2.3 WATER QUALITY ASSESSMENT

The Stevenson Creek Watershed is the largest watershed in the City of Clearwater. Residential land uses are dominant in this urban watershed, which provides drainage for the western portion of Clearwater as well as portions of Dunedin and unincorporated Pinellas County. The main stem of the creek originates near Belleair Road and flows northward to Clearwater Harbor.

The largest tributary is Spring Branch which flows from Dunedin and southward entering Stevenson Creek just upstream of Clearwater Harbor. Other major tributaries 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 the main channel near Glenn Oaks Golf Course.

Numerous small, natural water storage areas are located throughout the basin as well as several lakes. Most notable in size is Lake Bellevue which is around 25 acres. The two other largest lakes in the basin are Crest Lake and Lake Hobart which are about half the size of Lake Bellevue.

These storage areas and lakes provide stormwater runoff treatment. Best management practices (BMPs) for new (post-1982) development are also present; however, stormwater runoff treatment is lacking in many areas. New BMPs can help to improve water quality in the watershed; however, anthropogenic sources other than stormwater runoff appear to influence water quality in the Stevenson Creek Watershed to a significant degree.

Low dissolved oxygen levels, fecal contamination, and excessive nutrient concentrations are the primary water quality issues that have been identified in the watershed, and as such, water quality in Stevenson Creek is rated as “poor” by the state. The state’s rating is based on sampling conducted by the Pinellas County Department of

Environmental Management (PDEM). The city's ambient monitoring program as well as monitoring conducted for this study affirms these water quality issues.

Stevenson Creek is included on Florida's impaired waters list {303(d) List} due to concerns over dissolved oxygen, coliforms, and nutrients. The FDEP has given Stevenson Creek a priority rating of "High". Stevenson Creek is located in the "Crystal River to St. Petersburg Beach Basin" which is in Group 5 of the basin rotation cycle. TMDL development activity is expected to begin in 2004.

Water quality assessments conducted for this study included a

- Review of Existing Data (Section 2.3.1, *Existing Data*),
- Base flow and storm event monitoring program (Section 2.3.2, *Monitoring Program*),
- Water quality data interpretation (Section 2.3.3, *Water Quality Characteristics*), and
- Nonpoint source loading assessment (Section 2.3.4, *Nonpoint Source Loads*).

Each of these four elements is described separately in the following subsections.

2.3.1 Existing Data

During the last decade, Pinellas County and the city have conducted and documented water quality monitoring programs within the Stevenson Creek Watershed (Figure 2.3-1); likewise, the Marshall Street Wastewater Treatment plant (MWWTP) maintains operating records, and the Pinellas County Health Department maintains records concerning individual septic tanks. These monitoring programs and records were reviewed and are more specifically described as follows:

- **Pinellas County ambient surface water monitoring program**-- active Pinellas County monitoring program containing two stations within the Stevenson Creek Watershed (Refer to *Existing Water Quality Monitoring Programs*, Section 2.3.1.1)

Figure 2.3-1
Water Quality Monitoring Stations

- **City of Clearwater ambient surface water monitoring** program -- ambient surface water quality monitoring program from 1992 through 1995 containing ten stations within the Stevenson Creek Watershed (Refer to *Existing Water Quality Monitoring Programs*, Section 2.3.1.1)

- **Southwest Florida Water Management District, Lake Bellevue monitoring program--** short-term program from 1996-1997 (Refer to *Existing Water Quality Monitoring Programs*, Section 2.3.1.1)

- **Marshall Street Wastewater Treatment Plant operating reports --** ten-year record (Refer to *Other Existing Data*, Section 2.3.1.2)

- **Pinellas County Health Department septic tank records--** Recent septic tank construction and repair applications (Refer to *Other Existing Data*, Section 2.3.1.2)

2.3.1.1 Existing Monitoring Programs

Pinellas County, the Southwest Florida Water Management District (SWFWMD), and the City of Clearwater have conducted monitoring programs within the Stevenson Creek Watershed. Summary results from each of these monitoring programs are provided in Appendix I.

Pinellas County Department of Environmental Management (PDEM) maintains two stations in Stevenson Creek as part of its countywide ambient water quality monitoring program. The data from these two stations is the basis for the state's inclusion of Stevenson Creek on the impaired waters list, and the county has used these data to implicate Stevenson Creek as having some of the poorest water quality in the county (Myers et al. 2000).

PDEM provided the following description of these two stations to EPA's STORET database:

- "Stevenson's Creek off the southeast side of the Douglass Ave bridge just north of the Clearwater WWTP from mid span sampled monthly"

- "collected from Spring Branch of Stevenson's Creek off the west side of the Overbrook bridge just west of Douglass Ave at mid span sampled monthly"

Most prominent in each of these data sets are average fecal coliforms counts and ammonia nitrogen levels, which often exceed state standards. Phosphorous is high at the Spring Branch station, and nitrate + nitrite is high at both stations, particularly at the Stevenson Creek Station. The state reports a trophic state index of 65 for the Stevenson Creek estuary indicating that water quality is poor. A review of the nitrogen/phosphorus ratios shows that the estuary is nitrogen-limited.

A short-term monitoring program was conducted by SWFWMD on Lake Belleview (1996-1997). This program consisted of two sampling events- one in each year. The results showed low phosphorous levels for both measurements and high nitrogen levels for the 1996-measurement followed by low nitrogen levels during the 1997-measurement. Accordingly, a sharp drop in lake productivity was observed during the second year. Nitrogen forms were almost entirely organic.

The city conducted an ambient surface water quality monitoring program from years 1992 through 1995. The program included 10 stations in the Stevenson Creek Watershed. The monitoring program included grab samples analyzed for nutrients, oil and grease, suspended solids, coliforms and fecal streptococcus, biochemical oxygen demand (BOD_5), chlorides, and field parameters (dissolved oxygen, pH, etc.). Dissolved oxygen and fecal contamination were the most significant concerns identified for the Stevenson Creek Watershed during the city's monitoring program. Nutrient levels were also often elevated during the monitoring period.

2.3.1.2 Other Existing Data

Operating reports for Marshall Street Wastewater Treatment plant (MWWTP) were reviewed along with limited septic tank information made available by the Pinellas County Health Department. These records show that MWWTP (Figure 2.3-2) contributes significant quantities of nutrients, solids, and oxygen-demanding substances to the Stevenson Creek estuary, and, the septic tank information, considered in

Figure 2.3-2

Marshall Street Wastewater Treatment Plant

conjunction with coliforms sampling results, provides information concerning potential sources of fecal contamination in the basin.

The MWWTP discharges nutrients, solids, and oxygen-demanding substances to Stevenson Creek. While concentrations for these constituents in the plant effluents are within appropriate standards, the average 5.55 MGD-flow (6.8 MGD average daily flow minus 1.25 MGD flow to the reclaimed water system) results in masses that make up a significant percentage of total loads to the estuary originating from the Stevenson Creek Watershed. Information from the monthly operating reports for the year 1999 were averaged to produce the table below which compares loads from the treatment plant with loads measured during the 186-day monitoring period, of this study, at the two monitoring stations (Drew Street and Kings Highway). Stevenson Creek at the location of the MWWTP discharge has a much higher

Table 2.3-1
Loads During Monitoring Period

Input Source	Volume Discharged (ac-ft)	BOD_5 (Pounds)	TSS (Pounds)	TN (Pounds)	TP (Pounds)
Base and Storm Flow (1)	3,170	101,199	157,406	11,542	3,084
MWWTP	2,587	82,596	128,471	9,420	2,517

Note: Loads measured (based on mean concentration of all samples, this study, and the overall flow) at the Spring Branch (King's Highway) and Stevenson Creek (Drew Street) Station, May 2000 – November 2000

capacity to assimilate pollution than do the upper, freshwater reaches of the creek, and these mass loading calculations are provided only to add perspective to overall watershed load estimates presented elsewhere in this report.

Indirect evidence suggests that both the sanitary sewer system (i.e., cross-connections or inflow) and septic tanks may contribute to bacteria and nutrient levels in the Stevenson Creek Watershed. The MWWTP appears to receive a moderate increase in flow during the wet season. In addition, the locations and density of septic tank repair permits seem to coincide with the highest percent of human isolates found in the results of the fecal coliform sampling.

A fourteen-year flow record (January 1985- January 2000) was reviewed for the MWWTP. During this time period the average daily flow during the wet season (June-September) was 7.06 MGD as compared to 6.65 MGD during the remaining eight months of the year. If this variation is due to increased rainfall during the wet season, then possible explanations for the increase are infiltration, inflow, or cross connections between the sanitary and storm systems. Anecdotal evidence of one possible infiltration or cross connection problem is provided by a resident who reported that a lift station on Sunset Point Road (just west of Stevenson Avenue) overflows during heavy rains “causing the creek to stink like sewage”.

Pinellas County recently began keeping records of applications for septic tanks repairs. The locations of the septic tanks contained in this database were plotted (Figure 2.3-3), and seem to suggest that septic tanks within the city are concentrated between Union Street and Palmetto Street. These locations are near City of Clearwater monitoring Station STC1 and STC2, which happen to be the two stations with the highest percent of human isolates in fecal coliform samples (refer to Appendix J and Figure 2.3-1). While this seems to implicate septic tanks as a source of fecal contamination, a direct “cause and effect” statement concerning the use of septic tanks in the Stevenson Creek Watershed cannot be made. Other factors, such as the downstream position of STC1 and STC2, may be the cause of the higher human-source fecal contamination that was observed - in other words, the origin of the human-sourced fecal contamination measured at STC1 and STC2 could potentially be located upstream of the septic tanks.

Figure 2.3-3

Septic Tank Densities

2.3.2 Monitoring Program

A hydrologic and water quality monitoring program was implemented for the Stevenson Creek Watershed project. Two monitoring stations were installed – one station in Stevenson Creek (*Stevenson Creek Station*) just downstream of Drew Street and one station in Spring Branch (*Spring Branch Station*) just downstream of Kings Highway (Figure 2.3-4).

Each station logged rainfall depth and channel stage at 15-minute intervals from May 21,2001 through November 23, 2000. Flow-weighted composite samples were collected for seven (7) separate storm events and grab samples were taken for six (6) base flow events at each station. Savannah Laboratories in Tampa analyzed the samples in accordance with their FDEP-approved quality assurance plan. One equipment blank for each station was collected and analyzed prior to the first storm-sampling event.

Laboratory parameter included solids, oxygen demand, nutrients, metals and petroleum hydrocarbons. These parameters are more specifically described in Table 2.3-2 along with their corresponding minimum detection limits.

2.3.2.1 Monitored Basins

The majority (65%) of the watershed was monitored. Figure 2.3-4 shows the areas that drain to each of the monitoring stations. These areas include a 2400-acre area draining to the Stevenson Creek Station and a 1700-acre area draining to the Spring Branch Station. The unmonitored portion of the basin is approximately 2200 acres.

Both the Stevenson Creek and Spring Branch Stations are similar with respect to land use. The dominant land use is residential. The primary distinguishing factor is the presence of a larger amount of commercial land use in the Stevenson Creek Basin and a larger amount of high-density residential land use in the Spring Branch Basin. The Land uses in the unmonitored portion of the basin are similar to the monitored basins as shown in Figure 2.3-5 – shown as a doughnut graph to emphasize similarity.

