Total Maximum Daily Load

For

Nutrients and Dissolved Oxygen

In

Stevenson Creek

(WBID 1567)

Pinellas County, Florida

September 2007

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LIST OF ABBREVIATIONS

AWWTP	Advanced Wastewater Treatment Plant
BMP	Best Management Practices
BOD	Biochemical Oxygen Demand
CBOD	Carbonaceous Biochemical Oxygen Demand
CFR	Code of Federal Regulations
DO	Dissolved Oxygen
EMC	Event Mean Concentration
FAC	Florida Administrative Code
FDEP	Florida Department of Environmental Protection
FLUCCS	Florida Land Use Cover Classification System
FS	Florida Statutes
GIS	Geographic Information System
HUC	Hydrologic Unit Code
IWR	Impaired Waters Rule
LA	Load Allocation
LB/YR	Pounds per year
MGD	Million Gallons per Day
MG/L	Milligram per liter
MOS	Margin of Safety
MS4	Municipal Separate Storm Sewer Systems
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
SWFWMD	Southwest Florida Water Management District
TMDL	Total Maximum Daily Load
TN	Total Nitrogen
TP	Total Phosphorus
TSS	Total Suspended Solids
USGS	United States Geological Survey
WBID	Water Body Identification
WLA	Waste Load Allocation
WQS	Water Quality Standards
WMP	Watershed Management Plan

SUMMARY SHEET

Total Maximum Daily Load (TMDL)

1. **303(d) Listed Waterbody Information**
   State: Florida
   Major River Basins: Spring Coast HUC

1998 303(d) Listed Waterbodies for TMDLs addressed in this report:

WBID	Segment Name	County	Class and Waterbody Type	Constituent(s)
1567	Stevenson Creek	Pinellas	III marine	Dissolved Oxygen, Nutrients

2. **Water Quality Standards and TMDL Targets**

Dissolved Oxygen (DO): Shall not average less than 5.0 mg/l in a 24-hour period and shall never be less than 4.0. Normal daily and seasonal fluctuations above these levels shall be maintained. The target DO concentration is 4.0 mg/l as it was not possible to calculate the daily average concentrations with the available data.

Nutrients: The discharge of nutrients shall continue to be limited as needed to prevent violations of other standards contained in this chapter. In no case shall nutrient concentrations of a body of water be altered so as to cause an imbalance in natural populations of aquatic flora and fauna. A Chlorophyl-a (Chla) concentration of 8 µg/l is selected as the endpoint for the TMDLs. This value is within the range of concentrations measured in unimpaired marine waters in Clearwater Harbor.

Biochemical Oxygen Demand (BOD): Shall not be increased to exceed values which would cause dissolved oxygen to be depressed below the limit established for each Class and, in no case, shall it be great enough to produce nuisance conditions.

3. **TMDL Approach**

A multi-variable regression analysis was performed using nutrient and Chla data collected at Stevenson Creek stations in WBID 1567 to estimate percent reduction in nutrients required to achieve the Chla endpoint (8 µg/l). Results of the regression analysis indicate nutrient reductions of 75% for Total Nitrogen (TN) and 70% for Total Phosphorus (TP) are needed for the simulated Chla concentration to achieve the target. A similar correlation was found between DO, BOD and temperature. Results of this regression analysis indicate an 80% reduction in BOD is needed to achieve the DO target (4 mg/l).

EPA's simple approach to pollutant loading analysis (PLOAD) was used to estimate annual nutrient and BOD loads discharged into the estuary from the landscape. The PLOAD analysis calculates runoff based on average annual rainfall for the area (55.6 in/yr) and event mean concentrations (EMCs) of nutrients and BOD associated with the landuses in the watershed. The EMC data used in the PLOAD analysis were derived specifically for the Stevenson Creek watershed as part of the City's Watershed Management Plan for the creek.

The average annual existing load discharging into the estuary was calculated as the sum of the PLOAD results and the average annual load discharging from the Marshall Street Advance Wastewater Treatment Plant (AWWTP). This total existing load was then reduced by the percentages prescribed in the regression analyses to determine the TMDL for nutrients and BOD. The TMDL was separated into Waste Load Allocation (WLA), MS4, and Load Allocation (LA) components based on the percentage each contributes in the existing conditions. The AWWTP contributes TN, TP, and BOD loads of 46, 26, and 7 percent of the total existing load, respectively. Stormwater was assumed to contribute TN, TP, and BOD loads of 54, 74, and 93 percent of the total load, respectively. The stormwater load was separated into MS4 and Load Allocation (LA) components based on the percentage of land cover in the watershed. The MS4 accounts for about 86 percent of the landuse in the watershed whereas nonpoint sources account for about 14 percent.

Continuous flow gages have been recording flows in the freshwater portion of Stevenson Creek (WBID 1567B) and Spring Branch (WBID 1567C), a major tributary to WBID 1567, since June 2006. Because flow data are limited, and not collected during times when water quality was measured in WBID 1567, the TMDL allocations are expressed as annual loads with the intention of implementation on an annual basis. In compliance with EPA guidelines, the TMDL allocations are expressed in daily terms using seasonal flow values and target nutrient concentrations. The reductions prescribed in the regression analyses are multiplied by the median nutrient and BOD concentrations measured in the creek to obtain the target concentrations (see Appendix B).

4. TMDL Allocations

Parameter	TMDL (lb/year)	WLA[3] AWWTP (lb/year)	WLA[3] MS4 (lb/year)	LA (lb/year)	Percent Reduction (%)
TN	15,602	7,177	7,245	1,180	75%
TP	3,604	937	2,294	373	70%
BOD	68,800	4,816	55,026	8,958	80%

Note: Percent reduction in existing loadings required to achieve the TMDL load. BMPs implemented in the watershed since 2004 may have achieved a significant portion of the prescribed reduction; however, sufficient instream data are not available to confirm this.

5. **Endangered Species (yes or blank):** Yes

6. **USEPA Lead on TMDL (USEPA or blank):** USEPA

7. **TMDL Considers Point Source, Nonpoint Source, or both:** Both

8. **Major NPDES Discharges to Stevenson Creek:**

NPDES	FACILITY NAME
FL0021857	Marshall Street AWWTP
FLS000005	Pinellas County (MS4)

1 Introduction

Section 303(d) of the Clean Water Act requires each state to list those waters within its boundaries for which technology based effluent limitations are not stringent enough to protect any water quality standard applicable to such waters. Listed waters are prioritized with respect to designated use classifications and the severity of pollution. In accordance with this prioritization, states are required to develop Total Maximum Daily Loads (TMDLs) for those water bodies that are not meeting water quality standards. The TMDL process establishes the allowable levels of pollutants for a waterbody based on the relationship between pollution sources and in-stream water quality conditions, so that states can establish water quality based controls to reduce pollution from both point and nonpoint sources and restore and maintain the quality of their water resources (USEPA, 1991).

The State of Florida Department of Environmental Protection (FDEP) developed a statewide, watershed-based approach to water resource management. Under the watershed management approach, water resources are managed on the basis of natural boundaries, such as river basins, rather than political boundaries. The watershed management approach is the framework FDEP uses for implementing TMDLs. The state's 52 basins are divided into five groups, and water quality is assessed in each group on a rotating five-year cycle. Stevenson Creek (WBID 1567) is in Basin Group 5. The TMDL proposed for Stevenson Creek is based on information provided in the Stevenson Creek Watershed Management Plan (Clearwater, 2001).

FDEP established five water management districts (WMD) responsible for managing ground and surface water supplies in the counties encompassing the districts. The Stevenson Creek watershed resides in the Southwest Florida Water Management District (SWFWMD). For the purpose of planning and management, the WMDs divided the district into planning units defined as either an individual primary tributary basin or a group of adjacent primary tributary basins with similar characteristics. These planning units contain smaller, hydrological based units called drainage basins, which are further divided by FDEP into "water segments". A water segment usually contains only one unique waterbody type (stream, lake, canal, etc.) and is about 5 square miles. Unique numbers or waterbody identification (WBIDs) numbers are assigned to each water segment.

2 Problem Definition

Florida's final 1998 Section 303(d) list identified Stevenson Creek (WBID 1567) as not supporting water quality standards (WQS) due to low Dissolved Oxygen (DO) and excessive nutrients. WBID 1567 is the estuary portion of Stevenson Creek, and water quality data collected in the WBID are compared to Class III marine WQS. The TMDLs in this document are being established pursuant to USEPA commitments in the 1998 Consent Decree in the Florida TMDL lawsuit (Florida Wildlife Federation, et al. v. Carol Browner, et al., Civil Action No. 4: 98CV356-WS, 1998).

After assessing all readily available water quality data, USEPA is responsible for developing TMDLs to address low DO and nutrients in Stevenson Creek. The designated use of Class III marine water is recreation, propagation and maintenance of a healthy, well-balanced population of fish and wildlife. The upper portion of the Stevenson Creek watershed (WBID 1567B) is the freshwater portion, and Spring Branch (WBID 1567C), a major tributary to the Stevenson Creek estuary, are not included on the 1998 303(d) list. Data collected in these WBIDs are considered in the TMDL analysis to determine the impact water quality from these areas have on the estuary.

Water quality issues in Stevenson Creek have historically been attributed to urban storm water runoff and past discharges from the Marshall Street Wastewater Treatment Plant (WWTP). Low DO was likely caused by excessive nutrient loads discharged from the WWTP as the plant has a past history of Total Kjeldahl Nitrogen (TKN) violations. In the mid 1990’s the WWTP instituted advanced wastewater treatment (AWWTP) technology and the facility is currently not in violation of any National Pollutant Discharge Elimination System (NPDES) permit requirements. It is now believed that the poor water quality in Stevenson Creek is caused by the accumulated muck that acts as a source of trace metals and organic contamination when mixed (USACOE, 2003). Evaluation of sediment quality in the Stevenson creek estuary showed presence of anthropogenic chemicals, clearly from nonpoint runoff from the upstream watersheds. A heavy concentration of sediments within the estuary is contributing to fish and wildlife habitat loss, water quality decline, reduced tidal circulation, and sediment loading within the estuary. Sediment-bound pollutants are interacting with the water column through cycles of deposition, re-suspension, and re-deposition.

2.1 Previous Studies

The City of Clearwater adopted a watershed management plan (WMP) for Stevenson Creek in 2001 (Clearwater, 2001). The WMP identified areas with flooding and water quality issues, and proposed 28 projects to improve these issues. These projects were then prioritized using factors such as feasibility and cost benefit. The estimated cost (in 2001 dollars) of implementing the projects identified in the WMP was $28 million. An estimate of existing annual nutrient loads, loads removed by the management activities, and the net load remaining in the stream were included in the WMP. The City of Clearwater is currently in the process of implementing four Best Management Practices (BMPs). A summary and status of these projects is provided in Table 1. The City of Clearwater maintains current status information on these projects on the City’s website.

