Middle Hillsborough River: Water Levels, Water Quality and Water Management

February 13, 2009 Draft

Southwest Florida Water Management District

Douglas A. Leeper
Chief Environmental Scientist
Ecologic Evaluation Section
Resource Projects Department

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On the Cover: Aerial photograph of the lower end of the middle Hillsborough River and the City of Tampa Dam (South west Florida Water Management District files).

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Chapter 1

Introduction

At the request of the City of Temple Terrace River Watch Task Force, the District has completed a study of the middle segment of Hillsborough River. For the study, and presentation of study findings in this report, the middle Hillsborough River is defined as the segment of the Hillsborough River that extends from the City of Tampa Dam to the bridge at Fletcher Avenue. The portion of the Harney Canal between the river and District water control Structure S-161, as well as the portion of Cow House Creek downstream from District Structure S-163 are also considered part of the middle river.

The study included review of the history of the middle river, with emphasis on the impoundment of the river and other water management activities, an analysis of water level fluctuations in the river segment as compared to other Florida water bodies, development of a new bathymetric data set for characterization of river segment morphology, an evaluation of the applicability of the District's Water Levels and Rates of Flow rules (Chapter 40D-8, Florida Administrative Code or F.A.C.) as they pertain to the establishment of minimum flows and levels for the middle river, and a summary examination of water quality in the river segment.

Chapter 2

Middle Hillsborough River Setting and Description

Location

The middle segment of the Hillsborough River is located in central Hillsborough County, Florida, in the Hillsborough River Basin of the Southwest Florida Water Management District (Figure 2-1). As defined for this report, the "middle" river consists of the segment of the Hillsborough River from the City of Tampa Dam upstream to the point where Fletcher Avenue crosses the river (Figure 2-2). The portion of the Harney Canal between the river and District water control Structure S-161, as well as the portion of Cow House Creek downstream from District Structure S-163 are also considered part of the middle river. For the purpose of this report, river segments upstream and downstream from the middle river are designated as the "upper" and "lower" Hillsborough River, respectively. The City of Tampa Dam is situated approximately 10 miles upstream from the mouth of the river, and the Fletcher Avenue bridge is approximately 12.1 miles upstream from the dam. Other bridges span the river segment, including those associated with 40th Street, 56th Street, Harney Road, Bullard Parkway and Fowler Avenue. The middle river extends over portions of Sections 11-14, 20, 22-24, 26-29, 32 and 33, Township 28 South, Range 19 East. The shore of the river segment abuts portions of the City of Tampa, the City of Temple Terrace and unincorporated Hillsborough County.

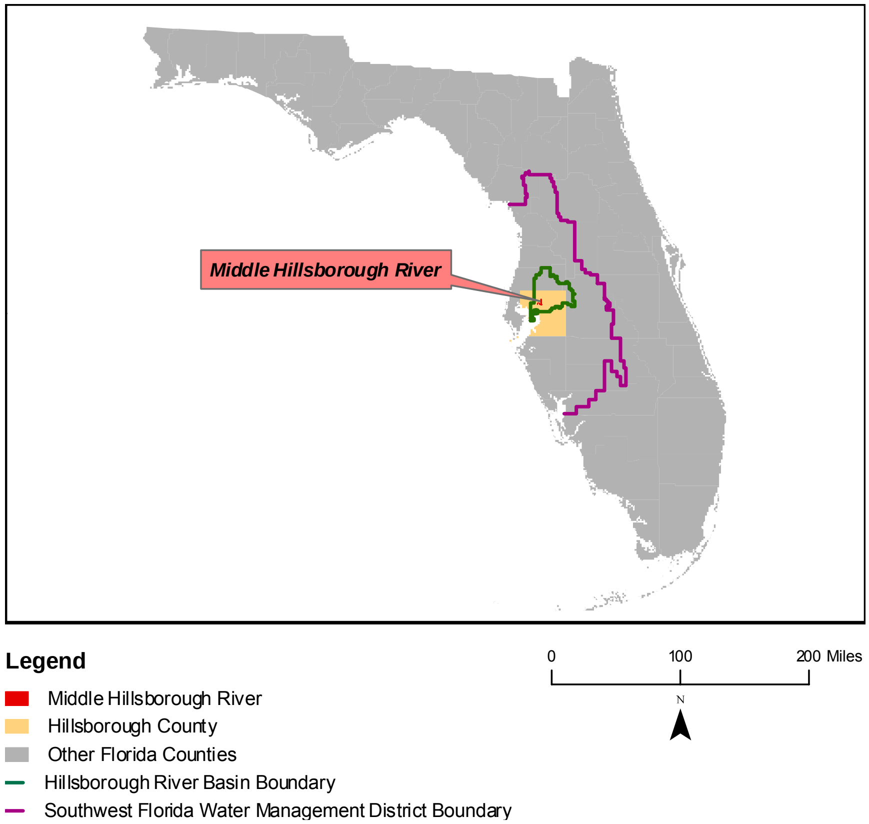


Figure 2-1. Location of the middle Hillsborough River in Hillsborough County. Boundaries of the Southwest Florida Water Management District and the Hillsborough River Basin of the District are also shown (image sources: Southwest Florida Water Management District 2003d, i, 2004e).

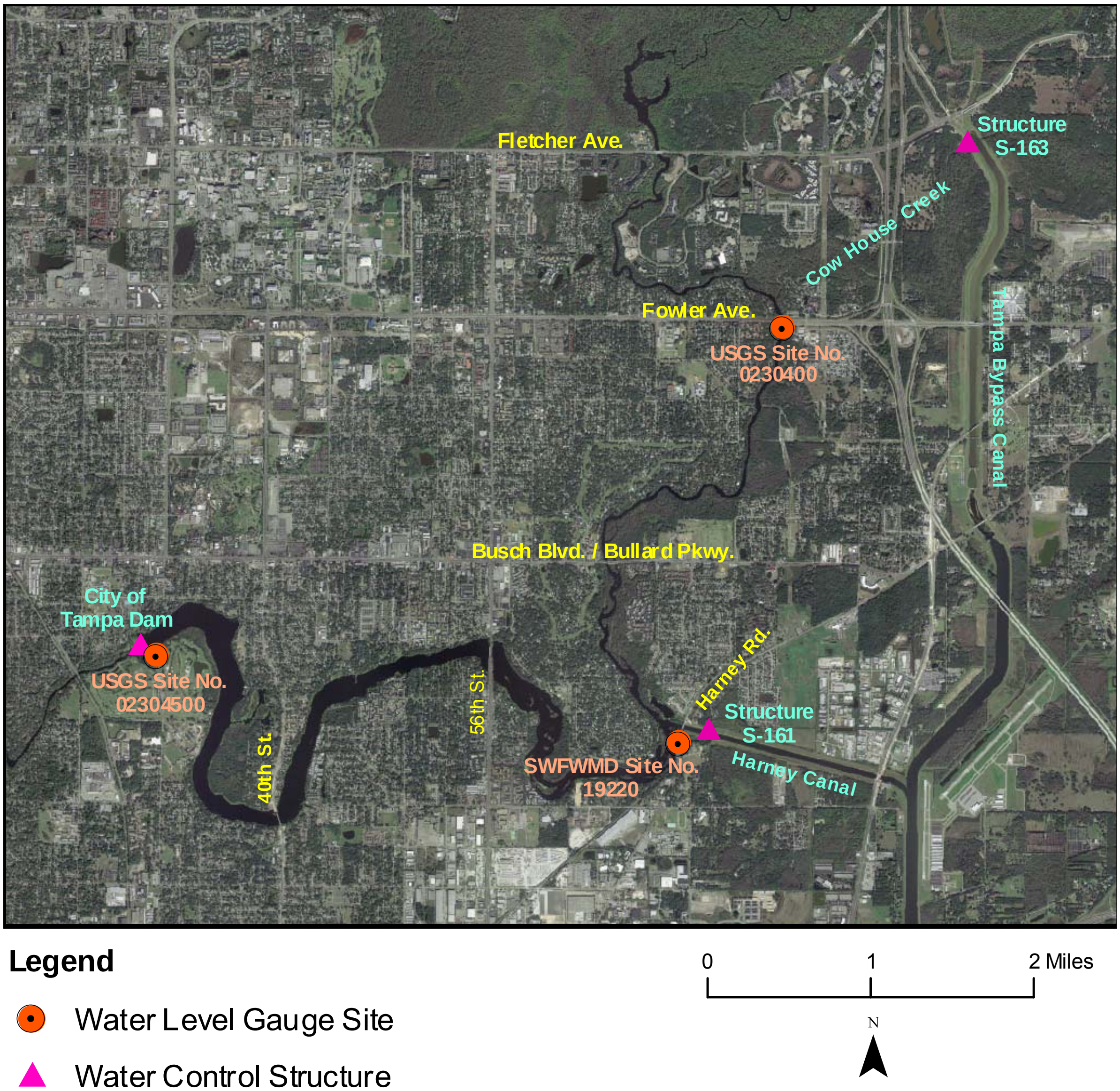


Figure 2-2. Aerial photograph of the middle Hillsborough River, which is defined for this report as the segment of the Hillsborough River from the City of Tampa Dam upstream to the bridge at Fletcher Avenue, the portion of the Harney Canal between the river and District water control Structure S-161, and the portion of Cow House Creek downstream from District Structure S-163. Locations of current United States Geological Survey and Southwest Florida Water Management District water level gauge sites in the river segment and the names of all roads with bridges crossing the middle river are shown (photographic image source: Fugro EarthData, Inc. 2007).

Physiography and Watershed Description

White (1970) classified the region of central or mid-peninsular Florida containing the middle Hillsborough River as the Western Valley physiographic region. Brooks (1981) categorized the area as the Hillsborough Valley of the Tampa Plain in the Ocala Uplift Physiographic District, and described the region as "an erosional basin that is the watershed of the Hillsborough River" where "[s]luggish surface drainage still is dominant, but there are many karst features…in which much of the surficial clastic sediments has been removed". He also notes that "[e]xcept for the relief in the headwaters, a considerable portion [of the watershed] is best termed a plain." As part of the Florida Department of Environmental Protection's Lake Bioassessment/ Regionalization Initiative, Grifith *et al.* (1997) note that few lakes occur within the lake region containing the middle river. Among area lakes that may drain to the river, Lake Thonotosassa, an 819 acre lake in Hillsborough County, is the largest.

The middle Hillsborough River lies within the Hillsborough River drainage basin of the Hillsborough River watershed (Figure 2-3), which includes portions of northeastern Hillsborough County, central Pasco County and northwestern Polk County. The river originates in eastern Pasco County in the Green Swamp, a large area of flatlands and swamps that also includes the headwaters of the Oklawaha, Peace and Withlacoochee Rivers.

The watershed area above the City of Tampa Dam extends over 624 square miles (United States Geological Survey 2007). Previous estimates ascribe an area of approximately 650 square miles to the watershed above the dam (Turner 1974, Goetz *et al*. 1978, Foose 1981, Knutilla and Corral 1984, Kane and Dickman 2005). Area estimates for the middle river watershed are confounded by significant alterations to natural drainage patterns within the region, including the Tampa Bypass Canal, which is an excavated drainage system developed to minimize flooding in the cities of Temple Terrace and Tampa. The canal system is used to divert high flows from the river to the McKay Bay portion of Tampa Bay.

Tributaries to the Hillsborough River upstream of the middle river include Cypress Creek, Trout Creek, Flint Creek, New River, Big Ditch, and Blackwater Creek. The Crystal Springs group, which includes a second-magnitude spring and several smaller springs with a long-term spring flow or discharge of approximately 40 million gallons per day (Champion and Starks 2001), occur along the Hillsborough River approximately 20 miles upstream from the middle river, and contribute much of the river flow during seasonal low-flow periods.

In addition to upstream inflow from the Hillsborough River, direct inputs to the middle river include precipitation on inundated areas of the river channel, runoff and storm-water drainage from immediately adjacent upland areas, inflow from Cow House Creek, groundwater discharge from Temple Terrace Spring, and water pumped from the Harney Canal/Tampa Bypass Canal system and Sulphur Springs (Figure 2-4). Cow House Creek enters the middle river approximately 9.9 miles upstream of the dam

(~ 700 feet upstream from the Fowler Avenue bridge). Temple Terrace Spring, a fifth magnitude spring located approximately 8.0 miles upstream of the dam (~0.7 miles upstream of the Bullard Parkway bridge), reportedly discharges approximately 75 gallons/min (or 0.1 million gallons per day) into the river (Stewart and Mills1984). Pumping of water from Sulphur Springs and the Harney Canal/Tampa Bypass Canal system into the middle river is considered augmentation, and may be implemented when water supply demand exceeds inflow from the upper Hillsborough River. Sulphur Springs is an artesian spring system that discharges to the Hillsborough River approximately 2.1 miles downstream from the City of Tampa Dam. Water pumped from the spring is introduced to the middle river a short distance upstream from the dam and is also discharged below the dam to address Minimum Flows and Levels compliance for the lower Hillsborough River. The Harney Canal, a component of the Tampa Bypass Canal system, connects the Tampa Bypass Canal to the middle river approximately 6.0 miles upstream from the dam. Augmentation of the middle river with water from the Harney Canal/Tampa Bypass Canal is achieved by the pumping of water across the District's water control structure S-161, which is located in the Harney Canal.

Discharge from the middle river occurs primarily through releases over the City of Tampa Dam to the lower Hillsborough River and secondarily through Structure S-161 on the Harney Canal to the Tampa Bypass Canal. Release of water at the City of Tampa Dam is coordinated to mitigate for potential flooding and for management of the middle river as a water-supply. Water released over the dam courses through the lower river to the northeast arm of Tampa Bay known as Hillsborough Bay. Releases at the dam are frequently minimized to promote storage of water within the middle river for direct withdrawal by the City of Tampa. These withdrawals occur at a the City of Tampa David L Tippin Water Treatment Facility located approximately 1.4 miles upstream from the dam. Discharge from the middle river through Structure S-161 is also controlled for flood mitigation and water supply purposes. For flood mitigation, water may be released to the canal system and ultimately discharged to McKay Bay. For water supply purposes, water released to the canal system is made available for withdrawal from the canal by Tampa Bay Water.

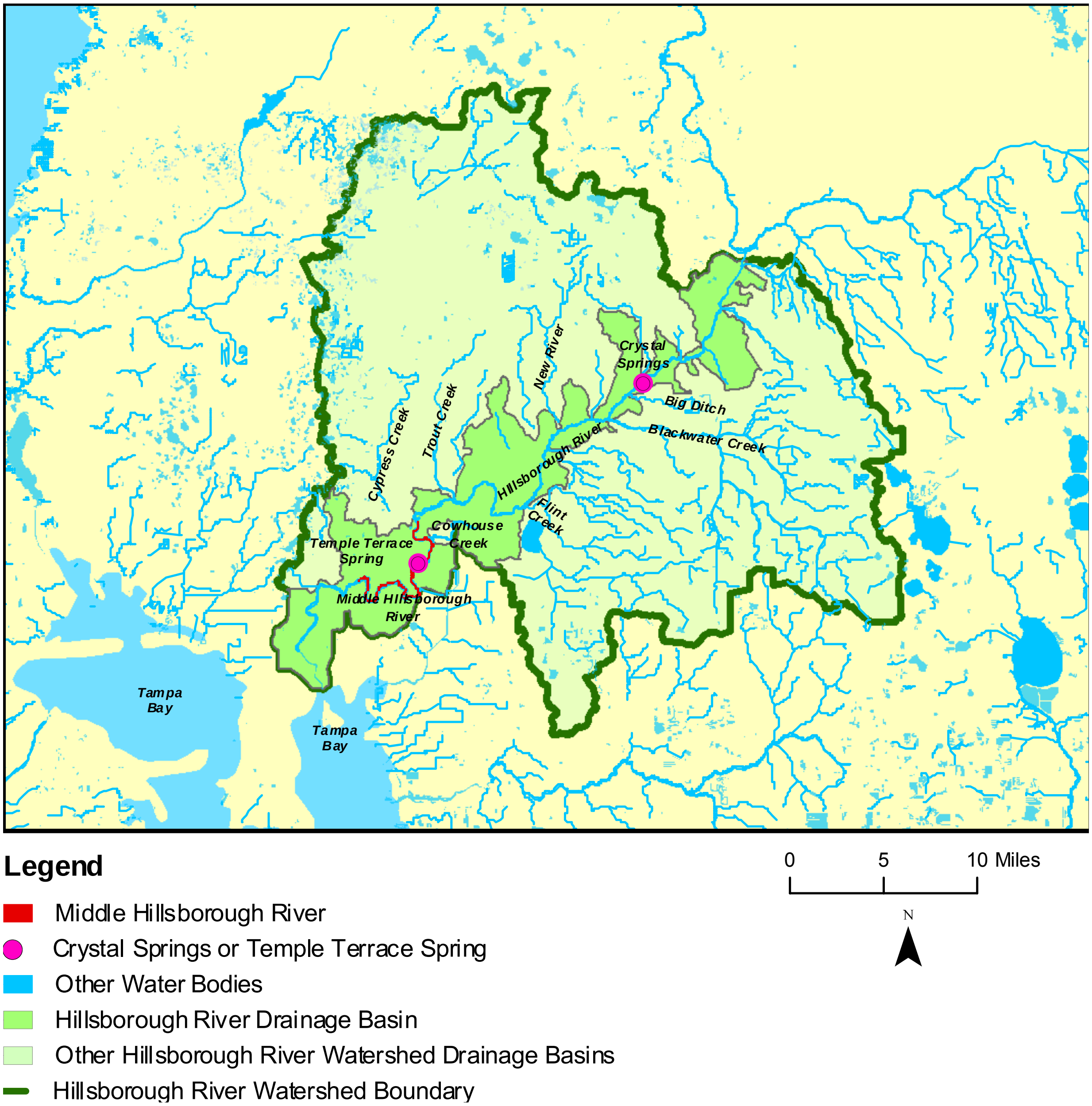


Figure 2-3. Location of the middle Hillsborough River within the Hillsborough River Drainage Basin of the Hillsborough River Watershed as delineated by the United States Geological Survey. Springs and major tributaries within the watershed are labeled along with Tampa Bay, which is the receiving water body for watershed drainage. For this report segments of the Hillsborough River up and downstream from the middle river are referred to as the "upper" and "lower" Hillsborough River (image sources: Southwest Florida Water Management District 2003b, c, e, f and Florida Department of Environmental Protection 2004a and b).

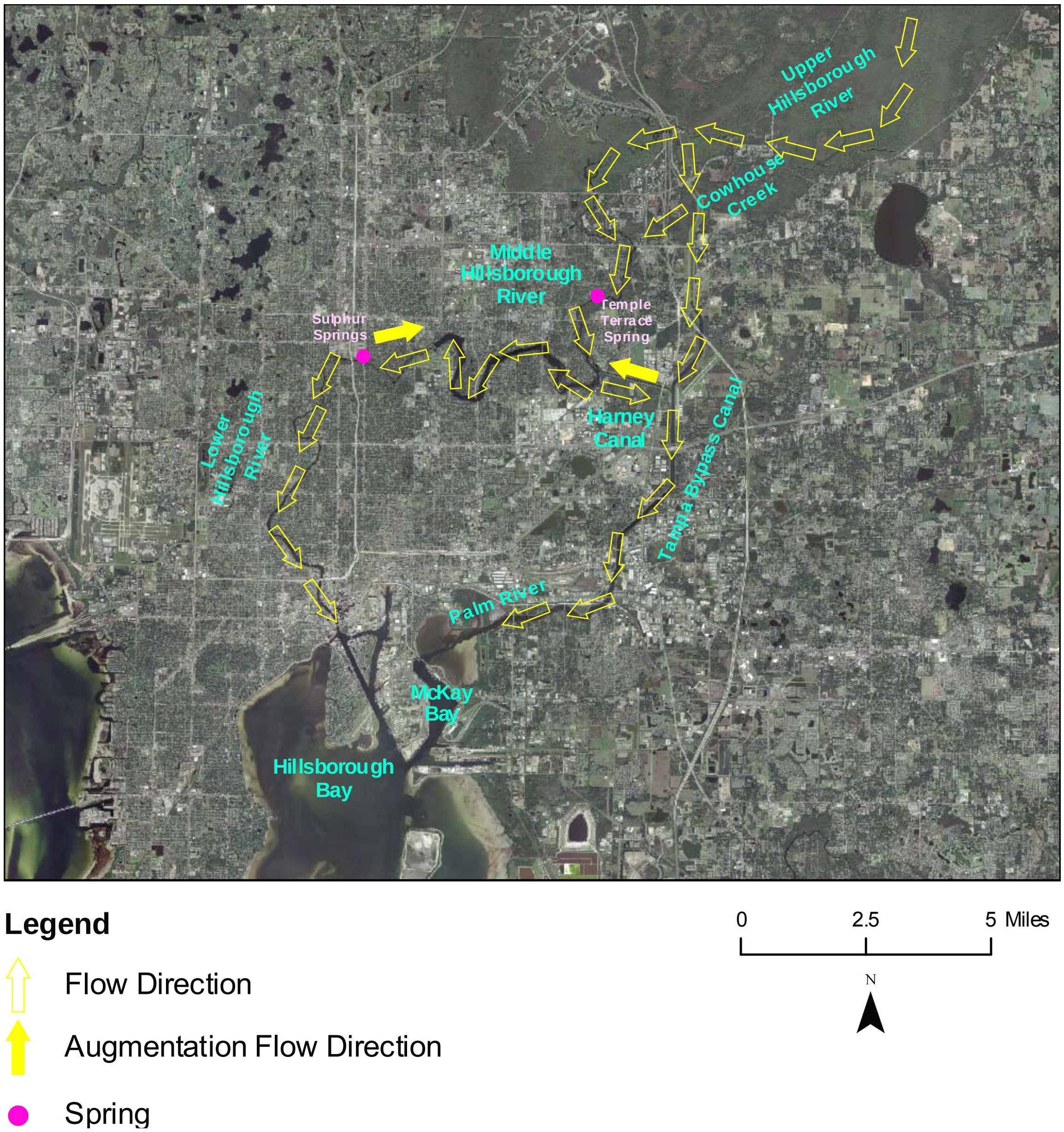


Figure 2-4. Surface water inflow and outflow patterns for the middle Hillsborough River and Tampa Bypass/Harney Canal system and location of springs that discharge directly into or are used for augmentation of the river segment. Augmentation flows are those associated with pumping of water from the Harney Canal or Sulphur Springs into the middle river (photographic image source: Fugro EarthData, Inc. 2007).

City of Tampa Dam and Middle River Characteristics

The City of Tampa Dam (Figure 2-5) extends approximately 520 feet across the Hillsborough River channel or valley at a point approximately 10 miles from mouth of the river. The dam includes fifteen 25-foot wide high-crested bays and two 20-foot wide low-crested bays with power-operated radial drop or lift Tainter gates (Figure 2-66; see cover photograph also). The gates may be used impound water behind the dam up to an elevation of 22.5 feet above the National Geodetic Vertical Datum of 1929 (NGVD29) or draw the impounded pool down to 12.0 feet above NGVD29 (City of Tampa 2008).

Goetz *et al.* (1978), Wolansky and Thompson (1987) and the Southwest Florida Water Management District (1999a) report that the dam allows storage or impoundment of water in the river channel upstream to Fletcher Avenue, and note that this corresponds to a linear distance of approximately 12.5 miles along the river course. In contrast, Turner (1974) reports that the "Tampa Reservoir" extends about 6 miles upstream from the dam and notes that "effects of [dam] regulation are detectable as far upstream as Temple Terrace Highway, a distance of nearly 7 miles above the Tampa Dam". Cited by personal communication in a 1999 Southwest Florida Water Management District report, Richard Gant notes that the "Hillsborough River Reservoir" extends 4 miles upstream from the City of Tampa Dam. Measurements of the length of the middle river based on current geographic information databases available from the District indicate that the river winds 12.1 miles from the dam to Fletcher Avenue.

Figure 2-5. Aerial photographs of the City of Tampa Dam on the Hillsborough River. Upper photograph is from 2000, date unknown for the lower photograph (Southwest Florida Water Management District files).

Figure 2-6. Upstream (upper panel) and downstream (lower panel) views of the City of Tampa Dam in 2008 (Southwest Florida Water Management District files).

The 1969 and 1984 photorevised 1954 United States Geological Survey 1:24,000 Sulphur Springs quadrangle 7.5 minute topographic maps include an elevation of 20 feet above mean sea level (mean sea level is approximately 0 feet above NGVD29) for the middle river surface at the spillway (see Figures 2-7 and 2-8). The "Gazetteer of Florida Lakes" (Florida Board of Conservation 1969, Shafer *et al.* 1986) includes a surface area of 320 acres for the "City of Tampa Waterworks", based on planimetry of the inundated area shown on United States Geological Survey topographic maps. A small number of data sets and studies have been developed or undertaken to describe relationships between water level, *i.e.,* stage, in the middle river and the inundated area and volume of water impounded upstream from the City of Tampa Dam. These morphometric data and studies are briefly summarized in subsequent paragraphs of this report along with a description of a new data set that was generated in support of the current District study of the middle river.

The United States Geological Survey published a stage-volume relationship (Figure 2-9) for the middle river in the mid-1970s based on channel geometry measured at an estimated 48 channel cross sections (Goetz *et al.* 1978). A river bed profile from the City of Tampa Dam to Fletcher Avenue (Figure 2-10) developed from the cross sections indicates that there are several relatively deep spots in the river segment, which Goetz *et al.* (1978) presumed to be sinkholes. The deepest hole extended down to 12 feet below sea level. Numerous ledges or river bed regions with relatively high elevation were also identified as part of the study, with elevations ranging up to 15.5 feet above mean sea level. Goetz *et al.* (1978) estimate that 2.15 billion gallons would be impounded upstream from the dam when the middle river is staged at 22.5 feet above mean sea level, and indicate that 2 billion gallons of this volume would be available for withdrawal at the City of Tampa Water Treatment Plant near the dam. The approximate 150 million gallon difference between these two estimates represents water that would remain pooled upstream of ledges in the river segment during low water periods, and is referred to as "dead storage". They also estimate that 1.3 and 0.7 billion gallons would be available for withdrawal when the river segment is, respectively, staged at 20 and 16.8 feet above mean sea level.

The City of Tampa has also developed a stage-volume data set for estimating water storage in the middle river. According to information provided by Brian Pickard, a Process Engineer with the City of Tampa Water Department (personal communication), the data were developed by Dames and Moore (1989; note: document was not available for review) and are based on updated information obtained originally by Heidt and Associates, Inc. The data set addresses the stage-volume relationships for the impounded river from the City of Tampa Dam upstream to Fowler Avenue, a portion of the Harney Canal (presumably the region that is downstream from District water control structure S-161, and an area referred to as the Harney retention pond. These data, which are reproduced in graphical (Figure 2-11) and tabular (Table 2-1) form for this report, indicate that the identified river segment contains 1.7 billion gallons of water when the impounded water is staged at an elevation of 22.5 feet above mean sea level. This estimate is approximately 0.45 billion gallons less than the volume estimated by Goetz *et al.* (1978) for the larger impounded area (upstream to Fletcher Avenue) at the same water elevation. The estimated water volume at a lower pool of 20 feet above mean sea level based on the data set provided by the City of Tampa is 1.2 billion gallons, a value more similar to the estimated 1.3 billion gallons made by Goetz *et al.* for the same elevation. A graphical representation of the stage-area-volume relationships based on data developed by the City of Tampa Water Department and Environmental Science and Engineers, Inc. is provided in Environmental Science and Engineers, Inc. (1987) and is reproduced for this report (Figure 2-12) to support summarization of all known stage-area-volume data sets for the middle river.

As part of the development of minimum flows for the lower Hillsborough River, the District (X.Chen, unpublished 1997 Southwest Florida Water Management District report) modified the City of Tampa's stage-volume data set for the middle river by including volume and area estimates for the system up to a pool of 25.0 feet above NGVD29 (Figure 2-13, Table 2-2). Area estimates ranged from 175 to 712 acres for stages ranging from 12 to 25 feet above NGVD29. At 22.5 feet above NGVD29, the area covered by water impounded upstream of the dam was estimated at 680 acres.

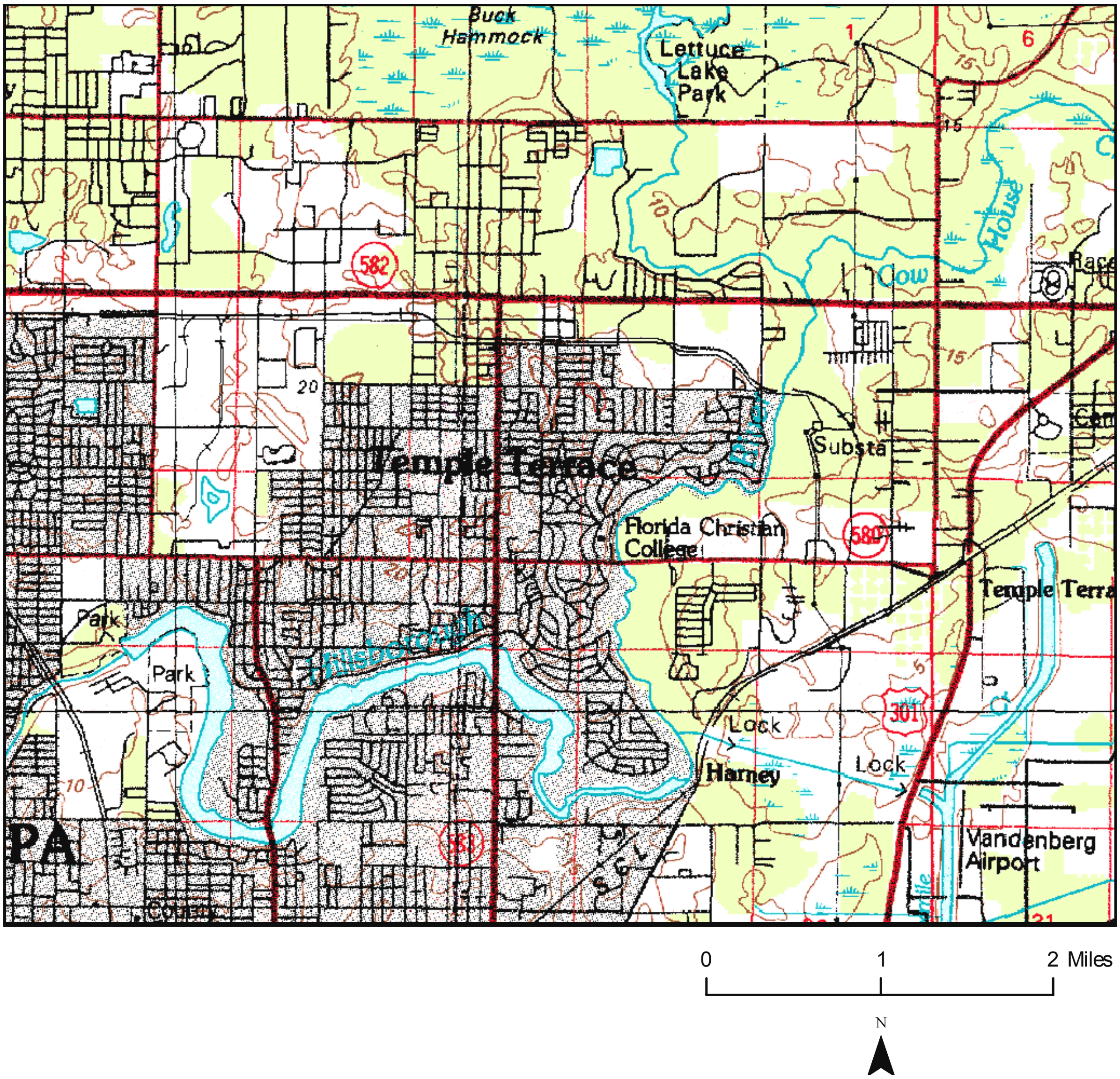


Figure 2-7. United States Geological Survey hydrography in the vicinity of the middle Hillsborough River (image source: Southwest Florida Water Management District 2002d).

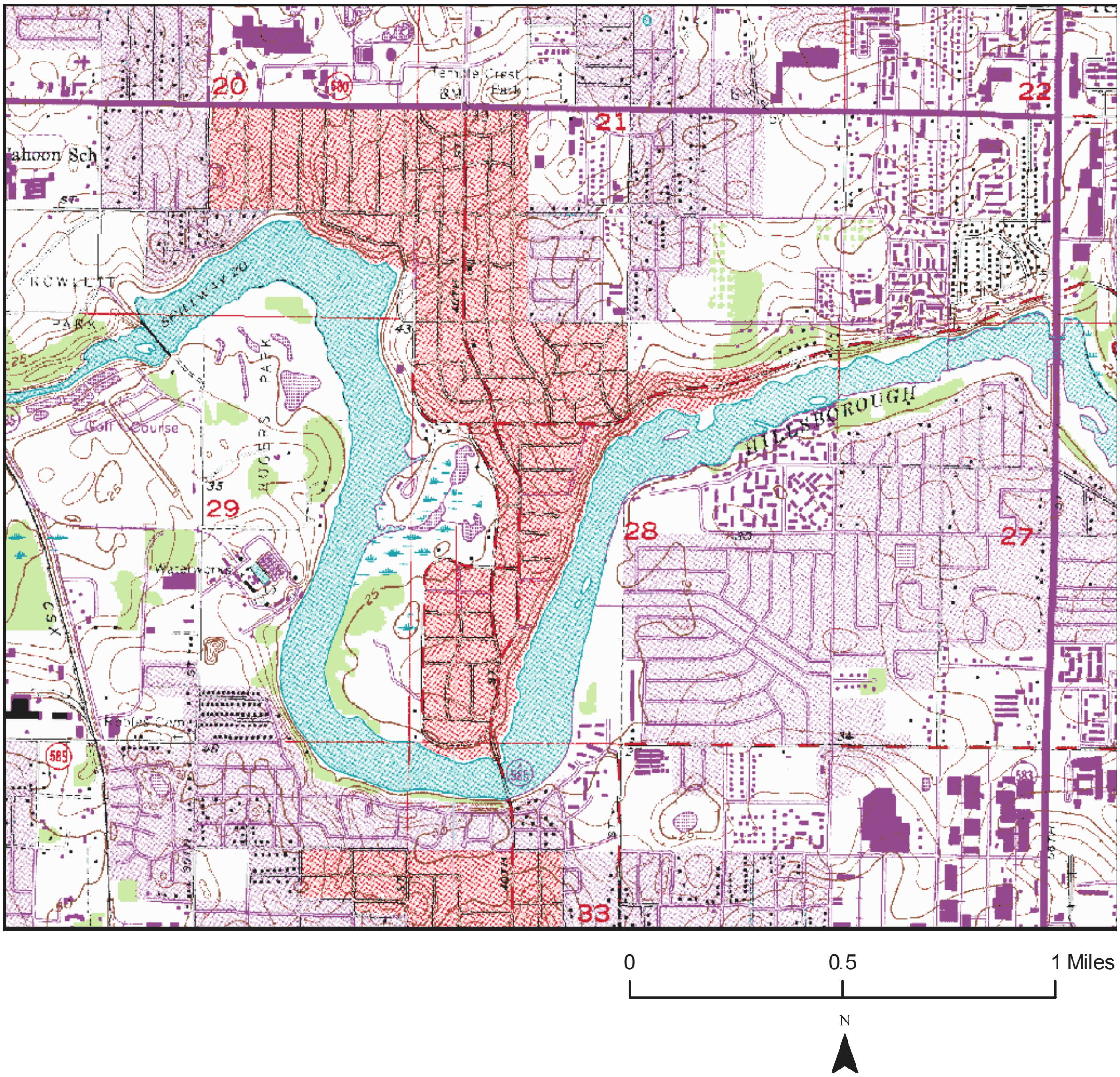


Figure 2-8. United States Geological Survey hydrography and five-foot elevation contours (feet above NGVD29) in the vicinity of the City of Tampa Dam on the Hillsborough River (image source: Southwest Florida Water Management District 2002c).

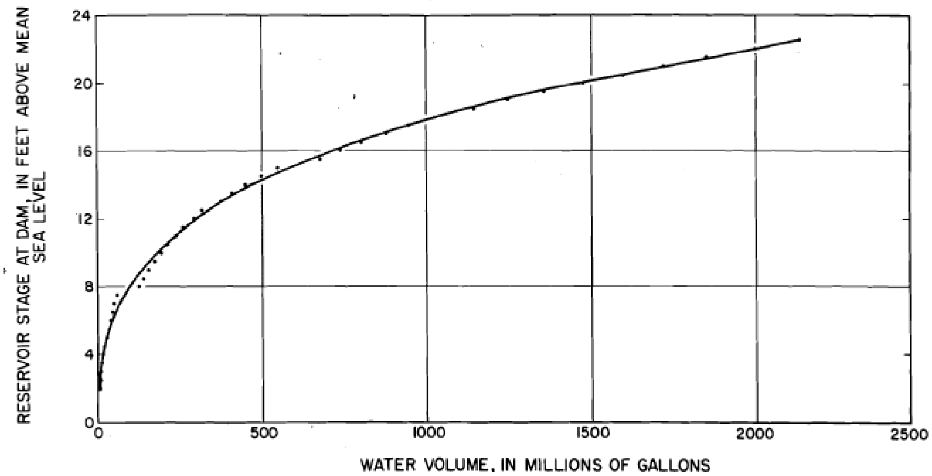


Figure 2-9. Stage-volume relationship developed by the United States Geological Survey for the middle Hillsborough River, from the City of Tampa Dam to Fletcher Avenue. Figure reproduced from Goetz, *et al.* (1978).

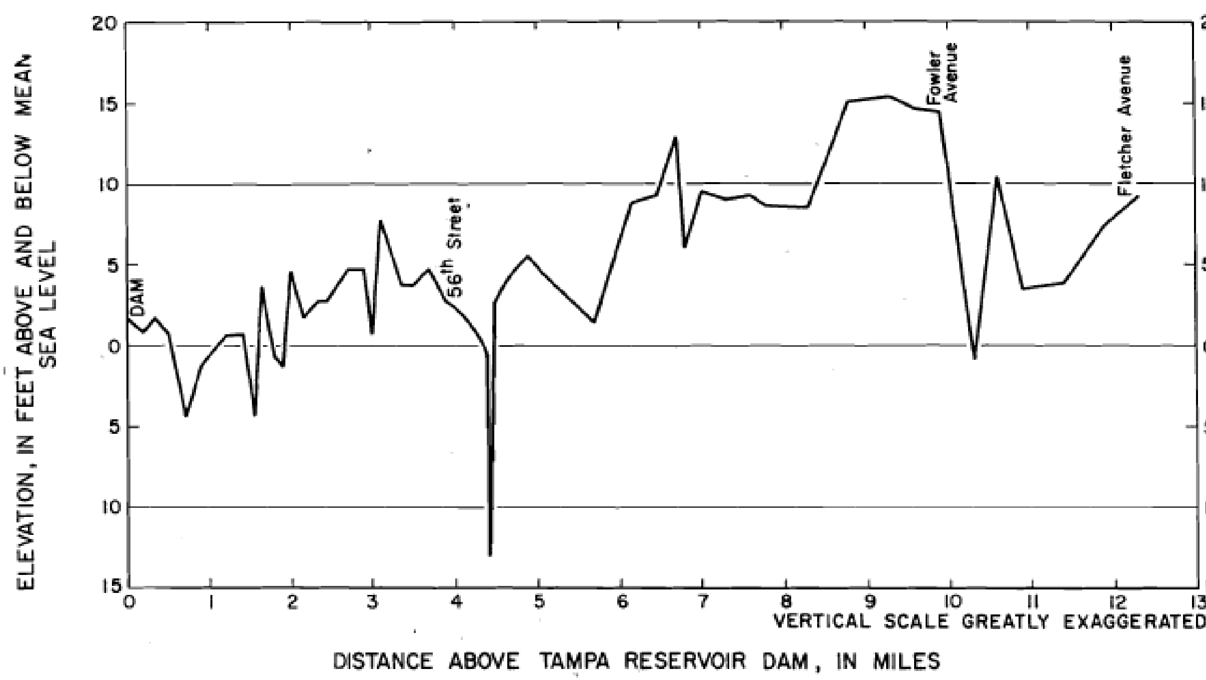


Figure 2-10. River bed elevation profile of the middle Hillsborough River developed by the United States Geological Survey. Figure reproduced from Goetz, *et al.* (1978).

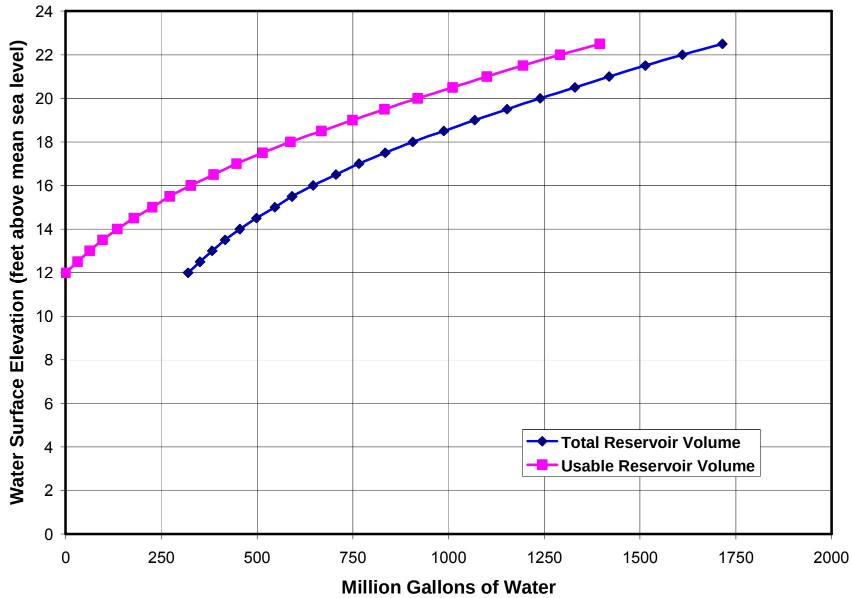


Figure 2-11. Stage-volume relationships developed by the City or Tampa for the portion of the middle Hillsborough River from the City of Tampa Dam to Fowler Avenue. Figure based on data provided by Brian Pickard (personal communication).

Table 2-1. Stage-volume data developed by the City of Tampa for various portions of the middle Hillsborough River. Data provided by Brian Pickard (personal communication).

Water Surface Elevation (feet above mean sea level	Volume (million gallons)						
	Dam to 40th Street	40th Street to 56th Street	56th Street to Fowler Ave.	Harney Canal	Harney Retention Pond	Total Volume	Usable Volume
22.5	535,000,000	455,571,004	687,476,902	26,261,212	10,607,222	1,714,916,340	1,395,188,946
22.0	509,000,000	432,807,018	634,325,046	25,067,796	9,304,726	1,610,504,586	1,290,777,192
21.5	485,000,000	410,202,410	586,843,330	23,884,480	8,045,256	1,513,975,476	1,194,248,082
21.0	460,000,000	387,728,496	542,184,564	22,720,758	6,842,548	1,419,476,366	1,099,748,972
19.5	436,000,000	365,394,164	501,347,436	21,576,832	5,700,036	1,330,018,468	1,010,291,074
19.0	413,000,000	343,237,794	457,796,438	20,453,914	4,624,992	1,239,113,138	919,385,744
18.5	390,000,000	321,287,868	418,518,548	19,352,408	3,638,424	1,152,797,248	833,069,854
18.0	367,000,000	299,612,864	380,885,342	18,269,688	2,777,298	1,068,545,192	748,817,798
17.5	345,000,000	278,325,902	345,638,362	17,202,724	1,503,890	987,670,878	667,943,484
17.0	323,000,000	257,501,722	309,242,002	16,151,516	995,860	906,891,100	587,163,706
16.5	302,000,000	237,112,246	279,467,808	15,115,458	743,158	834,438,670	514,711,276
16.0	281,000,000	217,449,566	253,330,018	14,092,530	238,562	766,110,676	446,383,282
15.5	262,000,000	198,737,902	232,309,292	13,082,328	72,720	706,202,242	386,474,848
15.0	242,000,000	181,299,552	211,297,565	12,084,650	6,666	646,688,433	326,961,039
14.5	224,000,000	164,909,568	191,699,010	11,102,526		591,711,104	271,983,710
14.0	207,000,000	149,866,830	179,467,506	10,192,718		546,527,054	226,799,660
13.5	190,000,000	136,335,860	162,600,304	9,394,414		498,330,578	178,603,184
13.0	175,000,000	124,365,744	146,999,036	8,643,176		455,007,956	135,280,562
12.5	161,000,000	113,891,034	133,481,398	7,921,834		416,294,266	96,566,872
12.0	148,000,000	104,633,172	123,003,860	7,243,316		382,880,348	63,152,954

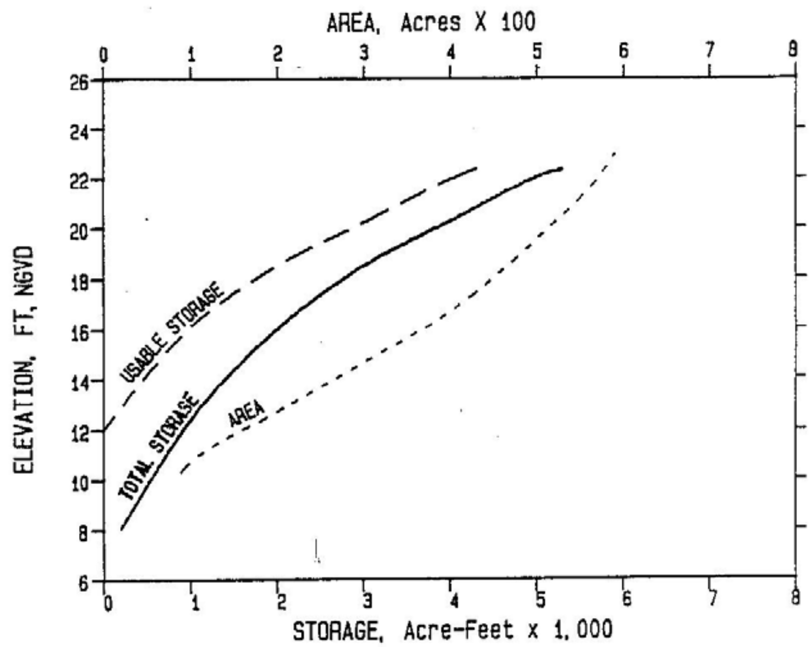
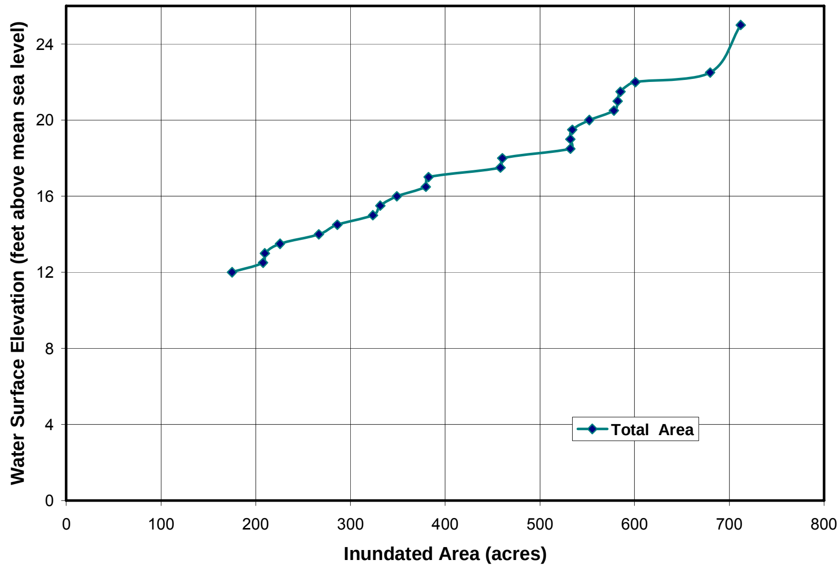


Figure 2-12. Stage-area-volume relationships developed by Environmental Science and Engineering, Inc. for an undefined portion of the middle Hillsborough River. Figure reproduced from Environmental Science and Engineering, Inc. (1987).



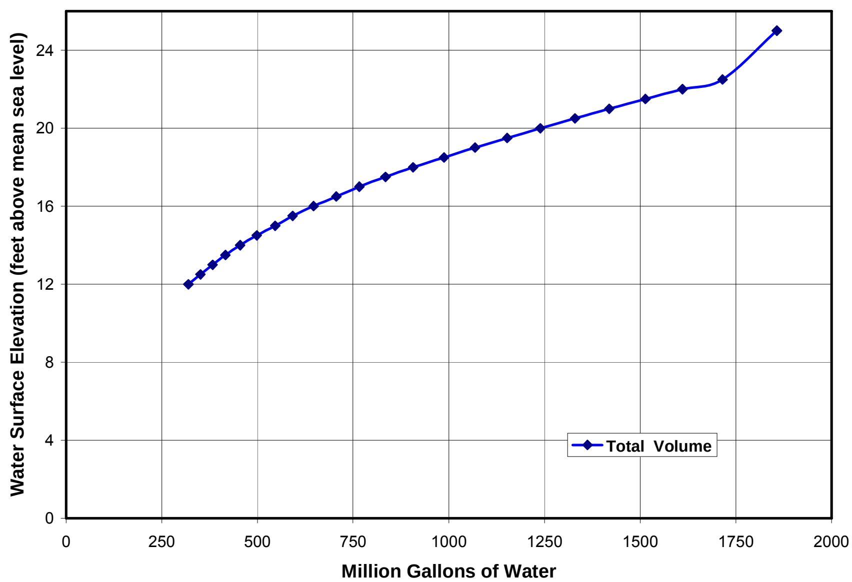


Figure 2-13. Stage-area-volume relationships for the middle Hillsborough River, developed by the Southwest Florida Water Management District for use in a model supporting development of minimum flows for the lower Hillsborough River. Figure based on data provided by the City of Tampa and modified by X.Chen (draft Southwest Florida Water Management District report) to reflect volume estimate associated with a stage of 25 feet above NGVD29.

Table 2-2. Stage-area-volume-area data for a portion of the middle Hillsborough River, developed by the Southwest Florida Water Management District for use in a model supporting development of minimum flows for the lower Hillsborough River. Data developed by X. Chen (draft Southwest Florida Water Management District report) based on data provided by the City of Tampa.

Water Surface Elevation (ft above NGVD29)	Inundated Area Dam to Fowler Avenue (acres)	Volume Dam to Fowler Avenue (gallons)
25	712.0	1,857,350,700
22.5	679.7	1,715,194,943
22	600.9	1,610,613,064
21.5	585.1	1,514,079,706
21	582.2	1,419,573,140
20.5	578.2	1,330,107,489
20	552.2	1,239,198,319
19.5	534.1	1,152,877,131
19	532.2	1,068,618,579
18.5	532.2	987,739,102
18	460.3	906,954,122
17.5	458.4	834,494,635
17	382.5	766,163,681
16.5	379.6	706,249,457
16	349.2	646,732,772
15.5	331.5	591,751,933
15	323.9	546,562,916
14.5	286.2	498,363,036
14	266.7	455,037,887
13.5	225.6	416,323,530
13	209.8	382,907,510
12.5	207.8	351,052,316
12	175.0	319,747,811

To support understanding and management of the middle Hillsborough River, the District has recently developed a new bathymetric/topographic data set for the river segment. The data set was created using surveyed river bottom cross section and channel profile elevations collected in 2008 for the Southwest Florida Water Management District by the University of South Florida, and spot and contour elevation data for the segment obtained from District aerial photography maps from the 1970s or 1980s. The surveyed elevation data (Wang and Black 2008) were collected using a Real-Time Kinematics global positioning system and a survey-grade Odom echo sounder mounted on a pontoon or jon boat. River bottom elevations were measured for areas accessible by the watercraft when the river segment water level was approximately 21.5 feet above NGVD29. Elevations were measured near the shoreline (including islands), along the approximate centerline of the river channel and at a total of 252 channel cross sections in the river segment from the City of Tampa Dam upstream to the District water control structure S-155, which is located approximately 730 feet upstream from the Interstate Highway 75 bridge that crosses the river. Spot and contour elevation data for areas not accessible by boat and typically at higher elevations than the data collected with the global positioning system/echo sounder equipment, were digitized from georeferenced District aerial photography with contours maps using ESRI® ArcMap™ 9.2. Digitized data were included in an area bounded by a 25 feet above NGVD29 contour for the river segment from the dam upstream to Fletcher Avenue. The portion of the Harney Canal upstream to the District water control structure S-161 was included along with the portion of Cow House Creek downstream from District water control structure S-163. Elevation data for a few small portions of the middle river were not available or incomplete. Data limitations included a lack of elevations below 23 feet above NGVD29 for a dredged canal connected to the west shore of the river approximately 0.45 miles upstream from the 40th Street bridge and a back-water area along the west river shore adjacent to and approximately 600 feet upstream from the Bullard Parkway bridge. Elevations lower than 23 or 24 feet above NGVD29 were also not available for portions of the Cow House Creek channel.

Data processing of the bathymetric data set with ArcMap included creation of a triangulated integrated network (TIN) of the river segment ground and river bottom elevations (Figures 2-14 through 2-20) and development of elevation contour data files from the TIN. The data set used for TIN development was modified by truncating digitized river segment contours at the City of Tampa Dam, at the Fletcher Avenue bridge and at the location of the District water control structures on the Harney Canal and Cow House Creek. Contours were truncated at these locations, as they represent boundaries of the mapped area. Minor modifications were also made to a few digitized elevation contours to improve correspondence between the digitized contours and the recently collected survey data and current aerial photography of the river segment. Area and volume estimates were developed from the TIN for various water levels in the river using a modified Python file (Multivolumes) to iteratively run the surface volume function in the ArcMap 3D-Analyst tool. Elevation contour data sets based on selected contour intervals (*e.g.*, one-foot and two-foot intervals) were also developed to visualize river segment bathymetry/topography.

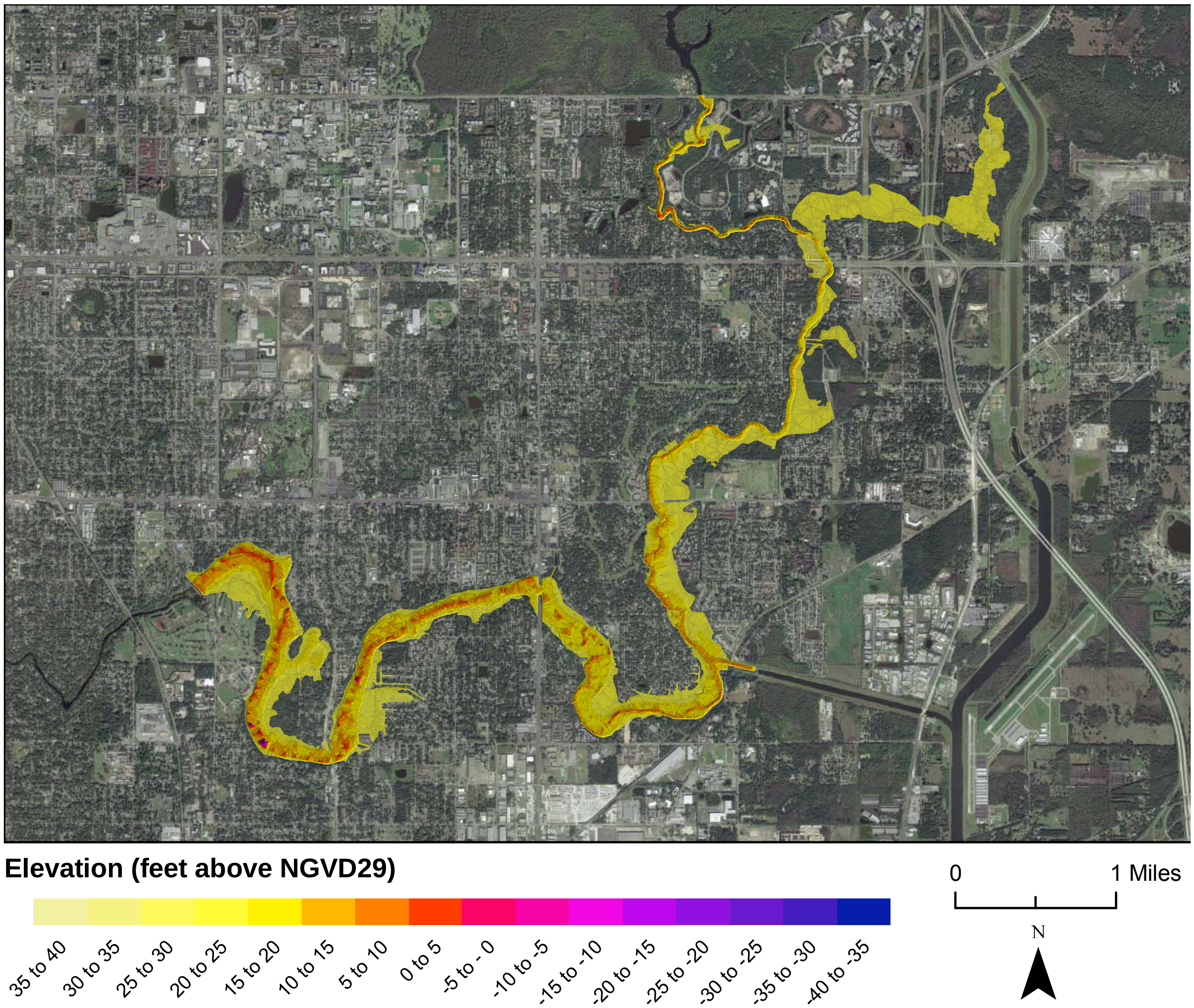


Figure 2-14. Triangulated Integrated Network (TIN) showing ground and river bottom elevations (feet above NGVD29) of the middle Hillsborough River area bounded by a 25 feet above NGVD29 contour surrounding the river segment (photographic image source: Fugra EarthData, Inc. 2007).

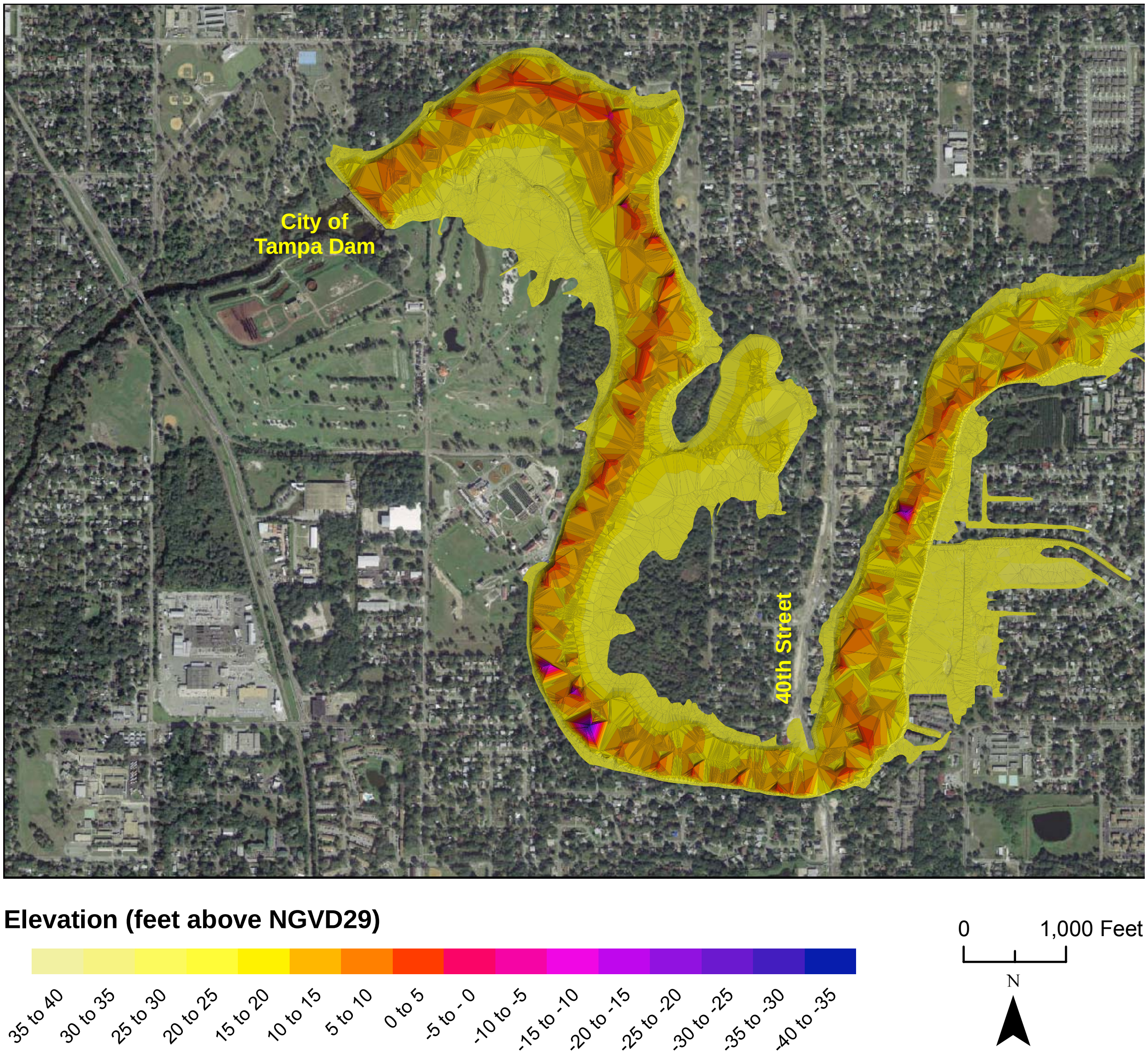


Figure 2-15. Triangulated Integrated Network (TIN) showing ground and river bottom elevations (feet above NGVD29) of the middle Hillsborough River from the City of Tampa Dam to 40th Street (photographic image source: Fugra EarthData, Inc. 2007).

