

INDIAN BEACH/SAPPHIRE SHORES STORMWATER MAPPING

DRAFT REPORT

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## INTRODUCTION

Indian Beach/Sapphire Shores (IBSS) is one of the most historically significant neighborhoods in Sarasota, Florida. Located adjacent to Sarasota Bay and west of US 41 in the northwest corner of the City of Sarasota (Map 2), IBSS is perhaps best known as the home of important cultural institutions such as the John and Mable Ringling Museum of Art, New College of Florida, Asolo Theater, and Sarasota Jungle Gardens. IBSS is also notable for its many historic homes constructed over several development eras and in a variety of architectural styles. The neighborhood landscape is further enriched by unusually large stands of native forest trees such as south Florida slash pine, southern magnolia, pignut hickory, and live oak that provide welcome shade for neighborhood residents and serve as important habitat for native wildlife. Important archaeological sites are also known throughout the neighborhood and provide the origin of the name “Indian Beach.” However, the seminal force underlying the natural and cultural heritage water of IBSS is the water of Sarasota Bay, which provides the clear inspiration for the name “Sapphire Shores.”

In this project, detailed geographic information system (GIS) databases of the current stormwater infrastructure for the IBSS neighborhood were developed. Non-point pollution from stormwater runoff has been identified as a primary cause of water quality degradation throughout Sarasota Bay (SWFWMD 2002), and areas such as IBSS that lack modern stormwater capture and treatment facilities are thought to pose a comparatively high risk of non-point pollutant loading into the bay. Previously available information about stormwater drainage in IBSS was known to be largely outdated and difficult to utilize for effective planning and outreach purposes. Thus, update of information about IBSS’s stormwater infrastructure into an integrated GIS format provides an important new tool for ongoing and future programs that may help to lessen non-point pollutant loading from the neighborhood. All work for this project was made possible by funds provided to New College of Florida from the National Oceanic and Atmospheric Administration (NOAA) through grant award number NA03NMF4720358.

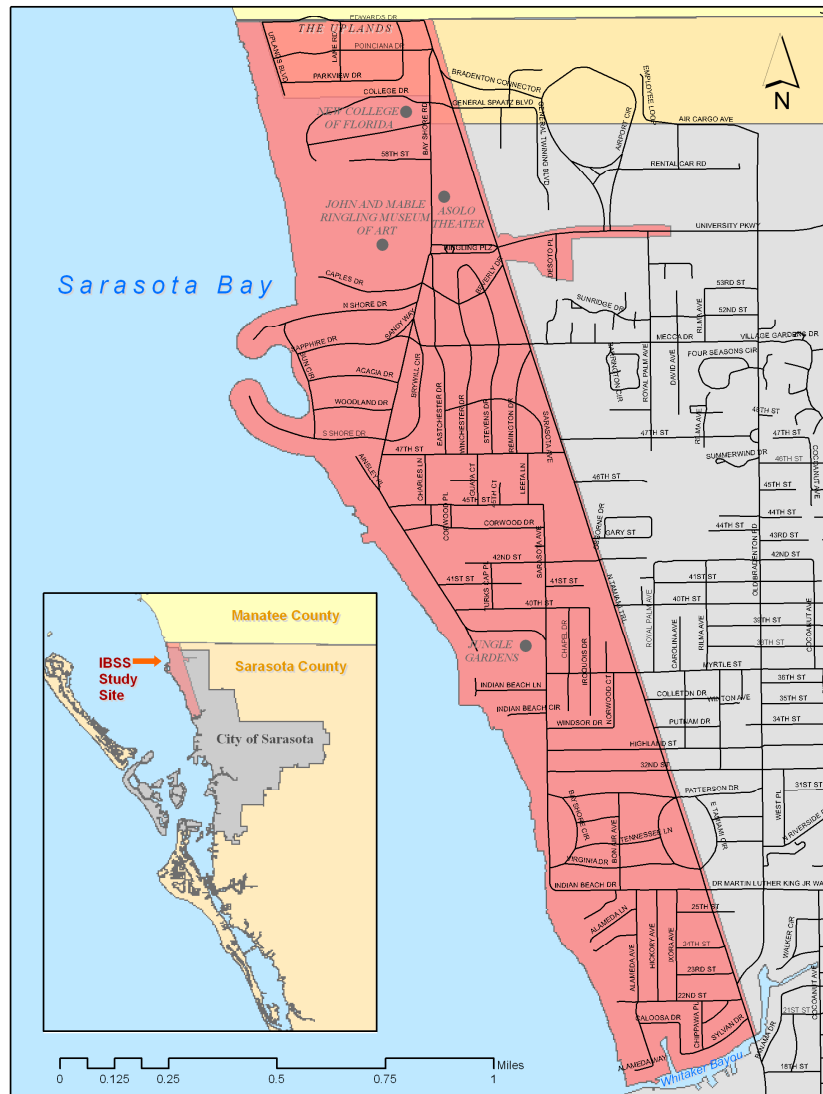
## SARASOTA BAY

Sarasota Bay is a subtropical estuary that has been long renowned for its great natural beauty and bountiful marine resources. Separated from the Gulf of Mexico by several narrow barrier islands that encompass 30 miles of coastline from Anna Maria Island to Casey Key, the water body referred to as Sarasota Bay is generally defined as being nautically bounded by Anna Maria Sound and Palma Sola Bay in the north and Venice Inlet in the south (Map 1). Sarasota Bay has an open water area of approximately 52 square miles and a contributing watershed of approximately 150 square miles (SWFWMD 2002). The average depth of the bay is 6 feet, with many shallow bottom areas receiving adequate sunlight through the water column to support rich sea grass communities (SWFWMD 2002).

# Map 1: Sarasota Bay Region



## Map 2: Indian Beach/Sapphire Shores and Surrounding Areas



Like many other water bodies throughout Florida, the cumulative effects of increased pollutant loading and direct habitat disturbance are known to have caused substantial declines in Sarasota Bay's ecological condition over the past sixty years. In 1987, growing concerns about continuing ecological degradation led to Sarasota Bay being named an estuary of national significance by the United States Environmental Protection Agency (EPA). This federal designation resulted in a number of ecosystem research and recovery programs being implemented through the Sarasota Bay National Estuary Program, which was first formed in 1989 and later renamed as the Sarasota Bay Estuary Program (SBEP). The activities of the SBEP were complemented on a state level in 1995

when the Southwest Florida Water Management District (SWFWMD) designated Sarasota Bay as a priority water body under the auspices of its Surface Water Improvement and Management (SWIM) Program (SWFWMD 2002).

Cooperative actions taken by federal, state, and local governments in support of the SBEP and SWIM Program over the past two decades are known to have resulted in significant pollutant load reductions and habitat improvement within Sarasota Bay (SBEP 2006). For example, loadings of nitrogen, a primary plant nutrient that can feed deleterious algae blooms when present in excess amounts, were reduced by almost 50% in Sarasota Bay from 1988 to 1998 (SWFWMD 2002). These reductions in nitrogen loading are thought to be responsible for increased water clarity and associated expansion of sea grass communities observed throughout some areas of the bay (SWFWMD 2002).

### NON-POINT POLLUTION: AN OVERVIEW

Virtually all of the water quality improvements that have been achieved in Sarasota Bay over the past two decades can be attributed to reduction of loadings from highly regulated point sources such as wastewater treatment plants (SBEP 2006). Although these point source reductions are an important achievement, better control of non-point pollution loading from stormwater sources will be critical for the maintenance and achievement of additional water quality improvements throughout Sarasota Bay in future years (SBEP 2006; SWFWMD 2002). Slight but steady rises observed in nitrogen loading into Sarasota Bay since 1998 can be almost wholly attributed to increased non-point pollution sources (SBEP 2006).