The Glen Oaks project is a 31.54 acre site owned by the City of Clearwater located in the headwaters of Stevenson Creek (WBID 1567B). The project was completed in 2006 and consists of five stormwater management areas totaling about 21 acres and 4.3 acres of created and restored wetlands. The five management areas consists of two in-stream detention facilities, two wet detention areas, and 1 dry detention area. The stormwater treatment areas provide flood protection for 33 structures (78 dwelling units) from the 100-year storm event and water quality treatment for 1,193 acres of a highly urbanized area. The treatment systems are estimated to provide annual pollutant reductions of 27,700 lbs TSS, 735 lbs TN, and 328 lbs TP.

Table 1. Implementation Activities in the Stevenson Creek Watershed

Project	Description	Status
1. Palmetto Street Sediment Trap	Move and expand a pond so it can better trap silt flowing downstream	Complete
2. Glen Oaks Stormwater Management Project	Construction of 2 stormwater treatment areas for 1,193 tributary drainage area within middle Stevenson Creek Basin.	Construction complete as of Nov. 30, 2006.
3. Stevenson Creek Estuary Restoration	Dredge 100,000 cubic yards of sediment and organic muck from estuary, remove nuisance vegetation and replant with native vegetation.	Construction complete as of June 2007.
4. Spring Branch Conveyance Enhancement / Flood Detention Basin	Widen about 700 ft of the Spring Branch channel of Stevenson Creek and construct a new wetland area (dependent on purchase of a church and school property.	Land acquisition complete but project stalled in 2002 due to lack of funding.

In 2003, the US Army Corps of Engineers (USACOE) completed an Environmental Assessment of the Stevenson Creek estuary for the purpose of restoring the existing system to a less degraded state (USACOE, 2003). The alternatives analyzed concentrated on removing accumulated sediments and muck, restoring inter-tidal and sub-tidal benthic substrate, removing exotic vegetation and the planting of native vegetation. Alternatives were also developed to restore hydrologic processes in the creek that were disrupted by urban development. Restoration of these processes should prevent re-accumulation of sediments.

3 Watershed Description

3.1 Hydrology

Stevenson Creek is a tidal creek in Clearwater, Florida. It is the largest and most urbanized watersheds in the City of Clearwater, draining an area of about 6,300 acres in western Pinellas County. About 65 percent of the watershed is within the city limits of Clearwater, 20 percent within the City of Dunedin, 14 percent within unincorporated Pinellas County, and 1 percent in the City of Largo. The entire watershed is within the jurisdiction of the Pinellas County Municipal Separate Storm Sewer System (MS4) permit. Most of the upstream areas of the watershed were developed before 1980 with minimal stormwater treatment, and is served by an advanced (tertiary) WWTP on the creek near the estuary (see Figure 1).

Stevenson Creek originates in the City of Clearwater and flows in a northwest direction for about three miles and eventually discharges into the Intracoastal Waterway and Clearwater Harbor. Clearwater Harbor is a receiving point for creek waters and immediately north it is connected to St. Joseph Sound. Clearwater Harbor has been designated as an Outstanding Florida Water, and is part of the Pinellas County aquatic Preserve.

Stevenson Creek receives most of its fresh water from the middle and upper reaches of the creek (i.e., WBID 1567B). Spring Branch (WBID 1567C) is the largest tributary to WBID 1567 and it flows from the City of Dunedin in a southwestern direction entering the creek upstream of Clearwater Harbor (see Figure 1). Other major tributaries to Stevenson Creek include two highly altered streams draining the eastern portion of the watershed. One of these streams drains into Stevenson Creek near Palmetto Street and the other empties into the creek near Jeffords Street. Another major tributary is a remnant stream that drains Lake Belleview, and enters Stevenson Creek near the Glenn Oaks Golf Course.

Numerous small, natural water storage areas are located throughout the basin as well as several lakes. These storage areas and lakes provide treatment for stormwater runoff. Lake Bellevue is about 25 acres in size and is the largest lake in the watershed. The two other largest lakes in the watershed are Crest Lake and Lake Hobart, and these are about half the size of Lake Bellevue.

3.2 Land Use

The Stevenson Creek watershed has experienced intense urban development over the last 50 years. Private property on both banks of the creek in the estuarine portion (WBID 1567) is characterized by medium density residential development. Upstream of this area, increasing levels of urbanization have occurred to the point where about 95 percent of the watershed is built-out. With the exception of golf courses and city parks, the watershed has little to offer in ways of natural systems. Wetlands are predominately small isolated stormwater retention ponds or natural lakes that have been altered such that their origin can only be determined from historical photographs. The waterways are predominately channelized with little riparian habitat. Land use types by basin in the Stevenson Creek watershed are shown in Table 2. Land uses classified as recreational, open land, agriculture, forest, water or wetlands account for about 14 percent of the watershed and are considered non-point sources of pollutants for the purposes of calculating the load allocation in this TMDL. Runoff from all other land uses (86 percent) is assumed captured by the stormwater conveyance system and is covered under the MS4.

Table 2. Land Use in acres (Clearwater, 2001)

Land Use	Hammond Branch	Jeffords Street	Lake Belleview	Lower Spring	Lower Stevenson	Middle Stevenson	Upper Spring	Upper Stevenson	Total
Residential	649	529	340	338	516	287	1226	491	4376
Commercial	34	31	178	11	56	145	115	41	610
Industrial	5	4	13	0	20	0	0	0	42
Institutional	21	14	16	23	31	11	53	15	182
Recreational	96	40	24	0	116	45	18	0	339
Open Land	41	2	13	37	11	11	105	14	234
Agriculture	10	0	0	0	0	0	5	0	15
Upland Forest	2	0	5	36	0	0	7	0	50
Water	27	22	37	8	40	7	56	7	205
Wetlands	1	1	7	7	5	2	40	0	63
Trans, Utilities, Communication	27	8	22	5	27	27	47	7	170
Total per basin	914	651	655	465	821	535	1673	575	6286

3.3 Environmental Justice / Brownfield Initiatives

The City of Clearwater has actively sought and received a designation for the estuary portion of Stevenson Creek as a Brownfield area. A Brownfield is a site, or portion thereof, that has actual or perceived contamination and an active potential for redevelopment or reuse. EPA Brownfield Economic Redevelopment Initiative is designed to empower states, communities, and other stakeholders in economic redevelopment to work together in a timely manner to prevent, assess, safely clean up, and sustainable reuse Brownfield’s. As part of the Clearwater Brownfield’s Area (CBA), which covers 1,842 acres, the Brownfield’s Cleanup Revolving Loan Fund will target cleanup and revitalization of North and South Greenwood communities and portions of the downtown area hit hardest by economic change. In this area, approximately 26 percent of the residents live below the poverty level and almost 10 percent are unemployed. Funds have been committed to cleaning up the 200 potentially contaminated sites in the CBA (USACOE, 2003).

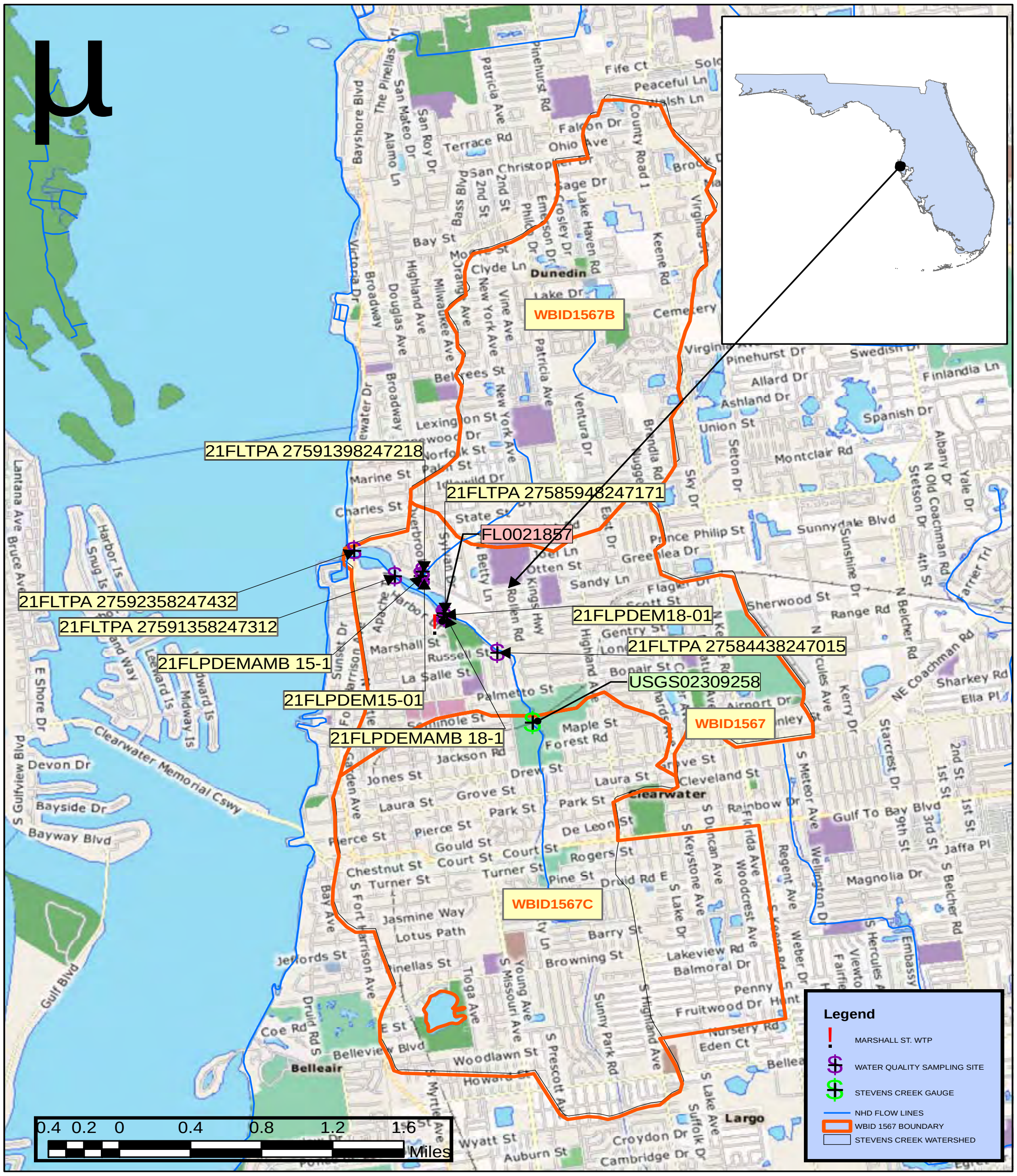

Figure 1. Stevenson Creek Location Map

4 Water Quality Standards and TMDL Targets

Stevenson Creek (WBID 1567) is a Class III marine water with a designated use of Recreation, Propagation and Maintenance of a Healthy, Well-Balanced Population of Fish and Wildlife. Designated use classifications are described in the Florida Administrative Code (F.A.C.), Section 62-302.400(1), and water quality criteria for protection of all classes of waters are established in F.A.C. 62-302.530. Individual criteria should be considered in conjunction with the other provisions in water quality standards that apply to all waters, including Section 62-302.500 F.A.C. [Surface Waters: Minimum Criteria, General Criteria], unless alternative criteria are specified in F.A.C. Section 62-302.530.