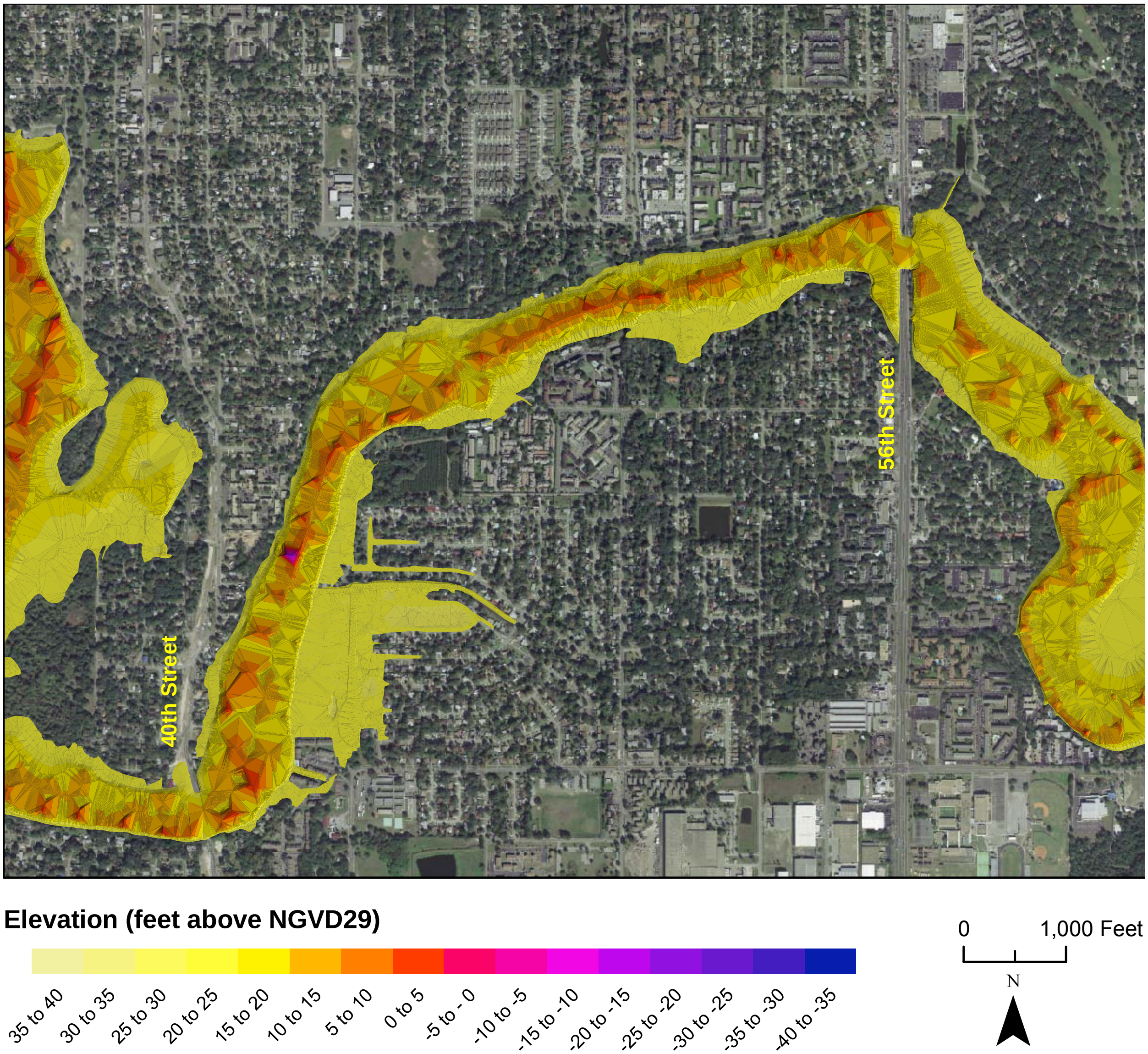


Figure 2-16. Triangulated Integrated Network (TIN) showing ground and river bottom elevations (feet above NGVD29) of the middle Hillsborough River from 40th Street to 56th Street (photographic image source: Fugra EarthData, Inc. 2007).

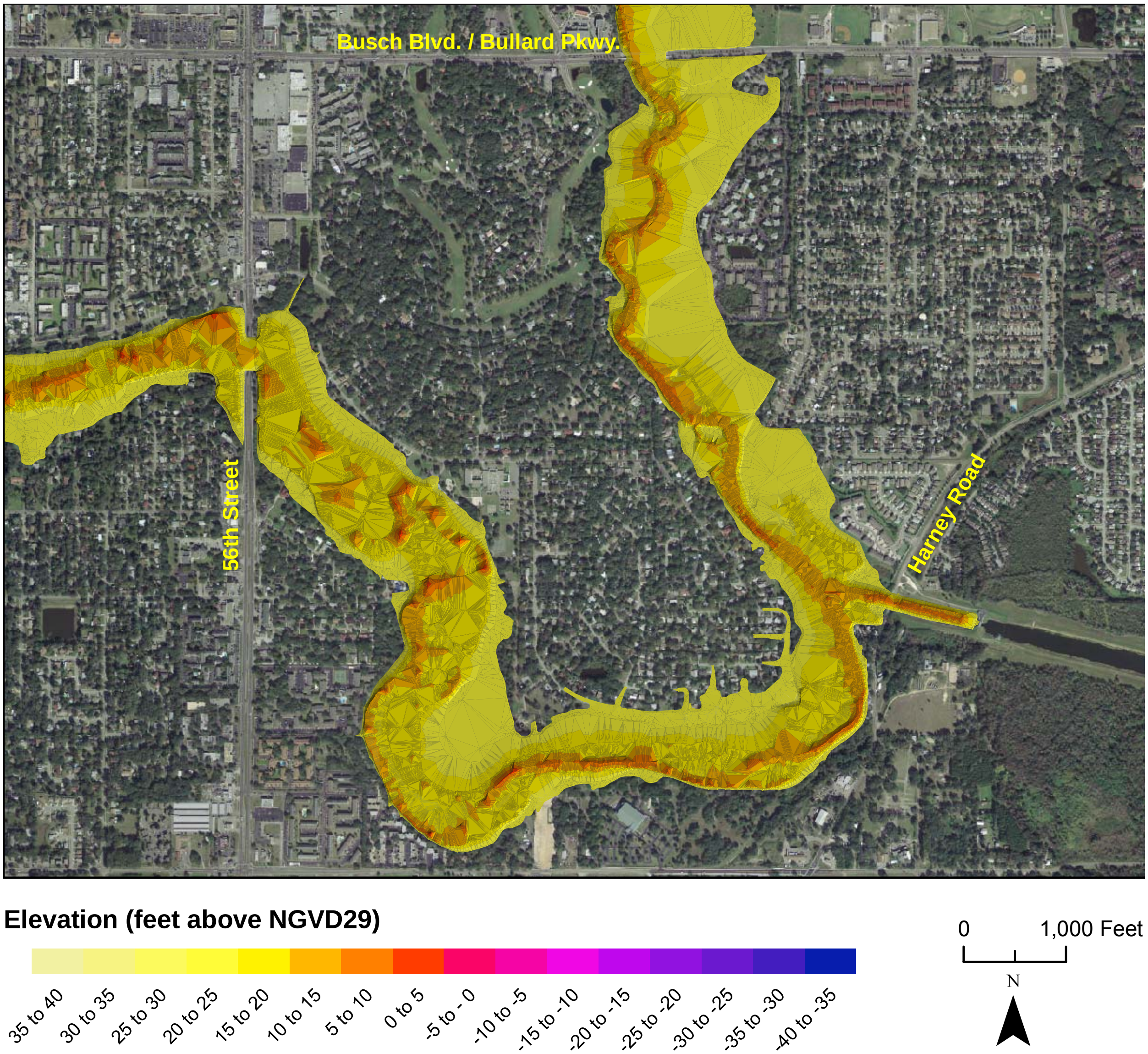


Figure 2-17. Triangulated Integrated Network (TIN) showing ground and river bottom elevations (feet above NGVD29) of the middle Hillsborough River from 56th Street to Busch Boulevard/Bullard Parkway (photographic image source: Fugra EarthData, Inc. 2007).

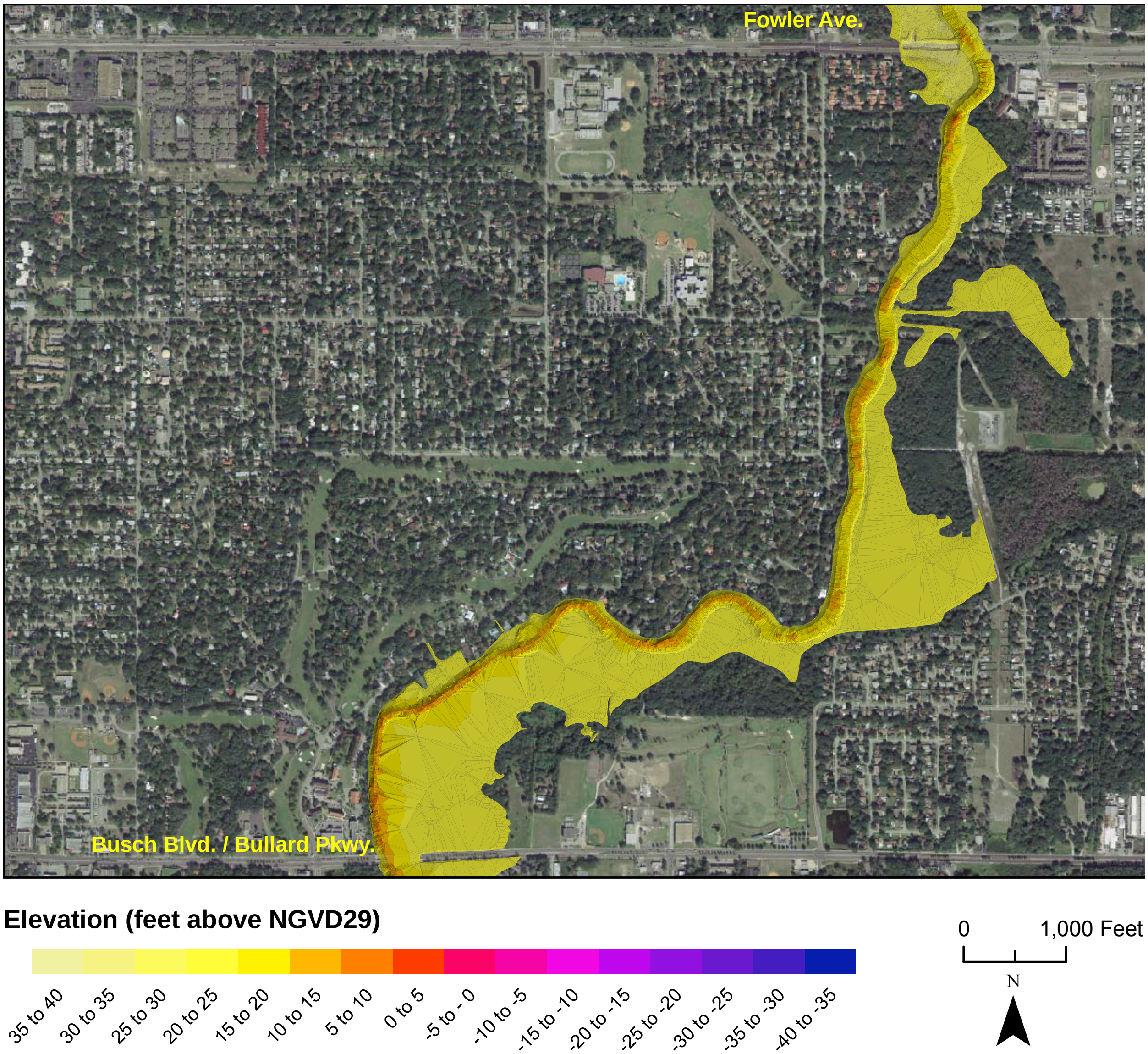


Figure 2-18. Triangulated Integrated Network (TIN) showing ground and river bottom elevations (feet above NGVD29) of the middle Hillsborough River from Busch Boulevard/Bullard Parkway to Fowler Avenue (photographic image source: Fugra EarthData, Inc. 2007).

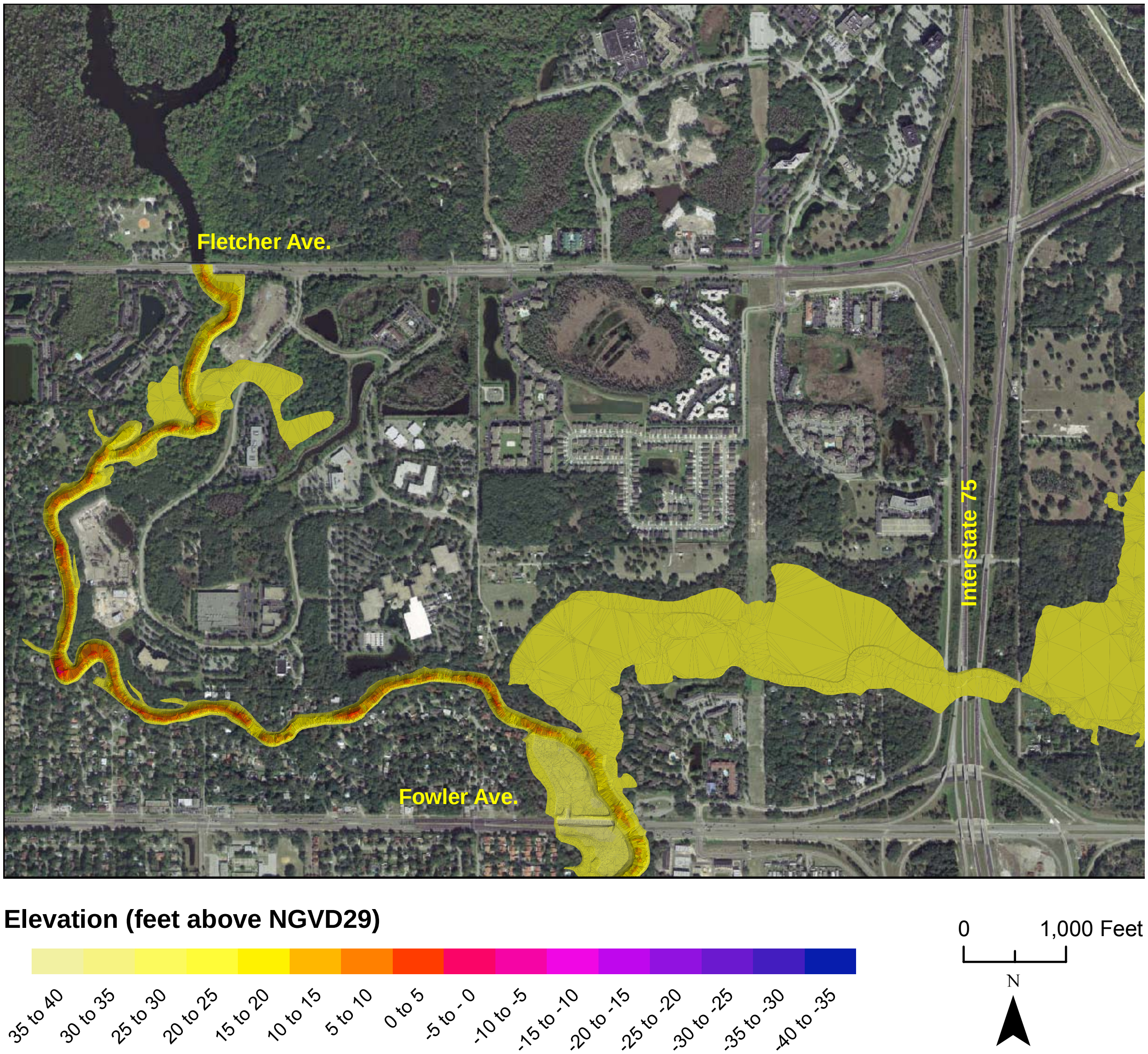


Figure 2-19. Triangulated Integrated Network (TIN) showing ground and river bottom elevations (feet above NGVD29) of the middle Hillsborough River from Fowler Avenue to Fletcher Avenue (photographic image source: Fugra EarthData, Inc. 2007).

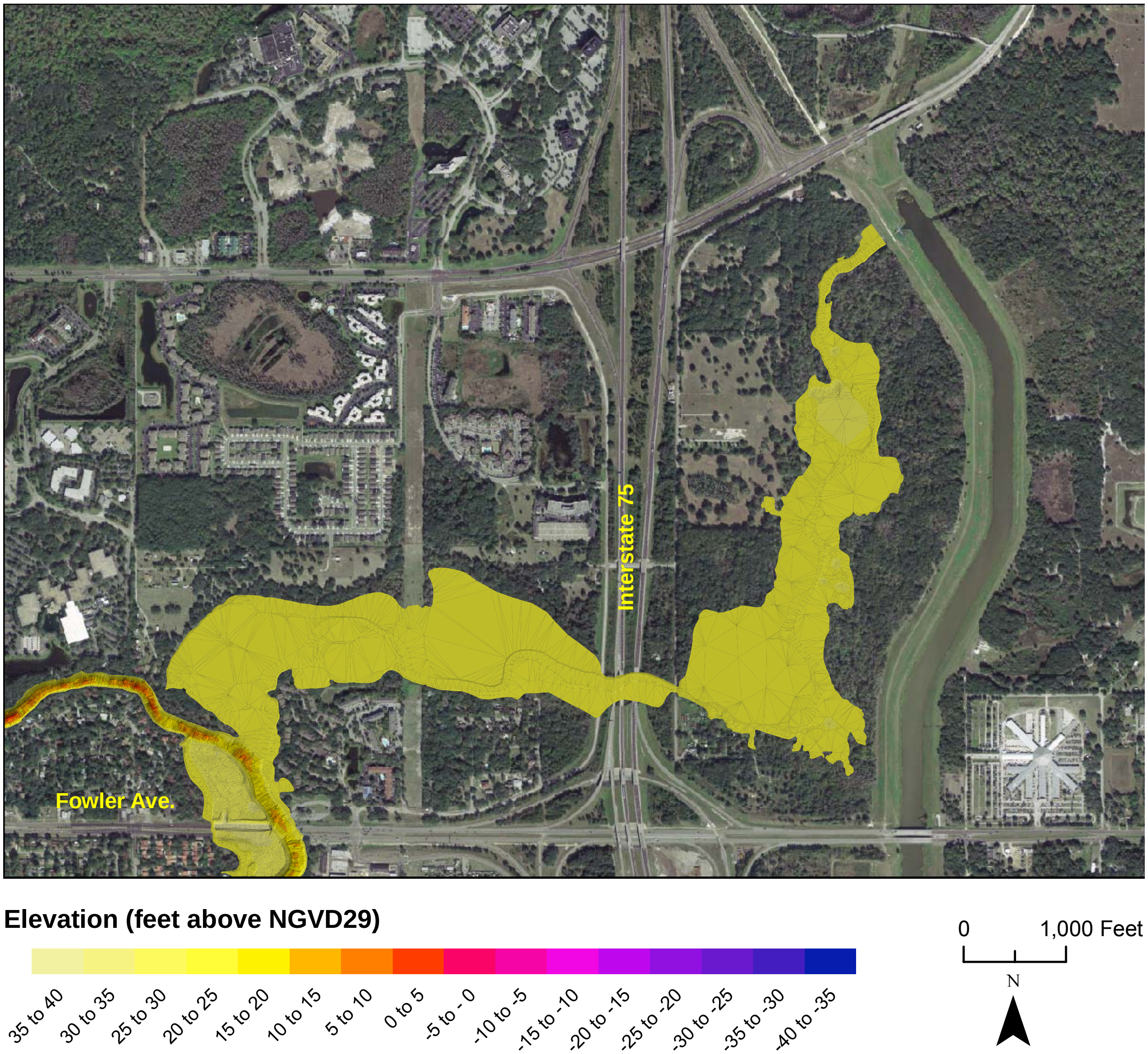


Figure 2-20. Triangulated Integrated Network (TIN) showing ground and river bottom elevations (feet above NGVD29) of the middle Hillsborough River in the vicinity of Fowler Avenue and Cow House Creek from the river to District Structure S-163 (photographic image source: Fugra EarthData, Inc. 2007).

Surveyed elevation cross-section data from 2008 were also used to develop an updated elevation profile of the river bottom from the City of Tampa Dam to District Structure S-155. Minimum elevations for each of 231 cross sections were used to develop the profile, which is shown in Figure 2-21. The survey data indicate that the lowest bed elevations for the segment cross sections ranged from 35.15 feet below NGVD29 to 19.11 feet above NGVD29. The highest cross-section minimum was observed approximately 1.5 miles upstream from the Fletcher Avenue bridge. The measured cross-section elevation minima suggest there is the potential for a backwater effect from the City of Tampa Dam to extend upstream to Structure S-155, given that all the values were lower than the 22.5 feet above NGVD29 dam crest elevation.

Measured cross-section elevation minima for the middle river ranged from 35.15 feet below NGVD29 to 17.87 feet above NGVD29. This range exceeds that reported previously for the river segment by Goetz *et al.* (1978), with both higher and lower bed elevations measured for the more recent survey data. The highest bed cross-section minimum in the middle river was observed at a site approximately 400 feet upstream from the Fowler Avenue bridge (Figure 2-22). Relatively high bed elevations also occur in the river stretch approximately 0.3 to 0.4 miles downstream from Fowler Avenue, where cross-section minima of 17.64 and 17.44 feet above NGVD29 were observed. Minimum bed elevations well below mean sea level were measured within the first few miles upstream from the City of Tampa Dam by Goetz *et al*. (1978). They characterized these depressions as sinkholes. The recently collected survey data identified an area approximately 0.4 miles upstream from the 40th Street bridge that has a minimum bed elevation of 35.15 feet below NGVD29 (Figure 2-23). This depression was not reported by Goetz, *et al.* and similarly, a depression they found upstream from the 56th Street bridge (see Figure 2-10) was not included in the recent survey data set. Differences such as these in bed elevation measurements that are based on cross section data are not unexpected, as these types of data are highly dependent on cross section location within the river segment.

Because cross-section elevation data reflect elevations in single planes across the river channel, river bed elevations were further evaluated using survey data collected along the approximate centerline of the river. These data may be associated with water depth conditions experienced while navigating through the entire river segment. Deepest, *i.e.,* areas with lowest mid-channel bed elevations were observed for the most downstream segment of the middle river, from the City of Tampa Dam to the 40th Street bridge (Table 2-3, Figure 2-24). Relatively deep areas were also noted in the upper reach of the middle river, *i.e.,* between the Fowler and Fletcher Avenue bridges and upstream of the middle river (Table 2-3, Figure 2-25). As expected, relatively high bed elevations were more common in upper reaches of the middle river and upstream of Fletcher Avenue.

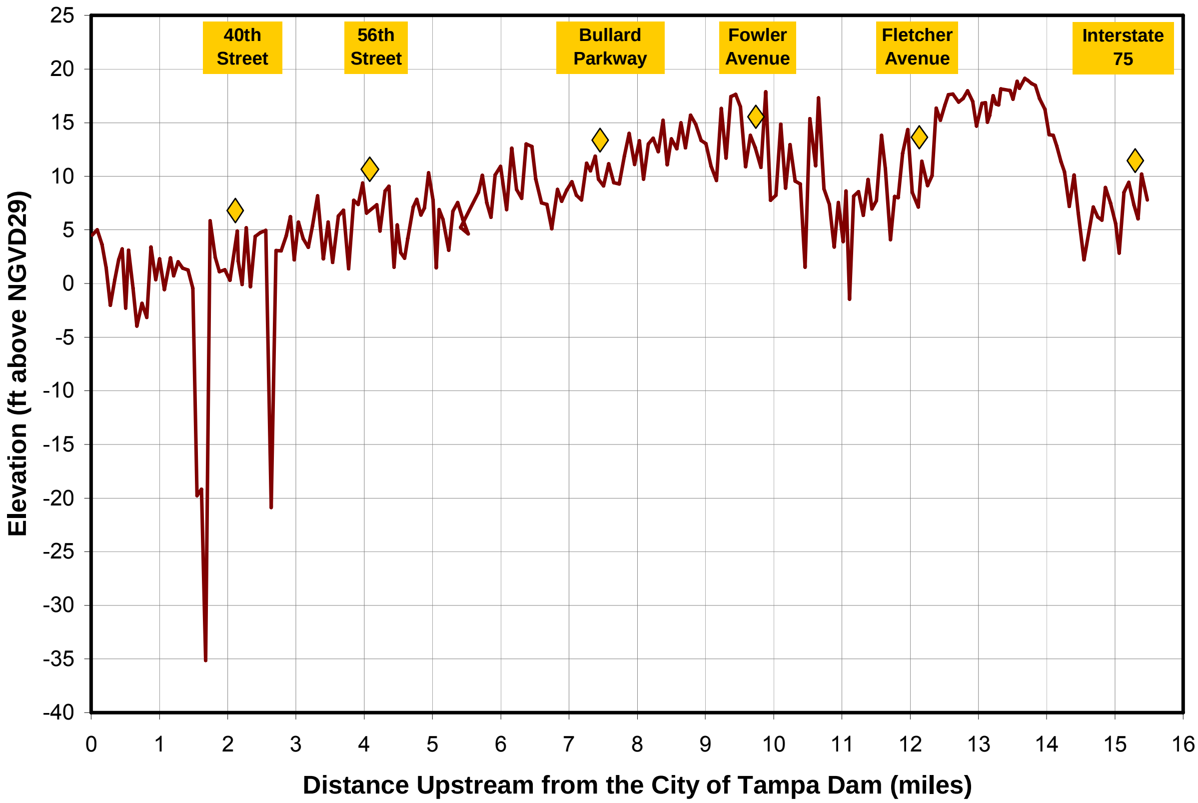


Figure 2-21. River bed elevation profile developed by the Southwest Florida Water Management District in 2009 for the middle Hillsborough River and the river segment from Fletcher Avenue to the District water control structure S-155, based on elevation minima for 231 cross-sections surveyed in 2008 by Wang and Beck (2008). Diamonds and labels indicate locations where bridges span the river segment.

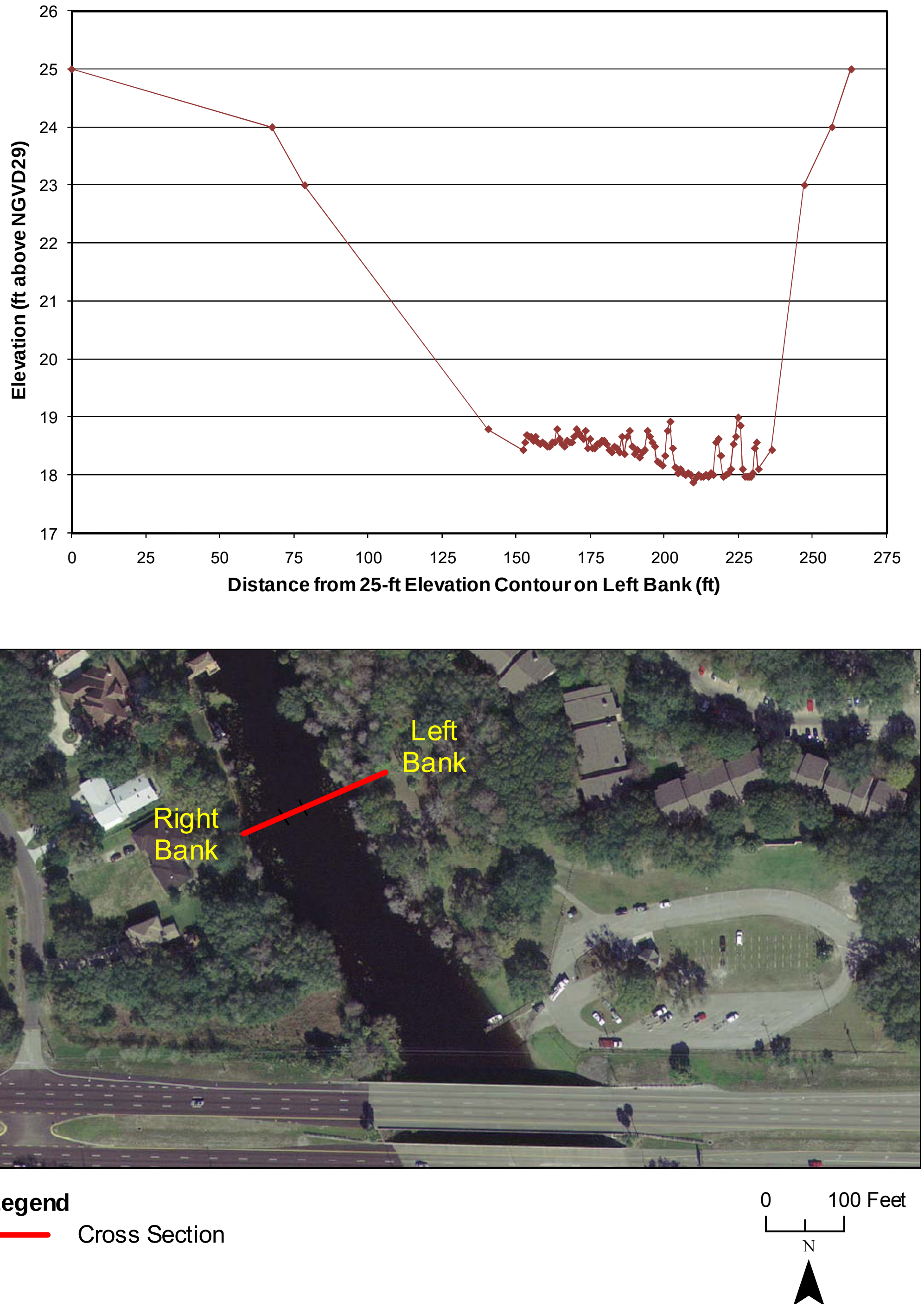
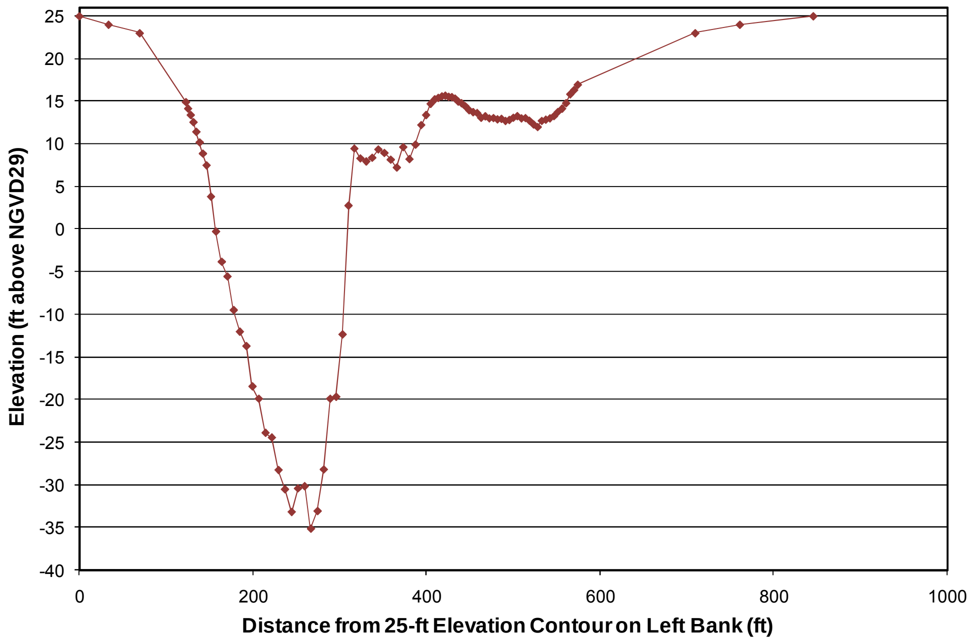
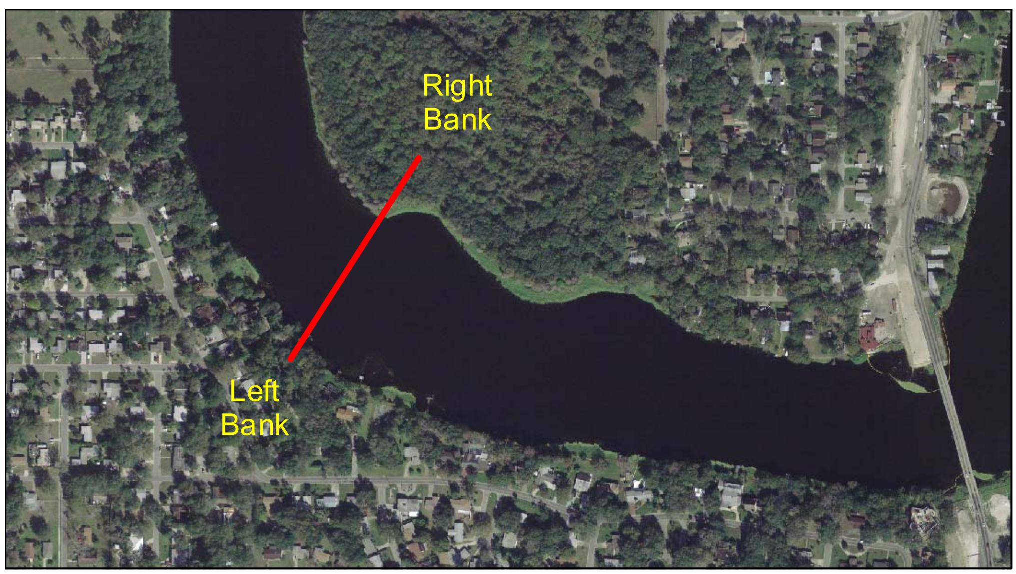


Figure 2-22. Cross-section and site map for the highest surveyed control point in the middle Hillsborough River, based on survey data collected in 2008 (Wang and Beck 2008) and elevation data from a District aerial photography with contours map (L. Robert Kimball & Associates 1978a). The site is located approximately 400 feet upstream from the Fowler Avenue bridge (photographic image source: Fugro EarthData, Inc. 2007).





Legend

Cross Section

0 500 Feet

N

Figure 2-23. Cross-section and site map for the location of the lowest surveyed elevation in the middle Hillsborough River, based on c based on survey data collected in 2008 (Wang and Beck 2008) and elevation data from a District aerial photography with contours map (L. Robert Kimball & Associates 1978b, c). The site is located approximately 260 feet downstream from the 56th Street bridge. Photographic image source: Fugro EarthData, Inc. (2007).

Table 2-3. Summary statistics for river bed elevations surveyed in 2008 along the centerline of contiguous segments of the Hillsborough River. Number of points surveyed in each segment is indicated by N; summary statistics include elevations equaled or exceeded by ten (P10), fifty (P50) and ninety (P90) of the measured points.

River Segment	N	Minimum Elevation	Maximum Elevation	P10 Elev.	P50 Elev.	P90 Elev.	Mean Elev.	Standard Deviation
		(feet above NGVD29)						(feet)
Dam to 40th Street	1,633	-2.47	17.44	15.60	12.59	6.00	12.06	3.68
40th Street to 56th Street	1,367	2.28	17.60	16.23	11.70	4.47	10.89	4.40
56th Street to the Harney Canal	1,419	3.47	18.83	16.99	13.02	6.03	12.48	4.18
Harney Canal to Bullard Parkway	1,138	4.10	14.72	13.38	10.49	7.05	10.29	2.39
Bullard Parkway to Fowler Avenue	6,377	3.86	18.46	17.44	14.26	10.52	13.99	2.51
Fowler Avenue to Fletcher Avenue	5,086	-0.28	19.11	15.98	10.16	5.33	10.34	3.94
Fletcher Avenue to Structure S-155	8,777	-1.92	20.26	18.75	16.13	7.30	13.83	4.66

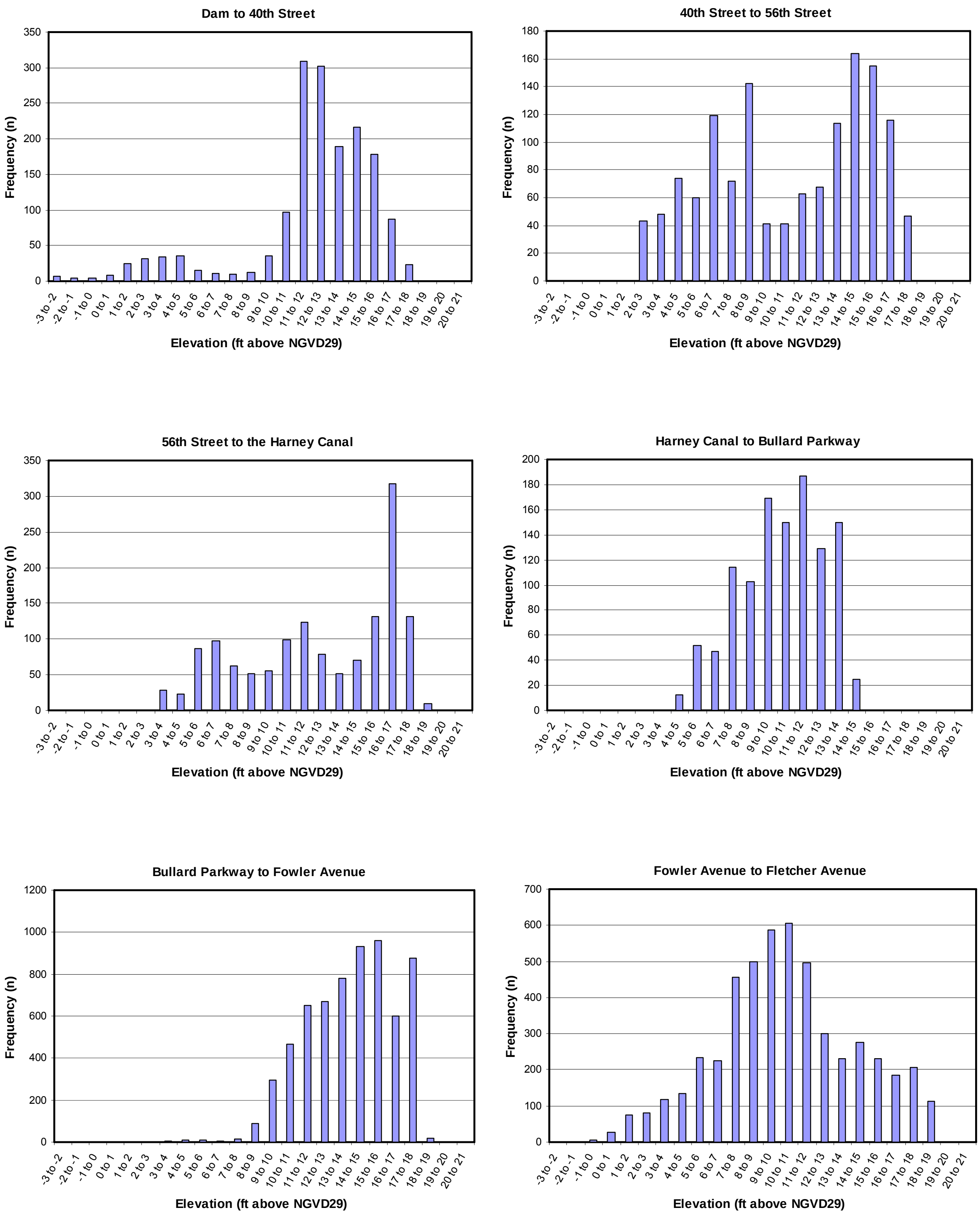


Figure 2-24. Frequency distribution of river bottom elevations of the middle Hillsborough River based on surveyed centerline data obtained in 2008.

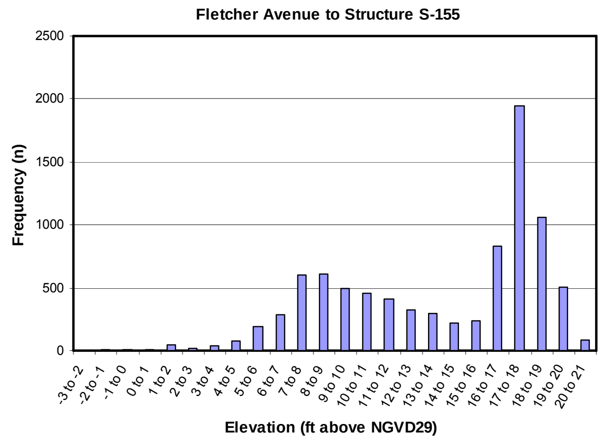


Figure 2-25. Frequency distribution of river bottom elevations of the segment of the Hillsborough River between Fletcher Avenue and District Structure S-155 based on surveyed centerline data obtained in 2008.

Development of the new bathymetric/topographic data sets also permitted development of updated morphometric characteristics for the middle river. Relationships between water surface elevation or stage and inundated area, the volume of water in the river segment, mean and maximum depth are listed in Table 2-4 and shown in Figures 2-26 and 2-27. Graphical representations of middle river area, volume, mean depth and maximum depth associated with specific water surface elevations was limited to illustration of values associated with water surface elevations of 0 feet above NGVD29 and higher for clarity of presentation and because only a relatively small portion of the middle river (~ 6 acres) was identified with a bed elevation less than 0 feet below NGVD29.

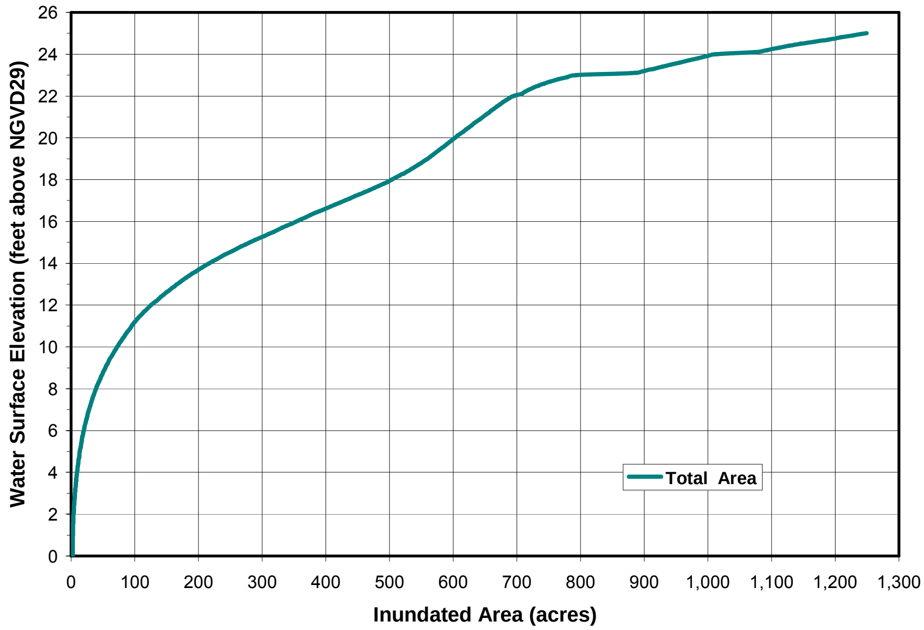
At a full-pool water level of 22.5 feet above NGVD29, the middle river extends over an area of approximately 734 acres and contains approximately 1.61 billion gallons of water. Mean water depth is 6.7 feet and the maximum depth at full-pool conditions is 57.7 feet. This maximum depth value is based on inclusion of the low elevation of 35.15 feet below NGVD29 identified for the deep depression located between the City of Tampa Dam and the 40th Street bridge (see Figures 2-15, 2-21 and 2-23).

Table 2-4. Summary morphometic data for the middle Hillsborough River, based on bathymetric data set developed by the Southwest Florida Water Management District in 2009 using surveyed elevations collected in 2008 (Wang and Beck 2008) and digitized elevation data from District aerial photography with contours maps from the 1970s and 1980s.

Water Surface Elevation (feet above NGVD29)	Inundated Area Dam to Fletcher Ave. (acres)	Volume Dam to Fletcher Ave. (million gallons)	Mean Depth (feet)	Maximum Depth (feet)
25	1249.3	2418.4	5.9	60.2
24.5	1145.1	2223.2	6.0	59.7
24	1012.0	2043.8	6.2	59.2
23.5	942.0	1884.6	6.1	58.7
23	793.3	1736.8	6.7	58.2
22.5	733.9	1612.9	6.7	57.7
22	694.1	1496.2	6.6	57.2
21.5	668.9	1385.3	6.4	56.7
21	646.6	1278.1	6.1	56.2
20.5	624.7	1174.5	5.8	55.7
20	602.9	1074.5	5.5	55.2
19.5	581.5	978.0	5.2	54.7
19	559.5	885.1	4.9	54.2
18.5	533.9	795.9	4.6	53.7
18	503.7	711.4	4.3	53.2
17.5	468.3	632.1	4.1	52.7
17	429.9	558.9	4.0	52.2
16.5	390.7	492.0	3.9	51.7
16	353.7	431.4	3.7	51.2
15.5	317.5	376.8	3.6	50.7
15	280.9	328.0	3.6	50.2
14.5	247.1	285.1	3.5	49.7
14	216.8	247.3	3.5	49.2
13.5	190.0	214.2	3.5	48.7
13	166.4	185.2	3.4	48.2
12.5	145.3	159.8	3.4	47.7
12	125.7	137.8	3.4	47.2
11.5	108.9	118.7	3.3	46.7
11	95.0	102.1	3.3	46.2
10.5	83.1	87.6	3.2	45.7
10	72.2	75.0	3.2	45.2
9.5	62.3	64.1	3.2	44.7
9	53.6	54.6	3.1	44.2
8.5	45.8	46.6	3.1	43.7
8	39.1	39.7	3.1	43.2
7.5	33.2	33.8	3.1	42.7
7	28.1	28.8	3.1	42.2
6.5	23.6	24.6	3.2	41.7
6	19.6	21.1	3.3	41.2
5.5	16.3	18.1	3.4	40.7
5	13.6	15.7	3.5	40.2

Water Surface Elevation (feet above NGVD29)	Inundated Area Dam to Fletcher Ave. (acres)	Volume Dam to Fletcher Ave. (million gallons)	Mean Depth (feet)	Maximum Depth (feet)
4.5	11.3	13.7	3.7	39.7
4	9.26	12.0	4.0	39.2
4	9.26	12.0	4.0	39.2
3.5	7.51	10.7	4.4	38.7
3	6.01	9.6	4.9	38.2
2.5	4.76	8.7	5.6	37.7
2	3.85	8.0	6.4	37.2
1.5	3.19	7.4	7.1	36.7
1	2.71	6.9	7.9	36.2
0.5	2.38	6.5	8.4	35.7
0	2.17	6.2	8.7	35.2
-0.5	2.00	5.8	8.9	34.7
-1	1.87	5.5	9.0	34.2
-1.5	1.76	5.2	9.1	33.7
-2	1.67	4.9	9.0	33.2
-2.5	1.60	4.7	8.9	32.7
-3	1.53	4.4	8.8	32.2
-3.5	1.47	4.2	8.7	31.7
-4	1.41	3.9	8.5	31.2
-4.5	1.35	3.7	8.4	30.7
-5	1.30	3.5	8.2	30.2
-5.5	1.24	3.3	8.1	29.7
-6	1.19	3.1	7.9	29.2
-6.5	1.14	2.9	7.8	28.7
-7	1.09	2.7	7.6	28.2
-7.5	1.04	2.5	7.5	27.7
-8	0.99	2.4	7.3	27.2
-8.5	0.94	2.2	7.2	26.7
-9	0.90	2.1	7.1	26.2
-9.5	0.85	1.9	6.9	25.7
-10	0.81	1.8	6.8	25.2
-10.5	0.76	1.7	6.7	24.7
-11	0.72	1.5	6.5	24.2
-11.5	0.68	1.4	6.4	23.7
-12	0.64	1.3	6.3	23.2
-12.5	0.60	1.2	6.2	22.7
-13	0.57	1.1	6.1	22.2
-13.5	0.53	1.03	6.0	21.7
-14	0.49	0.95	5.9	21.2
-14.5	0.46	0.87	5.8	20.7
-15	0.43	0.79	5.7	20.2
-15.5	0.40	0.73	5.6	19.7
-16	0.37	0.67	5.6	19.2
-16.5	0.34	0.61	5.5	18.7
-17	0.31	0.55	5.5	18.2
-17.5	0.29	0.51	5.4	17.7
-18	0.26	0.46	5.4	17.2
-18.5	0.24	0.42	5.4	16.7
-19	0.22	0.38	5.3	16.2
-19.5	0.21	0.35	5.2	15.7
-20	0.19	0.32	5.0	15.2

Water Surface Elevation (feet above NGVD29)	Inundated Area Dam to Fletcher Ave. (acres)	Volume Dam to Fletcher Ave. (million gallons)	Mean Depth (feet)	Maximum Depth (feet)
-20.5	0.18	0.29	4.9	14.7
-21	0.17	0.26	4.7	14.2
-21.5	0.16	0.23	4.5	13.7
-22	0.14	0.21	4.4	13.2
-21.5	0.16	0.23	4.5	13.7
-22	0.14	0.21	4.4	13.2
-22.5	0.13	0.18	4.2	12.7
-23	0.12	0.16	4.0	12.2
-23.5	0.11	0.14	3.9	11.7
-24	0.104	0.13	3.7	11.2
-24.5	0.095	0.11	3.5	10.7
-25	0.087	0.09	3.3	10.2
-25.5	0.079	0.08	3.2	9.7
-26	0.071	0.07	3.0	9.2
-26.5	0.063	0.06	2.8	8.7
-27	0.056	0.05	2.6	8.2
-27.5	0.050	0.04	2.4	7.7
-28	0.043	0.03	2.3	7.2
-28.5	0.037	0.03	2.1	6.7
-29	0.032	0.02	1.9	6.2
-29.5	0.026	0.015	1.7	5.7
-30	0.021	0.011	1.6	5.2
-30.5	0.017	0.008	1.5	4.7
-31	0.013	0.006	1.3	4.2
-31.5	0.010	0.004	1.2	3.7
-32	0.007	0.002	1.0	3.2
-32.5	0.005	0.0013847	0.9	2.7
-33	0.003	0.0007337	0.7	2.2
-33.5	0.002	0.0003315	0.6	1.7
-34	0.00090	0.0001122	0.4	1.2
-34.5	0.00029	0.0000203	0.2	0.6
-35	0.00002	0.0000002	0.1	0.1
-35.15	0.00000	0.0000000	0.0	0.0



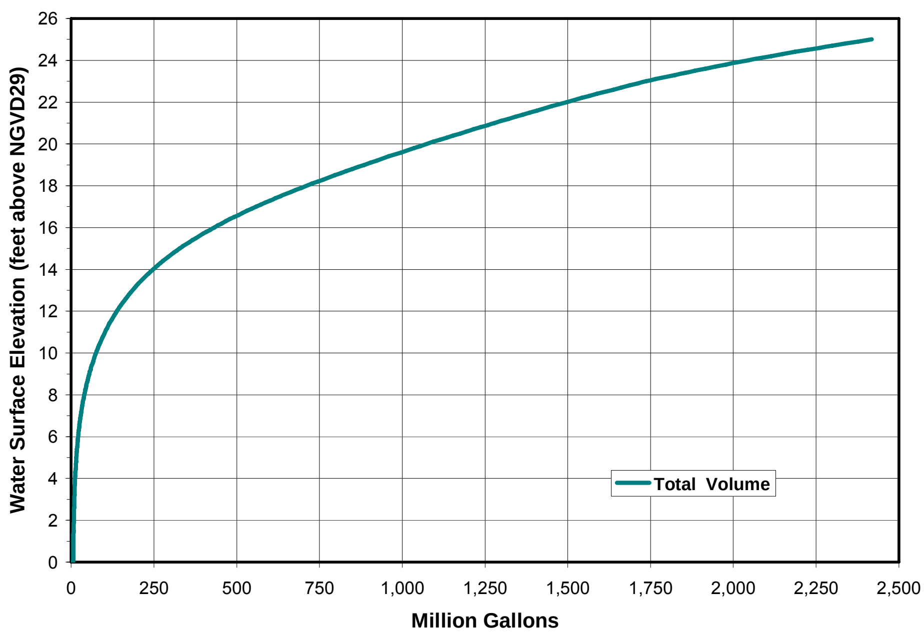
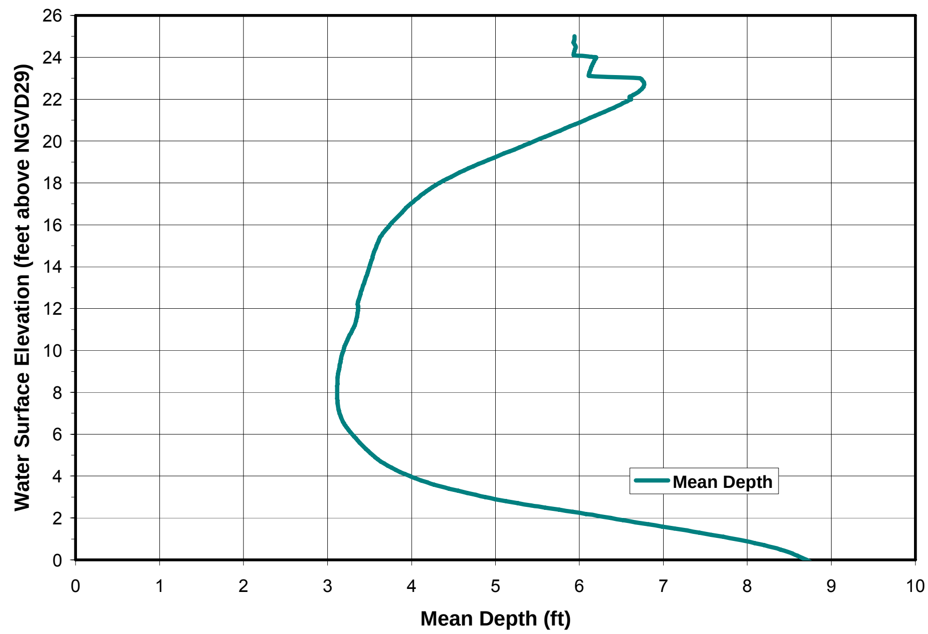


Figure 2-26. Stage-area-volume relationships developed for the middle Hillsborough River by the Southwest Florida Water Management District, based on bathymetric data developed using surveyed elevations collected in 2008 (Wang and Beck 2008) and digitized elevation data from District aerial photography with contours maps from the 1970s and 1980s.



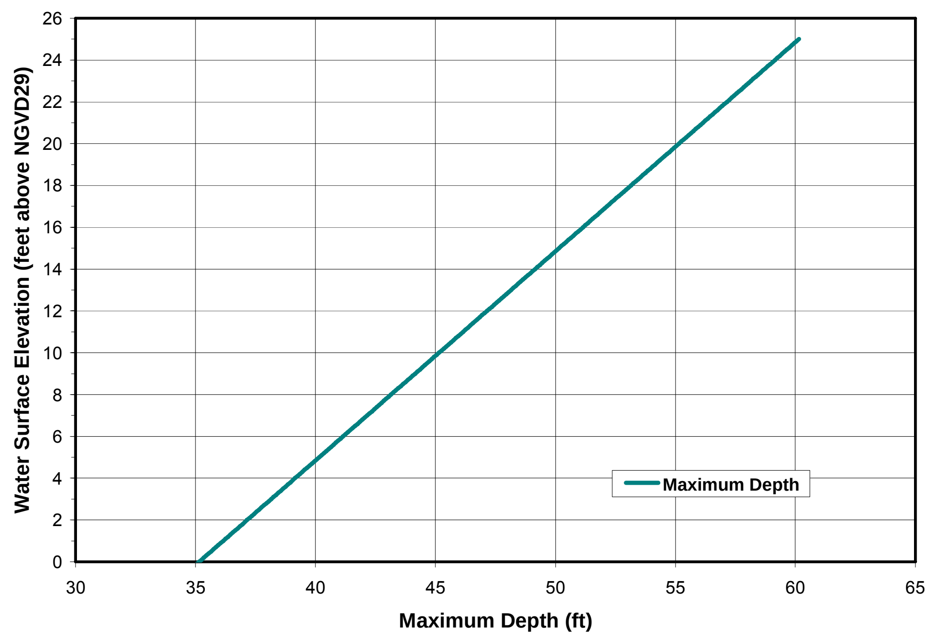


Figure 2-27. Mean and maximum water depth and stage relationships developed for the middle Hillsborough River by the Southwest Florida Water Management District, based on bathymetric data developed using surveyed elevations collected in 2008 (Wang and Beck 2008) and digitized elevation data from District aerial photography with contours maps from the 1970s and 1980s.

Highlights of Chapter 2

As defined for this report, the "middle" river consists of an approximate 12.1 mile segment of the Hillsborough River from the City of Tampa Dam upstream to point where Fletcher Avenue crosses the river, the portion of the Harney Canal between the river and District water control Structure S-161, as well as the portion of Cow House Creek downstream from District Structure S-163. The City of Tampa Dam can be used to impound water in the river segment to an elevation of 22.5 feet above NGVD29. At water levels higher than this elevation, water spills over the dam to the lower Hillsborough River.

To support the current District study of the middle river, an updated bathymetric/ topographic data set was developed for the river segment. The data set was based on survey data collected in 2008 and elevation data from historic District aerial photography with contours maps. Analysis of the bathymetric/topographic data indicated that when the water level at the City of Tampa Dam is at 22.5 feet above NGVD29, the middle river extends over 734 acres and contains approximately 1.613 billion gallons of water.

Survey data from 231 cross-sections across Hillsborough River channel that were used for development of the new bathymetric/topographic data set were also used to develop an updated elevation profile of the river bottom or bed from the City of Tampa Dam to District Structure S-155, which is located upstream from the middle river. The survey data indicate that the lowest bed elevations for cross sections for much of the first few miles upstream from the dam range in elevation from 0 to 5 feet above NGVD29, although several cross-sections in this stretch of the river include minimum that were lower than 0 feet above NGVD29. One are included a river bed elevation 35.15 feet below NGVD29.

The highest bed cross-section minimum in the middle river was observed at a site approximately 400 feet upstream from the Fowler Avenue bridge. Higher cross-section minima were measured upstream from the middle river. The highest minimum, 19.11 feet above NGVD29, was measured at a cross-section approximately 1.5 miles upstream from the Fletcher Avenue bridge. The measured cross-section elevation minima suggest there is the potential for a backwater effect from the City of Tampa Dam to cause the pooling of water upstream to Structure S-155, given that all bed elevations were lower than the 22.5 feet above NGVD29 dam crest elevation.