Unfortunately, pollutant loading from non-point sources is known to be much more difficult to effectively control and mitigate than pollutant loading from regulated point sources. These difficulties are especially acute in a region, such as the Sarasota Bay watershed, that continues to experience rapid population growth and associated development. Modern development practices result in the replacement of native soils and established vegetation that naturally retain and filter significant amounts of rainfall with large areas of “impervious surfaces” such as roads, parking lots, and buildings. Because impervious surfaces do not retain rainfall, the volume of runoff associated with storm events is greatly increased after a given piece of land is developed. Impervious roads, parking lots, and driveways also serve as a primary source of non-point pollutants such as oils, greases, oxidized nitrogen, and heavy metals that are associated with the operation of automobiles (Tomasko et al. 1997). Furthermore, areas that do remain unpaved after development are often converted into lawns and other intensive landscapes typically maintained through the application of chemical herbicides, pesticides, and fertilizer nutrients such as nitrogen and phosphorus. These landscaping chemicals are often captured within stormwater runoff and loaded into nearby water bodies as non-point pollution.

Modern stormwater capture and treatment systems can partially mitigate the effects of non-point pollutant loading from newer developments. For example, a typical stormwater retention pond is designed to retain most metals, greases, and oils contained in runoff,

while also reducing the amount of nitrogen that would otherwise be loaded into receiving water bodies by up to 44% (SPEB 2006). Recently developed stormwater treatment system designs and improved maintenance techniques for existing retention ponds have the potential to result in even larger load reductions of nitrogen and other typical contaminants found in runoff from developed areas (SBEP 2006). Outreach and education programs that result in decreased and appropriately timed application of landscaping chemicals are also thought to be an important tool for reducing non-point pollution.

Because the drainage infrastructure in IBSS was constructed before the advent of modern stormwater capture and treatment regulations, there is concern that the non-point pollution risks posed by neighborhood yards and roads may be higher than in more recently developed areas. Rather than entering into retention ponds or other treatment infrastructure, runoff throughout most of IBSS is drained from street inlets into underground pipe conveyance systems that directly discharge into Sarasota Bay. This drainage system can be expected to capture or treat very little of the runoff that enters into inlets, meaning that any contaminants that enter into the stormwater pipe system will be loaded directly into Sarasota Bay as non-point pollution.

Due to the high expense and other difficulties that would be associated with major infrastructural retrofits for stormwater treatment purposes in IBSS, outreach programs that educate residents about the direct connections their neighborhood has with Sarasota Bay and actions that they can take to help improve the bay's water quality are likely to serve as the primary strategy for reducing non-point pollutant loading. It is expected that this project's integration and update of knowledge about IBSS stormwater infrastructure into a GIS format can serve as an important tool for facilitating such outreach programs, while also assisting in efforts to more effectively measure the effects of these outreach programs on neighborhood landscaping practices and Sarasota Bay's water quality over time.

## MATERIALS AND METHODS

### MATERIALS

The primary workspace for creating and analyzing spatial data about IBSS stormwater infrastructure was ESRI's ArcGIS/ArcView 9 with Spatial Analyst and ArcHydro extensions. In addition, a Trimble GeoXT Global Positioning System (GPS) receiver with Trimble TerraSync was used to collect spatial locations and record field measurements of various stormwater features throughout IBSS. Trimble Pathfinder Office 3.00 provided the platform for upload and correction of GPS field data, and was also utilized to transform collected GPS data into ArcView's native shapefile format.

Collection of extant GIS files relevant to stormwater drainage in IBSS was an initial work step undertaken for this project (Flowchart 1). GPS field data collected by NCF students from 2003 – 2005 on IBSS stormwater inlets, IBSS stormwater outfalls into Sarasota Bay, IBSS street curb locations, stormwater inlets in NCF West Campus, stormwater

outfalls into Sarasota Bay from NCF West Campus, and retention areas in the NCF West Campus were obtained from NCF Environmental Studies. Soil type and watershed boundaries for Sarasota County were downloaded from the Florida Geographic Data Library website ([www.fgdl.org](http://www.fgdl.org)). Sarasota County water bodies, streets, property boundaries, and regional coastline boundaries were downloaded from Sarasota County Government's GIS website ([gis.co.sarasota.fl.us](http://gis.co.sarasota.fl.us)). GIS files with elevation contours delineated at 1 ft. intervals by SWFWMD in 2004 and partial coverage of IBSS stormwater pipes, stormwater inlets, bay outfalls, and surface drainage were obtained by compact disc from Sarasota County Stormwater Utility. A digital aerial photograph taken in February 2004 with 2 ft. pixel resolution was also obtained from Sarasota County Stormwater Utility. These files were uploaded into a new data file in the ArcMap program of Arc GIS 9. Files from NCF Environmental Studies and the Florida Geographic Data Library were transformed into the Transverse Mercator Florida State Plane projected coordinate system utilized by Sarasota County. All extant GIS files used in this project are summarized in Table 1.

Another initial project work step was collection of print maps and surveys containing additional information about IBSS stormwater infrastructure (Flowchart 1). Print maps with archival information of stormwater pipe extents for the IBSS neighborhood were obtained from the City of Sarasota's Engineering Department. A topographic survey with stormwater infrastructure throughout the NCF campus and detailed topographic surveys with stormwater infrastructure for the University Parkway corridor were both obtained from NCF Physical Plant. An infrastructural survey of the John and Mable Ringling Museum of Art containing stormwater pipe and inlet information was obtained from the Lawson Group, Inc. A summary of these print data sources is contained in Table 2.

#### PRELIMINARY DATA EXAMINATION AND SHAPEFILE CREATION

The next work step was examination and comparison of gathered GIS files and print source information (Flowchart 1). Detailed notes about clear gaps in digital files, conflicts among data sources, and other data needs were taken. This data examination process confirmed that existing GIS files lacked much of the stormwater infrastructure information found in the print sources. A polyline shapefile for stormwater pipe extents, polygon shapefile for surface drainage features, a point shapefile for stormwater outfalls, and a point shapefile for stormwater inlets were then created in ArcMap for the purpose of digitizing information contained within the print sources. A polygon shapefile for neighborhood boundary delineation was also created. Initial boundaries were drawn using the Sarasota/Manatee county line in the north, US 41 to the east, Sarasota Bay to the west, and Whitaker Bayou to the south. This boundary was later amended to include areas of the University Parkway corridor east of US 41 that drain into Sarasota Bay (see Map 2). The Transverse Mercator Florida State Plane coordinate system used by Sarasota County was imported as the spatial reference for all files. Table 3 contains a summary description of these files in their completed form.

## GPS DATA COLLECTION

Collection of spatial coordinates for stormwater inlets, bay outfalls surface ditches, and retention ponds using the Trimble GeoXT GPS receiver was then undertaken throughout IBSS (Flowchart 1). Data collection efforts were concentrated on areas in which this information was known to be absent from existing GIS files, although some field data were also collected in areas with existing coverage for positional and attribute comparison purposes. Field attributes including drainage inlet structure type, bearing of visible pipes, construction material of visible pipes, shape of visible pipes, and miscellaneous comments about inlet and pipe condition were recorded for inlet points. Construction material, measured dimensions, and shape of pipe outfalls were recorded for outfall points. In addition, digital photographs were taken of all stormwater pipe outfalls into Sarasota Bay and Whitaker Bayou.