4.1 Dissolved Oxygen (Class III Marine):

The water quality criteria for dissolved oxygen in Class III Marine waters states that DO “Shall not average less than 5.0 mg/l in a 24-hour period and shall never be less than 4.0. Normal daily and seasonal fluctuations above these levels shall be maintained.”

The target DO concentration is 4 mg/l, as it was not possible to address the daily average concentrations with the available data. Since DO is not a pollutant, the TMDL allocates limitations for pollutants that cause low DO. The causative pollutants targeted for these TMDLs are BOD, TN and TP. Reductions in nutrients and BOD loadings, along with the removal of organically-enriched muck sediments, are expected to result in improvements in DO within Stevenson Creek.

4.2 Nutrients

The water quality criteria for nutrients is a narrative standard stating that discharge of nutrients shall continue to be limited as needed to prevent violations of other standards contained in this chapter. In no case shall nutrient concentrations of a body of water be altered so as to cause an imbalance in natural populations of aquatic flora and fauna.

The TMDL for the Stevenson Creek estuary is based on achieving water quality observed in similar non-impaired marine waters. FDEP provided EPA a list of marine waters that sustain a healthy balance of flora and fauna for use as candidate WBIDs. A list of these waters and median concentrations of TN, TP, BOD, and Chla measured in each waterbody is provided in Table 3. Chla was selected as the target to achieve the nutrient criteria as this variable is an indicator of the instream response to nutrient (TN and TP) loadings. Chla measurements collected in Clearwater Harbor WBIDs were used to determine the Chla endpoint, as Stevenson Creek discharges directly into the Harbor. The Chla target for the Stevenson Creek

TMDL is 8 µg/l, and this is within the range reported in Table 3. Stevenson Creek should support a healthy estuary once these concentrations are achieved.

Table 3. Candidate WBIDs for Determining Nutrient Targets (source: FDEP, 2007)

Waterbody	TP (mg/)	TN (mg/l)	BOD (mg/l)	Chla (µg/l)
CLEARWATER HARBOR SOUTH - WBID 1528	0.04	0.51	2	7.71
THE NARROWS - WBID 1528A	0.06	0.58	2	8.3
DIRECT RUNOFF TO INTERCOASTAL WATERWAY - WBID 1528B	0.09	N/A	1	7.8
CLEARWATER HARBOR NORTH - WBID 1528C	0.04	0.52	2	6.26
BOCA CIEGA BAY CENTRAL - WBID 1694A	0.05	0.44	2	
BOCA CIEGA BAY NORTH - WBID 1694B	0.04	0.48	2	
BOCA CIEGA BAY - WBID 1694C	0.06	0.55	2	
ST. JOSEPH SOUND - WBID 8045D	0.02	0.51	2	
Anclote River - WBID 1440	0.07	0.66	1	4.6
Average Value:	**0.05**	**0.53**	**1.78**	**6.5**

4.3 Biochemical Oxygen Demand (BOD)

The water quality criterion for BOD is a narrative expressed in terms of achieving the DO standard, stating that BOD shall not be increased to exceed values which would cause dissolved oxygen to be depressed below the limit established for each Class and, in no case, shall it be great enough to produce nuisance conditions.

5 Water Quality Assessment

Data collected in WBID 1567 between 1994 and 2004 and distributed in IWR Run 28, was used to assess water quality in Stevenson Creek estuary. Data collected in WBID 1567 tends to cluster in four general areas: upstream of the AWWTP, downstream of the AWWTP but upstream of Spring Branch, Spring Branch, and downstream near the harbor. More recent data (2003-2006) have been collected in the Spring Branch (1567C) and Upper Stevenson Creek (1567B) watersheds, but only in 2004 was data collected in all three WBIDs. Water quality is displayed graphically for the period of record in all three WBIDs to identify trends, if any, in the data. Often, high pollutant loads in the estuary WBIDs are associated with high loads from the upstream contributing area. The data assessment for WBID 1567 also considers precipitation collected at the National Oceanic and Atmospheric Administration (NOAA) weather station near Tarpon Springs, FL, and uses these data to correlate exceedances of WQS with weather events (i.e., wet weather and drought conditions).

Two regression analyses were to determine the correlation, if any, between DO, nutrients (TN and TP), solids, and oxygen demanding substances: 1) using the data collected at all stations located on Stevenson Creek; and 2) with the data collected on Spring Branch only.

5.1 Water Quality Data and Sampling Stations:

A list of monitoring stations in WBID 1567 is provided in Table 4. Data collected at these monitoring stations during the Group 5 listing cycle (i.e. January 1999 - December 2004) as well as current data collected in the upstream watersheds are considered in the data assessment and TMDL analysis. The original data are included in the Administrative Record for this report, and are also available upon request. Water quality data are collected at nine stations in WBID 1567, but these stations are clustered in four general areas as described above (see Figure 1**).**

Data collected by Pinellas County Department of Environmental Management (PCDEM) is identified in Table 4 with the ID “21FLPDEM”, with the suffix “AMB” meaning ambient, or long term station. Data with the ID “21FLTPA” are collected by FDEP Southwest Florida district office to support the TMDL program and point source monitoring. The geographic location of the stations is shown in Figure 1. All but one of the nine stations are downstream of the Marshall Street WWTP. Table 5 provides summary statistics for water quality data collected at all stations in WBID 1567 for the period of record in IRW Run 28.

Table 4. Water Quality Stations in Stevenson Creek Estuary (WBID 1567)

Org ID	Station ID	Period of Record	Number of Sampling Events	Station Name / Location
21FLTPA	27584438247015	3/04 – 12/04	6	TP285-Stevenson Creek (above AWWTP)
21FLPDEM	15-01	1/1994 – 11/1998	124	SPRING BRNCH STEVENSON'S CR AT OVERBROOK ST
21FLPDEMAMB	15-1	1/1999 – 11/2002	106	Spring Branch Creek (near Sta. 15-01)
21FLTPA	27591398247218	3/04 – 12/04	6	TP281-Stevenson Creek (near Sta. 15-01)
21FLPDEM	18-01	1/1994 – 11/1998	101	STEVENSON'S CR SE SIDE DOUGLAS AVE BRDG (between AWWTP and Spring Branch)
21FLPDEMAMB	18-1	1/1999 – 11/2002	82	Stevenson's Creek (near Sta. 18-01)
21FLTPA	27585948247171	3/04 – 11/04	5	TP282-Stevenson Creek (near Sta. 18-01)
21FLTPA	27591358247312	3/04 – 12/04	5	TP284-Stevenson Creek (below confluence with Spring Branch)
21FLTPA	27592358247432	3/04 – 11/04	5	TP283-Stevenson Creek (near harbor)

Table 5. Water Quality Data for WBID 1567, Stevenson Creek Estuary

Parameter	Obs.	Min	Max	Mean	Median
BOD, carbonaceous 5-day (mg/l)	212	0.66	14	3.16	2
Chlorophyll A, corrected (mg/l)	232	1	492	31.45	13.25
Dissolved Oxygen (mg/l)	435	0.08	20.03	3.49	3.22
Conductance (µmhos/cm)	439	0.171	52100	15724	3650

Parameter	Obs.	Min	Max	Mean	Median
Water Temperature (Celsius)	438	12.44	32.43	25.09	26.005
Nitrogen Kjeldahl as N (mg/l)	241	0.55	5.2	1.160	0.97
Nitrogen Total as N (mg/l)	237	0.61	5.07	1.40	1.24
Nitrogen Ammonia as N (mg/l)	179	0.01	0.7202	0.10	0.09
Nitrate Nitrite (mg/l)	237	0.01	1.39	0.27	0.21
Total Organic Carbon (mg/l)	24	2.2	16	7.99	8.3
Phosphorus Total as P (mg/l)	241	0.035	1.400	0.244	0.21
Diss. Orthophosphate as P (mg/l)	160	0.02	0.4	0.111	0.1
Total Suspended Solids	112	1	210	13.93	8
Turbidity (NTU)	241	1	24	4.507	3.7

NOTES: Obs= number of observations; Max= maximum value; Min= mininum value.

5.2 Biology

In 1998, FDEP conducted a BioRecon Assessment of Stevenson Creek near monitoring station 18-1 (FDEP, 1998). BioRecon assessments area a rapid, cost-effective screening method for identifying biological impairment and are based on three measurements of the aquatic invertebrates present in the stream: the total number of different species (Total Taxa); the number of “good water quality” indicator species (Florida Index); and the total number of Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies) species present. A stream scoring above the threshold values for all three of these measurements is considered healthy. If two of the values are reached, the stream’s health may be considered ecologically suspect, and if one or none of the thresholds are reached, an impaired condition is concluded. The site where the measurements were collected failed all three measurements of the BioRecon. This indicates the stream did not support a healthy macroinvertebrate community, which may result in an inadequate food web for the support of vertebrate animals, such as fish and birds.

The BioRecon report concluded that habitat destruction for residential development may be responsible for the poor ecological health. Nutrients and excess coliforms were being introduced into the stream at the time of sampling, most likely due to residential runoff from lawn fertilizer; however, these concentrations alone are not responsible for the degraded macroinvertebrate community. The City of Clearwater and Pinellas County have invested a considerable amount of money in improving those areas of the stream that were not completely sea walled. The projects implemented in the watershed have resulted in improved flow, erosion control, and habitat restoration. Therefore, even though the stream functions as a stormwater conveyance, habitat conditions are improving.

5.3 Dissolved Oxygen

There are several factors that affect the concentration of DO in a waterbody. Oxygen can be introduced by wind, diffusion, photosynthesis, and additions of higher DO water (e.g. from tributaries). DO concentrations are lowered by processes that use up oxygen from the water, such as respiration and decomposition, and by additions of water with lower DO (e.g. swamp or groundwater). Natural DO levels are a function of water temperature, water depth and velocity, and relative contributions of salinity and groundwater. Warm water holds less oxygen than cool water, and slower-flowing, less turbulent water has less diffusion of atmospheric oxygen into it. Since oxygen dissolves more easily into water with low levels of dissolved or suspended solids, freshwater tends to have higher DO concentrations than saltwater. Organic wastes, such as dead plant and animal materials, may also affect DO since organic materials are decomposed by bacteria that use up oxygen from the water as they breathe. The more organic material there is for the bacteria to feed on, the more they will grow and use up oxygen from the water.

The available data indicate that the DO concentrations in the Stevenson Creek watershed are frequently below the Class III Marine Water Quality Criteria (Figure 2). The greatest number of exceedances appears to occur near Station 15-1, Spring Branch segment of Stevenson Creek. DO values measured in WBID 1567 between January 1994 and June 2006 range from 0.08 to 20.03 mg/l, with an average of 3.49 mg/l and a median of 3.22 mg/l. A seasonal pattern may be observed in the data, with DO tending to be higher in the winter months than in summer months. The lowest DO measurements appear to correspond to extended days of little to no rainfall.