Chapter 3

History of the Impounded Hillsborough River, Tampa Bypass Canal System and Sulphur Springs

History of the Dam and Impounded Hillsborough River

The area in the vicinity of the current City of Tampa Dam site has a long history of human activity associated with impounding the Hillsborough River to meet societal needs. The first water control structure in the area was reportedly constructed in 1895 (School District of Hillsborough County 2000) or 1897 (Friends of the River 2008, Funding Universe 2008) and may have been the first major alteration of the river segment from the relatively unaltered state depicted in the original federal land survey of the area (Figure 3-1). The early dam on the river was operated for electricity generation by Consumers Electric Light and Power, and was reportedly (T. Neal, personal communication) located between the present day 40th Street and 56th Street bridges that span the middle river. The dam was dynamited in 1898 by cattle barons upset about the inundation of grazing land along the Hillsborough River (School District of Hillsborough County 2000, Friends of the River 2008, Funding Universe 2008).

Following destruction of the original dam, Consumers Electric Light and Power sold its facility to Tampa Electric Company, which built a dam downstream at the site of the current dam in 1899 or 1900 and utilized the dam and impounded river for power generation (see Figure 3-2). The impounded river was also used as a water supply by the City of Tampa following construction of a water treatment plant and pumping facility in 1920s upstream from the dam (Tampa Water Department 2008). Miller and Silverston (date unknown) indicate the plant/facility was completed in 1926; the School District of Hillsborough County (2000) reports that the system was operational in 1923.

Flooding in 1933 led to the collapse of the Tampa Electric Company dam (Reynolds, Smith and Hill 1961, Turner 1974, Funding Universe 2008, Tampa Water Department 2008). Following destruction of the dam by flood waters, the river was not fully impounded until October 1945 when the City of Tampa completed construction of the currently existing dam (Turner 1974) following acquisition of the dam site facility from Tampa Electric Company in 1944 (Tampa Water Department 2008). Historical aerial photography from 1938 (Figures 3-3 and 3-4) indicates that the river was at least partially impounded prior to completion of the currently existing dam.

The current configuration of the City of Tampa dam was established in the early 1960s when power-operated radial gates were installed at the dam crest after flooding in 1960 (see Pride 1962 for an account of the flood) destroyed several dam spillway flashboards (Turner 1974, Tampa Water Department 2008). The existing dam gates reportedly became operational in March 1962 (Turner 1974) or 1963/1964 (Tampa Water Department 2008).

Construction of regional flood control systems, augmentation and modifications to permitted withdrawal volumes since the 1960s have continued to affect the middle Hillsborough River. The Lower Hillsborough Flood Detention Area, Tampa Bypass Canal, Harney Canal and associated water control structures were constructed to prevent flooding in the Cities of Temple Terrace and Tampa. Intermittent use of these systems has resulted in diversion of some Hillsborough River flows from the middle river. The flood control system has been used as an augmentation source for the middle river since the mid-1980s and beginning in the mid-1960s, water from Sulphur Springs, an artesian spring that discharges to the lower river downstream from the City of Tampa Dam has been used for augmentation purposes. Additional information pertaining to construction and operation of regional flood control systems, middle river augmentation, and use of the river and Tampa Bypass Canal/Harney Canal system as a water supply are provided in subsequent sections of this chapter and in Chapter 4.

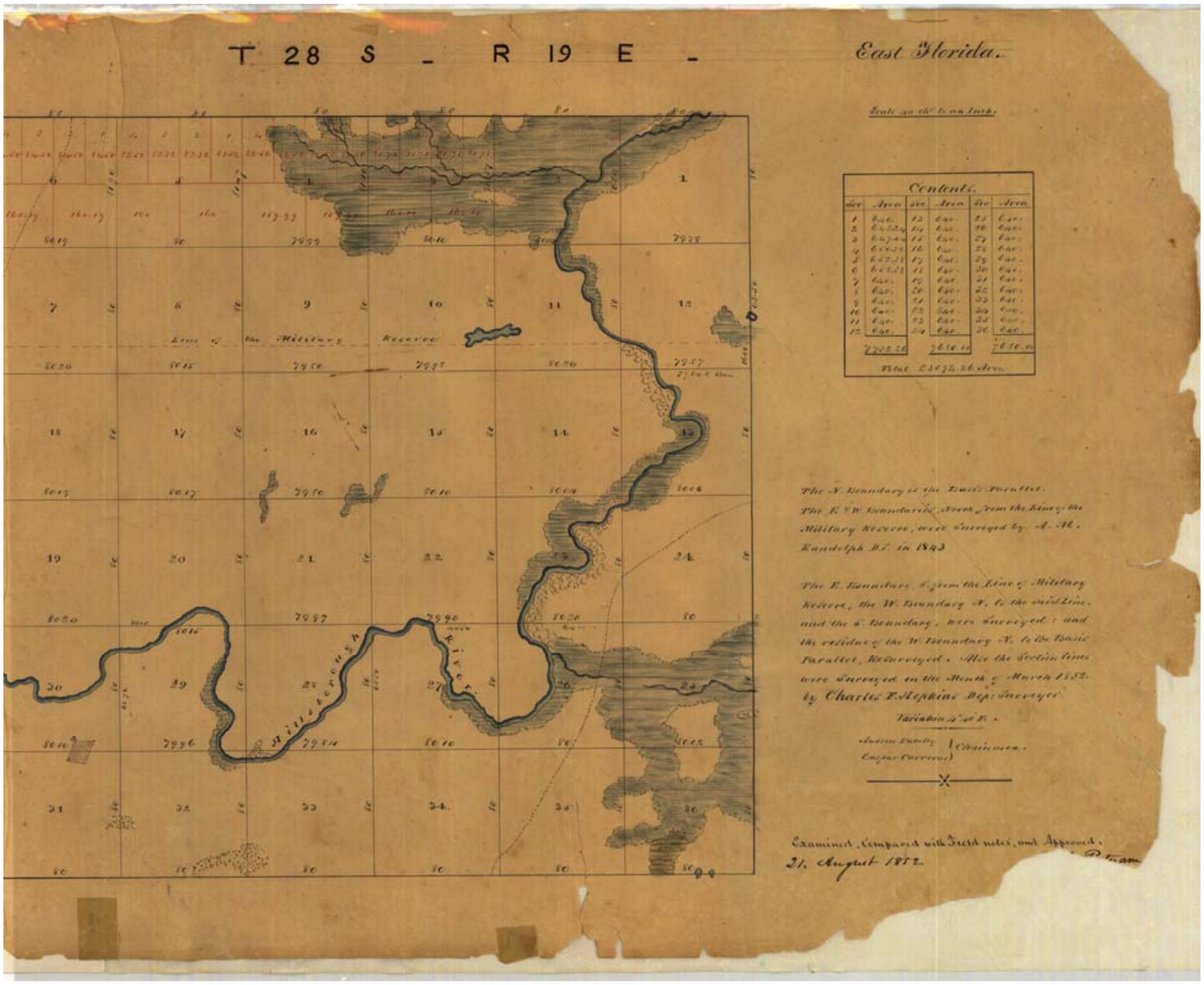


Figure 3-1. 1852 map of the middle Hillsborough River area based on surveys completed by A. M. Randolph in 1843 and C. F. Hopkins in 1852 (image source: Florida Department of Environmental Protection 2008a).

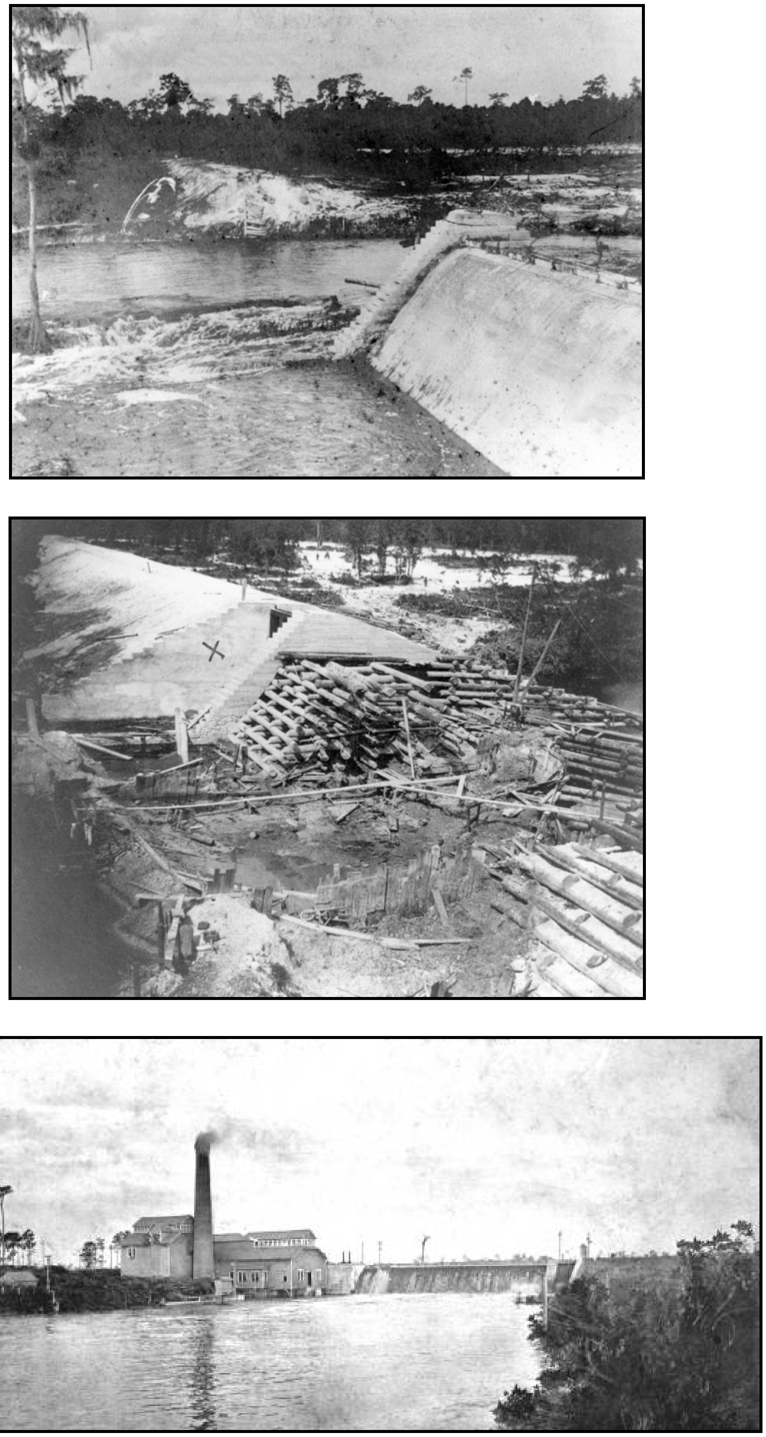


Figure 3-2. Photographs of the construction (upper and middle panels, ca. 1899) and use (lower panel, ca. 1906) of the dam on the Hillsborough River that was destroyed in a 1933 flood (photographic image sources: upper and middle panels – Florida Center for Instructional Technology 2008; lower panel – Florida Department of State 2008)

Figure 3-3. Aerial photography from November 1938, showing the existence of a dam across the Hillsborough River at the site of the current City of Tampa Dam (United States Department of Agriculture 1938c).

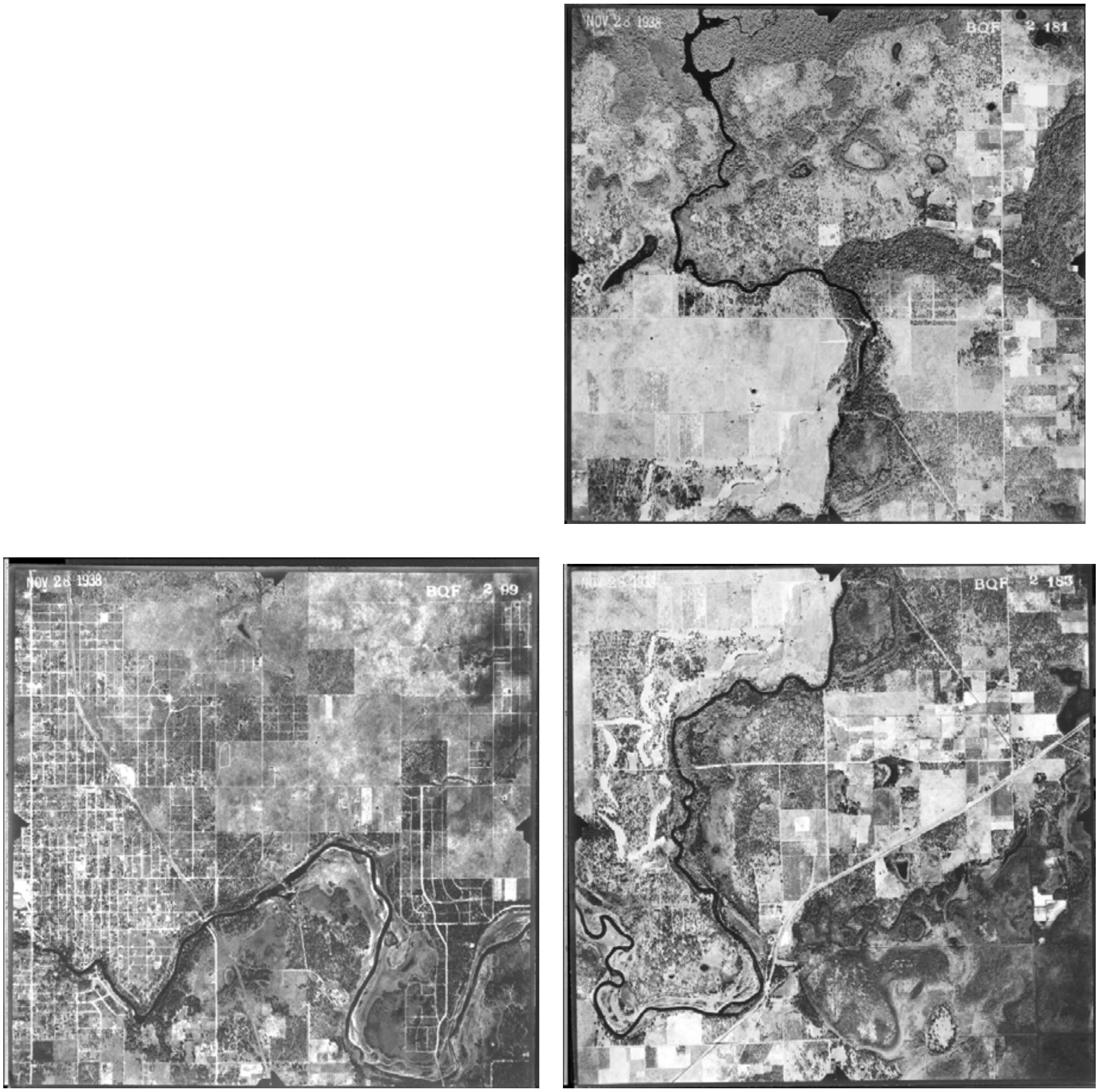


Figure 3-4. Aerial photography of the middle Hillsborough River area in November 1938 (United States Department of Agriculture 1938c,k,l).

History of the Lower Hillsborough Flood Detention Area, Tampa Bypass Canal, Harney Canal and Associated Water Control Structures

The Southwest Florida Water Management District was created in 1961 by a special act of the Florida Legislature to be the local sponsor of a project known as the Four River Basins project. The project was a major flood control project sponsored at the Federal level by the United States Army Corps of Engineers after Hurricane Donna caused massive damage to southwest Florida in 1960. The Four Rivers Basin project initially involved work to be completed in the Hillsborough, Oklawaha, Peace, and Withlacoochee River basins. Environmental and other concerns led to a reduction in the original project scope, although significant landscape alterations were completed in the Hillsborough River basin to mitigate for potential flooding in the cities of Temple Terrace and Tampa. The alterations included construction of the Lower Hillsborough Flood Detention Area, Tampa Bypass Canal, Harney Canal and water control structures associated with these facilities, all of which are owned and maintained the Southwest Florida Water Management District. The Tampa Bypass Canal (designated as C-135) was designed for diversion of floodwaters from the upper 453 square miles of the Hillsborough River watershed to McKay Bay. The Harney Canal (designated as C-136) was designed for diversion of floodwaters to the Tampa Bypass Canal that originate in the 192-square mile watershed draining to the river between the Lower Hillsborough Flood Detention Area and the City of Tampa Dam (United States Army Corps of Engineers 1983). Comparison of recent aerial photography from 2007 with that from 1973 (see Figures 3-5 and 3-6) provides a landscape perspective on the extent of the changes associated with construction of the detention area, canal systems and water control structures.

The Lower Hillsborough Flood Detention Area is comprised of approximately 17,000 acres upstream from the middle Hillsborough River and adjacent to the Hillsborough River and Cow House Creek. The property was acquired over a fifteen year period, beginning in the mid-1960s (Southwest Florida Water Management District (1989). A levee (TBC L-112) constructed to retain water in the detention area and an operable water control structure (S-155) on the Hillsborough River are used to impede or divert river flow onto the detention area. A second operable structure (S-163), located where the levee intersects Cow House Creek is used to retain water in the detention area and limit creek discharge to the middle river. A third operable structure (Trout Creek) provides conveyance under the levee to a ditch that drains to the Hillsborough River. Construction of the levee and structures S-155 and S-163 occurred from 1977 or 1978 through 1982 (Knutilla and Corral 1984, Barcelo 1985). The Trout Creek structure is assumed to have been constructed during this same period, although reports reviewed for this study do not include completion data information for the structure. An excavated floodway in the detention area was completed in 1982 to facilitate drainage from areas north of Cow House Creek to the point where the Tampa Bypass Canal intersects the Creek (Knutilla and Corral 1984).

The Tampa Bypass Canal (C-135) originates near Cow House Creek in the Lower Hillsborough Flood Detention Area and extends approximately 14 miles southward towards its terminus at McKay Bay. The southern segment of the canal was created by excavating Six Mile Creek, including the lower portion of the creek, which is known as the Palm River. Construction of the canal was initiated in 1966 and reportedly continued through 1981 (Knutilla and Corral 1984, Southwest Florida Water Management District 1990) or 1982 (Barcelo 1985, Southwest Florida Water Management District 2005a).

The Tampa Bypass Canal is divided into three pools, separated by water control structures that are used to manage pool water levels and flow between the pools, the upper Hillsborough River and the middle Hillsborough River. Flow from the upper Tampa Bypass Canal pool and Lower Hillsborough Flood Detention Area into the middle canal pool is managed through operation of the Upper S-159 structure, which was completed in 1982 (Knutilla and Corral 1984). Two fixed-crest structures that were completed in 1981 (Knutilla and Corral 1984), the Middle S-159 and Lower S-159 structures, are also used to manage flow from the upper to middle canal pools. The middle pool of the canal is maintained by operation of the S-162 structure, which was completed in 1977 (Knutilla and Corral 1984) and controls flows to the lower pool. Discharge from the lower pool into the excavated remains of the Palm River is facilitated through operation of structure S-160. This structure also serves as a salinity barrier, preventing upstream movement of salt water from McKay Bay. Construction of lower portions of the canal and Structure S160 was completed by 1969 (Knutilla and Corral 1984, Barcelo 1985, Southwest Florida Water Management District 1990); Structure S-162 was completed in 1977 (Knutilla and Corral 1984, Barcelo 1985).

The Harney Canal (C-136) and Structure S-161 provided an additional means for exchanging surface water between the Hillsborough River and the Tampa Bypass Canal. The 9,000 foot canal connects the middle river with the middle pool of the Tampa Bypass Canal. Gates on Structure S-161 may be operated to permit flow between the middle river and canal. A pumping facility at the structure site can also be used to exchange water between the two systems. The Harney Canal and structure S-161 were constructed from 1975 through 1977 (Knutilla and Corral 1984, Southwest Florida Water Management District 1990).

The District assumed responsibility from the United States Army Corps of Engineers for operation and maintenance of the Tampa Bypass Canal, Harney Canal and associated water control structures in September 1972 (United States Army Corps of Engineers 1983, Southwest Florida Water Management District 1990) and the Trout Creek Structure in 1978 (Southwest Florida Water Management District 2001). Operations and maintenance activities are conducted in accordance with regulations established for the system by the Corps (United States Army Corps of Engineers 1983). During periods of "normal or low" flows (ranging up to about 4,000 cubic feet per second at the structure site), structure S-155 is left open to convey water downstream to the middle river. Navigation on the river through the structure is permitted at flows up to 2,900 cubic feet per second, which corresponds to a stage of 28.6 feet above NGVD29 at the structure site. During higher flow periods, when the river water level downstream at the Fowler Avenue gauge site approaches 28.0 feet above NGVD29, the structure is lowered to divert water to the Lower Hillsborough Flood Detention Area. Operational guidelines dictate that when S-155 is operated, S-163 and the Trout Creek structure must be closed. Once water levels in the detention area reach or exceed 30.0 feet above NGVD29, Structure S-159 Upper is opened to discharge water to the Tampa Bypass Canal. When the water level in the detention area receded to 30.0 feet above NGVD29, S-159 is closed, S-155 and the Trout Creek structure are reopened and S-163 is reopened after appropriate tail water conditions are achieved.

Operational guidelines for the flood control system also indicate that when the river stage at S-155 is between 38.0 and 41.0 feet above NGVD29, regulatory releases to the river may be required and the S-155 gates are opened accordingly. Regulatory releases to the river are required when the river stage at structure S-155 exceeds 41.0 feet above NGVD29. Structure S-161 on the Harney Canal is also operated to mitigate flooding on the river. During high flow periods when structure S-155 is opened for regulatory releases, structure S-161 should be opened to permit design capacity discharge from the middle river to the Harney Canal/Tampa Bypass Canal system.

During high flow periods, Hillsborough River flows have occasionally been diverted to the Lower Hillsborough Flood Detention Area and Tampa Bypass Canal. Wolanksy and Thompson (1987) report that diversions first occurred in May 1977, although Knutilla and Corral (1984) and Kane and Dickman (2005) report that diversions from the river did not start until 1979. The Tampa Bypass Canal system was, however, reportedly first used for flood control purposes in September 1985 when Hurricane Elena threatened the west coast of Florida (Southwest Florida Water Management District 1990, HDR Engineering Inc. 1994). The first diversions of water from the middle river to the Tampa Bypass Canal through the Harney Canal and Structure S-161 reportedly occurred in March 1987 (Water and Air Research, Inc. 1988, as cited in HDR Engineering, Inc. 1994 and Southwest Florida Water Management District 1990) and were followed by additional diversion periods in 1988 (Southwest Florida Water Management District 1990) and 2004 (Southwest Florida Water Management District 2005).

The Lower Hillsborough Flood Detention Area, Tampa Bypass Canal, Harney Canal and associated structures were originally developed for flood control purposes, although management goals for the systems have expanded to include water storage and supply, natural system protection and recreational use. Historical summaries of the use and management of these areas are included in the District land-use plans for the Lower Hillsborough Flood Detention Area (Southwest Florida Water Management District 1989) and the Tampa Bypass Canal/Harney Canal (Southwest Florida Water Management District 1990). With regard to water supply goals, the Tampa Bypass/Harney Canal system has been used by the City of Tampa or Tampa Bay Water (previously known as the West Coast Regional Water Supply Authority) since 1985 for augmentation of the middle river impounded (The Planning Commission 1998, Southwest Florida Water Management District 1999). Also, diversions to the canal system from the river for subsequent withdrawal by Tampa Bay Water have been authorized by District permit since 1999. Based on use of the Tampa Bypass Canal for water supply purposes, the District has authorized Tampa Bay Water to operate water control structures on the Tampa Bypass Canal/Harney Canal system, except during flood-control events (Southwest Florida Water Management District 2005).

Use of the Tampa Bypass Canal as a water supply is possible due to ground water discharge to the canal from several springs and areas where breaches to the underling aquifer systems occurred during canal system construction. Several named springs, including Eureka Springs, Sixmile Creek Spring and Lettuce Lake Spring, discharge to the canal system and Knutilla and Corral (1984) note that several smaller springs are also located in the area. Although construction of the canal system is estimated to have lowered the potentiometric surface of the Upper Floridan Aquifer system two to four feet in the upper portions of the canal area and reduced discharge from area springs, Knutilla and Corral (1984) note that groundwater inflow or base-flow discharge from the canal area approximately doubled as a result of breaches to the underlying aquifers. Subsequent analyses by the Southwest Florida Water Management District (1999e) indicate that post-construction base-flow to the Tampa Bypass Canal system is approximately 1.7 times the pre-construction level. Additional information pertaining to use of the Tampa Bypass Canal/Harney Canal system for water supply purposes is presented in Chapter 4 of this report.

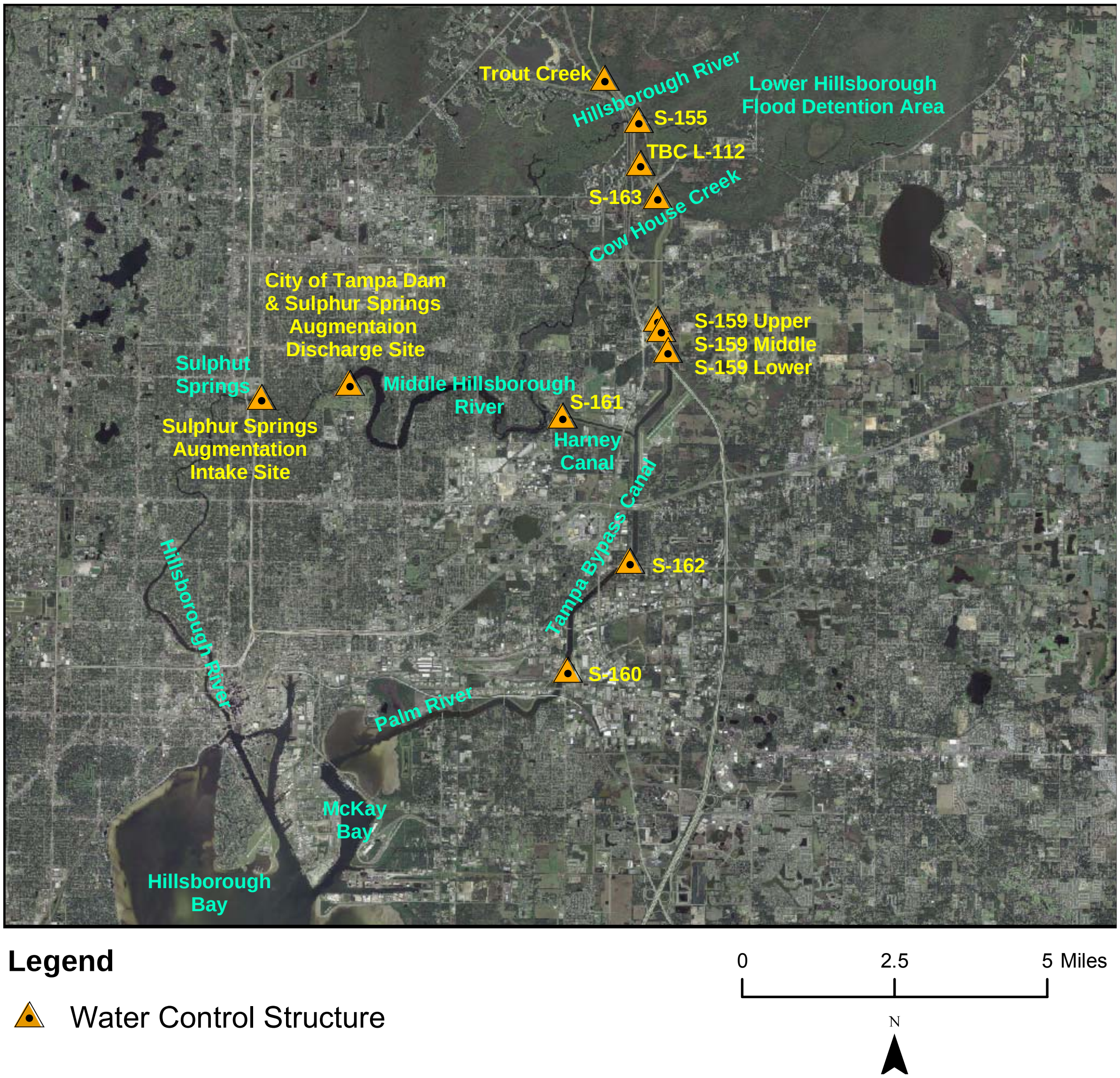


Figure 3-5. Aerial photography of the lower and middle Hillsborough River and Tampa Bypass Canal area in 2007 showing locations of City and District water control structures used to manage flow through the systems (photographic image source: Fugro EarthData, Inc. 2007).

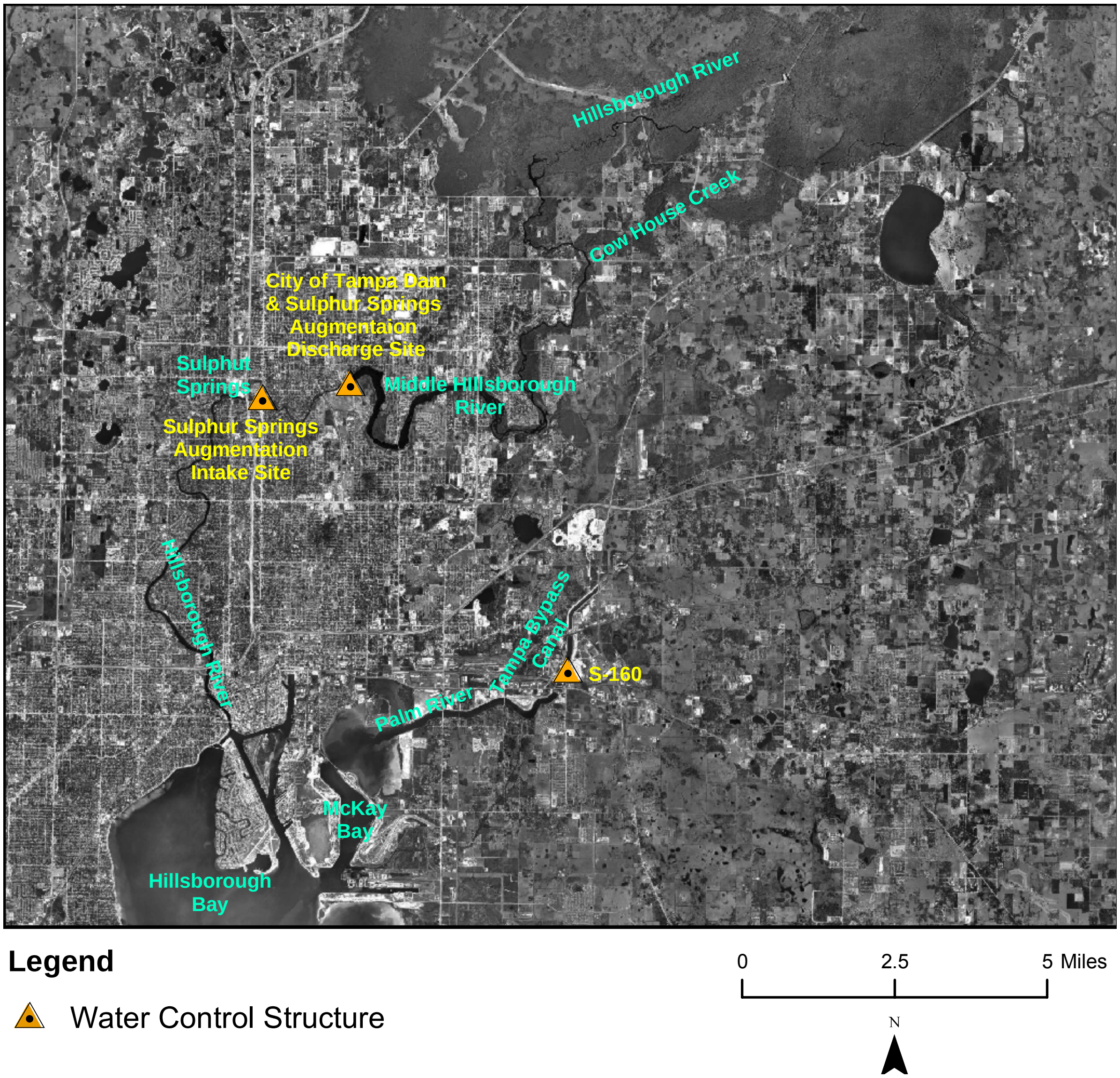


Figure 3-6. Aerial photography of the lower and middle Hillsborough River and Tampa Bypass Canal area in 1973 showing locations of City and District water control structures used to manage flow through the systems. Note that at the time of the photography, the dredging of the Palm River and lower portions of the Tampa Bypass Canal and construction of Structure S-162 was completed. The Lower Hillsborough Flood Detention Area, the Harney Canal, much of the Tampa Bypass Canal and several currently existing water control were not, however, yet constructed (photographic image source: Woolpert, Inc. 2005).

History of Sulphur Springs and the Middle River

Sulphur Springs is an artesian spring located in the City of Tampa Sulphur Springs Park adjacent to the Hillsborough River approximately 2.2 miles downstream from the City of Tampa Dam (see Figure 2-4). The spring pool is enclosed by a circular concrete wall, with an operable structure that permits discharge to a short spring run that drains to the river. Discharge of moderately mineralized water from the single vent in the pool has averaged 34 cubic feet per second, or 22 million gallons per day in recent decades (Southwest Florida Water Management District 2004h).

The spring system has historically been used for recreational purposes and since the mid-1960s, as a water supply. In May 1964, the City of Tampa installed a pump at Sulphur Springs to be used for intermittent augmentation of the middle river (Stewart and Mills 1984). Augmentation was reportedly initiated in 1965 (Southwest Florida Water Management District 2004h), although Watson and Company (1967) report that augmentation with water from Sulphur Springs began in April 1964. The spring water is pumped to the middle river for blending with impounded river water because the concentrations of several mineral constituents in the spring water exceed Class I potable water supply standards. The mineralized nature of the spring water may lead to water-treatment issues associated with withdrawals for water supply upstream of the City of Tampa Dam during periods of low water levels in the middle river. For this reason, the City attempts to minimize augmentation of the middle river with water from Sulphur Springs (Southwest Florida Water Management District 2004h).

During periods of low water levels in the middle river, water from the spring has historically been discharged upstream of the dam for augmentation of the impounded water supply. Following adoption of Minimum Flows for the lower Hillsborough River in 2000, the pumping system used for augmenting the middle river with spring water was modified to allow discharge of water to the lower river below the dam as well as augmentation of the middle river. Subsequent evaluations dictated in the Minimum Flow rule required additional modification of the pumping system, which led to system changes that permit some of the water which is withdrawn or pumped from the spring to be returned to the spring pool. Additional information concerning use of Sulphur Springs as a water supply is included in the discussion of augmentation of the middle river in Chapter 4 of this report.

Highlights of Chapter 3

The segment of the Hillsborough River corresponding to the middle river has been impounded since the late 1890s. The impoundment created by previous dams or the currently existing dam was historically used for electricity generation and since the 1920s as a water supply. Flooding in 1933 led to the collapse of the then existing dam and in 1945 construction of the currently existing dam by the City of Tampa was completed.

Flooding in the Hillsborough River basin in 1960 precipitated construction of the Lower Hillsborough Flood Detention Area, Tampa Bypass Canal, Harney Canal and water control structures associated with these facilities. Construction of these flood control systems was initiated in the mid-1960s and continued through the early 1980s. They allow diversion of flood waters from the upper Hillsborough River away from the City of Temple Terrace and the City of Tampa for discharge to Tampa Bay.

The Lower Hillsborough Flood Detention Area, Tampa Bypass Canal, Harney Canal and associated structures were originally developed for flood control purposes, although management goals for the systems have expanded to include water storage and supply, natural system protection and recreational use. Water from the Tampa Bypass Canal and Harney Canal is used to augment the middle river for water supply purposes. Water pumped from Sulphur Springs, an artesian spring located downstream from the middle river is also used to augment the middle river.

Chapter 4

Water Budget Concepts and Parameters for the Middle River

Concepts and Water Budgets

Water budgets provide a means for quantifying changes in the storage of water in a watershed or a watershed segment, such as an impounded river. Water budgets are essential to many water management decisions including those associated with water-supply availability and sustainability. Healy *et al.* (2007) provide an excellent review of the application of water budget approaches to a wide range of water-resource studies and projects. A water budget is an accounting system or equation used to describe relationships between water input, water output and change in water storage components. In simplest form, a water budget may be described by the three components of the following equation:

Inflow (or Inputs) – Outflow (or Outputs) = Change in Storage.

Some water budget components are typically subdivided into separate parameters to better characterize or understand hydrologic processes. For example, the Inflow component may be subdivided into parameters such as precipitation and surface or groundwater inflow. Similarly, the Outflow component could be subdivided into evapotranspiration and surface or groundwater outflow.

The United States Geological Survey (Goetz *et al.* 1978) used a water budget approach to evaluate the water supply potential of the Hillsborough River and the "Tampa Reservoir" during periods of low rainfall, *i.e.*, during periods of low river flow. Supporting data for the analyses included estimation of storage volume upstream from the City of Tampa Dam relative to water level and inflow estimates for the river segment at the Fowler Avenue bridge during low-flow (dry) periods. Inflow estimates were based on flows measured at the Fowler Avenue site and at the long-term gauging stations maintained at the dam and upstream (Hillsborough River near Zephyrhills). Parameters missing from the water budget analysis included evaporative losses, seepage into and from the middle river, and augmentation of the river segment with water from Sulphur Springs

Environmental Science and Engineering, Inc. (1987) provide information on another water budget study of the "Tampa Reservoir" that was completed by Camp, Dresser and McKee, Inc. (1986). The 1986 report, which was not directly evaluated as part of the current District study of the middle river, reportedly included estimates for evaporative losses, seepage from the middle river, and augmentation of system with water pumped from Sulphur Springs. The purpose of the Camp, Dresser and McKee study was to provide information on water-supply capacity of the middle river.

Environmental Science and Engineering, Inc. (1987) also used a water budget approach to evaluate the water supply potential of the middle river. The modeling effort presented in the 1987 report was predicated on a previous water budget study (Environmental Science and Engineering, Inc. 1986, as cited in Environmental Science and Engineering, Inc. 1987) that incorporated estimates of change in storage in the impounded river segment, inflow from the Hillsborough River, outflow across the City of Tampa Dam, and augmentation with water from Sulphur Springs and the Tampa Bypass Canal. Improvements to the analyses for the 1987 study included better representation of the effects of operation of the Tampa Bypass Canal on the river. Predicted groundwater influences associated with Tampa Bypass Canal operation and withdrawals at the Morris Bridge Well Field were also evaluated.

A relatively complex water budget equation was developed as part of the 1987 study by partitioning the total Inflow and Outflow parameters as described by the following equations:

Inflow = IFA + RO + QSS + QBC;

where:

Inflow	=	Total inflow to the middle river:
IFA	=	inflow from the Hillsborough River at Fowler Avenue;
RO	=	rainfall on the middle river and runoff from ungauged areas;
QSS	=	pumpage from Sulphur Springs used for middle river augmentation;

and;

QBC	=	pumpage from the Tampa Bypass Canal used for middle river augmentation.

Outflow = QR +QWS +QSEP +E

where:

O	=	total outflow from the middle river:
QR	=	discharge across the dam;
QWS	=	withdrawals for water supply;
QSEP	=	net seepage loss to ground water systems; and
E	=	evaporative loss from the middle river

Development of data pertaining to each of these parameters required substantial effort. In some cases, records for some parameters were incomplete and had to be synthesized using other available data. For example, inflow from the Hillsborough River at Fowler Avenue was estimated using gauging records for three sites in the watershed above the middle river and simulated records based on regressions between flow records at a longer-term stream flow gauging station. Values used for other parameters were estimated based using standard engineering methods and best professional judgment. For example, an operational plan for augmentation of the middle river with water from Sulphur Springs and the Tampa Bypass Canal was developed to support the water-budget modeling effort.

Environmental Science and Engineering, Inc. (1987) calibrated their water budget model using the long-term discharge data available at the City of Tampa Dam site and comparisons based on estimated water budget components and observed data collected during two “drought” events. They found close correspondence between reported annual discharge from the middle river for the period from 1939 through 1978, *i.e.*, 383 million gallons per day, and the estimate of 353 million gallons derived from the water budget model. Model predictions for shorter term periods of low rainfall similarly corresponded well with available hydrologic data. Simulated water budget components for the two “drought” periods from the Environmental Science and Engineering, Inc. (1987) report are presented in Table 4-1 to provide an example of the relative magnitude of the various water budget components for the middle river.

Table 4-1. Simulated water budget components and parameters for the middle Hillsborough River estimated by Environmental Science and Engineering, Inc, (1987) for two three-month (March through May) periods in 1981 and 1985. Periods were selected to represent water budget components during drought conditions.

Component	Parameter	Component Description	Million Gallons per Day	
			1981	1985
Inflows	IFA	Hillsborough River inflow at Fowler Avenue	50.8	33.9
	RO	Rainfall on the middle river and ungauged inflows	0.4	0.4
	QSS	Augmentation with water from Sulphur Springs	11.2	14.7
	QBC	Augmentation with water from the Tampa Bypass Canal	7.3	24.1
Outflows	QR	Discharge across the City of Tampa Dam	0	0
	QWS	Withdrawals for water supply	56.8	54.3
	QSEP + E	Net seepage loss and evaporative loss	23.8	29.5
Change in Storage		Change in the volume of water in the system	-10.9	-10.7

Limno Tech, Inc. (1997) also used a water budget approach to support an investigation of nutrient loading to the “Hillsborough River Reservoir”. Annual water budgets and nutrient load estimates were developed for three years considered representative of high, low and average rainfall conditions. Hydrologic inputs to the middle river included combined measured flows at three upstream United States Geological Survey gauge sites, estimated inflows for ungauged portions of the watershed above Fowler Avenue, runoff to the middle river, rainfall on the inundated river segment and augmentation with water from Sulphur Springs and the Tampa Bypass Canal. Estimated inflows from the ungauged area upstream from Fowler Avenue were derived using measured flows and relative drainage areas associated with the stream flow gauges at stations 02303350 (Trout Creek near Sulphur Springs, Florida), 02303330 (Hillsborough River at Morris Bridge near Thonotosassa, Florida) and 02303800 (Cypress Creek near Sulphur Springs, Florida). Inflows at Fowler Avenue were estimated by multiplying the combined flows for these three stations by 1.129 to account for the 11.4% of the watershed upstream of Fowler Avenue that does not drain past the three gauge sites. Hydrologic outputs included in the annual water budgets were withdrawals by the City of Tampa, evapotranspiration and discharge over the City of Tampa Dam.

Relative contributions of individual hydrologic input and output parameters to the water budget for 1983, 1987 and 1990 are listed in Table 4-2. Withdrawals by the City of Tampa were estimated to account for a substantial hydrologic loss to the system during periods of low rainfall, based on the model results for 1990. It should be noted, however, that comparisons of withdrawal effects among the three years could be confounded by demand increases associated with factors other than rainfall variability. Limno-Tech, Inc. notes that augmentation of the middle river may account for substantial inputs during dry periods; however they report that data on pumping from Sulphur Springs and the Tampa Bypass Canal to the river were not available for 1983 or 1987.

Table 4-2. Percent contribution of individual parameters to hydrologic input and output components of middle Hillsborough River water budgets estimated for 1983, 1987 and 1990 by Limno-Tech, Inc. (1997). Years were selected to represent periods of relatively high (1983), normal (1987) and low (1990) rainfall.

Component	Parameter	Percentage of Input or Output		
		1983	1987	1990
Inputs	Estimated inflow above Fowler Avenue	94.6	93.5	75.1
	Estimated inputs below Fowler Avenue	5.0	6.0	9.3
	Direct rainfall on the middle river	0.4	0.5	1.1
	Augmentation with water from Sulphur Springs	nd	nd	1.6
	Augmentation with water from the Tampa Bypass Canal	nd	nd	13.0
Outputs	Withdrawals by the City of Tampa	9.6	17.8	56.0
	Direct evapotranspiration from the middle river	0.3	0.5	1.4
	Estimated discharge over the City of Tampa Dam	90.0	81.7	42.6

nd = pumping data for augmentation not available

Davis *et al.* (2008) recently developed a water budget for the middle river as part of a peer-review of one the recovery strategies identified for achieving compliance with minimum flows in the lower Hillsborough River. Water budget components were evaluated for the period from October 23, 2005 to October 23, 2006 and are presented in Table 4-3. Withdrawals by the City of Tampa for public supply purposes accounted for approximately 61% of the outputs from the system. Diversion of water to the Tampa Bypass Canal accounted for approximately 8% of the outputs and a comparable percentage of the total inputs was added to the river through augmentation.

Table 4-3. Water budget components and parameters for the middle Hillsborough River estimated by Davis *et al.* (2008) for the period from October 24, 2005 through October 23, 2006.

Component	**Parameter**	**Million Gallons per Day**
		Oct 2005 to Oct 2006
Inputs	Estimated inflow [A]	117.84
	Estimated rainfall	1.71
	Augmentation	11.01
	Total Inputs	130.56
Outputs	Discharge over the City of Tampa Dam	30.48
	Diversions through Structure S-161 to Harney Canal	10.15
	Withdrawals by the City of Tampa	78.13
	Evaporation [A]	2.33
	Groundwater outflow	8.00
	Total Outputs	129.09
Change in Storage		0.42

A = parameter value credited to SDI (1997) by Davis et al. (2008)

Information pertaining to published reports on water budgets for the middle Hillsborough River is not presented in this report as a prelude for development of a new water budget for the system. Rather, the previous work is highlighted to illustrate specific issues concerning development of a water budget for the system. The information also provides a framework for evaluation and presentation of information pertaining to the various water budget parameters that must be considered to gain an understanding of middle river hydrology. These factors include inflow from the upper Hillsborough River, groundwater inflows/outflows, augmentation from Sulphur Spring and the Tampa Bypass Canal system, discharge across the City of Tampa Dam to the lower river, withdrawals and diversions from the river used for water supply purposes, and water level fluctuations associated with change in storage in the impounded river segment. Each of these water budget parameters are reviewed in subsequent sections of this chapter.

Ground Water Inflow and Outflow from the Middle River

Wolansky and Thompson (1987) provide an overview of ground and surface water interactions in the Hillsborough River basin. They note that upstream of the confluence of Trout Creek and the Hillsborough River (in the upper Hillsborough River as defined in this report), the river tends to be a gaining stream, *i.e.,* water from the underlying Upper Floridan Aquifer system typically flows into the river channel. Downstream from this area, the river has the potential to be a losing stream, with net flow from the river channel downward to the aquifer system. Based on differences in reported discharge measurements from the United States Geological Survey gauge sites at Fowler Avenue and the City of Tampa Dam, they note that it is likely that the river segment between these two sites is a losing stream. Water diversion into and out of the middle river, withdrawals and augmentation of the river segment limited quantification of potential losses or leakance from the basin. Impoundment of the river upstream from the dam would, however, be expected to increase downward leakance.

East of the middle river, in the vicinity of the Harney Canal and Tampa Bypass Canal, groundwater is discharged to the surface from the underlying aquifer. This discharge is derived from flows associated with several springs and through areas in the canal system where the underlying Upper Florida Aquifer system was breached. Construction of the canal system is estimated to have lowered the potentiometric surface of the Upper Floridan Aquifer system two to four feet in the portions of the canal area and reduced discharge from the area springs, although the increased discharge through though the breached areas has had a net effect of increasing ground water discharge in the canal area approximately 70 to 100%. Lowering of the potentiometric surface of the aquifer and increasing discharge in the canal system has likely increased groundwater seepage from the middle river, although quantitative estimates of this relationship are not well known.

Studies conducted for evaluation of potential water supplies provide some information on the extent of ground water losses from the middle river. As cited by Wolansky and Thompson (1987), Geraghty and Miller, Inc. (1982) pumped water from the Harney Canal to the middle river near District structure S-161 during a dry period to evaluate the potential water yield from the Tampa Bypass Canal. Results from their study indicate that approximately 2% of the water that was pumped from the canal system into the middle river was returned to the canal system via groundwater leakance from the river and discharge back into the canal. As part of the middle river water budget Environmental Science and Engineering, Inc. (1987) estimated that 10 to 15% of the base-flow in the Tampa Bypass Canal may be derived from the middle river. Their water budgets derived for the middle river and described in the previous section of this report, included estimates of 24 to 30% for summed groundwater losses and evapotranspiration.

Based on a recent modeling scenarios developed for evaluation of a recovery project associated with minimum flows for the lower Hillsborough River, Davis *et al.* (2008) report that approximately 10 to 15% of the ground water discharged into the Tampa

Bypass Canal system may originate from the middle river. They also conservatively report that a maximum of 1.2 million gallons per day may leak from the middle river into the Harney Canal in the vicinity of Structure S-161. Davis *et al.* (2008) considered this potential output from the middle river to be insignificant as the water is returned to the middle river when water from the Tampa Bypass Canal is pumped into the river for the purpose of augmenting the water supply impounded upstream from the City of Tampa Dam.

Surface Water Inflows and Augmentation of the Middle River

Inflows

Surface water inflow to the middle river may be estimated based on discharge measured at three upstream sites within the watershed that are maintained by the United States Geological Survey. The Southwest Florida Water Management District (2006) reports that discharge measured at the Hillsborough River at Morris Bridge near Thonotosassa, Florida (Site No. 02303330), Trout Creek near Sulphur Springs, Florida (Site No. 02303350) and Cypress Creek near Sulphur Springs, Florida (Site No. 02303800) gauging stations accounts for all but about 16.5% of the surface water runoff to the middle river (note that for their water budget analyses, Limno Tech, Inc. [1997] estimated the ungauged area of the watershed was 11.4% of the total watershed area). Summing discharge for these three sites therefore provides a means for conservatively estimating inflows to the middle river. However, because river flow had reportedly been intermittently diverted to the Tampa Bypass Canal downstream from the gauge site at Morris Bridge since 1979 (Wolansky and Thompson 1987, Kane and Dickman 2005) or 1985 (Southwest Florida Water Management District 1999z, 2005a), and because the region between the Trout Creek gauge and the middle river is potentially an area of downward ground-water seepage (Wolansky and Thompson 1987), inflow estimates based on the gauging records may be inflated. Unfortunately, diversions from the river to the Tampa Bypass Canal and area ground-water losses have not been well documented or quantified. Given concerns about contributions of flow from ungauged areas, surface- and ground-water interactions and diversions from the river to the Tampa Bypass Canal, Inflow estimates for the middle river derived based on discharge records for the three United States Geological Survey sites should be considered only approximate.

Daily average inflows to the middle river, based on summed annual discharge totals for the Hillsborough River at Morris Bridge near Thonotosassa, Florida, Trout Creek near Sulphur Springs, Florida and Cypress Creek near Sulphur Springs, Florida gauge sites for the period from January 1975 through December 2008 are show in Figure 4-1. Inflows ranged from 41.3 to 602.2 million gallons per day and averaged 227.3 million gallons per day for the thirty-three year period.

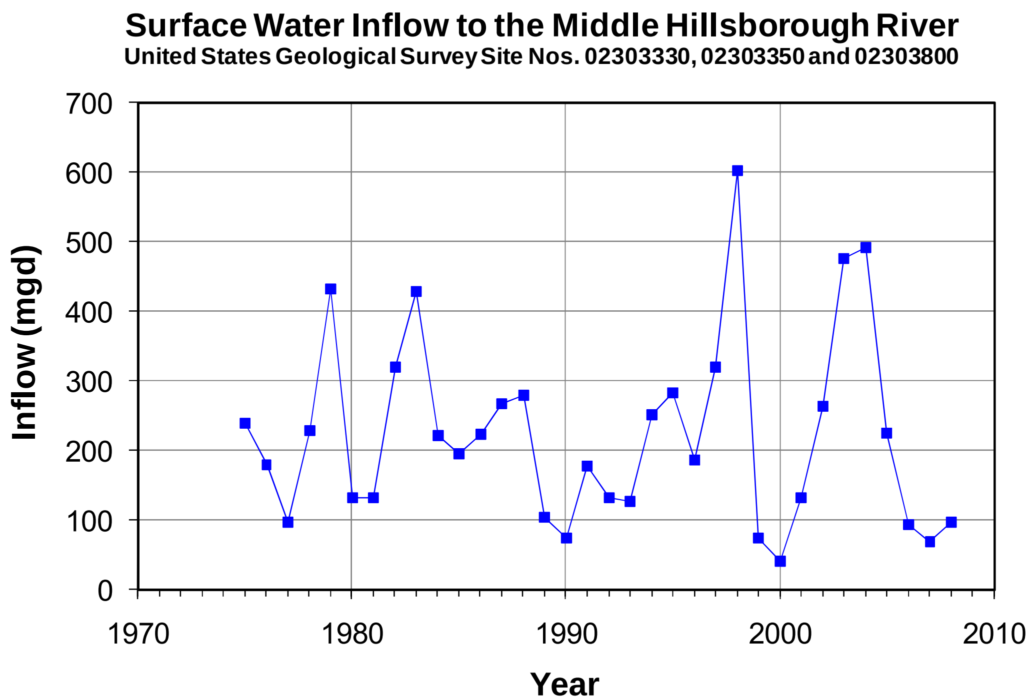


Figure 4-1. Estimated annual daily-average inflow to the middle Hillsborough River for the period from 1975 through 2008 based on summed discharge measured at three upstream United States Geological Survey streamflow gauging stations: Hillsborough River at Morris Bridge near Thonotosasssa, Florida (No. 02303330); Trout Creek near Sulphur Springs, Florida (No. 02303350); and Cypress Creek near Sulphur Springs, Florida (No. 02303350). Inflow estimate for 2008 includes some data classified by the Geological Survey as "provisional". Inflows not determined prior to 1975 based on lack of data for one or more of the gauging stations.

Comparison of daily average inflows with releases from the middle river suggests that inflows were historically higher than the estimates derived for the 1975 through 2008 period. The United States Geological Survey has measured and reported discharge over the City of Tampa Dam since October 1938 at the Hillsborough River near Tampa, Florida gauge site (No. 02304500) at the City of Tampa Dam. Close correspondence between estimated inflows and reported discharge over the dam for the 1975 through 2008 period (Figure 4-2), indicates that historic inflows may be approximated using discharge records available prior to 1975. Correspondence between estimated inflows and measured outflows would be expected to be better for periods of relatively lower withdrawals from the river and prior to the initiation of diversions from the river the Tampa Bypass Canal.

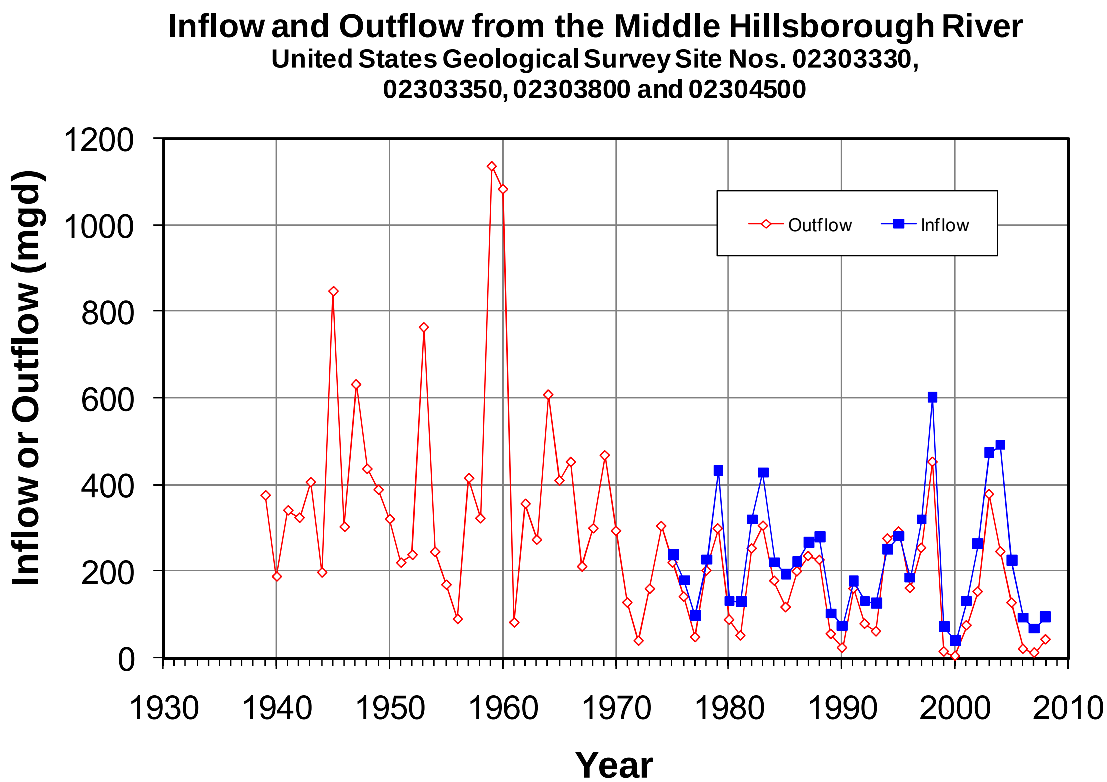


Figure 4-2. Estimated annual daily-average inflow to the middle Hillsborough River for the period from 1975 through 2008 and outflow across the City of Tampa Dam for the period from 1939 through 2008. Inflow values are based on summed discharge for three upstream United States Geological Survey streamflow gauging stations: Hillsborough River at Morris Bridge near Thonotosasssa, Florida (No. 02303330); Trout Creek near Sulphur Springs, Florida (No. 02303350); and Cypress Creek near Sulphur Springs, Florida (No. 02303350). Inflow estimate for 2008 includes some data classified by the Geological Survey as "provisional". Outflow values based on discharge reported for the United States Geological Survey station Hillsborough River near Tampa, Florida (No 02304500). Outflow records provide some indication of historical inflows, based on the close correspondence between inflows and discharge across the dam from 1975 through 2008.

Augmentation

During periods of low inflow from the upper Hillsborough River, the middle river is augmented with water from Sulphur Springs and the Tampa Bypass Canal/Harney Canal system. The augmentation is associated with water use permits issued by the District for water supply purposes. Details of these permits associated with augmentation of the middle river are discussed in this sub-section; information pertaining to direct withdrawals for water supply are discussed in the next sub-section of this chapter.

In 1964 or 1965 the City of Tampa began using water pumped from Sulphur Springs to augment the middle river for water supply purposes (Watson and Company 1967, Stewart and Mills 1984, Southwest Florida Water Management District 2004h). District regulation of the augmentation was initiated on November 2, 1983 when Consumptive Use Permit Number 202062.001 was issued to the City. The permit authorized withdrawal of an annual average of 10 million gallons per day and a daily maximum of 20 million gallons from the spring. The January 17, 1991 revision of the permit (Number 20002062.002) decreased the allowable annual daily average withdrawal from Sulphur Springs to 5 million gallons per day while continuing to allow maximum daily withdrawals of up to 20 million gallons per day.

Executive Director Orders were issued by the District in 2000 and 2001 to temporarily modify permit conditions pertaining to augmentation of the middle river with water from Sulphur Springs (Ralph Kerr, personal communication). On April 20, 2000, Executive Director Order Number SWF 00-17 authorized the City of Tampa to pump 20 million gallons per day from the spring on an annual average and peak monthly basis. The order also allowed the City to augment Jasmine Springs with water from Blue Sink as a means of indirectly augmenting Sulphur Springs. These increased pumping limits and the withdrawals from Jasmine Springs were authorized through August 20, 2000. On April 27, 2001, Executive Director Order Number SWF 01-22 again allowed the City to again pump up to 20 million gallons per day from the spring on an annual and peak monthly basis. The order expired on June 1, 2001, and was subsequently extended through July 6, 2001 and extended a second time, though August 3, 2001.

Augmentation of the middle river with water pumped from Sulphur Springs is currently regulated by conditions included in Water Use Individual Permit Number 20002062.006, which was issued to the City of Tampa on December 14, 2004. Conditions in the permit limit withdrawals from the spring for augmentation of the middle river to an annual average of 5 million gallons per day and a maximum daily total of 20 million gallon per day. Use of water from Sulphur Springs for augmentation of the middle river is conditional, based on water surface elevations of the river segment. During January and February and July through December, augmentation is permitted only if the river water surface elevation is at or is lower than 18.0 feet above NGVD29 as measured at the United States Geological Survey gauge site at the dam (Hillsborough River near Tampa, Florida – Site Number 02304500). From March through June, use of water from Sulphur Springs for augmentation purposes is permitted only when the river water surface is at, or lower than 20.0 feet above NGVD29. The permit also requires augmentation of the middle river with water from the Tampa Bypass Canal rather than Sulphur Springs whenever practicable.