Table 2.3-2

Water Quality Sampling Parameters

Parameter	MDL[1] (mg/l)
Hardness as $CaC0_3$	3.3
Petroleum Hydrocarbons	
Oil and Grease	5.0
Total Recoverable Petroleum Hydrocarbons, TRPH	0.30
Oxygen Demand	
Biochemical Oxygen Demand (5 Day), BOD_5	2.0
Chemical Oxygen Demand, COD	20
Total Organic Carbon, TOC	1.0
Solids	
Total Suspended Solids, TSS	5.0
Total Dissolved Solids, TDS	5.0
Metals	
Aluminum, Al	0.20
Arsenic, As	0.010
Cadmium, Cd	0.0050
Chromium, Cr	0.010
Copper, Cu	0.020
Lead, Pb	0.0050
Nickel, Ni	0.040
Zinc, Zn	0.020
Nutrients	
Ortho Phosphate, P	0.050
Total Phosphorus, TP	0.10
Ammonia, NH_3	0.03
Total Kjeldahl Nitrogen, TKN	0.20
Nitrate + Nitrite, NO_3, NO_2	0.05

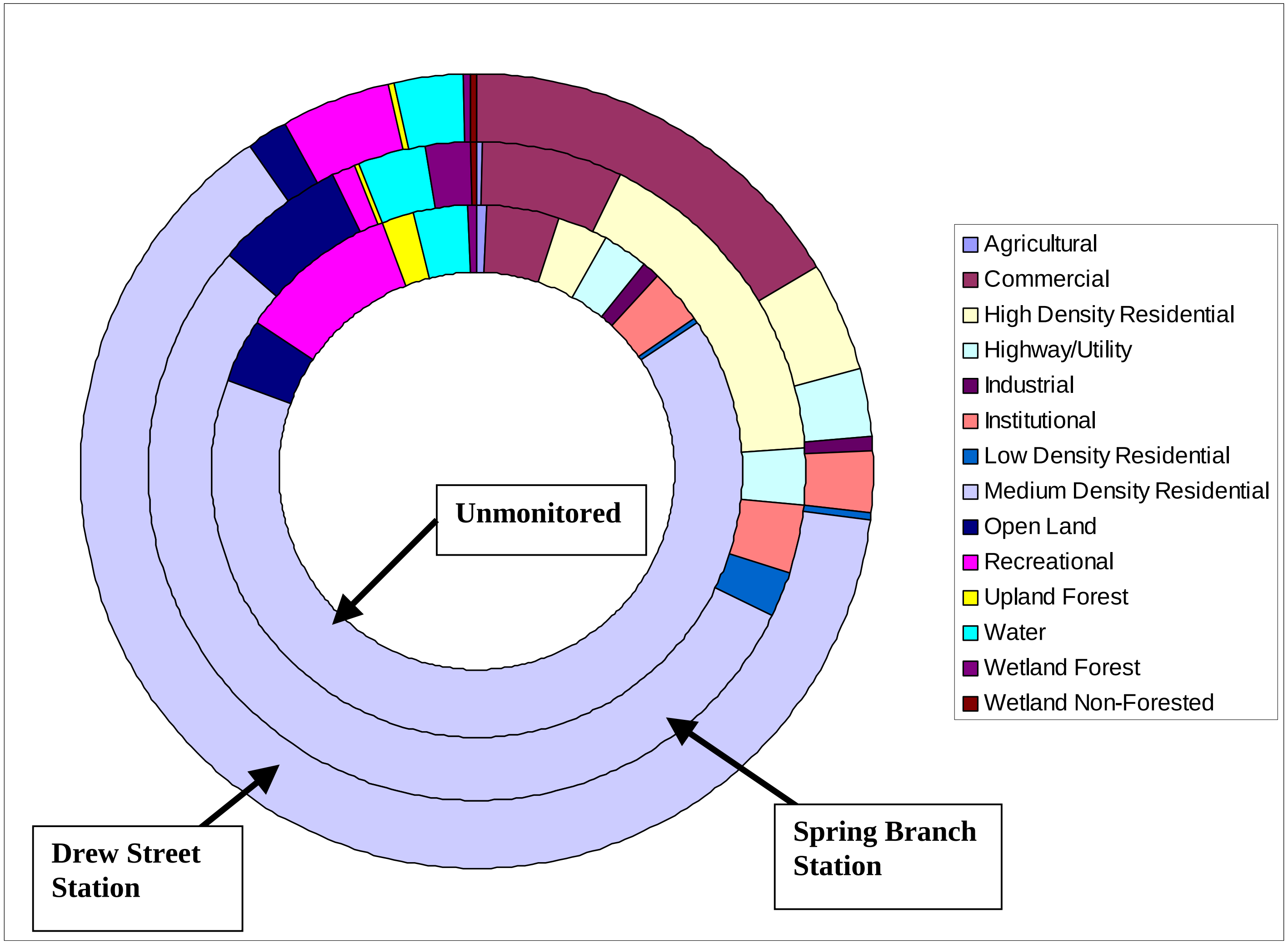
[1] Minimum Detection Limit

Figure 2.3-4

Monitoring Stations Location and Coverage

Figure 2.3-5

Land Use by Monitoring Station



2.3.2.2 Hydrologic Monitoring

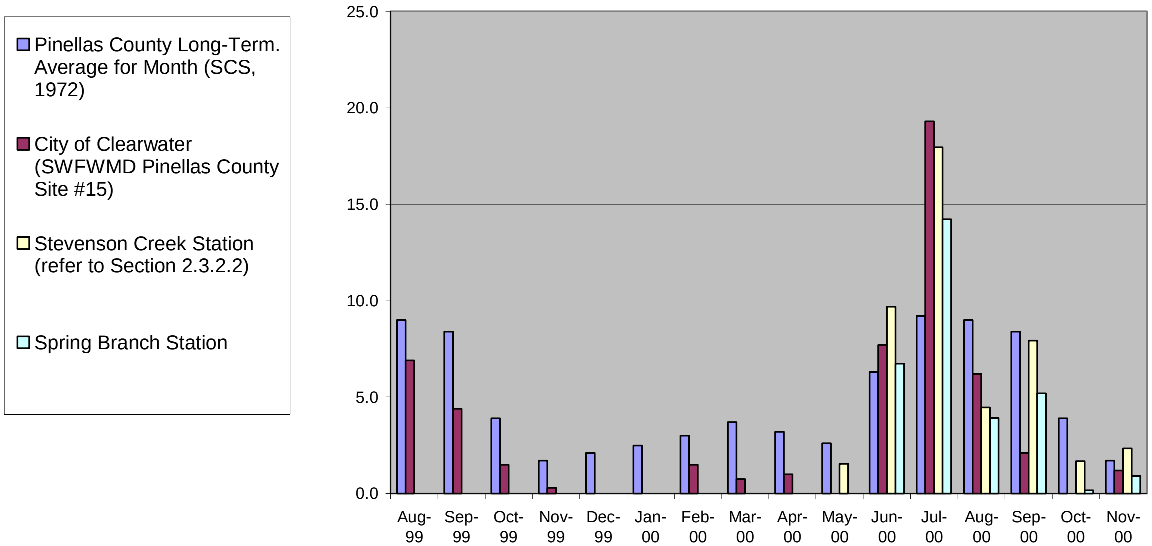
Hydrologic monitoring was conducted from May 21, 2000 through November 23, 2000. Rainfall conditions preceding and during the monitoring period were, in general, drier than normal. Rainfall conditions leading up to and including the monitoring period as compared to normal conditions are shown on Figure 2.3-6. The monitoring period followed an extremely dry "dry season" (5.1 inches of rainfall were received October 1999 to May 2000 at SWFWMD's Site #15 rain gauge) with monthly rainfall conditions recovering to normal during the second month (June 2000) of monitoring. July 2000 was wetter than normal due chiefly to a large storm event that occurred on July 15 dropping 7.7 inches at the Stevenson Creek Station and 5.7 inches at the Spring Branch Station. Drier-than-normal conditions returned after July.

Towards the end of May 1999 it was discovered that the Stevenson Creek rain gage was receiving inputs from the Clearwater Country Club's sprinkler system. The rain gauge was moved away from the influence of the sprinklers as far as possible; however, minor inputs were still received from the sprinklers.

Translating the total measured flow during the monitoring period to a depth (flow volume divided by basin area), at the Stevenson Creek station 11.0 inches of rainfall appeared as flow the creek; likewise, 31.16 inches of rainfall at the Spring Branch Station resulted in 6.9 inches of flow. The remaining rainfall was lost to initial abstraction and evapotranspiration or became groundwater - later to appear as base flow of aquifer recharge. A simplified technique of base flow separation was applied to determine the relative magnitude of base flow. This technique uses the minimum daily flow during dry periods together with professional judgment to separate the flow into two components-base flow and storm event runoff. Overall hydrologic conditions for the monitoring period are listed in Table 2.3-3. Daily flow along with rainfall for the two monitoring stations is shown on Figures 2.3-7 and 2.3-9. Figures 2.3-8 and 2.3-10 provide a more detailed view for low flow conditions.

Figure 2.3-6

Rainfall Conditions



	Aug-99	Sep-99	Oct-99	Nov-99	Dec-99	Jan-00	Feb-00	Mar-00	Apr-00	May-00	Jun-00	Jul-00	Aug-00	Sep-00	Oct-00	Nov-00
Pinellas County Long-Term. Average for Month (SCS, 1972)	9.0	8.4	3.9	1.7	2.1	2.5	3.0	3.7	3.2	2.6	6.3	9.2	9.0	8.4	3.9	1.7
City of Clearwater (SWFWMD Pinellas County Site #15)	6.9	4.4	1.5	0.3	0.0	0.0	1.5	0.8	1.0	0.0	7.7	19.3	6.2	2.1	0.0	1.2
Stevenson Creek Station (refer to Section 2.3.2.2)										1.54	9.70	17.95	4.46	7.93	1.68	2.34
Spring Branch Station										0.00	6.74	14.22	3.92	5.20	0.17	0.91

Table 2.3-3
Overall Hydrologic Conditions at Monitoring Stations

Watershed	Item	Quantity	Percent of Rainfall
Spring Branch	Area (AC)	1,673.50	--
	Rainfall Depth (in.)	31.16	100%
	Volume of Rain (AC-Ft.)	4,345.52	100%
	Total Flow (AC-Ft.)	960	22%
	Base Flow (AC-Ft.)	184	4%
	Storm Flow (AC-Ft.)	776	18%
Stevenson Creek	Area (AC)	2,415.50	
	Rainfall Depth (in.) (1)	45.61	100%
	Volume of Rain (AC-Ft.)	9,181.91	100%
	Total Flow (AC-Ft.)	2210	24%
	Base Flow (AC-Ft.)	376	4%
	Storm Flow (AC-Ft.)	1834	20%

Note 1 : Rainfall depth reflects inputs from Clearwater Country Club sprinkler system- refer to Section 2.3.2.2.