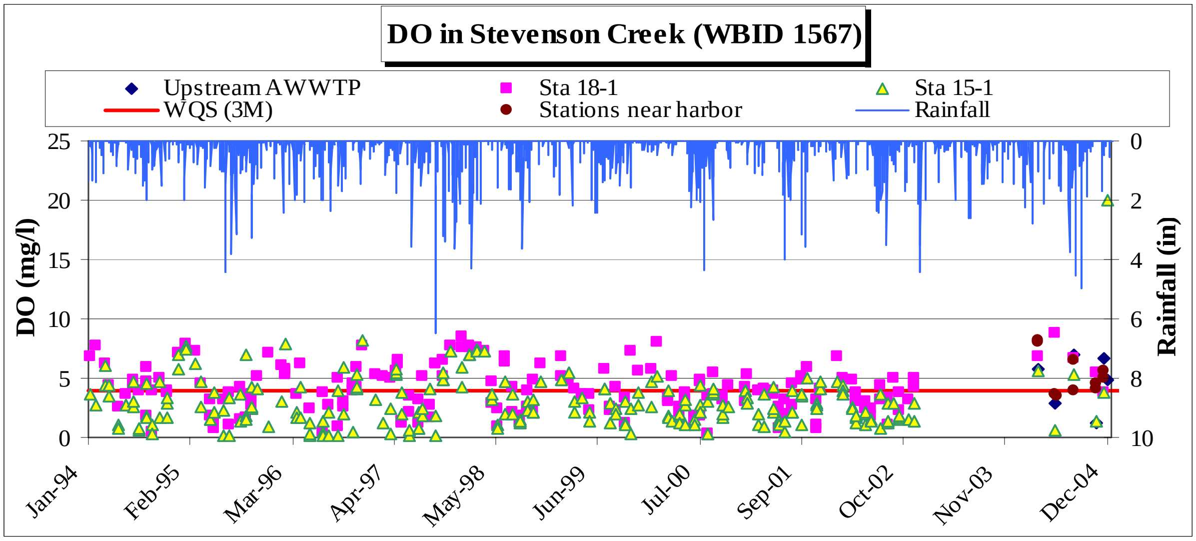

Figure 2. Dissolved Oxygen concentrations in Stevenson Creek (WBID 1567)

5.4 Nutrients

Nutrient concentrations also have an impact on DO levels. Excessive nutrients can lead to overgrowth of algae and aquatic plants, the decomposition of which uses up oxygen from the water. In turn, low oxygen levels near bottom sediments can free additional phosphorus from the sediments. Nitrification of ammonia to nitrite and then nitrate can use up DO from the water. Nutrient concentrations measured in WBID 1567 are displayed graphically in Figure 3. The highest TN concentrations are observed in the Spring Branch station (station 15-1), and it's not surprising that this is the station with the lowest DO measurements (see Figure 4).

FDEP has developed screening level concentrations of nutrients that indicate levels of concern for TN and TP for consideration during assessments. The screening levels for TN and TP in estuaries are 1.0 mg/l and 0.19 mg/l, respectively. These screening values were compared to the median values of TN and TP measured in Stevenson Creek. As can be seen in Figure 3, median nutrient concentrations exceed these screening thresholds.

The state of Florida typically uses Chla as the primary indicator of nutrient enrichment, as it is a good measure of the biomass of phytoplankton, (i.e., microscopic algae that drift in the water column). While there is no water quality standard specifically for Chla, elevated levels of Chla are frequently associated with a violation of the narrative nutrient standard. Figure 5 provides a comparison of Chla and DO measurements collected in WBID 1567. As shown in this figure, elevated levels of Chla are associated with depressed DO levels.

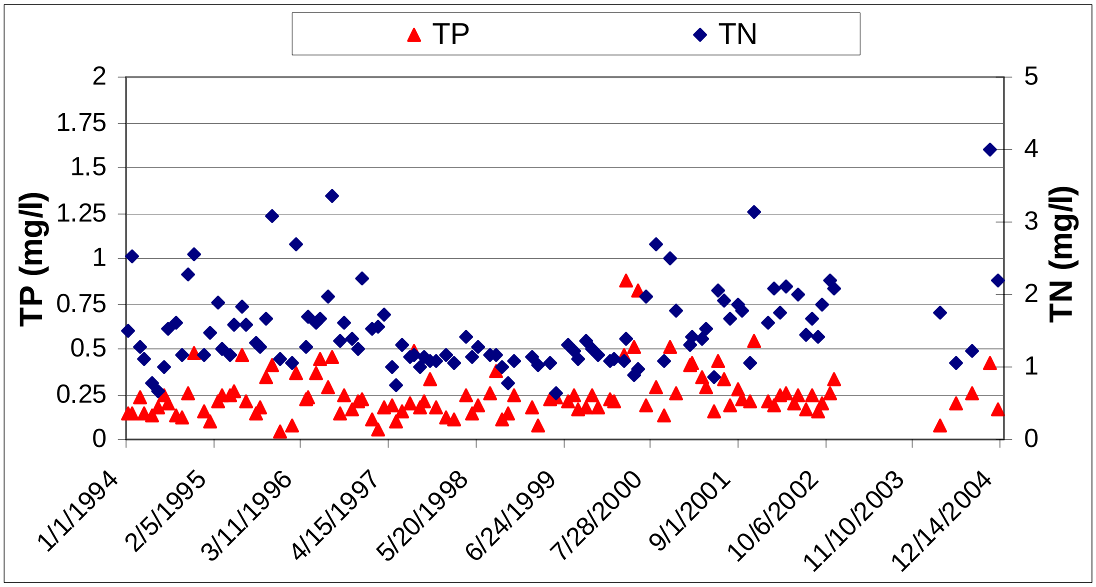

Figure 3. TP Concentrations Measured in Stevenson Creek Estuary

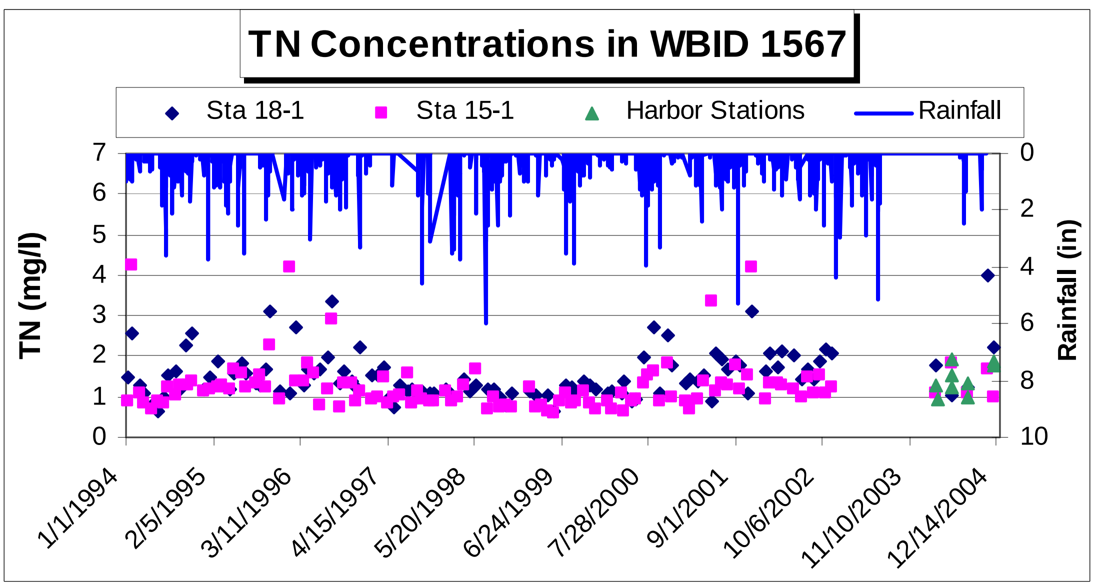

Figure 4. TN Concentrations Measured in Stevenson Creek Estuary

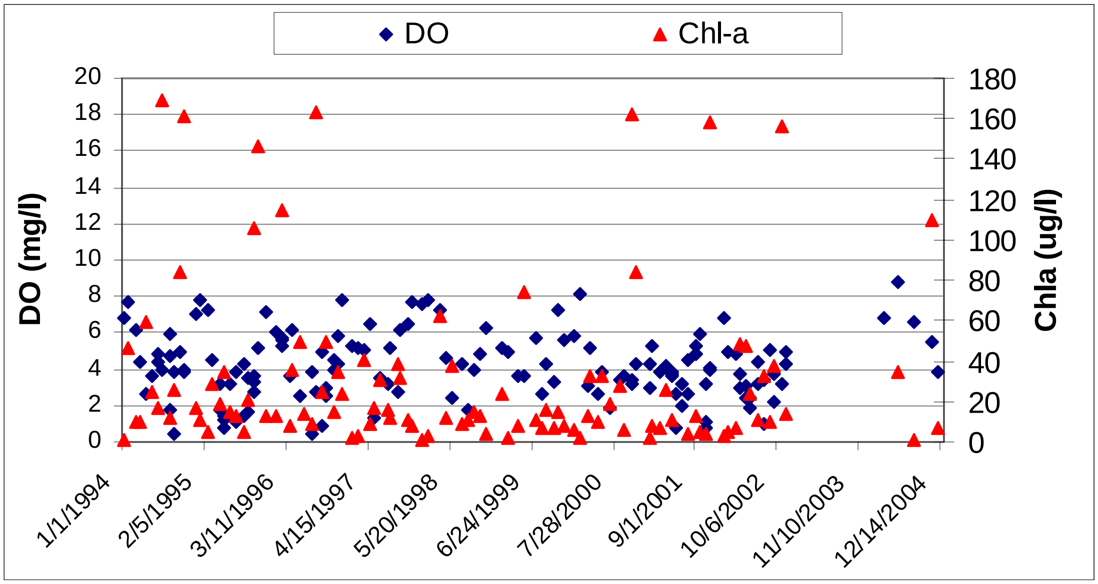

Figure 5. DO and Chla Concentrations Measured in WBID 1567

5.5 Total Suspended Solids (TSS)

TSS refers to materials in the water such as sediment (primarily silt) and decaying plant and animal matter that are too large to pass through a filter. Sources of TSS include bank erosion, overland runoff, algal growth and other fine organics. Suspended solids negatively impact DO and are a source of nutrients in the waterbody. Solids affect dissolved oxygen levels by blocking light from reaching submerged vegetation, reducing photosynthesis. Plants that cannot survive under the reduced light conditions may die, and their decomposition uses up DO. Suspended particles can also negatively impact DO by absorbing heat from sunlight, raising the water temperature. As discussed above, higher temperature water holds less oxygen. The dataset for WBID 1567 consists of 112 TSS samples collected mostly at stations near 18-1 and 15-1. The highest TSS samples are collected in the Spring Branch stations of WBID 1567 (Figure 6). It's not surprising that this station also has elevated nutrient and depressed DO levels. Controlling sediment in the Spring Branch subwatershed and possibly dredging the lower portion of the creek would improve the water quality discharging from the tributary, resulting in a positive impact on water quality in the downstream estuary.