Augmentation of the middle Hillsborough River with water from the Tampa Bypass Canal was first authorized in Consumptive Use Permit Number 206675 issued to the West Coast Regional Water Supply Authority (the precursor of Tampa Bay Water) and the City of Tampa on November 2, 1983. The permit limited withdrawals from the canal to an annual average of 20 million gallons per day and a daily maximum of 40 million gallons per day. Permit conditions stipulated that withdrawals from the canal were not allowed when water was being released from the middle river to the lower river at the City of Tampa Dam. To protect the integrity of Structure S-161 on the Harney Canal, withdrawals were to cease when the water surface elevation in the canal receded to 12 feet above NGVD29. Withdrawals were similarly not allowed when the difference in the water level on the two sides of the structure was 12 feet or greater. Augmentation of the middle river with water from the Tampa Bypass Canal was reportedly not initiated until 1985 (The Planning Commission 1998, Southwest Florida Water Management District 1999e), although approximately 680 million gallons of water was pumped from the canal to the middle river in 1981 as part of an investigation of the potential use of the Tampa Bypass Canal as a water supply (Southwest Florida Water Management District 1990, 1999e).

On November 27, 1990, Water Use Permit Number 20006675.001 was issued to the West Coast Regional Water Supply and the City of Tampa and required that the Tampa Bypass Canal would "be the first and primary augmentation source for the reservoir", *i.e.,* water from the canal was to be used to meet augmentation needs in preference to using water pumped from Sulphur Springs. The revised permit required the development of a coordination plan by June 1, 1991 that addressed use of the canal system for flood management and water supply purposes and which provided for the construction of a permanent facility for pumping water to the middle river. The condition requiring that augmentation must cease when the water surface elevation in the Harney Canal recedes to 12 feet above NGDV29 was retained from the first version of the permit. Regulatory limits in the revised permit prohibited augmentation when the water level in the middle river was at or higher than 22.5 feet above NGVD29. Augmentation was similarly prohibited from March through June until the water surface receded to 21.0 feet above NGVD29 and from July through February until the water level dropped to 19.0 feet above NGVD29. In addition to these limitations, the permit required additional “mitigation” augmentation of the middle river with water from the Tampa Bypass Canal when water was not being discharged across the City of Tampa Dam and the middle river surface receded to 22.0 feet above NGVD29. The required mitigation augmentation was intended to offset permitted withdrawals from the middle river for water supply and promote storage in the impounded river segment.

Subsequent versions of the permit included some notable changes. Permit Number. 206675.03, issued on February 15, 1994 required that augmentation with water from the Tampa Bypass Canal was not to begin until the water surface elevation in the middle river receded to 21 feet above NGVD29, unless mitigation augmentation was required. In addition, augmentation was to be discontinued when the river water surface rose to 22.0 feet above NGVD29 (unless mitigation augmentation was required) or the difference between water levels on either side of Structure S-161 was 12 feet or greater. Through letter modification of the permit on December 15, 1999, Permit Number 206675.04 allowed augmentation only when the water surface in the middle river was below 22.5 feet above NGVD29, the crest gates and the two Tainter gates on the dam were closed and the flow in the Hillsborough River measured at the United States Geological Survey gauge at Morris Bridge Road was less than the volume of water withdrawn from the middle river by the City of Tampa for water supply purposes. The requirement concerning water level differences on either side of Structure S-161 was also modified; withdrawals from the canal were to cease if the difference was 10 feet or greater.

In 2000, three Executive Director Orders were issued by the District for increased augmentation of the middle river by Tampa Bay Water (Ralph Kerr, personal communication). Executive Director Order Number SWF 00-16 was issued on April 11, 2000 and allowed withdrawals from the Tampa Bypass Canal for augmentation of the middle river to be increased beyond limits included in the then existing permit through December 1, 2000. On May 22, 2000, Executive Director Order Number SWF 00-26 authorized Tampa Bay Water to withdraw water from the Morris Bridge Road Sink through August 20, 2000 for augmentation of the river. Withdrawals from the sink for augmentation purposes were authorized again later in the year, when Executive Director Order Number SWF 00-57 was issued on November 22, 2000. This order allowed withdrawals of up to 15 million gallons per day from the sink through January 9, 2001.

The most recent version of the Water Use Individual Permit (Number 20006675.005) authorizing augmentation of the middle river with water from the Tampa Bypass Canal was issued to Tampa Bay Water on June 26, 2001. The permit allows an annual average withdrawal from the Tampa Bypass Canal of up to 20 million gallons per day and a peak monthly rate of 40 million gallons per day for augmentation of the river. Augmentation is permitted when the middle river water surface is below 22.50 feet above NGVD29, the crest gates and the two Tainter gates on the City of Tampa Dam are closed and the flow in the Hillsborough River at the Morris Bridge gauge site is less than the withdrawal rate from the middle river at the City of Tampa's David L. Tippin Water Treatment Facility (see the next sub-section of this chapter for information on withdrawals from the middle river). Augmentation must cease when the water surface elevation in the Harney Canal at Structure S-161 is at or below 12 feet above NGVD29; or the difference in water surface elevation on either side of the S-161 structure is 10 feet or greater; or the water level in the middle river equals or exceeds 22.5 feet above NGVD29.

A water shortage emergency in 2006 led to the issuance of Executive Director Order Number SWF 06-31 on May 11, 2006. The order allowed augmentation of the river with water from the Tampa Bypass Canal until the water surface elevation in the canal dropped below 10 feet above NGVD29. The order, which was in effect through July 31, 2006, did not alter the permitted annual average daily withdrawal or peak monthly withdrawal volumes specified by conditions in the existing permit.

In response to another water shortage emergency in 2007, the District issued an Executive Order to temporarily modified permit conditions pertaining to augmentation of the middle river with water from the Tampa Bypass Canal. Executive Director Order Number SWF 07-033 which was issued on May 18, 2007 and was in effect through

September 30, 2007, authorized Tampa Bay Water to withdraw up to 40 million gallons per day from the Tampa Bypass Canal for augmentation of the middle river. The order also temporarily modified permit conditions pertaining to limits on augmentation associated with the water surface in the canal and the difference between water levels on either side of Structure S-161. Through September 30, 2007, augmentation of the middle river was authorized until the water surface elevation in the canal upstream of Structure S-161 dropped to 10 feet above NGVD29 or the difference between the water levels on either side of the structure exceeded 12 feet.

Based on continued drought conditions in 2008, Executive Director Order Number SWF 08-043 was issued on October 16, 2008 to again allow increased augmentation of the middle river with water from the Tampa Bypass Canal. The order remains in effect through July 31, 2009 and authorizes Tampa Bay Water to continue augmentation from the canal until the water surface elevation in the middle pool of the Tampa Bypass Canal recedes below 10 feet above NGVD29 and the difference between water levels on either side of Structure S-161 exceeds 12 feet. As was allowed in 2007, the order authorizes daily withdrawals of up to 40 million gallons per day. A modification to the order, authorizing augmentation until the water surface in the middle pool of the Tampa Bypass Canal recedes below 9 feet above NGVD29, was issued on December 10, 2008.

Pumpage values associated with withdrawals for augmentation of the middle river with water from Sulphur Springs and the Tampa Bypass Canal are available from the District Water Management Information System, beginning respectively, in December 1984 and January 1985. Annual average daily withdrawals used to augment the middle river from 1984 through 2007 are shown in Figure 4-3; augmentation pumpage records for 2008 were available only through November 2008, so an annual value for 2008 was not included in the figure. Augmentation from both sources combined averaged 9.5 million gallons per day for the 24 year period. Annual pumpage ranged from 0 million gallons per day in 1987 to peak value of 32.5 million gallons per day pumped into the middle river during the 2000 drought year. The Tampa Bypass Canal rather than Sulphur Springs has been the primary source for augmentation of the river since pumping from the canal was initiated in 1985 (Figure 4-4).

Stewart and Mills (1984) provide information regarding augmentation of the middle river for a period that pre-dates the period evaluated using pumpage data from the District Water Management Information System. Based on the review of pumpage records from 1965, when water from Sulphur Springs was first used to augment the middle river, through early 1980, spring flow was used for augmentation during two or more months in twelve of the sixteen years examined (Figure 4-5). Augmentation was limited to one month in 1966, 1970 and 1980 and no pumpage was reported for 1969. Monthly mean withdrawals from the spring exceeded 6.5 million gallons per day (10 cubic feet per second) during nearly three-quarters of the months with reported pumpage.

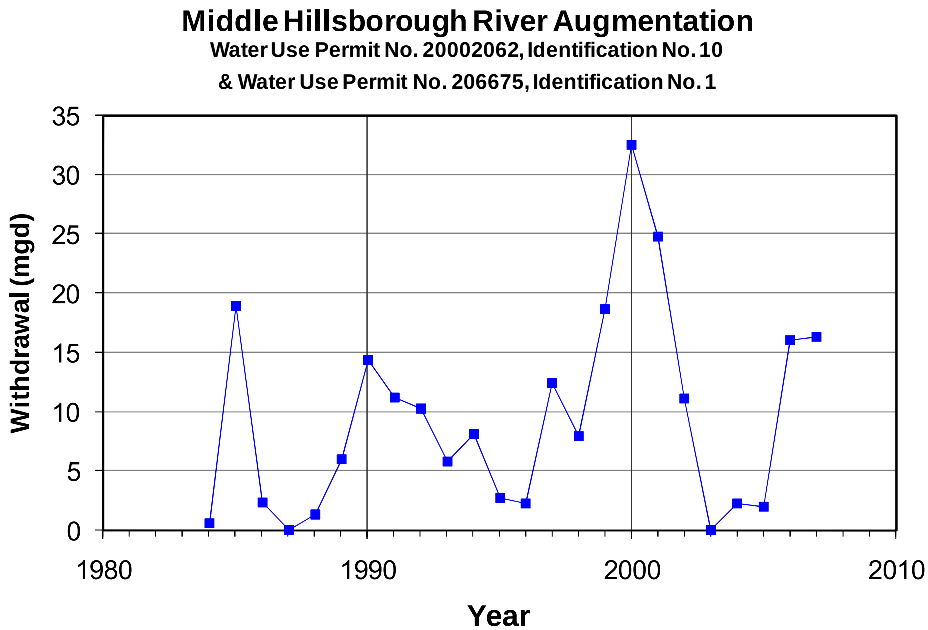


Figure 4-3. Combined annual daily-average withdrawals from Sulphur Springs and the Tampa Bypass Canal used to augment the middle Hillsborough River for the period from 1984 through 2007.

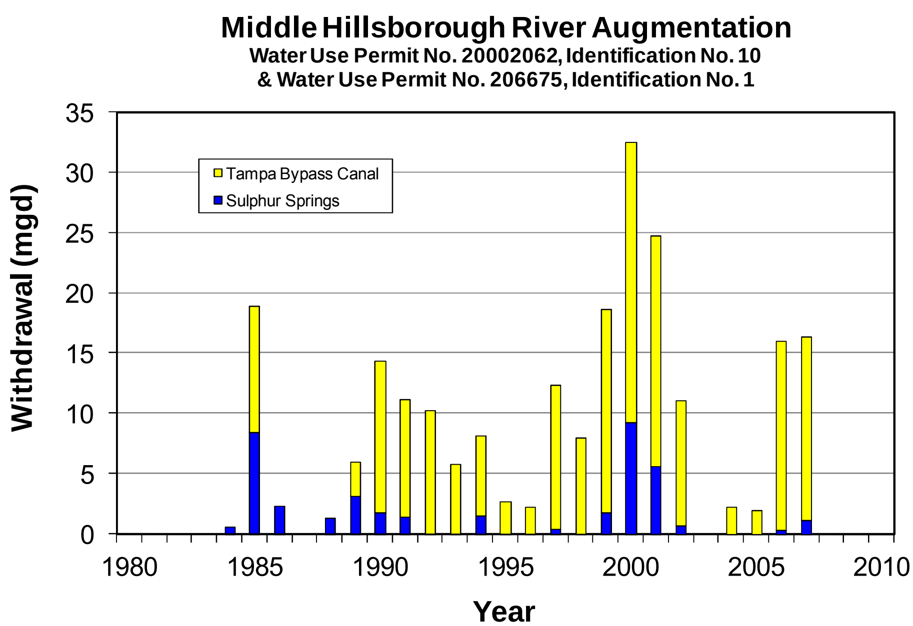


Figure 4-4. Annual daily-average withdrawals from Sulphur Springs and the Tampa Bypass Canal used to augment the middle Hillsborough River for the period from 1984 through 2007.

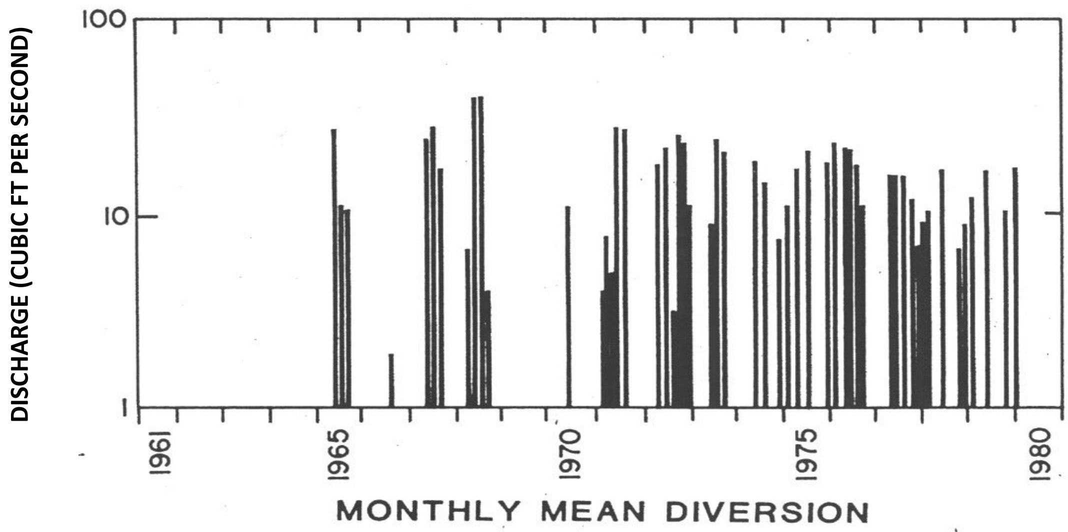


Figure 4-5. Monthly-average withdrawals from Sulphur Springs used to augment the middle Hillsborough River for the period from 1965, when augmentation was initiated, through 1980, as reported by the United States Geological Survey. Figure is a scanned reproduction of a plot presented by Stewart and Mills (1984).

<u>Surface Water Outflows and Withdrawals from the Middle River</u>

Surface Water Outflows

Surface water outflow from the middle river occurs primarily across the City of Tampa Dam to the lower Hillsborough River, although flows may also be routed to the Tampa Bypass Canal through Structure S-161 on the Harney Canal. As noted in the first sub-section of this chapter, Limno-Tech, Inc. (1997) estimated that discharge over the City of Tampa Dam accounted for approximately 43, 82 and 90 percent, respectively, of the annual outflow component for water budgets developed for the middle river for representative years of low, normal and high rainfall.

The United States Geological Survey has measured and reported discharge over the City of Tampa Dam since October 1938 at the Hillsborough River near Tampa, Florida gauge site (No. 02304500). Average daily discharge at the site ranged from 6.2 to 1,137 million gallons per day on an annual basis from 1939 through 2008 (Figure 4-6). Mean-annual discharge for the period was 272.6 million gallons per day. Years with daily-averaged discharge less than 200 million gallons per day have increased during the past four decades. This pattern of recent, decreased outflow from the middle river is also evident when the number of days with no discharge over the dam are examined (Figure 4-7, upper panel). Prior to 2001, there were few days with a reported discharge from the middle river of 0 million gallons per day. Since that time the number of days with a reported discharge of 0 million gallons has ranged from 4 to 265 per year.

The Southwest Florida Water Management District (2006) reports that for much of the period of record, reported discharge values at the City of Tampa Dam have included a leakage estimate. Leakage estimates have reportedly varied, but have generally been less than 1.3 million gallons per day. This means that examination of the number of day with reported discharge values less than or equal to 1.3 million gallons per day provided a better estimate of the number of days that there was no discharge over the dam. A plot of the annual number of days that discharge across the dam was less than 1.3 million gallons per day indicates that the number of days with no flow over the City of Tampa Dam has been high during the past several decades, peaking at 316 days in 2000 (Figure 4-7, lower panel).

The United States Geological Survey (Stoker *et al.*1996) has also reported declining trends in outflow from the middle river. For the period from 1939 through 1992, a decrease in mean annual flows of 7.7 cfs (5.0 million gallons per day) per year was noted. Although Stoker *et al.* did not attempt to identify the cause or causes for the flow decline they assert that rainfall deficits, drainage basin alterations, decreasing base-flow and increasing water withdrawals all likely contributed to the observed flow trend.

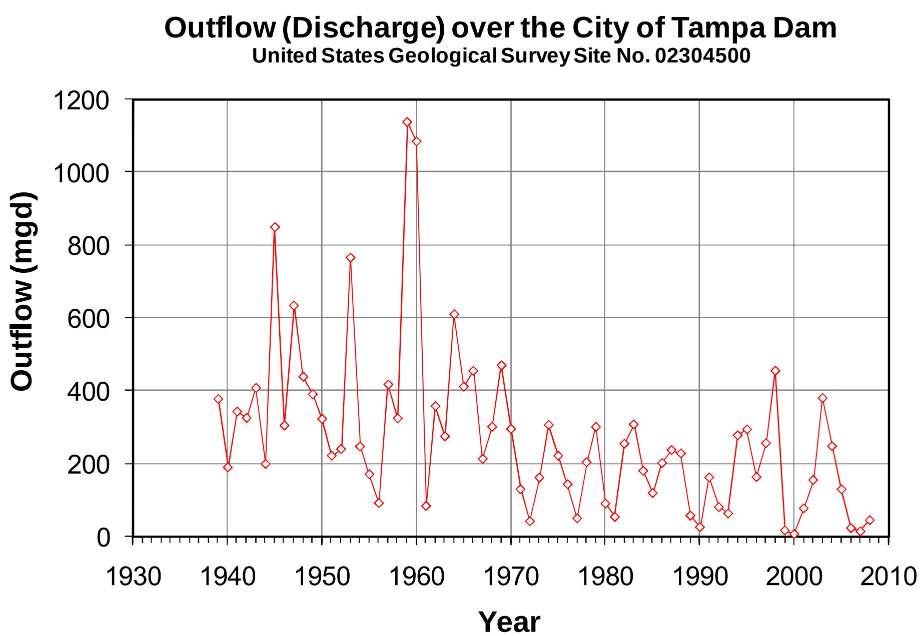
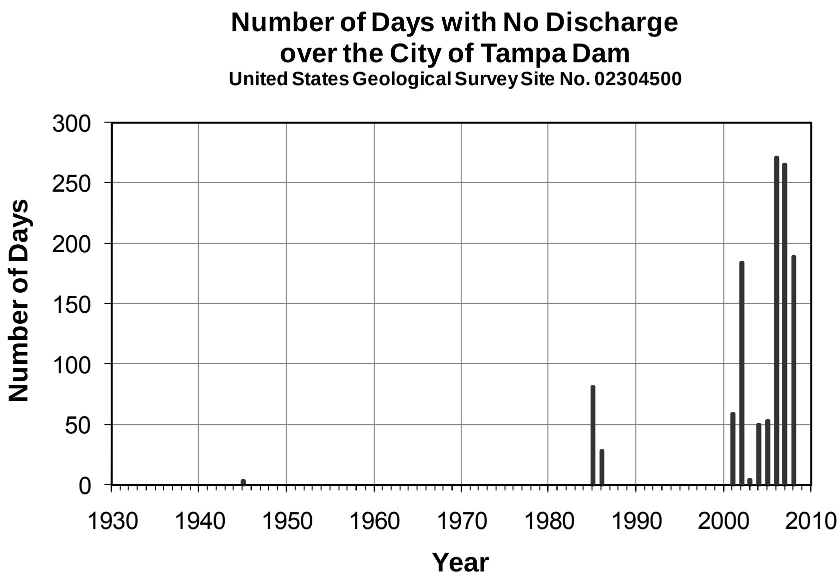


Figure 4-6. Annual daily-average outflow (discharge) from the middle Hillsborough River over the City of Tampa Dam for the period from 1939 through 2008 based on daily measurements reported by the United States Geological Survey for the Hillsborough River near Tampa, Florida gauge site (No. 02304500).



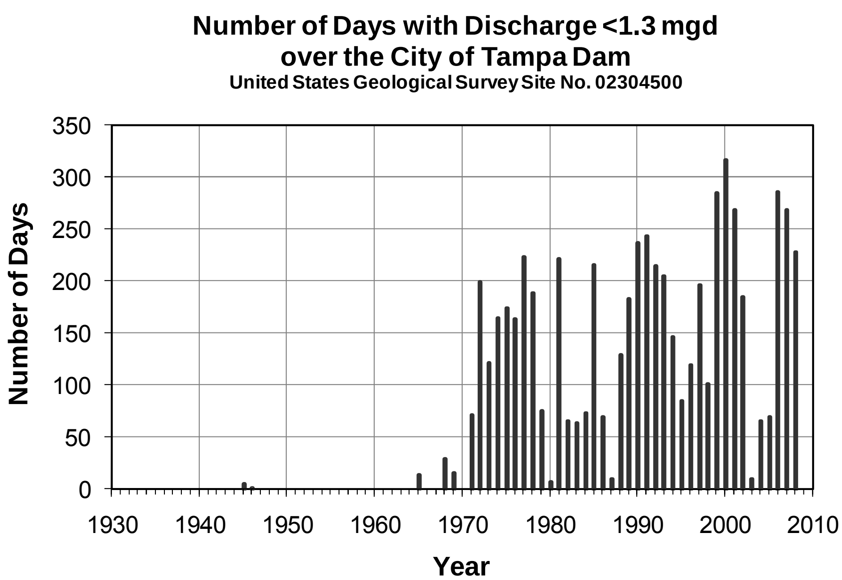


Figure 4-7. Annual number of days with no discharge (upper panel) or discharge less than 1.3 million gallons per day from the middle Hillsborough River over the City of Tampa Dam for the period from 1939 through 2008. Values based on daily discharge values reported by the United States Geological Survey for the Hillsborough River near Tampa, Florida gauge site (No. 02304500).

Infrequent flow diversions from the middle river through Structure S-161 and the Harney Canal to the Tampa Bypass Canal have been made historically for flood control purposes and more recently for water supply purposes. Structure S-161 was reportedly operated for flood control purposes for the first time in 1987 in response to a major storm event (Water and Air Research, Inc. 1988, as cited in HDR Engineering, Inc. 1994 and Southwest Florida Water Management District 1990) and was followed by additional diversions in 1988 and 2004 (Southwest Florida Water Management District 1990, 2005a). In 1999, revision of an existing water use permit authorized Tampa Bay Water to divert water from the middle river through structure S-161 for subsequent withdrawal from the Tampa Bypass Canal for public supply. This diversion is considered a water withdrawal and is discussed further in the next sub-section of this chapter.

Surface Water Withdrawals

The City of Tampa and Tampa Bay Water withdraw water from the middle river in accordance with water use permits issued by the District. The City of Tampa Water Department supplies potable and reclaimed water to more than 148,000 customers (Tampa Water Department 2008). Tampa Bay Water, a regional water provider established by the State Legislature, supplies water to more than 2.5 million people in Hillsborough County, Pasco County, Pinellas County, New Port Richey, St. Petersburg and the City of Tampa (Tampa Bay Water 2007). The middle river withdrawal represents the majority of the water demand met by the City of Tampa (Tampa Water Department 2007), while the water withdrawn from the system by Tampa Bay Water represents a much smaller percentage of their daily production.

Use of the middle river as a water supply by the City of Tampa was initiated in the 1920s (Tampa Water Department 2008). Miller and Silverston (date unknown) indicate the City's water withdrawal and treatment plant on the river shore was completed in 1926; the School District of Hillsborough County (2000) reports that the plant was operational in 1923. The plant, which is currently known as the David L. Tippin Water Treatment Facility (Figure 4-8) is located approximately 1.4 miles upstream of the City of Tampa Dam. Based on configuration of intake apparatus, withdrawals are limited to periods when the middle river water surface elevation is greater than 12 feet above NGVD29.

The first version of the District permit allowing the City to withdraw water from the river was issued on December 16, 1976 (Ralph Kerr, personal communication) shortly after the Florida Legislature identified the need for state-wide water use permitting. The original Consumptive Use Permit (Number 2062) allowed withdrawal of an annual average volume of 67.1 million gallons per day from the impounded river and limited daily maximum withdrawals to 103.7 million gallons per day (Ralph Kerr, personal communication). A revised version of the permit (Number 202062.001), issued on November 2, 1983, reduced the annual average withdrawal quantity to 62 million gallons per day and established a maximum daily withdrawal rate at 104 million gallons per day.

The January 17, 1991 version of the permit (Number 20002062.002) increased the annual average withdrawal quantity from the middle river to 82 million gallons per day, the limit identified in the current version of the permit. The 1991 version of the permit also required development of a Structure Operation Coordination Plan that described how the City of Tampa Dam was operated in conjunction with the District's Tampa Bypass Canal system. The permit also included requirements for "mitigation" augmentation of the middle river with water from the Tampa Bypass Canal when water was not being discharged across the City of Tampa Dam and the water level of the middle river receded to 22.0 feet above NGVD29. The required mitigation augmentation was intended to offset permitted withdrawals from the middle river for water supply and promote storage in the impounded river segment.

The current permit (Water Use Individual Permit Number 20002062.006) for use of the middle river by the City of Tampa for water supply purpose was issued by the District on December 14, 2004. The permit authorizes withdrawal of an annual average of 82 million gallons per day and limits daily maximum withdrawals to 120 million gallons per day. The maximum daily withdrawal limit represents a 14 million gallon per day increase in the limit included in previous versions of the permit. A peak monthly limit of 92 million gallons per day that was included in previous versions of the permit was eliminated from the current permit conditions. These changes were implemented to provide the City with the flexibility to store surface water in eight Aquifer Storage and Recovery wells during periods of high river flows, with the goal of maintaining the water supply in the impounded river and reducing the number of "low-flow" days at the dam. Withdrawal of up to a total of 10 million gallons per day is authorized in the permit. Permit conditions also stipulate that: 1) the City must maintain a minimum flow of at least 6.5 million gallons per day to the lower Hillsborough River at all times; 2) that the City release an additional 6.5 million gallons per day downstream when possible; and 3) that when withdrawals equal or exceed 104 million gallons per day, a minimum of 22.6 million gallons per day is to be released to the lower river prior to withdrawing water stored in the permitted Aquifer Storage and Recovery wells.

Continuous records of withdrawals from the middle river are available from October 1945 through November 2008. Daily average withdrawals from the river based on annual total withdrawal volumes are show for the period from 1945 through 2007 in Figure 4-9. Pumping of water from the river increased steadily from approximately 14.8 million gallons per day in 1946, the first full year with available pumping records, to approximately 55 million gallons per day in the early to mid-1970s. In the late 1970s, use of river water declined when the City began withdrawing ground water at the Morris Bridge Well Field to supply public demand. Increased demand for water since the mid-1980s has resulted in withdrawals from the river that are currently approaching the annual average permitted limit of 82 million gallons per day. In 2005, daily average withdrawals were 79.4 million gallons per day. Daily withdrawals reported through November 2008 indicate that approximately 71.7 million gallons per day was withdrawn from the river by the City in 2008, although this value is not included in Figure 4-9.

Figure 4-8. The City of Tampa David L. Tippin Water Treatment facility on the middle Hillsborough River (Southwest Florida Water Management District files).

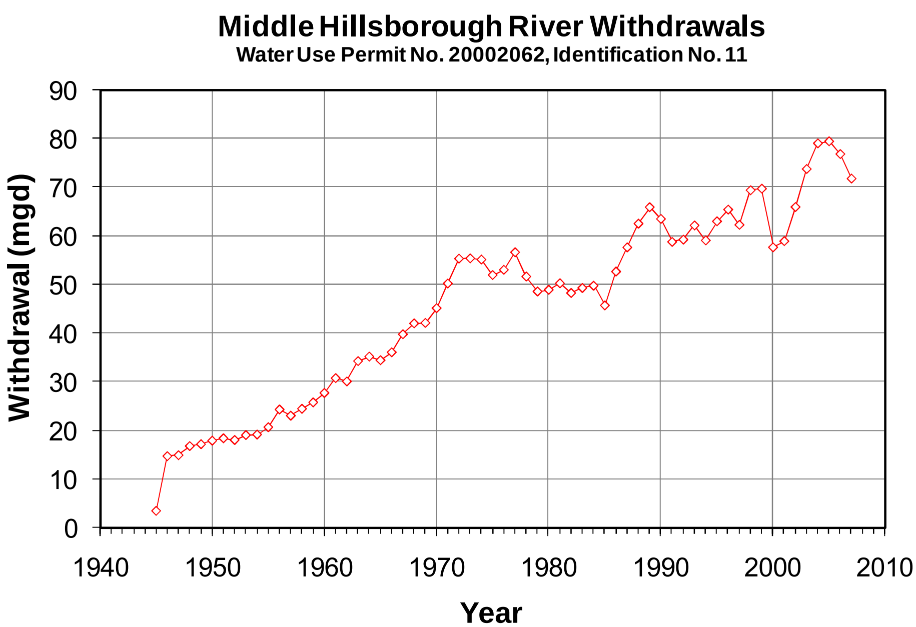


Figure 4-9. Daily-average withdrawals from the middle Hillsborough River by the City of Tampa for the period from 1945 through 2007. Withdrawals were initiated in the 1920s, but records for withdrawal volumes prior to October 1945 are not available.

Tampa Bay Water also uses water from the middle Hillsborough River for public supply. The utility does not withdraw water directly from the river, but instead diverts water through Structure S-161 and the Harney Canal to the Tampa Bypass Canal where it is pumped to the Tampa Bay Regional Surface Water Treatment Plant or to the South Central Hillsborough Intertie for transport and storage in the C.W. Bill Young Reservoir. This diversion of water for public supply purposes was first authorized by the District on March 30, 1999 through issuance of Water Use Individual Permit Number 2011796.00. The original permit specified maximum diversion rates based on discharge to the lower river at the City of Tampa Dam on the previous day as specified in Table 4-4. During periods of no flow at the dam, no water could be diverted to the canal system. During the highest flow periods a maximum of 194 million gallons per day could be diverted from the river. Volumes that could be diverted to the canal system during periods of intermediate flows were specified as percentages of the discharge over the dam.

Table 4-4. Original schedule for maximum permitted diversion of water from the middle Hillsborough River to the Tampa Bypass Canal based on Hillsborough River discharge at the City of Tampa Dam as defined in Water Use Individual Permit No. 2011796.00 issued to Tampa Bay Water on March 30, 1999. Diversions and discharge values are expressed as million gallons per day (mgd) and cubic feet per second (cfs).

Maximum Diversion Rate mgd / cfs	Hillsborough River Discharge Measured at Tampa Dam in Million Gallons Per Day (mgd) / Cubic feet per Second (cfs)
0 (no Diversions)	0 to 65 / 0 to 100
10% of total flow	65 to 97 / 100 to 150
10% to 30% - sliding scale	979 to 141 / 150 to 215
30% of total flow	141 to 647 / 215 to 1001
194 / 300	Above 647 / 1001

A revised version of the permit, No. 2011796.001 was issued on June 26, 2007, but was only in effect for three months (Ralph Kerr, personal communication). During this period Executive Director Order Number 07-042, which modified some conditions in the permit was issued by the District. The order was issued on August 3, 2007 to allow augmentation with water from the Tampa Bypass Canal to proceed through August 29, 2008 when the water surface elevation in the canal was at or higher than 9 feet above NGVD29. The Order also authorized diversion of water through Structure S-161 according to the schedule shown in Table 4-5. On August 29, 2007, Executive Order Number 07-042 was modified to extend the expiration date to September 26, 2008.

Table 4-5. Schedule for maximum permitted diversion of water from the middle Hillsborough River to the Tampa Bypass Canal system based on Hillsborough River discharge at the City of Tampa Dam as defined in Executive Director Order No. 07-042, issued on August 3, 2007. Diversions and discharge values are expressed as cubic feet per second (cfs) and million gallons per day (mgd), and were authorized through August 29, 2007.

Maximum Diversion Rate cfs (mgd)	Hillsborough River Discharge Measured at the City of Tampa Dam cfs (mgd)
0 cfs (0 mgd)	< 100 cfs (65 mgd)
0 (0 mgd) to 67 cfs (43 mgd) (0 to 40% of Flow-Sliding Scale) The diversion must leave a discharge rate of 100 cfs at the Tampa Dam. When there is more than 100 cfs at the Tampa Dam, TAMPA BAY WATER may take all of the flow in excess of 100 cfs as long as no more than 40% of the total flow over the Tampa Dam is diverted.	100 cfs (65 mgd) to 166 cfs (108 mgd)
67 cfs (43 mgd) to 300 cfs (194 mgd) (40% of the Total Flow) The Diversion must leave a discharge rate of 100 cfs at the Tampa Dam.	166 (108 mgd) to 746 cfs (485 mgd)
300 cfs (194 mgd) Maximum	>746 cfs (485 mgd)

Current allowable withdrawals from the middle river and the Tampa Bypass Canal are identified in Water Use Individual Permit No. 20011796.002, which was issued to Tampa Bay Water on August 28, 2007. The current permit authorizes the diversion of up to 194 million gallons per day from the middle Hillsborough River to the Tampa Bypass Canal through the Harney Canal and Structure S-161, and also allows the withdrawal of up to 258 million gallons per day from the Middle and Lower pools of the canal for regional use. The permit includes a slightly modified version of the schedule for diversions that was included in Executive Order Number 07-042. Diversions are limited to periods when discharge at the City of Tampa Dam exceeds 65 million gallons per day and are capped at a maximum of 194 million gallons per day during periods of high flows (Table 4-6). During periods of intermediate flows, diversions are limited to volumes corresponding to no more than 40% of the previous daily flow over the dam. Withdrawal of water from the Tampa Bypass Canal for consumptive use is authorized based on allowable diversions from the middle river and conditions pertaining to water surface elevations in the Harney Canal and the Middle and Lower Pools of the Tampa Bypass Canal. The quantities of water withdrawn from the middle pool are typically limited to the volume of water diverted from the middle river through Structure S-161, and withdrawals from the lower pool are derived from runoff from the Tampa Bypass Canal watershed and groundwater inflow to the canal system from the Surficial and Floridan Aquifer systems (PBS&J 2005).

Table 4-6. Current schedule for maximum permitted diversion of water from the middle Hillsborough River to the Tampa Bypass Canal based on Hillsborough River discharge at the City of Tampa Dam as defined in Water Use Individual Permit No. 20011796.002 issued to Tampa Bay Water on August 28, 2007. Diversions are expressed as cubic feet per second (cfs) and million gallons per day (mgd).

Maximum Diversion Rate	Hillsborough River Discharge at the City of Tampa Dam
0 cfs; or equivalently, 0 mgd	Less than 100 cfs; or equivalently, less than 65 mgd
0 to 67 cfs; or equivalently, 0 to 43 mgd The diversion must not cause the discharge to the river at the City of Tampa Dam to be less than 100 cfs (65 mgd). Also, no more than 40% of the flow over the dam may be diverted.	100 to 166 cfs; or equivalently, 65 to 108 mgd
67 to 300 cfs; or equivalently, 43 to 194 mgd The diversion must not cause the discharge to the river at the City of Tampa Dam to be less than 100 cfs (65 mgd). Also, no more than 40% of the flow over the dam may be diverted.	166 to 746 cfs; or equivalently, 108 to 485 mgd
300 cfs; or equivalently, 194 mgd	More than 746 cfs; or equivalently, more than 485 mgd

Discharge records for diversion of water from the middle river to the Harney Canal through Structure S-161 are available from August 30, 2002 through the present. Daily average discharge from the middle river based on annual total withdrawal volumes for 2002 through 2007 ranged from 4.7 to 110.4 million gallons per day (Figure 4-10).

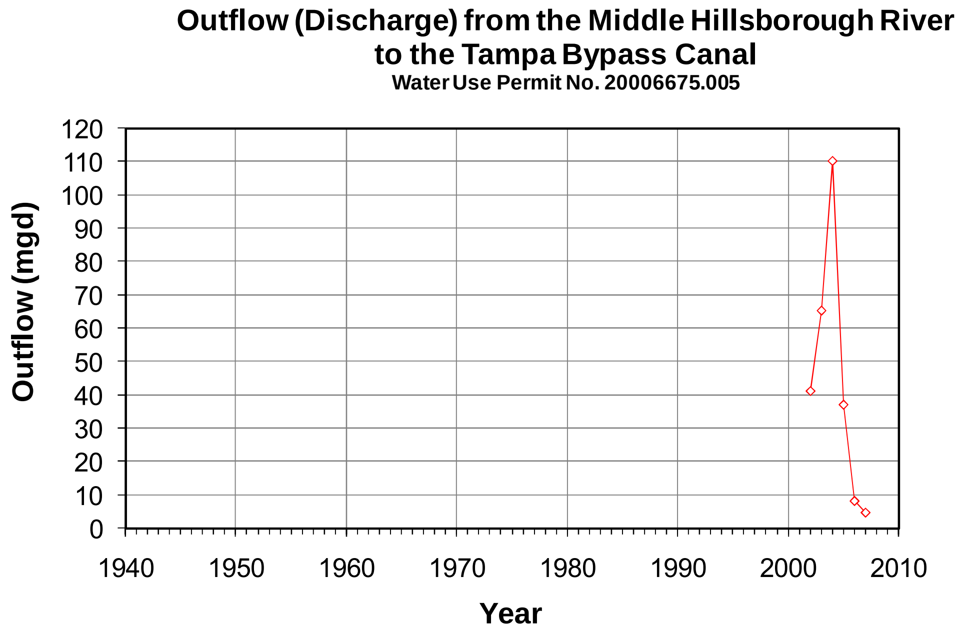


Figure 4-10. Daily-average outflow (discharge) from the middle Hillsborough River through Structure S-161 to the Tampa Bypass Canal for the period from 2002 through 2007. Value for 2002 is based on discharge recorded from August 30, 2002 through the end of December 2002. Water is discharged from the river to the Tampa Bypass Canal for subsequent withdrawal by Tampa Bay Water.

Change in Storage – Middle River Water Level Fluctuations

The various water budget parameters evaluated in preceding sub-sections of this chapter, including groundwater inflows/outflows, surface water inflows/outflows, augmentation and water withdrawals are all integrated into changes in storage in the middle river. Change in storage is often evaluated in terms of changes in the volume of water contained within a basin, but may also be evaluated as change in water levels since the water surface elevation is directly proportional to the storage volume. Available water level records for the middle river were, therefore, compiled to examine temporal and spatial variability of water levels within the river segment.

Mean daily water surface elevations are available for two gauge sites in the middle river that are maintained by the United States Geological Survey and at a site formerly maintained by the Geological Survey near the upstream boundary of the river segment. Less frequently measured water surface elevations are also available for the middle river at a site maintained by the Southwest Florida Water Management District. The locations of the United States Geological Survey and District gauge sites are shown in Figure 4-11). United States Geological Survey site number 02304500 is named "Hillsborough River near Tampa, Florida" and is located near the left bank (south shore) at the downstream end of the middle river on the upstream side of the City of Tampa Dam. Measurement of water levels at this site was initiated in October 1945 and continues through the present date. Untied States Geological Survey site number 02304000 is named "Hillsborough River at Fowler Avenue near Temple Terrace, FL" and is located near the right bank (west shore) of the middle river on the downstream side of the Fowler Avenue bridge. Water levels were recorded at this site from October 1969 through September 1990 and data collection at the site was reinitiated in May 2008 and continues to the present date. United States Geological Survey site number 02303360 is located just upstream from the Fletcher Avenue bridge at a park maintained by the University of South Florida. Water level records are available from the site, which is named "Hillsborough River at Riverfront Park near Tampa, FL" from August 2002 through October 2005. The Southwest Florida Water Management District has maintained a gauge site named “Hillsborough River at Spooners” (Identification number 19220) since September 1996 and continues to collect data at the site. Measurement of water levels at the District site has typically been made on a monthly or semi-monthly basis. To simplify presentation and discussion of water level records for the four gauge sites within or near the middle river, may be referred to as the "dam", "Fowler Avenue", "Fletcher Avenue" and “Spooners” sites.

Mean daily water surface elevations measured at the dam site through December 31, 2008 ranged from 12.38 feet above NGVD29 on November 26, 1945 to 22.83 feet above NGVD29 on August 2 1960 (Figure 4-12). Water surface elevations measured at the Fowler Avenue site through December 31, 2008 (Figure 4-13) ranged from 18.48 feet above NGVD29 on June 7, 8 and 12 in 2008 to 29.32 feet above NGVD29 on October 1, 1979. Water surface elevations measured at the site upstream of Fletcher Avenue through October 15, 2005 (Figure 4-14) ranged from 20.34 feet above NGVD29 on June 3, 2004 to 27.56 feet above NGVD29 on September 7, 2004. At the Spooner site, available water surface elevations ranged from a low of 17.24 feet above NGVD29 on May 30, 2002 to a high of 24.38 on July 30, 1980 (Figure 4-15).

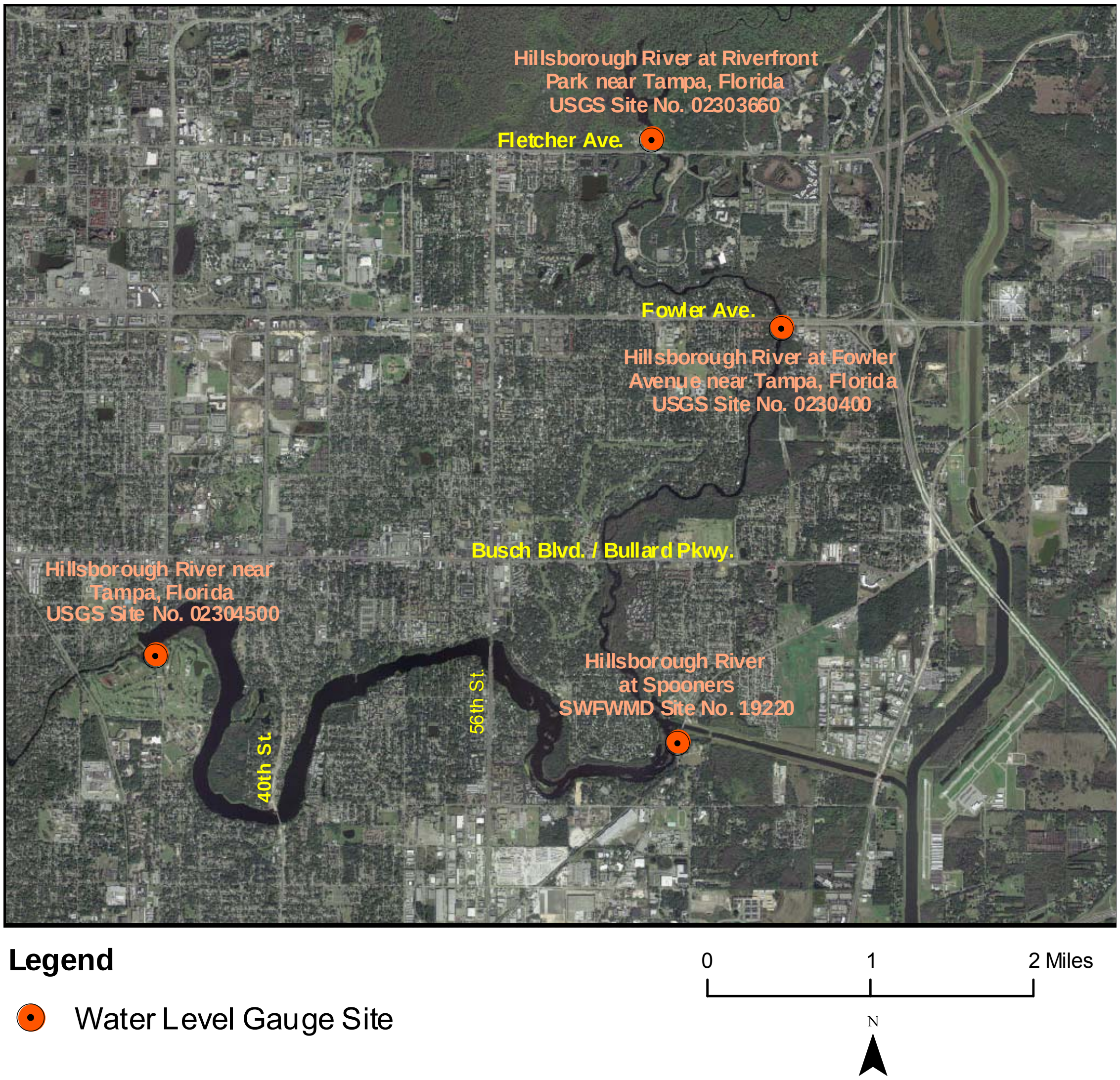


Figure 4-11. Locations of current United States Geological Survey and Southwest Florida Water Management District water level gauge sites on the middle Hillsborough River and just upstream from the river segment (photographic image source: Fugro EarthData, Inc. 2007).

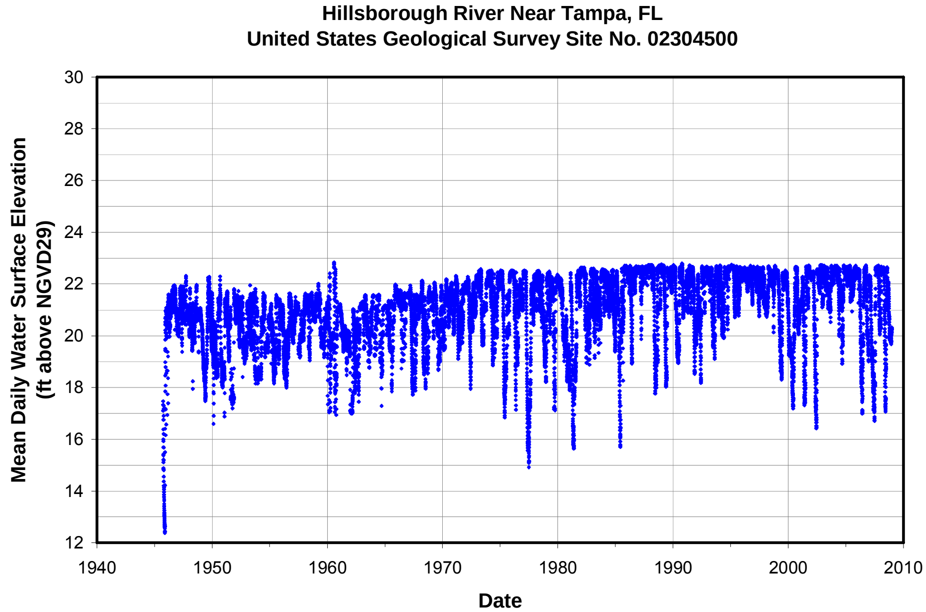


Figure 4-12. Mean daily water surface elevations of the middle Hillsborough River, as measured at the United States Geological Survey Hillsborough River near Tampa, Florida gauge site at the City of Tampa Dam from October 1, 1945 through December 31, 2008.

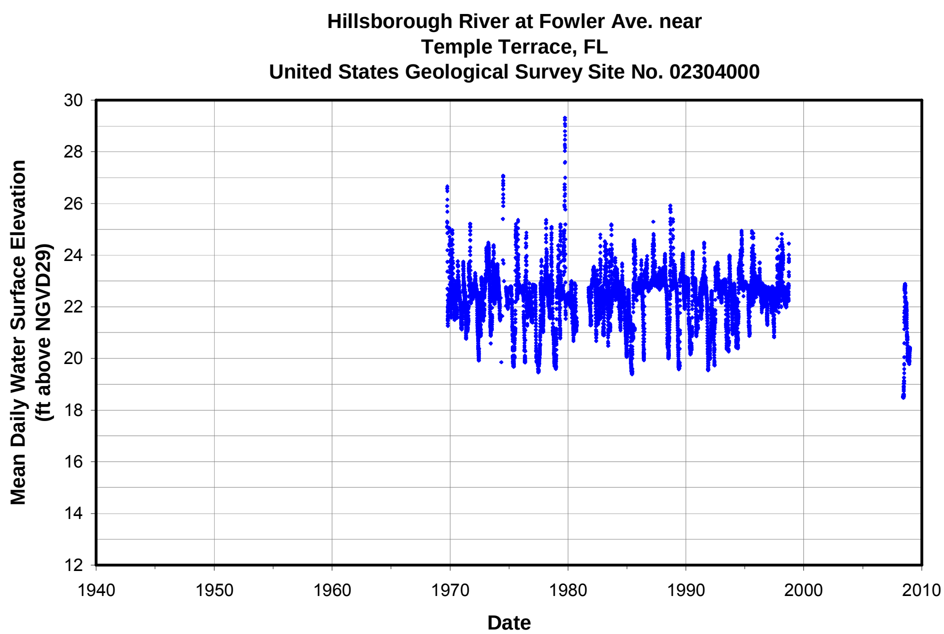


Figure 4-13. Mean daily water surface elevations of the middle Hillsborough River, as measured at the United States Geological Survey Hillsborough River at Fowler Ave. near Temple Terrace, Florida gauge site from October 1, 1969 through December 31, 2008.

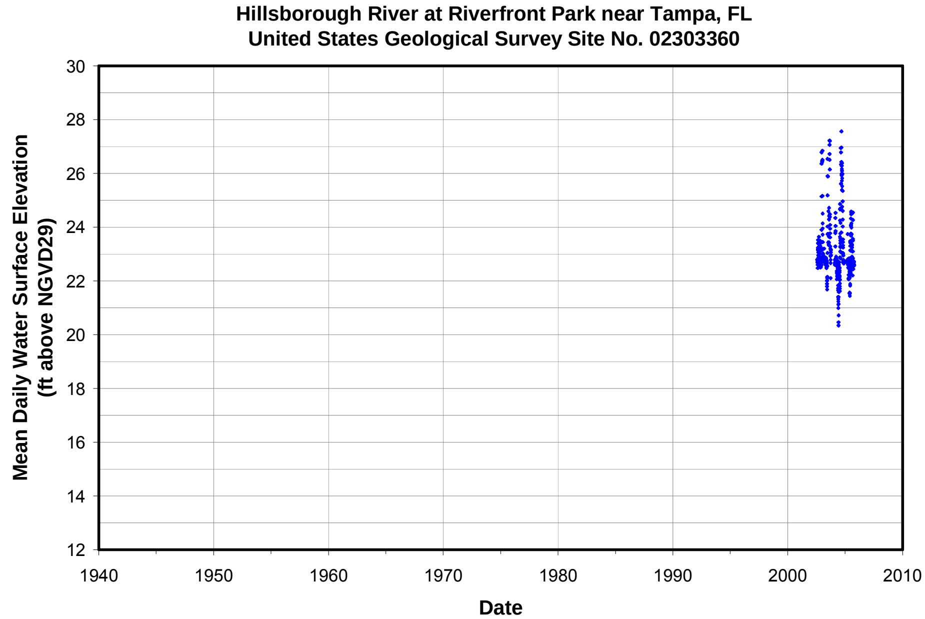


Figure 4-14. Mean daily water surface elevations at a site near the upstream boundary of the middle Hillsborough River, as measured at the United States Geological Survey Hillsborough River at Riverfront Park near Tampa, Florida gauge site from August 1, 2002 through October 15, 2005.

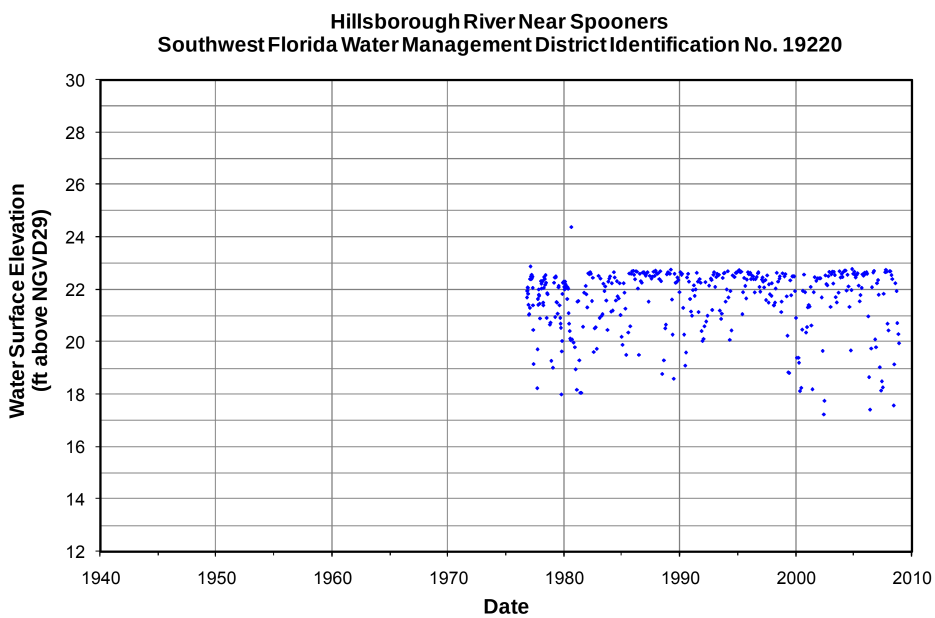


Figure 4-15. Daily water surface elevations of the middle Hillsborough River, as measured at the Southwest Florida Water Management District Hillsborough River at Spooners gauge site from September 29, 1976 through December 31, 2008.

There is no period of overlap for all four gauge site records, although records for the site near the dam overlap with those collected at the Spooners, Fowler Avenue and Fletcher Avenue sites (Figure 4-16). For periods of relatively high inflow to the middle river, water surface elevations at the upstream gauge sites, especially those at Fowler Avenue and Fletcher Avenue, tended to be higher than at the dam. For example, on October 1, 1979, the date of the highest recorded water surface elevation at the Fowler Avenue site, the water level at Fowler Avenue was 11.15 feet higher than reported at the dam. Water levels at the Fletcher Avenue and Spooners sites were not available on that date, but a few days later, on October 4, 1979, when the water surface elevation at Fowler Avenue was still relatively high, the levels at the Spooners and dam sites were, respectively, 9.0 and 10.91 feet lower than at the Fowler Avenue gauge. The highest value reported for the site near Fletcher Avenue, recorded on September 7, 2004, exceeded the water surface elevation at the dam on that date by 7.56 feet.

Available high-water marks based on flooding that occurred along the Hillsborough River in March 1960 provide additional support for the observed differences in water surface elevations among the gauge sites on some dates. Based on information presented in an earlier flood study by Pride (1962), Turner (1974) reports an 11.41 foot difference between water surface elevations measured at the upstream side of the Fowler Avenue bridge and a location twenty feet upstream from the dam. He also estimates that the difference in water surface elevation between Fletcher Avenue and the dam was on the order of 11.4 to 13.4 feet, and the difference in water levels between the Harney Canal area and the dam was on the order of 2 feet. Interestingly, Pride (1962) notes that the flood of 1933 (which resulted in the destruction of the then exiting dam on the river) produced water surface elevations in the middle river that were approximately three feet higher than those observed during the flooding of 1960. High-water surface elevation profiles for a portion of the middle river and the lower river that were developed by Pride (1962) for the floods of 1933 and 1960 are reproduced in Figure 4-17. Kane and Dickman (2005) report that the highest recorded water surface elevation for the middle river occurred on September 7, 1933, when the water level was 25.6 feet above NGVD29 at a former gauge site located 2.1 miles upstream from the current gauge site, in the area of the existing 40th Street bridge.

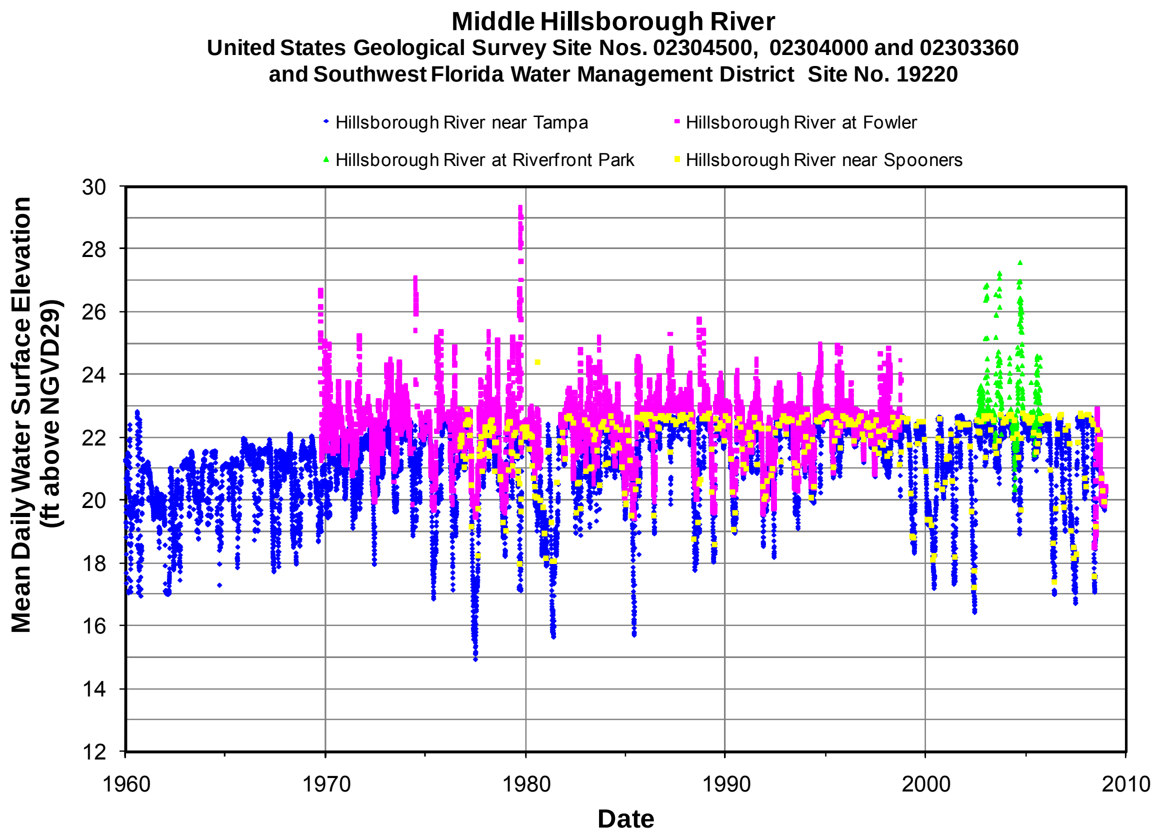


Figure 4-16. Mean daily water surface elevations of the middle Hillsborough River, as measured at United States Geological Survey sites at the City of Tampa Dam (No. 02304500, Hillsborough River near Tampa, FL), at Fowler Avenue (No. 02304000, Hillsborough River at Fowler Avenue near Temple Terrace, FL) and near Fletcher Avenue (No 02303360, Hillsborough River at Riverfront Park near Tampa, FL), and at the Southwest Florida Water Management District “Spooners” site near the Harney Canal (No. 19220, Hillsborough River near Spooners) from January 1, 1960 through December 31, 2008.