Figure 2.3-7

Stevenson Creek Hydrologic Record

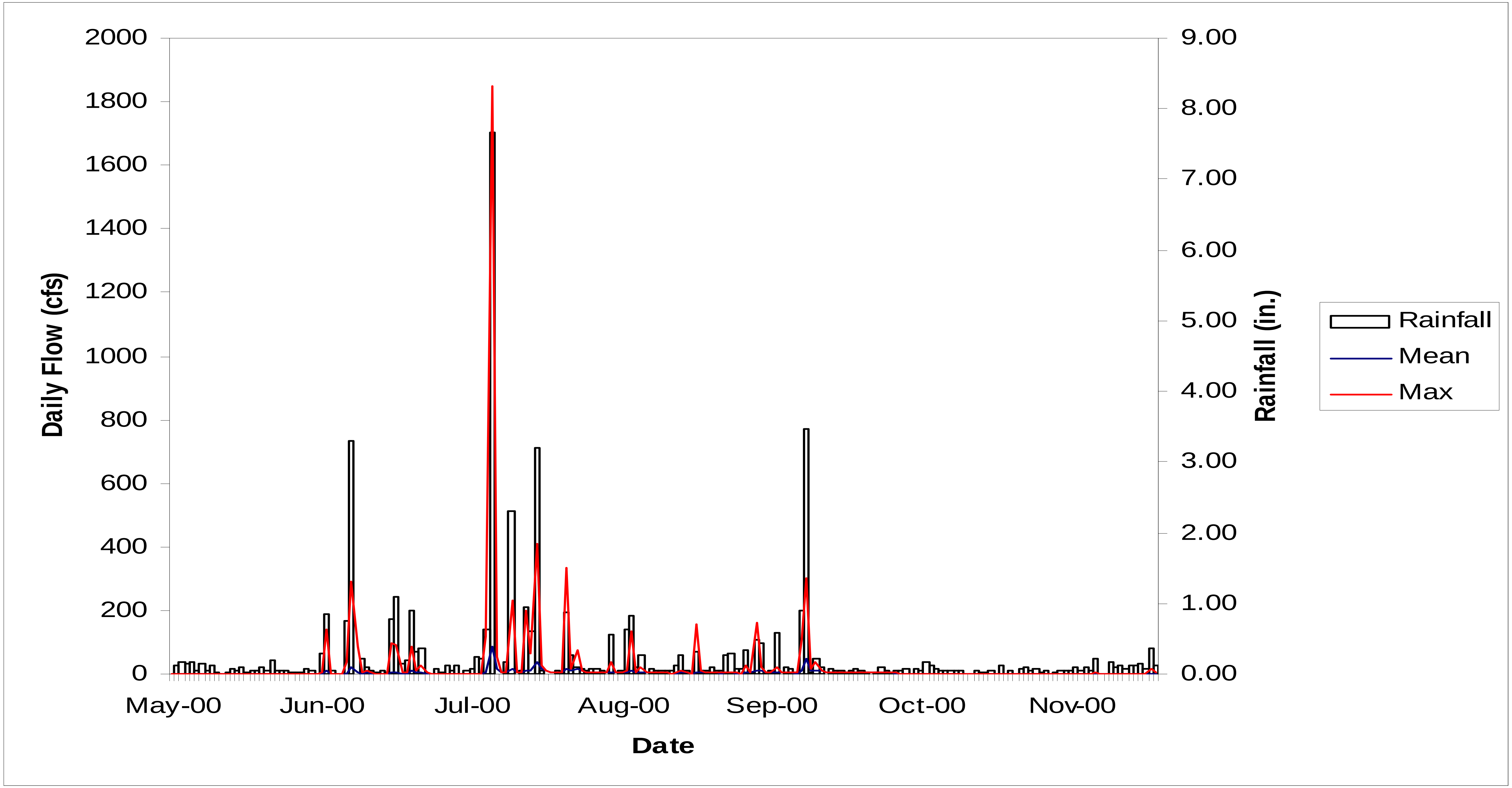


Figure 2.3-8
Stevenson Creek Hydrologic Record
Low Flow Detail

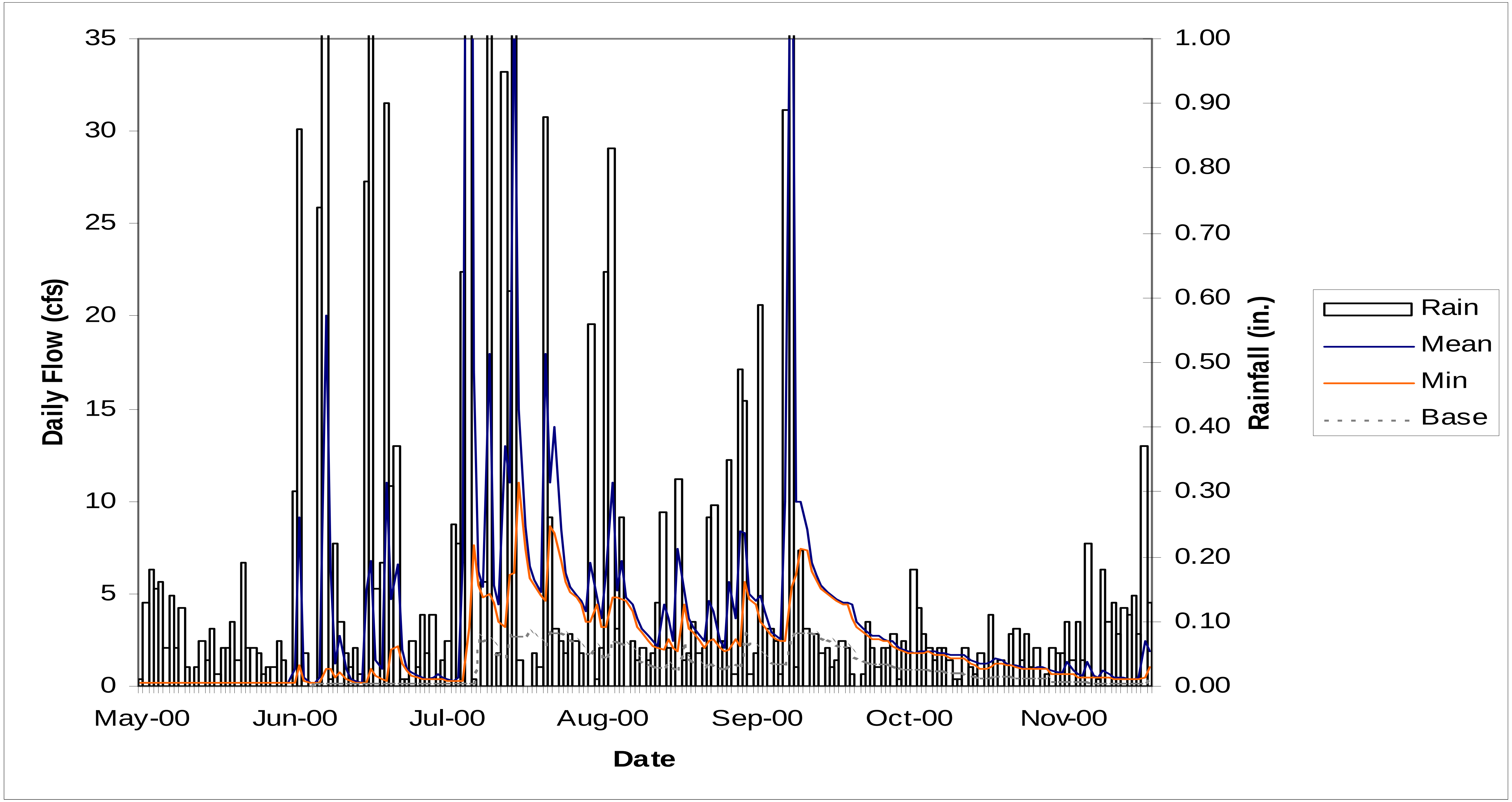


Figure 2.3-9
Spring Branch Hydrologic Record

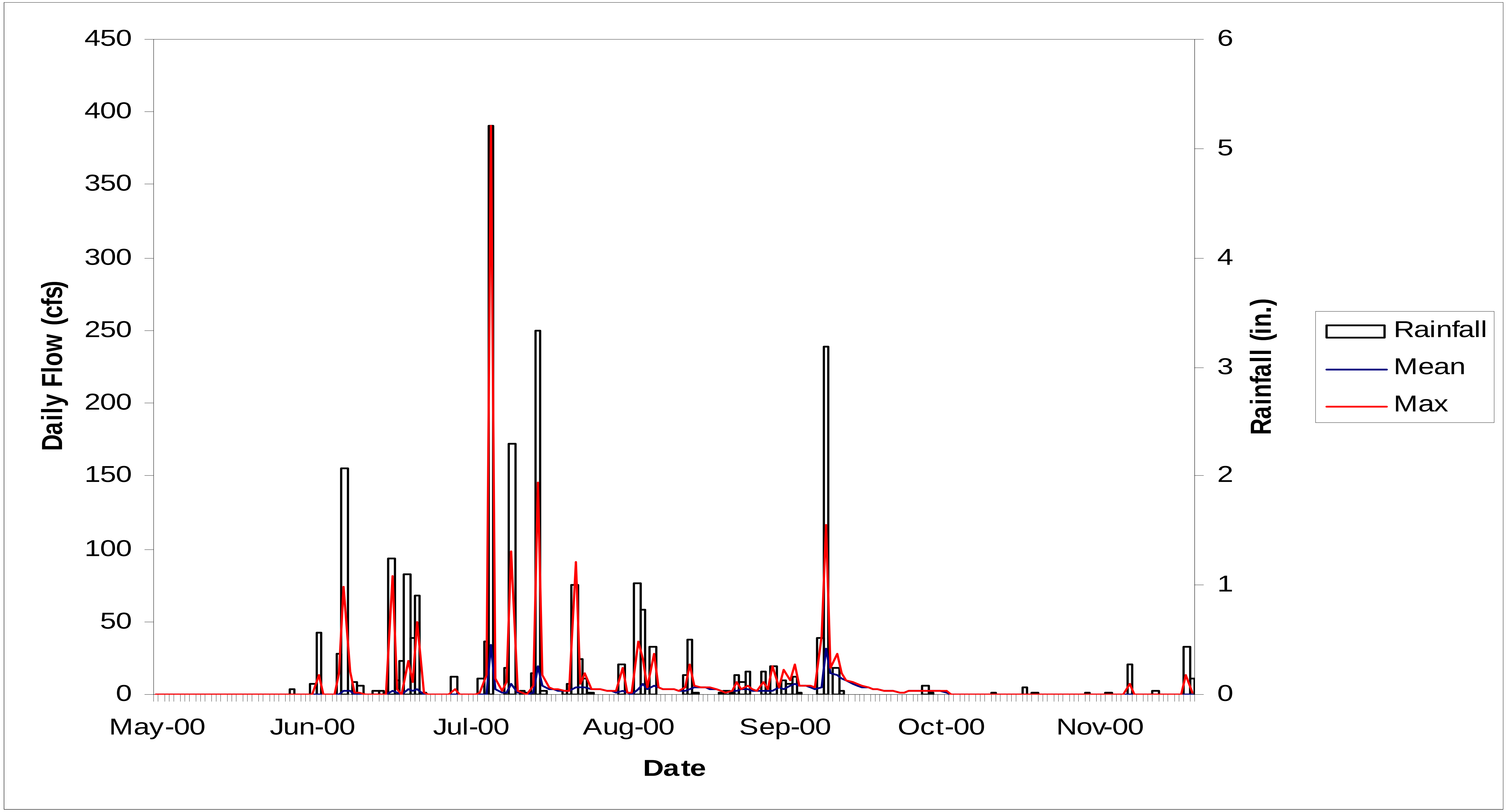
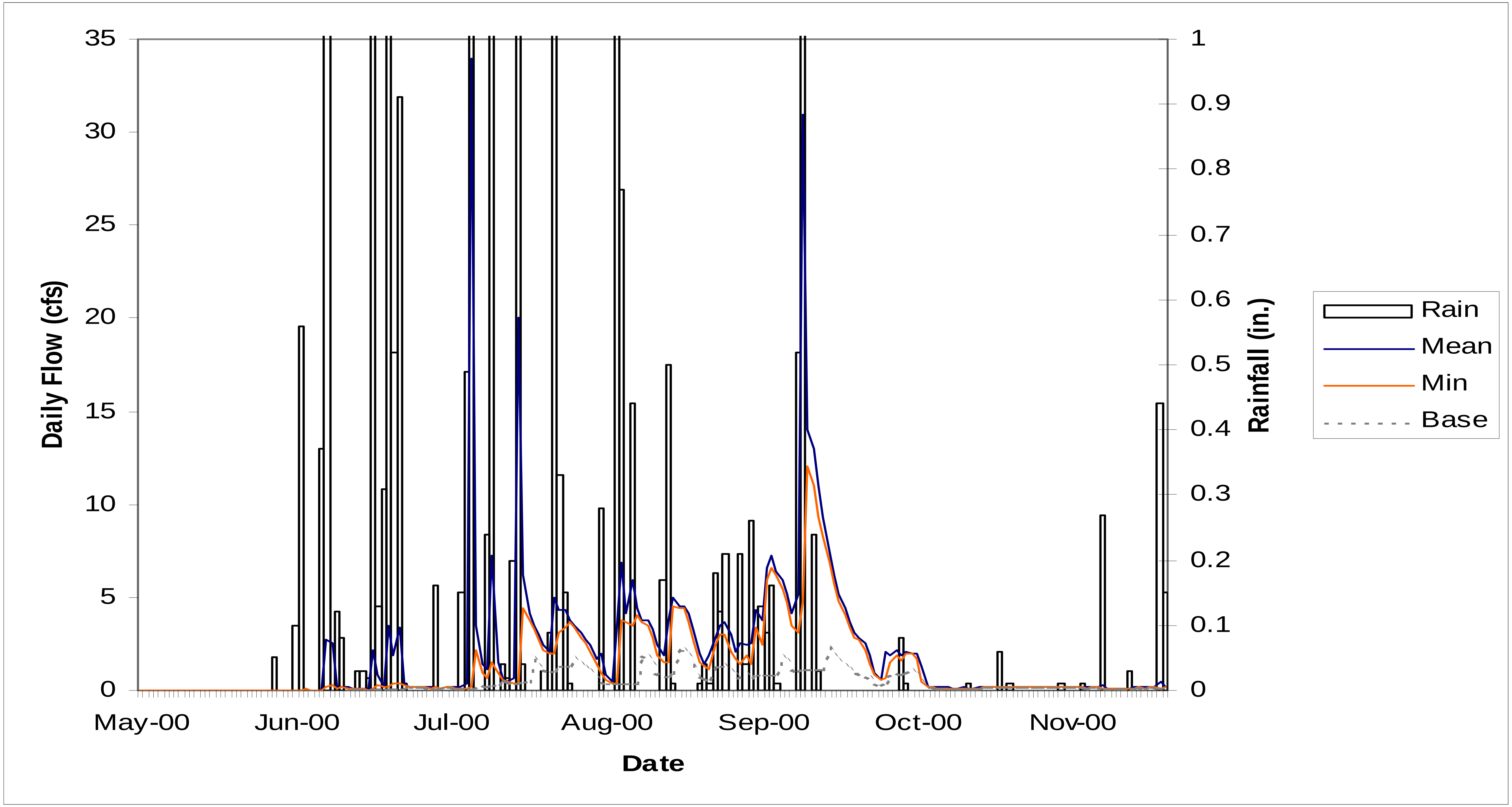


Figure 2.3-10
Spring Branch Hydrologic Record
Low Flow Detail



2.3.2.3 Water Quality

Seven (7) storm event samples and six (6) base flow samples were collected at each monitoring station. The laboratory results are provided in Table 2.3-4. Violations of Class III water quality criteria occurred in a number of instances. Details concerning these exceedences as well as other information concerning the findings of the sampling program are described in the following section.

2.3.3 Water Quality Characteristics

Water quality in the Stevenson Creek Watershed is described in the following subsections. These descriptions include assessments of base flow and storm flow and identify probable sources of pollution. Water quality parameters measured during this project are compared to Florida water quality criteria (*Chapter 62-302, Florida Administrative Code*- referred to as water quality standards in this report*)*, STORET database values (as published in the 2000 state Section 305(b) report), and comparable literature values, as appropriate. More specifically, comparisons are made with state water quality standard where numeric standards exists; otherwise, comparison is made with Florida averages as published in the 305(b) report (for base flow samples) or literature values (for stormwater runoff samples). Water quality indices are calculated for the base flow samples.

The Florida Department of Environmental Protection (FDEP) recommends the use of a Water Quality Index (WQI) to summarize water quality conditions in rivers and streams (Hand et al. 1996). The WQI is based on six categories of water quality indicators (water clarity, dissolved oxygen, oxygen-demanding substances, bacteria, nutrients, and biological diversity). Several categories contain multiple constituents (e.g., total organic carbon and BOD_5, within the category of oxygen-demanding substances). In such cases, data availability determines constituent(s) used in calculating the WQI. For each measured constituent, the raw data (e.g., monthly or quarterly observations) are converted to annual averages. The annual averages are then converted to percentiles,

Table 2.3-4 – Laboratory Results

						Metals								Oxygen Demand			Solids		Nutrients						
Date	Log #	Time	Type	Oil and Grease	Hardness as CaC03	Al	As	Cd	Cr	Cu	Pb	Ni	Zn	BOD5	COD	Total Organic	Total Suspended	Total Dissolved	Ortho Phosphate	Total Phosphoru	Ammonia	Total Kieldahl	Nitrate + Nitrite	Organic-N	Total Nitrogen
Stevenson Creek (Drew Street)																									
"June 20, 2000"	61864-2	10:19	Base Flow #1	<5.0	140	<0.20	<0.010	<0.0050	<0.010	<0.020	<0.0050	<0.040	<0.020	5.9	30	15.0	6.8	200	0.450	0.56	0.088	1.10	<0.050	1.01	1.10
"June 30, 2000"	61983-1	14:15	Storm Event #1	<5.0	76	<0.20	<0.010	<0.0050	<0.010	<0.020	<0.0050	<0.040	<0.020	2.1	30	9.3	<5.0	130	0.170	0.22	0.059	0.66	<0.050	0.60	0.66
"July 12, 2000"	62071-2	12:08	Base Flow #2	<5.0	210	<0.20	<0.010	<0.0050	<0.010	<0.020	<0.0050	<0.040	<0.020	<2.0	37	12.0	<5.0	350	0.370	0.36	0.140	1.80	<0.050	1.66	1.80
"July 20, 2000"	62194-1	12:30	Storm Event #2	<5.0	68	<.20	<0.01	<0.005	<0.01	<0.02	<0.005	<0.04	0.029	24	54	15	15.0	110	0.10	0.17	0.12	0.78	<0.050	0.66	0.78
"July 24, 2000"	62218-1	11:35	Storm Event #3	<5.0	71	<0.20	<0.010	<0.0050	<0.010	0.02	<0.0050	<0.040	<0.020	7.2	26	8.2	6.0	94	0.110	0.16	0.290	0.88	<0.050	0.59	0.88
