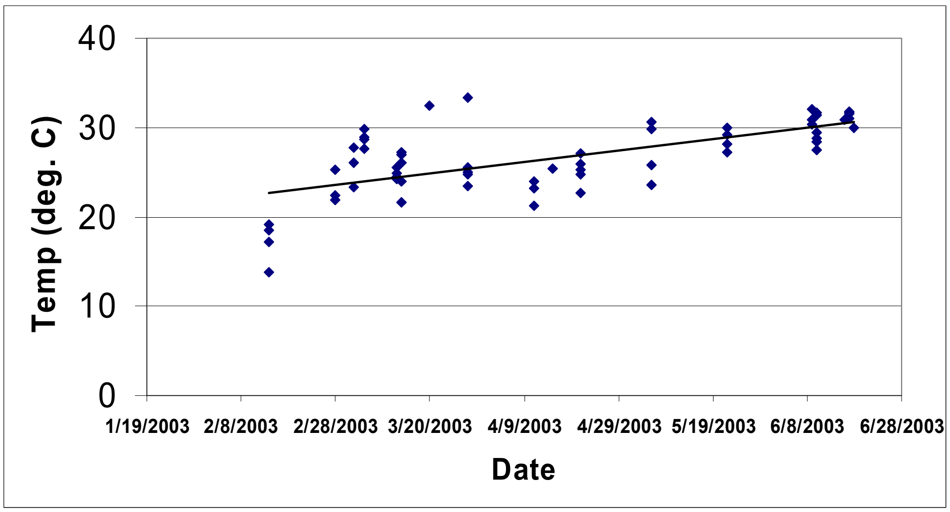


Figure 3-1. Water temperature over time at each of the sediment sampling stations.

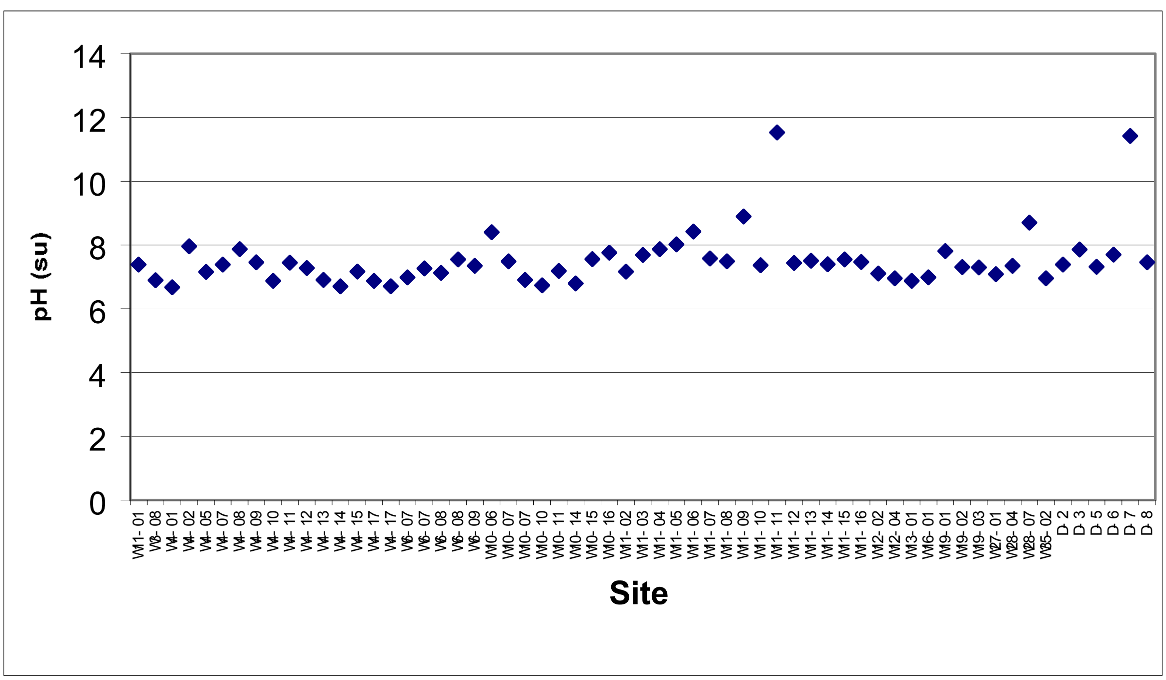


Figure 3-2. pH values for each sediment sampling site.

3.0 Results and Discussion

Table 3-1. Physicochemical data from sediment sampling sites in Sarasota County.

Site	Total Depth (m)	Sediment Thickness (cm)	Temp °C	pH (s.u.)	D.O. mg/L	Cond. umho/cm	Salinity (psu)
W11-01	0.6	18	25.97	7.39	4.09	970.8	0.51
W3-08	0.78	9.14	17.14	6.89	6.02	755	0.39
W4-01	0.22	11	21.89	6.67	4.71	480.2	0.24
W4-02	0.3	40.64	18.5	7.96	5.97	262.8	0.13
W4-05	0.65	6	24.94	7.16	6.57	612.7	0.31
W4-07	0.48	36	28.97	7.39	8.33	679.9	0.35
W4-08	0.4	35	27.74	7.87	10.18	661.2	0.34
W4-09	0.17	12	25.5	7.46	4.99	728.9	0.38
W4-10	0.25	9	21.57	6.87	5.28	660.5	0.39
W4-11	1.1	37	24.01	7.45	6.31	654.8	0.34
W4-12	0.6	30	27.01	7.28	6.41	476.7	0.24
W4-13	0.48	19	26.05	6.9	2.51	448.4	0.23
W4-14	0.25	15	27.18	6.7	5.82	697.7	0.36
W4-15	1	10	27.43	7.17	3.73	506.8	0.26
W4-17	0.45	12	27.62	6.87	0.89	578.8	0.3
W4-17	1	15	29.42	6.7	1.43	518.6	0.26
W6-07	0.25	15	22.41	6.98	4.03	969.9	0.51
W6-07 (downstream)	0.15	18	27.27	7.27	3.91	1226	0.65
W6-08	0.52	45.72	19.2	7.13	11.01	841.1	0.44
W6-08 (downstream)	0.5	25	29.14	7.55	8.15	640.6	0.33
W6-09	0.43	45.72	13.84	7.35	8.9	754.7	0.39
W10-06	0.45	16	29.87	8.4	9.25	725	0.37
W10-07	0.25	18	28.66	7.49	1.3	930.8	0.49
W10-07 (downstream)	0.25	23	29.99	6.9	3.16	1067	0.56
W10-10	0.67	23.5	26.1	6.73	5.41	625.8	0.32
W10-11	0.49	15	24.47	7.19	2.13	816.4	0.42
W10-14	0.54	14	24.24	6.79	3.66	619.4	0.32
W10-15	1.5	25	31.78	7.56	6.98	452.4	0.23
W10-16	1.5	22	31.62	7.76	7.87	463.6	0.23
W11-02	0.85	22	25.34	7.17	2.42	1120	0.59
W11-03	1	24	31.46	7.69	7.88	870.6	8.45
W11-04	1	18	31.72	7.87	5.89	896.1	0.47
W11-05	1.5	34	31.54	8.02	7.96	746.6	0.39
W11-06	0.15	20	33.35	8.42	2.77	557.3	0.28
W11-07	0.34	22	30.86	7.58	2.24	46617	30.34
W11-08	0.45	14	30.33	7.49	2.38	42770	27.59
W11-09	0.75	20	25.51	8.89	7.45	625.7	0.32
W11-10	0.5	30	24.8	7.37	5.68	868.7	0.45
W11-11	1.12	22	29.78	11.53	7.76	858.9	0.45
W11-12	1	28	25.05	7.44	8.18	848.9	0.44
W11-13	0.45	20	23.46	7.51	4.88	803.4	0.42
W11-14	1	22	32.08	7.4	4.41	853	0.44
W11-15	1	42	28.41	7.55	3.5	774	0.4
W11-16	1	24	28.78	7.47	2.39	772.1	0.4
W12-02	0.67	18	23.28	7.11	3.25	631.4	0.32
W12-04	0.7	20	25.26	6.95	5.62	628.8	0.32
W13-01	1	13	30	6.87	4.6	332.7	0.16
W16-01	0.05	20	21.3	6.98	4.64	2212	1.19
W19-01	1.05	25	24.02	7.81	4.86	1076	0.56
W19-02	2	40	25.39	7.31	6.21	484	0.24
W19-03	0.15	30	32.49	7.3	6.58	136.3	0.72
W27-01	0.05	11	23.16	7.09	7.06	0.5	0
W28-04	1.5	20	30.91	7.35	2.6	865.5	0.45
W28-07	1	12	31.02	8.7	6.39	339.1	0.17
W35-02	0.3	45	25.85	6.95	0.61	11.24	0.59
D-2	0.28	11	23.62	7.39	4.75	13.2	0.7
D-3	1.27	16	24.82	7.86	2.8	51691	34.05
D-5	0.16	12	22.71	7.32	2.21	1294	0.68
D-6	1	30	27.15	7.7	4.24	45840	29.77
D-7	0.28	15	30.66	11.42	3	11.51	0.61
D-8	0.2	18	28.16	7.46	5.18	1090	0.57