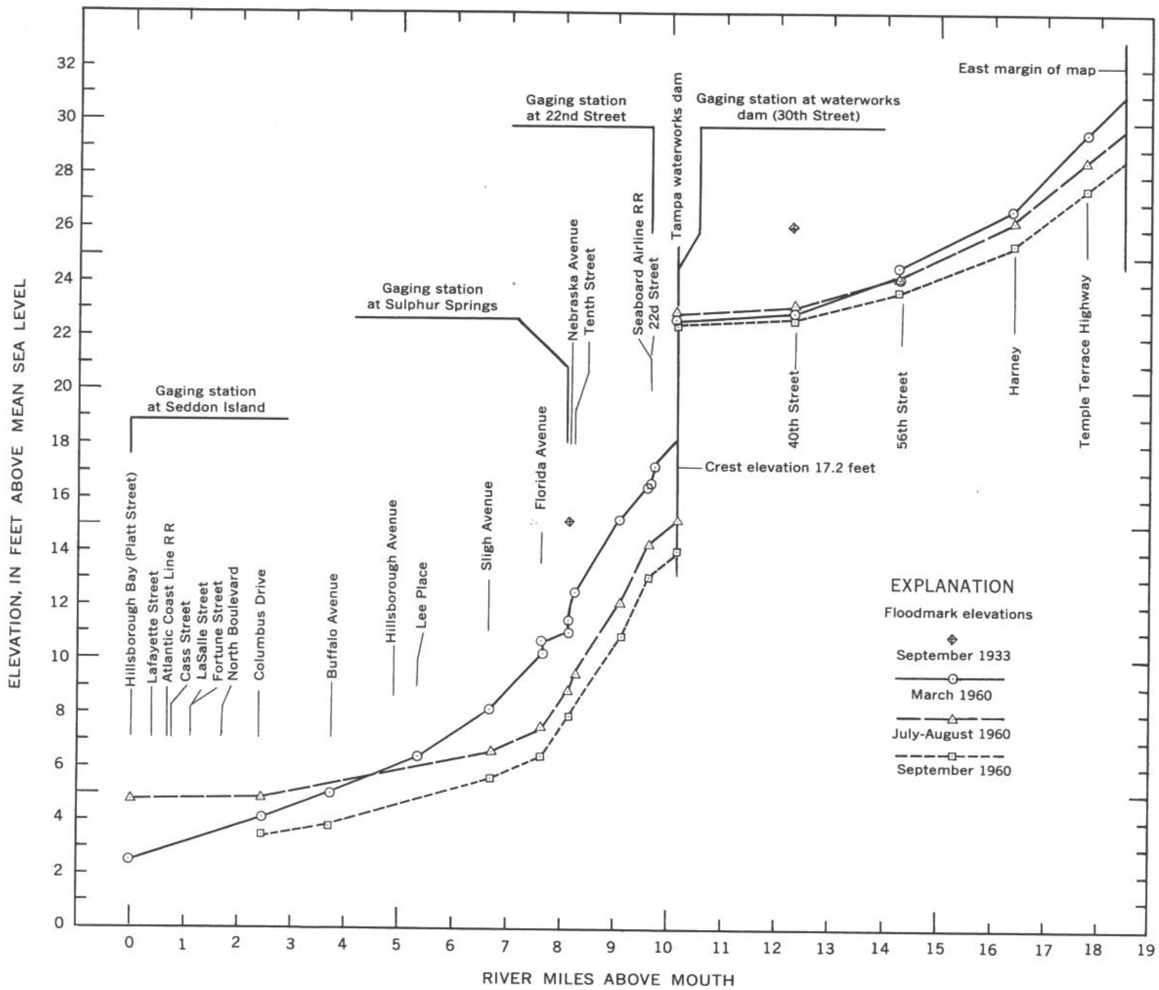


FIGURE 3.— PROFILES OF FLOODS ON HILLSBOROUGH RIVER AT TAMPA, FLORIDA

Figure 4-17. Water surface elevation profiles and spot elevations for a portion of the middle Hillsborough River and the lower river during floods in 1933 and 1960. Figure reproduced from United States Geological Survey Hydrologic Investigations Atlas HA-66 (Pride 1962).

Comparison of mean daily water surface elevations at the City of Tampa dam and the upstream gauge sites yielded some insight on the temporal and spatial variability of water levels in the middle river. For example, water surface elevations measured at the Spooners site and near the City of Tampa Dam showed good correspondence over a wide range of water levels (Figure 4-18). An ordinary least-squared regression equation for paired measurements collected at the two sites on the same day accounted for 95% of the variance in the data set (Figure 4-19). Mean and median differences for the 418 paired observations were 0.08 and 0.04 feet, respectively, although on one date, July 30, 1980, a 4.22 foot difference between water levels for the two sites was recorded. The relatively small differences in water levels measured at the dam and at the Spooners during most of the 32 years of overlap between the two data records indicate that the water surface of the middle river is typically relatively flat between the dam and the Harney Canal area.

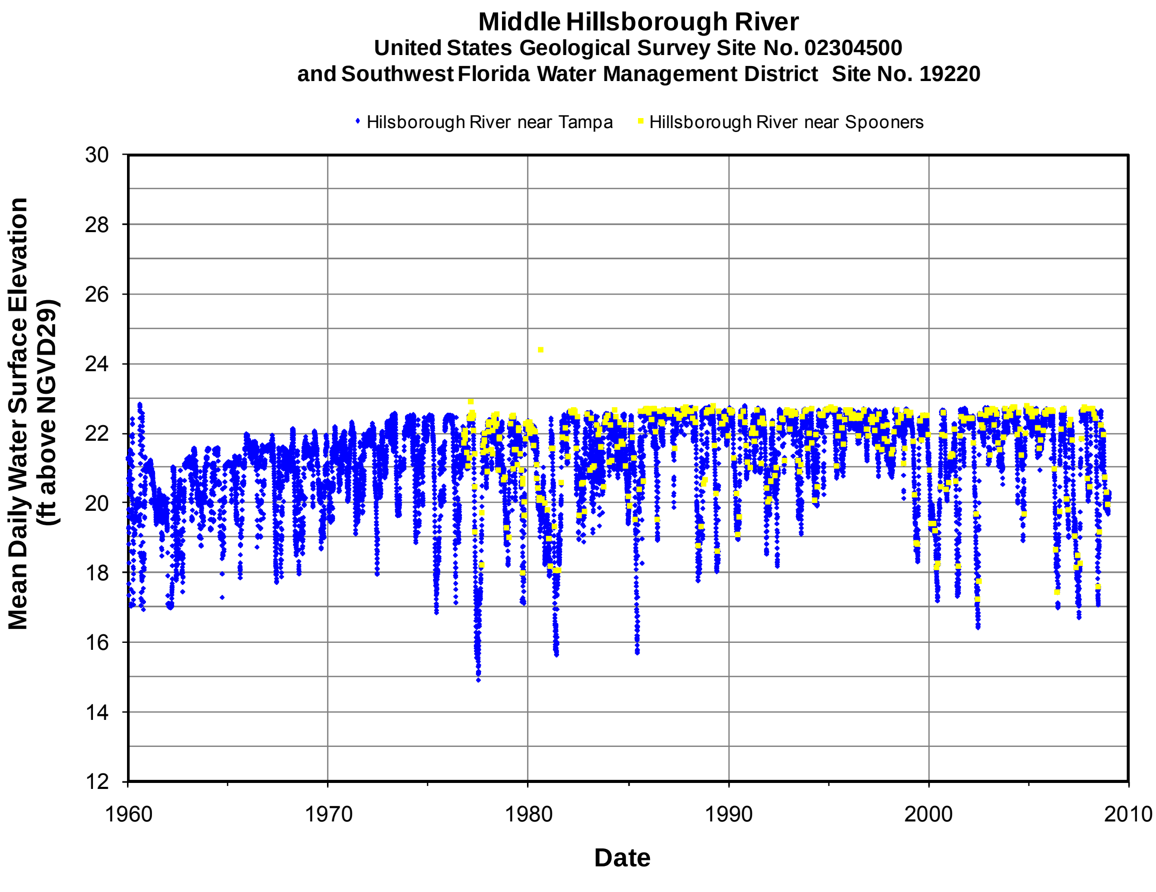


Figure 4-18. Mean daily water surface elevations of the middle Hillsborough River, as measured at United States Geological Survey site at the City of Tampa Dam (No. 02304500, Hillsborough River near Tampa, FL), and at the Southwest Florida Water Management District "Spooners" site (No. 19220, Hillsborough River near Spooners) near the Harney Canal from January 1, 1960 through December 31, 2008.

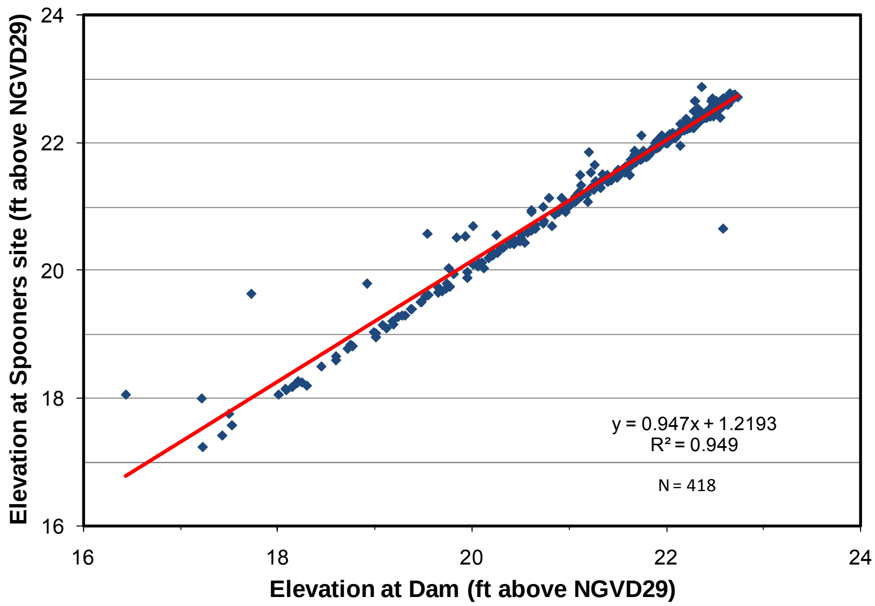


Figure 4-19. Relationship between mean daily water surface elevations of the middle Hillsborough River, as measured at the United States Geological Survey site at the City of Tampa Dam and the Southwest Florida Water Management District "Spooner" site near the Harney Canal. Blue symbols represent the paired water surface elevation measurements; red line and equation describe the linear relationship between the paired values.

Examination of daily water level records measured on the same days at the dam and the Fowler Avenue or Fletcher Avenue gauge sites suggested that relationships between the dam and upstream sites are less predictable than for the dam and the Spooners site. Ordinary least-squares regression equations for the paired measurements taken at the dam and the Fowler Avenue or Fletcher Avenue sites accounted for less than a third of the variance in the respective data sets (Figure 4-20). The linear regression line for the paired dam and Fletcher Avenue water levels had a negative slope, suggesting that when water levels are at their lowest near the dam they are at their highest at the site near Fletcher Avenue. This paradoxical result typifies the relatively poor linear relationships between water levels at the dam and the sites at Fowler Avenue and Fletcher Avenue.

The plots of the paired water levels for the dam, Fowler Avenue and Fletcher Avenue sites did however, exhibit a pattern indicative of probable relationships in water levels among the sites. The generally linear alignment of the paired observations associated with the lowest water elevations for the Fowler Avenue or Fletcher Avenue sites over the range of elevations measured at the dam (see Figure 4-20) indicates that under certain conditions, water levels at the upstream sites in the middle river are comparable to or directly proportional to the water level at the dam. This means that under certain conditions, the water level in the middle river may be relatively "flat" from the dam upstream to the gauge sites at Fowler Avenue and Fletcher Avenue. The paired water level points that lie on or are approximated by this generally linear pattern likely reflect days when inflows from the upper river were low to moderate and the water level in the middle river was high enough to exceed the hydraulic controls associated with the shoal areas between the dam and the upstream gauge sites. Paired data points associated with relatively higher water levels at the upstream sites likely correspond to periods of higher inflows from the upper river. The data shown in Figure 4-20 therefore illustrates how relative water levels at various sites within the middle river may vary as a function of inflows and water levels at the dam.

The relationship between water levels at the dam and the Fowler Avenue gauge sites based on recently collected data at the Fowler site further illustrates the spatial and temporal variability of water levels in the middle river. Since May 31, 2008, when the United States Geological Survey resumed data collection at the site, the relationship between water levels collected on the same day at Fowler Avenue and at the dam has been relatively predictable (Figure 4-21, upper panel). A least ordinary squares regression equation for the paired records accounts for 97% of the variance in the relationship between water surface elevations at the two sites. Examination of the difference in water elevation between the two sites indicates that the water level in the middle river was relatively flat from the dam upstream to Fowler Avenue when the water surface elevation at the dam exceeded approximately 18 to 18.2 feet above NGVD29 (Figure 4-21, lower panel). This observation is supported by the river bed elevations recently surveyed near the Fowler Avenue bridge by Ping and Beck (2008). At a cross-section site approximately 400 feet upstream from Fowler Avenue, a hydraulic control point of 17.87 feet above NGVD29 was identified, and much of the river bed at the site was found to exceed and elevation of 18.2 feet above NGVD29 (see Figure 2-17 and 2-18 in Chapter 2). The recent survey results and the water level gauging records for the sites near the dam and at Fowler Avenue provide evidence that during periods of relatively low inflow, the water surface of the middle river remains relatively flat from the dam upstream to at least Fowler Avenue. These data also suggest that water levels recorded in the middle river at Fowler Avenue and upstream at Fletcher Avenue may differ from the recorded water level at the City of Tampa Dam (and at the Spooners gauge site near the Harney Canal) when the water level at the dam recedes below approximately 18.2 feet above NGVD29.

Based on review of the river bed elevation data collected in 2008 for the middle river and the river segment between Fletcher Avenue and Structure S-155, the water surface for this entire stretch of the river could potentially be “flat” when the water level at the dam exceeds 19.11 feet above NGDV29 (see Figure 2-17). Consideration of the variability seen between measurements collected on the same day at the dam, Fowler Avenue and Fletcher Avenue sites, it seems reasonable to assume that this condition would only occur during periods of relatively low inflow from the upper river. Moderate to high inflows from the upper river would be expected to increase water levels in the river segment between Fletcher Avenue and S-161, relative to water levels at the dam, due to hydraulic constraints in the intervening river segment.

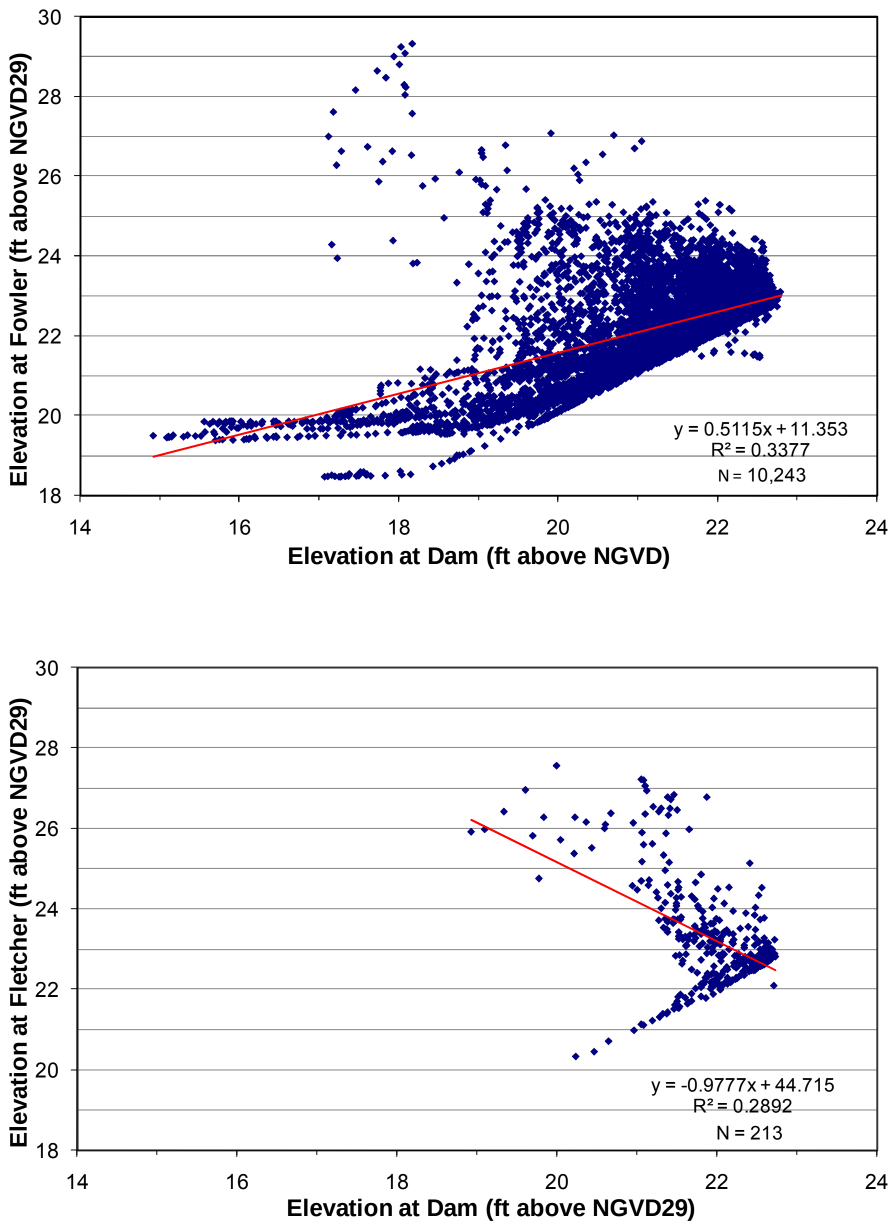
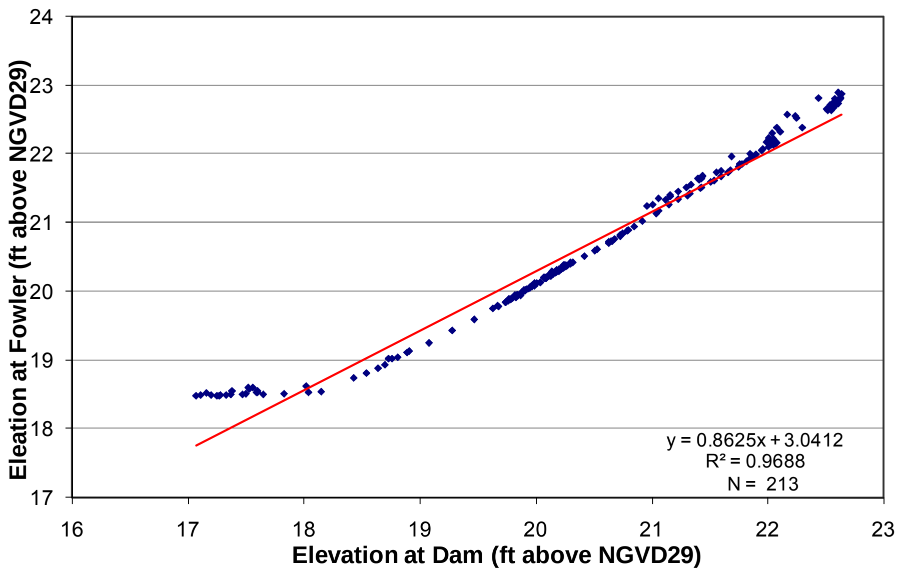


Figure 4-20. Relationships between mean daily water surface elevations of the middle Hillsborough River, as measured at United States Geological Survey sites at the City of Tampa Dam and Fowler Avenue (upper panel) or Fletcher Avenue (lower panel). Blue symbols represent the paired water surface elevation measurements; red lines and equations describe the linear relationships between the paired values.



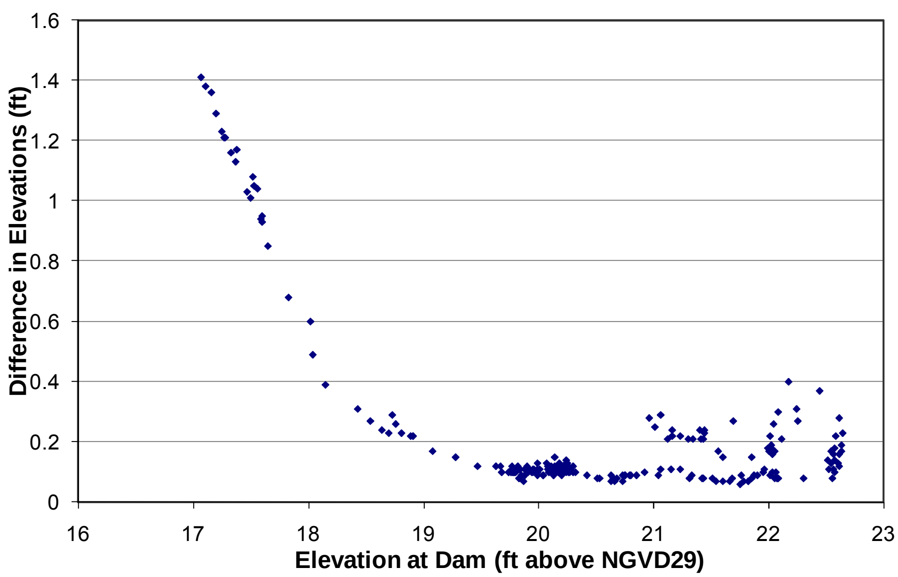


Figure 4-21. Relationships between mean daily water surface elevations of the middle Hillsborough River, as measured at United States Geological Survey sites at the City of Tampa Dam and Fowler Avenue for the period from May 31 through December 31, 2008. Blue symbols in the upper panel show paired water surface elevation measurements and the red line and equation describe the linear relationship between the paired values. Blue symbols in the lower panel show differences in water surface elevation between the two sites as a function of the water level at the dam site.

Long-term temporal variation in water levels of the middle river may be expected to respond to variation in inflows, outflows, back-water effects, water withdrawals and augmentation. The water level record available for the United States Geological Survey gauge site near at the City of Tampa Dam (No. 02304500, Hillsborough River near Tampa, Florida) was considered the best data set for evaluating long-term variation in the middle river based on the length and completeness of the data record (see Figure 4-12).

Stage exceedance percentile elevations for the site were calculated for the period of record, from October 1, 1945 through December 31, 2008, and for various periods associated with the augmentation of the middle river (Table 4-7). A "pre-augmentation" period was defined for the period prior to 1965, based on the reported initial use of Sulphur Springs for augmentation of the middle river in 1965 (Southwest Florida Water Management District 2004). Because Watson and Company (1967) report that augmentation with water from Sulphur Springs began in April 1964, exceedance percentiles for the pre-augmentation period pre-dating April 1964 were also examined. Differences between percentiles calculated for the two pre-augmentation periods were 0.01 to 0.02 feet (data not shown). Exceedance percentile values for the pre-1965 records were therefore considered representative of conditions in the middle river prior to the onset of augmentation using water from Sulphur Springs. A second "augmentation" period, from January 1, 1965 through December 31, 1984, which represented the period when only Sulphur Springs was used for augmentation, was also evaluated. Finally, a third augmentation" period considered representative of current augmentation conditions, which include augmentation from both Sulphur Springs and the Tampa Bypass Canal, was examined. This latter augmentation period was based on records collected from January 1, 1985 through December 31, 2008.

Based on period or record data collected from October 1, 1945 through December 31, 2002 at the gauge site at the dam, the middle river water surface water level equaled or 19.06 and 22.53 feet above NGVD29 ten and ninety percent of time, respectively (Table 4-7). In other words, the water level was between these two elevations eighty percent of the time. The median water surface elevation for the period of record was 21.23 feet above NGVD29.

Augmentation of the middle river with water pumped from Sulphur Springs and the Tampa Bypass Canal coincided with increases in stage-exceedance percentile elevations. The median water surface elevation (P50) for the period when water from Sulphur Springs was the sole augmentation source, 1965 through 1984, was 0.9 feet higher than for the pre-augmentation period. During the period that Sulphur Springs and the Tampa Bypass Canal were used for augmenting the middle river (1985 through 2008), the median river surface elevation was 0.83 feet greater than the median elevation for the period when only Sulphur Springs was used as an augmentation sources. The median water surface elevation for the period when both Sulphur Springs and the Tampa Bypass Canal were used for augmentation purposes was, therefore, 1.7 feet higher than the period when the river was not augmented.

Increases in water levels equaled or exceeded ten (P10) and ninety (P90) percent of the time were also evident when periods of augmentation were compared with the pre-augmentation period. The P10 and P90 water surface elevations from 1985 through 2008 were, respectively, 1.2 and 1.1 feet higher than the corresponding values for the period prior to 1965 when the middle river was not augmented.

Comparisons of periods when the middle river was augmented versus when it was not augmented should be made cautiously. Variation in rainfall, river inflow, structure operation, structure alteration, water withdrawals and water diversions throughout the period of record would also be expected to influence river water levels. Although inflows pre-dating the onset of augmentation of the middle river were not estimated for this report, historical discharge measurements to the lower Hillsborough River at the City of Tampa Dam suggest that inflows (and presumably rainfall) were likely higher historically than during the past three to four decades (see Figure 4-2). The relatively higher water levels in the middle river during recent decades therefore likely reflect the combination of changing management activities, including augmentation, structure modification and structure operation, rather than increased inflows from the watershed.

To examine the relationship between withdrawals or diversion of water from the middle river for water supply, monthly mean water surface elevations were plotted with annual average withdrawals from the river made by the City of Tampa and Tampa Bay Water. For the graphical analysis, monthly mean water surface elevations for the river were calculated from daily mean values reported by the United States Geological Survey for the gauge site at the dam. Records of withdrawals from the river by the City of Tampa at the David L. Tippin Water Treatment Facility are available from October 1945 through the present date. Records of daily volumes withdrawn from the middle river by the City of Tampa for years with complete records (1946 through 2007) were used to calculate annual average withdrawals. Discharge records for diversion of water by Tampa Bay Water from the middle river to the Harney Canal through S-161 for years with complete records, 2003 through 2007, were similarly used to calculate annual average diversions to the canal system. These diversions were considered to be withdrawals and were summed with the withdrawals made by the City of Tampa to estimate total withdrawals from the middle river for water supply purposes for the period from 2003 through 2007.

Although withdrawals from the middle river have increased during the period from the 1970s through 2007, Figures 4-22 and 4-23 illustrate that water levels in the middle river were higher during that period as compared to the levels occurring from the 1940s through the 1960s. During the most recent five year period, when annual estimates for withdrawals by the City of Tampa and diversions to the Tampa Bypass Canal by Tampa Bay Water were available, *i.e.* 2003 through 2007, combined withdrawals from the river averaged 121.3 million gallons per day. Water levels in the middle river were relatively high during the first few years of the five-year period, but short-term periods of low water levels occurred in 2006 and 2007.

Table 4-7. Water surface elevation (stage) exceedance percentiles of the middle Hillsborough River for selected periods, based on mean daily water surface elevations recorded at the United States Geological Survey gauge site at the City of Tampa Dam.

Stage Exceedance Percentile	Water Surface Elevation (feet above NGVD29)			
	Period of Record Oct 1, 1945 through Dec 31, 2008	Pre-Augmentation Period Oct 1, 1945 through Dec 31, 1964	Augmentation Period (Sulphur Springs Only) Jan 1, 1965 through Dec 31, 1984	Augmentation Period (Sulphur Springs and Tampa Bypass Canal) Jan 1, 1985 through Dec 31, 2008
P10	22.53	21.38	22.34	22.62
P50	21.23	20.46	21.36	22.19
P90	19.06	18.57	19.15	19.66

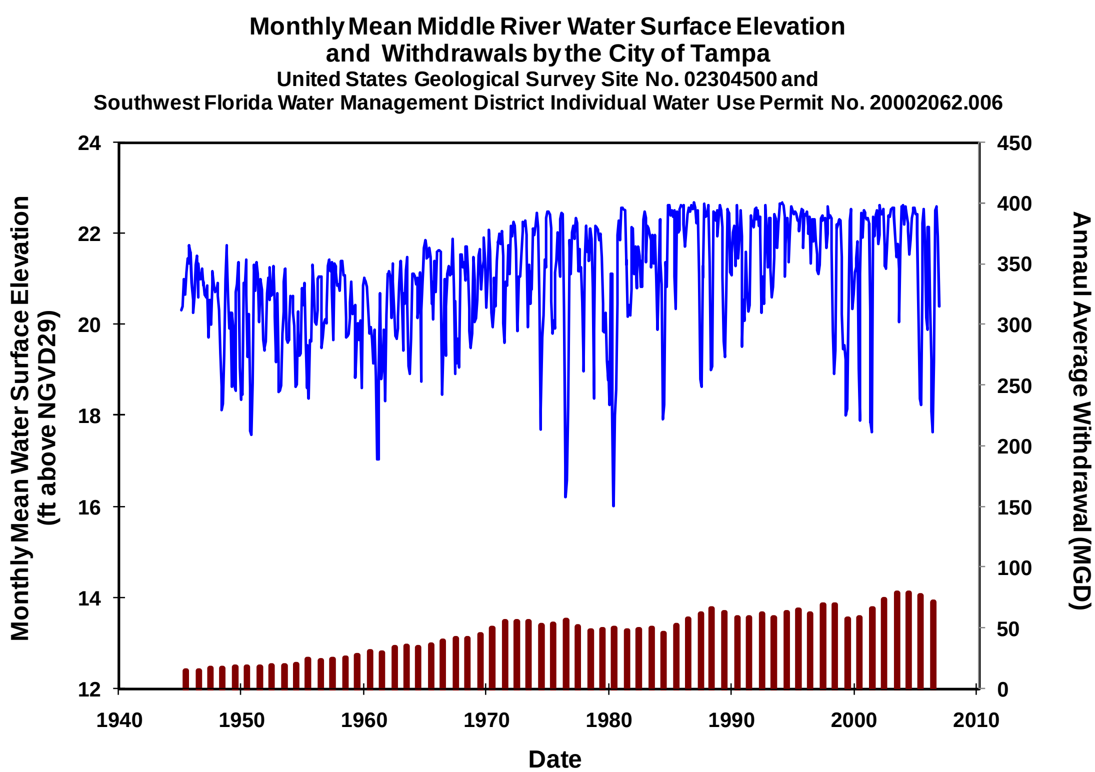


Figure 4-22. Monthly mean water surface elevations of the middle Hillsborough River, as measured at the United States Geological Survey Hillsborough River near Tampa, Florida gauge site at the City of Tampa Dam from January 1, 1946 through December 31, 2007 (blue line) and annual average withdrawals from the river by the City of Tampa from 1946 through 2007 (red bars).

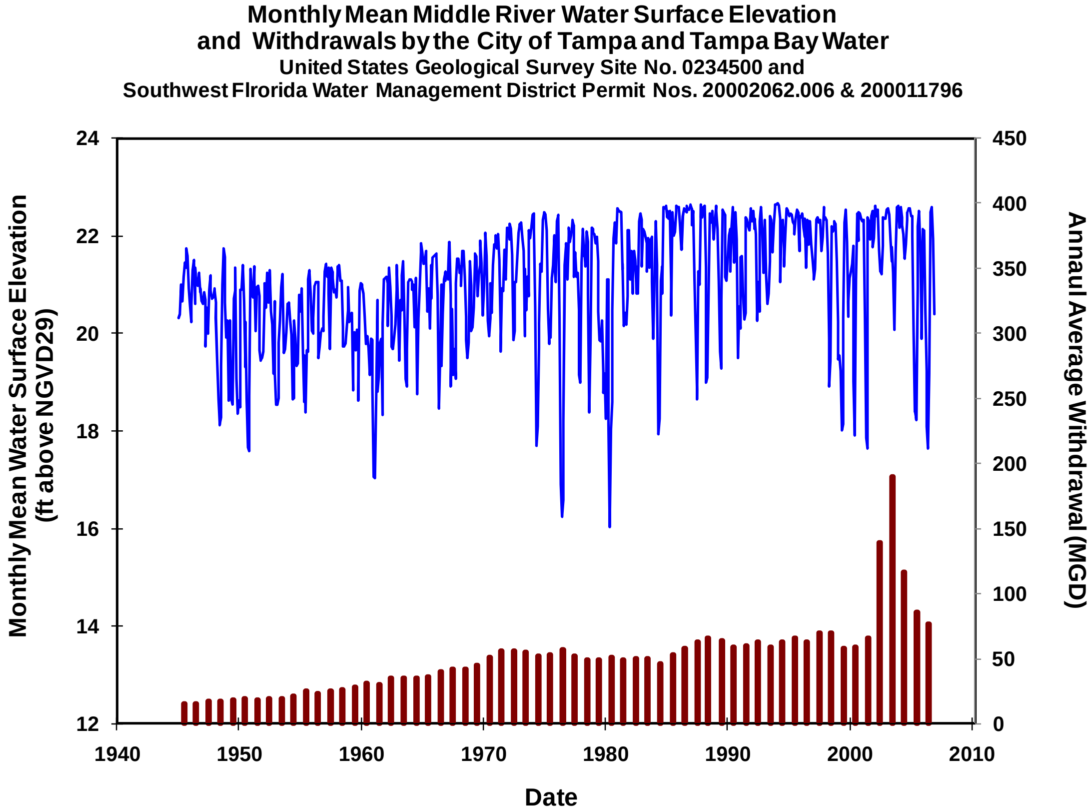


Figure 4-23. Monthly mean water surface elevations of the middle Hillsborough River, as measured at the United States Geological Survey Hillsborough River near Tampa, Florida gauge site at the City of Tampa Dam from January 1, 1946 through December 31, 2007 (blue line) and summed annual average withdrawals from the river by the City of Tampa from 1946 through 2007 and Tampa Bay Water from 2003 through 2007 (red bars).

<u>Highlights of Chapter 4</u>

Inflow to the middle river was conservatively estimated by summing discharge records available for three upstream gauge sites ranged from 41 to 602 million gallons per day from 1975 through 2008. Annual outflow from the middle river at the City of Tampa Dam ranged from 6.2 million gallons per day up to 1.13 billion gallons per day and averaged 227.3 million gallons per day for the period from 1939 through 2008, indicating that inflows to the middle river higher than observed from 1975 through 2008 were likely to have occurred.

The middle river has been augmented with water from Sulphur Springs since the mid-1960s and from the Tampa Bypass Canal/Harney Canal system since the mid-1980s (although some water was pumped from the canal to the river in the early 1980s). District regulation of augmentation with water from Sulphur Springs began in 1983 following issuance of a Consumptive Use Permit to the City of Tampa. Regulation of augmentation with water from the Tampa Bypass Canal/Harney Canal system was authorized beginning in 1983 when a Consumptive Use Permit was issued to the West Coast Regional Water Supply Authority (now known as Tampa Bay Water). For the period from 1984 through 2007 the combined volume of water pumped from Sulphur Springs and the Tampa Bypass Canal/Harney Canal system ranged from 0 to 32.5 million gallons per day and averaged 9.5 million gallons per day. Augmentation of the middle river with water pumped from Sulphur Springs and the Tampa Bypass Canal has increased water levels in the middle river by approximately 1.1 to 1.7 feet.

Use of the middle river as a water supply by the City of Tampa was initiated in the 1920s, but the District did not begin regulating withdrawals from the river until 1976, shortly after the Florida Legislature identified the need for state-wide water use permitting. The original Consumptive Use Permit (Number 2062) allowed withdrawal of an annual average volume of 67.1 million gallons per day from the impounded river. The current permit limits daily withdrawals on an annual average to 82 million gallons per day. From 1946 through 2007, daily withdrawals on an annual basis have ranged from 15 million gallons per day to 79.4 million gallons per day. Pumpage records available through November 2008 indicate that approximately 71.7 million gallons per day was withdrawn from the river last year.

Since 1999, Tampa Bay Water has been authorized to divert up to 194 million gallons per day from the middle Hillsborough River to the Tampa Bypass Canal through the Harney Canal and Structure S-161, and also allows the withdrawal of up to 258 million gallons per day from the Middle and Lower pools of the canal for regional use. Diversions from the river to the canal system are limited to periods when discharge at the City of Tampa Dam exceeds 65 million gallons per day. Daily average discharge from the middle river for 2002 through 2007 ranged from 4.7 to 110.4 million gallons per day.

Relatively long-term sets of water level records are available for three gauge sites on the middle river; at the dam, near the Harney Canal and at Fowler Avenue. Water level records are also available for a shorter time period at a site just upstream from the middle river, near Fletcher Avenue. Comparison of water level measurements made on the same day indicated that water levels at the dam upstream to the Harney Canal area are relatively comparable indicating the surface of the pooled water in this segment of the middle river is typically relatively “flat”. Comparisons of water levels at the dam and at the gauge sites at Fowler Avenue and near Fletcher Avenue indicate that during periods of high inflow from the upper river, water levels at the upstream gauges may be substantially higher than at the dam. The data also indicate that under certain conditions, *e.g.,* during periods of low to moderate inflows from the upper river, the water surface of the middle river is relatively “flat” from the dam upstream to Fletcher Avenue. Review of water level records and recently collected cross-section survey data indicated that when the water level at the dam recedes below 18 to 18.2 feet above NGVD29 water levels at the upstream sites may deviate from the water level at the dam.

Chapter 5

Comparisons of Water Level Fluctuations in the Middle River and Other Florida Water Bodies

Water Level Fluctuations in the Middle and Upper Hillsborough River and Other West-Central Florida River Segments

As noted in the previous chapter, water levels in the middle river may differ between downstream and upstream portions of the river segment. Water level records for sites at the City of Tampa Dam and near the Harney Canal show close correspondence most of the time, while correspondence between the dam and gauge sites further upstream, at Fowler Avenue and Fletcher Avenue is more variable. Recent records collected at the Fowler Avenue gauge site indicate that when the water level at the dam exceeds approximately 18.2 feet above NGVD29, the water surface of the middle river is relatively flat from the dam upstream to at least Fowler Avenue. When the water surface at the dam is lower than this elevation, water levels in the upper portion of the river segment may be higher due to inflows from the upper river segment. Historic records for the Fowler Avenue gauge site in the middle river and Fletcher Avenue gauge site just upstream from the middle river indicate that during periods of high inflows water levels in the upstream portion of the middle river may also deviate from the levels occurring at the dam.

To further evaluate water level fluctuations in the middle river, water level fluctuations at the gauge site at the City of Tampa Dam were contrasted with water level fluctuations at United States Geological Survey long-term gauge sites on the upper Hillsborough River and other west-central Florida rivers. Mean daily water level records collected from January 1, 1985 through December 31, 2008 were used for the evaluation, as this period was coincident with augmentation of the middle river with water from Sulphur Springs and the Tampa Bypass Canal. Gauge sites evaluated for the Hillsborough River included the Hillsborough River near Tampa, FL site (No. 02304500), the Hillsborough River at Morris Bridge near Thonotosassa, FL site (No. 02303330) and the Hillsborough River near Zephyrhills, FL site (No. 02303000). Sites evaluated for the Alafia River system included the Alafia River at Lithia, FL site (No. 02301500), the South Prong of the Alafia River near Lithia, FL site (No. 02301300) and the North Prong Alafia River at Keysville, FL site (No. 02301000). Three stations on the Withlacoochee River, the Withlacoochee River at Trilby, FL site (No. 02312000), the Withlacoochee River near Holder, FL site (Site No. 02313000) and the Withlacoochee River at Croom, FL site (No. 02312500) were also evaluated. Tributaries to the southern portion of Tampa Bay, were also compared with the middle river. Sites evaluated on these rivers included the Manatee River near Myakka Head FL site (Site No. 02299950), the Myakka River near Sarasota FL site (Site No. 02298830), the Braden River near Lorraine FL site (Site No. 02300032) and the Myakka Rive near Sarasota FL site (Site No 02298830). Data for the Braden River gauge site were only available from July 12, 1988 through February 7, 2007, but were considered representative of water level fluctuations in the river.

Time-series plots comparing mean daily water surface elevations in the middle river and the gauge site on the other rivers all exhibited a common pattern (see Figures 5-1 through 5-5). With the exception of the middle river site at the dam, all of the river gauge sites exhibited spikes or rapid increases and decreases in water levels above a relatively flat or stable lower water level. The spikes or rising and falling limbs of the hydrographs represent seasonal and shorter term responses to rainfall-runoff events within the catchment or watershed that contributes to flow past the gauge site. The lower, more stable portions of the hydrographs likely represent the base-flow or ground water component of the river flows.

Interestingly, the hydrograph for the middle river site appears to be a mirror-image of the hydrographs for the other river gauge sites. In contrast to the relatively stable base-flow condition evident for the lower water levels in the other hydrographs examined, the middle river site exhibited a relatively stable high-water condition. This phenomenon is, of course, a function of the elevation at which water is discharged over or across the City of Tampa dam and the augmentation of the river segment. Analogous to the rising and falling limbs of the hydrographs for the other river sites, the middle river hydrograph exhibited declines and increases back to the full pool elevation, *i.e.,* the maximum elevation of the pool of water impounded upstream of the dam. The deviations from full pool stage are associated with water budget parameters including inflows from the upper river, augmentation of the river, ground water inputs and outputs, evapotranspiration, discharges across the dam and water withdrawals as outlined in Chapter 4 of this report.

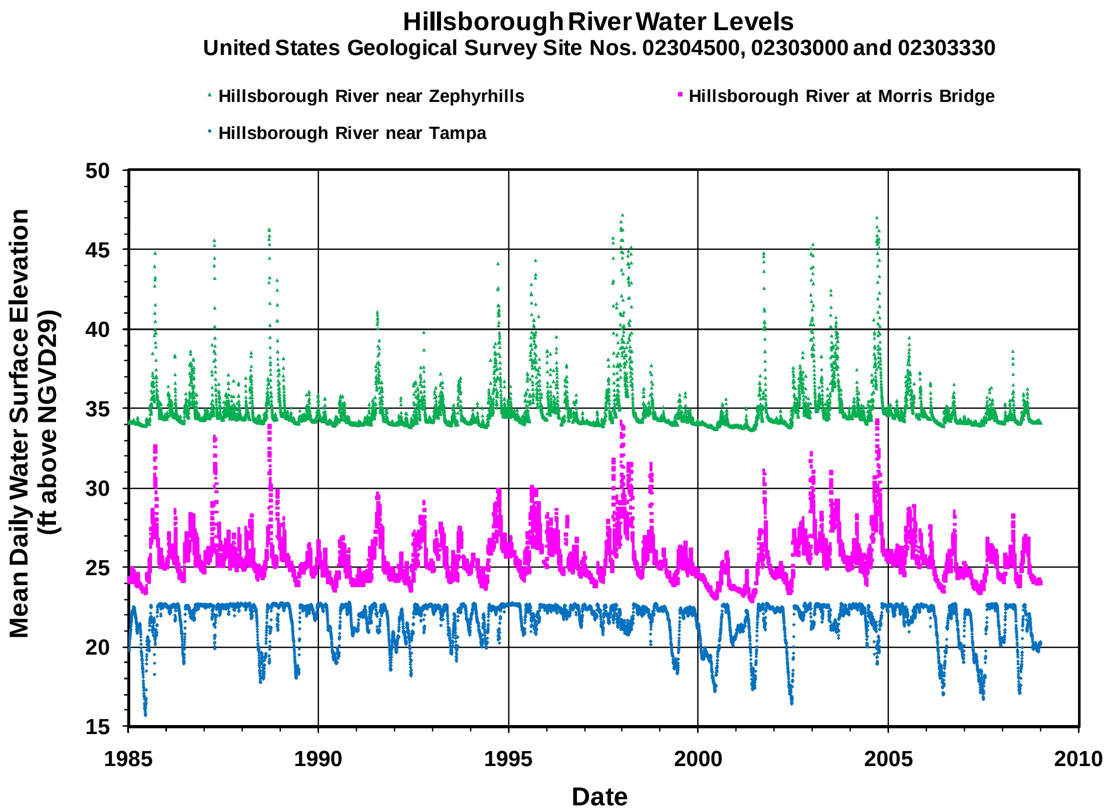


Figure 5-1. Mean daily water surface elevations of the Hillsborough River at the City of Tampa Dam (Site No. 02304500, Hillsborough River near Tampa, FL), at Morris Bridge (Site No. 02303330, Hillsborough River at Morris Bridge near Thonotosassa, FL) and near Zephyrhills (Site No. 02303000, Hillsborough River near Zephyrhills, FL) from January 1, 1985 through December 31, 2008.

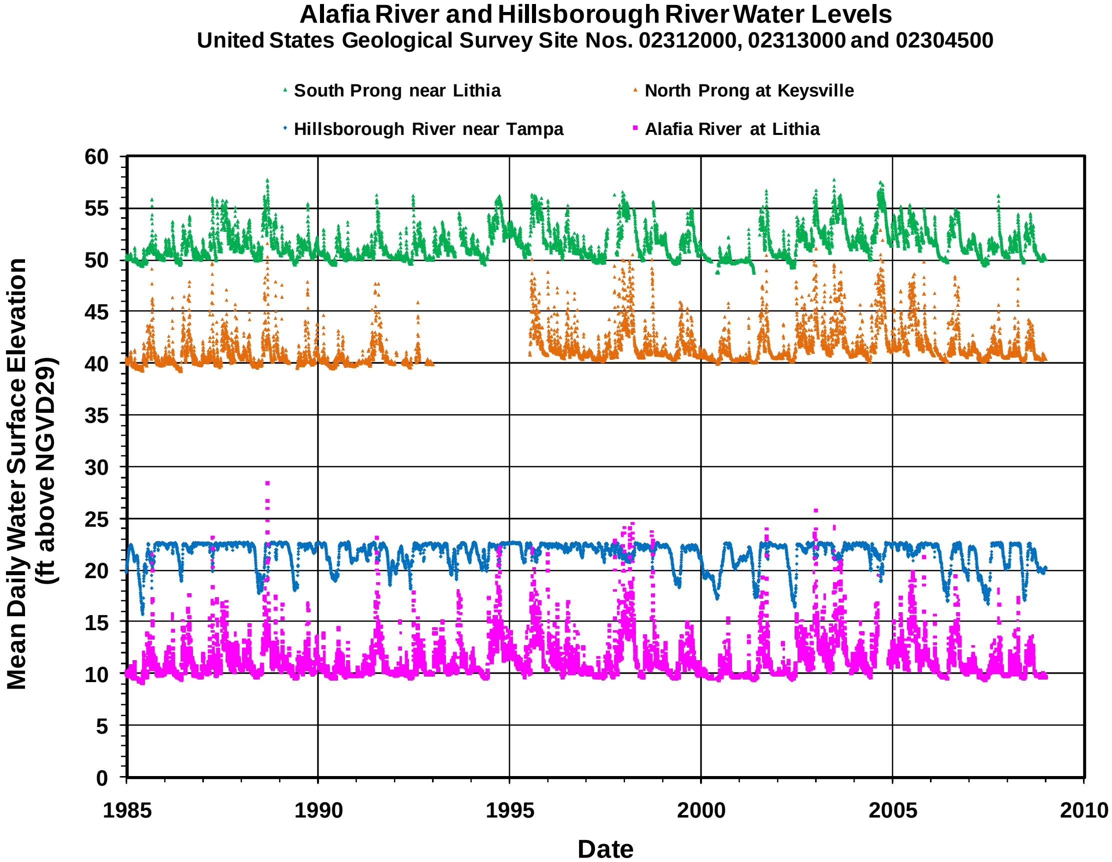


Figure 5-2. Mean daily water surface elevations of the Hillsborough River at the City of Tampa Dam (Site No. 02304500, Hillsborough River near Tampa, FL), the Alafia River at Lithia (Site No. 02301500, Alafia River at Lithia FL), the South Prong of the Alafia River near Lithia (Site No. 02301300, South Prong Alafia River near Lithia FL) and the north prong of the Alafia at Keysville (Site No. 02301000, North Prong Alafia River at Keysville FL) from January 1, 1985 through December 31, 2008.

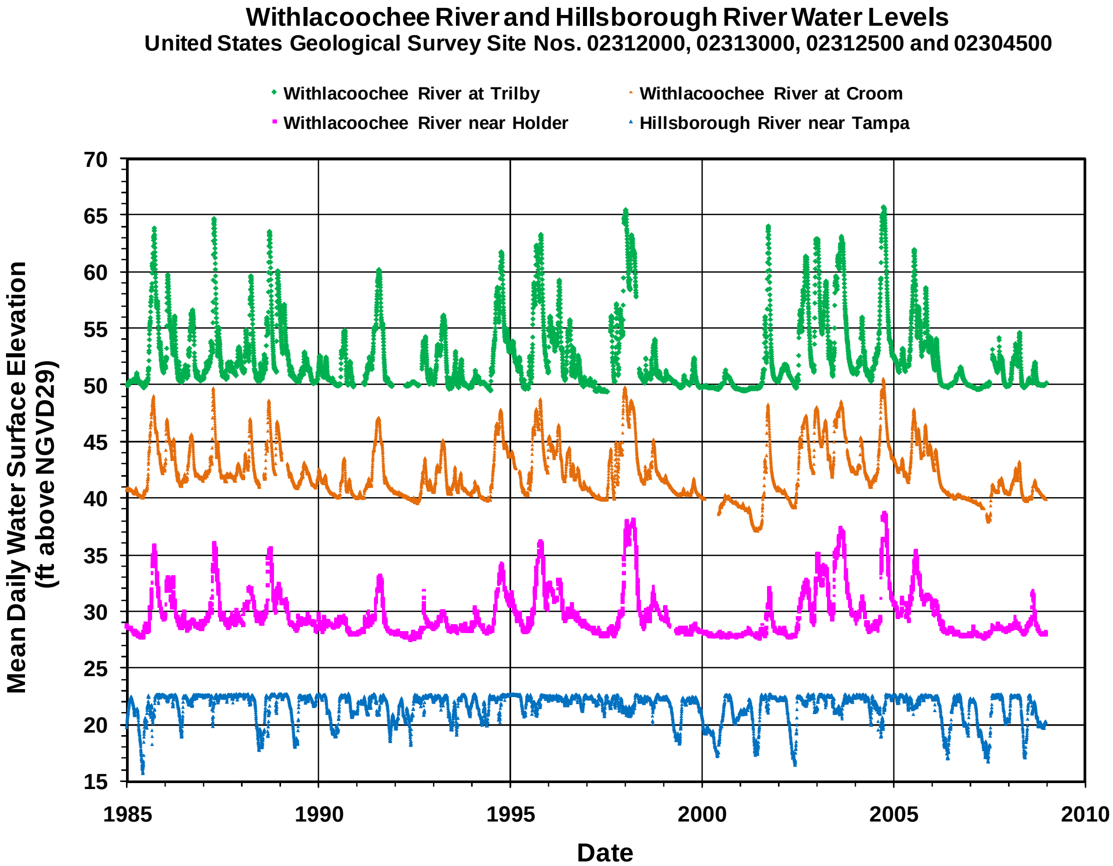


Figure 5-3. Mean daily water surface elevations of the Hillsborough River at the City of Tampa Dam (Site No. 02304500, Hillsborough River near Tampa, FL) and of the Withlacoochee River at Trilby (Site No. 02312000, Withlacoochee River at Trilby, FL), near Holder (Site No. 02313000, Withlacoochee River near Holder, FL) and at Croom (Site No. 02312500, Hillsborough River at Croom, FL) from January 1, 1985 through December 31, 2008.

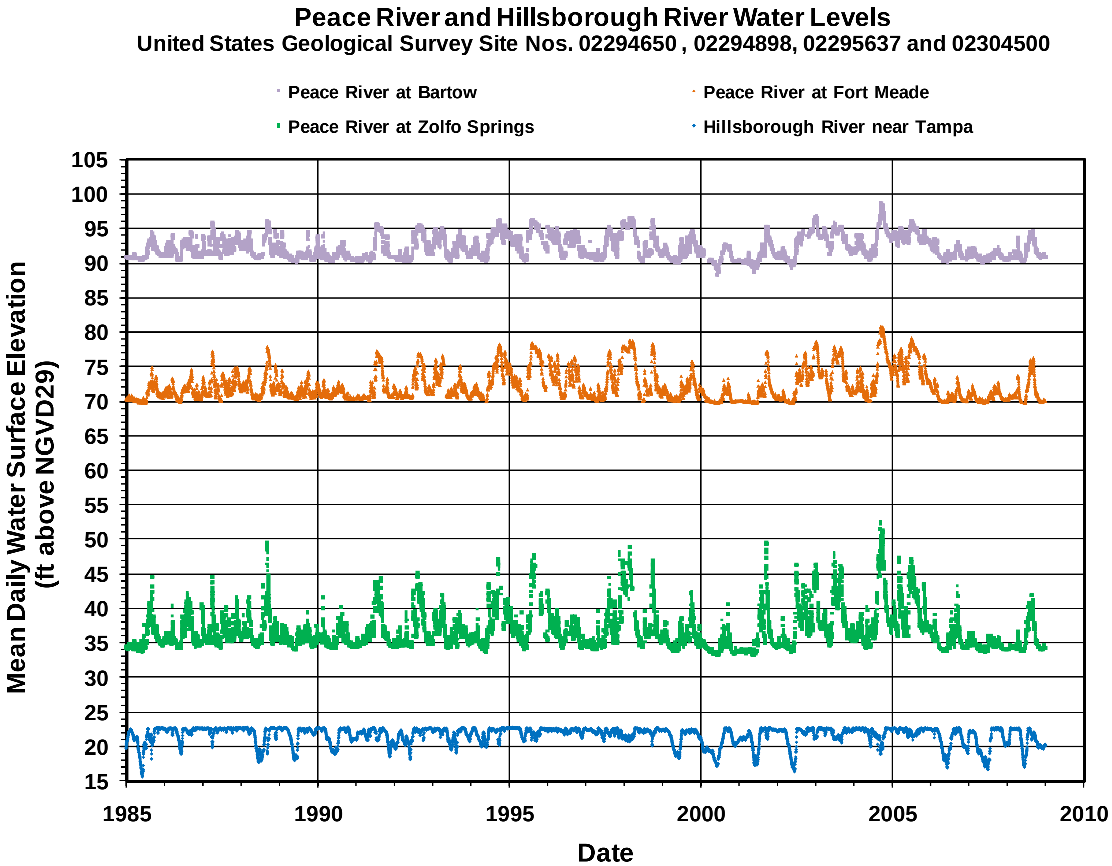


Figure 5-4. Mean daily water surface elevations of the Hillsborough River at the City of Tampa Dam (Site No. 02304500, Hillsborough River near Tampa, FL) and of the Peace River at Bartow (Site No. 02294650, Peace River at Bartow, FL), Fort Meade (Site No. 02294898, Peace River at Fort Meade, FL) and Zolfo Springs (Site No. 02295637, Peace River at Zolfo Springs, FL) from January 1, 1985 through December 31, 2008.

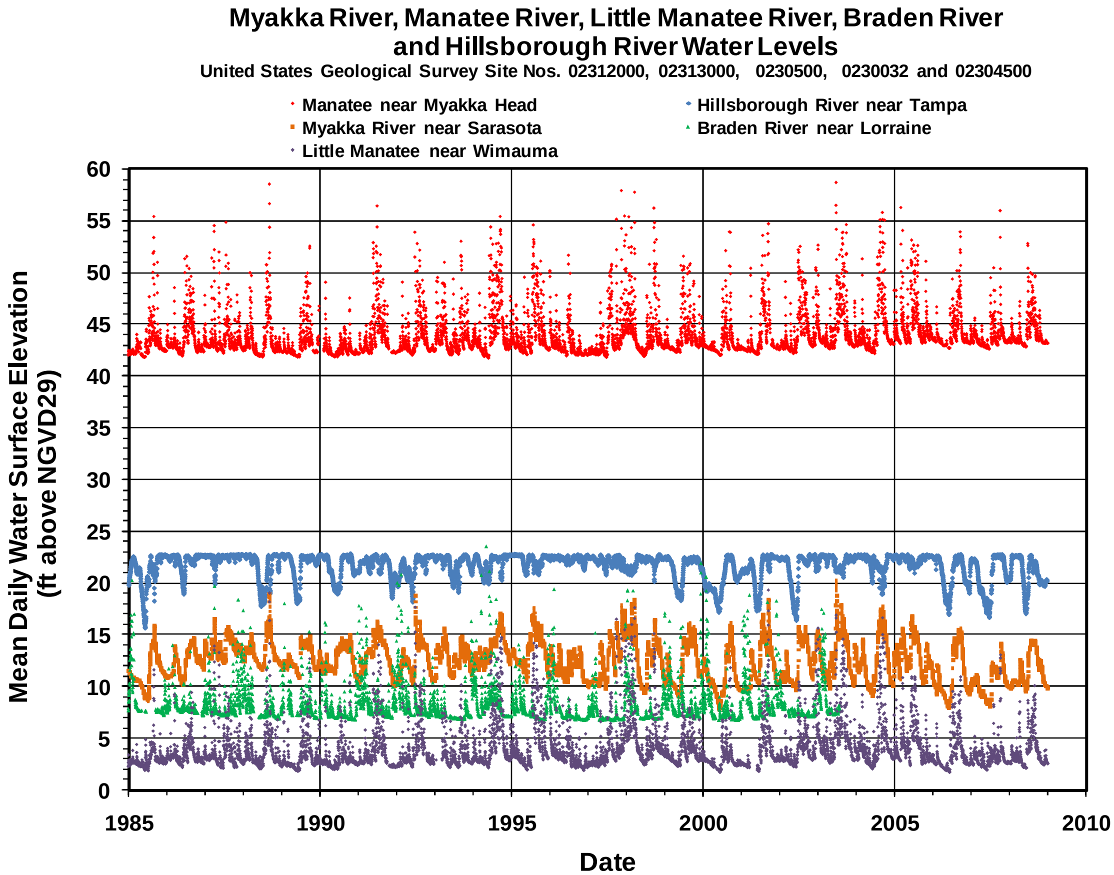


Figure 5-5. Mean daily water surface elevations of the Hillsborough River at the City of Tampa Dam (Site No. 02304500, Hillsborough River near Tampa, FL), the Manatee River near Myakka Head FL (Site No. 02299950), Myakka River near Sarasota FL (Site No. 02298830), Braden River near Lorraine FL (Site No. 02300032) and Little Manatee River near Wimauma FL (Site No 02300500) gauge sites from January 1, 1985 through December 31, 2008, except for the Braden River site, where data were available only from July 12, 1988 through February 7, 2007.

Review of summary statistics describing the water level fluctuations of the river sites provided an additional means for contrasting the hydrologic regime of the middle river with other west-central Florida river sites. The fluctuation range defined by the difference between maximum and minimum daily water levels for the middle river site was 7.09 feet, and was lower than the range (9.06 to 19.35 feet) observed at each of the other 15 river gauge sites (Table 5-1). Of the sites examined, the middle river site exhibited the second smallest range between the water surface elevation equaled or exceeded ten percent of the time, *i.e.,* the P10, and the water level equaled or exceeded ninety percent of the time, or the P90. The P10 to P90 range for the upper Hillsborough River site near Zephryhills was 0.64 feet less than that of the middle river site. The low variability of the Zephyrhills gauge site may reflect the influence of the relatively constant discharge from Crystal Spring, which is located approximately 4.3 miles upstream. The difference between the P10 elevation and the median, or P50 elevation, for the middle river site was the smallest among the sites examined, a likely reflection of management activities directed towards maintaining storage in the impounded river. Graphical representation of the water level fluctuation summary statistics (Figure 5-6) further illustrates difference between the hydrologic regime of the middle river at the City of Tampa Dam and the other river gauge sites examined.

Table 5-1. Summary statistics for water level fluctuations at United States Geological Survey gauge sites on the middle Hillsborough River at the City of Tampa Dam and on the upper Hillsborough and the Alafia, Braden, Little Manatee, Manatee, Myakka, Peace and Withlacoochee Rivers. Fluctuations are expressed as differences between maximum, minimum and water surface elevations equaled or exceeded ten (P10) , fifty (P50) and ninety (P90) percent of the time, based on daily mean values collected from January 1, 1985 through December 31, 2008, except for the Braden River site, which only had data available from July 12, 1988 through February 7, 2007.