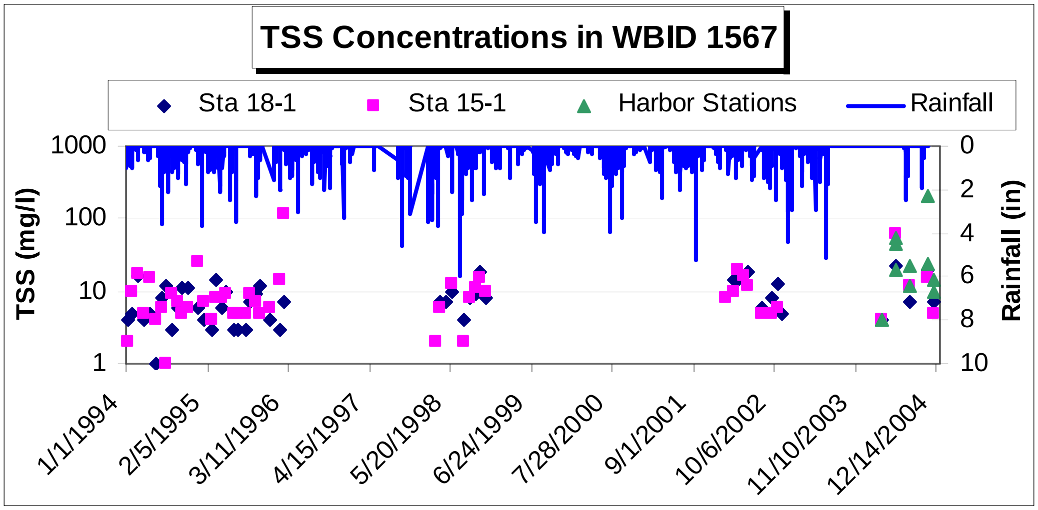

Figure 6. TSS Concentrations in Stevenson Creek Estuary (WBID 1567)

5.6 Biochemical Oxygen Demand (BOD)

BOD is a measure of the amount of oxygen consumed by organisms while breaking down organic material. The BOD dataset for WBID 1567 consists of 212 samples. BOD values range from 0.66 mg/l (below the Method Detection Limit) to 14 mg/l, with an average of 3.16 mg/l, and a median of 2 mg/l. The data are displayed graphically in Figure 7. Some of the values are high enough to contribute to suppression of DO levels.

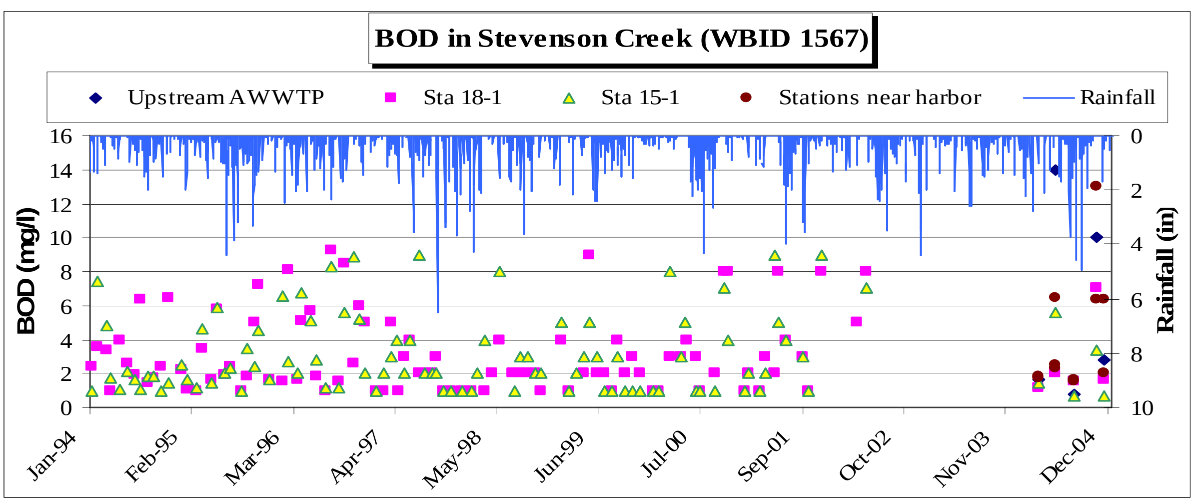

Figure 7. Biochemical Oxygen Demand in Stevenson Creek (WBID 1567)

5.7 Water Quality Correlations

A comparison of DO and Chla data collected at all locations in the Stevenson Creek watershed (i.e., WBIDs 1567, 1567B, and 1567C) for the time period where data values coincide is shown in Figure 8 and Figure 9, respectively. In these figures, only data collected below the confluence of Spring Branch is used to represent WBID 1567. Although the time period where the data coincides is limited, data trends indicate that DO and Chla values in Stevenson Creek estuary (1567) mimic those measured in the upstream WBIDs. Therefore, water quality improvements in the upstream watershed should have a positive impact on water quality in the estuary. Rainfall data superimposed on the data indicates low DO and elevated Chla values often occur after extended periods of little to no rain. The upstream WBIDs are classified as Class III Freshwater, but are compared to marine criteria for purposes of meeting the downstream designated use.

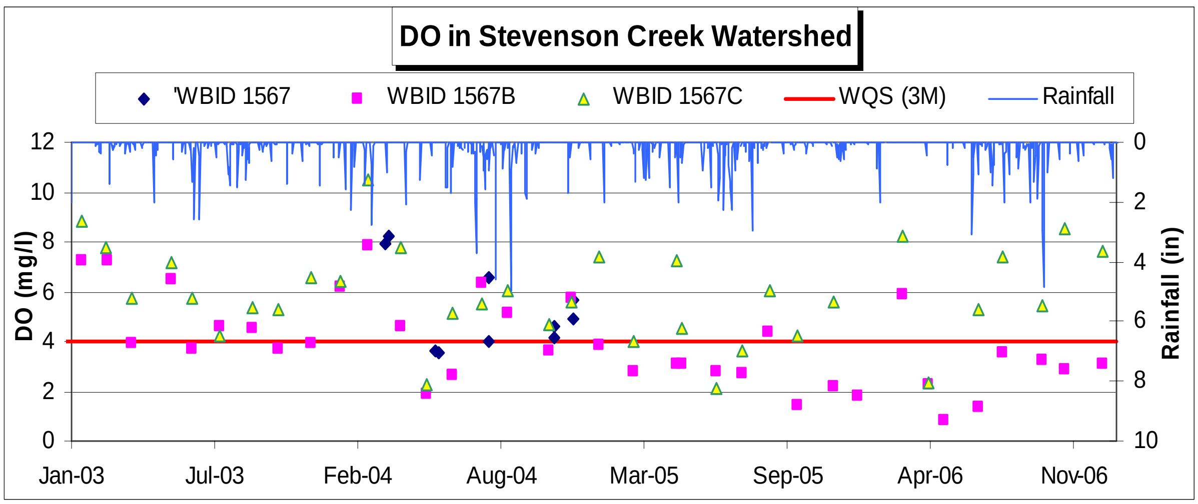

Figure 8. DO Measurements Collected in all WBIDs in Stevenson Creek Watershed

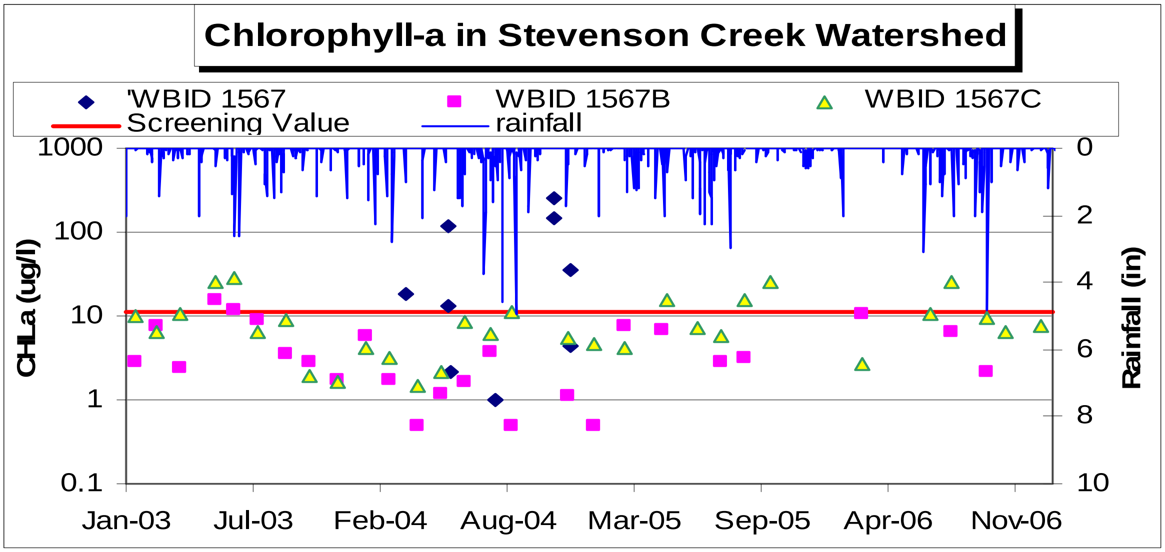

Figure 9. Chla Measurements Collected in all WBIDs in Stevenson Creek Watershed

6 Source and Load Assessment

An important part of the TMDL analysis is the identification of source categories, source subcategories, or individual sources of pollutants in the watershed. Sources are broadly classified as either point or nonpoint sources. A point source is defined as a discernable, confined, and discrete conveyance from which pollutants are or may be discharged to surface waters. Point source discharges of industrial wastewater and treated sanitary wastewater must be authorized by National Pollutant Discharge Elimination System (NPDES) permits. NPDES permitted facilities, including certain urban stormwater discharges such as municipal separate stormwater systems (MS4 areas), certain industrial facilities, and construction sites over one acre, are stormwater driven sources considered "point sources" in this report.

Nonpoint sources of pollution are diffuse sources that cannot be identified as entering a waterbody through a discrete conveyance at a single location. For nutrients, these sources include runoff from agricultural fields, golf courses, lawns and open areas (e.g., parks), malfunctioning septic tanks, and residential developments outside of MS4 areas, if any. Nonpoint sources generally, but not always, involve accumulation of nutrients that bind to sediments on the landscape, and wash-off during storm events.

6.1 Point Sources

6.1.1 Permitted Point Sources

Point source facilities are permitted through the NPDES Program. The Marshall Street AWWTP (FL0021857) is a 10 MGD plant discharging to Stevenson Creek (see Figure 1). A portion of the treated effluent is routed through the Reuse System and used for irrigation on public-access areas under the City of Clearwater Master Reuse System (FL186261). Between 1999 and 2006, between 1 and 2 MGD are discharged through the reuse system. Water quality of effluent discharged through the reuse system is reported for biological and physical parameters (i.e., pH, flow, TSS, turbidity, chlorine fecal coliform, and CBOD) but not for nutrients. The reuse system is regulated by a state-issued permit. The system is not given a wasteload allocation in this TMDL, as it is not permitted through the NPDES process. The reuse system is a no discharge permit, and if properly maintained should not cause or contribute to water quality problems in Stevenson Creek.