3.0 Results and Discussion

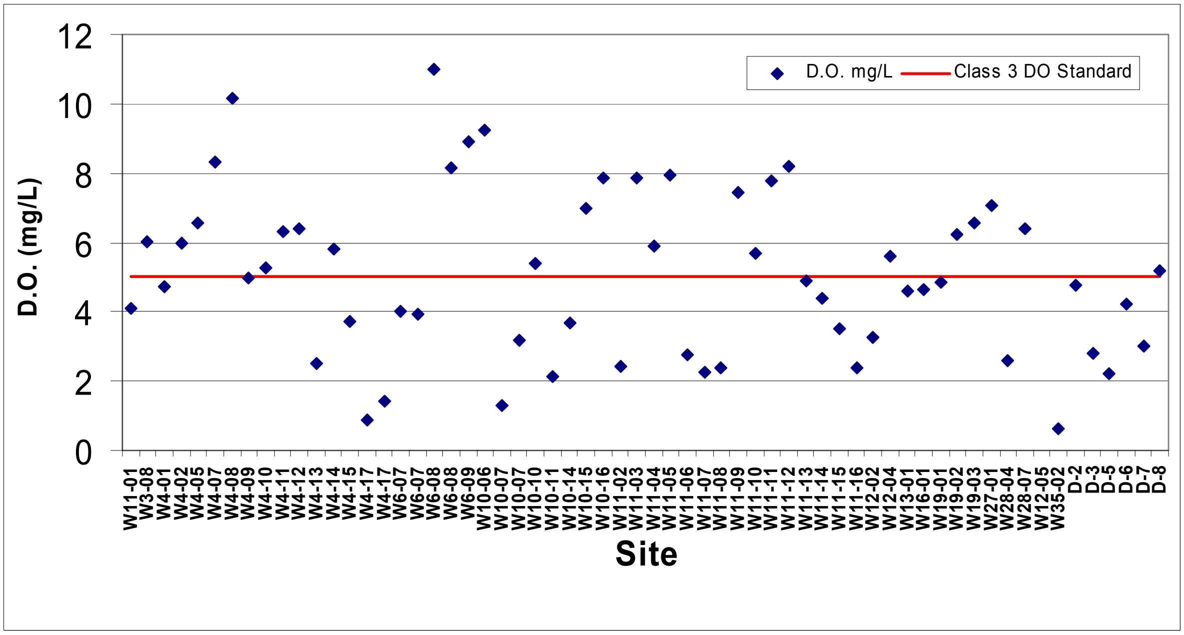


Figure 3-3. Dissolved oxygen concentrations for each sediment sampling site.

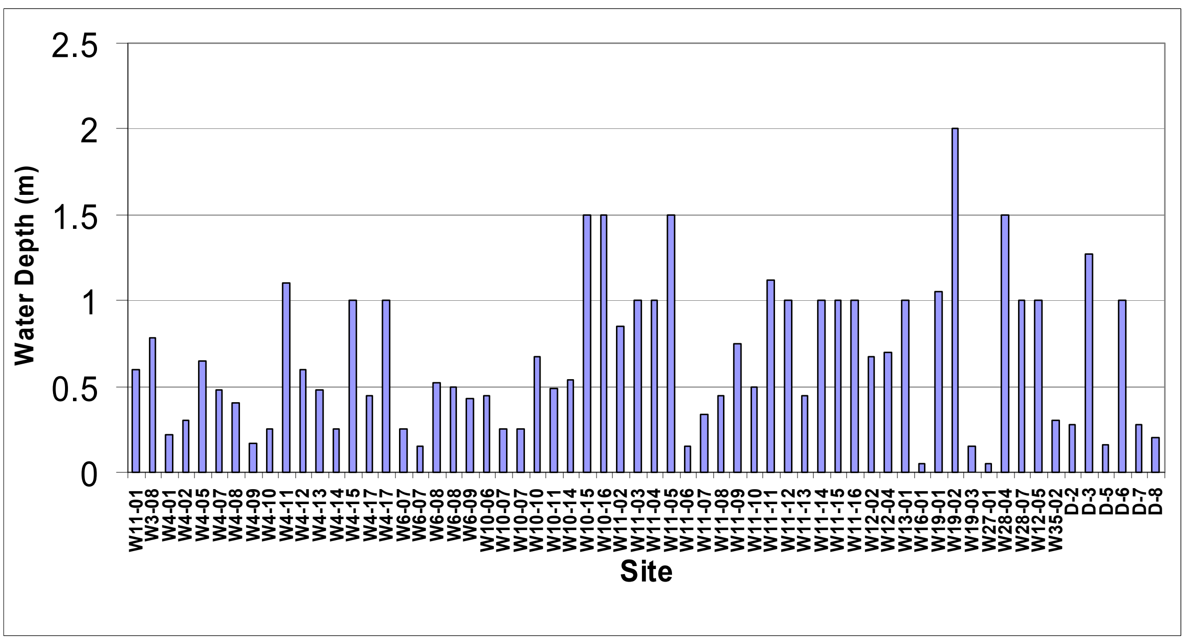


Figure 3-4. Water depths at each sediment sampling site.

3.3 Sediment Quality at Weir Locations

Sediment thickness (depth of penetration with coring device) varied widely among the sites with a range between 6 to 46 cm (Figure 3-5). The shorelines and channel beds adjacent to some control structures were often covered with rip rap or a concrete sill, thereby limiting the depth of core penetration. Site conditions were also varied with some locations having deep water depths at major canal water control structures (e.g., Cow Pen Slough) and shallow depths along smaller tributaries and drainage ditches.

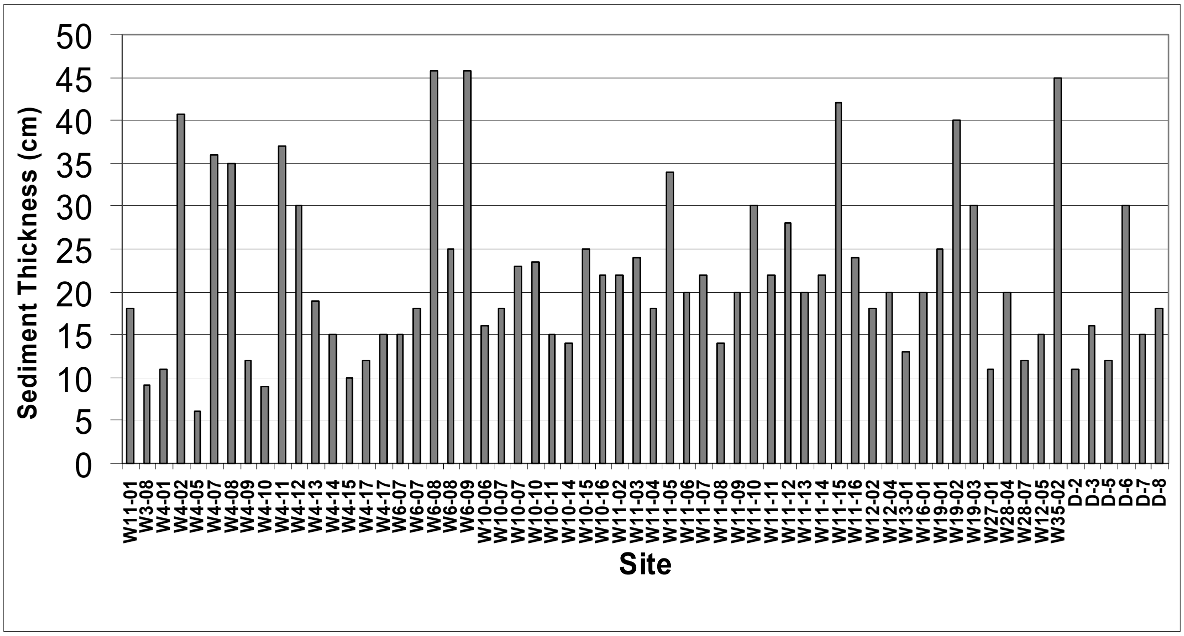


Figure 3-5. Sediment thickness (maximum depth of core penetration) at sediment sampling sites.