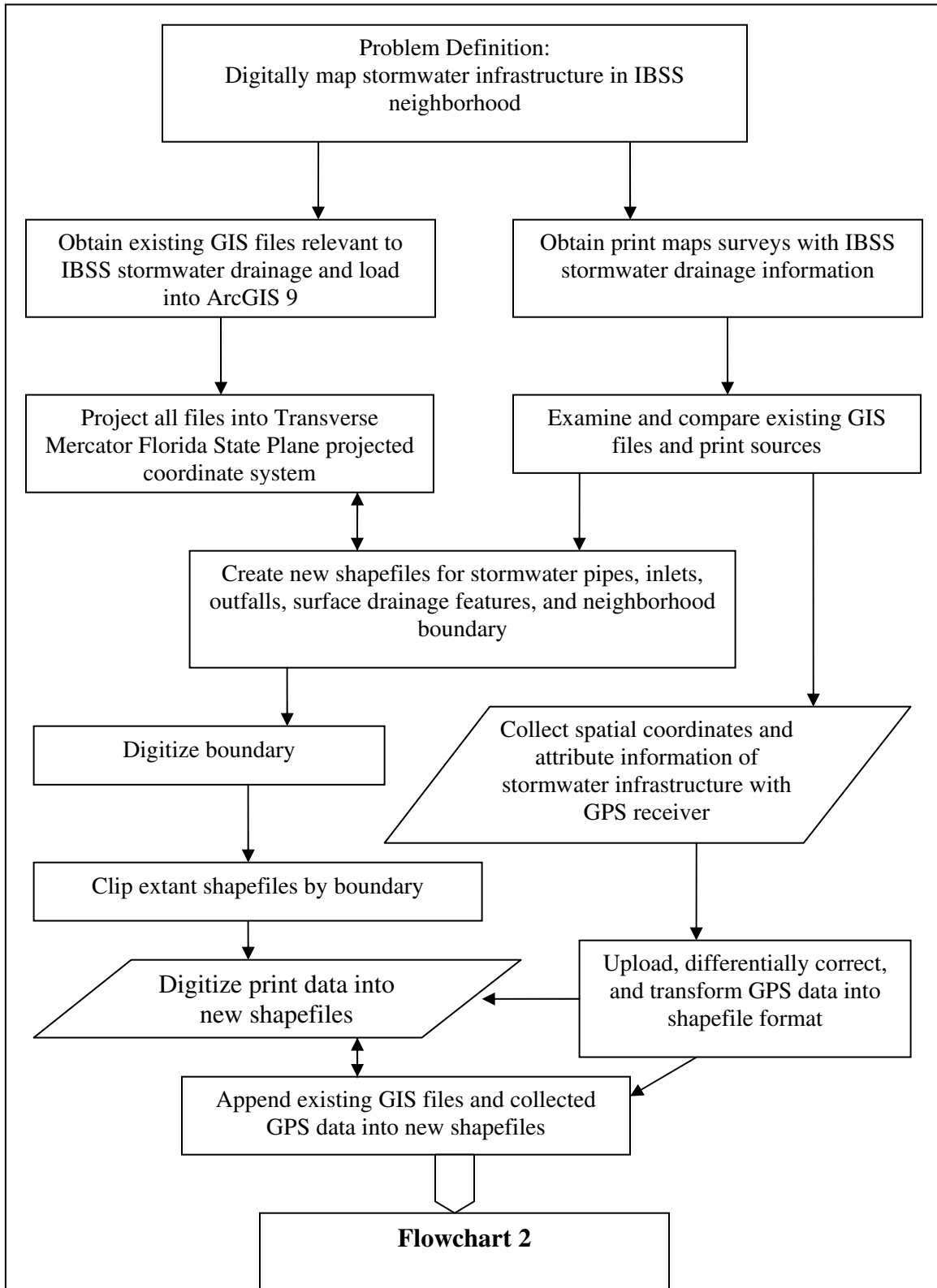
Upon completion of field data collection, files from the GPS receiver were transferred onto a computer hard drive and post-processed with the Pathfinder Office program (Flowchart 1). Differential correction post-processing was utilized for the purpose of improving positional accuracy (see Chivers 2003), with the continuously operating reference station (CORS) at Mac Dill Air Force Base in Tampa serving as the base point for the differential correction procedure. Differentially corrected data files were then exported from Pathfinder Office in shapefile form and loaded into ArcMap.

## FILE INTEGRATION AND DIGITIZATION

Extant point shapefiles and newly collected GPS data shapefiles of stormwater inlets were next appended into one master file. Overlapping point features from NCF and Sarasota County GIS files were identified through 10 ft. buffer searches. Points from the Sarasota County files were used preferentially to resolve these initial data conflicts. Outlets from surface drainage features into stormwater pipes were defined as inlets and are contained in the master inlet file. An additional point shapefile of outfalls from pipes into surface drainage features other than Sarasota Bay and Whitaker Bayou (e.g., ditch, retention ponds, and swales) was also created. GPS data supplemented by print survey information were used as source for spatial and attribute information for outfalls into surface drainage features. Due to a number of identified conflicts, data errors, and omissions among existing bay outfall shapefiles, newly collected GPS data were used as the primary source for spatial and attribute information in the final bay outfall shapefile. Invert elevation data contained in print sources were manually entered into the attribute table for appropriate inlet and outlet features. Attribute tables were integrated and simplified for all shapefiles after performance of the append operation. Table 3 contains a summary of the inlet, bay outfall, and pipe outfall to surface drainage shapefiles with methods used.

The master inlet file and outfall files were then used to manually digitize stormwater pipe extents and attribute information for the IBSS neighborhood in the ArcMap program of ArcGIS 9 (Flowchart 1; Table 3). Extant GIS shapefiles of stormwater infrastructure and GPS point shapefiles of stormwater inlets were used as snapping points for the manual