Gauge Site Name	County, State	Period Evaluated	Maximum to Minimum Difference (feet)	P10 to P90 Difference (feet)	P10 to P50 Difference (feet)	P50 to P90 Difference (feet)
Hillsborough River near Tampa, FL	Hillsborough, FL	Jan 1985 –Dec 2008	7.09	2.96	0.43	2.53
South Prong Alafia River near Lithia FL	Hillsborough, FL	Jan 1985 –Dec 2008	9.06	3.94	2.68	1.26
Peace River at Bartow, FL	Polk, FL	Jan 1985 –Dec 2008	10.45	4.19	2.98	1.21
Withlacoochee River at Holder, FL	Marion, FL	Jan 1985 –Dec 2008	11.22	4.63	3.64	0.99
Peace River at Fort Meade, FL	Polk, FL	Jan 1985 –Dec 2008	11.27	6.07	4.69	1.38
Hillsborough River at Morris Bridge	Hillsborough, FL	Jan 1985 –Dec 2008	11.42	3.47	2.21	1.26
Myakka River near Sarasota FL	Sarasota, FL	Jan 1985 –Dec 2008	12.51	4.783	2.47	2.31
Withlacoochee River at Croom, FL	Hernando, FL	Jan 1985 –Dec 2008	13.43	6.03	4.30	1.73
Hillsborough River near Zephyrhills	Hillsborough, FL	Jan 1985 –Dec 2008	13.61	2.32	1.92	0.40
North Prong Alafia River at Keysville, FL	Hillsborough, FL	Jan 1985 –Dec 2008	13.68	3.78	2.84	0.94
Withlacoochee River at Trilby, FL	Hernando, FL	Jan 1985 –Dec 2008	16.35	7.519	6.159	1.36
Braden River near Lorraine, FL	Manatee, FL	July 1988 – Feb 2007	16.82	3.574	2.944	0.63
Manatee River near Myakka Head FL	Manatee, FL	Jan 1985 –Dec 2008	16.92	4.54	3.61	0.93
Little Manatee River near Wimauma, FL	Hillsborough, FL	Jan 1985 –Dec 2008	17.63	4.09	3.29	0.80
Peace River at Zolfo Springs, FL	Hardee, FL	Jan 1985 –Dec 2008	19.2	6.48	4.92	1.56
Alafia River at Lithia, FL	Hillsborough, FL	Jan 1985 – Dec 2008	19.35	4.31	3.36	0.95

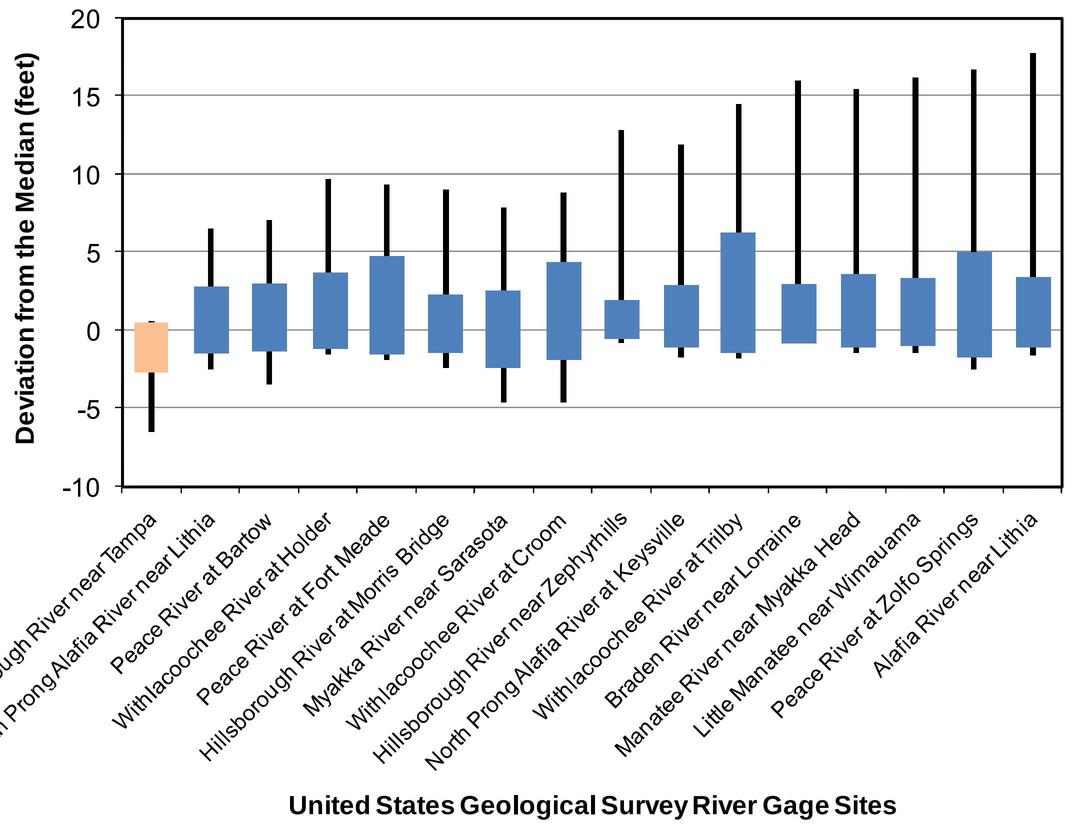


Figure 5-6. Water level fluctuations at United States Geological Survey gauge sites on the Hillsborough, Alafia, Braden, Little Manatee, Manatee, Myakka Peace and Withlacoochee Rivers in west central Florida expressed as deviations in feet from the median water surface elevation for each site based on mean daily water records for the collected from January 1, 1985 through December 31, 2008 (except for the Braden River site, which only had data available from July 12, 1988 through February 7, 2007). Vertical lines represent range of recorded daily water levels. Boxes represent differences between water levels equaled or exceeded ten and ninety percent of the time; middle Hillsborough River site identified by the mauve box.

Water Level Fluctuations in the Middle Hillsborough River and Florida Reservoirs

The City of Tampa Dam, Structure S-161 on the Harney Canal and facilities associated with augmentation of the middle river are operated to maintain the river segment as a water supply for the City of Tampa and Tampa Bay Water. Based on this purpose and the reviews presented in previous sections of this report which indicated that the hydrologic regime of the river segment differs substantially from other river sites in west-central Florida, it seemed reasonable to compare water level fluctuations in the middle river with fluctuation of reservoirs used for water supply purposes within Florida and to also compare middle river fluctuations with in-state reservoirs used for other purposes.

Water level records for known reservoirs in Florida were obtained from the District Water Management Information System, the United States Geological Survey and a variety of other sources including the United States Army Corps of Engineers, Tampa Bay Water, Manatee County Government Utilities Department, the Peace River Manasota Water Supply Authority, the Northwest Florida Water Management District and Florida Power and Light Company. Systems evaluated included in-line (Bill Evers Reservoir, Deer Point Lake, Lake Manatee and Shell Creek Reservoir) and off-line (C.W. Bill Young Reservoir, Peace River Reservoir, Tampa Bypass Canal – Middle Pool and Tampa Bypass Canal – Lower Pool) reservoirs used for water supply purposes. Reservoirs used for purposes other than water supply were also evaluated and included several in-line systems (Medard Reservoir, Rodman Reservoir, Lake Rousseau, Lake Seminole and Lake Talquin) and a single off-line system (Lake Parrish). The reservoirs range from approximately 200 to over 37,000 acres in size. The geographic range of the reservoirs that were evaluated extended from Jackson County in the Florida panhandle to Charlotte County near Charlotte Harbor on the southwestern Gulf coast.

Water level records collected prior to June 2008 were used to calculated monthly mean water surface elevations for each reservoir and the middle river. Monthly mean values were calculated to minimize potential errors associated with comparison of water level records that may have been collected at widely varying time-intervals. Use of data collected prior to June 2008 was based on the timing of data compilation; the analyses required compilation of data from a variety of non-District sources and was completed in the spring of 2008. A time-series plot or hydrograph of monthly mean water surface elevations for the middle Hillsborough River based on records collected through June 2008 is shown in Figure 5-8. In contrast to plots presented in the previous sub-section of this Chapter for water level fluctuations at selected river sites in west-central Florida, hydrographs for most of the evaluated reservoirs exhibit a pattern that is similar to the pattern of water level fluctuations in the middle Hillsborough River (Figures 5-9 through 5-21).

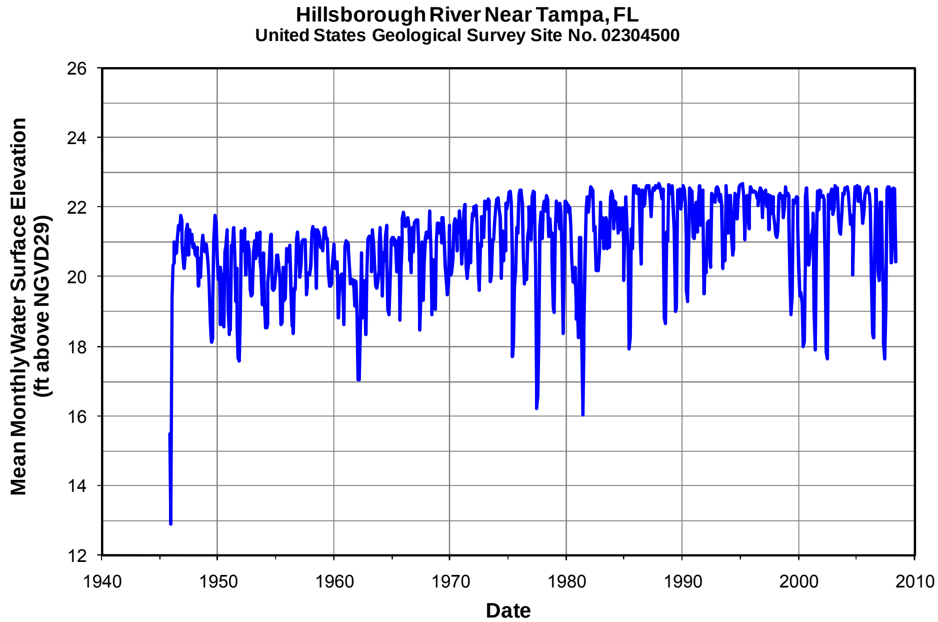


Figure 5-7. Monthly mean water surface elevations of the middle Hillsborough River, based on mean daily values measured at the United States Geological Survey Hillsborough River near Tampa, FL gauge site (No. 0230304500) for the period from October 1, 1945 through May 31, 2008.

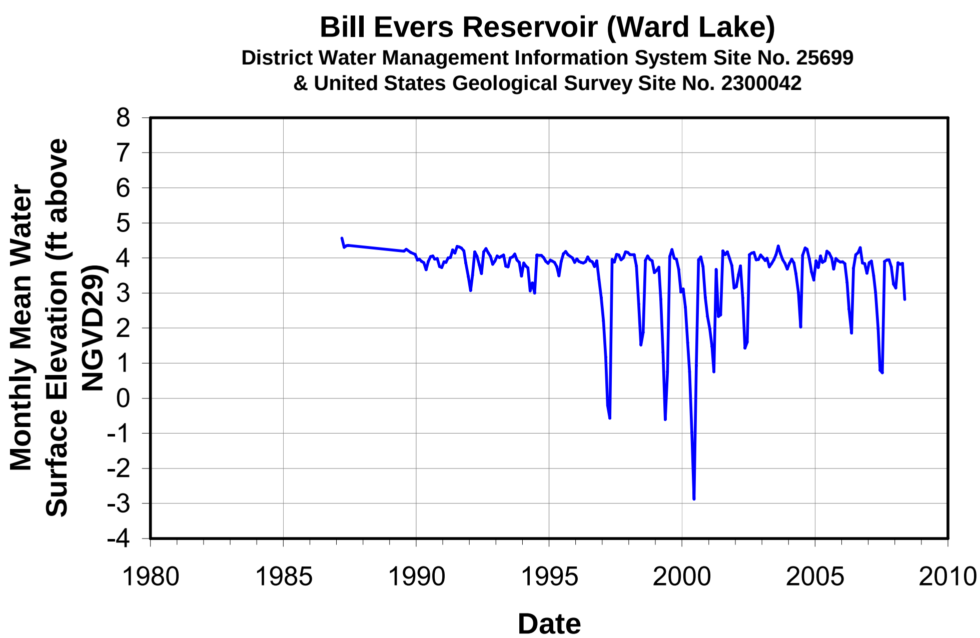


Figure 5-8. Monthly mean water surface elevations of the Bill Evers Reservoir (Ward Lake) in Manatee County, Florida, based on mean daily values for the period from March 2, 1987 through May 31, 2008.

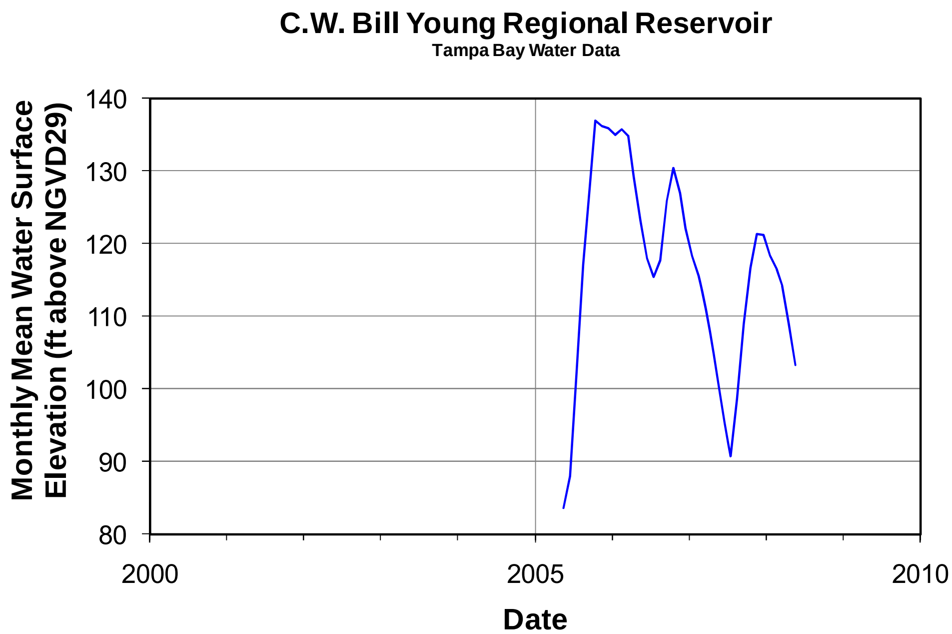


Figure 5-9. Monthly mean water surface elevations of the C.W. Bill Young Reservoir in Hillsborough County, based on mean daily values for the period from May 9, 2005 through May 31, 2008.

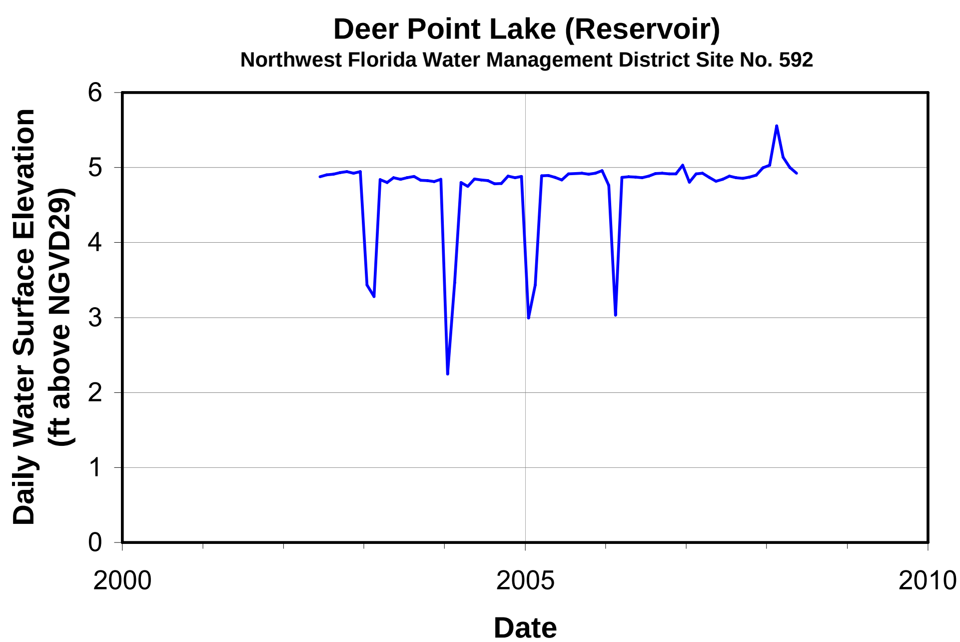


Figure 5-10. Monthly mean water surface elevations of Deer Point Lake in Bay County, Florida, based on mean daily values for the period from June 17, 2002 through May 5, 2008.

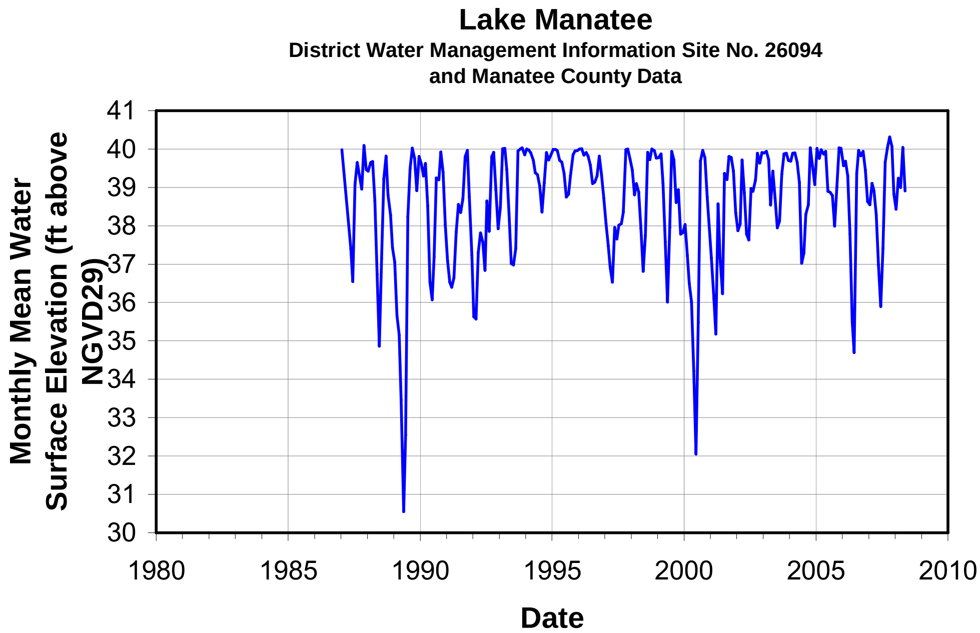


Figure 5-11. Monthly mean water surface elevations of Lake Manatee in Manatee County, Florida, based on mean daily values for the period from January 26, 1987 through May 31, 2008.

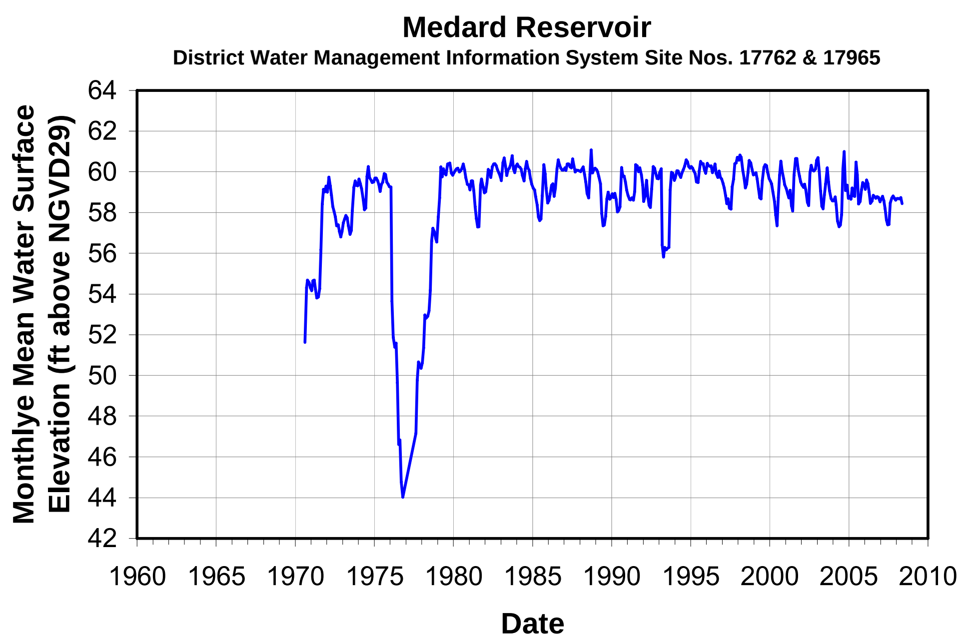


Figure 5-12. Monthly mean water surface elevations of Medard Reservoir in Hillsborough County, based on mean daily values for the period from August 2, 1970 through May 31, 2008.

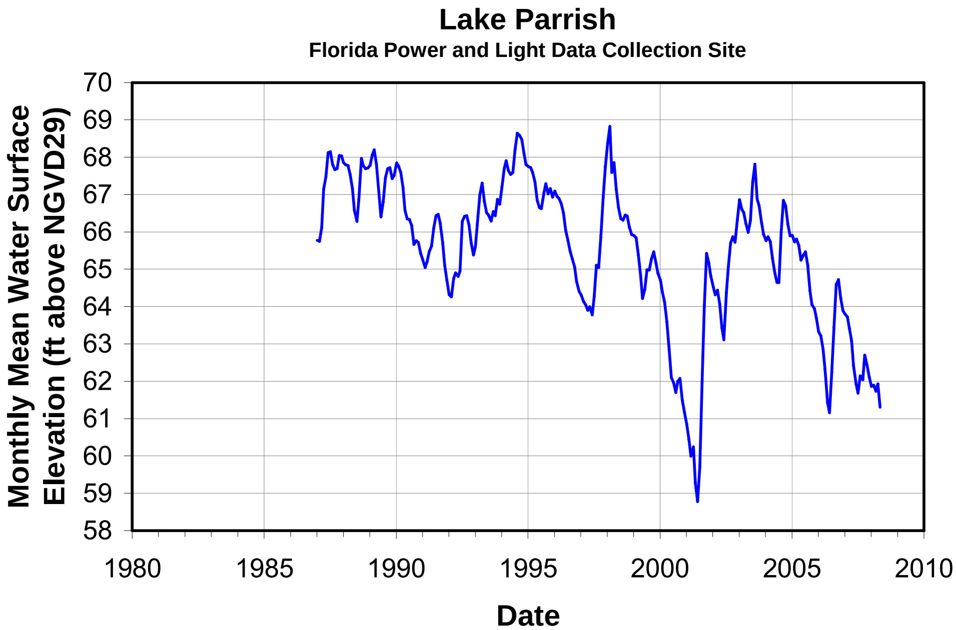


Figure 5-13. Monthly mean water surface elevations of Lake Parrish in Manatee County, Florida, based on mean daily values for the period from January 1, 1987 through May 31, 2008.

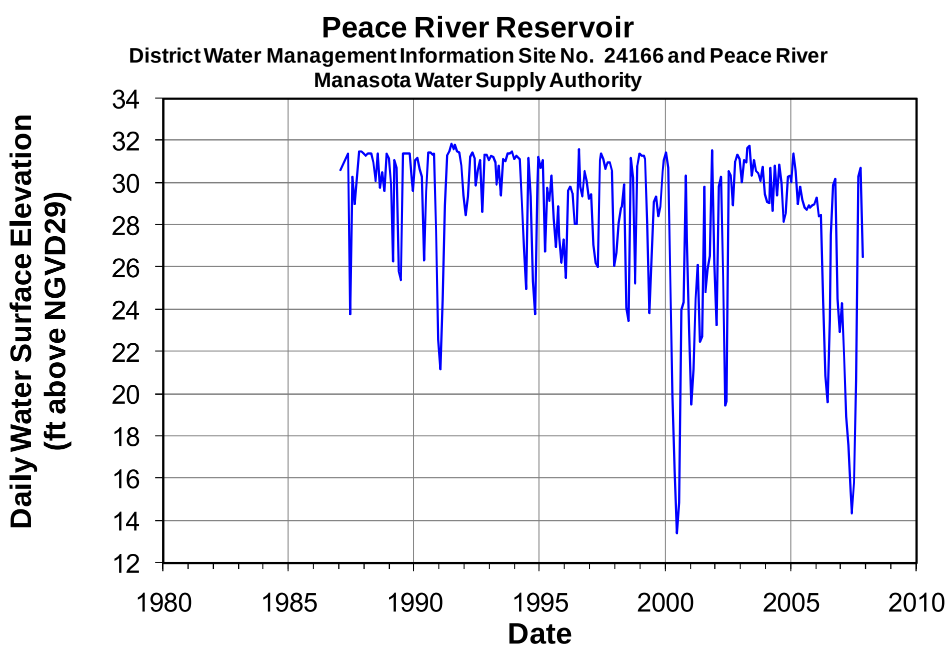


Figure 5-14. Monthly mean water surface elevations of the Peace River Reservoir in DeSoto County, based on mean daily values for the period from January 26, 1987 through November 30, 2007

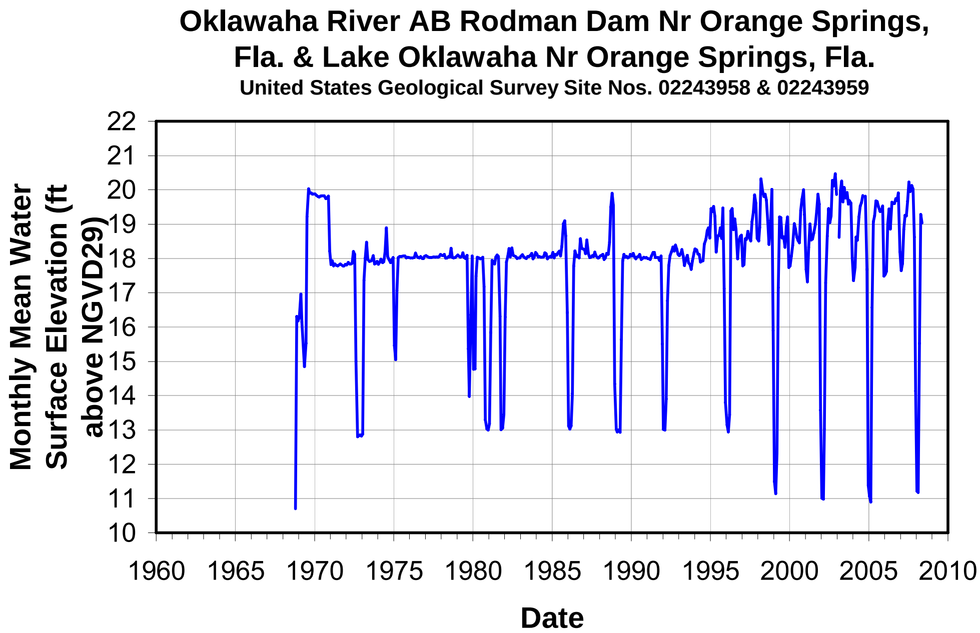


Figure 5-15. Monthly mean water surface elevations of Rodman Reservoir (Lake Oklawaha) in Citrus, Levy and Marion Counties, based on mean daily values for the period from October 1, 1968 through May 31, 2008.

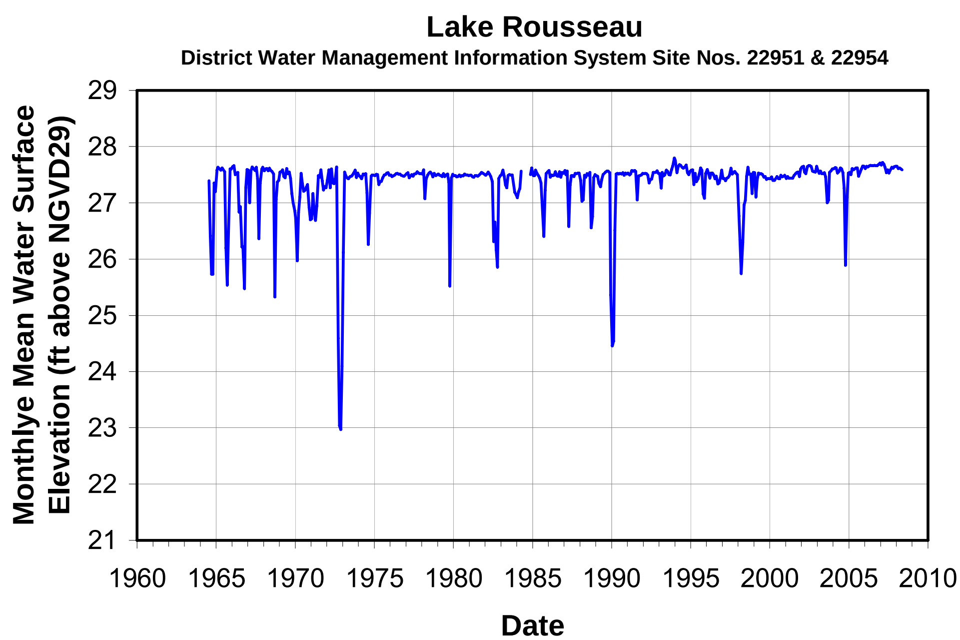


Figure 5-16. Monthly mean water surface elevations of Lake Rousseau in Citrus, Levy and Marion Counties, based on mean daily values for the period from July 2, 1964 through May 31, 2008.

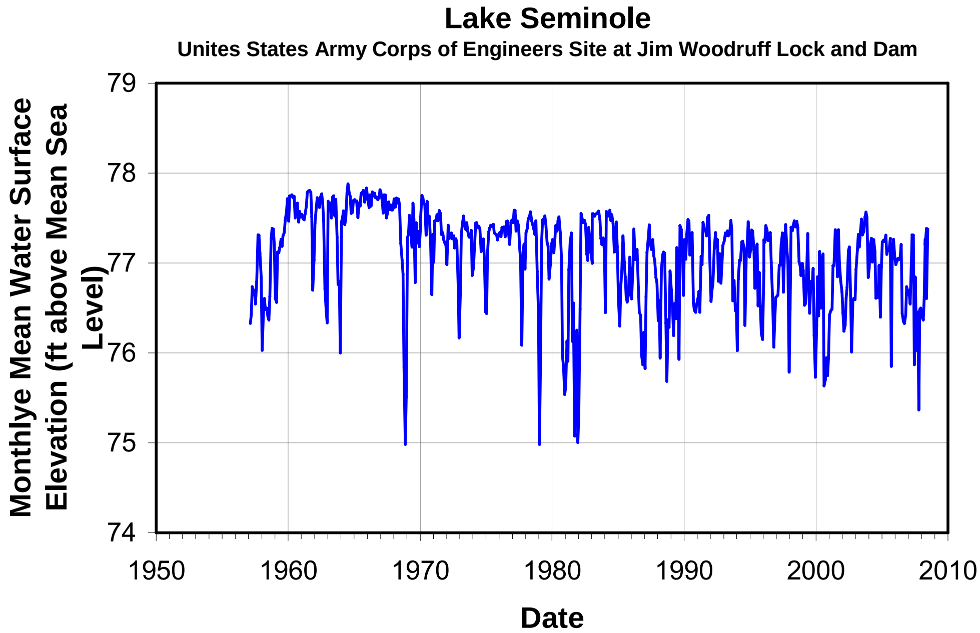


Figure 5-17. Monthly mean water surface elevations of Lake Seminole in Gadsen and Jackson Counties, Florida and Decatur and Seminole Counties, Georgia, based on mean daily values for the period from February 1, 1957 through May 31, 2008.

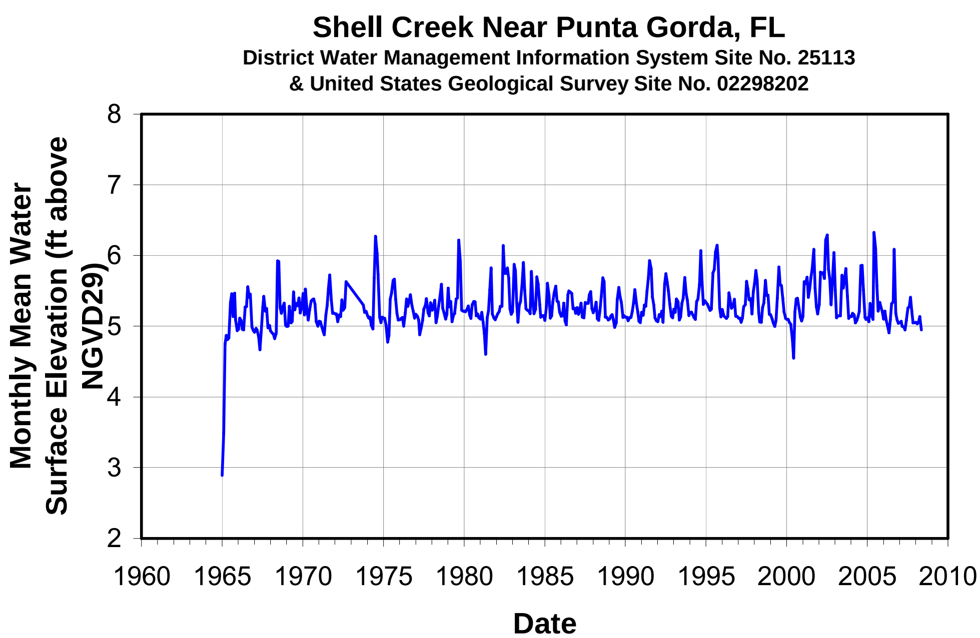


Figure 5-18. Monthly mean water surface elevations of the Shell Creek Reservoir in Charlotte County, Florida, based on mean daily values for the period from January 2, 1965 through May 31, 2008.

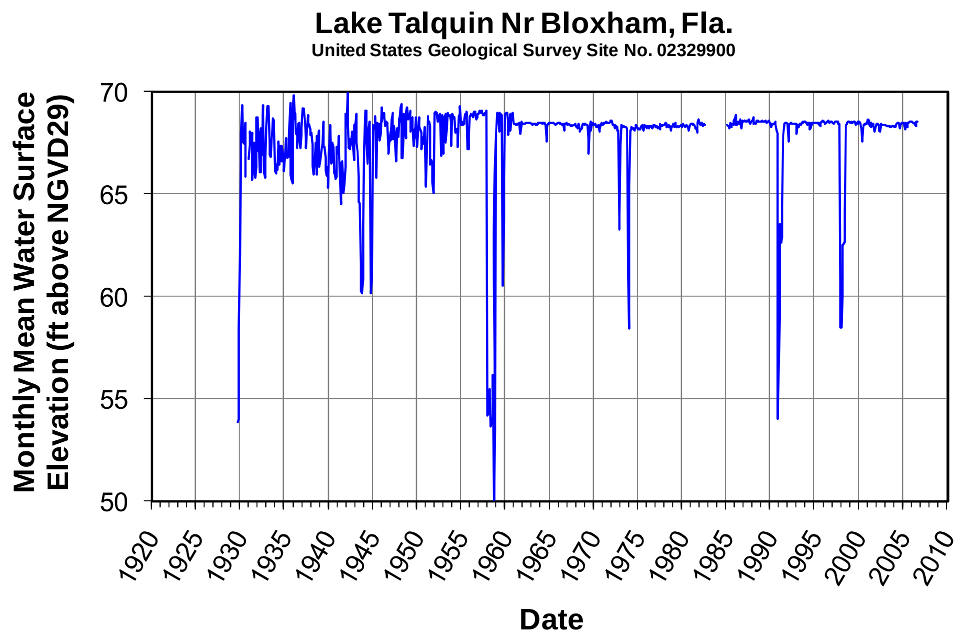


Figure 5-19. Monthly mean water surface elevations of Lake Talquin in Gadsen and Leon Counties, based on mean daily values for the period from October 1, 1929 through September 30, 2007.

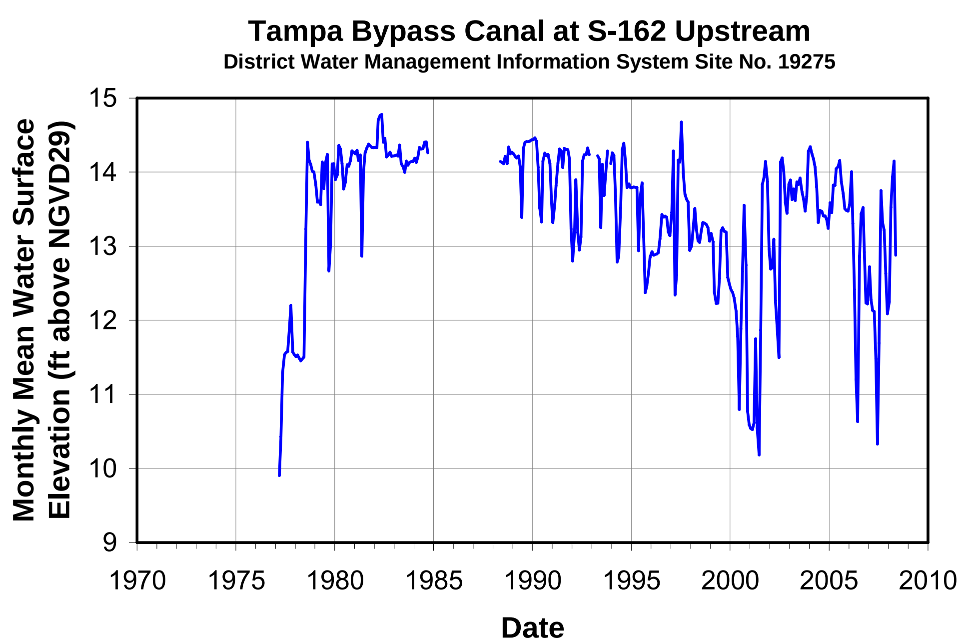


Figure 5-20. Monthly mean water surface elevations of the Middle Pool of the Tampa Bypass Canal in Hillsborough County, Florida, based on mean daily values for the period from March 23, 1977 through May 31, 2008.

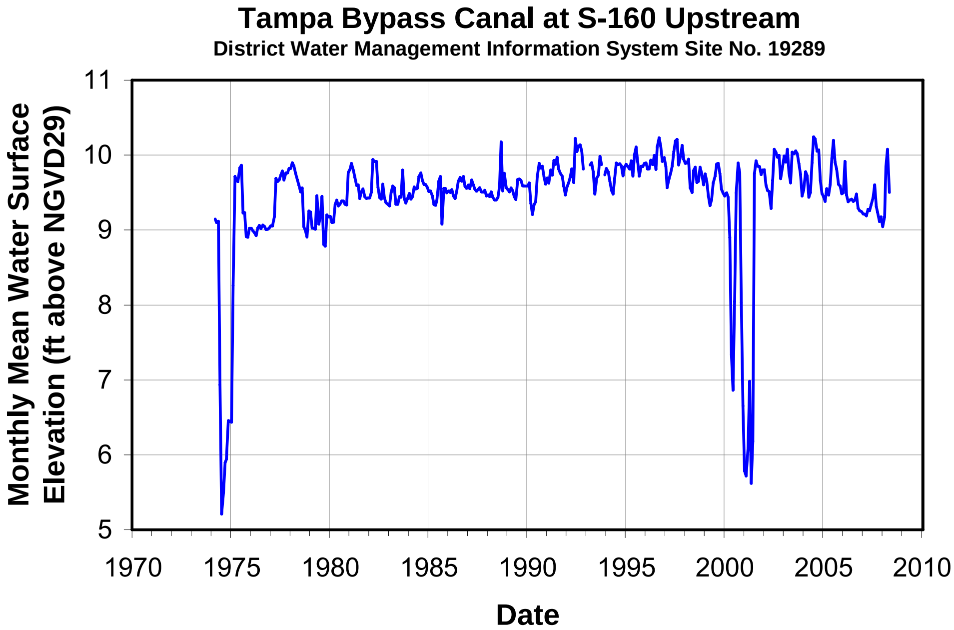


Figure 5-21. Monthly mean water surface elevations of the Lower Pool of the Tampa Bypass Canal in Hillsborough County, Florida, based on mean daily values determined for the period from March 8, 1974 through May 31, 2008.

Summary statistics describing the water level fluctuations of the middle river and the reservoirs were examined for further evaluation of middle river water level fluctuations. Calculation of these statistics was limited to monthly mean water surface elevations for the period from January 1985 through May 2008. Data collected only after January 1985 were selected for analyses as they correspond to the period for the middle river considered representative of current structural conditions and during which augmentation from both Sulphur Springs and the Tampa Bypass Canal has been implemented. Water levels for most of the systems were available for the entire evaluation period, *i.e.,* from January 1985 through May 2008. Systems lacking complete water level records were retained for the analysis, as they were expected to provide useful comparative information for evaluation of water level fluctuations in the middle river.

Differences between maximum and minimum monthly mean water surfaces for the evaluation period ranged from 1.78 at the Shell Creek Reservoir to 46.17 feet at the C.W. Bill Young Reservoir (Table 5-2). The wide fluctuation range for the C.W. Bill Young Reservoir likely reflects the recent, purposeful lowering of water levels in the basin to permit maintenance activities. The range between maximum and minimum monthly mean water levels in the middle Hillsborough River during the evaluated period was 5.03 feet and was less than the median fluctuation range calculated for all 14 reservoirs (6.37 feet) and the range calculated for the 8 reservoirs used for water supply (6.02 feet). The middle river minimum-maximum range was similar to the 5.28 foot range determined for the Medard Reservoir, a 770 acre reservoir inundating a portion of the Little Alafia River that was previously mined for phosphate and which is currently maintained for recreational use, groundwater recharge and flood control (Kelly 1991). Differences between maximum and minimum monthly mean values for the middle river were also similar to those of the middle (4.49 feet) and lower pools (4.63 feet) of the Tampa Bypass Canal.

Several of the reservoirs exhibited P10 to P90 differences of less than one foot, a range indicative of very stable water levels. The difference between the water-surface elevation equaled or exceeded ten percent of the time, *i.e.,* the P10, and the water level equaled or exceeded ninety percent of the time, or the P90, was 2.56 feet for the middle river while the median value for the reservoirs examined was 2.02 feet. Inflows to these systems are presumably high or hydrologic outputs and inputs are comparable. The difference between the P10 and median or P50 elevation for the reservoir, 0.38 feet, was less than the 0.6 feet median value for the reservoirs. The difference between the P50 and P90 for the middle river was 2.19 feet and was greater than the 1.25 foot median calculated for the 14 reservoirs. Graphical representation of the water level fluctuation summary statistics for the middle Hillsborough River and the reservoirs evaluated (Figures 5-22 and 5-23) illustrates that water levels in the river segment tend to fluctuate in the mid-range reported for reservoirs located throughout the state.

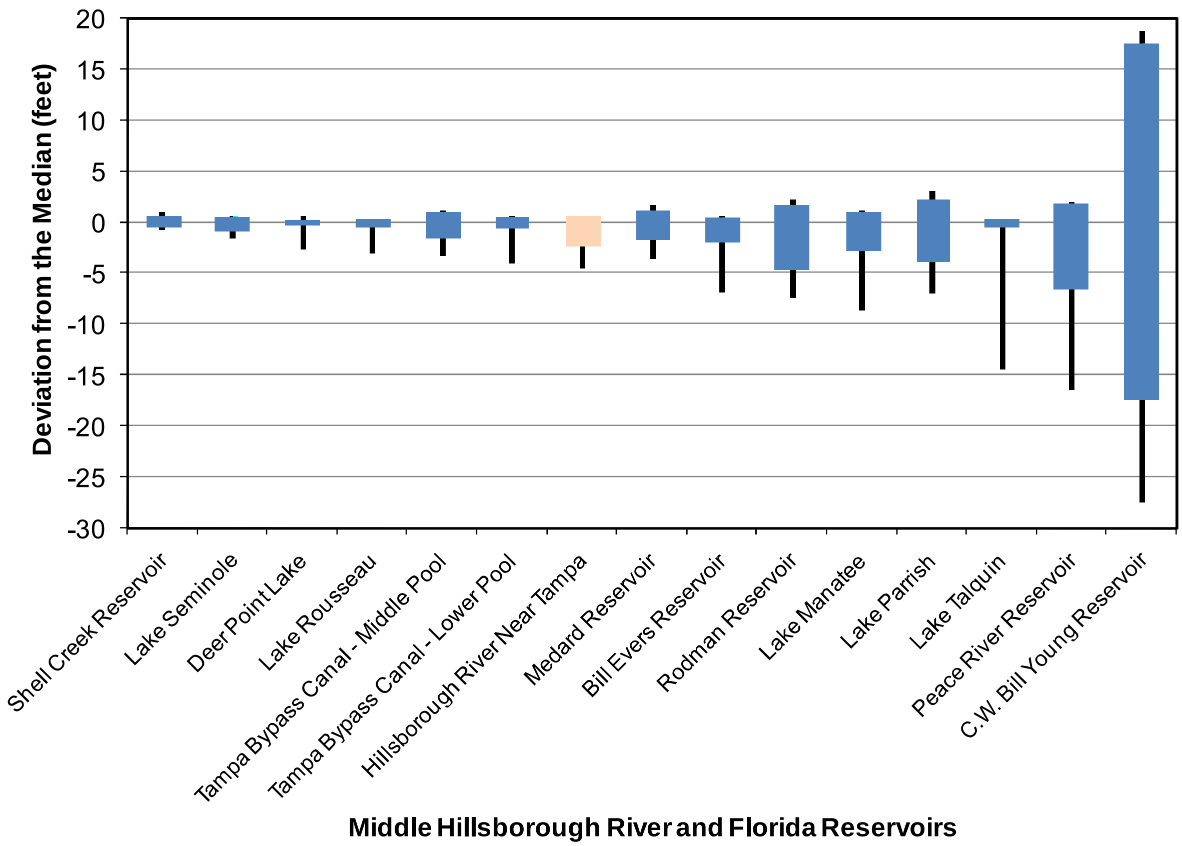


Figure 5-22. Water level fluctuations in the middle Hillsborough River at the United States Geological Survey Hillsborough River near Tampa, FL gauge site and at known Florida reservoirs expressed as deviations in feet from the median water surface elevation for each system based on mean daily water records for the collected from January 1985 through May 2008. Vertical lines represent range of monthly mean water levels. Boxes represent differences between monthly mean water levels equaled or exceeded ten and ninety percent of the time; middle Hillsborough River denoted by the mauve box.

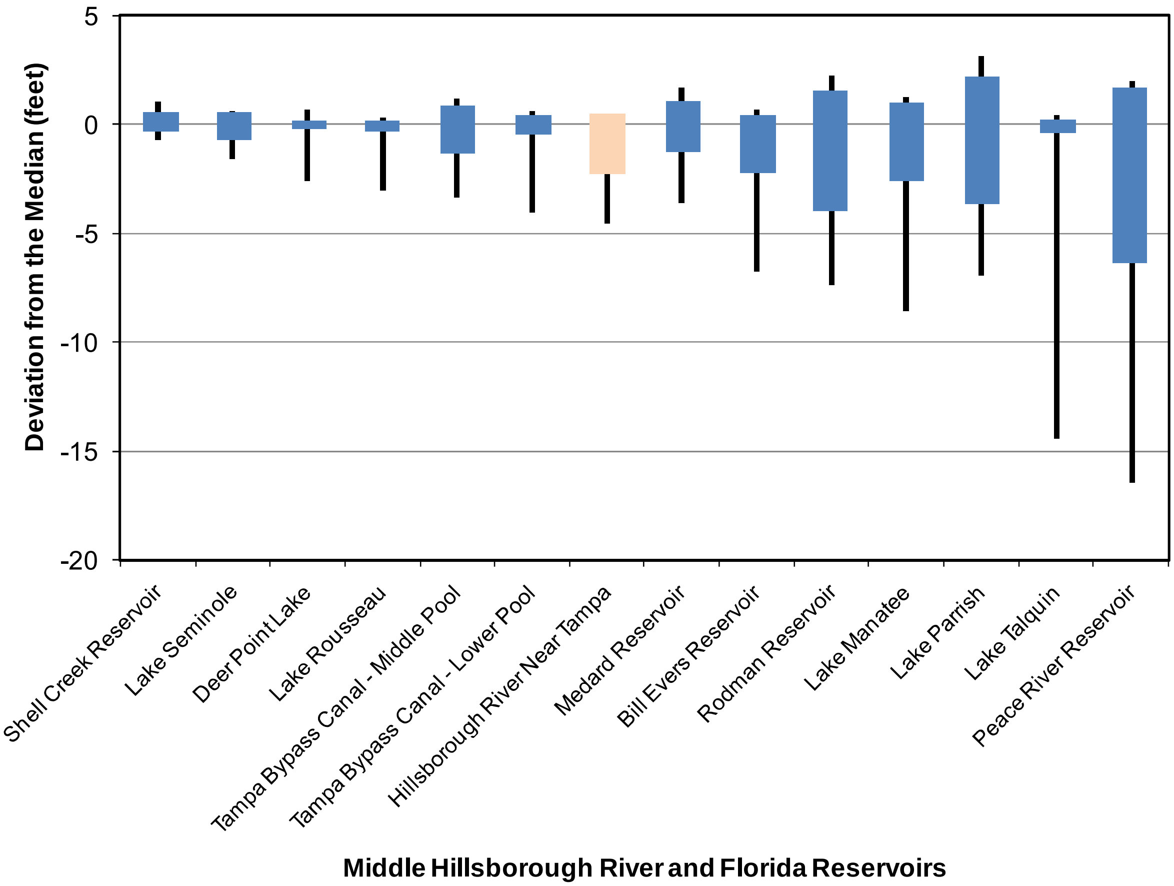


Figure 5-23. Water level fluctuations as depicted in Figure 5-22, with a narrower y-axis scale and without data for the C.W. Bill Young Reservoir.

Table 5-2. Summary statistics for water level fluctuations in the middle Hillsborough River at the City of Tampa Dam and Florida reservoirs. Fluctuations are expressed as differences between maximum, minimum and water surface elevations equaled or exceeded ten (P10), fifty (P50) and ninety (P90) percent of the time, based on monthly mean values for the period from January 1985 through May 2008 (except as noted). System types include in-line (In) and off-line (Off) systems and those used for water supply (WS).

Water Body	County, State	System Type	Size (~Acres)	Period Evaluated	Maximum to Minimum Difference (feet)	P10 to P90 Difference (feet)	P10 to P50 Difference (feet)	P50 to P90 Difference (feet)
Shell Creek Reservoir	Charlotte, FL	In/WS	230	Jan 1985 – May 2008	1.78	0.63	0.44	0.18
Lake Seminole	Gadsen & Jackson, FL; Decatur & Seminole, GA	In	37,600	Jan 1985 – May 2008	2.20	1.06	0.39	0.67
Deer Point Lake	Bay, FL	In/WS	4,550 to 5,500	Jun 2002 – May 2008[A]	3.31	0.20	0.07	0.12
Lake Rousseau	Citrus, Levy & Marion, FL	In	3,657 to 4,163	Jan 1985 – May 2008	3.34	0.36	0.13	0.24
Tampa Bypass Canal – Middle Pool	Hillsborough, FL	Off/WS	na	May 1988 – May 2008[B]	4.49	2.04	0.75	1.28
Tampa Bypass Canal – Lower Pool	Hillsborough, FL	Off/WS	na	Jan 1985 – May 2008	4.63	0.70	0.35	0.35
Middle Hillsborough River	Hillsborough, FL	In/WS	734	Jan 1985 – May 2008	5.03	2.56	0.38	2.19
Medard Reservoir	Hillsborough, FL	In	770	Jan 1985 – May 2008	5.28	2.14	0.92	1.22
Bill Evers Reservoir	Manatee, FL	In/WS	255 to 359	Mar 1987 – May 2008[C]	7.45	2.00	0.27	1.73
Rodman Reservoir	Putnam & Marion, FL	In	9,000	Jan 1985 – May 2008	9.57	5.39	1.44	3.95
Lake Manatee	Manatee, FL	In/WS	900 to 1,800	Jan 1987 – May 2008[D]	9.76	3.40	0.87	2.53
Parrish Lake	Manatee, FL	Off	3,560	Jan 1987 – May 2008[D]	10.05	5.63	2.04	3.58
Lake Talquin	Gadsen & Leon, FL	In	8,850 to 9,700	Mar 1985 – Sep 2007[E]	14.88	0.40	0.10	0.30
Peace River Reservoir	DeSoto, FL	Off/WS	na	Jan 1987 – Nov 2007[F]	18.44	7.88	1.55	6.33
C.W. Bill Young Regional	Hillsborough, FL	Off/WS	1,100	Oct 2005 – May 2008[G]	46.17	34.63	17.47	17.16

[A] Data not available prior to June 2002
[B] Data not available prior to May 1988.
[C] Data not available prior to March 1987
[D] Data not available prior to January 1987
[E] Data not available for January or February 1985 of after September 2007
[F] Data not available prior to January 1987 or after November 2007
[G] Initial reservoir filling completed and maximum reported in October 2005
na = not available

Water Level Fluctuations in the middle Hillsborough River and Selected Area Lakes

Although the Hillsborough River watershed is not considered a high-density lake area, there are a number of lakes in the vicinity of the middle river. Water level fluctuations in selected area lakes were therefore contrasted with those of the middle river to further evaluate water level fluctuations in the river segment. For the analyses, water level records for selected lakes in the vicinity of the middle Hillsborough River were obtained from the District Water Management Information System. The lakes included Lake Thonotosassa, Valrico Lake, Long Pond, Lake Weeks and Lake Hooker, which are located in Hillsborough County east of the river segment. Other Hillsborough County lakes included in the analysis included Bellows Lake, which is located south of the river, and Egypt Lake, Lake Carroll and Lake Magdalene which are located west of the middle river. Horse Lake and Starvation Lake, two additional Hillsborough County located northwest of the river, were also evaluated. These latter two lakes were included in the evaluation as they located near major regional wellfield withdrawals and are more affected by water-use than the other systems. Lake Panasoffkee, located in Sumter County was also included in the evaluation because the groundwater discharge accounts for a substantial portion of the water budget inputs for the lake (Lake Panasoffkee Restoration Council 1998) and inflows to the middle river are similarly influenced by discharge from Crystal Springs during low flow periods. The Hillsborough County lakes evaluated range in size from approximately 37 to over 819 acres. Lake Panasoffkee is much larger, with an area of approximately 4,500 acres.

Available water level records collected for the period January 1, 1985 through December 31, 2008 were used to calculated monthly mean water surface elevations for each lake and the middle river. Monthly mean values were calculated to minimize potential errors associated with comparison of water level records that may have been collected at widely varying time-intervals. Data collected from January 1985 forward were selected for analyses as they correspond to the period when the middle river was augmented with water from Sulphur Springs and the Tampa Bypass Canal. Hydrographs of monthly mean water surface elevations for the middle Hillsborough River based on records collected at the United States Geological Survey Hillsborough River near Tampa, FL gauge site and the District gauge sites for the lakes evaluated are shown in Figures 5-25 through 5-26.

Concordance between water level fluctuations in the middle Hillsborough River at the City of Tampa Dam and the lakes evaluated was intermediate between that of the middle river fluctuations and the various river gauge sites and reservoirs within the state (refer to Figures 51 through 5-5 and 5-7 through 5-21). Rising and falling water levels, presumably reflecting rainfall patterns, were clearly evident in the lake and middle river hydrographs, although the stability of peak levels observed for the middle river (associated with discharge across the City of Tampa Dam) was not evident in the lake level time-series plots (Figures 5-25 through 5-27).

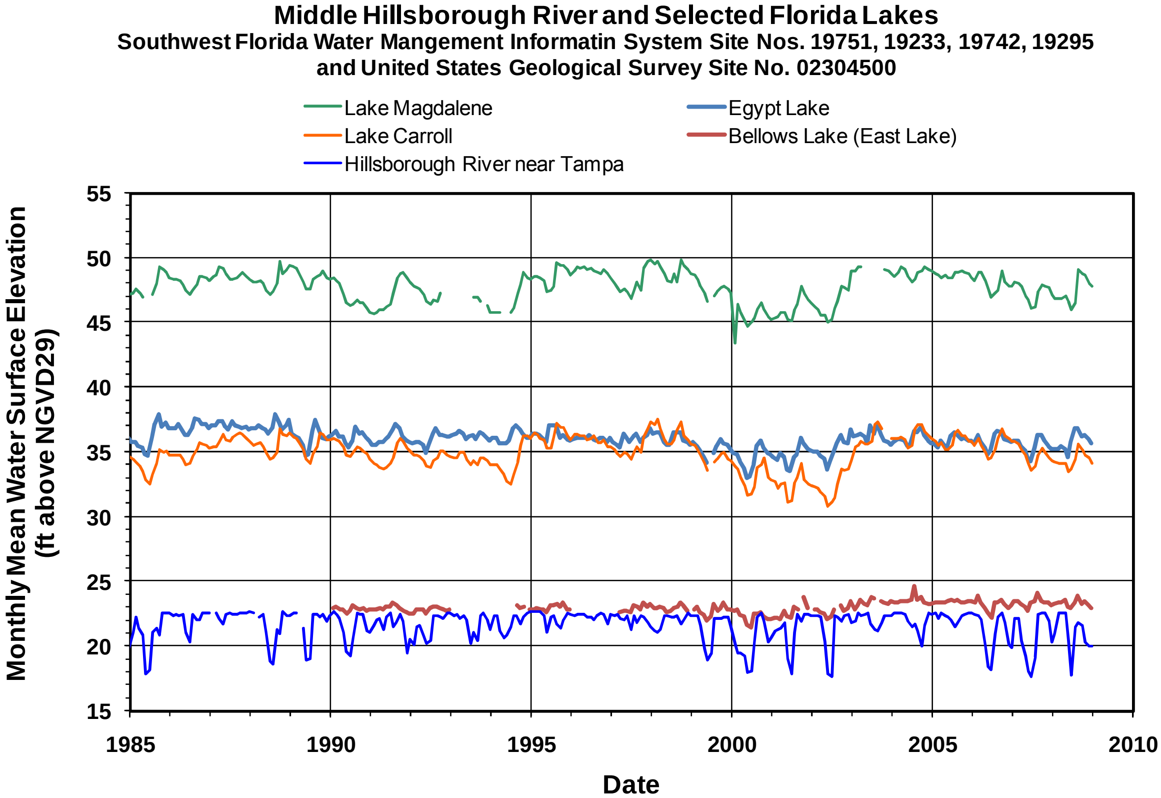


Figure 5-24. Monthly mean water surface elevations of the middle Hillsborough River and selected Hillsborough County lakes located south and west of the river segment. Elevations derived from mean daily values measured at the United States Geological Survey Hillsborough River near Tampa, FL gauge site (No. 0230304500) and District lake gauge sites for the period from January 1, 1985 through December 31, 2008.

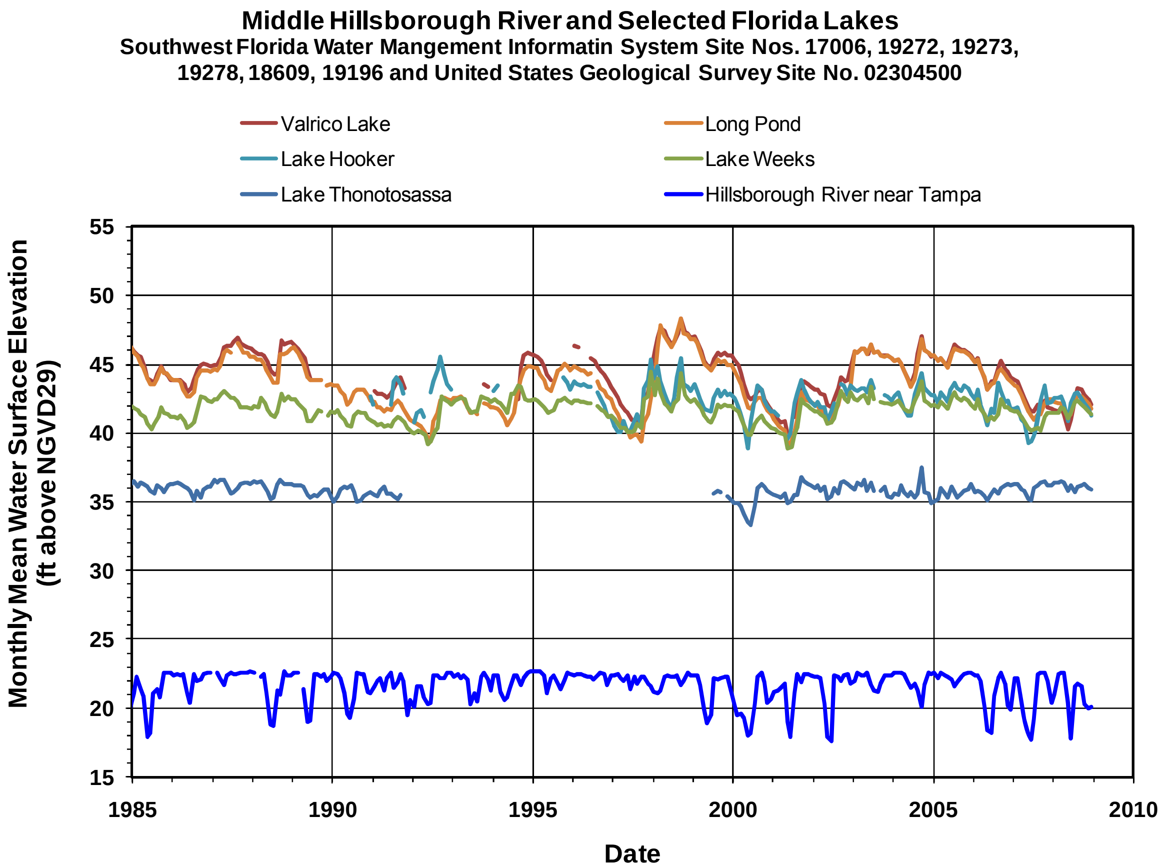


Figure 5-25. Monthly mean water surface elevations of the middle Hillsborough River and selected Hillsborough County lakes located east of the river segment. Elevations derived from mean daily values measured at the United States Geological Survey Hillsborough River near Tampa, FL gauge site (No. 0230304500) and District lake gauge sites for the period from January 1, 1985 through December 31, 2008.