Sediment samples collected from weir locations represented a wide range of metals and nutrient concentrations (**Appendices C and D**) and sediment grain size characteristics. No sample exceeded the Soil Cleanup Target Level (SCTL) for Al and the highest concentration recorded was for the NIST Buffalo River reference sample. Arsenic concentrations were generally above the SCTL Residential and Commercial levels but below the TEL and PEL thresholds. Only three samples exceeded the TEL (W6-07B, W12-05T, and W12-05B), and one exceeded the PEL (D-3B). Cadmium concentrations were typically below the PEL, but 65 of the total 114 samples were greater than the TEL. For Cr, all but one sample were below the TEL, PEL, and SCTLs. Chromium concentration for sample W12-05B was below the PEL, but greater than the TEL. Copper concentrations were typically lower than the TEL, however, seven samples were slightly greater than the TEL but less than the PEL and SCTLs. For Fe, all samples were less than the SCTLs. All but four samples were less than the TEL for lead. Samples W12-05T, W12-05B, D5T, and D5B were above the TEL, but below the PEL. All but two samples for Zn were below the TEL and SCTLs, these were samples W12-05T and W12-05B.

Total nitrogen concentrations were generally less than 0.003 g/g except for samples W12-05T, W12-05B, and W4-11B which were all greater than 0.007 g/g. Total phosphorus concentrations were generally less than 0.006 g/g except for samples W10-6B, W11-11B, D6B which were all greater than 0.008 g/g.

Average heavy metals and nutrient concentrations by watershed are presented graphically in **Appendix E**. Because sample sizes varied widely among the various basins (some had only one sampling site), statistical comparisons were not possible for heavy metals or nutrients. However, general comparisons could be made by reviewing box plots of each metal across each of the various watersheds. Arsenic values were typically constant across all basins with a greater range of values in the Phillippi Creek basin. This is likely due to the larger sample size in this area.

3.0 Results and Discussion

Cadmium values varied widely among the basins, however, the range was only between approximately 0.2 and 1.6 mg/kg with greatest median values in the Fox Creek, Curry Creek, Forked Creek, and Hog Creek basins. Median chromium values were relatively consistent among the basins with the greatest value in Fox Creek. This sampling site is adjacent to I-75, and so roadway runoff may be the source of these higher chromium values. Median copper concentrations were relatively consistent among the basin, however, the range of values was relatively wide. Catfish Creek had several high outliers which may be the result of herbicide treatment in residential stormwater ponds that drain to weirs along this creek. Iron concentratons varied widely which is likely a function of differences in soil characteristics among the various watersheds. Phillippi Creek had the greatest range of values.

Lead concentrations were relatively consistent among the basins, however, concentrations in Phillippi Creek varied widely and Hog Creek had the greatest median concentration. Sites in the Hog Creek basin were located at uncontrolled/untreated stormwater outfalls. Zinc concentrations also varied widely among the basins with the greatest range of values in Phillippi Creek. The greatest median value for Zn was in Hudson Bayou, an area known to have elevated sediment metals concentrations and which has received significant residential and commercial runoff.

Total nitrogen concentrations were relatively consistent among the basins with the greates median concentration in Clower Creek. Concentrations varied widely within the Phillippi Creek basin. Total phosphorus concentrations were more variable and the greatest median concentration was in the Matheny Creek basin. Total organic carbon percentages varied among the basins with the highest median percentages in the Clower and Holiday basins. Concentrations varied widely within the Phillippi Creek basin.

Differences between top versus bottom core layers were not significant for any of the metals or nutrients. Plots of top and bottom concentrations for each parameter are presented in **Appendix F**. The lack of a significant difference in concentrations may be due to turbulence at the base of many of the weir structures which resuspends/mixes sediments over time. Several sites had layers of organic/fine material at multiple depths/layers in the core.

Using the interpretative tool for measuring metals enrichment in Florida freshwater sediment (Carvalho et al., 2002), sediments metals concentrations were normalized with Al and plotted as separate graphs. These plots are presented in **Appendix G** and represent the metals data regression lines and 95% prediction limits for metal/aluminum relationships. The range of the prediction limits varies depending on the metal concentrations and strength of the regressions. These prediction limits provide a valid statistical estimate of the range of metal concentrations one can expect from uncontaminated sediments in Florida freshwater sediments based on an analysis of over 100 reference samples from throughout central and north Florida. Points that plot close to the upper 95% confidence line may not necessarily be enriched and statistical confidence of metals enrichment increases with distance from this line. A plot of the number of weir/outfall samples for each metal that exceeded this 95% confidence interval is shown in Figure 3-6.

Despite approximately 66% of all samples exceeded the arsenic residential and commercial SCTL values, only three samples (D-3, D-8, W11-06) were shown to be enriched based on the FDEP's interpretive tool. This suggests that arsenic may naturally occur at somewhat elevated concentrations throughout Sarasota County. Thirty-two Cd samples appear to be enriched based on normalization with Al. These typically included the uncontrolled outfall sites (e.g., D-5, D-8, etc.) and weir structures throughout the study area. Only three Cr samples appeared to be enriched (D-7, W11-09, W6-08). For Cu, 46 samples were enriched. This is likely due to the widespread use of copper sulfate as an herbicide in roadside ditches and in stormwater ponds which drain to many of these weir structures. Only 12 samples had enriched Pb and 16 samples had enriched Zn.

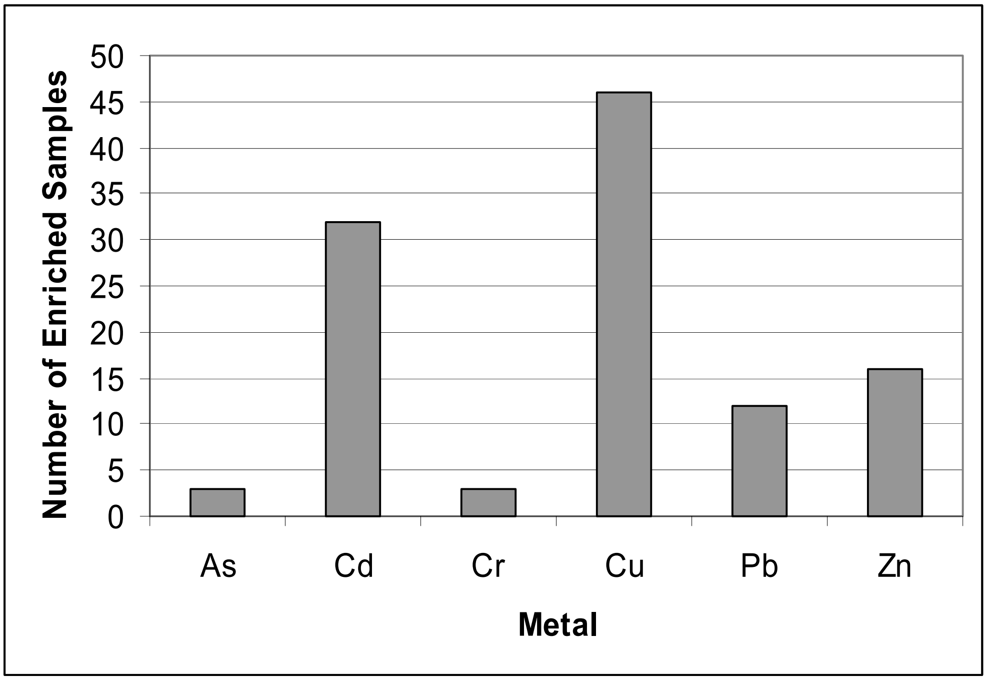


Figure 3-6. Numbers of Sarasota County sediment samples with metals concentrations considered enriched when normalized with aluminum concentrations.