"July 31, 2000"	62290-1	17:30	Storm Event #4	<5.0	59	0.69	<0.010	<0.0050	<0.010	<0.020	0.0071	<0.040	0.038	8.9	29	7.4	30.0	86	0.140	0.30	0.058	0.65	0.51	0.59	1.16
"August 3, 2000"	62336-2	14:34	Base Flow #3	<5.0	140	<0.20	<0.010	<0.0050	<0.010	<0.020	<0.0050	<0.040	<0.020	2.0	45	11.0	8.4	210	0.200	0.27	0.091	0.81	0.18	0.72	0.99
"August 23, 2000"	62526-1	10:27	Base Flow #4	<5.0	210	<0.20	<0.010	<0.0050	<0.010	<0.020	<0.0050	<0.0040	0.200	<2.0	<20	11.0	<5.0	300	0.17	0.21	0.088	0.82	0.27	0.73	1.09
"September 13, 2000"	62731-1	13:45	Base Flow #5	<5.0	180	<0.20	<0.010	<0.0050	<0.010	<0.020	<0.0050	<0.040	<0.020	19.0	58	24.0	<5.0	240	0.12	0.21	0.150	0.89	0.44	0.74	1.33
"September 13, 2000"	62737-3	13:30	Storm Event #5	<5.0	140	<0.20	<0.010	<0.0050	<0.010	<0.020	<0.0050	<0.040	<0.020	<2.0	58	11.0	6.0	220	0.20	0.26	0.037	0.87	0.55	0.83	1.42
"September 17, 2000"	62758-2	12:45	Storm Event #6	<5.0	89	0.62	<0.010	<0.0050	<0.010	<0.020	<0.0050	<0.040	0.036	60	38	30.0	26	140	0.24	0.49	0.054	1.20	0.23	1.15	1.43
"October 12, 2000"	62999-2	14:50	Base Flow #6	<5.0	190	0.33	<0.010	<0.0050	<0.010	<0.020	<0.0050	<0.040	0.022	<2.0	22	10.0	18	300	0.18	0.38	0.038	1.10	0.27	1.06	1.37
"November 15, 2000"	63376-2	13:30	Storm Event #7	<5.0	140	0.27	<0.010	<0.0050	<0.010	<0.020	0.0054	<0.040	0.066	14	93	27.0	26	240	0.34	0.57	0.031	1.60	0.34	1.57	1.94
Spring Branch (Kings Highway)																									
"June 20, 2000"	61864-1	9:10	Base Flow #1	<5.0	150	0.25	<0.010	<0.0050	<0.010	<0.020	<0.0050	<0.040	<0.020	7.8	43	19.0	16.0	270	0.560	0.76	0.110	1.90	<0.050	1.79	1.90
"June 30, 2000"	61983-2	15:00	Storm Event #1	<5.0	64	<0.20	<0.010	<0.0050	<0.010	<0.020	<0.0050	<0.040	<0.020	3.3	<20	10.0	8.8	100	0.290	0.33	0.079	0.80	0.06	0.72	0.86
"July 12, 2000"	62071-1	11:17	Base Flow #2	<5.0	130	<0.20	<0.010	<0.0050	<0.010	<0.020	<0.0050	<0.040	<0.020	6.1	62	20.0	15.0	240	0.640	0.73	<0.030	2.10	<0.050	2.10	2.10
"July 17, 2000"	62131-1	15:30	Storm Event #2	<5.0	34	0.44	<0.010	<0.0050	<0.010	<0.020	0.0130	<0.040	0.049	2.2	<20	4.6	39.0	41	0.210	0.45	0.150	1.40	<0.050	1.25	1.40
"July 20, 2000"	62194-2	13:25	Storm Event #3	<5.0	58	0.32	<0.01	<0.005	<0.01	<0.02	<0.005	<0.04	<0.020	14	43	12	14.0	120	0.20	0.27	0.110	0.93	<0.050	0.82	0.93
"July 31, 2000"	62290-2	18:45	Storm Event #4	<5.0	56	0.70	<0.010	<0.0050	<0.010	<0.020	0.0078	<0.040	0.037	25.0	58	23.0	23.0	200	0.220	0.35	0.160	0.95	0.18	0.79	1.13
"August 3, 2000"	62336-1	13:45	Base Flow #3	<5.0	130	0.65	<0.010	<0.0050	<0.010	<0.020	<0.0050	<0.040	0.024	<2.0	26	13.0	19.0	240	0.260	0.46	0.067	0.94	0.36	0.87	1.30
"August 23, 2000"	62526-2	12:05	Base Flow #4	<5.0	160	0.21	<0.010	<0.0050	<0.010	<0.020	<0.0050	<0.0040	0.200	98.0	38	21.0	7.2	220	0.230	0.30	0.097	1.10	0.068	1.00	1.17
"August 23, 2000"	62526-3	11:45	Storm Event #5	<5.0	120	0.28	<0.010	<0.0050	<0.010	<0.020	<0.0050	<0.0040	0.250	52.0	<20	15.0	21.0	170	0.190	0.36	0.084	1.40	0.32	1.32	1.72
"September 13, 2000"	62731-2	15:00	Base Flow #5	<5.0	120	0.22	<0.010	<0.0050	<0.010	<0.020	<0.0050	<0.040	<0.020	12.0	54	18.0	9.2	220	0.17	0.27	0.046	1.20	<0.050	1.15	1.20
"September 17, 2000"	62758-1	11:00	Storm Event #6	<5.0	92	0.41	<0.10	<0.0050	<0.010	<0.020	0.0063	<0.040	0.037	12	36	10.0	21	120	0.14	0.41	0.110	0.81	0.25	0.70	1.06
"October 12, 2000"	62999-1	13:30	Base Flow #6	<5.0	220	0.39	<0.010	<0.0050	<0.010	<0.020	<0.0050	<0.040	<0.020	2.1	35	11.0	10	330	0.067	0.15	0.120	0.89	0.05	0.77	0.94
"November 15, 2000"	63376-1	12:00	Storm Event #7	<5.0	140	0.52	<0.010	<0.0050	<0.010	<0.020	0.0087	<0.040	0.100	21	110	37.0	44	370	0.60	1.00	0.078	2.80	<0.050	2.72	2.80