Discharge Monitoring Reports (DMRs) from the Marshall Street AWWTP were reviewed for permit compliance history and summarized in Table 6 (FDEP, 2005). In general, facility effluent has been within permit limits, but violations were reported between 2000 and 2002 for several parameters. While nutrient and BOD concentrations in plant effluent are within appropriate standards, the average existing discharge from the facility of 4.41 MGD results in masses that make up a significant percentage of total loads to the estuary (Clearwater, 2001). Bioassay samples were collected in October 2004 as part of a third year inspection of the facility. Effluent Algal Growth Potential (AGP) exceeded the “problem” threshold for fresh receiving waters, suggesting nutrient enrichment may be an issue for marine receiving waters (FDEP, 2005).

DMR data collected between the years 2001 and 2006 were used to calculate pollutant loads discharged into Stevenson Creek. Pollutant loads are provided in Table 7 and were calculated using monthly concentrations and flows reported in the DMRs. The average annual load was equal to the sum of the monthly loads. A summary of average annual TN, TP, and CBOD concentrations for the years 2001 through 2006 are provided in Table 8.

Table 6. Permit Limits for Marshall Street AWWTP

Parameter	Permit Limit	No. of Violations (2000 - 2006)
DO (mg/l)	$\geq$ 4 (single sample)	1 (6/2001)
CBOD (mg/l)	10.0 (single sample max)	1 (7/2000)

Parameter	Permit Limit	No. of Violations (2000 - 2006)
TP (mg/l)	2.0 (single sample max); 1.0 (annual average)	2 (7/2000, 2/02)
TN (mg/l)	6.0 (single sample max); 3.0 (annual average)	3 (7/00, 2/02, 3/02)
TSS (mg/l)	10.0 (single sample max)	5 (3/00, 4/00. 5/00, 6/00, 7/00)

Table 7. Average Pollutant Loads Discharging from Marshall Street AWWTP

Year	Average Flow (MGD)	CBOD (lb/yr)	TN (lb/yr)	TP (lb/yr)
2001	4.83	31,605	24,941	7897
2002	4.57	38,670	36,007	3793
2003	5.38	26,760	33,657	2436
2004	4.59	20,380	34,214	2262
2005	3.41	17,762	24,237	1661
2006	2.83	17,752	19,208	851
Average	4.41	25,488	28,710	3150

Table 8. Average Annual Nutrient and CBOD Concentrations in AWWTP Effluent

Year	TP (mg/l)	TN (mg/l)	CBOD (mg/l)
2001	0.59	1.89	2.20
2002	0.28	2.62	2.82
2003	0.18	2.29	1.82

Year	TP (mg/l)	TN (mg/l)	CBOD (mg/l)
2004	0.17	2.49	1.63
2005	0.16	2.37	1.73
2006	0.10	2.26	2.09
Average	0.31	2.23	2.03

6.1.2 Municipal Separate Storm System Permits

Municipal Separate Stormwater Systems (MS4s) are point sources also regulated by the NPDES program. According to 40 CFR 122.26(b)(8), a municipal separate storm sewer (MS4) is “a conveyance or system of conveyances (including roads with drainage systems, municipal streets, catch basins, curbs, gutters, ditches, man-made channels, or storm drains):

> (i) Owned or operated by a State, city, town, borough, county, parish, district, association, or other public body (created by or pursuant to State law)...including special districts under State law such as a sewer district, flood control district or drainage district, or similar entity, or an Indian tribe or an authorized Indian tribal organization, or a designated and approved management agency under section 208 of the Clean Water Act that discharges into waters of the United States.
>
> (ii) Designed or used for collecting or conveying storm water;
>
> (iii) Which is not a combined sewer; and
>
> (iv) Which is not part of a Publicly Owned Treatment Works.”

MS4s may discharge nutrients, sediment, and other pollutants to waterbodies in response to storm events. In 1990, USEPA developed rules establishing Phase I of the NPDES stormwater program, designed to prevent harmful pollutants from being washed by stormwater runoff into MS4s (or from being dumped directly into the MS4) and then discharged from the MS4 into local waterbodies. Phase I of the program required operators of “medium” and “large” MS4s (those generally serving populations of 100,000 or greater) to implement a stormwater management program as a means to control polluted discharges from MS4s. Approved stormwater management programs for medium and large MS4s are required to address a variety of water quality related issues including roadway runoff management, municipal owned operations, hazardous waste treatment, etc. The entire Stevenson Creek watershed is within the jurisdiction of the Pinellas County Phase I permit.

6.2 Nonpoint Sources

Nonpoint source pollution generally involves a buildup of pollutants on the land surface that wash off during rain events and as such, represent contributions from diffuse sources, rather than from a defined outlet. Nonpoint sources in the Stevenson Creek watershed include landscape runoff from golf courses, recreational areas and houses built in the floodplain, atmospheric deposition, improperly functioning septic tank systems, and animal waste.

Pinellas County keeps records of applications for septic tank repairs. The locations of septic systems in the Pinellas County database were geo-referenced in the WMP and are included in this report as Figure 10. The highest concentrations of repairs are located in the Spring Branch watershed. It is not surprising that some of the highest nutrient loads originate in this area (Clearwater, 2001).

Animal waste can also be a source of nutrients. Bacterial source tracking completed as part of the Stevenson Creek WMP suggests the sources most frequently contributing to excessive fecal coliform counts was wild animals followed by humans and dog isolates (Clearwater, 2001). During the course of this study, migratory birds and water fowl were the most frequently observed wild vertebrates.

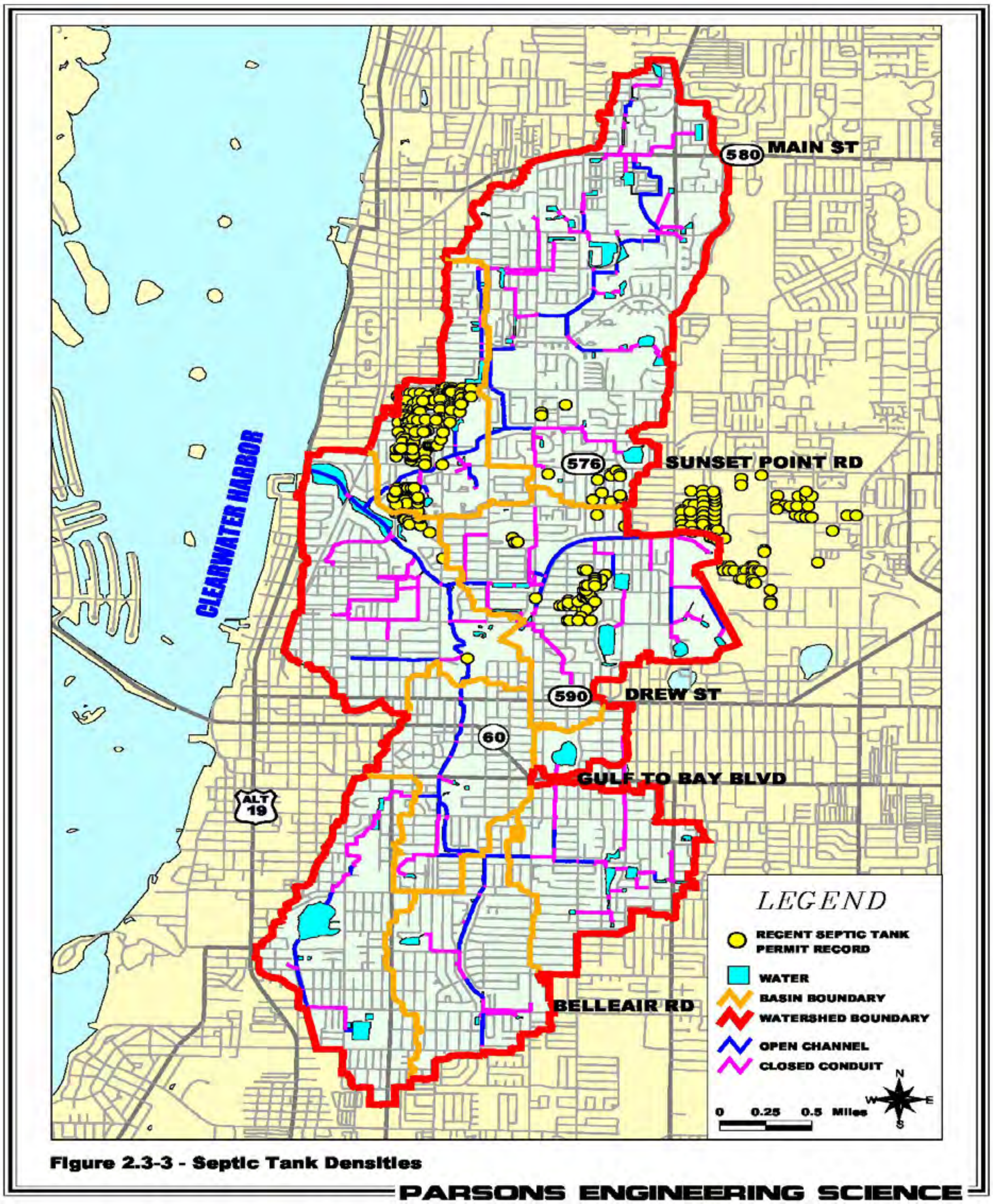

Figure 10. Septic tank permit records (Clearwater, 2001)

7 Analytical Approach

7.1 Existing Conditions

EPA's simple approach to pollutant loading analysis (PLOAD) was used to estimate annual TN, TP, and BOD loads discharged into the estuary from the landscape. The PLOAD analysis calculates runoff based on average annual rainfall for the area (55.6 in/yr) and event mean concentrations (EMCs) for nutrients and BOD associated with landuses in the watershed. In the PLOAD analysis, 90 percent of the storms are assumed to produce runoff. The EMC data used in the PLOAD analysis were derived specifically for the Stevenson Creek watershed as part of the Watershed Management Plan adopted by City of Clearwater. PLOAD calculations are provided in Appendix A. The total existing load discharging into the estuary was calculated as the sum of the PLOAD results and the average annual load discharging from the Marshall Street AWWTP between the years 2001 through 2006. Average annual loads for existing conditions and the percentage of the total load each source contributes are shown in Table 9.

Table 9. Average Annual Loads for Existing Conditions

Source	TN		TP		BOD	
	Load (lb/day)	Percent of total	Load (lb/yr)	Percent of total	Load (lb/yr)	Percent of total
Watershed Runoff (stormwater load)	33,700	54%	886	74%	318,491	93%
AWWTP	28,710	46%	3150	26%	25,500	7%
Total Load	62,410		12,013		343,991	

7.2 TMDL Conditions

A multi-variable regression model was developed to predict Chla and DO concentrations based on the nutrient, BOD, and temperature measurements. Two regression analyses were established with data collected in Stevenson Creek: 1) regression demonstrating the response in Chla to changes in TN and TP concentrations; and 2) regression demonstrating the response in DO concentrations to changes in BOD and temperature. Data collected at the Spring Branch station in WBID 1567 is robust in size for statistical analyses, but the only correlation found was between DO and temperature. Increases in water temperature are associated with low DO concentrations. Developing the correlation using data from the

Stevenson Creek stations only yielded a higher correlation coefficient than using the data from all stations in the WBID; thus yielding greater confidence in the results.