## Flowchart 1: Data Assembly and Construction



**Table 1: Extant GIS Sources for IBSS Stormwater Infrastructure**

File Name	Description	Source	Date Created
IBSS_infalls.shp	Point shapefile of stormwater inlets in IBSS	NCF Environmental Studies	2004
IBSS_outfalls.shp	Point shapefile of stormwater outfalls into Sarasota Bay in IBSS	NCF Environmental Studies	2004
IBSS_Curbs.shp	Polyline shapefile of curb data in IBSS	NCF Environmental Studies	2005
NCFW_Inlets.shp	Point shapefile of stormwater inlets in New College West Campus	NCF Environmental Studies	2005
NCFW_Outfalls.shp	Point shapefile of stormwater outfalls in New College West Campus	NCF Environmental Studies	2005
NCFW_Retention.shp	Polygon shapefile of stormwater retention areas in New College West Campus	NCF Environmental Studies	2005
ssoils58.shp	Polygon shapefile of soil types for Sarasota County	Florida Geographic Data Library ( <a href="http://www.fgdl.org">www.fgdl.org</a> )	1990
basins58.shp	Polygon shapefile of watershed basins for Sarasota County	Florida Geographic Data Library ( <a href="http://www.fgdl.org">www.fgdl.org</a> )	1998
WATERFEATURES.shp	Polygon shapefile of water features in Sarasota County	Sarasota County GIS ( <a href="http://gis.co.sarasota.fl.us">gis.co.sarasota.fl.us</a> )	Unknown
STREETS.shp	Polyline shapefile of streets in Sarasota County	Sarasota County GIS ( <a href="http://gis.co.sarasota.fl.us">gis.co.sarasota.fl.us</a> )	Unknown
PARCELS.shp	Polygon shapefile of property parcels in Sarasota County	Sarasota County GIS ( <a href="http://gis.co.sarasota.fl.us">gis.co.sarasota.fl.us</a> )	Unknown
REGIONAL_BOUNDARIES.shp	Polygon shapefile with detailed coastline, county, and city boundaries of Sarasota Bay region	Sarasota County GIS ( <a href="http://gis.co.sarasota.fl.us">gis.co.sarasota.fl.us</a> )	Unknown
contours.shp	Polyline shapefile of 1 ft. contours for Sarasota County	SWFWMD (Obtained from Sarasota County Stormwater Utility)	2004
DrainagePipes2001PNT.shp	Point shapefile of stormwater drainage pipes and outfalls in IBSS	Sarasota County Stormwater Utility	2001
DrainagePipeline2001.shp	Polyline shapefile of stormwater drainage pipes in IBSS	Sarasota County Stormwater Utility	2001
DrainagePipeline2002.shp	Polyline shapefile of stormwater drainage pipes in IBSS	Sarasota County Stormwater Utility	2002
DrainageInlets2001.shp	Point shapefile of stormwater inlets in IBSS and other areas	Sarasota County Stormwater Utility	2001
DrainageInlets2002.shp	Point shapefile of stormwater inlets in IBSS and other areas	Sarasota County Stormwater Utility	2002
DrainageResidentialDitch2002.shp	Polyline shapefile of surface drainage in IBSS and other areas	Sarasota County Stormwater Utility	2002
DrainageOpenDitch2002.shp	Polyline shapefile of surface drainage in IBSS and other areas	Sarasota County Stormwater Utility	2002
aerial2004_color2ft.tif	Georeferenced TIFF aerial photo of IBSS and surrounding areas	Sarasota County Stormwater Utility	2004

**Table 2: Print Sources for IBSS Stormwater Infrastructure**

Print Map Name	Description	Project Contribution	Source	Date Created
City of Sarasota Drainage Atlas	Drainage and parcel blueprints, scaled at 1 in = 100 ft	Digitization of pipe extent and pipe size information in IBSS neighborhood	City of Sarasota Engineering Department	1955, 1970
Boundary and Topographic Survey of Leased Lands for the University of South Florida Sarasota Campus	Topographic survey with existing sanitary sewer and water distribution, scaled at 1 in = 150 ft	Digitization of pipe extent, pipe size, and inlet invert elevation information for New College of Florida West and Caples campuses	Mosby Engineering Associates, Inc. (obtained from New College of Florida Physical Plant)	1995
Desoto Rd. Survey, Project Number 8606	Detailed blueprints and topographic surveys for Desoto Rd. (University Pkwy.) widening and expansion, multiple scales	Digitization of pipe extent, pipe size, and inlet invert elevation information for University Parkway corridor	Post, Buckley, Schuh, and Jernigan, Inc. (obtained from New College of Florida Physical Plant)	1988, 1989
John and Mable Ringling Museum of Art Site Plan North	Topographic survey and infrastructural site plan for Ringling Museum of Art property, scaled at 1 in = 60 ft	Digitization of pipe extent, pipe size, and inlet invert elevation for Ringling property	Lawson Group, Inc.	2002

digitization operation. A protractor was used to measure pipe intersection angles and a ruler was used to measure pipe extents on print surveys. These measurements were cross referenced with angle and distance measures displayed during the digitization operation in ArcMap to ensure correct matching of print survey information with spatial data contained in the GIS files. Distance anomalies between inlets that were measured to be over 10 ft. from survey measures were flagged for collection of GPS groundtruthing data. These GPS groundtruthing data files were uploaded into ArcMap through the method described above and used as the spatial control point reference for all noted anomalies. Upon completion of the manual digitization process, existing stormwater pipe shapefiles were then appended into the final stormwater pipe shapefile. The attribute table was integrated and simplified for this file after performance of the append operation. Table 3 contains a summary of this stormwater pipe shapefile and methods used.

Integration of information about surface drainage in IBSS into one polygon shapefile was the next data assembly step. Linear ditch drainage features in existing shapefiles were assumed to have an average diameter of 6 ft., transformed into polygon features using a 3 ft. buffer operation, and appended as polygon features into the surface drainage shapefile. Polygon features such as surface streams, ponds, and retention areas contained in extant GIS files and collected GPS data were appended directly into the new surface drainage shapefile. The attribute table for this shapefile was integrated and simplified after performance of the append operation. Table 3 contains a summary of this surface drainage shapefile and methods used.

Polygon shapefiles for manual digitization of tree canopy and impervious surface areas in IBSS were then created in ArcMap and spatially referenced using the Transverse

Mercator Florida State Plane projected coordinate system. Tree canopy and impervious building, parking lot, sidewalk, and driveway polygons were manually digitized by visual inspection from the 2 ft. resolution aerial photograph described in Table 1. Impervious road surface polygons were first created through performance of a 10 ft. buffer operation on polyline street features, and then corrected as necessary for better visual fit with street extents represented in the aerial photograph. Although such manual digitization methods are known to be inherently time-consuming and prone to subjective operator judgments, the high cost of advanced image processing software and general accuracy (>90%) of manual digitization at the spatial scale of this project indicate that this was the appropriate method (see Rogers et al. 2004). Descriptions of the canopy and impervious surface shapefiles and methods used are contained in Table 3. Raster files with 5 ft. pixel size were later created from both the canopy and impervious surface shapefiles for use in Spatial Analyst calculations (Flowchart 2).