using a database constructed by FDEP staff (Hand et al. 1990, 1996) using data from 2,000 Florida stream monitoring locations. These percentile values, which range from 0 (best quality) to 100 (poorest quality), are then averaged to generate the WQI. The final averaging process ignores water quality categories for which no data are available. The WQI calculated for a given stream-monitoring site can therefore represent the average of from 1 to 6 categories. Although the index can be calculated based on a single category, the use of additional categories provides greater reliability (Hand et al. 1990, 1996).

FDEP recommends the following interpretation of WQI values, based on an analysis of Florida stream data and the US EPA National Profiles Water-Quality Index (Hand et al. 1996):

$0 < WQI < 45$ = "good" water quality

$45 < WQI < 60$ = "fair" water quality

$WQI > 60$ = "poor" water quality.

Data for four of the six possible water quality index categories was collected at the two sampling stations. Overall water quality at both stations is rated "poor" based on

Table 2.3-5
Water Quality Indices

Category	Subcategory	Drew Street	Spring Branch
Water Clarity	TSS	50.9	70.9
Oxygen Demand	Overall	57.1	64.9
	BOD	89.3	90
	COD	32.8	46.2
	TOC	49.2	58.6
Nutrients	Overall	66.1	62.9
	Total Nitrogen	54	61.8
	Nitrate + Nitrite	70.2	47.7
	Total Phosphorous	74.2	79.3
Bacteria	Fecal Coliform	90	90
Overall		**66.0**	**72.2**

the average of base flow samples taken during this monitoring program with quality at the Spring Branch station rated moderately poorer than at the Drew Street station Table (2.3-5).

2.3.3.1 Petroleum Hydrocarbons

Petroleum hydrocarbons include oil and grease; the "BTEX" compounds: benzene, toluene, ethyl benzene, and xylene; as well as other polynuclear aromatic hydrocarbons (PAHs). The most common sources of petroleum hydrocarbons are associated with vehicle usage. These sources include parking lots and roads, leaking storage tanks, automobile emissions, and improper or careless handling or disposal of oil; therefore, petroleum hydrocarbons are typically concentrated along transportation routes. Petroleum hydrocarbons are acutely toxic at relatively low concentrations.

For this study, oil and grease was used as an "indicator" pollutant for petroleum hydrocarbons. The sampling plan specified that if oil and grease concentrations above 5.0 mg/l were detected, then tests would also be conducted for petroleum hydrocarbons. Oil and grease was not detected; therefore, tests for petroleum hydrocarbons were not conducted. While petroleum hydrocarbons are certainly present in any urban area, they do not appear to be a significant concern in the portion of the Stevenson Creek Watershed that was monitored.

2.3.3.2 Oxygen Demand

Oxygen-demanding substances were measured by testing for Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), and Total Organic Carbon (TOC). Maintaining appropriate levels of dissolved oxygen is one of the most important considerations for the protection of fish and aquatic life. The state standard for dissolved oxygen in Class III waters is 5.0 mg/l or greater.

The direct impact of storm water runoff on dissolved oxygen conditions in receiving waters is normally not as important as the secondary impacts. Secondary impacts of low dissolved oxygen conditions include nutrient enrichment, eutrophication, and increased sediment oxygen demand.

Base flow sampling results values (Table 2.3-6) in comparison to Florida averages), and storm event sampling results (Table 2.3-7) in comparison with Nationwide Urban Runoff Program (NURP) data from the Tampa Bay Sampling sites are provided. Three laboratory measurements appear to be in error and, therefore, were not used. The laboratory is unable to specifically identify the source of the error; however, the error may have been caused by a standard solution that was more concentrated than specified by the test. These erroneous measurements include the base flow sample taken on August 23, 2000 at the Kings Highway Station, the storm event sample that was composited on the same day and location, and the September 17, 2000 storm event sample taken at Drew Street. These readings are suspect due to the much lower COD measurements taken on the same sample. COD should normally be higher than BOD_5, and no case should BOD_5 be significantly greater than COD. This is because BOD measures the actual oxygen consumption of microorganisms, and COD measures the amount of oxidant required to oxidize the available organic matter; therefore, a BOD that is higher than a COD implies that more organic material was consumed than was available for consumption.

Table 2.3-6, Base Flow Oxygen Demand

Date	BOD_5 (mg/l)	COD (mg/l)	TOC (mg/l)
Stevenson Creek - Drew Street			
June 20, 2000	5.9	30	15
July 12, 2000	<2.0	37	12
August 3, 2000	2	45	11
August 23, 2000	<2.0	<20	11
September 13, 2000	19	58	24
October 12, 2000	<2.0	22	10
Mean	5.0	34	14
WQI	89.3	32.8	49.2
Spring Branch - Kings Highway			
June 20, 2000	7.8	43	19
July 12, 2000	6.1	62	20
August 3, 2000	<2.0	26	13
August 23, 2000	98	38	21
September 13, 2000	12	54	18
October 12, 2000	2.1	35	11
Mean	5.8	43	17
WQI	90	46.2	58.6
Frequency of Exceedance in Florida Streams			
STORET-10%	0.8	16	5
Median	1.5	46	14
STORET-90%	5.1	146	37

BOD was still high relative to typical Florida streams even without considering the erroneous measurements. Moderately higher BOD concentrations were present at the

Table 2.3-7

Storm Event Oxygen Demand

Date	BOD_5 (mg/l)	COD (mg/l)	TOC (mg/l)
Drew Street			
June 30, 2000	2.1	30	9.3
July 20, 2000	24	54	15
July 24, 2000	7.2	26	8.2
July 31, 2000	8.9	29	7.4
September 13, 2000	<2.0	58	11
September 17, 2000	60[i]	38	30
November 15, 2000	14	93	27
EMC	12.19	47.3	15.7
Kings Highway			
June 30, 2000	3.3	<20	10
July 17, 2000	2.2	<20	4.6
July 20, 2000	14	43	12
July 31, 2000	25	58	23
August 23, 2000	52[1]	<20	15
September 17, 2000	12	36	10
November 15, 2000	21	110	37
EMC	15.35	43.5	16.5
Tampa Bay NURP			
Minimum	0.7	5	0
Mean	5.4	58	14
maximum	28	210	88

[i] Erroneous measurement – not used

Spring Branch station than were observed at the Stevenson Creek station. COD and BOD were near the state average.

2.3.2.3 Solids

Solids are one of the most common contaminants found in urban storm water. Solids originate from many sources including the erosion of pervious surfaces and dust, litter and other particles deposited on land surfaces from human activities and the atmosphere. Stream bank and streambed erosion also appears to be a major source of solids in the Stevenson Creek Watershed.

Solids contribute to water quality, habitat and maintenance problems in Stevenson Creek Watershed. Elevated levels of solids increase turbidity, reduce the depth of light penetration within the water column, and limit the growth of desirable aquatic plants. Solids that settle out as bottom deposits and can alter habitat for fish and bottom-dwelling organisms. Solids also provide a medium for the accumulation, transport and storage of other pollutants including nutrients and metals. Sediment- bound pollutants interact with the water column through cycles of deposition, re-suspension, and re-deposition.

Suspended solids (TSS) concentrations in base flow were high at the Spring Branch station and near the Florida average at the Drew Street station. As expected, suspended solids concentrations increased substantially during storm events with the Spring Branch station experiencing higher concentrations than the Drew Street station. Results are provided on Tables 2.3-8 and 2.3-9.

2.3.2.4 Metals

Metals detected in the Stevenson Creek Watershed include aluminum, lead, and zinc. This finding is typical. Aluminum is the second most abundant naturally occurring metal and lead and zinc are the most commonly detected metals in stormwater runoff[1]. Likely sources of the lead and zinc present in the Stevenson Creek Watershed include vehicle usage, atmospheric deposition, and erosion. A major finding of the NURP study is as follows:

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1 Lead and zinc were detected in 94% of NURP samples.