3.4 Upstream versus Downstream Concentrations

Three weirs (W6-07, W6-08, and W10-07) were sampled at both upstream and downstream locations to evaluate the effectiveness of these structures on reducing sediment transport and contamination downstream. Although most parameters did not show a statistically significant difference in concentration (likely due to the small sample size), several of the metals and TN showed a large percent difference in mean concentration between the two sides of the weir. Mean As, Cu, and Fe concentrations were more than 120% greater upstream of the weir and Zn was 55% greater upstream. Mean TN concentration was 225% greater upstream but the mean TP concentration was actually 31% less upstream than downstream. Surprisingly, both Pb and Cd concentrations were greater downstream of the weir. The percent silt/clay fraction was 144% and percent organics was 207% greater upstream versus downstream. Since many of the metals were significantly correlated with the silt/clay fraction, it appears that the weir structures are effective in trapping both fine grained sediments and metals upstream of receiving waters.

In addition to upstream versus immediate downstream sediment comparisons, weirs that occur in series along the same drainage feature were also evaluated. Four weirs occur in series (spaced approximately 1,000 to 1,500 feet apart) in the South Creek basin and three weirs in the Phillippi Creek basin (spaced approximately 200 feet apart). Four weirs also are located in series along Catfish Creek in the Palmer Ranch subdivision. Upper core layer concentrations of Cr, Cd, Pb, and Zn were typically greater at the most upstream weir versus the most downstream weir for the South

Creek weir series (Figure 3-7). However, Cu did not follow a similar pattern, possibly due to differences in herbicide treatment (copper sulfate) along this ditch system. In the Phillippi Creek weir series, only Zn and Pb had similar trends of declining concentrations with distance downstream (Figure 3-8). The most upstream station at this series is located in close proximity to a major road (Bee Ridge Road) and may receive a greater input of roadway runoff than the weirs located further downstream, which drain a residential neighborhood.

Table 3-2. Comparison of upstream versus downstream sediment metals and nutrient concentrations and grain size characteristics for sites W6-07, W6-08, and W10-07.

Parameter	No. Samples	Mean [Up]	Mean [Down]	% Difference	p-value
Al	6	3216.67	1973.33	63%	0.19862
As	6	2.44	1.11	120%	0.63036
Cd	6	0.65	1.01	-35%	0.00988
Cr	6	7.68	5.78	33%	0.52111
Cu	6	7.50	3.30	127%	0.10932
Fe	6	4971.67	1900.00	162%	0.12755
Pb	6	3.15	4.37	-28%	0.87256
Zn	6	14.95	9.63	55%	0.20019
TN	6	0.00100	0.00031	225%	0.19941
TP	6	0.00227	0.00327	-31%	0.26234
TOC%	6	0.88	0.41	112%	0.51965
GRAVEL%	6	3.23	6.73	-52%	0.42335
SAND%	6	92.17	91.38	1%	0.87278
SILTCLAY%	6	4.60	1.88	144%	0.29711
ORGANIC%	3	7.93	2.58	207%	0.02535

Upper core layer concentrations of Pb increased from upstream to downstream weirs at the Catfish Creek weir series (Figure 3-9). Lead may be greatest at the downstream location due to the proximity to a larger arterial road (Sarasota Central Parkway) which is adjacent to the downstream reach and weir structure. Copper was high at the most upstream weir, then declined at the middle two weirs and then increased at the most downstream weir. A large residential stormwater pond drains to a point just upstream of the most downstream weir (W11-12) and so an additional pollutant load (and herbicide by-product) may be entering this lower reach which is not present in the middle reaches of this section of Catfish Creek.

3.0 Results and Discussion

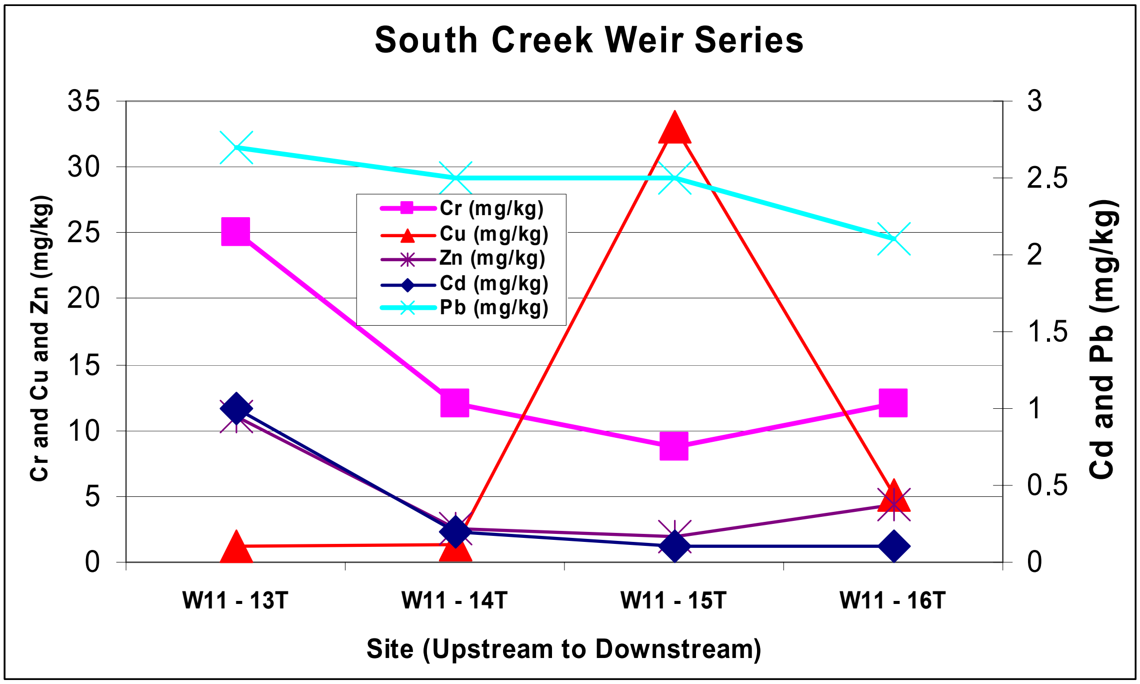


Figure 3-7. Sediment concentrations of heavy metals at a series of weirs in the South Creek basin. Weirs are shown from upstream (left) to downstream (right) along x-axis.

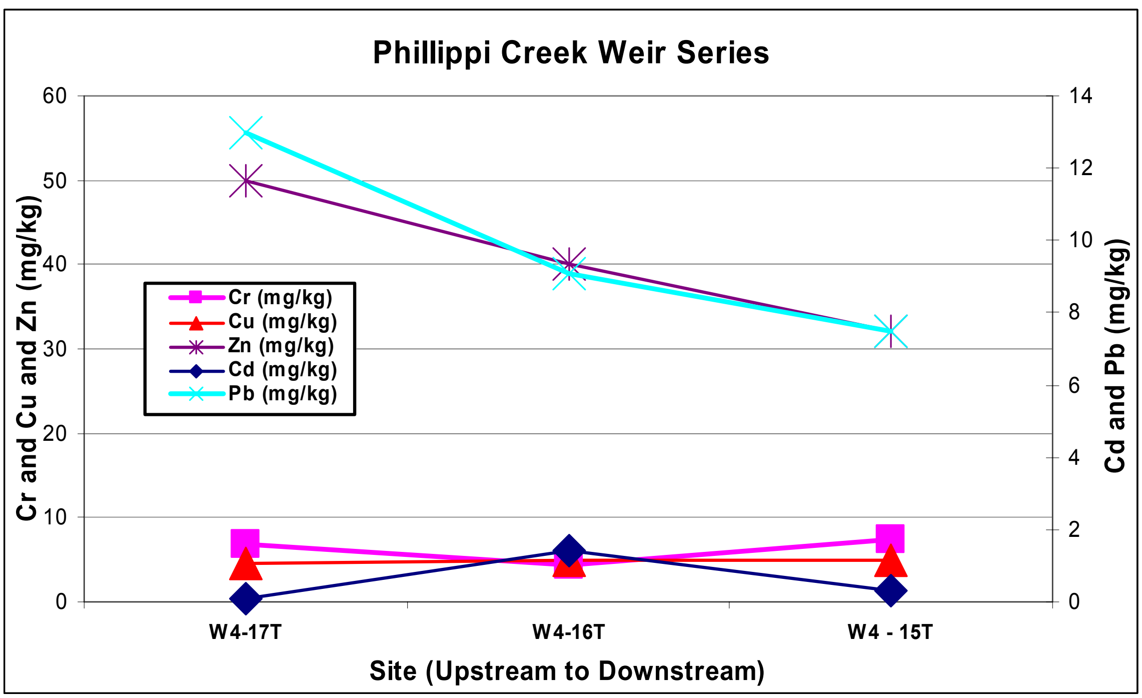


Figure 3-8. Sediment concentrations of heavy metals at a series of weirs in the Phillippi Creek basin. Weirs are shown from upstream (left) to downstream (right) along x-axis.