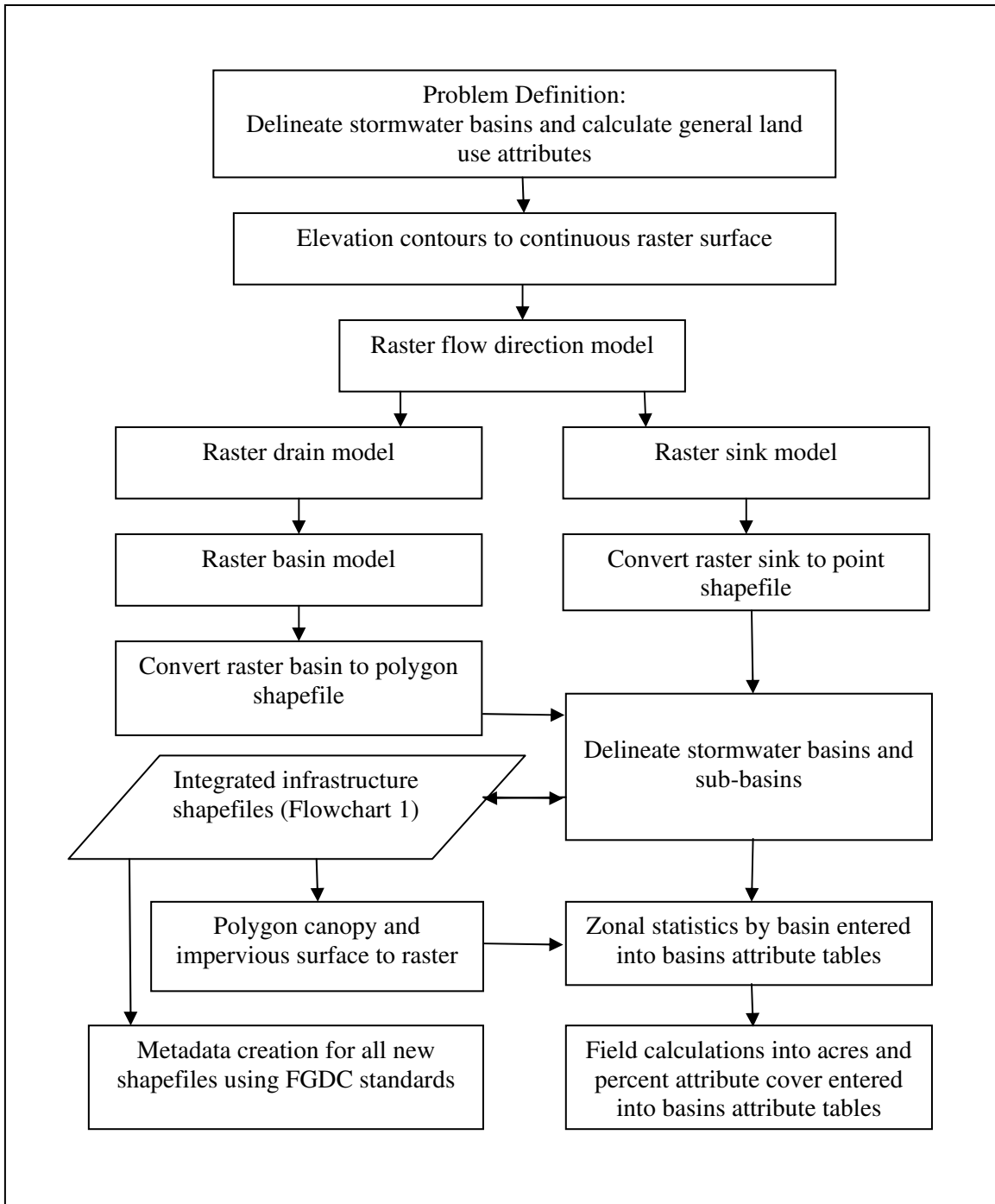
The final data assembly procedure performed for this project was delineation of stormwater basin boundaries (Flowchart 2). The first step in basin delineation was interpolation of polyline contours into a continuous raster elevation surface. A raster flow direction model was then created from the continuous raster elevation surface. This flow direction model was next used as the basis for creating raster basin and sink models. The raster basin model was converted into a polygon shapefile with smoothed edge, and then clipped by the neighborhood boundary. The raster sink model was converted into a point shapefile. Stormwater infrastructure data were then used in conjunction with sink points to manually modify the drainage basin model according to hydrologic behavior caused by surface drainage features not noted in elevation contours.

Three types of stormwater basins were identified in IBSS: pipe outfalls to Sarasota Bay or Whitaker Bayou, coastal sheet flow into Sarasota Bay or Whitaker Bayou, and surface water “sub-basins” for retention features. The stormwater basin file contains delineation of pipe outfall basins without separate sub-basin polygons. The stormwater sub-basin file contains sub-basins as distinct polygons. Canopy and impervious acreage and percentage coverage for all basins and sub-basins were calculated in Spatial Analyst using data from canopy and impervious surface raster files (Flowchart 2). The detailed procedures used to delineate stormwater basins and calculate attribute data are shown in Flowchart 2 and summarized in Table 3.

#### METADATA DOCUMENTATION

Metadata documentation was added into each file through the ArcCatalog program of ArcGIS 9 (Flowchart 2). Federal Geographic Data Committee (FGDC) standards for metadata were used for all files. These metadata contain detailed information about shapefile purpose, content, author, institutional funding, contact information, creation date, methods, attributes, and reference documents. Metadata also describe public access information and contain suggested time tables for shapefile update.

## Flowchart 2: Basin Delineation and Attribute Calculation



**Table 3: IBSS Stormwater GIS Files**

File Name	File Description	Methods Summary
IBSS_Boundary.shp	Polygon shapefile of IBSS boundary	Northern boundary manually snapped to county line (REGIONAL_BOUNDARIES.shp). Eastern boundary manually snapped to US 41 (STREETS.shp). Southern and western boundaries loosely drawn outside boundary and clipped by detailed coastline (REGIONAL_BOUNDARIES.shp). Eastern boundary later amended to include University Parkway corridor that discharges into Sarasota Bay.
IBSS_Curb_Gutter.shp	Polyline shapefile of IBSS curbs and gutters	Original NCF file groundtruthed and attribute table added.
IBSS_StormPipes.shp	Polyline shapefile of IBSS stormwater pipes	Spatial and attribute information from print sources manually digitized. GPS inlet and outlet data and existing GIS files (IBSS_infalls.shp; IBSS_outfalls.shp; DrainagePipes2001PNT.shp; DrainagePipeline2001.shp; DrainagePipeline2002.shp; DrainageInlets2002.shp; DrainageInlets2001.shp; NCFW_Inlets.shp; NCFW_Outfalls.shp) used as snapping points. Protractor angles and ruler measures of survey features used as cross reference to ensure positional accuracy. Additional GPS points collected to resolve measurement anomalies. Existing GIS pipe shapefiles appended into final shapefile. Attribute table integrated and simplified to contain pipe size, material, shape, and comments.
IBSS_Inlets.shp	Point shapefile of IBSS stormwater inlets	Append existing files (IBSS_infalls.shp; DrainageInlets2002.shp; DrainageInlets2001.shp; NCFW_Inlets.shp) and GPS data into one master file. Overlapping point features identified through 10 ft. buffer searches. Sarasota County points used preferentially to resolve overlaps. Invert data from print sources manually entered into attribute table for appropriate features.
IBSS_BayOutfalls.shp	Point shapefile of IBSS stormwater pipe to bay outfalls	GPS data used for spatial location and attribute information at outfall points.
IBSS_Pipe_Outflow.shp	Point shapefile of pipe outflows into IBSS surface drainage features	GPS data used for spatial locations. Print surveys and GPS data used for attribute information.
IBSS_SurfaceWater.shp	Polygon shapefile of IBSS surface drainage features, including retention ponds, culverts, and ditches.	Existing polyline shapefiles (DrainageResidentialDitch2002.shp; DrainageOpenDitch2002.shp) transformed into polygon through 3 ft. buffer operation and appended into file. Extant drainage feature polygons (WATERFEATURES.shp) for IBSS selected and appended into file. GPS data appended into file. Attribute data integrated and table simplified.
IBSS_Impervious.shp	Polygon shapefile of IBSS impervious surface	Street polyline features (STREETS.shp) for IBSS converted into polygon through 10 ft. buffer. Buildings, houses, and parking lots manually digitized from aerial photograph (aerial2004_color2ft.tif).
IBSS_Canopy.shp	Polygon shapefile of IBSS canopy	Canopy features manually digitized from aerial photograph (aerial2004_color2ft.tif)
IBSS_StormBasins.shp IBSS_Subbasins.shp	Polygon shapefile of IBSS stormwater basins	Polyline contours (contours.shp) interpolated into continuous raster surface. Raster flow direction model run from raster elevation surface. Raster basin and sink models run from flow direction model. Raster basin model converted into polygon shapefile (BasinModel.shp) and clipped by neighborhood boundary. Raster sink model converted into point shapefile. Stormwater infrastructure data (IBSS_Inlets.shp; IBSS_Outfalls.shp; IBSS_Surface_Drain.shp; IBSS_Curbs; IBSS_Impervious) used in conjunction with sink points to manually modify drainage model. Surface sub-basins within pipe outfall basins delineated in sub-basins file (IBSS_Subbasins.shp). Files clipped by neighborhood boundary. Raster models of canopy and impervious surface used to calculate canopy and impervious area by delineated basins.