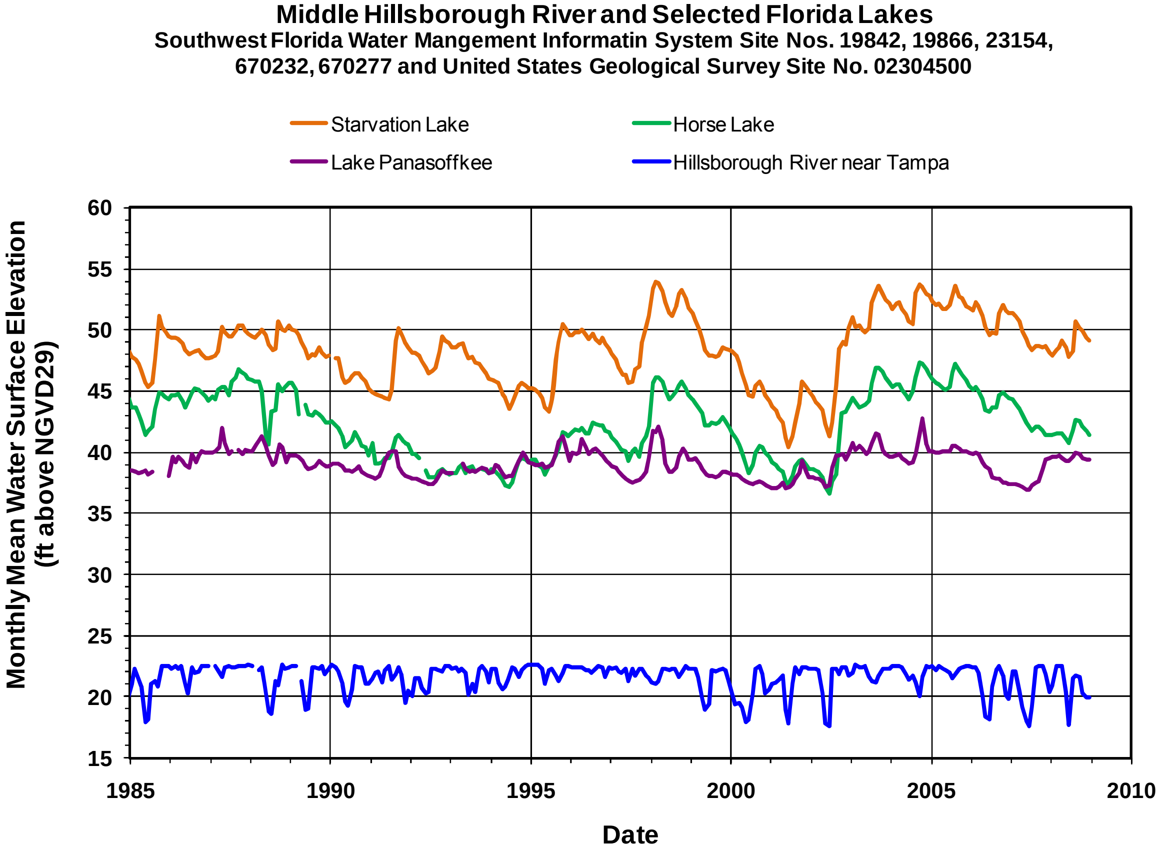


Figure 5-26. Monthly mean water surface elevations of the middle Hillsborough River, two Hillsborough County lakes (Horse Lake and Starvation Lake) located northwest of the river segment and a Sumter County Lake (Lake Panasoffkee). Elevations derived from mean daily values measured at the United States Geological Survey Hillsborough River near Tampa, FL gauge site (No. 0230304500) and District lake gauge sites for the period from January 1, 1985 through December 31, 2008.

Summary statistics describing the water level fluctuations of the middle river and the lakes were examined for comparative evaluation of the magnitude of middle river and lake water level fluctuations. Water levels for most of the lakes were available for the much of the evaluation period*, i.e.,* from January 1985 through December 2008. Systems lacking complete water level records were retained for the analyses, as they were expected to provide useful comparative information for evaluation of water level fluctuations in the middle river.

Differences between maximum and minimum monthly mean water surfaces for the 1985 through 2008 period ranged from 3.29 feet in Bellows Lake to 13.50 feet in Starvation Lake (Table 5-3). The wide stage fluctuation range for Starvation Lake, and Horse Lake also, reflects localized effects of public-supply wells located near the lakes. The range between maximum and minimum monthly mean water levels in the middle Hillsborough River was 5.03 feet, an intermediate value when compared with the lakes evaluated; the median fluctuation ranges calculated for the full set of lakes and with Horse Lake and Starvation Lake excluded, were 6.5 and 6.05 feet.

The difference between the mean monthly water surface elevation equaled or exceeded ten percent of the time, *i.e.,* the P10, and the mean monthly water level equaled or exceeded ninety percent of the time, or the P90, was 2.63 feet for the middle river while the median value for the set of lakes with Horse Lake and Starvation Lake excluded was 2.86 feet. The difference between the monthly mean P10 elevation and median or P50 elevation for the middle river was 0.40 feet, and was lower than the P10 to P50 difference calculated for each of the evaluated lakes. The difference between the P50 and P90 for the middle river was 2.23 feet and was greater than 8 of the lakes evaluated and exceeded the median value of 1.63 feet calculated for the set of lakes with Horse Lake and Starvation Lake excluded.

Graphical representation of the water level fluctuation summary statistics for the middle Hillsborough River and the 12 lakes evaluated (Figure 5-27) showed that water level fluctuations in the middle river were within the range observed for lakes in the region. As was the case for the time-series water level plots, Figure 5-27 also shows that water level fluctuations in the middle river were not completely analogous to those occurring within lake basins. The difference between the median water surface elevation and the P10 and maximum elevations was relatively small for the middle river as compared to area lakes.

Comparison of the statistics calculated for water level fluctuations in the middle Hillsborough River with those determined previously for other northern Tampa Bay area lakes further illustrates the similarities and differences noted between the middle river and area lakes. Analysis of water level fluctuation statistics based on water surface elevation records for 22 area lakes available for periods when water withdrawals were not influencing water level variation within the basins yielded differences between P10 and P90 elevations ranging from 1.2 to 4.4 feet, with a median value of 2.1 feet (Southwest Florida Water Management District 1999c). Differences between P10 and P50 elevations for the lakes ranged from 0.4 to 2.4 feet with a median of 1.0 foot and differences between P50 and P90 elevations ranged from 0.8 to 2.1 feet, with a median of 1.1 feet. Differences in summary statistics for water level fluctuations in the middle river, with the exception of the P50 to P90 difference (which was ~0.1 feet greater than the maximum difference reported for the 22 lake set), fall within these reported ranges, suggesting that the hydrologic regime of the middle river shares characteristics with the regimes of area lakes. However, because: 1) the P10 to P50 difference calculated for the middle river, 0.40 feet, was equivalent to the lowest difference observed for the 22 lake set; 2) the P50 to P90 difference for the river slightly exceeded the range reported for the other lakes; and 3) the P10 to P90 difference for the river exceeds the median of the 22 lake set by approximately 0.5 feet, water level fluctuations in the middle river may not be considered completely analogous to fluctuations in area lake basins.

Sacks *et al.* (2008) provide additional information regarding stage water level fluctuations in west-central Florida lakes that is useful for evaluating middle river water levels. They report medians of 4.6, 1.4 and 2.9 feet for P10 and P90, P10 and P50 and P50 and P90 differences for 98 “highland” and “lowland” lakes for a recent ten-year period, from 1996 through 2005. For their study, highland lakes were those located on ridge and upland areas; lowland lakes were those occurring in the Gulf Coastal Lowlands and Western Valley physiographic provinces in the northern Tampa Bay area. Stage fluctuation statistics for a smaller number of highland and lowland lakes (n = 20) for an earlier period (1954 through 1963), when impacts on lake levels associated with water use were presumably lower, yielded median P10 to P90, P10 to P50 and P50 to P90 differences of 2.7, 0.9 and 1.6 feet. The P10 to P90 difference for the 20 lakes ranged from 0.8 to 4.9 feet, the P10 to P50 differences ranged from 0.4 to 3.1 feet and the P50 to P90 differences ranged from 0.4 to 2.5 feet. Differences between the two data sets were attributed to sample size differences, differences in lake size, and an increase in the effect of water withdrawals on lake level fluctuations during the recent period. Median P10 to P90, P10 to P50 and P50 to P90 differences for 42 lowland lakes in Hillsborough and Pasco County for the 1996 through 2005 period were 4.3, 1.2 and 3.0 feet, respectively. The P10 to P90 differences for the 42 lakes ranged from 1.3 to 9.4 feet. Differences between P10 and P50 elevations ranged from 0.5 to 3.8 feet and differences between P50 and P90 values ranged from 0.8 to 6.5 feet. Maximum to minimum difference for monthly mean elevations for the 42 lakes ranged from 2.7 to 13.9 feet with a median value of 6.9 feet. Reported ranges for summary statistic differences for the middle river fall within the ranges or were comparable to the values reported by Sacks *et al.* (2008).

Table 5-3. Summary statistics for water level fluctuations in the middle Hillsborough River at the City of Tampa Dam and selected area lakes. Fluctuations are expressed as differences between maximum, minimum and water surface elevations equaled or exceeded ten (P10), fifty (P50) and ninety (P90) percent of the time, based on monthly mean values for the period from January 1985 through December 2008 (except as noted).

Lake	County, State	Size (~Acres)	Period Evaluated	Maximum to Minimum Difference (feet)	P10 to P90 Difference (feet)	P10 to P50 Difference (feet)	P50 to P90 Difference (feet)
Bellows Lake (East Lake)	Hillsborough, FL	88	May 1986 – Dec 2008 [A]	3.29	1.02	0.52	0.50
Lake Thonotosassa	Hillsborough, FL	819	Jan 1985 – Dec 2008 [B]	4.24	1.21	0.55	0.66
Egypt Lake	Hillsborough, FL	67	Jan 1985 – Dec 2008	4.88	2.03	0.92	1.11
Middle Hillsborough River	Hillsborough, FL	734	Jan 1985 – Dec 2008	5.03	2.63	0.40	2.23
Lake Weeks	Hillsborough, FL	55	Jan 1985 – Dec 2008	5.54	2.19	0.85	1.34
Lake Panasoffkee	Sumter, FL	4,460	Jan 1985 – Dec 2008	5.75	2.81	1.33	1.48
Lake Magdalene	Hillsborough, FL	238	Jan 1985 – Dec 2008 [C]	6.35	3.12	1.05	2.07
Lake Hooker	Hillsborough, FL	37	Sep 1989 – Dec 2008 [D]	6.64	2.90	1.12	1.78
Lake Carroll	Hillsborough, FL	191	Jan 1985 – Dec 2008	6.69	3.32	1.23	2.09
Valrico Lake	Hillsborough, FL	127	Jan 1985 – Dec 2008 [E]	8.45	4.50	1.97	2.53
Long Pond	Hillsborough, FL	52	Jan 1985 – Dec 2008 [E]	9.10	4.85	2.32	2.53
Horse Lake	Hillsborough, FL	28	Jan 1985 – Dec 2008	10.63	7.25	3.59	3.66
Starvation Lake	Hillsborough, FL	52	Jan 1985 – Dec 2008	13.50	7.36	3.44	3.92

[A] *Moderate amount of missing data; water level recording initiated in May 1986 – see Figure 5-24*
[B] *Missing data from October 1991 through June 1999 – see Figure 5-25*
[C] *Moderate amount of missing data – see Figure 5-24*
[D] *Moderate amount of missing data; water level recording initiated in September 1989 – see Figure 5-25*
[E] *Moderate amount of missing data – see Figure 5-25*

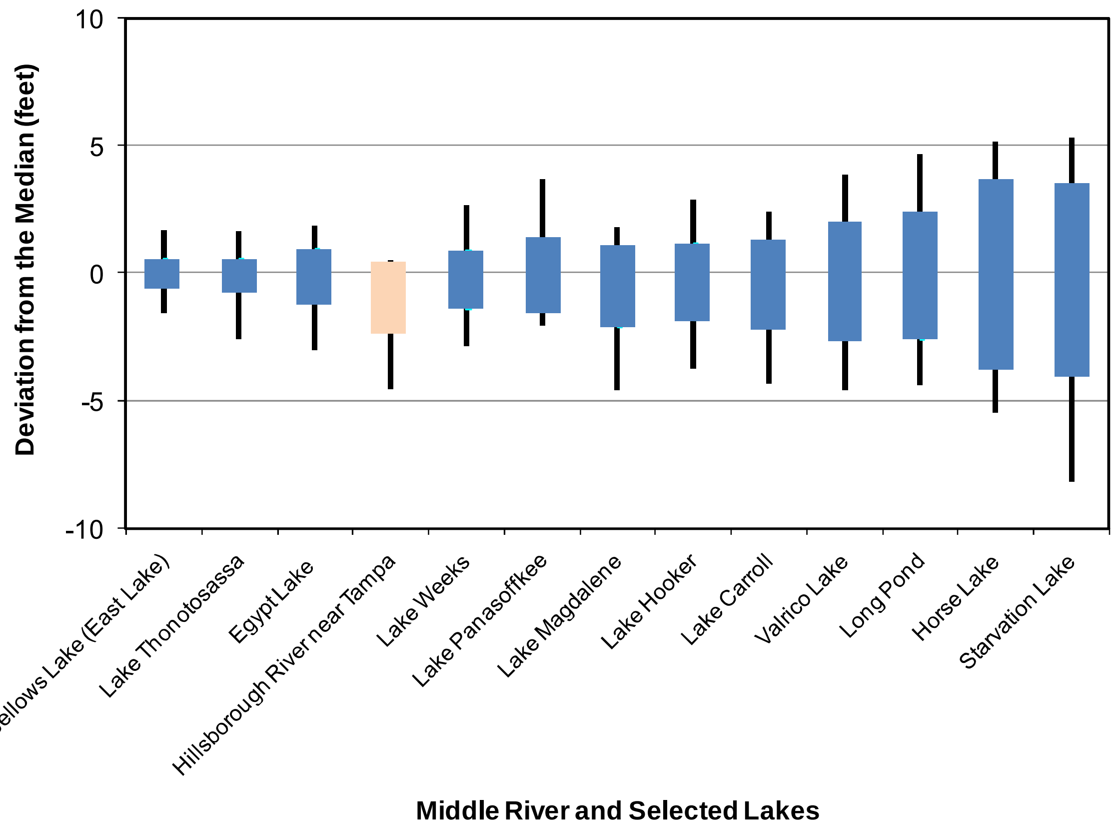


Figure 5-27. Water level fluctuations in the middle Hillsborough River at the United States Geological Survey Hillsborough River near Tampa, FL gauge site and at selected area lakes, expressed as deviations in feet from the median water surface elevation for each system based on mean daily water records for the collected from January 1985 through December 2008. Vertical lines represent range of monthly mean water levels. Boxes represent differences between monthly mean water levels equaled or exceeded ten and ninety percent of the time; middle Hillsborough River denoted by the mauve box.

Highlights of Chapter 5

Review of time-series plots of water surface elevations in the middle Hillsborough River at the City of Tampa Dam and at other river gauge sites in west-central Florida indicated substantial differences between the hydrologic regime of the middle river and the other sites. Water levels at all of the river gauge sites except the middle river site exhibited spikes or rapid increases and decreases above a relatively flat or stable lower water level. The hydrograph for the middle river site appeared to be a mirror-image of the hydrographs for the other river gauge sites. In contrast to the relatively stable base-flow condition evident for the lower water levels in the other hydrographs examined, the middle river site exhibited a relatively stable high-water condition. This phenomenon is, of course, a function of the elevation at which water is discharged over or across the City of Tampa dam and the augmentation of the river segment. The fluctuation range defined by the difference between maximum and minimum daily water levels for the middle river site was 7.09 feet, and was lower than the range (9.06 to 19.35 feet) observed at each of the other 15 river gauge sites.

The time-series plot of middle river water levels was much more similar to that of reservoirs located throughout the state. The range between maximum and minimum monthly mean water levels in the middle Hillsborough River during an evaluation period from January 1985 through May 2008 was 5.03 feet and was less than the median fluctuation range calculated for 14 Florida reservoirs evaluated (6.37 feet) and was also less than the fluctuation range calculated for the 8 reservoirs that are used for water supply purposes (6.02 feet).

Concordance between water level fluctuations in the middle river at the City of Tampa Dam and at fluctuations at twelve area lakes was intermediate between that of the middle river fluctuations and the various river gauge sites and reservoirs within the state Rising and falling water levels, presumably reflecting rainfall patterns, were clearly evident in the lake and middle river hydrographs, although the stability of peak levels in for the middle river which was associated with discharge across the City of Tampa Dam, was not evident in the lake level time-series plots. The range between maximum and minimum monthly mean water levels in the middle Hillsborough River (5.03 feet), was less than the median fluctuation range calculated for the full set of lakes, 6.5 feet, and was also less than the median of 6.05 feet calculated for the lakes when the two lakes that are known to be impacted by water withdrawals excluded.

Similarities in the hydrographs of the middle Hillsborough River, Florida reservoirs and area lakes indicated that it may be appropriate to consider water level fluctuations in the middle river analogous to those occurring in standing water bodies such as lakes.

Chapter 6

Minimum Flows and Levels Criteria and the Middle River

Minimum Flows and Levels Laws and Rules and the Hillsborough River Watershed

State law (Section 373.042, Florida Statutes; hereafter F.S.) directs the Department of Environmental Protection or the water management districts to establish minimum flows and levels for lakes, wetlands, rivers and aquifer systems. As defined by statute, the minimum flow for a given watercourse "shall be the limit at which further withdrawals would be significantly harmful to the water resources or ecology of the area", and the minimum level of an aquifer or surface water body is "the level of groundwater in the aquifer and the level of surface water at which further withdrawals would be significantly harmful to the water resources of the area". Minimum flows and levels are established and used by the Southwest Florida Water Management District for water resource planning, as one of the criteria used for evaluating water use permit applications, and for the design, construction and use of surface water management systems.

Development of a minimum flow or level does not in itself protect a water body from significant harm; however, resource protection, recovery and regulatory compliance can be supported once the flow or level standards are established. State law governing implementation of minimum flows and levels (Section 373.0421, F.S.) requires development of a recovery or prevention strategy for water bodies if the " existing flow or level in a water body is below, or is projected to fall within 20 years below, the applicable minimum flow or level". Recovery or prevention strategies are developed to: "(a) achieve recovery to the established minimum flow or level as soon as practicable; or (b) prevent the existing flow or level from falling below the established minimum flow or level." Periodic re-evaluation and as necessary, revision of established minimum flows and levels are also required by state law.

Minimum flows and levels are to be established based upon the best available information with consideration given to "…changes and structural alterations to watersheds, surface waters and aquifers, and the effects such changes or alterations have had, and the constraints such changes or alterations have placed on the hydrology of the affected watershed, surface water, or aquifer…", with the caveat that these considerations shall not allow significant harm caused by withdrawals (Section 373.0421, F.S.). The Florida Water Resources Implementation Rule (Rule 62-40.473, Florida Administrative Code or F.A.C.) provides additional guidance for the establishment of minimum flows and levels, requiring that "consideration shall be given to the protection of water resources, natural seasonal fluctuations in water flows, and environmental values associated with coastal, estuarine, aquatic and wetland ecology, including: a) recreation in and on the water; b) fish and wildlife habitats and the passage of fish; c) estuarine resources; d) transfer of detrital material; e) maintenance of freshwater storage and supply; f) aesthetic and scenic attributes; g) filtration and absorption of nutrients and other pollutants; h) sediment loads; i) water quality; and j) navigation." The Water Resource Implementation Rule also indicates that "minimum flows and levels should be expressed as multiple flows or levels defining a minimum hydrologic regime, to the extent practical and necessary to establish the limit beyond which further withdrawals would be significantly harmful to the water resources or the ecology of the area".

The Southwest Florida Water Management District has developed specific methodologies for establishing minimum flows or levels for lakes, wetlands, rivers and aquifers, subjected the methodologies to independent, scientific peer-review, and in some cases incorporated the methods into its Water Level and Rates of Flow Rule (Chapter 40D-8, F.A.C). For lakes, Chapter 40D-8, F.A.C. also provides for the establishment of Guidance Levels, which serve as advisory information for the District, lakeshore residents and local governments, or to aid in the management or control of adjustable water level structures.

Initial development of methods for establishing minimum flows and levels for isolated cypress wetlands, lakes, rivers and aquifers, were completed and documented by the District in 1999 (Southwest Florida Water Management District 1999a-f). Since that time additional methods have been developed for establishing minimum flows or levels for wetlands (Hancock 2006), lakes (Ellison 2002, Leeper 2006, Leeper *et al.* 2001), river systems, including springs (Flannery et al. 2007, Kelly et al. 2005a-c, 2007a-b, Southwest Florida Water Management District 2002b, 2004h, 2005a, 2006, 2007, 2008a-b), and aquifer systems (Basso and Hood 2005, Southwest Florida Water Management District 2002a).

Following development of initial approaches to establishing minimum flows and levels in 1999, the District, in conjunction with several interested parties, subjected the proposed methods and minimum flows and levels resulting from their application to a formal peer-review process in accordance with procedures outlined in Section 373.0421(4)(b), F.S. Subsequent to completion of these initial peer-review efforts, which are documented by Bedient *et al.* (1999) and Montagna *et al.* (1999), the District has opted to subject newly developed minimum flows and levels methods to independent scientific peer review on a voluntary basis. Results from these "voluntary" peer-review efforts are presented by Bennett *et al.* (2002), Cichra *et al.* (2005, 2007), Dierberg and Wagner (2001), Gore *et al*. (2002), Montagna et al. (2007, 2008, date not specified), Powell *et al.* (2005, 2008), Shaw *et al.* (2005) and Wagner and Dierberg (2006).

Minimum flows or levels methods have been applied to a number of water bodies in the Hillsborough River watershed. Minimum levels for 21 cypress wetlands and 9 lakes within the watershed have been developed and incorporated into District rules (Figure 6-1). Guidance levels have also been adopted for each of the 9 lakes with adopted minimum levels and for 32 additional lakes in the watershed. Minimum flows have been established for the upper and lower Hillsborough River and for Crystal Springs. The adopted minimum flows include flow requirements at specific sites or segments of the river and springs and are protective of upstream contributing areas of the watershed.

Minimum flows or levels have also been adopted for numerous water bodies adjacent to the Hillsborough River watershed, most notably the Tampa Bypass Canal. Minimum flows and levels established for water bodies in the vicinity of the Hillsborough River watershed are important for resource protection and management of the watershed because the contributing groundwater basin for the Hillsborough River extends beyond the boundary of the surface watershed (Figure 6-2).

The first minimum flow for a flowing water body in the Hillsborough River watershed was established for the lower Hillsborough River in August 2000, following Governing Board approval in February 1999 of a staff recommended a minimum flow of 10 cfs at the base of the City of Tampa Dam as measured at the United States Geological Survey gauging station at the Rowlett Park Drive bridge. Because the minimum flow was based on limited available information, rules containing the minimum flow and a recovery strategy for the lower river stipulated that the District and the City of Tampa would complete a study of the effect of low flows on the river segment and also required re-establishment of the minimum flow, as necessary, based on the results of the study or other appropriate information. Following completion of the study, revised minimum flows for the lower river, Sulphur Springs and the Tampa Bypass Canal were adopted in August 2007. Minimum flows were subsequently adopted for the upper Hillsborough River and Crystal Springs in December 2007. Minimum flows for these water bodies and the lower Hillsborough River are contained in Rules 40D8.041(1), (2), (3), (4) and (9), F.A.C. and are reproduced below.

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- Current Version -

RULES OF THE
SOUTHWEST FLORIDA WATER MANAGEMENT DISTRICT
CHAPTER 40D-8
WATER LEVELS AND RATES OF FLOW

40D-8.041 Minimum Flows.

(1) Minimum Flows for the Lower Hillsborough River.
(a) For the purposes of Minimum Flows, the Lower Hillsborough River is defined as the River downstream of Fletcher Avenue. A tributary of the Lower Hillsborough River is Sulphur Springs, an artesian spring which enters the River via a short spring run at a point 2.2 miles downstream of the City's dam.
(b) The Minimum Flows for the Lower Hillsborough River are based on extending a salinity range less than 5 ppt from the Hillsborough River Dam toward Sulphur Springs. The Minimum Flows for the Lower Hillsborough River are 20 cubic feet per second ("cfs") freshwater equivalent from July 1 through March 31 and 24 cfs fresh water equivalent from April 1 through June 30 at the base of the dam as adjusted based on a proportionate amount that flow at the United States Geological Survey Gauge No. 01203000 near Zephyrhills, Florida ("Gauge") is below 58 cfs. The adjustment is that for each one cfs that Hillsborough River flow at the Gauge is below 58 cfs, when 20 cfs freshwater equivalent is otherwise required, the Minimum Flow is adjusted by reducing it by 0.35 cfs; when 24 cfs freshwater equivalent is otherwise required, the Minimum Flow is adjusted by reducing it by 0.40 cfs. For purposes of this paragraph 40D-8.041(1)(b), F.A.C., freshwater equivalent means water that has a salinity concentration of 0.0 ppt for modeling purposes.

(2) Minimum Flows for the upper Hillsborough River.
(a) The Minimum Flows are to ensure that the minimum hydrologic requirements of the water resources or ecology of the natural systems associated with the river are met.
(b) Minimum Flows for the upper Hillsborough River at the USGS Hillsborough River near Morris Bridge Gauge USGS # 02303330 ("Morris Bridge Gauge") are set forth in Table 8-12 below. The long-term compliance standards set forth in Table 8-13 are established based on the application of the Minimum Flows to the lowest anticipated natural flow conditions. Minimum Flows for the upper Hillsborough River are both seasonal and flow dependent. Two standards are flow based and applied continuously regardless of season. The first is a Minimum Low Flow threshold of 52 cfs at the Morris Bridge Gauge. The second is a Minimum High Flow threshold of 470 cfs at the Morris Bridge Gauge. The Minimum High Flow is based on changes in the number of days of inundation of floodplain features. There are also three seasonally dependent or Block specific Minimum Flows. The Block 1 and Block 2 Minimum Flows are based on potential changes in habitat availability for fish species and macroinvertebrate diversity. The Block 3

Table 8-12 Minimum Flow for Upper Hillsborough River at USGS Hillsborough River near Morris Bridge Gage			
Period	Effective Dates	Where Flow on Previous Day Equals:	Minimum Flow Is
Annually	January 1 to December 31	≤52 cfs >52cfs and <470 cfs ≥470 cfs	52 cfs Seasonally dependent – see Blocks below Previous day flow minus 8%
Block 1	April 20 to June 24	≤52 >52cfs and <470 cfs ≥470 cfs	52 cfs previous day flow minus 10% Previous day flow minus 8%
Block 2	October 28 to April 19	≤52 >52cfs and <470 cfs ≥470 cfs	52 cfs previous day flow minus 11% previous day flow minus 8%
Block 3	June 25 to October 27	≤52 cfs >52 cfs and <470cfs ≥470 cfs	52 cfs previous day flow minus 13% previous day flow minus 8%

(c) Compliance - The Minimum Flows are met when the flows in Table 8-13 are achieved.
Table 8-13 Compliance Standards for the Hillsborough River near Morris Bridge Gauge

Table 8-13 Compliance Standards for the Hillsborough River near Morris Bridge Gage		
Minimum Flow	Hydrologic Statistic	Flow (cfs)
Annual Flow	10-Year Mean 10-Year Median	190 96

Table 8-13 Compliance Standards for the Hillsborough River near Morris Bridge Gage		
Minimum Flow	Hydrologic Statistic	Flow (cfs)
	5-Year Mean 5-Year Median	149 74
Block 1	10-Year Mean 10-Year Median 5-Year Mean 5-Year Median	74 62 57 52
Block 2	10-Year Mean 10-Year Median 5-Year Mean 5-Year Median	153 89 105 72
Block 3	10-Year Mean 10-Year Median 5-Year Mean 5-Year Median	287 150 235 107

(3) Minimum Flow for Sulphur Springs - The Minimum Flow for Sulphur Springs is based on minimization of salinity incursions into the Upper Sulphur Springs Run ("Upper Run") from the Lower Hillsborough River ("LHR") and to moderate temperature levels within the manatee protection zone of the LHR.
(a) As of October 1, 2012, the City of Tampa shall maintain a Minimum Flow for Sulphur Springs of: 1. 18 cfs, as measured at the United States Geological Survey Sulphur Springs Gauge No. 02306000 at Sulphur Springs, Florida, or; 2. 13 cfs when water levels in the Hillsborough River reservoir fall below 19 feet NGVD; and 3. 10 cfs during low tide stages in the LHR, provided that salinity incursions from the LHR into the upper spring run do not occur. Salinity incursions shall be defined as when salinity values in the upper spring run as measured at the United States Geological Survey Gauge Sulphur Springs Run at Sulphur Springs, Florida (#023060003) are greater than 1 ppt than the concurrent salinity value in the spring pool as measured at the United States Geological Survey Gauge Sulphur Springs Run at Sulphur Springs, Florida (#023060000) for a period of greater than 1 hour.
(b) Notwithstanding paragraph 40D-8.041(2)(a), F.A.C., above, and beginning the effective date of this rule, when spring flow is available, a Minimum Flow of 18 cfs shall be required if the temperature of either surface or bottom waters in the LHR near the Spring Run's outlet is below 15º C.
(c) The City of Tampa may propose to the District modifications to the weirs and gates located within the upper and lower spring run that affect the flow rates and salinity levels in the Upper Run and the LHR. The District shall evaluate the modifications to determine whether the flow resulting from the operating capabilities of the modifications and modeling simulations of the resulting salinity incursions into the Upper Spring Run achieve the salinity goal of the Minimum Flow for Sulphur Springs. If the District determines that flows different from the Minimum Flows ("Different Flows") will achieve the salinity goal and otherwise protect the resources of the Upper Spring Run, the District, upon request by the City, will recommend to the Governing Board revision of the Minimum Flow to reflect the Different Flow.

(4) The Minimum Flow for the Tampa Bypass Canal at structure 160 shall be 0 cfs.

(5) through (8) NOT SHOWN

(9) Minimum Flows for Crystal Springs Located Within the Hillsborough River Basin, Hillsborough County, Florida
(a) The Minimum Flows are to ensure that the minimum hydrologic requirements of the water resources or ecology of the natural systems associated with the upper Hillsborough River are met.
(b) The Minimum Flow for Crystal Springs is stated as the flow measured by USGS physical measurements. Flows from Crystal Springs are calculated as the difference between upstream

flow measurements at USGS Gauge No. 02301990 – Hillsborough River Above Crystal Springs near Zephyrhills, FL and downstream flow measurements at USGS Gauge No. 02302010 – Hillsborough River Below Crystal Springs near Zephyrhills, FL measurements and constitute the combined flow of the main spring vent and numerous smaller vents in the river channel. The minimum flow for the Crystal Springs complex is 46 cfs based on a 5-year running mean and median.

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Because several adopted minimum flows and levels in the northern Tampa Bay area are not being met, the District has implemented a regional recovery strategy for restoration of numerous lakes and wetlands, the Floridan Aquifer system and a localized recovery strategy for the lower Hillsborough River. The regulatory portions of the recovery strategies are codified in rule 40D-80.073, F.A.C. in the District's Recovery and Prevention Strategies for Minimum Flows and Levels Rule. For regional recovery of lakes, wetlands and the aquifer, the District's strategy involves requiring reduction of groundwater withdrawals from regional water supply well fields and providing financial support for development of alternative water supplies, *i.e.,* alternatives to groundwater use. The recovery strategy was initiated in 1998 with development of the Northern Tampa Bay New Water Supply and Ground Water Withdrawal Reduction Agreement, commonly known as the Partnership Agreement, between the District and Tampa Bay Water. The agreement provides for disbursement of $183 million in matching funds to the utility and a forty percent reduction in groundwater withdrawals from a then current level of 158 to 90 million gallons per day by the end of December 2007. Development of alternative supplies has involved construction of the C.W. Bill Young Reservoir, the Tampa Bay Regional Surface Water Treatment Plant, the Tampa Bay Seawater Desalination facility and other infrastructure components (Southwest Florida Water Management District 2009). The agreement also stipulates that the District Basin Boards in the northern Tampa Bay area provide up to $90 million in funds for conservation and water reuse projects. District rules pertaining to the Partnership Agreement and recovery of water bodies in the northern Tampa Bay area are included in Appendix A of this report.

The original recovery strategy for the lower Hillsborough River was adopted by the District Governing Board in February 1999 and subsequently incorporated into Rule 40D-80.073(4), F.A.C. The recovery strategy was revised in November 2007 and currently involves potential augmentation of the lower river below the City of Tampa Dam, with water from Sulphur Springs, Blue Sink, Morris Bridge Sink and the Tampa Bypass Canal. Most projects associated with the recovery strategy are expected to be completed by 2013. Funding for these efforts is to be provided by the District and the City of Tampa and is not to exceed $44.5 million. District rules pertaining to the lower Hillsborough River recovery strategy are included in Appendix A.

Collectively, the minimum flows and levels adopted for water bodies in the region, the northern Tampa Bay area and lower Hillsborough River recovery strategies and the District's regulatory program provide a framework for protection of the Hillsborough River watershed.

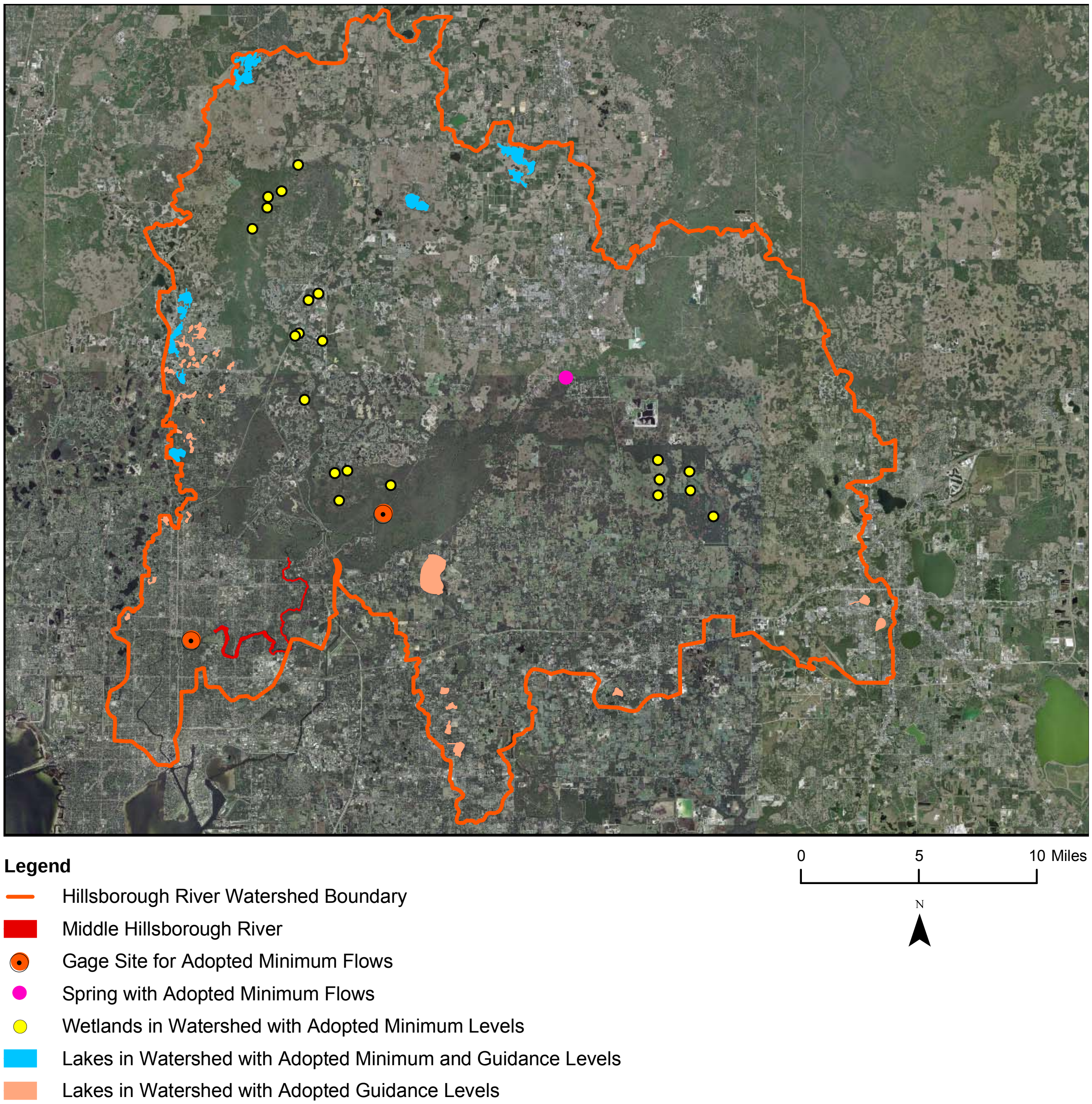

Figure 6-1. Locations of middle Hillsborough River and sites within the Hillsborough River watershed with adopted minimum flows and levels or adopted guidance levels (photographic image source: Fugro EarthData, Inc. 2007).

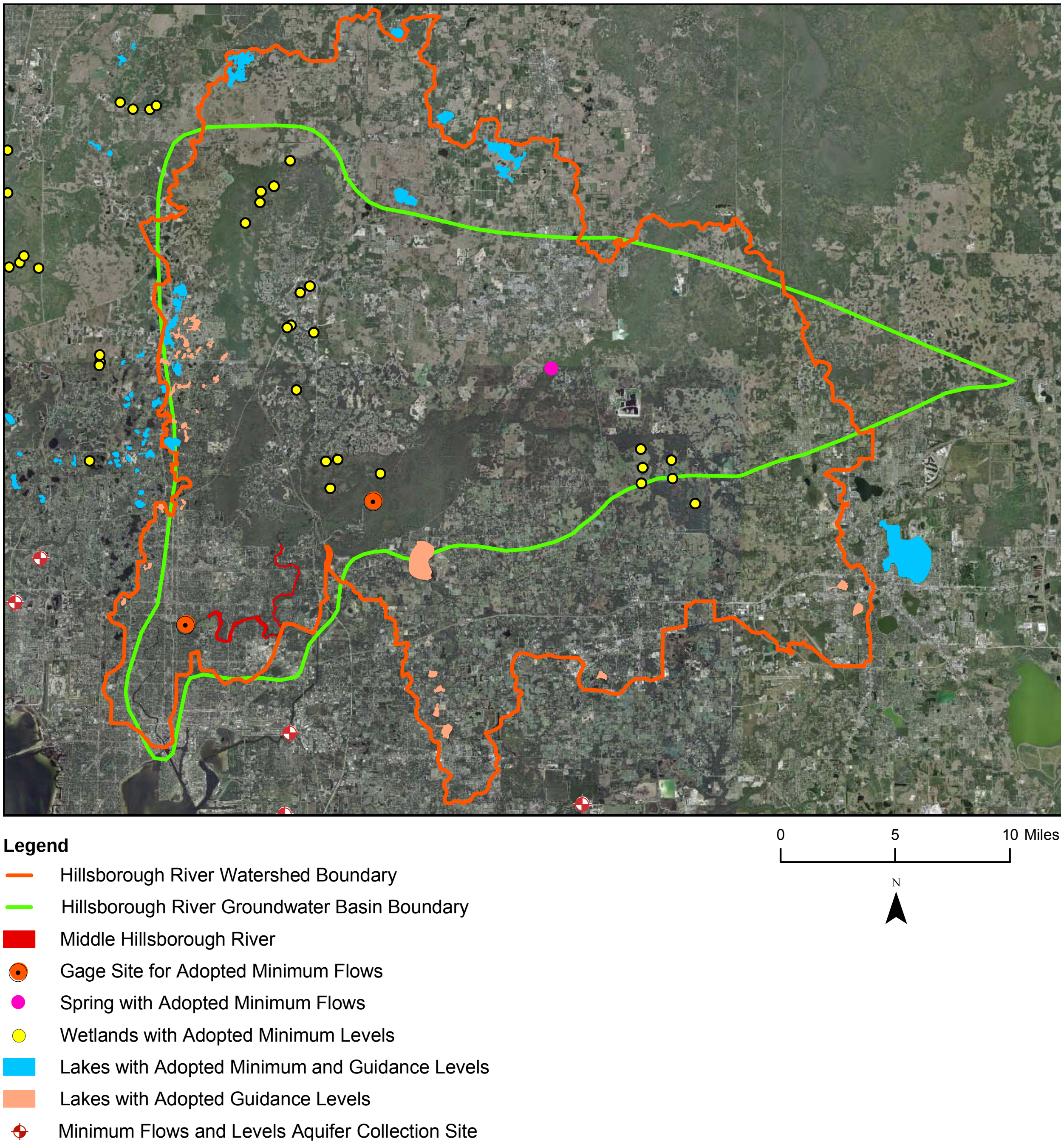

Figure 6-2. Locations of middle Hillsborough River, Hillsborough River watershed and groundwater basin boundaries and sites in the area with adopted minimum flows and levels or adopted guidance levels (photographic image source: Fugro EarthData, Inc. 2007).

Minimum Flows and Levels Laws and Rules and the Middle Hillsborough River

The determination whether minimum flows or levels should be established for the middle Hillsborough River involves consideration of statutory and regulatory rule directives and constraints as well as evaluation of methods that could be used for development of the minimum flows or levels. State laws and District rules relevant to minimum flows and levels and the middle river are highlighted in this sub-section. Suggestions for improving the clarity of specific rules are also presented. The applicability of minimum flows and levels methods for the middle river is discussed in subsequent sections of this chapter.

State law pertaining to establishment of minimum flows and levels includes language related to consideration of structural alterations to systems and exclusion of certain water bodies from the minimum flows and levels establishment process. Language in the law that addresses changes and structural alterations to watersheds and surface waters is considered relevant to the middle Hillsborough River based on the existence of the City of Tampa Dam, the Lower Hillsborough Flood Detention Area, Tampa Bypass Canal, Harney Canal and associated water control structures that may affect the hydrology of the river segment. Language that addresses potential exclusion of water bodies constructed prior to the requirement for a permit also seems applicable to the middle river, given that the current dam on the river was constructed prior to the existence of the District. The section of Chapter 373.0421, F.S. that addresses these issues is reproduced below.

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The 2008 Florida Statutes

Title XXVIII
NATURAL RESOURCES; CONSERVATION, RECLAMATION, AND USE Chapter 373
WATER RESOURCES

373.0421 Establishment and implementation of minimum flows and levels.--

(1) ESTABLISHMENT.--

(a) Considerations.--When establishing minimum flows and levels pursuant to s. 373.042, the department or governing board shall consider changes and structural alterations to watersheds, surface waters, and aquifers and the effects such changes or alterations have had, and the constraints such changes or alterations have placed, on the hydrology of an affected watershed, surface water, or aquifer, provided that nothing in this paragraph shall allow significant harm as provided by s. 373.042(1) caused by withdrawals.

(b) Exclusions.--

1. The Legislature recognizes that certain water bodies no longer serve their historical hydrologic functions. The Legislature also recognizes that recovery of these water bodies to historical hydrologic conditions may not be economically or technically feasible, and that such recovery effort could cause adverse environmental or hydrologic impacts. Accordingly, the department or governing board may determine that setting a minimum flow or level for such a water body based on its historical condition is not appropriate.

2. The department or the governing board is not required to establish minimum flows or levels pursuant to s. 373.042 for surface water bodies less than 25 acres in area, unless the water body or bodies, individually or cumulatively, have significant economic, environmental, or hydrologic value.

3. The department or the governing board shall not set minimum flows or levels pursuant to s. 373.042 for surface water bodies constructed prior to the requirement for a permit, or pursuant to an exemption, a permit, or a reclamation plan which regulates the size, depth, or function of the surface water body under the provisions of this chapter, chapter 378, or chapter 403, unless the constructed surface water body is of significant hydrologic value or is an essential element of the water resources of the area.

The exclusions of this paragraph shall not apply to the Everglades Protection Area, as defined in s. 373.4592(2)(i).

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State law addressing the establishment of minimum flows and levels also requires the District to develop and annually update a priority list and schedule for the establishment of minimum flows and levels. The priority list and schedule is based on the importance of the waters to the state or region and the existence of or potential for significant harm to the water resources or ecology of the state or region. The priority list is required to include waters that are currently or may reasonably be expected to experience adverse impacts associated with consumptive water use. The section of Chapter 373.042, F.S. that addresses the priority list and schedule is reproduced below; sections omitted are denoted as “NOT SHOWN”.

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The 2008 Florida Statutes

Title XXVIII
NATURAL RESOURCES; CONSERVATION, RECLAMATION, AND USE Chapter 373
WATER RESOURCES

373.042 Minimum flows and levels.--

(1) NOT SHOWN

(2) By November 15, 1997, and annually thereafter, each water management district shall submit to the department for review and approval a priority list and schedule for the establishment of minimum flows and levels for surface watercourses, aquifers, and surface waters within the district. The priority list shall also identify those water bodies for which the district will voluntarily undertake independent scientific peer review. By March 1, 2006, and annually thereafter, each water management district shall include its approved priority list and schedule in the consolidated annual report required by s. 373.036(7). The priority list shall be based upon the importance of the waters to the state or region and the existence of or potential for significant harm to the water resources or ecology of the state or region, and shall include those waters which are experiencing or may reasonably be expected to experience adverse impacts. Each water management district's priority list and schedule shall include all first magnitude springs, and all second magnitude springs within state or federally owned lands purchased for conservation purposes. The specific schedule for establishment of spring minimum flows and levels shall be commensurate with the existing or potential threat to spring flow from consumptive uses. Springs within the Suwannee River Water Management District, or second magnitude springs in other areas of the state, need not be included on the priority list if the water management district submits a report to the Department of Environmental Protection demonstrating that adverse

impacts are not now occurring nor are reasonably expected to occur from consumptive uses during the next 20 years. The priority list and schedule shall not be subject to any proceeding pursuant to chapter 120. Except as provided in subsection (3), the development of a priority list and compliance with the schedule for the establishment of minimum flows and levels pursuant to this subsection shall satisfy the requirements of subsection (1).

(3) through (5) NOT SHOWN

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The District has not included the middle Hillsborough River on the current or previous versions of the minimum flows and levels priority list and schedule. Omission of the middle river from the list and schedule has been based on consideration of the river segment as a water body constructed prior to the requirement for a permit and judgment that the system is not expected to experience adverse impacts or significant harm associated with water withdrawals. In addition, the District's Water Levels and Rates of Flow Rules stipulate that guidance levels shall not be developed for the "City of Tampa Reservoir on the Hillsborough River in Hillsborough County" and other regional water supply impoundments (Rule 40D-8.031(2), F.A.C.). Current rules that include the definition of guidance levels and reference to establishment of minimum flows and levels for water supply impoundments are reproduced below; rule sections that were omitted are denoted as "NOT SHOWN".

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- Current Version -

Rules of the Southwest Florida Water Management District
Chapter 40D-8
Water Levels and Rates of Flow

40D-8.021 Definitions.

The terms set forth herein shall have the meanings ascribed to them unless the context clearly indicates otherwise, and such meanings shall apply throughout these rules. The terms defined in Rule 40D-1.102, F.A.C., shall also apply throughout Chapter 40D-8, F.A.C., and the terms defined in this 40D-8.021, F.A.C., apply throughout the District rules except that where there is a conflict or a difference between 40D-1.102, F.A.C., and this 40D-8.021, F.A.C., the definition in this Chapter 40D-8, F.A.C., will control.

(1) and (2) NOT SHOWN

(3) "Guidance Levels" means Levels, determined by the District using the best available information and expressed in feet relative to the National Geodetic Vertical Datum (of 1929), or in feet relative to the National Vertical Datum (of 1988) used as advisory information for the District, lake shore residents, and local governments, or to aid in the management of control of adjustable structures.

(4) through (17) NOT SHOWN

40D-8.031 Implementation.

(1) No Guidance Levels shall be prescribed for any reservoir or other artificial structure which is

located entirely within lands owned, leased, or otherwise controlled by the user, and which require water only for filling, replenishing, and maintaining of the water level thereof, provided however:
(a) That Chapter 40D-2, F.A.C., shall apply to the use of water for such filling, replenishing, and maintaining of the water level and
(b) That the High Guidance Level, determined pursuant to the procedures set forth in Rule 40D-8.624, F.A.C., may be established for any lake determined by the Board to be in the public interest.

(2) No Guidance Levels shall be prescribed for Lake Manatee in Manatee County, Evers Reservoir in Manatee County, the City of Tampa Reservoir on the Hillsborough River in Hillsborough County, and the Peace River/Manasota Regional Water Supply Authority Reservoir in DeSoto County.

(3) through (5) NOT SHOWN

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Since 1978, the District's Rule Chapter on Water Levels and Rates of Flow (formerly 16J-8, F.A.C.) has stipulated that no "management" levels shall be prescribed for the "City of Tampa Reservoir on the Hillsborough River in Hillsborough County." Minimum water levels to be set for surface waters could potentially include minimum levels referred to as low management levels and extreme low management levels. The rules used minimum levels and management levels interchangeably. In 2000, the District's Rule Chapter on Water Levels and Rates of Flow (now 40D-8, F.A.C.) included a renaming of lake levels so that management levels are sometimes now referred to as Guidance Levels, but the prohibition against setting levels for the City of Tampa Reservoir on the Hillsborough River in Hillsborough County continues to exist. Relevant excerpts from a 1978 version of the rule are reproduced below.

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- 1978 Version -

Rules of the Southwest Florida Water Management District
Chapter 16J-8
Water Levels and Rates of Flow

16J-8.02 Definitions.

The terms set forth herein shall have the meanings ascribed to them unless the context clearly indicates otherwise, and such meanings shall apply throughout these rules. To facilitate easier reference, certain terms defined by applicable statute have been included verbatim with appropriate citation. The terms defined in Rule 16J-0.02 shall also apply throughout Part 8.

(1) "Management range" means the difference between the established minimum water levels and minimum flood levels, and represents the capability of a impoundment to receive, carry, or store water, to preserve non-consumptive uses of a surface water body, and within this range the District applies and requires best surface water management practices.

(2) "Minimum water level" means the level of surface water at which further withdrawals would be significantly harmful to the water resources of the area. Such level shall be expressed as an elevation, in feet above sea level, and may incorporate a low management level and an extreme low management level, which together establish lower limits of the management range, to which a water body shall be allowed to fluctuate naturally.

(3) through (5) NOT SHOWN

16J-8.03 Implementation.
(1) and (2) NOT SHOWN

(3) No management levels shall be prescribed for Lake Manatee in Manatee County, Ward Lake in Manatee County, the City of Tampa Reservoir on the Hillsborough River in Hillsborough County, and the General Development Utilities Reservoir constructed in connection with the Southwest Florida Water Management District's Permit Numbers 7500016, 74-172, and 75-290 in DeSoto County.

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In accordance with current and previous District rules and the sections of the Florida Statutes that address establishment and implementation of minimum flows and levels, the District has not pursued adoption of minimum flows and levels for the middle Hillsborough River. This management decision was and is based on: 1) the stipulation in previous versions of District rules that management levels were not to be developed for the middle river and other impoundments used for water supply purposes; 2) the stipulation in current District rules that guidance levels are not to be developed for the middle river and other impoundments used for water supply purposes; 3) consideration of the river segment as a water body constructed prior to the requirement for a permit; and 4) judgment that the system is not expected to experience adverse impacts or significant harm associated with water withdrawals.

Current District rules include a definition of the lower Hillsborough River that is relevant to evaluation of the middle river, and also include monitoring requirements for the middle river. Rule 40D-8.041(1)(a), F.A.C., defines the lower Hillsborough River as the river downstream from Fletcher Avenue. This is in contrast with the definitions utilized for this report, with the lower river defined as the Hillsborough River downstream from the City of Tampa Dam, the middle Hillsborough River defined as the river segment between the dam and Fletcher Avenue and the upper Hillsborough River defined as the river upstream from Fletcher Avenue. Rule 40D-80.073(4)(h), F.A.C., requires the District to monitor and evaluate the effect of the lower Hillsborough River recovery strategy on water levels in the river upstream from the City of Tampa Dam to at least Fletcher Avenue. The rule also requires that the District evaluate all recovery projects for the river relative to their potential to cause unacceptable adverse impacts. Rule excerpts associated with the provisions described in this paragraph are shown below.

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- Current Version -

Rules of the Southwest Florida Water Management District
Chapter 40D-8
Water Levels and Rates of Flow

40D-8.041 Minimum Flows.

(1) Minimum Flows for the Lower Hillsborough River.

(a) For the purposes of Minimum Flows, the Lower Hillsborough River is defined as the River downstream of Fletcher Avenue. A tributary of the Lower Hillsborough River is Sulphur Springs, an artesian spring which enters the River via a short spring run at a point 2.2 miles downstream of the City's dam.
(b) NOT SHOWN

(2) through (10) NOT SHOWN

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- Current Version -

Rules of the Southwest Florida Water Management District
Chapter 40D-80
Recovery and Prevention Strategies for Minimum Flow and Levels

40D-80.073 Regulatory Portion of Recovery Strategy For Pasco, Northern Hillsborough and Pinellas Counties.

(1) through (3) NOT SHOWN

(4) Hillsborough River Strategy.
(a) through (g) NOT SHOWN

(h) In 2013, and for each five year period through 2023, the District shall evaluate the hydrology, dissolved oxygen, salinity, temperature, pH and biologic results achieved from implementation of the recovery strategy for the prior five years, including the duration, frequency and impacts of the adjusted minimum flow as described in 40D-8.041(1)(b), F.A.C. As part of the evaluation the District will assess the recording systems used to monitor these parameters. The District shall also monitor and evaluate the effect the Recovery Strategy is having on water levels in the Hillsborough River above the City's dam to at least Fletcher Avenue. The District will evaluate all projects described in this Recovery Strategy relative to their potential to cause unacceptable adverse impacts prior to their implementation.

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Review of District rules that may be relevant to the middle Hillsborough River led to identification of a few potential rule changes that could be implemented to improve clarity and therefore improve regulatory activities associated with the rules. First, it would be useful to clarify District intent regarding establishment of minimum flows and levels for the middle river and other impoundments used for water supply purposes. To accomplish this goal, Rule 40D-8.031(2), F.A.C., which currently indicates that no guidance levels be established for several water bodies, including the City of Tampa Reservoir, could be amended to indicate that no minimum flows, minimum levels or guidance levels should be established for the middle river and the other impoundments identified in the rule. Also to more clearly identify the middle Hillsborough River, the reference in the rule to the “City of Tampa Reservoir on the Hillsborough River in Hillsborough County” could be changed to the “City of Tampa Reservoir on the Middle Hillsborough River”. Another potential rule change concerning the middle river would involve revision of the definition of the lower Hillsborough River included in Rule 40D-80.041(1)(a), F.A.C. The segment is currently defined in the rule as the river downstream of Fletcher Avenue. This reference could be changed to indicate that the lower Hillsborough River is the river segment downstream from the dam on the City of Tampa's Reservoir.

Although unrelated to the middle river, it may also be appropriate to amend District rules to include Shell Creek Reservoir in Charlotte County among the impoundments for which minimum flows, minimum levels and guidance levels are not to be developed. This action would require inclusion of the Shell Creek Reservoir in Rule 40D-8.031(2), F.A.C. Also unrelated to the middle river, but potentially useful for regulatory activities, would be an amendment to Rule 40D-8.031(1) to indicate that no minimum flows, minimum levels or guidance levels be established for reservoirs or other artificial structures located entirely on lands owned, leased, or otherwise controlled by a user.

Applicability of Minimum Flows Methods for the Middle River

As noted in the first sub-section of this chapter, minimum flows have been established for the upper and lower segments of the Hillsborough River, Crystal Springs and the Tampa Bypass Canal. The adopted minimum flows include flow requirements at specific sites or segments of the river and springs and are protective of upstream contributing areas of the watershed. These minimum flows, in conjunction with the minimum levels established for wetlands, lakes and aquifer systems within or in the vicinity of the Hillsborough River watershed afford protection to the middle river. Nonetheless, the application of District methods for establishing minimum flows for freshwater river or stream segments was examined in support of the study of middle river water level fluctuations.

District methods for establishing minimum flows for freshwater river segments involves development of a historic or natural flow regime that reflects flows that would be expected in the absence of water withdrawals or augmentation. This flow record is usually associated with a long term gauge site or station and a hydraulic model is then used to determine flows or water levels at relevant sites throughout the river segment. These relevant sites include shoal areas that are potential barriers to flow, movement of biota up and down the river corridor and navigations during periods of low river flow. Floodplain inundate at selected sites is also examined using the hydraulic model. Finally representative reaches of the river segment are evaluated for potential change in available habitat based on a second hydraulic model and water depth, substrate and flow requirements of key aquatic species. This information is used to identify a low flow threshold which identifies flows that are to be protected in their entirety, *i.e.,* flows that are not available for consumptive-use and to develop seasonal flow prescriptions that identify the quantities of water that may be withdrawn from the river as a percentage of the daily flow.

Development of minimum flows is clearly contingent upon identification of the flow requirements necessary for the functioning of critical chemical, physical and biological processes and systems, and evaluation of these flow requirements at critical and representative sites. Because water levels and flows in the middle river are strongly influenced by the backwater effect of the City of Tamp Dam, application of flow-based methods for determining minimum flows is not practical. However, a theoretical exercise, involving consideration of the low flow threshold concept, was undertaken to support evaluation of middle river water level fluctuations. Consideration of a low flow threshold for the river segment involved evaluation of the wetted perimeter and a water depth requirement for fish passage as applied to shoal areas identified as hydraulic controls for the middle river and the river segment between Fletcher Avenue and District Structure S-155.

The “wetted perimeter” is defined as the distance along the stream or river bed and banks at a cross section where there is contact with water. This interface between the river bed and the water column represents potential available habitat for aquatic organisms and is therefore a useful metric for evaluating potential effects of changes in flows. As flow through a cross-section increases from theoretical or actual no-flow conditions, the wetted perimeter increases also. By plotting the response or extent of wetted perimeter to incremental changes in flow, an inflection can be identified in the resulting curve where small decreases in flow result in increasingly greater decreases in wetted perimeter. This point on the curve represents a flow at which the water surface recedes from stream banks and fish habitat is lost at an accelerated rate. Flows associated with these points are identified for all shoal cross-sections in a river segment and the lowest of the flows is considered for establishment of the low flow threshold.

Identification of flows sufficient for the passage or movement of fishes across shoal areas is also considered for development of the low flow threshold. Maintenance of these flows is expected to ensure continuous flow within the channel or river segment, allow for recreational navigation (e.g., canoeing), improve aesthetics, and avoid or lessen potential negative effects, such as high water temperatures, low dissolved oxygen concentrations, localized phytoplankton blooms, and increased predatory pressure associated with lack of longitudinal connectivity in the river channel.
To secure the benefits associated with longitudinal river connectivity, flows required to ensure a minimum water depth of 0.6 feet at the lowest spot of shoal cross-sections are identified. The lowest flow meeting this requirement is then considered for the establishment of the low flow threshold.