Results of the regression analyses indicates increases in nutrients are associated with higher Chla concentrations, while elevated BOD and temperature are associated with lower DO concentrations. A comparison between predicted and observed Chla and DO concentrations is shown in Figure 11 and Figure 12. The ratio of the explained variation to the total variation is called the coefficient of correlation and is denoted by the variable R^2. This ratio is always non-negative and the value lies between zero and one. A value of zero indicates that there is no explained correlation in the data. The higher the R^2 value the greater the confidence the independent variables (i.e., nutrient or BOD) relate to the dependent variable (Chla or DO). A strong correlation is found between Chla and nutrient concentrations (and a slightly weaker one between DO, BOD and temperature), thus implying confidence that allocating reductions to nutrients and BOD should achieve WQS.

The multi-variable regression models were used to predict reductions in TN and TP required to achieve a Chla concentration of 8µg/l, and the reduction in BOD required to achieve the DO criterion of 4 mg/l. Model results indicate a 75% reduction in TN, 70% reduction in TP, and 80% reduction in BOD achieve the target concentrations. Although, the multivariable regression model between Chla and nutrients (TN and TP) showed a strong correlation, the model is not sensitive to changes in TP as it is when a single variable regression model was develop between Chla and TP. The multi-variable regression was used to develop the TMDL rather than single variable regressions (i.e., Chla and TP, or Chla and TN) because nutrient impairments are often caused by a combination of the TN and TP concentrations.

The total existing pollutant loads discharging into the estuary were reduced by the percentages prescribed in the regression analysis to determine the TMDL allocations for nutrients and BOD. The TMDL was separated into point and nonpoint source components based on the distribution each source contributes for the existing condition scenario (see Table 9). The nonpoint source component was further separated into MS4 and Load Allocation (LA) components based on relative landuse percentage associated with each source in the watershed (i.e., 86 percent of watershed is assumed to discharge to the creek via storm drains (MS4) and 14 percent of the landuses in the watershed is associated with nonpoint sources).

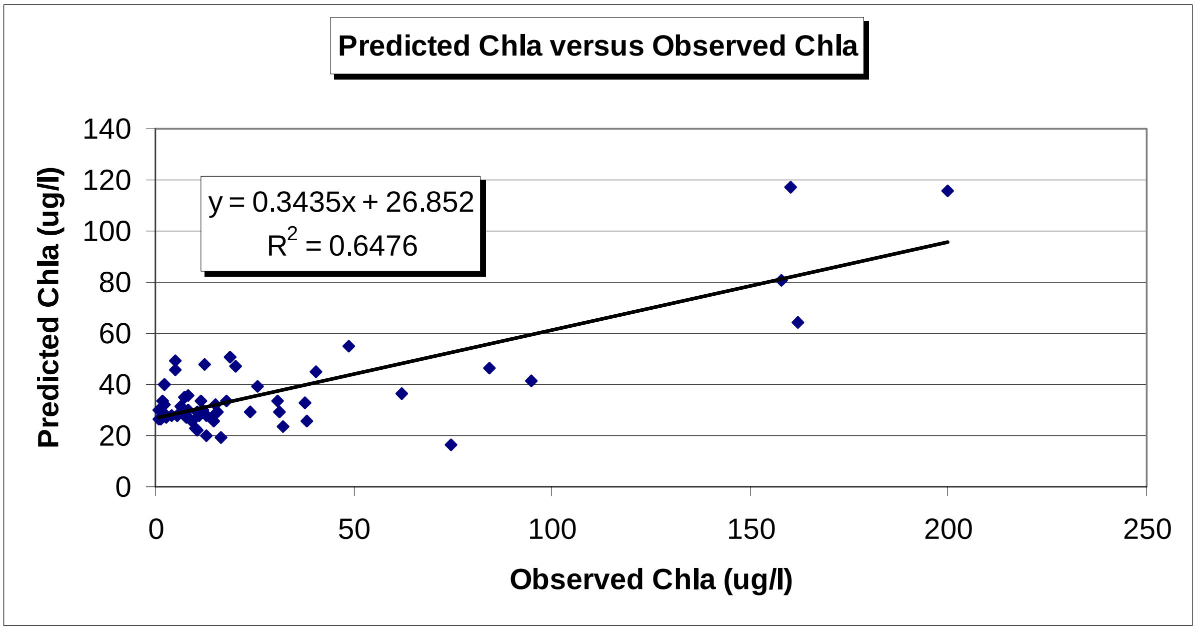

Figure 11. Predicted and Observed Chla Concentrations in Stevenson Creek

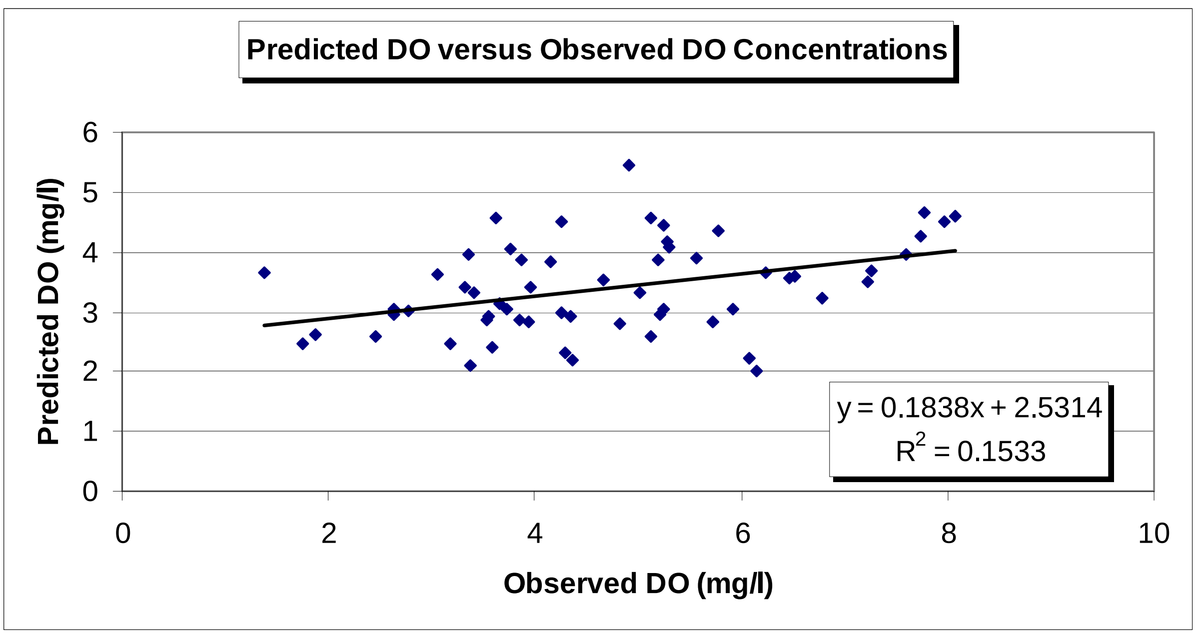

Figure 12. Predicted and Observed DO Concentrations in Stevenson Creek

8 TMDL

A Total Maximum Daily Load (TMDL) for a given pollutant and waterbody is comprised of the sum of individual wasteload allocations (WLAs) for point sources, and load allocations (LAs) for both nonpoint sources and natural background levels. In addition, the TMDL must include a margin of safety (MOS), either implicitly or explicitly, to account for the uncertainty in the relationship between pollutant loads and the quality of the receiving waterbody. Conceptually, this definition is represented by the equation:

$$\text{TMDL} = \sum \text{WLAs} + \sum \text{LAs} + \text{MOS}$$

The TMDL is the total amount of pollutant that can be assimilated by the receiving waterbody and still achieve water quality standards and the waterbody's designated use. In TMDL development, allowable loadings from all pollutant sources that cumulatively amount to no more than the TMDL must be set and thereby provide the basis to establish water quality-based controls. These TMDLs are expressed as annual mass loads, since the approach used to determine the TMDL targets relied on annual loadings. Daily load calculations are provided in Appendix B.

The TMDLs for Stevenson Creek are calculated by reducing the total existing loads by the percent reductions derived from the regression analyses. The TMDL loads should result in a Chla concentration in the estuary equivalent to those observed in unimpaired marine waters in Clearwater Harbor. TMDLs for Stevenson Creek are provided in Table 10. The percent reductions prescribed in the TMDL should allow the waters to achieve natural DO and chlorophyll regimes. BMPs implemented in the watershed since 2004 are not considered in the analyses as data are not available to measure their impact. It is anticipated that the recent completion of the Stevenson Creek estuary restoration project will result in a significant improvement in tidal circulation and reduce nutrient loads embedded in the sediments. Therefore, the percent reductions are considered conservative.

Table 10. TMDL values for TN, TP and BOD

	TN[1] TMDL (lb/yr)	TN[2] Reduction (%)	TP[1] TMDL (lb/yr)	TP[2] Reduction (%)	BOD[1] TMDL (lb/yr)	BOD[2] Reduction (%)
Stevenson Creek	15,602	75%	3,604	70%	68,798	80%

Notes: 1. The TMDL approach yields values on an annual basis. 2. Reduction in total existing loadings. BMPs implemented in the watershed since 2004 may have achieved a significant portion of the prescribed reduction; however, sufficient instream data are not available to confirm this.

8.1 TMDL Components

The TMDLs and their components are summarized in **Error! Reference source not found.**. A discussion of the individual components is provided in the following sections.

Table 11. TMDL Components

Parameter	TMDL (lb/yr)	WLA		LA (lb/yr)	Percent Reduction (%)
		AWWTP (lb/yr)	MS4 (lb/yr)		
TN	15,602	7,177	7,245	1,180	75%
TP	3,604	937	2,294	373	70%
BOD	68,800	4,816	55,026	8,958	80%

Note: Percent reduction of total existing load required to achieve the TMDL allocation.

8.1.1 Waste Load Allocations

Only MS4s and NPDES facilities discharging directly into Stevenson Creek are assigned a WLA. The WLAs are expressed separately for continuous discharge facilities (e.g., AWWTP) and MS4 areas, as the former discharges during all weather conditions whereas the latter discharges in response to storm events.

The Marshall Street AWWTP (FL0021857) is assigned a WLA based on the percentage of the total existing load the facility contributes of each pollutant (see Table 9). Permit limits for BOD are expressed in terms of CBOD. When the permit for the facility is reissued, it will be necessary to convert the BOD allocation into an appropriate CBOD limit.