# ANALYSIS

## LAND AREA

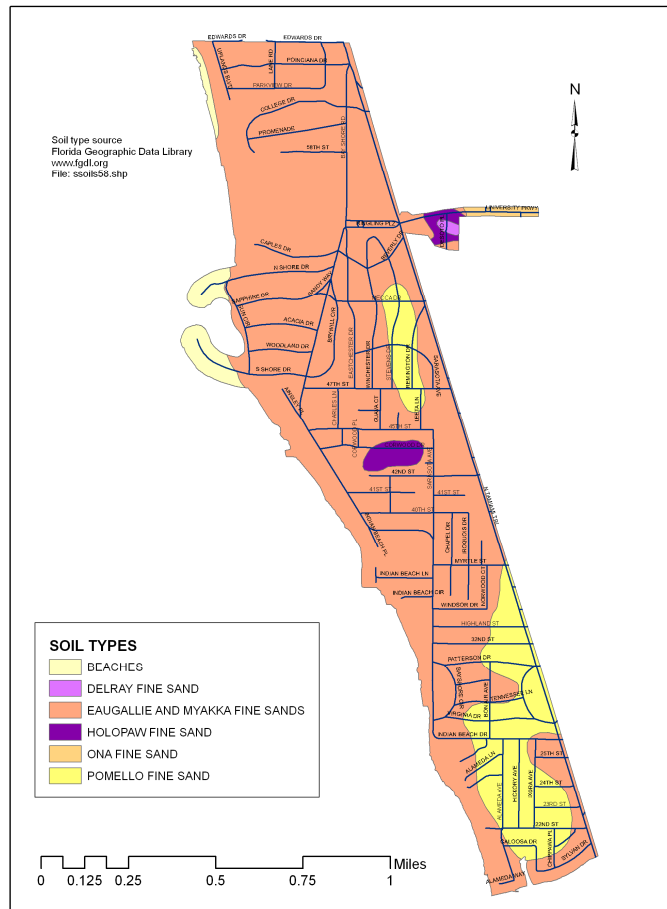
Based upon the boundaries used in this project (see Map 2), the total land area of the IBSS study site is approximately 722 acres. This area is approximately 50 acres larger than the official boundaries of the IBSS neighborhood due to the inclusion of 36 acres contained within the Sarasota County portions of the Uplands neighborhood located directly north of the NCF west campus and 14 acres of the University Parkway corridor that are located east of US 41. The Uplands neighborhood was included from the outset in this study due to its geographic and hydrologic contiguity with the IBSS neighborhood. The University Parkway corridor was added into the study site after it was determined that this area is drained through stormwater infrastructure that discharges directly into Sarasota Bay within the IBSS boundary. No other area east of US 41 appears to have any direct hydrologic connection with stormwater pipe outfalls to Sarasota Bay located in IBSS. Some areas east of US 41 do drain into a stormwater pipe that discharges directly into Whitaker Bayou at the US 41 bridge.

## SOILS

Like most coastal areas in Florida, the soils in IBSS are composed almost entirely of fine, marine-originated sands. Six major soil types are found within the study site boundary: EauGallie and Myakka fine sands, Pomello fine sand, Holopaw fine sand, Delray fine sand, Ona fine sand, and coastal beach sand.

The dominant soil type throughout most of IBSS is undifferentiated EauGallie and Myakka fine sands, which are found on approximately 583 acres (81% of land area). EauGallie and Myakka are poorly drained soils that generally have high water tables (NRCS 2006). These soils are typically associated with Florida's pine flatwood vegetation community. The

**Map 3: IBSS Soil Map**



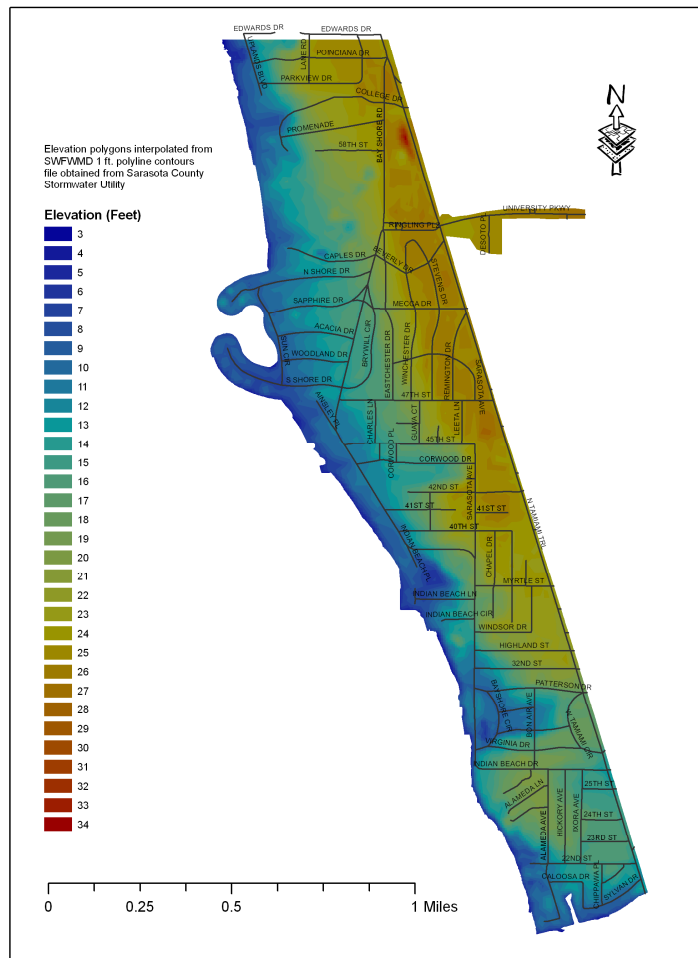
next most common soil type in IBSS is Pomello fine sand, which is found on approximately 100 acres (14% of land area). Pomello fine sand is generally associated with elevation ridges in pine flatwoods communities and tends to be somewhat better drained than the EauGallie and Myakka\_sands (NRCS 2006).

Other soil types occupy small percentages of IBSS land area. Coastal beach sands are located on approximately 18 acres (3% of land area) adjacent to Sarasota Bay, with most of this acreage associated with bay bottom fill deposited to create new land area for home development. Holopaw fine sands, located on approximately 11 acres (1.5% of land area), are poorly drained soils typically found in lowland depression and marginal wetland areas (NRCS 2006). Very small areas (<1% of land area) of Delray fine sand and Ona fine sand are found in the University Parkway corridor section of the study area. Delray sands are fairly permeable lowland soils that indicate seasonal wetlands and/or floodplain areas, while Ona fine sands are poorly drained soils commonly associated with coastal flatwood communities (NRCS 2006).

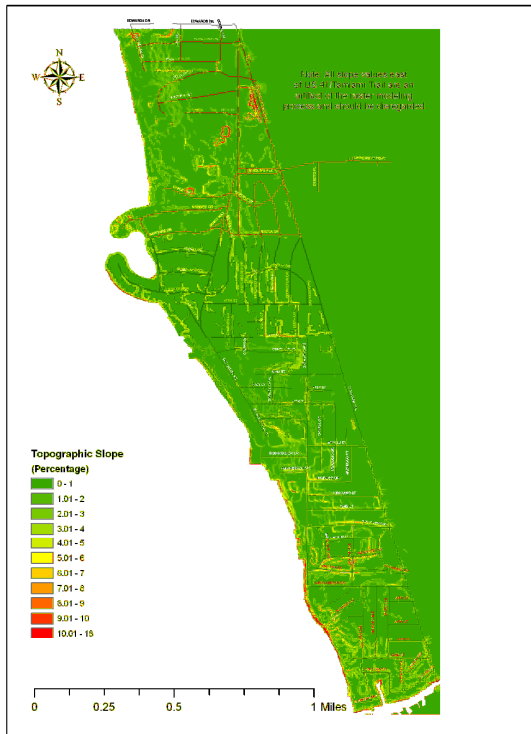
ELEVATION

Elevation in IBSS ranges from just above sea level on the coastline to 25 to 30 ft. on a ridge area located just west of US 41 (Map 4). The topographic slope throughout most of IBSS is under 1%, with significantly higher slopes generally found adjacent to roads, drainage features, and the coastline (Map 5). Such a topographic slope profile is typical for a developed coastal flatwood landscape in Florida. However, the ridgeline and associated coastal elevation gradient are relatively high in IBSS as compared to most other coastal areas in Sarasota County (Map 6).