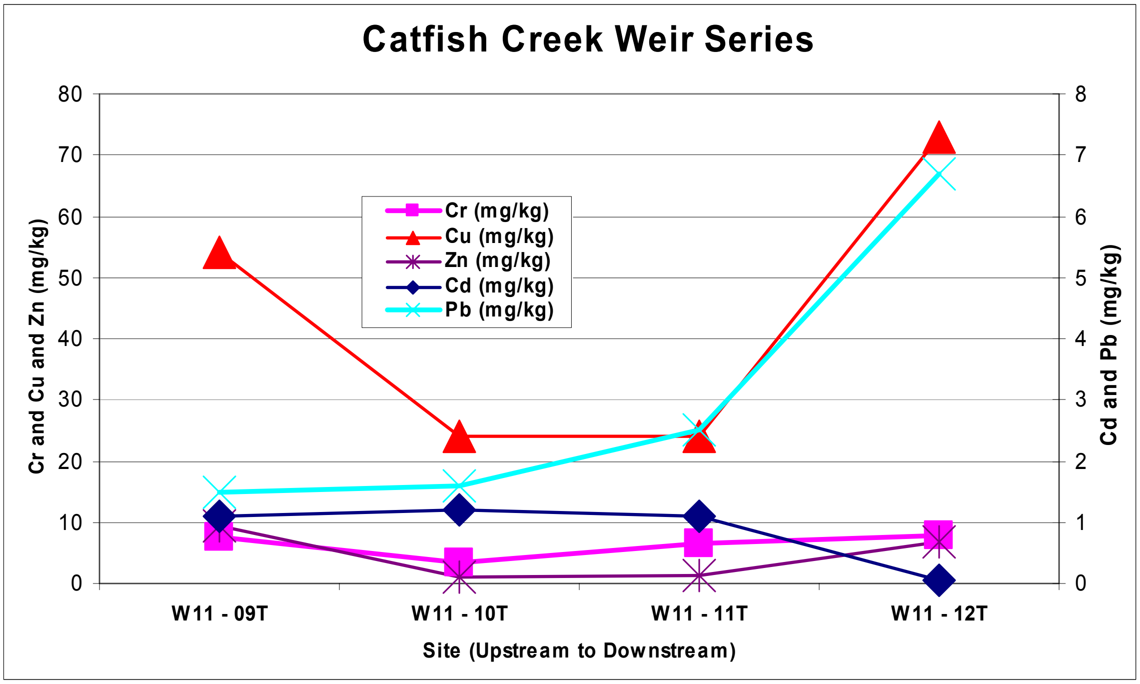


Figure 3-9. Sediment concentrations of heavy metals at a series of weirs in the Phillippi Creek basin. Weirs are shown from upstream (left) to downstream (right) along x-axis.

3.5 Relationships with Sediment Grain Size

Several metals (As, Cd, Pb, Zn) and total nitrogen were significantly correlated with percent silt clay in sediment samples. This relationship has been found in a number of other similar studies, particularly those involving analyses of roadway runoff and sources of heavy metal contaminants (Davies et al., 2000, De Groot et al. 1976). Specifically, the percent fines (silt/clay fraction) in sediments and the concentration of metal in the sediment are strongly correlated due to the fact that as grain size decreases, the surface to volume ratio increases. Smaller particles have a greater potential for surface processes like ion exchange, absorption, and coating formation. Various fine grained materials include organics (humic acids, etc.), clays, and oxyhydroxides of Fe and Al. As grain size decreases, the fraction of silica decreases, surface area increases, ion exchange capacity increases, and clay mineral content increases.

Table 3-3. Relationships between silt-clay fraction and metals concentrations.

Metal	R^2	P value
As	0.714961019	0.0000001
Cd	0.293016147	0.002
Cr	0.070143157	0.46
Cu	0.105837089	0.27
Pb	0.576323611	0.0000001
Zn	0.498947635	0.0000001
TN	0.624149485	0.0000001
TP	0.157839319	0.096

3.6 Comparisons with Other Similar Studies

Several sediment studies have been performed in Florida to evaluate the distribution and levels of heavy metal contamination in aquatic environments. These include several evaluations and risk analyses for riverine and estuarine sediments in Tampa Bay (McConnell et al., 1996; Zarbock et al., 1996; Long, 1995), a recent regional sediment quality survey in the St. Johns River Water Management District (SJRWMD) (Battelle, 2000), and a similar sediment chemistry study Dixon (1992) for the Sarasota Bay National Estuary Program. Summaries of metals concentrations for the present study and the Mote and Battelle studies are presented in Table 3-4.

Overall, sediment metals concentrations were similar among the three studies and most concentrations were within an order of magnitude of concentration for each metal. Mean Al concentrations were slightly greater in the SJRWMD area than in Sarasota, while Cd was slightly higher in the present study. Copper, lead, and zinc were highest in the Dixon (1992) study, which included several stations in Hudson Bayou – an area known to have high levels of heavy metals as a result of past industrial and commercial activities in its upstream watershed.

Several of the watersheds sampled by Mote coincided with our study including Phillippi Creek, South Creek, Matheny Creek, Elligraw Bayou, Clower Creek, and Hudson Bayou. Zinc was enriched at the several of the Mote stations (44 stations), with the most enriched sediments located in Hudson Bayou. Overall, sediments sampled within Hudson Bayou were the most contaminated, enriched at four of six stations. The average cadmium, lead, and zinc values were the highest of all 35 areas sampled, and second highest for copper. Of the values reported for 240 different samples, aluminum and copper were detected in all. Pollutants most often detected were copper, zinc, arsenic, mercury and lead, in order of frequency. Cadmium was detected in the fewest number of samples. Lead, zinc, and copper, and to a lesser extent cadmium, were substantially enriched at some stations. Greatest concentrations were typically found at the mouths of tributaries and lowest concentrations were found in the bay and at offshore locations.

The Dixon (1992) study results are similar to the findings of the present study, with high concentrations found at several untreated outfalls along Sarasota Bay (D-5, D-3). However, the present evaluation involved sampling stations much further upstream with concentrations for most of the metals lower than those found in the earlier Dixon (1992) study.

Table 3-4. Comparison of heavy metal concentrations with similar sediment studies in Florida.

		Aluminum (mg/kg)	Arsenic (mg/kg)	Cadmium (mg/kg)	Chromium (mg/kg)	Copper (mg/kg)	Iron (mg/kg)	Lead (mg/kg)	Zinc (mg/kg)
Weir Study (2003)	*Mean*	5,384	2.0	0.8	10.6	10.8	3,874	8.2	19.8
	Max	67,000	25.0	3.7	110.0	100.0	43,000	120.4	345.0
	Min	640	0.1	0.1	0.9	0.03	400	0.7	0.5
Sarasota Bay Study (1992)	*Mean*	6,763	2.2	0.3	N/A	20.2	N/A	38.3	55.4
	Max	27,290	9.2	1.9	N/A	115.8	N/A	307.8	589.1
	Min	710	0.03	0.003	N/A	0.9	N/A	0.1	1.9
SJRWMD Study (2000)	*Median*	8,840	1.2	0.2	14.1	4.0	4,670	13.4	19.5
	Max	48,400	15.2	1.3	139.0	59.7	29,400	343.0	361.0
	Min	239	ND	ND	0.5	0.3	111	0.7	0.9

3.7 Ranking of Sites for Prioritizing Maintenance Activities

Due to the large number of sampling locations and strata, a ranking matrix was developed to help identify those sites with the highest concentrations of heavy metals which could then be used to prioritize future maintenance/sediment removal activities. The matrix utilized the concentration values for each metal in each sample along with the TEL, PEL, SCTL residential, and SCTL commercial concentration limits. For each heavy metal in a given sample, a comparison of the concentration was made with each of these guidance levels and a score was assessed according to the following criteria:

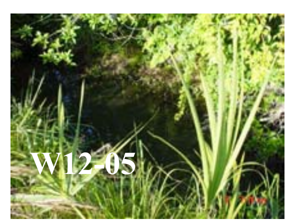
- Exceedence of TEL concentration – 1 point
- Exceedence of PEL concentration – 2 points
- Exceedence of SCTL residential concentration – 3 points
- Exceedence of SCTL commercial concentration – 4 points

These scores were then summed for each metal across each sample (row) to calculate a total score by sample. The scores were then ranked from highest to lowest with higher scores indicating greater numbers of guidance/cleanup level exceedences. By using each heavy metal for each sample in the scoring process, the sites could be evaluated not only on the basis of concentration values, but also on the number of metals that exceeded a criterion. The complete ranking matrix is presented in **Appendix H**.