Table 2.3-8
Base Flow Solids

Date	Total Suspended Solids (TSS, mg/l)	Total Dissolved Solids (TDS, mg/l)
Stevenson Creek		
June 20, 2000	6.8	200
July 12, 2000	<5.0	350
August 3, 2000	8.4	210
August 23, 2000	<5.0	300
September 13, 2000	<5.0	240
October 12, 2000	18	300
Mean	6.78	267
WQI	50.9	-
Spring Branch		
June 20, 2000	16	270
July 12, 2000	15	240
August 3, 2000	19	240
August 23, 2000	7.2	220
September 13, 2000	9.2	220
October 12, 2000	10	330
Mean	12.73	253
WQI	70.9	-
Frequency of Exceedance in Florida Streams		
STORET-10%	2	-
Median	6.5	-
STORET-90%	26.5	-

Table 2.3-9
Storm Event Solids

Date	Total Suspended Solids (TSS, mg/l)	Total Dissolved Solids (TDS, mg/l)
Stevenson Creek		
June 30, 2000	<5.0	130
July 20, 2000	15	110
July 24, 2000	6	94
July 31, 2000	30	86
September 13, 2000	6	220
September 17, 2000	26	140
November 15, 2000	26	240
EMC	18.3	147
Spring Branch		
June 30, 2000	8.8	100
July 17, 2000	39	41
July 20, 2000	14	120
July 31, 2000	23	200
August 23, 2000	21	170
September 17, 2000	21	120
November 15, 2000	44	370
EMC	25.13	168
NURP Mixed Urban - Mean	67	-

> *Heavy metals (especially copper, lead and zinc) are by far the most prevalent priority pollutant constituents found in urban runoff. End-of-pipe concentrations exceed EPA ambient water quality criteria and drinking water standards in many instances. Some of the metals are present often enough and in high enough concentrations to be potential threats to beneficial uses.*

Metals can be toxic to aquatic life, and lead and zinc concentrations exceeding state standards were often measured during the monitoring program- more often in storm flow and more often at Spring Branch. Metals concentration for both of the monitoring stations are shown on Table 2.3-10 along with comparison to state water quality criteria and NURP data. The standards for lead and zinc are hardness-dependant, and the standard for lead was often less than the detection limit.

2.3.3.5 Nutrients

Nitrogen and phosphorus are the principal nutrients of concern in urban storm water. The major sources of nitrogen and phosphorus in the Stevenson Creek Watershed are likely associated with landscape runoff (fertilizers and organic debris) and atmospheric deposition. Improperly functioning septic tank systems and animal waste may also be an important source.

There are a number of parameters used to measure the various forms of nitrogen. Ammonia (NH_3) nitrogen is the nitrogen form that is usually the most readily toxic to aquatic life. Nitrate (NO_3) and nitrite (NO_2) are the inorganic fractions of nitrogen. Very little nitrite is usually found in storm water. Total Kjeldahl nitrogen (TKN) measures the organic and ammonia nitrogen forms. The organic fraction is determined by subtracting the NH_3 from the TKN.

Total phosphorus measures the total amount of phosphorus in both the organic and inorganic forms. Ortho-phosphate measures phosphorus that is most immediately biologically available. Most of the soluble phosphorus in storm water is usually present in the ortho-phosphate form.

Table 2.3-10
Metals

Date	Type of Flow	Aluminum[1] Measurement (1)	Lead Measurement	Lead Class III-Fresh Standard	Zinc Measurement	Zinc Class III-Fresh Standard
Stevenson Creek						
June 20, 2000	Base Flow #1	<0.20	<0.0050	0.00488	<0.020	0.14096
July 12, 2000	Base Flow #2	<0.20	<0.0050	0.00818	<0.020	0.19874
August 3, 2000	Base Flow #3	<0.20	<0.0050	0.00488	<0.020	0.14096
August 23, 2000	Base Flow #4	<0.20	<0.0050	0.00818	0.200	0.19874
September 13, 2000	Base Flow #5	<0.20	<0.0050	0.00672	<0.020	0.17441
October 12, 2000	Base Flow #6	0.33	<0.0050	0.00720	0.022	0.18258
June 30, 2000	Storm Event #1	<0.20	<0.0050	0.00224	<0.020	0.08400
July 20, 2000	Storm Event #2	<.20	<0.0050	0.00195	0.029	0.07645
July 24, 2000	Storm Event #3	<0.20	<0.0050	0.00206	<0.020	0.07929
July 31, 2000	Storm Event #4	0.69	0.0071	0.00163	0.038	0.06778
September 13, 2000	Storm Event #5	<0.20	<0.0050	0.00488	<0.020	0.14096
September 17, 2000	Storm Event #6	0.62	<0.0050	0.00274	0.036	0.09603
November 15, 2000	Storm Event #7	0.27	0.0054	0.00488	0.066	0.14096
Spring Branch						
June 20, 2000	Base Flow #1	0.25	<0.0050	0.00533	<0.020	0.14944
July 12, 2000	Base Flow #2	<0.20	<0.0050	0.00444	<0.020	0.13238
August 3, 2000	Base Flow #3	0.65	<0.0050	0.00444	0.024	0.13238
August 23, 2000	Base Flow #4	0.21	<0.0050	0.00579	0.200	0.15784
September 13, 2000	Base Flow #5	0.22	<0.0050	0.00401	<0.020	0.12370
October 12, 2000	Base Flow #6	0.39	<0.0050	0.00868	<0.020	0.20673
June 30, 2000	Storm Event #1	<0.20	<0.0050	0.00180	<0.020	0.07262
July 17, 2000	Storm Event #2	0.44	0.0130	0.00081	0.049	0.04249
July 20, 2000	Storm Event #3	0.32	<0.005	0.00159	<0.020	0.06681
July 31, 2000	Storm Event #4	0.70	0.0078	0.00152	0.037	0.06485
August 23, 2000	Storm Event #5	0.28	<0.0050	0.00401	0.250	0.12370
September 17, 2000	Storm Event #6	0.41	0.0063	0.00286	0.037	0.09876
November 15, 2000	Storm Event #7	0.52	0.0087	0.00488	0.100	0.14096

	Lead	Zinc
NURP -Nationwide Mean		
Residential	0.144	0.135
Mixed Urban	0.114	0.154
Commercial	0.104	0.226
Tampa Bay NURP		
Minimum	0.012	0.020
Mean	0.058	0.097
Maximum	0.320	0.300

[1] There is no aluminum standard for freshwater. The aluminum standard for Class III marine waters is 1.5 mg/l.

The degree to which nitrogen and phosphorus are present can determine the trophic status and amount of algal biomass produced. Excess nutrients increase biological productivity. The major impact associated with nutrient over-enrichment is excessive growth of algae that leads to nuisance algal blooms and eutrophic conditions. A secondary impact is the residual negative effect of decomposing algae in the form of sediment oxygen demand that depletes dissolved oxygen concentrations, particularly in bottom waters.

Nutrient concentrations measured during the monitoring period are presented on Tables 2.3-11 and 2.3-12 in comparison with STORET and NURP data. Nutrient concentrations do not appear to increase with storm event flow; however, since storms produce high flows the resulting increases in masses are significant.

With respect to nutrients, the Spring Branch station had slightly worse water quality than did the Drew Street station with the primary difference being nitrogen forms at each of the station. Higher-than-average levels of inorganic nitrogen levels were recorded at the Drew Street station and higher-than-average organic nitrogen levels were recorded at the Spring Branch station. Ammonia nitrogen often exceeded the state standard during the monitoring period at both stations.

2.3.3.6 Bacteria

Fecal contamination is one of the most severe water quality issues in Stevenson Creek. The magnitude and frequency of fecal counts reported in past monitoring (City of Clearwater 1992-1995)) as well as this current program are very high. The state threshold for ranking a stream in the top ten percent of Florida's worst water quality with respect to fecal coliforms is 960 colony-forming units (CFU) per 100ml. The highest count during this study was 20,000 and previous studies have recorded similarly high counts. The state standard for fecal coliforms in Class III waters is 800 counts per 100 ml.

The University of South Florida Department of Biology accomplished sampling for fecal contamination under a separate monitoring program. A bacterial source tracking

Table 2.3-11

Base Flow Nutrients

Date	Ortho Phosphate (mg/l)	Total Phosphorus (mg/l)	Total Kjeldahl Nitrogen (mg/l)	Nitrate + Nitrite (mg/l)	Organic-N (mg/l)	Ammonia (mg/l)	Total Nitrogen (mg/l)
Stevenson Creek - Drew Street Station							
June 20, 2000	0.45	0.56	1.1	<0.050	1.012	0.088	1.1
July 12, 2000	0.37	0.36	1.8	<0.050	1.66	0.14	1.8
August 3, 2000	0.2	0.27	0.81	0.18	0.719	0.091	0.99
August 23, 2000	0.17	0.21	0.82	0.27	0.732	0.088	1.09
September 13, 2000	0.12	0.21	0.89	0.44	0.74	0.15	1.33
October 12, 2000	0.18	0.38	1.1	0.27	1.062	0.038	1.37
Mean	0.25	0.33	1.09	0.20	0.988	0.10	1.28
WQI	-	74.2	-	70.2	-	-	54.0
Spring Branch - Kings Highway Station							
June 20, 2000	0.56	0.76	1.9	<0.050	1.79	0.11	1.9
July 12, 2000	0.64	0.73	2.1	<0.050	2.1	<0.030	2.1
August 3, 2000	0.26	0.46	0.94	0.36	0.873	0.067	1.3
August 23, 2000	0.23	0.3	1.1	0.068	1.003	0.097	1.168
September 13, 2000	0.17	0.27	1.2	<0.050	1.154	0.046	1.2
October 12, 2000	0.067	0.15	0.89	0.052	0.77	0.12	0.942
Mean	0.32	0.45	1.36	0.093	1.28	0.088	1.44
WQI	-	79.3	-	47.7	-	-	61.8
Frequency of Exceedence in Florida Streams							
STORET-10%	0.02	-	-	0.01	-	-	0.5
Median	0.09	--	-	0.1	-	-	1.2
STORET-90%	0.89	-	-	0.64	-	-	2.7
State Class III Standard		-	-	-	-	<0.02	

Table 2.3-12

Storm Event Nutrients

Date	Ortho Phosphate (mg/l)	Total Phosphorus (mg/l)	Total Kjeldahl Nitrogen (mg/l)	Nitrate + Nitrite (mg/l)	Organic-N (mg/l)	Ammonia (mg/l)	Total Nitrogen (mg/l)
Stevenson Creek - Drew Street Station							
June 30, 2000	0.17	0.22	0.66	<0.050	0.601	0.059	0.66
July 20, 2000	0.1	0.17	0.78	<0.050	0.66	0.12	0.78
July 24, 2000	0.11	0.16	0.88	<0.050	0.59	0.29	0.88
July 31, 2000	0.14	0.3	0.65	0.51	0.592	0.058	1.16
September 13, 2000	0.2	0.26	0.87	0.55	0.833	0.037	1.42
September 17, 2000	0.24	0.49	1.2	0.23	1.146	0.054	1.43
November 15, 2000	0.34	0.57	1.6	0.34	1.569	0.031	1.94
EMC	0.19	0.31	0.95	0.36	0.86	0.09	1.31
Spring Branch - Kings Highway Station							
June 30, 2000	0.29	0.33	0.8	0.055	0.721	0.079	0.855
July 17, 2000	0.21	0.45	1.4	<0.050	1.25	0.15	1.4
July 20, 2000	0.2	0.27	0.93	<0.050	0.82	0.11	0.93
July 31, 2000	0.22	0.35	0.95	0.18	0.79	0.16	1.13
August 23, 2000	0.19	0.36	1.4	0.32	1.316	0.084	1.72
September 17, 2000	0.14	0.41	0.81	0.25	0.7	0.11	1.06
November 15, 2000	0.6	1	2.8	<0.050	2.722	0.078	2.8
EMC	0.26	0.45	1.30	0.14	1.19	0.11	1.41
State Class III Standard		-	-	-	-	<0.02	-
NURP -Nationwide Mean							
Residential	0.143	0.383	1.9	0.736			2.636
Mixed Urban	0.056	0.263	1.288	0.558			1.846
Commercial	0.08	0.201	1.179	0.572			1.751
Tampa Bay NURP							
Minimum	0.02	0.02		0.01	0.18	0.04	0.52
Mean	0.09	0.23		0.34	1.1	0.4	2.0
Maximum	0.22	1.1		0.81	2.7	1.5	3.2

(BST) method was applied to classify the source of fecal matter into three categories – human, dog, and wild animal. The report, which documents the results and findings, is provided in Appendix J.