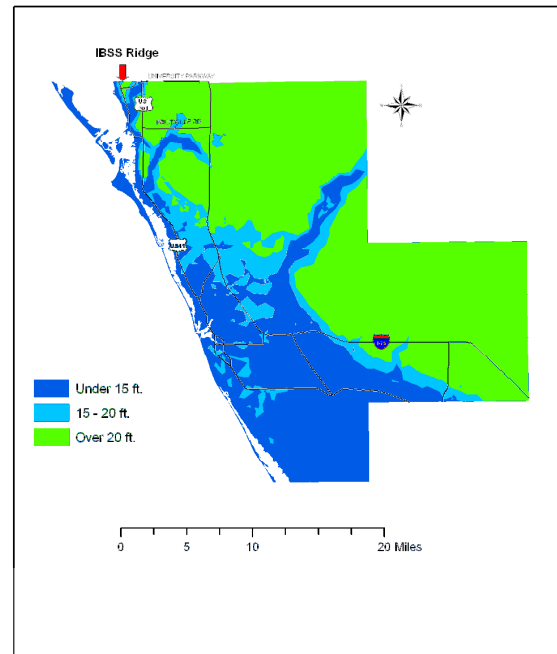
**Map 4: IBSS Elevation**



Map 5: IBSS Topographic Slope



Map 6: Sarasota County Elevation

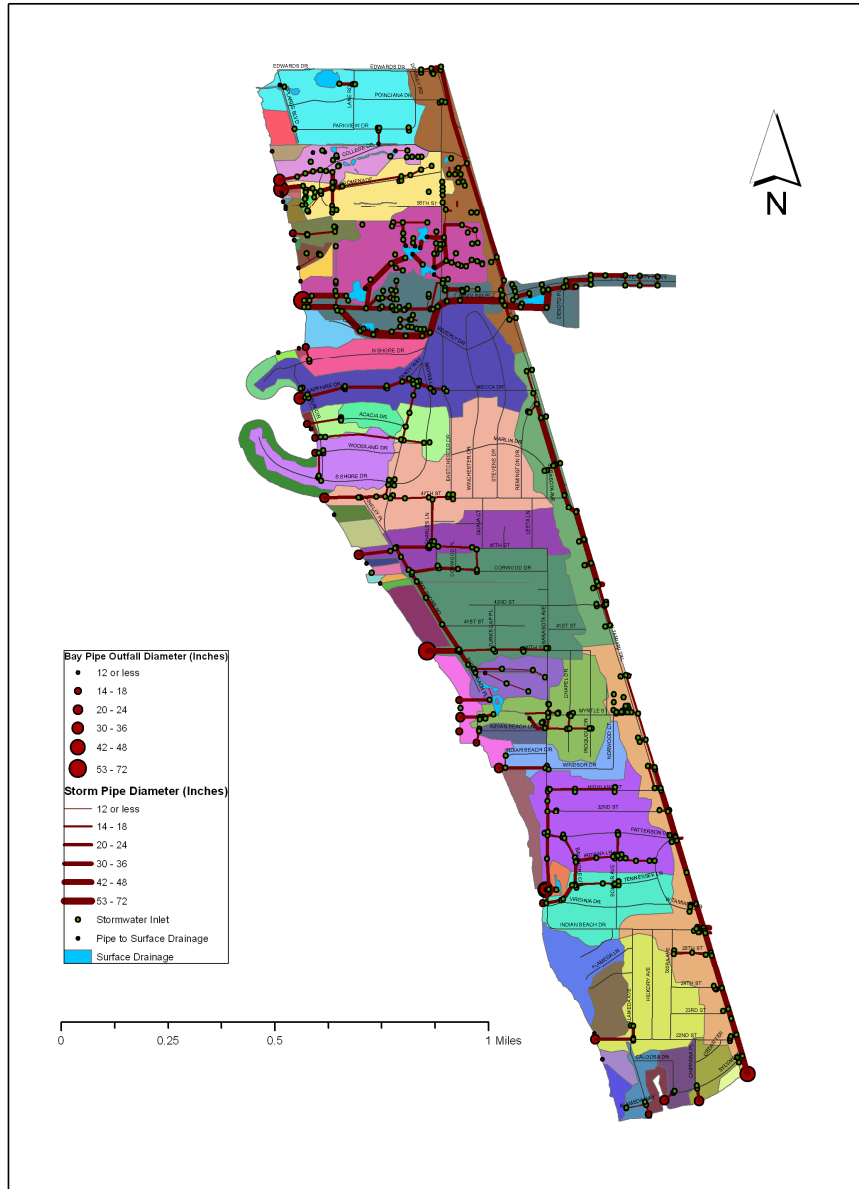


### STORMWATER DRAINAGE

As described in Flowchart 2, elevation contours (Map 4) and stormwater infrastructure data together were used to delineate 62 distinct drainage basins within the IBSS neighborhood (Map 7). The drainage basins in IBSS vary greatly by size, with the largest measuring over 55 acres and the smallest measuring well under one acre. Of the 62 delineated basins, 47 are associated with outfall pipes that discharge into Sarasota Bay or Whitaker Bayou. These pipe outfall drainage basins occupy approximately 569 acres in IBSS, or about 79% of the total land area. Sarasota Bay is the receiving water for 43 of these pipe basins, accounting for 510 acres or 71% of neighborhood land area. The 4 pipe basins that discharge into Whitaker Bayou have an area of approximately 59 acres or 8% of total land area. Treatment areas such as swales and ponds that are hydrologically connected to bay outfalls capture stormwater for about 93 acres in IBSS, which amounts to about 16% of the area associated with stormwater pipe discharge and 13% of total area in the neighborhood.

Interestingly, 20 pipe outfalls to Sarasota Bay do not have any clear connection to surface inlets (Map 7). These pipe outfalls are small in diameter (generally less than or equal to 12 inches), and pipe extents associated with these outfalls mostly are not known. It

**Map 7: IBSS Stormwater Drainage Basins**



is likely that pipe features associated with these outfalls were installed for additional water table and landscape drainage by bay front property owners. Basins for these outfalls were drawn according to surface hydrology, with the assumption that coastal sheet flow in nearby areas would be preferentially channeled through subsurface conduits provided by drainage pipes. The total basin land area associated with these 20 outfalls is 24 acres, or approximately 3% of IBSS land area.