Based on the range of values calculated using these criteria, samples were categorized as either High, Medium, or Low with respect to this scoring system. Maps depicting each site's ranking are shown in Figures 3-10 and 3-11 below. Samples with a score of zero (0) were ranked Low, while samples with scores greater than 0 and less than 5 were ranked Medium. There were 8 Low ranked samples and 91 Medium ranked samples. Medium samples had at least one metal that exceeded the TEL concentration, and also typically had at least one metal exceeding the SCTL residential concentration. In many cases, arsenic exceeded both the TEL and SCTL residential concentrations for Medium ranked samples. When samples (top and bottom) were combined to represent a single site, the higher score was used. If the top sample for a site was ranked Low and the bottom was ranked Medium, the Medium value was used in the above-referenced map. Based on a total of 58 sites, only one site ranked Low (W19-03 on Shakett Creek) and 44 sites ranked Medium.

Samples with scores greater than 5 were ranked as High. There were 15 High ranked samples representing 13 different sites (weirs/outfalls) and sediments from all of these sites had arsenic concentrations which exceeded the SCTL residential guidance concentrations, and several exceeded the copper TEL guidance concentrations. Other exceedences included those for lead, zinc, cadmium, and chromium. The highest ranked sample was for the NIST reference sediment (not from Sarasota County) which was originally derived from a contaminated river bed (Buffalo River). Sites which ranked High were as follows:

- W12-05 - was the highest ranked Sarasota County sample which is located south of Bee Ridge Road near the Bent Tree subdivision. A former wastewater plant was located in the vicinity of this sampling location and may be the source of high heavy metals concentrations at this site.



- W6-07 – located at an old bridge/weir structure along the upper reaches of Phillippi Creek. Historically, this channel received runoff from primarily agricultural areas including the Celery Fields.

- W10-10 - located immediately south of Bee Ridge Road and just west of Cattlemen Road in the Phillippi Creek basin. A large impervious area drains to this weir including several large parking lots and commercial and residential roads.

- W11-03 - located on Beneva Road (west of) just after Curtis, within the Elligraw Bayou basin. A large concrete control structure extends across the channel. The banks of the waterway are artificially impounded and lined with concrete. The major land uses within the immediate area are residential and commercial (gas station, office buildings).

- W11-04 - located at the intersection of Captiva Drive and Tuckerstown Drive (just west of Beneva), within the Elligraw Bayou basin. A metal sheet pile that extends across the entire waterway that was approximately 50 feet wide. The banks of this site were not artificially impounded though were comprised of sod/ornamental plants up to the waters edge, with no defined vegetative buffer. The major land use within the immediate area is residential.

- W11-06 - located west of Beneva Road and south of Eugene Road, within the Holiday Bayou basin. Samples were collected immediately upstream of a concrete fish ladder that extends across the waterbody. The major land use within the immediate area is low density commercial.

- W11-08 - located on Clower Creek Drive (Pelican Bay subdivision) west of Vamo Road in the Clower Creek basin. Samples were collected immediately upstream of a concrete sill that extended the entire width of the waterway (approximately 50 feet). The banks of the creek were relatively steep though occupied by a vegetative buffer, primarily composed of mangroves. The major land use within the immediate area is residential.

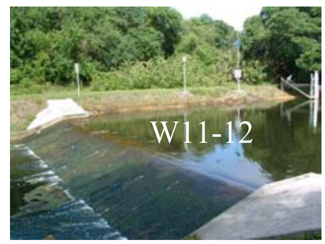
- W11-09 - located between Prestancia and Country Club Road, within the Catfish Creek basin. Samples were collected immediately upstream of a concrete sill that extends across the entire ditch. The banks of this site are covered with grass and frequently maintained. The primary land use within the immediate area is residential.

- W11-10 - located east of McIntosh Road and south of Sarasota Square Boulevard, within the Catfish Creek basin. Samples were collected immediately upstream of a concrete sill that extends across the entire ditch. Both banks are sodded and frequently mowed. The primary land use in the immediate area is residential.

- W11-12 - located north of Central Sarasota Parkway and west of

McInstosh Road, within the Catfish Creek basin. Samples were collected immediately upstream of a concrete sill that extends across the entire waterway. Both banks are sodded and frequently mowed. Several large trees were observed within the adjacent uplands and the percent canopy cover was determined to be lightly shaded (11-45%). The major land use within the immediate area is residential.

- W11-14 - located on Honore Avenue east of the Turtle Rock subdivision within a trunk ditch in the Catfish Creek basin. Samples were collected upstream of a concrete weir structure that extends across the width of the trunk ditch (approximately 50 feet) and drains water through a concrete culvert underground. The banks are not artificially impounded and have a narrow vegetative buffer of obligate vegetation. The major land use within the immediate area is currently residential with some agricultural use (both historic and present).



- D-3 – located at an untreated/uncontrolled outfall into Sarasota Bay at the eastern end of the basin at the 10th Street Boat Ramp (Centennial Park) – an enclosed sediment sump could be constructed at this outfall (across the existing boat basin) to prevent contamination of Sarasota Bay.

- D-5 – located at an untreated/uncontrolled outfall on Hog Creek immediately west of Cocoanut Avenue. A shallow wetland treatment area which appears to be retaining sediments exists immediately downstream from this sampling location.