The TMDL component for stormwater is composed of both point (MS4) and nonpoint sources. Allocations to these sources are proportioned consistent with the percentage each contributes in existing conditions. The WLA assigned to the MS4 is based on the percentage of the stormwater load discharging to Stevenson Creek via storm drains in the watershed. Based on 2004 landuse data, this accounts for about 86 percent of the watershed. Stormwater comprises about 54 percent of the total existing TN load; therefore, 54 percent of the TMDL, or 8,425 lb/yr of TN, enters the creek from stormwater. Of this amount, 86 percent, or 7,245 lb/yr of TN, is discharged through the MS4. Similarly, stormwater contributes 74 and 93 percent of the TP and BOD total loads, respectively. The MS4 portion of these loads is 86 percent, or 2,294 lb/yr TP and 55,026 lb/yr BOD.

Permitted MS4s will be responsible for reducing the loads associated with stormwater outfalls which it owns, manages, or otherwise has responsible control. MS4s are not responsible for reducing other nonpoint source loads within its jurisdiction. Best management practices for the MS4 service should be implemented to meet the prescribed allocations.

8.1.2 Load Allocations

Nonpoint sources exist in the watershed despite the watershed being entirely within the jurisdiction of the Pinellas County MS4. Runoff from nonpoint source land categories accounts for about 14 percent of the total stormwater load (see Table 2); therefore, 14 percent of the stormwater load is assigned to the LA component. In the TMDL scenario, stormwater is allocated a TN load of 8,425 lb/yr, of which 14 percent, or 1180 lb/yr, is allocated to nonpoint sources. Similarly, stormwater is allocated 74 percent of the TP load and 93 percent of the BOD loads. These percentages equate to TP and BOD stormwater allocations of 2667 and 63,984 lb/yr, respectively. The LA component is 14 percent of these loads, or 373 and 8958 lb/yr TP and BOD, respectively.

8.1.3 Margin of Safety

The Margin of Safety (MOS) accounts for uncertainty in the relationship between a pollutant load and the resultant condition of the waterbody. There are two methods for incorporating a MOS into TMDLs (USEPA, 1991):

- Implicitly incorporate the MOS using conservative model assumptions to develop allocations

- Explicitly specify a portion of the total TMDL as the MOS and use the remainder for Allocations

An implicit MOS is provided in the TMDLs as nutrient reductions achieved from BMPs implemented in the watershed were not included in the calculation of existing conditions. In addition, the target Chla concentration is considered conservative as it is below the value the State of Florida uses for assessing impairment in marine waters (i.e., 11 µg/l).

8.2 Critical Conditions and Seasonal Variation

USEPA regulations at 40 CFR 130.7(c)(1) require TMDLs to take into account critical conditions for stream flow, loading, and water quality parameters. The critical condition is the combination of environmental factors creating the "worst case" scenario of water quality conditions in the waterbody. By achieving the water quality standards at critical conditions, it is expected that water quality standards should be achieved during all other times. Seasonal variation must also be considered to ensure that water quality standards will be met during all seasons of the year, and that the TMDLs account for any seasonal change in flow or pollutant discharges, and any applicable water quality criteria or designated uses (such as swimming) that are expressed on a seasonal basis.

The critical condition for nonpoint source loadings is typically an extended dry period followed by a rainfall runoff event. During the dry weather period, nutrients and sediment build up on the land surface, and are washed off by rainfall. The critical condition for continuous point source loading typically occurs during periods of low stream flow when dilution is minimized. Although loading of nonpoint source pollutants contributing to a nutrient impairment may occur during a runoff event, the expression of that nutrient impairment is more likely to occur during warmer months, and at times when the waterbody is poorly flushed.

Since nutrients and sediment can accumulate in waterbodies, it is important to consider their loading over longer time periods. The regression model used to determine load reductions account for loading during both wet and dry conditions. Point source contributions were also incorporated as the total annual loads discharged in those years. The years between 2001 and 2006, on which the WLA calculations are based, also represent conditions above and below 30-year average annual precipitation.

Seasonal variation was incorporated in the TMDL analysis by including data collected during all seasons over multiple years.

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Appendix A- PLOAD Analysis

The PLOAD model can be used to estimate nutrient and BOD nonpoint source loadings to the stream based on existing land use conditions. This approach estimates the effect of anthropogenic sources on runoff loadings of nutrients and oxygen demanding substances in the watershed. The model uses average annual rainfall and event mean concentrations (EMCs) to estimate pollutant loading transported off a particular land use. The model assumes all lands are connected to the stream, resulting in a conservative estimate of average annual loads. An assumed annual average rainfall of 55.6 inches was used for Stevenson Creek (Clearwater, 2001). The default ratio of 0.9 for storms producing runoff was assumed and this implies that 90 percent of the storms produce runoff. Land use data entered into the spreadsheet were based on the Southwest Florida Water Management District (SWFWMD) 2004 land use/cover features categorized according to the Florida Land Use and Cover Classification System (FLUCCS). EMC values derived in Watershed Management Plan were assumed for the various land uses in the Stevenson Creek watershed.

Table 3. EMCs for Storm Events

Land Use	BOD (mg/L)	Total N (mg/L)	Total P (mg/L)
Urban Open	10.7	0.81	0.10
Low Density Residential	11.5	1.14	0.250
Medium Density Residential	14.7	1.48	0.280
High Density Residential	20.5	2.35	1.14
Agriculture	15.4	1.27	0.960
Rangeland	3.8	2.32	0.344
Forest/Rural Open	7.68	1.03	0.180
Open Water	2.73	0.81	0.10
Water/ Wetlands	7.68	1.03	0.18
Barren land/Transition	12.3	1.16	0.430
Communication and Transportation	20.5	1.35	0.32

PLOAD estimates pollutant loadings using the following equation:

$$LP = \Sigma_u (P * PJ * RV_u * C_u * A_u * 2.72 / 12)$$

Where:

LP = Pollutant load, lbs

P = Precipitation, inches/year

PJ = Ratio of storms producing runoff (default = 0.9)

Rvu= Runoff Coefficient for land use type u, inches of runoff/inches of rain

Rvu=0.05 + (0.009 * Iu); Iu = percent imperviousness

Cu = Event Mean Concentration for land use type u, milligrams/liter

Au = Area of land use type u, acres

Appendix B- Daily Load Calculations

PCDEM installed continuous flow monitoring stations in the Upper Stevenson Creek and Spring Branch watersheds to estimate pollutant loadings from the freshwater portions of the watershed. The gages came on-line in 2006, and the limited data available was used to estimate freshwater flow into the downstream end of the WBID. The freshwater flow component for Stevenson Creek (WBID 1567) was calculated by adding the flows recorded at these gages with the average annual discharge from the AWWTP. Using a longer period of record to estimate flow, as what is available from the AWWTP, rather than one year (2006-2007) provides a better estimate of average conditions, as it incorporates numerous seasons. Water discharged through the Reuse System was not included in the flow calculation as this water is applied to recreational areas and golf courses and under normal conditions should infiltrate into the soils.

Average annual and seasonal flows estimates for the watershed are provided in Table A- 1. The flow values are considered conservative as 2006 was a drought, flow draining the area between the gages is not accounted for, and water from the reuse system is assumed not to discharge into the MS4 system. Although 2006 was a drought year, relatively high flows were recorded during the summer wet season (June – September). The TMDL allocations for TN, TP and BOD are expressed in daily units of lb/day using seasonal flow values, as water quality data collected in the WBID indicates violations of WQS often occur in response to rainfall events. By representing the daily loads using the highest average seasonal flows the TMDL allocations represent the maximum load the stream can transport and meet WQS. The average seasonal flow from the AWWTP is not significantly different from the average annual flow, indicating minimal infiltration and inflow of stormwater into the sewage collection system.

Table A- 1. Freshwater Inflows to Stevenson Creek Estuary (WBID 1567)

Location	Period of Record	Average Seasonal Flow (cfs)	Average Annual Flow (cfs)
Stevenson Creek gage	8/2006 – 6/2007	14.50 (summer)	4.32
Spring Branch gage	8/2006 – 6/2007	5.01 (summer)	1.29
AWWTP	1/2001 – 12/2006	6.88 (summer)	6.82
Total Freshwater Flow into Estuary		26.39	12.43

The pollutant concentrations used in the daily loads calculations are estimated from the regression analyses, with the exception of BOD. The median concentrations of TN and TP measured in Stevenson Creek are reduced by the percentages calculated from the regression analyses as shown in Table A- 2. These concentrations, although conservative, are within the range of values observed in non-impaired marine waters (see Table 3). BOD concentration assumed in the daily load calculations is 2 mg/l and this is equivalent to the median values measured in Stevenson Creek as well as in un-impaired streams. The nutrient concentrations are considered conservative as the reductions predicted from the regression models do not account for BMP activities implemented in the watershed since 2004.

Table A- 2. Existing and Target Nutrient Concentrations

Pollutant	Existing Concentration (mg/L)	Percent Reduction (from regressions)	Daily Load Target Concentration (mg/L)
TN	1.17	75%	0.293
TP	0.21	70%	0.063

Daily pollutants loads and TMDL components are calculated using the equation below, and summarized in Table A- 3. The wasteload allocation is assigned a load consistent with the percentage the facility contributes in the annual load analysis (i.e., 46% for TN, 26% for TP, and 7% for BOD). The portion of the load remaining once the WLA is subtracted from the TMDL is allocated to stormwater, which is then separated into MS4 and LA components based on percentage of contributing landuse (i.e., 86% of landuse is MS4 and 14% is assumed nonpoint sources). Equations used to calculate the TMDL components are shown below.

TMDL (lb/day) = Flow (cfs) * Conc. (mg/L) * 5.3938 (conversion: mg-cf/sec-L to lb/day)

TMDL (TN) = 26.39 cfs * 0.293 mg/L * 5.3938 = 41.70 lb/day

TMDL (TP) = 26.39 cfs * 0.063 mg/L * 5.3938 = 8.971 lb/day

TMDL (BOD) = 26.39 cfs * 2.0 mg/L * 5.3938 = 284.81 lb/day

WLA (lb/day) = TMDL * percentage of load from AWWTP

WLA (TN) = 41.70 * 0.46 = 19.18 lb/day

WLA (TP) = 8.971 * 0.26 = 2.33 lb/day

WLA (BOD) = 284.81 * 0.07 = 19.94 lb/day

LA (lb/day) = percent land cover represented by nonpoint sources * (TMDL – WLA)

LA = 0.14 * (TMDL – WLA)

LA (TN) = 0.14 * (41.70 – 19.18) = 3.15 lb/day

MS4 (lb/day) = percent land cover represented by MS4 * (TMDL – WLA)

MS4 = 0.86 * (TMDL – WLA)

MS4 (TN) = 0.86 * (41.70 – 19.18) = 19.37 lb/day

Table A- 3. TMDL Components Expressed in Daily Units

Pollutant	TMDL (lb/day)	WLA		LA (lb/day)	MOS
		AWWTP (lb/day)	MS4 (lb/day)		
TN	41.70	19.18	19.37	3.15	Implicit
TP	8.971	2.33	5.71	0.93	Implicit
BOD	284.81	19.94	227.79	37.08	Implicit