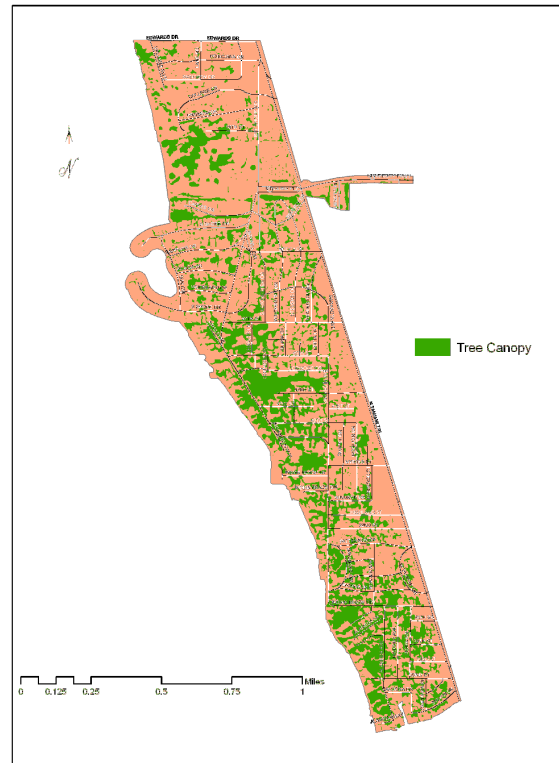
Most other basins in IBSS are composed of coastal sheet flow discharge into Sarasota Bay and Whitaker Bayou. These sheet flow basins account for just over 60 acres, or 8%

of the total IBSS land area. In addition, a 26 acre basin in the US 41 commercial corridor from Mecca Dr. south to 40<sup>th</sup> St. drains east through a stormwater pipe that then discharges into a surface ditch hydrologically connected to Whitaker Bayou, and approximately 27 acres adjacent to US 41 north of Mecca Dr. to the Manatee County line is drained through pipe flow into a retention pond hydrologically connected to Bowlees Creek. These two commercial corridors together account for 7% of the total IBSS land area. The remainder of the drainage in the study area is provided by a surface creek slough into Sarasota Bay that receives both pipe and ditch flow from a 36 acre basin in the Uplands neighborhood.

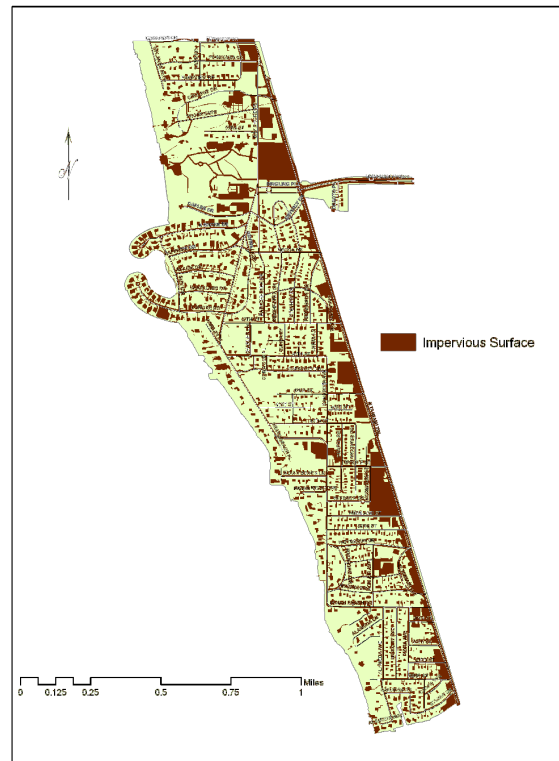
#### TREE CANOPY

Tree canopy coverage in IBSS amounts to approximately 213 acres, or 30% of the total land area (Map 8). Percentage canopy coverage varies considerably among different areas and corresponding drainage basins in IBSS. For example, the large (55 acre) drainage basin that discharges into the pipe outfall near Bayshore Rd. and 40<sup>th</sup> St. contains approximately 31 acres of canopy cover, which amounts to over 56% of the basin area. Other significant canopy areas are found on the Ringling Museum grounds, Jungle Gardens, and the southwestern corner of the IBSS neighborhood. By contrast, more commercial areas adjacent to US 41 have well under 10% canopy coverage. Maintenance and expansion of tree canopy coverage in IBSS may be an

**Map 8: IBSS Tree Canopy**



**Map 9: IBSS Impervious Surface**





greatly increased amounts of direct runoff volume into stormwater drainage infrastructure and receiving waters compared to street areas that lack these features.

## CONCLUSIONS AND RECOMMENDATIONS

This project developed detailed GIS databases of stormwater drainage in the IBSS neighborhood. Most of the IBSS neighborhood is drained through underground pipe conveyance systems that discharge stormwater runoff directly into Sarasota Bay and Whitaker Bayou with little treatment of runoff contaminants. Such a stormwater drainage system likely poses an inherently high risk of non-point pollutant loading into Sarasota Bay from neighborhood streets and yards.

Some features of the IBSS neighborhood may, however, mitigate contamination risks in certain areas. Previous research studies (Keating 2002) and ongoing research in IBSS both suggest that areas with significant canopy coverage may have less runoff onto impervious surfaces due to intercept by tree leaves, thereby lessening the amount of runoff that is loaded directly into Sarasota Bay. In addition, areas of the neighborhood without curbs or gutters generally can be expected to load significantly less runoff volume and associated runoff contaminants into stormwater inlets than areas that do have curbs or gutters.

Areas in which runoff is captured in swales, ditches, dry detention areas, and retention ponds before discharge into Sarasota Bay are likely to have a decreased risk of non-point loading due to attenuation of runoff volume and sequestration of pollutants within these facilities. However, further research and monitoring are needed to better understand roles that specific biotic communities, management practices, and design parameters associated with stormwater treatment areas in IBSS may have on treatment efficacy. For example, frequent blooms of nitrogen-fixing cyanobacteria observed in the retention pond located on the NCF Caples campus suggest that this pond may not be effectively reducing nitrogen and may actually even be serving as a source of additional nitrogen loading into Sarasota Bay (see SWFWMD 2005). Depending upon the management practices used in stormwater treatment areas, loading of herbicides, pesticides, nutrients, and organic matter as a result of maintenance in treatment areas may also be a significant concern (SWFWMD 2005).

Although additional construction of retention ponds or other large-scale stormwater treatment facilities is not feasible in most areas of IBSS due to the scarcity and high expense of undeveloped land, several neighborhood residents have expressed interest in removing street side curbs and constructing swale features to capture stormwater in their front yards. If designed and constructed appropriately, front yard swales could reduce stormwater runoff into Sarasota Bay and provide attractive landscaping amenities. However, such infrastructural retrofits should only be performed in coordination with Sarasota County Stormwater Utility, the City of Sarasota, SWFWMD, and surrounding homeowners.

More research into the effects of homeowner landscaping behavior on the quality of stormwater runoff discharged into receiving waters is clearly needed. The stormwater basins in IBSS may provide a fairly unique opportunity for detailed a study of landscaping behavior and associated quality of discharged stormwater at very fine spatial scales. For example, a protocol for measuring landscaping intensity could be developed and used to characterize the intensity of IBSS yards at the parcel level. Such landscaping characterization data would make it possible to calculate an aggregate landscaping intensity score for each delineated stormwater outfall basin, providing a numeric variable that could then be statistically related with water quality measures taken at outfalls following storm events. Ideally, measurable relationships between water quality and landscaping intensity could be used to develop scientifically rigorous landscaping standards for water quality improvement purposes. Re-characterization of landscaping intensity data throughout the neighborhood at periodic time-scale intervals would also provide a means of gauging changes in landscaping behavior over time. Patterns of landscaping behavior change could then be used to help evaluate, adjust, and refine outreach strategies in IBSS and other areas where homeowner outreach programs are expected to serve as the pillar of non-point pollutant reduction.

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