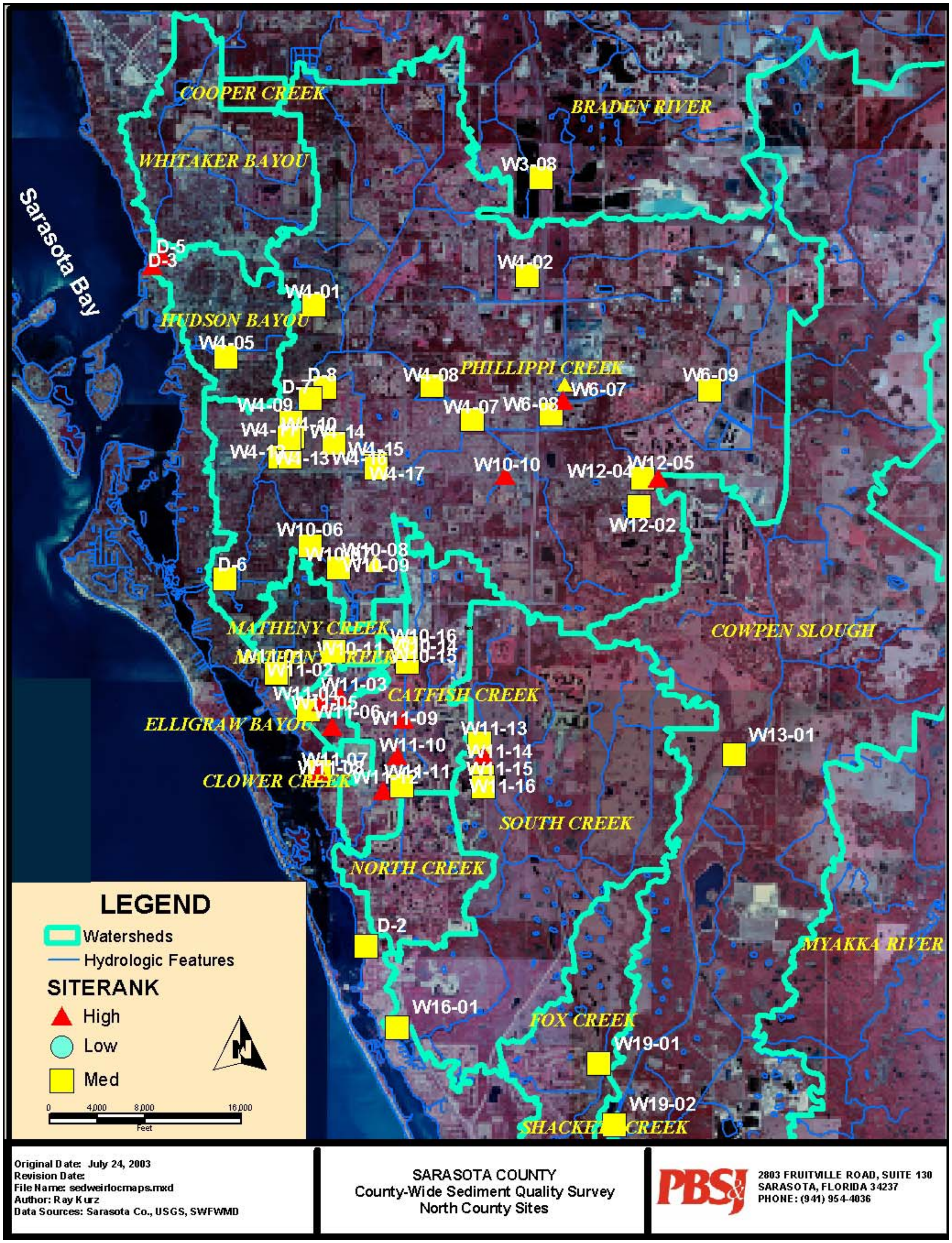


Figure 3-10. Scoring of North County weir/outfall sites based on sediment quality ranking matrix.

3.0 Results and Discussion

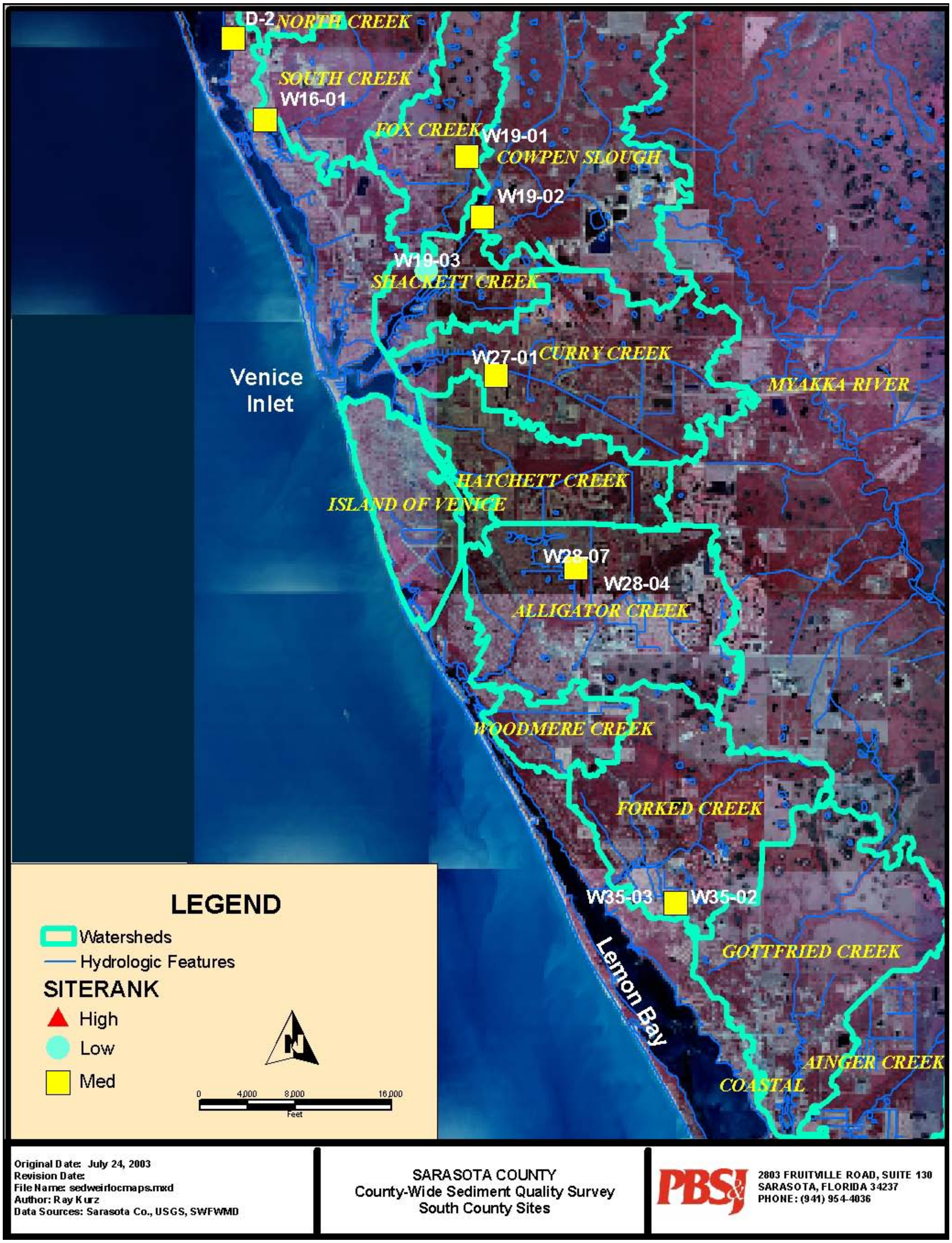


Figure 3-11. Scoring of South County weir/outfall sites based on sediment quality ranking matrix.

3.8 Disposal Options

Several disposal options exist for sediments removed from weir structure areas. During the dredging of Phillippi Creek in 2002, excess dredge material was disposed at Sarasota County's solid waste facility. This method could also be used for material removed from weir structures. The FDEP regulates the management and disposal of solid waste and the operation of solid waste facilities such as landfills. In addition, some local governments impose more stringent rules upon the management of solid waste based upon site-specific conditions that may affect public and/or environmental health.

Solid Waste Management Facilities are regulated by DEP under Chapter 62-701, Florida Administrative Code (F.A.C.). Non-hazardous solid waste is a Class I waste which by definition can be disposed of at lined landfills, pursuant to Chapter 62-701.520, F.A.C. Also, non-petroleum, contaminated soil can be disposed of at most lined solid waste facilities. Contaminated soil has a meaning given by Chapter 62-713.200(3), F.A.C., as soil that has become contaminated with concentrations of chemical constituents that are a.) in excess of Residential Direct Exposure soil cleanup target levels b.) are in excess of the soil cleanup target levels calculated in accordance with 62-713.520(2)(c), F.A.C, (see next paragraph) or c.) are expected to result in exceedances of DEP's ground water or surface water standards as evaluated in 62-713.510(6)(d), F.A.C. (leachability impacts). Although several weir sites did have at least one metal concentration exceeding the residential SCTL, these sediments could be disposed of at a lined landfill.

Chapter 62-713.520(2)(c), F.A.C., (as referenced above*) refers to contaminated soils that have been treated or cleaned to be utilized for other projects, not disposed of within a Class I landfill. These soils must be properly managed so they will not pose a significant threat to public health of the environment. Cleaned soil can be land applied without further restrictions provided that it is not deposited in surface waters or wetlands: unless it can be demonstrated that it will not cause surface water violations or be toxic to aquatic life or cause nuisance odors if saturated.*

Cleaned soil, or treated soil, must be at concentrations at or below the Residential Direct Exposure soil cleanup target level. If not, the treated soil can be evaluated on a case-by-case basis based upon a number of rule-defined calculations that evaluate the toxicity of the contaminant.