The source of most of the fecal contamination was identified as wild animal; however, significant human-sourced contamination was also discovered. The presence of fecal coliform bacteria from human sources was particularly evident at sample site STC1 (near the confluence of Spring Branch with the main branch), a site that is surrounded by onsite wastewater treatment and disposal systems (OSTDS). STC2, on Hammond Branch, was also impacted frequently by indicator bacteria from human sources, and is downstream from another cluster of residences serviced by OSTDS.

Some percent of isolates from other sources will misclassify as human isolates-this is true of all BST methodologies. The rate of misclassification of isolates into the human category can be used to develop a cut-off point for significant levels of human isolates. In this database, about 20% of wild animal isolates are misclassified as human, and wild animal isolates have the highest rate of misclassification as human of all sources. The conservative rate of 25% is used as the cut-off point for identification of a significant percentage of isolates from human sources in any sample.

Valerie J. Harwood, a professor at the University of South Florida who conducted the BST study for this project, provided the following description of the significance of fecal coliform in surface waters.

> *The goal of bacteriological water quality testing is, in large part, to identify water that contains human pathogens in order to protect public health. Ideally, water quality testing would reliably identify public health threats, while allowing full use of waters that do not constitute a health threat. This goal has been elusive, in part because of the limitations of the methods we use. It is difficult, time-consuming and expensive to directly quantify disease-causing bacteria and viruses, and virtually impossible to test for all possible pathogens in a water sample. Thus, we quantify indicator bacteria, whose presence more-or-less reflects the probability that there are pathogens in the water. A major problem with the fecal coliform indicator is that it is a poor predictor of some human pathogens, particularly enteric viruses, but can also be present in waters where there are few or no viral, bacterial or protozoan pathogens. The same problem exists when* E. coli, *a member of the fecal coliform group, or* Enterococcus, *a different bacterial group, are used as indicator organisms for water quality.*

> *One of the major reasons that fecal coliforms are inadequate indicators is that they are present in the gastrointestinal tract of all warm-blooded animals and some cold-blooded animals. Some animal feces, i.e. those of humans, cattle, and swine, have a higher probability of containing human pathogens than the feces of most other species, therefore many water quality experts would place contamination from these animals in a "high risk" group. Human feces are considered particularly dangerous because of the human-specific viruses transmitted exclusively by human sources. Very low levels of fecal indicator bacteria from a high-risk animal group indicate a greater potential health hazard than higher levels of indicator bacteria from a low risk animal group. There is, however, no testing method approved by regulatory agencies such as the EPA that can be used to determine the source (i.e. cow, human, dog) of fecal indicator bacteria. Such a method would allow much more accurate risk assessment than we can achieve with standard testing methods. It would also allow regulatory agencies to more effectively identify and eliminate the source of bacterial contamination to natural waters, and would contribute greatly to the accuracy of total maximum daily load (TMDL) models.*
>
> *Due to the history of high fecal coliform numbers in the urban Stevenson Creek watershed in Clearwater, Florida, the City of Clearwater funded a cutting-edge study of the sources of bacteria in this area. Based on land use patterns in the waters studied, one could predict significant fecal inputs from wild animals, particularly birds and raccoons, and from dogs. Other major candidates for fecal coliform contamination in this watershed include onsite wastewater treatment and disposal systems (OSTDS) whose drainfields are not functioning properly, or which have been bypassed. While limited steps can be taken to reduce the amount of dog wastes that enter surface waters, runoff from yards and other surfaces inevitably transports such waste to waters. Contributions from wild animal feces to the watershed are, if anything, more difficult to control than contributions from dogs. It is, however, possible to control the impact of human waste on water quality. Improvements in central sewer systems and OSTDS installations have greatly improved water quality overall in the U.S. since the implementation of the Clean Water Act in 1970. However, continued degradation of water quality in many surface waters, combined with heightened awareness of the dangers of waterborne pathogens, has led to renewed efforts to understand and mitigate the sources of microbial pollution in natural waters.*

2.3.4 Nonpoint Source Loading Model

A nonpoint source loading model was prepared to estimate pollutant loads from Stevenson Creek Watershed. This model uses the EPA Simple Method, which is an event mean concentration (EMC) approach. In this approach, mass loads are calculated as the product of the EMC and the stormwater runoff volume. The stormwater runoff volume is estimated as the fraction of rainfall appearing as runoff multiplied by the basin area. The EMC is constant; thus, this method is also refereed to as the "constant concentration" method.

This loading model is intended to serve as an estimate. The water quality estimating procedures used for this project are very simple, yet water quality estimations by any means are not precise. Dr. Wayne Huber in the EPA SWMM User's Manual expressed this fact very well.

> *Simulation of urban runoff quality is a very inexact science if it can even be called such. Very large uncertainties arise both in the representation of the physical, chemical and biological processes and in the acquisition of data and parameters for model algorithms*

Nevertheless, the loading estimates for the Stevenson Creek Watershed presented herein represent a reasonable estimate that can be used to guide management actions.

The flow and water quality data collected for this project (Section 2.3.2) were used along with soils and land use coverage information to develop the runoff coefficients (Section 2.3.4.1) and EMCs (2.3.4.2); subsequently, this information was used in combination with an existing stormwater treatment evaluation to determine mass loads and loading rates. Additional details concerning the individual elements of the analysis are contained in the following subsections.

2.3.4.1 Runoff Coefficients

Runoff coefficients are based on soils and landuse and represent the fraction of rainfall appearing as runoff. The relationship between rainfall and runoff is, however, not truly linear; thus, each unique rainfall event will have a different runoff coefficient for a given basin. During the dry season less runoff occurs because more water is required to wet the ground surface, and infiltration occurs at a faster rate. This is because there is less soil moisture. Runoff will occur on a pervious surface only if the rainfall rate exceeds the soil infiltration rate. Infiltration rates are lower when the ground is wet and become equal to zero when the ground is saturated.

The runoff coefficients developed for the Stevenson Creek Watershed are intended to represent the fraction of rainfall appearing as runoff for an average year. The vast majority of published runoff coefficients are intended for use in the Rational Formula for peak discharge rate estimation as opposed to runoff volume estimation.

While, by definition, there is no difference between these two types of runoff coefficients (peak rate or flow volume), runoff coefficients used in the Rational formula generally have factors of safety built in. For this reason the runoff coefficients developed for the Stevenson Creek Watershed are generally lower than published runoff coefficients.

The overall runoff coefficients for the monitored basin are 0.29 for the Stevenson Creek Station and 0.27 for the Spring Branch Station. These overall coefficients were calculated using the overall storm event runoff coefficients (Table 2.3-3) for the monitoring period and the overall runoff coefficient for a September 17, 2000 event. Assuming that, in an average year, 60% of the total rainfall depth occurs during the four wet months (June, July, August, and September), the overall coefficients were weighted 60-40 between the "typical wet season event" (September 17, 2000) and the overall monitoring period coefficients. Runoff coefficients developed for this project are shown in Table 2.3-13.

Runoff coefficients for each unique soil-landuse combination were then developed. The weighted average of these coefficients match the calculated overall runoff coefficients which, in turn, are based on the monitoring data; thus, the runoff coefficients are, in a sense, calibrated. Obviously, runoff coefficients for soils/landuse combinations that are well represented in the monitored basins will be more accurate than combinations that are not well represented.

2.3.4.2 Event Mean Concentrations

An EMC is the concentration that has a 50% probability of being exceeded during a storm event; thus, over the course of time, half of the storms will produce concentrations higher than the EMC and half of the storms will produce concentrations lower than the EMC.

Landuse-based EMCs were developed based on a two-step process. In the first step, in-stream EMCs and runoff coefficients were developed using the monitoring data;

Table 2.3-13

Stevenson Creek Watershed Runoff Coefficients

Landuse	Soil	RC
Agricultural	A	0.075
	B/D	0.104
	C	0.133
	D	0.154
	UND	0.098
Commercial	A	0.421
	B/D	0.439
	C	0.457
	D	0.469
	W	1.000
High Density Residential	A	0.421
	B	0.439
	B/D	0.448
	C	0.457
	D	0.469
	W	1.000
Highway/Utility	A	0.347
	B/D	0.367
	C	0.387
	D	0.402
	UND	0.363
	W	1.000
Industrial	A	0.347
	B/D	0.367
	C	0.387
	D	0.402
Institutional	A	0.298
	B/D	0.319
	C	0.341
	D	0.357
	W	1.000
Low Density Residential	A	0.100
	B/D	0.128
	C	0.156
	D	0.177
	W	1.000
Medium Density Residential	A	0.149
	B	0.176
	B/D	0.189
	C	0.202
	D	0.222
	UND	0.170
	W	1.000

Landuse	Soil	RC
Open Land	A	0.075
	B	0.104
	B/D	0.119
	C	0.133
	D	0.154
	W	1.000
Recreational	A	0.124
	B/D	0.152
	C	0.179
	D	0.199
	UND	0.146
	W	1.000
Upland Forest	A	0.050
	B/D	0.080
	C	0.110
	D	0.132
	W	1.000
Water	A	1.000
	B	1.000
	B/D	1.000
	C	1.000
	D	1.000
	W	1.000
Wetland Forest	B/D	0.046
	C	0.110
	D	0.132
	W	1.000
Wetland Non-Forested	B/D	0.046
	C	0.110
	D	0.132
	W	1.000

subsequently, the in-stream EMCs were used to develop landuse-based EMCs. The process used to develop EMCs for this project is described in the following three subsections.

2.3.4.2.1 In-stream EMCs

Statistical analyses were conducted using the storm event monitoring data to develop the in-stream EMCs. EMCs are commonly assumed to follow a lognormal distribution. A normal distribution is the familiar bell-shaped curve. The lognormal distribution is similarly shaped; however, it is the natural log of the data that is distributed symmetrically about the mean rather than the data itself. Studies[1] have shown that a lognormal distribution best represents EMCs. Lognormal distributions are used for many applications when the sample size is relatively small and variations between individual measurements are extreme. As the sample size increases the mean calculated using a lognormal distribution will approach the arithmetic mean.

Table 2.3-14
In-Stream EMCs

Paramete	Spring Branch EMC (mg/l)	Stevenson Creek EMC (mg/l)
Pb	0.006	0.004
Zn	0.079	0.030
BOD5	15.350	12.190
TSS	25.129	18.260
TP	0.452	0.310
TN	1.412	1.310

In-stream EMCs for the Stevenson Creek and Spring Branch Stations are shown in Table 2.3-14.

2.3.4.2.2 Existing Stormwater Runoff Treatment

Exiting stormwater treatment areas are present in the Stevenson Creek Watershed. These treatment areas consist of permitted dry retention and wet detention pond as well as natural lakes and man-made depressional storage areas. The general locations of these treatment areas are shown on Figure 2.3-11 inside the subbasin in which they are contained. Assumptions used in this evaluation of existing treatment are as follows:

Figure 2.3-11

Existing Stormwater Treatment Areas

- ***Treatment depth***. Permitted stormwater treatment areas are assumed to provide one inch of treatment for wet detention areas and one-half inch of treatment for dry retention areas. This is consistent with SWFWMD and City of Clearwater design criteria for stormwater treatment areas. Lakes and other "natural" BMPs are assumed to provide a maximum treatment depth of one inch adjusted downward based on the ratio of the BMP area to the tributary basin. This results in a treatment depth range of 0.01 to 1 inch. BMP efficiencies equal to one-half those for wet detention were applied and adjusted by the estimated treatment depth.

- ***Treatment Coverage***. Water is treated only once. In other words water from a BMP (BMP A) which drains to a downstream basin that also contains a BMP (BMP B) is not treated again in BMP B. This assumption simplified the analysis and is rational for a number of reasons. First, most permitted BMPs do not receive runoff from offsite basins and, instead, drain directly to the primary storm sewer system. Second, BMPs in-line to the main storm sewer system will fill with water from the nearest areas first. Subsequent flows will either bypass treatment or reduce the treatment efficiency; therefore, it is reasonable to assume that these flows will not be treated. Treatment coverage is illustrated on Figure 2.3-12.

BMP efficiencies (Table 2.3-15) are based on literature values and adjusted for agreement with measurements taken during the monitoring program.

Table 2.3-15

BMP Maximum Efficiencies

Parameter	Wet Detention	Dry Retention	Natural Treatment
Pb	**75%**	80%	0.38
Zn	**60%**	80%	0.3
BOD5	**50%**	80%	0.25
TSS	**75%**	80%	0.38
TP	**60%**	80%	0.3
TN	**30%**	80%	0.15

Figure 2.3-12
Treatment Coverage

2.3.4.2.3 Landuse-Based EMCs

Landuse-based EMCs were developed based on the measured in-stream EMCs. The process used to develop EMCs was to vary estimates of landuse-based EMCs until agreement with recorded data as well as agreement between the two monitoring stations was achieved. This process was performed mindful of literature values of EMCs so that individual EMC values were not assigned outside of a reasonable range.

The results agree well with the recorded data at the Stevenson Creek Station; however, lead, zinc, BOD and TSS estimates agree less well with measured values at the Spring Branch Station. Obviously, land use variation alone cannot precisely account for variations in water quality from one location to the next; nevertheless, landuse-based EMCs can provide good wash-off quality estimates- both the strengths and the shortcomings of landuse-based EMCs are apparent in the Stevenson Creek Watershed water quality monitoring data.

EMC combinations that “made the numbers work” were found for lead, zinc, BOD, and TSS; however, these EMC combinations produced EMC values that were not reasonable for the land uses. The “true EMC” may not have been measured because of the limited number of samples that were collected. Another possible explanation for the difference is sediment re-suspension in Byrum Sump. The Spring Branch Station is located just downstream of Byrum Sump and it is likely that re-suspended sediments made up significant portions of the samples at this location. This would explain the elevated TSS levels as well as lead and zinc levels. There is normally a correlation between TSS and metals concentrations in stormwater runoff; furthermore, since lead and zinc tend to accumulate in sediments, higher levels could be expected in storm flow as well as base flow.

The landuse-based EMCs are presented in Table 2.3-16 along with the percent variation from measured values at each station. Table 2.3-17 provides a listing of some of the literature values used for reference in this study.

Table 2.3-16

Landuse-Based EMCs for Stevenson Creek Watershed[1]

LAND USE	Pb	Zn	BOD_5	TSS	TP	TN
Agricultural	0.004	0.029	15.36	27.64	0.96	1.27
Commercial	0.006	0.044	14.68	38.36	0.40	1.37
High Density Residential	0.013	0.147	20.49	51.41	1.14	2.35
Highway/Utility	0.029	0.138	20.49	40.80	0.32	1.35
Institutional	0.006	0.044	6.83	35.91	0.43	0.97
Industrial	0.004	0.081	12.29	51.14	0.43	1.16
Low Density Residential	0.001	0.009	11.52	7.75	0.25	1.14
Medium Density Residential	0.001	0.011	14.72	11.02	0.28	1.48
Open Land	0.001	0.010	10.67	5.98	0.10	0.81
Recreational	0.001	0.007	1.71	5.98	0.10	0.81
Natural Areas	0.001	0.002	7.68	2.72	0.18	1.03
Water	0.001	0.002	2.73	0.82	0.10	0.81

Agreement with Monitoring Data[2]						
Monitoring Station	**Pb**	**Zn**	**BOD_5**	**TSS**	**TP**	**TN**
Stevenson Creek	0%	0%	0%	0%	0%	0%
Spring Branch	32%	43%	21%	24%	11%	1%

[1] All concentrations in mg/l

[2] Percent difference between measured loads and calculated loads using landuse-based EMCs.

Table 2.3-17

Landuse-Based EMCs – Selected Literature Values[1]

NURP Median						
LAND USE	Pb	Zn	BOD_5	TSS	TP	TN
Residential	0.1440	0.1350	10	101	0.383	2.636
Mixed Urban	0.1140	0.1540	7.8	67	0.263	1.846
Commercial	0.1040	0.2260	9.3	70	0.201	1.751

Stormwater Loading Rate Parameters for Central and South Florida						
LAND-USE	Pb	Zn	BOD5	TSS	TP	TN
General Agricultural	-	-	3.80	55.30	0.344	2.32
Commercial-High Intensity	0.2140	0.1700	17.20	94.00	0.430	2.83
Multi-Family	0.0870	0.0550	11.00	71.70	0.490	2.42
Highway	0.1890	0.1340	5.60	50.30	0.340	2.08
Industrial	0.2020	0.1220	9.60	93.90	0.310	1.79
Low Density Residential	0.0370	0.0320	4.40	19.10	0.177	1.77
Single Family	0.0480	0.0570	7.40	27.00	0.300	2.29
Open Land/Recreational	0.0250	0.0060	1.45	11.10	0.053	1.25
Water	0.0250	0.0280	1.60	3.10	0.110	1.25
Wetland	0.0250	0.0060	4.63	10.20	0.190	1.6

Hillsborough County						
LAND-USE	PB	ZN	BOD5	TSS	TP	TN
Agricultural	0.003	0.017	18.30	12.70	2.349	2.97
Commercial	0.004	0.026	2.67	22.92	0.279	2.032
High Density Residential	0.006	0.058	2.60	29.00	1.337	2.047
Highway/Utility	0.960	0.410	24.00	261.00	0.120	4.13
Institutional	0.004	0.026	2.67	22.92	0.279	2.032
Light Industrial	0.006	0.096	2.87	18.20	0.332	2.275
Low/Medium Density Residential	0.008	0.022	1.00	19.00	0.401	1.363
Open Land	0.001	0.006	3.80	11.10	0.050	2.598
Recreational	0.006	0.004	3.80	11.10	0.050	2.598
Upland Forest	0.000	0.000	0.00	0.00	0.000	0
Water	0.000	0.000	0.00	0.00	0.000	0
Wetland Forest	0.000	0.000	0.00	0.00	0.000	0
Wetland Non-Forested	0.000	0.000	0.00	0.00	0.000	0

[1] All concentrations in mg/l

2.3.4.3 Results

Mass loads are divided into three parts: Gross load, removed load, and net load. These three types of loads are described as follows:

- Gross Load - The mass washed off, or mass generated.
- Removed Load - The mass removed by BMPS.
- Net Load - Gross load minus removed load.

Load totals are provided on Table 2.3-18 and presented visually in terms of loading rate (lb./ac) on Figures 2.3-13 through 2.3-16. Additional details concerning the results of the nonpoint source loading analysis are provided in Appendix K.

These loading estimates are intended to represent an average year. The annual rainfall used for these calculations was 55.6 inches – this is based on the average annual rainfall depth reported by the SCS in the Pinellas County Soil Survey. According to the "constant concentration" method which was used (refer to Table 2.3.4.2), load estimates for other years (or time periods) could be made by multiplying the loads presented here by the ratio of rainfall, for the period of interest, to 55.6.

The highest load totals were calculated for the Upper Spring basin. Upper Spring basin is also the largest in terms of area; therefore, this result can be misleading. A better indicator of "hot spots" is loading rate, or pound per acre (refer to Figures 2.3-13 to 2.3-16). Reviewing the results from a loading rate perspective shows the Middle Stevenson basin to have the worst stormwater runoff quality. For example, the net load of TSS originating from Upper Spring Branch is 108,743 pounds per year, and the net TSS loading rate is 65 pounds per acre per year. For Middle Stevenson Creek the net annual load of TSS is estimated at 59,604 pounds and the net TSS loading rate is 111 pounds per acre per year – a smaller load than Upper Spring Branch but a higher loading rate. The Middle Stevenson basin has an abundance of the three factors that cause high loads – soils with low infiltration rates, intense developed land use, and lack of treatment.

Table 2.3-18

Major Basin Loads

Watershed	Pb	Zn	BOD_5	COD	TSS	TP	TN
Gross Load (pounds per year)							
Hammond Branch	10	80	36,441	46,777	903	3,861	10
Jeffords Street	5	38	26,273	29,436	574	2,790	5
Lake Belleview	15	118	37,515	73,482	1,080	3,903	15
Lower Spring	4	36	17,527	22,031	451	1,831	4
Lower Stevenson	11	75	33,941	49,546	817	3,715	11
Middle Stevenson	13	104	31,534	61,338	903	3,172	13
Upper Spring	36	325	84,074	147,929	2,907	9,021	36
Upper Stevenson	6	49	26,642	33,141	633	2,704	6
Total	100	826	293,948	463,680	8,269	30,997	100
Load Removed (pounds per year)							
Hammond Branch	1	9	3,049	6,362	104	236	1
Jeffords Street	1	5	2,889	4,090	74	208	1
Lake Belleview	5	27	8,861	24,454	274	554	5
Lower Spring	1	8	2,250	4,379	78	188	1
Lower Stevenson	-	-	-	-	-	-	-
Middle Stevenson	0	2	678	1,734	19	68	0
Upper Spring	10	71	15,068	39,186	607	1,048	10
Upper Stevenson	1	6	1,781	4,936	48	101	1
Total	20	128	34,576	85,142	1,205	2,403	20
Net Load (pounds per year)							
Hammond Branch	9	71	33,393	40,415	799	3,625	9
Jeffords Street	4	34	23,384	25,345	500	2,582	4
Lake Belleview	10	90	28,654	49,028	807	3,349	10
Lower Spring	3	29	15,277	17,651	373	1,644	3
Lower Stevenson	11	75	33,941	49,546	817	3,715	11
Middle Stevenson	13	102	30,856	59,604	884	3,104	13
Upper Spring	25	254	69,006	108,743	2,300	7,974	25
Upper Stevenson	4	43	24,861	28,205	585	2,603	4
Total	80	697	259,372	378,538	7,064	28,594	80