If the dredged material exceeds the Commercial Direct Exposure soil cleanup target levels, it may be considered a hazardous waste, which is regulated differently by the FDEP. The FDEP has adopted EPA rules for the regulation of hazardous materials and are referred to as 40CFR Part 264, 265, and 268 throughout Chapter 62-730, F.A.C. However, if this threshold is exceeded the parameter will have to be evaluated specifically to determine whether or not the concentrations are considered to be at a hazardous level. The only metal exceeding the residential and commercial SCTL was arsenic at site W12-05. The remaining weir sites had metals concentrations below the commercial SCTL.

3.9 Summary and Recommendations

Considering the extent of development within Sarasota County, sediment concentrations for most metals upstream of weirs were relatively low compared to FDEP guidelines and soil cleanup standards. However, sediments at several locations did exhibit heavy metals concentrations above the TEL and PEL and SCTL guidance levels.

Based on a limited number of samples, sediment concentrations for As, Cr, Cu, Zn, and total nitrogen were higher upstream of weirs versus downstream. Silt/clay fractions and percent organic material was also higher upstream of weirs versus downstream and metals and nutrient concentrations were correlated with silt/clay fractions. Based on these relationships, it appears that fine-grained sediments are detained by weirs along with elevated concentrations of metals and total nitrogen. The weirs appear to be acting as in-line sediment sumps or traps and prevent metals and nutrient enriched sediments from being transported downstream to the lower reaches of major creek systems and also Sarasota Bay and Lemon Bay. Similarly, weirs constructed in series showed greater concentrations of heavy metals at the most upstream sites versus weirs located several hundred feet downstream.

Using the ranking system developed to prioritize channel maintenance at weir locations, the highest priority watersheds for removal of the most enriched sediments (for metals) are in Phillippi Creek, Catfish Creek, Elligraw Bayou, Holiday Bayou, Clower Creek, Hog Creek (City of Sarasota), and one Coastal basin. Removal of heavy metal-enriched sediments would reduce the potential for contamination at the mouths of these creek systems and also in the adjacent estuaries. Based on concentrations measured during this study, sediments from most weir locations (where no metal exceeded the residential SCTL) could be used as landfill cover or other uses (road construction).

There are a number of different weir designs used throughout Sarasota County. The original function of many of these structures was for maintaining groundwater levels and flood protection - not for sediment management or control. In areas exhibiting elevated heavy metals loading or concentrations, improvements in weir design could be made to increase the potential for sediment trapping (e.g., higher control elevations to increase freeboard for sediment accumulation). In addition, future weir construction should take into account a site's location with respect to various stream and estuarine habitats and salinity zones (e.g., used by juvenile fisheries species). Use of fish ladders or avoidance of weir installation at sites near the mouths of tributaries should be considered to avoid the disruption of fish/shellfish migration upstream into tidal and freshwater reaches.

4.0 References

Battelle. 2000. Sediment quality in the St. Johns River Water Management District: physical and chemical characterization of new sites and detailed assessment of previously sampled locations. Special Publication SJ2001-SP1. Palatka, Florida.

BCI Engineers & Scientists, Inc. and PBS&J. 1999. Impacts of Atmospheric Deposition on Stormwater Quality.

Davies, J., S. Vukomanovic, M. Yan. 2000. Stormwater quality in Perth, Australia. Presentation at Hydro 2000, 3rd International Hydrology and Water Resources Symposium, Institution of Engineers, Australia.

DeGroot, A. J., W. Salomons, and E. Allersma. 1976. Processes affecting heavy metals in estuarine sediments. In J.D. Burton and P.S. Liss (eds), Estuarine Chemistry, 131-153. London, Academic Press.

Dixon, L. K. 1992. Sediment contaminants in selected Sarasota Bay tributaries. Sarasota Bay National Estuary Program. Mote Marine Laboratory Technical Report no 242. 12 p.

Dixon, L. K., and M. G. Heyl. 1999. Trend Analysis of Water Quality Data for the Sarasota Bay National Estuary Program. Mote Marine Laboratory Technical Report Number 645.

Florida Department of Agiculture and Consumer Services. 2000. Summary of Shellfish Harvesting Area Classification and Management. Division of Aquaculture, Shellfish Environmental Assessment.

Florida Department of Environmental Regulation. 1998. A Guide to the Interpretation of Metal Concentrations in Estuarine Sediments. Tallahasse, Florida.

Frithsen, J. B., S. P. Schreiner, D. E. Strebel,, R. M. Laljani, D. T. Logan, H. W. Zarbock. 1995. Chemical Contaminants in the Tampa Bay Estuary: A summary of distributions and inputs. Tampa Bay Estuary Program Technical Report 01-95

Grabe, S. A. 1997. Trace Metal Status of Tampa Bay Sediments 1993 – 1996. Environmental Protection Commission of Hillsborough County. Tampa Bay Estuary Program Technical Report 04-97.

Harper, H.H., and E.H. Livingston. 1999. Everything you always wanted to know about stormwater management practices but were afraid to ask, or stormwater BMPs: the good, the bad, and the ugly. Syllabus prepared for the Southwest Florida Water Management District Biennial Stormwater Research Conference, September 14, 1999, Tampa, FL.

Long, E. R., D. MacDonald and C. Cairncross. 1991. Status and Trends in toxicants and the Potential for their Biological effects in Tampa Bay, Florida. NOAA Technical Memorandum NOS OMA 58.

4.0 References

Long, E. R. and H. S. Greening. 1999. Chemical Contamination in Tampa Bay: Extent, Toxicity, Potential Sources and Sediment Quality Management Plans. National Oceanic and Atmospheric Administration and Tampa Bay National Estuary Program Special Report.

Long, E. R., D. MacDonald, S. L. Smith and F. D. Calder. 1995. Incidence of Adverse Biological Effects Within Ranges of Chemical Concentrations in Marine and Estuarine Sediments. Environmental Management 19(1): 81-97.

Lowrey S. 1993. Physical and Chemical Properties - bay water and sediment quality. Sarasota Bay National Estuary Program. Mote Marine Laboratory Technical Report No 266. 36 p.

MacDonald Environmental Sciences Ltd. and United States Geological Survey. 2003. Development and Evaluation of Numerical Sediment Quality Assessment Guidelines for Florida Inland Waters. Technical Report for the Florida Department of Environmental Protection

MacDonald, D. D. 1994. Approach to the Assessment of Sediment Quality in Florida Coastal Waters. Volume 1. Development and Evaluation of Sediment Quality Assessment Guidelines. Prepared for the Florida Department of Environmental Protection, Office of Water Policy.

McConnell, R. and T. Brink. 1997. Toxic Contamination Sources Assessment: Sources of Sediment Contaminations of Concern and Recommendations for Prioritization of Hillsborough and Boca Ciega Sub-Basins. Tampa Bay Estuary Program Technical Report 03-97.

McConnell, R., R. DeMott, Ph.D. and J. Schulten. 1996. Toxic Contamination Sources Assessment: Risk Assessment for Chemicals of Potential Concern and Methods for Identification of Specific Sources. Tampa Bay Estuary Program Technical Report 09-96.

Schropp, S. J., and H. L. Windom. 1988. A Guide to the Interpretation of Metal Concentrations in Estuarine Sediments. Published by the Florida Department of Environmental Regulation: Coastal Zone Management Section.

Schropp, S. J., F.G. Lewis, H.L. Windom, J.D. Ryan, F.D. Calder, L.C. Burney. 1990. Interpretation of Metal Concentrations in Estuarine Sediments of Florida Using Aluminum as a Reference Element. Estuaries: 13(3): 227-235.

Schuler, T. R. 1987. Controlling urban runoff: a practical guide for planning and designing urban BMPs. Metropolitan Washington Council of Governments, Washington, D.C.

Smith, D.L., and B.N. Lord. 1990. Highway water quality control – summary of 15 years of research. Transportation Research Record, No. 1279, Washington, D.C.

Stoker, Y.E. 1996. Effectiveness of a stormwater collection and detention system for reducing constituent loads from bridge runoff in Pinellas County, Florida. U.S. Geological Survey Open File Report 96-484. 38 pp.

Wanielista, M.P., and Y. Yousef. 1993. Stormwater Management. John Wiley & Sons, Inc., New York. 579 pp.

Zarbock, H. W., A. J. Janicki, D. T. Logan and D. D. MacDonald. 1996. An Assessment of Sediment Contamination in Tampa Bay, Florida Using the Sediment Quality Triad Approach. Tampa Bay Estuary Program Technical Report 04-96.