Following identification of low flows associated with application of the wetted perimeter technique and evaluation of flows necessary for fish passage, the low flow threshold is established at the higher of the two low-flow criteria, provided that comparison of that criterion with historic flow records indicates that the criterion is reasonable. Unfortunately, identification of low-flow wetted perimeter inflection points and fish passage depths at shoal sites is contingent upon the existence of a known relationship between flow and water level at the shoal site and the ability, typically achieved through development of a hydraulic model, to transfer the site-specific flow or water level requirements to a long-term gauge site. Development of a robust relationship between flow and water levels in the middle river is unfortunately not practical.

Although application of the low flow threshold is not tenable for the middle river, it is possible to evaluate the fish-passage depth requirement in relation to water levels in the river segment. Adding 0.6 feet to the hydraulic control elevation of 17.87 feet above NGVD29 identified for the middle river at the cross-section upstream from Fowler Avenue (see Figures 2-16 and 2-17) would yield an elevation of 18.47 feet above NGDV29. Based on daily water level records for the United States Geological Survey gauge at the City of Tampa Dam, this elevation was exceeded 96% of the time from January 1, 1985 through December 31, 2008 and 95% of the time base on the full period of record for the gauge site. Assuming that water levels at the cross-section site may be higher than at the dam during high-flow periods, these percentages likely underestimate the amount of time that the water depth at the site is at least 0.6 feet deep. A similar analysis for the hydraulic control elevation of 19.71 feet above NGVD29, at a cross-section upstream from the middle river, between Lettuce Lake and District Structure S-155, also indicates that water levels in the middle river (based on daily records at the dam) exceeded the fish-passage elevation associated with the site 90% of the time for 1985 through 2008 and 83% of the time for the period of record.

Applicability of Minimum Lake Levels Methods for the Middle River

As described in Chapter 5, water level fluctuations in the middle Hillsborough River are more analogous to the hydrologic regimes of Florida reservoirs and lakes than the regimes evident for rivers of the state. It may, therefore, be useful to consider methods used for establishing minimum lake levels as an additional means for evaluating water level fluctuations in the middle river.

The District has developed minimum level methods that are used to prevent significant harm to lakes (see Southwest Florida Water Management District 199a, b, Leeper et al. 2001, Hancock 2006, Leeper 2006 and Section 40D-8.624, F.A.C.) and subjected the methodologies to independent scientific review (Bedient *et al.*1999, Dierberg and Wagner 2001, Wagner and Dierberg 2006). Two minimum levels are typically developed and include the Minimum Lake Level and the High Minimum Lake Level. The Minimum Lake Level is the elevation that a lake's water levels are required to equal or exceed fifty percent of the time on a long-term basis. The High Minimum Lake Level is the elevation that a lake's water levels are required to equal or exceed ten percent of the time on a long-term basis. Guidance Levels, including the High Guidance Level and Low Guidance Level, are also developed through application of minimum levels methodologies. The High Guidance Level and Low Guidance Level are developed to identify water levels that would be equaled or exceed ten and ninety percent of the time on a long-term basis, in the absence of water withdrawals. This pre-withdrawals condition is referred to as the “historic” condition when evaluating water level fluctuations with respect to minimum levels development. Guidance levels are developed as advisory information for the District, lakeshore residents and local governments, or to aid in the management or control of adjustable water level structures.

Minimum levels development is contingent upon lake classification*, i.e.,* whether a lake is classified as a Category 1, 2 or 3 lake. Lakes with fringing cypress wetlands greater than 0.5 acres in size where water levels regularly rise to an elevation expected to fully maintain the integrity of the wetlands, *i.e.,* the Historic P50 or median long-term water level in the absence of water withdrawals, is not more than 1.8 feet below a reference elevation termed the Normal Pool elevation, are classified as Category 1 Lakes. Lakes with fringing cypress wetlands greater than 0.5 acres in size that have been structurally altered such that the Historic P50 is more than 1.8 feet below the Normal Pool elevation are classified as Category 2 Lakes. Lakes without fringing cypress wetlands or with less than 0.5 acres of fringing cypress wetlands are classified as Category 3 Lakes. Based on the abundance of lake-fringing cypress wetlands of 0.5 acre or more in size in or adjacent to the middle Hillsborough River (see Figure 6-3), minimum level methods for Category 1 or 2 Lakes were considered to be more appropriate for consideration as compared to methods used for Category 3 Lakes.

Final determination of which lake category methods to use for evaluation of the middle river was contingent upon classification of available lake stage data as "Historic" or "Current" and development of a Historic P50 elevation. For the purpose of minimum levels determination, lake stage data may be categorized as "Historic" for periods when there were no measurable impacts due to water withdrawals, and impacts due to structural alterations were similar to existing conditions. Lake stage data may alternatively be categorized as "Current" for periods when there were measurable, stable impacts due to water withdrawals, and impacts due to structural alterations were stable. In the context of minimum levels development, "structural alterations" means man's physical alteration of the control point, or highest stable point along the outlet conveyance system of a lake, to the degree that water level fluctuations are affected.

Water level records available for the middle Hillsborough River do not strictly adhere to the classification scheme for either "historic" or "current" data. Withdrawal impacts have occurred throughout the period or record for available data and structural alterations, including modifications to the City of Tampa dam and construction of the Lower Hillsborough Flood Detention Area, Tampa Bypass Canal, Harney Canal and associated structures represent significant structural alterations that have exerted influence on middle river water levels. Effects of changes in dam operation and augmentation of the river with water from Sulphur Springs and the Tampa Bypass Canal have also varied temporally and confound classification of available river water level records as "Historic" or "Current" data.

Notwithstanding these confounding factors, for the purpose of evaluating middle river water level fluctuations through application of current District minimum level methods, available mean daily water level records for the United States Geological Survey Hillsborough River near Tampa, FL gauge site from January 1, 1985 forward were classified as "Current" data. As was the case for the previous hydrologic analyses described in Chapter 5, water level records collected after 1984 were considered representative of current conditions since augmentation of the river segment with water from both Sulphur Springs and the Tampa Bypass Canal was initiated in 1985. Monthly mean water surface elevations were calculated from daily mean values collected from January 1, 1985 through December 31, 2008 and used to determine Current P10, P50 and P90 elevations. The Current P10 elevation, *i.e.,* the elevation the lake water surface equaled or exceeded ten percent of the time during the current period, was 22.57 feet above NGVD29. The Current P50 and Current P90, elevations that the water surface equaled or exceeded fifty and ninety percent of the time during the current period, were respectively, 22.17 and 19.94 feet above NGVD29.

Identification of a Normal Pool elevation was the next step in the minimum levels evaluation for the middle river. The Normal Pool elevation, a reference elevation used for development of minimum lake and wetland levels, is established using elevations of Hydrologic Indicators of sustained inundation, including biological and physical features. The buttress inflection point of cypress trees (Figure 6-4) are routinely used by District staff for establishing the Normal Pool elevation (Carr *et al.* 2006). Based on the median of 20 cypress buttress inflection point elevations measured in the river segment in May 2008, the Normal Pool for the middle Hillsborough River was established at 22.7 feet above NGVD29. Summary information for the Normal Pool indicator measurements is provided in Table 6-1.

Using current District rules as a guideline, a provisional High Guidance Level was established for the middle river. The level is established at the control point, Historic P10, the Current P10, or the Normal Pool elevation. The control point elevation is the elevation of the highest stable point along the outlet profile of a surface water conveyance system (*e.g.,* a weir, canal or culvert) that is the principal control of water level fluctuations in the lake. A control point may be established at the invert or crest elevation associated with a water control structure at a lake outlet, or at a high, stable point in a lake-outlet canal, ditch or wetland area. An invert or crest elevation is the lowest point on the portion of a water-control structure that provides for conveyance of water across or through the structure. For operable structures, the invert elevation represents the lowest elevation at which flow may occur past the structure, and the crest elevation corresponds to the highest elevation that must be exceeded for flow to occur. The control point associated with an operable structure may, therefore, range from the invert elevation to the crest elevation. For the middle river, the control point was set at 22.5 feet above NGVD29, the crest elevation for City of Tampa Dam. Because only Current data were available and the control point is lower than the Normal Pool elevation, the Current P10 elevation, 22.6 feet above NGVD29 was used to establish the provisional High Guidance Level.

The Historic P50 elevation is the elevation that the lake surface is expected to equal or exceed fifty percent of the time on a long-term basis. The level is derived to support development of minimum lake levels, and is established using Historic or Current data and, in some cases, reference lake water regime statistics. Reference lake water regime statistics are necessary when adequate Historic or Current data are not available. Reference lake water regime statistics represent differences between P10, P50 and P90 elevations for typical, regional lakes that exhibit little or no impacts associated with water withdrawals (*i.e.*, reference lakes). The statistics include the RLWR50, RLWR90 and RLWR5090, which are, respectively, median differences between P10 and P50, P50 and P90, and P10 and P90 percentiles for the set of reference lakes. For the northern Tampa Bay area, RLWR50, RLWR90 and

RLWR5090 statistics have been established at 1.0, 2.1 and 1.1 feet, respectively (Southwest Florida Water Management District 1999, Leeper *et al.* 2001). These statistics were discussed previously in this report, in the section of Chapter 5 addressing middle river water level fluctuations relative to area lake water level fluctuations.

Because Historic data are not available for the middle river, and the difference between the Current P10 and Current P50 (0.4 feet) is less than the northern Tampa Bay area RLWR50 (1.0 feet), a provisional Historic P50 was established at 22.2 feet above NGVD29 by subtracting the Current P10 to Current P50 difference from the High Guidance Level (22.6 feet above NGVD29).

The Low Guidance Level is provided as an advisory guideline for water dependent structures, information for lakeshore residents and operation of water management structures. The Low Guidance Level is the elevation that a lake's water levels are expected to equal or exceed ninety percent of the time on a long-term basis, and is established using Historic or Current data and, in some cases, reference lake water regime statistics. Because Historic data are not available for the middle river and the difference between the Current P10 and Current P90 (2.6 feet) exceeds the northern Tampa Bay RLWR90 (2.1 feet), a provisional Low Guidance Level was established at 20.5 feet above NGVD29 by subtracting the RLWR90 from the High Guidance Level.

Based on the occurrence of lake-fringing cypress wetlands of 0.5 acre or more in size within the middle river basin, and given that the Historic P50 (22.2 feet above NGVD29) is less than 1.8 feet below the Normal Pool elevation, it was determined that the minimum level methods used for Category 1 Lakes would be most appropriate for evaluation of water level fluctuations in the river. For this lake category, the Minimum Level is established at an elevation 1.8 feet below the Normal Pool elevation. Application of this approach for the middle Hillsborough River would yield a provisional Minimum Lake Level of 20.9 feet above NGVD29. For Category 1 lakes, the High Minimum Lake Level is established at 0.4 feet below the Normal Pool elevation. Application of this approach would yield a provisional High Minimum Lake Level of 22.3 feet above NGVD29 for the middle river.

Comparison of the provisional minimum levels with long-term stage exceedance percentiles indicated that water level fluctuations within the middle river in recent years would have been in compliance with the minimum levels. For the period from January 1985 through December 2008, the median water level in the river was 22.2 feet above NGVD29, an elevation 1.3 feet higher than the provisional Minimum Lake Level. Similarly, the water level equaled or exceeded ten percent of the time from 1985 through 2008, was 22.6 feet above NGVD29, an elevation 0.3 feet higher than the provisional High Minimum Lake Level.

Review of exceedance percentiles calculated for the shorter periods typically used for annual evaluation of minimum lake levels also indicated that water level fluctuations within the middle river since 1985 would have been in compliance with the provisional minimum levels. Water levels exceeded ten (P10) and fifty (P50) percent of the time for the moving six-year periods from 1985 through 2008 (*e.g.,* 1985 through 1990, 1986 through 1991, …….., 2003 through 2008) respectively exceeded the provisional High Minimum Lake Level and Minimum Lake Level (Figure 6-5). Percentiles for moving ten-year periods similarly exceeded the provisional minimum levels (Figure 6-6).

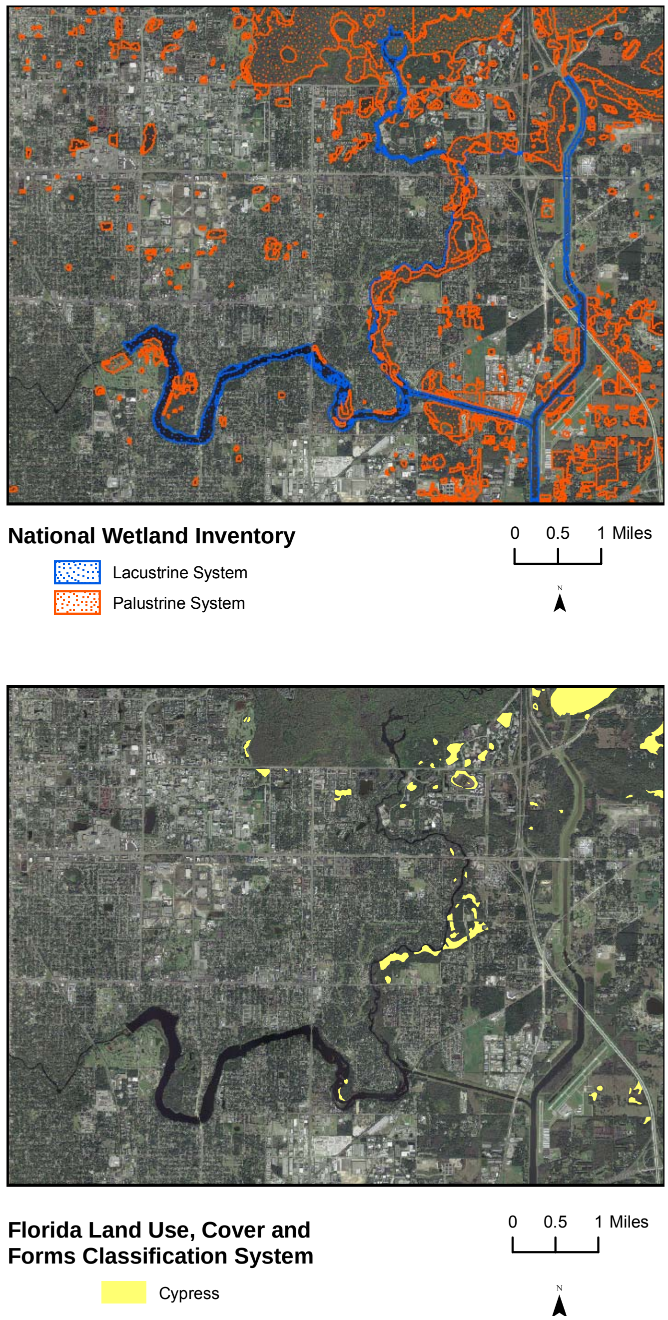


Figure 6-3. Lacustrine and palustrine systems in the vicinity of the middle Hillsborough River based on National Wetland Inventory information (upper panel, Southwest Florida Water Management District 2003h) and wetland areas classified as Cypress based on 2006 Florida Land Use, Cover and Forms Classification System Classification data (Lower panel, Southwest Florida Water Management District 2007a) and (photographic image source for both panels: Woolpert, Inc. 2007). Lacustrine areas include wetlands and deepwater habitat; palustrine areas include only wetlands (Cowardin *et al.* 1979).

Figure 6-4. Cypress tree on the shore of the middle Hillsborough River showing an example of a buttress inflection point used for determination of the Normal Pool elevation for the river segment.

Table 6-1. Summary statistics for hydrologic indicator measurements (elevations of the buttress inflection points of cypress trees) used for establishing the Normal Pool Elevation for the middle Hillsborough River. Elevations were measured by District staff in May 2008.

Statistic	Statistic Value (N) or Elevation (feet above NGVD29)
N	20
Median	22.7
Mean (SD)	22.6 (0.20)
Minimum	22.1
Maximum	22.8

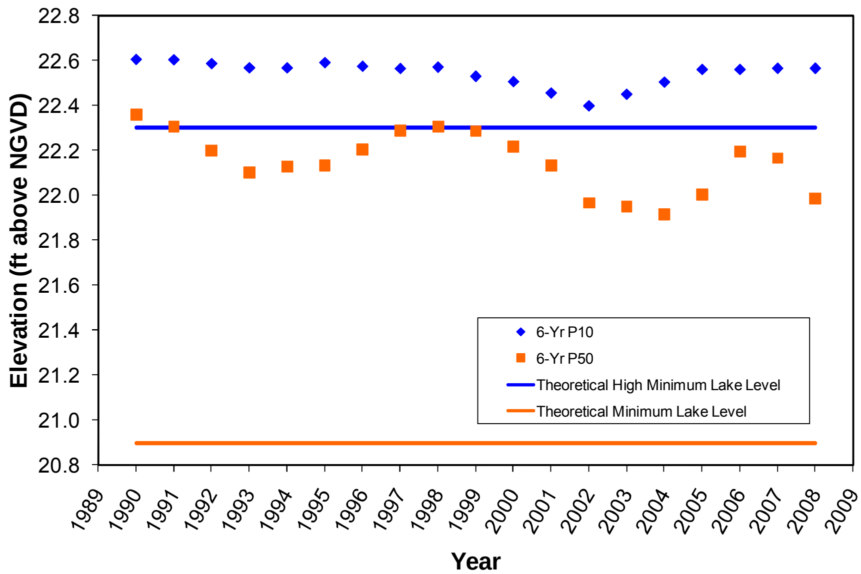


Figure 6-5. Water surface elevations equaled or exceeded ten (P10) and fifty (P50) percent of the time for six-year periods ending in 1990, 1991 …… 2008, and provisional High Minimum Lake Level and Minimum Lake Level developed for the middle Hillsborough River.

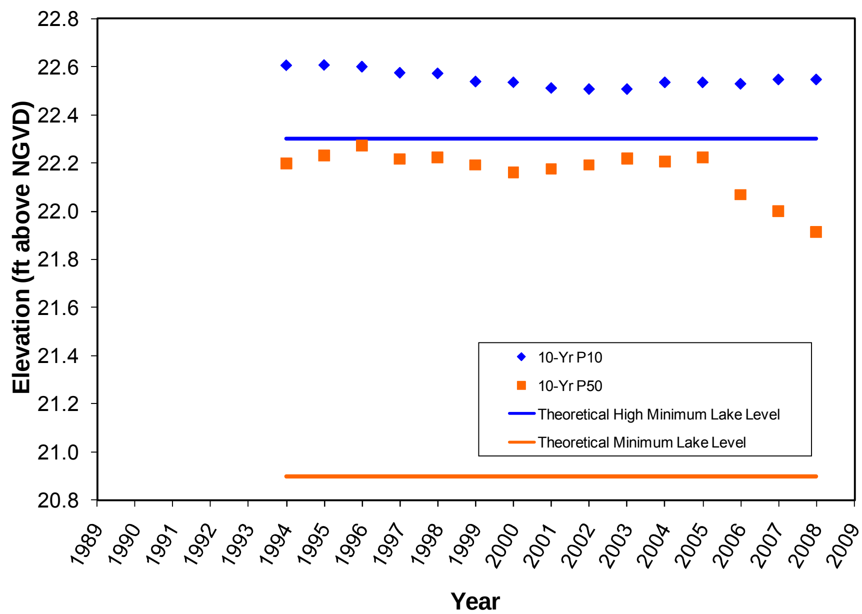


Figure 6-6. Water surface elevations equaled or exceeded ten (P10) and fifty (P50) percent of the time for ten-year periods ending in 1994, 1995 …… 2008, and provisional High Minimum Lake Level and Minimum Lake Level developed for the middle Hillsborough River.

Other Considerations for Minimum Lake Levels Relevant to the Middle River

Minimum lake levels for lakes with fringing cypress wetlands are developed based on the significant change standard, 1.8 feet below the Normal Pool elevation, which is used to identify levels that prevent significant harm to the cypress wetlands. Application of this standard for consideration of provisional minimum levels was described in the previous sub-section of this Chapter.

Other information or unique factors may also be evaluated when establishing minimum lake levels, including: potential changes in the coverage of herbaceous wetland vegetation and aquatic macrophytes; elevations associated with residential dwellings, roads or other structures; frequent submergence of dock platforms; faunal surveys; aerial photographs; typical uses of lakes (*e.g.,* recreation, aesthetics, navigation, irrigation); surrounding land-uses; socio-economic effects; and public health, safety and welfare matters. Significant change standards addressing most of these factors have been included in District rules for establishing minimum levels for lakes that lack fringing cypress wetlands. For the purpose of developing minimum lake levels, these lakes are referred to as Category 3 Lakes.

Six significant change standards, including a Species Richness Standard, a Lake Mixing Standard, a Basin Connectivity Standard, an Aesthetics Standard, a Recreation/Ski Standard and a Dock-Use Standard are developed for Category 3 Lakes. These standards identify desired median lake stages that if achieved, are intended to preserve various natural system and human-use lake values. Although the middle Hillsborough River is best classified as a Category 1 Lake, in terms of the applicability of minimum lake level methods due to the abundance of cypress in the basin, provisional Category 3 Lake standards were evaluated for the river segment for comparative purposes. These standards were not, however, used to develop provisional minimum levels.

Species Richness Standard

The Species Richness Standard is developed to prevent a decline in the number of bird species that may be expected to occur at or utilize a lake for any of the suite of activities that comprise a bird's behavioral repertoire. Based on an empirical relationship between lake surface area and the number of birds expected to occur at a lake developed from data reported by Hoyer and Canfield (1994) and confirmed by a recently completed District-funded study (Emery *et al.* 2009), the standard is established at the lowest elevation associated with less than a fifteen percent reduction in lake surface area relative to the lake area at the Historic P50 elevation. For the middle Hillsborough River, the provisional Species Richness Standard would be established at 20.4 feet above NGVD29. The Species Richness Standard was equaled or exceeded eighty-three percent of the time during the 1985 through 2008 period used for provisional minimum level development; the standard therefore corresponds to a P83 elevation.

Lake Mixing Standard

The Lake Mixing Standard is developed to prevent significant changes in patterns of wind-driven mixing of the lake water column and sediment re-suspension. The standard is established at the highest elevation at or below the Historic P50 elevation where the dynamic ratio (see Bachmann *et al.* 2000), which is equivalent to the basin slope, shifts from a value of <0.8 to a value >0.8, or from a value >0.8 to a value of <0.8. For the middle river this was determined to occur at a lake surface elevation of 13.1 feet above NGVD29 (Figure 6-7). Based on monthly mean water levels for the period from 1985 through 2008, the elevation of the provisional Lake Mixing Standard was exceeded one hundred percent of the time.

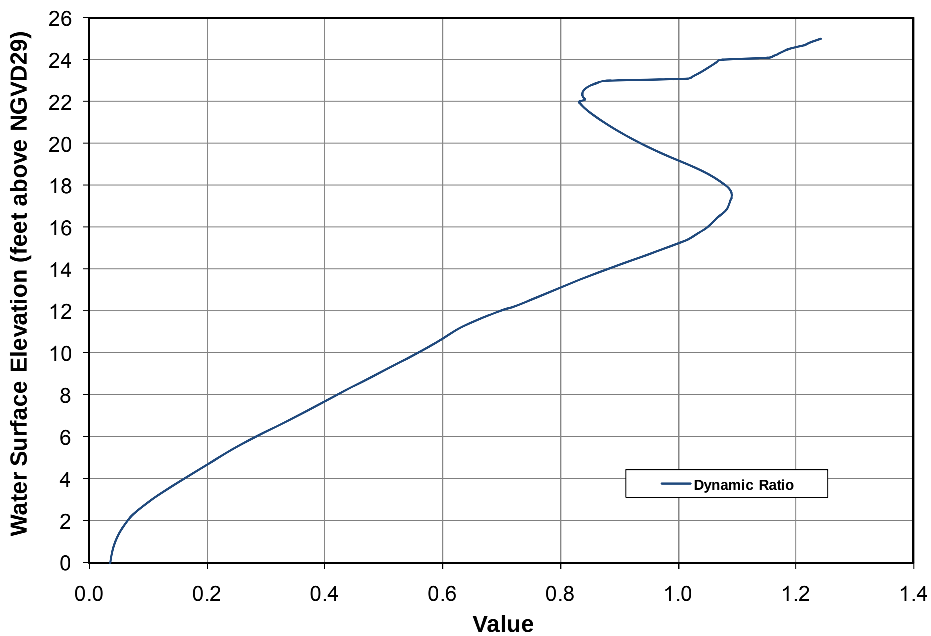


Figure 6-7. Dynamic ratio (basin slope) versus water surface elevation for the middle Hillsborough River.

Basin Connectivity Standard

The Basin Connectivity Standard is developed to protect surface water connections between lake basins or among sub-basins within lake basins to allow for movement of aquatic biota, such as fish, and support recreational use of the lake. The standard is based on the elevation of lake sediments at a critical high spot between lake basins or lake sub-basins, identification of water depths sufficient for movement of biota and/or watercraft across the critical high spot, and use of Historic lake stage data or region-specific reference lake water regime statistics. A provisional Basin Connectivity Standard for the middle river would be established at 22.1 feet above NGVD29, based on the elevation (17.87 feet above NGVD29) that ensures connectivity throughout the river segment, a two-foot water depth in the areas of connectivity to allow for movement of watercraft and biota between the sub-basin, and the difference between the Historic P50 and Historic P90 elevations (2.2 feet). Based on monthly mean water levels for the 1985 through 2008 record, the provisional Basin Connectivity Standard was equaled or exceeded fifty-three percent of the time, *i.e*., the standard corresponds to the P53 elevation.

Aesthetics Standard

The Aesthetics Standard is developed to protect aesthetic values associated with the inundation of lake basins. The standard is intended to limit potential change in aesthetic values associated with the median lake level from diminishing beyond the values associated with the lake when it is staged at the Low Guidance Level. The Aesthetic Standard is established at the Low Guidance Level. A provisional Low Guidance Levels of 19.9 feet above NGVD29 was identified for the river segment, so a provisional Aesthetics Standard would be set at that elevation. Because the provisional standard was set at the provisional Low Guidance Level, which corresponds to the Historic P90 elevation, water levels in the middle river equaled or exceeded the provisional Aesthetics Standard ninety percent of the time during the 1985 through 2008 evaluation period.

Recreation-Ski Standard

The Recreation/Ski Standard is developed to identify the lowest elevation within the lake basin that will contain an area suitable for safe water skiing. The standard is based on the lowest elevation (the Ski Elevation) within the basin that can contain a 5-foot deep ski corridor delineated as a circular area with a radius of 418 feet, or a rectangular ski corridor 200 feet in width and 2,000 feet in length, and use of Historic lake stage data or region-specific reference lake water regime statistics. For the middle Hillsborough River, a provisional Recreation-Ski Standard was established at 20.8 feet above NGVD29, based on the sum of the Ski Elevation (18.6 feet above NGVD29) and the 2.2-foot difference between the provisional Historic P50 and Historic P90. Based on monthly mean water levels for the period from 1985 through 2008, the elevation of the provisional Recreation-Ski Standard was exceeded 82 percent of the time. The provisional standard therefore corresponds to the P82 elevation.

Dock-Use Standard

Change in lake water levels may have important consequences for human safety, navigation or recreational use of lakes, affecting activities such as the mooring and launching of boats and other watercraft. In addition, boating activity in water of insufficient depth may adversely affect lake water quality and impact benthic and littoral flora and fauna. The Dock-Use Standard is developed to provide for sufficient water depth at the end of existing docks to permit mooring of boats and prevent adverse impacts to bottom-dwelling plants and animals caused by boat operation. The standard is based on a percentile statistic for elevations of lake sediments at the end of existing docks, a two-foot water depth for boat mooring, and use of Historic lake stage data or region-specific reference lake water regime statistics.

The elevation of sediments (river bed) at the end of all docks in the middle river that were judged to be potentially used for boat mooring were measured relative to the existing water surface elevation for comparison with long-term water level fluctuations in the river segment. Similarly, dock platform elevations were determined by measuring the distance (in feet) between the sediments and the top of the platforms. Platform heights, or elevations, were not determined for floating docks, as they are designed and constructed to rise and fall with changing water levels. Sediment and platform elevations were also not measured for dilapidated docks that were obviously not currently used for accessing the middle river. Sediment and dock platform elevations were not measured for the estimated ten boat slips/docks located in a dredged canal system connected to the east shore (left bank) of the river upstream from the 40^{th} Street bridge.

Sediments elevations at the end of the 284 docks apparently or potentially used for boat mooring on the middle river ranged from 10.0 to 22.7 feet above NGVD29 and platform elevations ranged from 21.6 to 29.4 feet above NGVD29 (Table 6-2). The median and mean sediment (±standard deviation) sediment elevations were 17.7 and 17.6 (±2.1) feet above NGVD29, respectively. Median and mean (±standard deviation) platform elevations were 24.2 and 24.5 (±1.2) feet above NGD29. The tenth percentile sediment elevation, *i.e.,* the elevation that is high enough to include all but ten percent of the measured elevations, was 20.1 feet above NGVD29. A two-foot water depth based on use of powerboats on the river and the 2.2 foot difference between the provisional Historic P50 and P90 elevations were added to the tenth-percentile sediment elevation to identify a provisional Dock-Use Standard of 24.4 feet above NGVD29 for the middle river. Monthly mean or mean daily in the middle river, as measured at the City of Tampa Dam, did not rise to this elevation during the 1985 through 2008 period, nor was this elevation achieved on any date during the water level period of record, which began in October 1945. This information suggests that application of the current method for developing Dock-Use Standards for lakes was not appropriate for the middle river.

Table 6-2. Summary statistics for elevations associated with docks on the middle Hillsborough River, based on measurements made by District staff in June 2006. Percentiles (P10, P50, P90) represent elevations exceeded by 10, 50 and 90 percent of the sediment or dock measurements.

Summary Statistic	Statistic Value (N) or Elevation (feet above NGVD29) of Sediments at Waterward End of Docks	Statistic Value (N) or Elevation (feet above NGVD29) of Dock Platforms
N	284	263
Mean (Standard Deviation)	17.6 (2.1)	24.5 (1.2)
P10	20.1	26.1
P50 or Median	17.7	24.2
P90	15.1	23.2
Maximum	22.7	29.4
Minimum	10.0	21.6

Although development of a provisional Dock-Use Standard for the middle river was not considered appropriate, dock information was examined further with respect to water level fluctuations in the river. Dock elevations were evaluated for longitudinal portions of the middle river, based on segments associated with the bridges spanning the river at 40th Street, 56th Street, Bullard Parkway, Fowler Avenue and Fletcher Avenue.

Dock-end sediment elevations were similar from the City of Tampa Dam upstream to the Bullard Parkway bridge, and were approximately one-half of a foot higher in the upper segments of the river (Figure 6-8, upper panel). The mean elevation at the end of the 284 docks within the entire middle river was exceed over 98% of the time based on mean daily water surface elevations measured at the dam from January 1, 1985 through December 31, 2008. Mean sediment elevations at docks located between the dam and the Bullard Parkway bridge were inundated over 99% of the time, and docks between the Bullard Parkway and Fletcher Avenue bridges were inundated 97% of the time. Because water levels in the upstream segments of the river may have been higher than measured at the dam, the sediments at the ends of docks in the upper reaches of the river may have been inundated more than these reported amounts of time.

Longitudinal variation in dock platform elevations within the middle river was similar to that of the dock-end sediment elevations. Elevations of dock platforms upstream of the Bullard Parkway bridge tended to be higher than those of more downstream docks (Figure 6-8, lower panel). The mean elevation of dock platforms on the river, 24.5 feet above NGVD29, was 1.7 feet higher than the maximum daily water surface elevation measured at the dam for the period from January 1, 1985 through September 5, 2008.

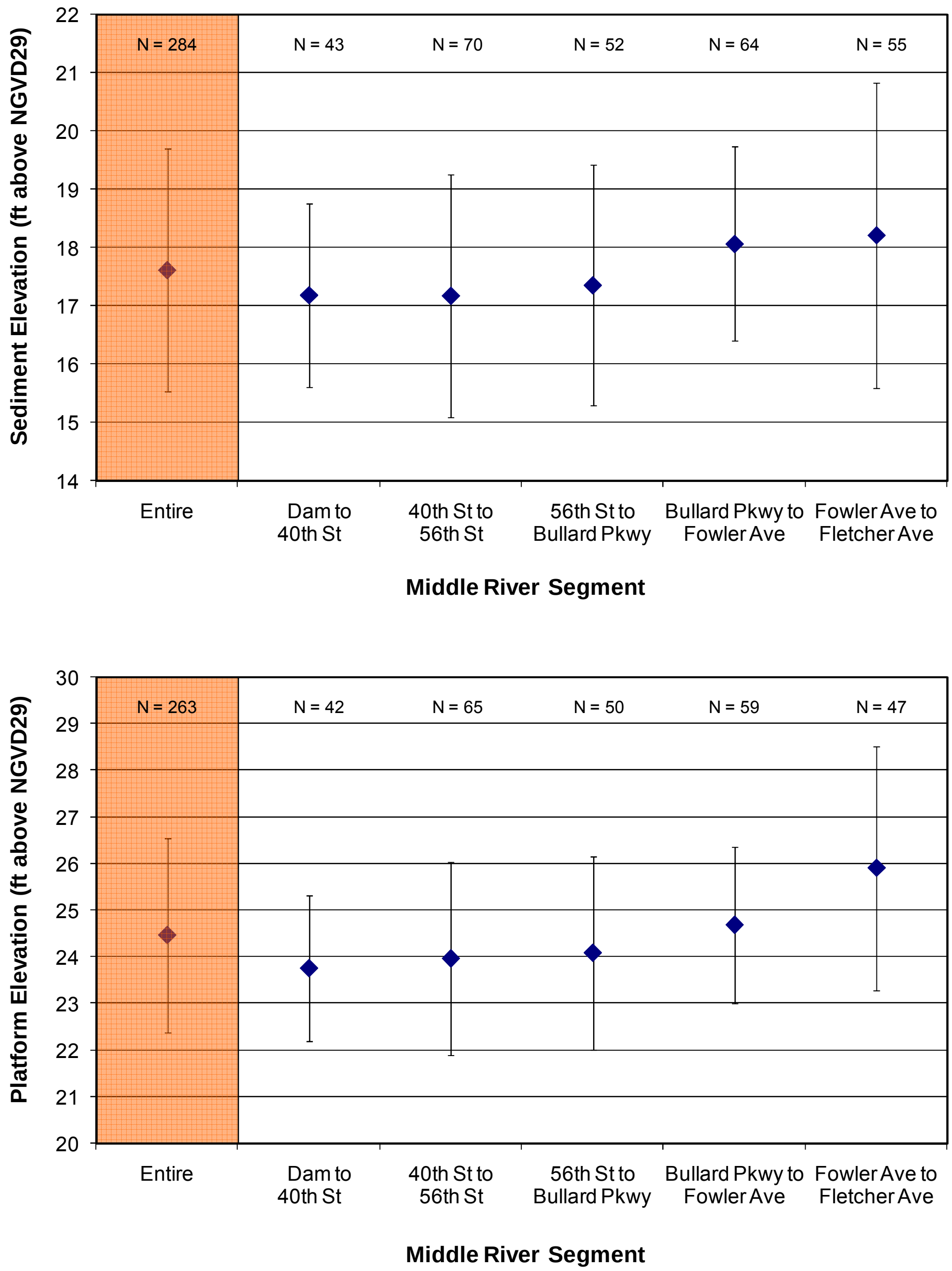


Figure 6-8. Mean (± standard deviation) sediment or river bed elevations at the end of docks (upper panel) and dock platform elevations (lower panel) located on the middle Hillsborough River and within five portions of the river segment. Numbers (N) of sediment and platform elevations differ because platform heights above the sediments were not measured for floating docks.

Regulations governing the installation of docks, piers, and other similar structures have been developed at numerous jurisdictional levels (see reviews by Czerwinski and McPherson 1995 and Yingling 1997). In Florida, compliance with Florida Department of Environmental Protection rules may be required if the proposed dock or pier is located within an Aquatic Preserve (Florida Department of Environmental Protection 1999, 2000). Within the District, additional requirements specified in District Rules and county ordinances or codes must also be met.

A minimum water depth requirement is typically included in regulations concerning dock construction and installation. This requirement is usually intended to prevent degradation of water quality or habitat destruction which may occur when watercraft come into contact with or disturb lake sediments or benthic biota. For example, District Rules governing Environmental Resource Permits (Chapter 40D-400 F.A.C.) require "a minimum depth of two feet below the mean low water level in tidal waters or two feet below the mean annual low water level in non-tidal waters" for installation, alteration or maintenance of boat ramps and associated accessory docks", and similarly require a two-foot depth for all areas designed for boat mooring and navigational access for single-family piers (Southwest Florida Water Management District 2001b). For Class II Waters, which are waters approved for shellfish harvesting, permits for private, single-family boat docks may be issued if (among other factors) the mooring area "is located in water sufficiently deep to prevent bottom scour by boat propellers" (Southwest Florida Water Management District 2001a).

Local codes and ordinances may also require specific water depths at dock areas designed for boat mooring or loading. In Hillsborough County, the Environmental Protection Commission requires that a dock proposed for use with a boat "must be located so that a minimum of two feet of depth exists under the slip area during Ordinary Low or Mean Low Water conditions. This condition is meant to minimize the potential for any prop-dredging of the substrate during periods of lowered lake level" (Hillsborough County Environmental Protection Commission 2001). Similarly, in Pinellas County, docks in tidal and non-tidal waters are required to have at least 18 inches of water depth at mean low tide, or as measured at the ordinary low water elevation, respectively, and shall have a continuous channel with a minimum of 18 inches of water depth to allow access to open water (Pinellas County Code 1996). At Lake Tarpon, the largest lake in Pinellas County, the minimum depth requirement is increased to 30 inches at the docking slip. In Hernando County, approval of dock installation is contingent upon assurance that "a minimum of one (1) foot clearance is provided between the deepest draft of the vessel and the bottom at mean low water" and that "a water depth of minus three feet (-3) mean low water must be provided for mooring a vessel at a dock" (Hernando County 2001). In Charlotte County "docking facilities in natural surface waters shall be designed to prevent or minimize impacts to grassbeds and other biologically productive bottom habitats" and "dock length shall be sufficient to provide for a minimum water depth of minus three (-3) feet (mean low water) at all slips and mooring sites, unless it is demonstrated that a lesser depth will not result in impacts to sensitive bottom communities" (Charlotte County 2000).

Water depth requirements for existing docks on the middle Hillsborough River were examined with respect to water level fluctuations for the 1985 through 2008 period. For the analyses, the mean elevation of sediments at the end of existing docks (17.6 feet above NGVD29) was increased by two feet to account for a two-foot water depth requirement at the end of the “average” dock. The resulting elevation, 19.6 feet above NGVD29, was exceed 90% of the time based on daily mean water surface elevations for the river measured at the City of Tampa Dam from January 1, 1985 through December, 2008. The water level associated with a two-foot depth above the mean sediment elevation for docks located upstream of the Bullard Parkway Bridge was inundated 86% of the time during the same period, based on water level records at the dam gauge site.

Water depths at the lower ends of the two public boat ramps located on the middle river (see Figure 6-9), both of which are located in City of Temple Terrace community parks, were also evaluated for the 1985 through 2008 period. The lower end of the concrete ramp at Rotary Park near the Fowler Avenue bridge includes a raised lip to limit the extent that a boat trailer may be backed onto the ramp. At this lower limit, the ramp has an elevation of 17.61 feet above NGVD29. Based on mean daily water levels recorded from January 1, 1985 through December 31, 2008 at the gauge site near the City of Tampa Dam, water levels associated with water depths of 2, 3 and 4 feet at the lower end of the ramp were equaled or exceeded 91, 83 and 67% of the time.

The lower end of the concrete ramp at Riverhills Park, which is located upstream from the 56th Street bridge, is not as distinct as the lower end of the Rotary Park Ramp. The Riverhills Park Ramp grades into river bed substrate and rip-rap that has been deposited at the site. Substrate elevations at the ramp site adjacent to the pier associated with the ramp averaged 17.4 feet above NGVD29. Water surface elevations associated with water depths of 2, 3 and 4 feet above this elevation were equaled or exceeded 92, 84, and 70 percent of the time based on mean daily water surface elevations reported from January 1, 1985 through September 15, 2008 at the City of Tampa Dam.

Figure 6-9. Photographs of public boat ramps and piers on the middle Hillsborough River at Rotary Park (upper panel) and Riverhills Park (lower panel) in June 2006 (District files).

Wetland Offset

Because herbaceous wetlands are common within the middle Hillsborough River, it was determined that an additional measure of wetland change should be considered for the evaluation of river water level fluctuations. Based on a recent review (Hancock 2006) of the development of minimum level methods for cypress-dominated wetlands, it was determined that up to an 0.8 foot decrease in the Historic P50 elevation would not likely be associated with significant changes in the herbaceous wetlands occurring within lake basins. A provisional Wetland Offset elevation of 21.4 feet above NGVD29 was therefore established for the middle river by subtracting 0.8 feet from the Historic P50 elevation. The standard elevation was equaled or exceeded seventy percent of the time based on mean daily water levels measured at the City of Tamp Dam from January 1, 1985 through December 31, 2008.

Herbaceous Wetland Information is also taken into consideration to determine the elevation at which changes in lake stage would result in substantial changes in potential wetland area within the lake basin (*i.e*., basin area with a water depth of four or less feet). Similarly, changes in lake stage associated with changes in lake area available for colonization by rooted submersed or floating-leaved macrophytes are also evaluated, based on water transparency values. Maximum depth of plant colonization for the middle river was estimated at 6.6 feet, based on 238 water transparency measurements (Secchi depths) collected by the United States Geological Survey and the Southwest Florida Water Management District and the predictive model for macrophyte colonization depth and water transparency in Florida lakes (Caffrey et al. 2006).

Review of changes in potential herbaceous wetland area (Figure 6-10) or area available for aquatic plant colonization (Figure 6-11) in relation to change in water level in the middle river did not indicate substantial shifts in availability of plant habitat would be associated with the range of water surface elevations corresponding to the elevations identified for the provisional minimum levels developed using the Category 2 Lake minimum level methodology. A shift in the median water surface elevation from the estimated Historic P50 elevation of 22.2 feet above NGDV29 to the 20.9 foot elevation corresponding to the provisional Minimum Lake Level would potentially be associated with only an 11% reduction in the area of shallow (<= 4 feet deep) water that could be utilized by wetland plants. Similarly, a change in the long-term median water elevation from the Historic P50 to the provisional Minimum Lake Level would potentially result in no more than a 5% decrease in the area available for colonization by submersed aquatic plants.

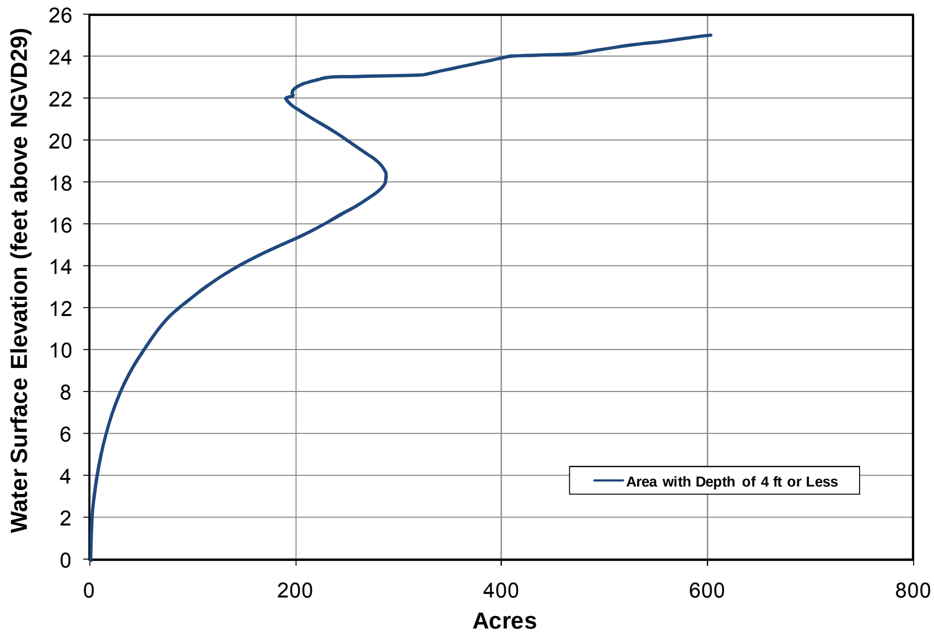


Figure 6-10. Inundated area of the middle Hillsborough River with a water depth of 4 feet or less as a function of water surface elevation in the river segment.

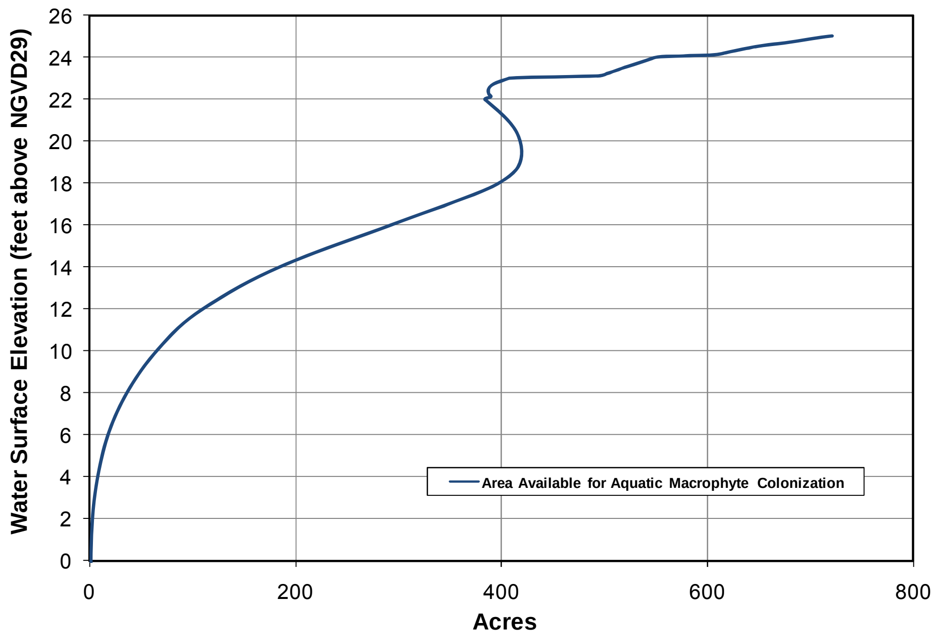


Figure 6-11. Inundated area of the middle Hillsborough River available for colonization by aquatic macrophytes as a function of water surface elevation. Available area determined based on relationship between water transparency and maximum depth of plant colonization in Florida lakes.

Highlights of Chapter 6

The District has established minimum flows and levels for numerous water bodies in the Hillsborough River watershed, including 21 cypress wetlands, 9 lakes, a portion of the Upper Floridan Aquifer system, the upper Hillsborough River, Crystal Springs and the lower Hillsborough River. Because minimum flows or levels are not being met in some of these systems, a regional recovery strategy for the northern Tampa Bay area and a site-specific recovery strategy for the lower Hillsborough River are currently being implemented to achieve compliance with the minimum flows and levels.

State law pertaining to establishment of minimum flows and levels and the District's Water Levels and Rates of Flow rules include sections that are relevant to determining whether minimum flows and levels rules are applicable to the middle Hillsborough River. State law includes provisions for excluding certain water bodies from the minimum flows and levels establishment requirement. In addition District rules state that no guidance levels shall be prescribed for the "City of Tampa Reservoir" and several other regional impoundments used for water supply purposes. Based on these sections of state law and District rules, the District has not pursued adoption of minimum flows and levels for the middle Hillsborough River. This management decision was and is based on: 1) the stipulation in previous versions of District rules that management levels were not to be developed for the middle river and other impoundments used for water supply purposes; 2) the stipulation in current District rules that guidance levels are not to be developed for the middle river and other impoundments used for water supply purposes; 3) consideration of the river segment as a water body constructed prior to the requirement for a permit; and 4) judgment that the system is not expected to experience adverse impacts or significant harm associated with water withdrawals.

Review of District rules that may be relevant to the middle Hillsborough River led to identification of a few potential rule changes that could be implemented to improve clarity and therefore improve regulatory activities associated with the rules. First, it would be useful to clarify District intent regarding establishment of minimum flows and levels for the middle river and other impoundments used for water supply purposes. To accomplish this goal, Rule 40D-8.031(2), F.A.C., which currently indicates that no guidance levels be established for several water bodies, including the City of Tampa Reservoir, could be amended to indicate that no minimum flows, minimum levels or guidance levels should be established for the middle river and the other impoundments identified in the rule. Also to more clearly identify the middle Hillsborough River, the reference in the rule to the "City of Tampa Reservoir on the Hillsborough River in Hillsborough County" could be changed to the "City of Tampa Reservoir on the Middle Hillsborough River". Another potential rule change concerning the middle river would involve revision of the definition of the lower Hillsborough River included in Rule 40D-80.041(1)(a), F.A.C. The segment is currently defined in the rule as the river downstream of Fletcher Avenue. This reference could be changed to indicate that the lower Hillsborough River is the river segment downstream from the dam on the City of Tampa's Reservoir.

Although unrelated to the middle river, it may also be appropriate to amend District rules to include Shell Creek Reservoir in Charlotte County among the impoundments for which minimum flows, minimum levels and guidance levels are not to be developed. This action would require inclusion of the Shell Creek Reservoir in Rule 40D-8.031(2), F.A.C. Also unrelated to the middle river, but potentially useful for regulatory activities, would be an amendment to Rule 40D-8.031(1) to indicate that no minimum flows, minimum levels or guidance levels be established for reservoirs or other artificial structures located entirely on lands owned, leased, or otherwise controlled by a user.

The applicability of District methods for establishing minimum flows and levels was evaluated with respect to the middle river, and application of the method used for establishing minimum levels for lakes with fringing cypress wetlands was found to be the most appropriate. Following development of a provisional significant change standard for the river based on protecting the integrity of cypress wetlands, the appropriate methods were applied and permitted identification of two provisional minimum levels; a High Minimum Lake Level at 22.3 feet above NGVD29 and a Minimum Lake Level at 20.9 feet above NGVD29. The Minimum Lake Level is an elevation that a lake's water levels must equal or exceed 50% of the time, on a long-term basis. The High Minimum Lake Level is the elevation that must be equaled or exceeded 10% of the time. Comparison of these provisional levels with measured water surface elevations recorded at the City of Tampa Dam indicated that the levels have been met for an evaluation period of 1985 through 2008.

Significant change standards that are developed when establishing minimum levels for lakes that lack fringing cypress wetlands were also examined for the middle river. Provisional standards were developed to identify median water levels that protect species richness, ensure natural patterns of water column mixing, maintain connectivity within the basin, protect aesthetics, preserve recreational use of the lake for waterskiing, maintain specified water depths at the end of docks, and protect herbaceous wetlands. In all cases except the provisional standard developed for dock-use, measured water levels in the middle river from 1985 through 2008 exceeded the elevations associated with the provisional standards more than 50% of the time.

The provisional dock-use standard was not considered appropriate for consideration for the middle river because the elevation associated with the standard, 24.4 feet above NGVD29, was higher than the monthly mean water surface elevations determined for the middle river and used for the minimum lake level analyses. Although the dock-use standard was not considered appropriate for the middle river, an analysis of mean river bed elevations at the end of existing docks for various sub-segments of the middle river indicated that a two-foot water depth requirement at the end of the docks was met over 86% of the time for the period from 1985 through 2008.

Chapter 7

Water Quality of the Middle Hillsborough River

Water Body Classification, Water Quality and Total Maximum Daily Loads

All surface waters in Florida are classified according to present and future most beneficial uses (Section 403.061(10), F.S.) and associated with class-specific water quality standards for selected physical and chemical parameters (Chapter 62-302, F.A.C.). Because the middle Hillsborough River is used as a drinking water source, the river segment from the City of Tampa Dam upstream to Flint Creek, and Cow House Creek are classified as a Class I waters, *i.e.*, potable water supplies (Rule 62-302.400 (12)(b), F.A.C.). Waters may also be designated as Outstanding Florida Waters, a classification that affords additional water quality protection. The middle Hillsborough River is not classified as an Outstanding Florida Water, although the Hillsborough River upstream from Fletcher Avenue and several tributaries to the upper river are classified as Outstanding Florida Waters (Rule 62-302.700, F.A.C.).

With regard to compliance with water quality standards, Section 303(d) of the Federal Clean Water Act requires each state to identify and list "impaired" waters where applicable water quality criteria are not being met after implementation of technology-based effluent limitations, and also requires development of Total Maximum Daily Loads (TMDLs) for the water bodies. Total Maximum Daily Loads are the amount of pollutant that a receiving water body can assimilate without causing violation of a pollutant-specific water quality standard. The TMDLs development process identifies allowable loadings of pollutants or other factors and supports implementation of management strategies for reducing pollutant loads and ensuring appropriate water quality standards are met.

The most recent 303(d) list for impaired Florida waters was approved by the United States Environmental Protection Agency in 1998. The 1998 list is available from the Department of Environmental Protection web site at http://www. dep.state.fl.us/ water/tmdl/303drule.htm. The 1998 list identified Water Basin Identification (WBID) number 1443E, which includes the lower and middle Hillsborough River and the river segment from Fletcher Avenue upstream to the mouth of Trout Creek as being impaired for [plant] nutrient concentrations, coliform bacteria levels and mercury (based on fish consumption advisories). Cow House Creek, identified as WBID number 1534, was also identified as impaired based on levels of dissolved oxygen, coliform bacteria, nutrients, turbidity and total suspended solids.

In 1998 the United States Environmental Protection Agency settled a lawsuit concerning implementation of the TMDLs program in Florida. The 1999 consent order resulting from the lawsuit requires development of TMDLs for all parameters included for each water body listed on the 1998 303(d) list within 13 years (Florida Department of Environmental Protection 2005). If the TMDLs are not developed by the State of Florida in accordance with this schedule, the Environmental Protection Agency is required to do so.

Based on concern that the 1998 303(d) impaired waters list was based on incomplete or inadequate data, the Florida Legislature passed the Florida Water Resources Act of 1999. The act included provisions prohibiting the use of the 1998 list for other than planning purposes and requiring adoption by rule of new methods for identifying impaired waters (Drew 2005). The current state methodology for identifying and listing impaired water was subsequently codified in 2001 as the Identification of Impaired Surface Water Rule (Section 62-303, F.A.C.). The rule methodology provides for development of a "planning list", which includes waters that may be potentially impaired and for which a final determination of impairment may require additional study. The rule also requires development of a "verified list" which includes water bodies that have been assessed as part of the Department's watershed management approach, and found to be impaired due to anthropogenic pollutant discharges.

In 2002, the Florida Department of Environmental Protection (2002) published a status report as a first phase of the implementation of their watershed approach for restoring or protecting water resources through development of TMDLs for the Tributaries of Tampa Bay planning unit. For the status report, the bay tributaries were classified as a Group 2 basin, based on the anticipated order of evaluating the 29 basins identified for the state – Group 2 basins were the second group to be evaluated. The report included a planning list which identified potentially impaired waters in the Tampa Bay Tributaries Basin that might require development of TMDLs, based on previous listing on the 1998 303(d) list and application of methods outlined in the Identification of Impaired Surface Water Rule. For the portion of the planning unit that includes the lower and middle Hillsborough River and the river segment from Fletcher Avenue upstream to the mouth of Trout Creek (WBID 1443E), potential impairment based on the 1998 303(d) list was noted for coliform bacteria and nutrient levels as well as fish advisories based on mercury contamination. Impairment associated with the mercury-based fish advisories was not, however, listed for WBID1443E based on application of the Impaired Surface Water Rule methodology. Cow House Creek (WBID 1534) was also included on the planning list based on identification of dissolved oxygen, coliform bacteria, nutrients, turbidity and total suspended solids parameters on the 1998 303(d) impaired waters list, but only dissolved oxygen level was identified as a parameter of concern based on application of the Identification of Impaired Surface Water methodology.

In 2005, the second phase of the watershed management approach for identification of impaired water bodies in the Tampa Bay Tributaries Basin culminated in the publication of an assessment report for the basin (Florida Department of Environmental Protection 2005). The report included a "verified" list of impaired waters which included impaired waters in the Tampa Bay Tributaries Basin that would potentially require development of TMDLs, based on meeting the data sufficiency and quality requirements of the state Identification of Impaired Surface Water Rule. The assessment report included subdivision of WBID 1443E (the Hillsborough River from Trout Creek downstream to McKay Bay) into estuarine and freshwater components, with: 1) the freshwater

"Hillsborough Reservoir", which extends from the City of Tampa Dam upstream to a point just north of Fletcher Avenue, identified as a "lake" and assigned the new number WBID 1443E1; 2) the freshwater segment upstream from the “Hillsborough Reservoir” to District Structure S-155 identified as a “stream” and assigned the new WBID number 1443E2; and 3) the estuarine portion of the unit identified as an “estuary” and retaining the WBID number 1443E. Dissolved oxygen and mercury in fish were identified as parameters leading to verified impairment for the "Hillsborough Reservoir" (WBID 1443E1), based on implementation of the Identification of Impaired Surface Water Rule methodologies. Dissolved oxygen concentrations were also used to include Cow House Creek (WBID 1530) on the verified impaired list.

In May 2004, the Verified List of Impaired Waters for the Group 2 Basins was adopted by Secretarial Order of the Florida Department of Environmental Protection and according to Drew (2005) approved by the United States Environmental Protection Agency. The verified 2004 list is available at the Florida Department of Environmental Protection web site at http://www.dep.state.fl.us/ water/tmdl/adoptedgp2.htm along with a list of waters proposed by the Department for removal or delisting from the 1998 303(d) impaired waters list. The list of waters identified for delisting indicates that Cow House Creek should not be identified as impaired based on levels of fecal and total coliform bacteria, nutrients, total suspended solids and turbidity.

The Florida Department of Environmental Protection has developed draft 2008 updates to the approved 2004 verified list of impaired waters. The current draft verified list for the Tampa Bay Tributaries Basin is available at the Department web site at http://www.dep.state.fl.us/water/tmdl/verified_gp2-c2.htm and includes dissolved oxygen and fish mercury levels in the "Hillsborough Reservoir" (WBID 1443E1) as parameters assessed for impairment under provisions of the Identification of Impaired Surface Water Rule and also lists total phosphorus as a pollutant of concern. Dissolved oxygen in Cow House Creek (WBID 1534) is identified on the draft list as a parameter leading to impairment, and total phosphorus is identified as a pollutant of concern. Note that the draft 2008 updates include an additional subdivision for the lower river. The river segment from the base of the dam to the point where Sulphur Springs discharges into the river is referred to as the “Lower Hillsborough River Fresh” and has been assigned the WBID number 1443F.

As of January 2009, none of the required TMDLs have been finalized for the middle Hillsborough River, although ongoing work for some required TMDLs has been published in draft form. The United States Environmental Protection Agency (2004a) has, for example, developed draft TMDLs for dissolved oxygen and nutrients in Cow House Creek (WBID 1534), and has also developed draft TMDLs for the same parameters for lower Hillsborough River (WBID 1443E) and a segment of the Hillsborough River upstream from Trout Creek (WBID 1443D). The Florida Department of Environmental Protection is currently engaged in development of a state-wide approach for addressing TMDLs addressing mercury levels in state waters (Florida Department of Environmental Protection 2007), and upon completion the approach will likely be applicable to the middle river. Although no TMDLs have been finalized for the middle river, TMDLs for several other Hillsborough River and watershed segments have been completed. For example, the Florida Department of Environmental Protection (2004a, b) has finalized TMDLs for total and fecal coliforms for the lower Hillsborough River (WBID 1443E) and for total coliforms for the Hillsborough River segment upstream from Trout Creek (WBID 1443D). Total and/or fecal coliform TMDLs have also been finalized for several upper Hillsborough River tributaries, including Blackwater Creek (Tyler and Petrus 2004), Cypress Creek (Donner 2004), Flint Creek (Magley 2004) and the New River (O'Donnell, Tyler and Wu 2004).

Upon development of TMDLs for the middle Hillsborough River, the Department will develop a Basin Management Action Plan (BMAP) for meeting the identified TMDLs. The BMAP will represent a set of strategies that address the activities, timeline and funding necessary for restoration of the impaired waters. Plan development will involve input from local stakeholders, including public and private groups or individuals.

The middle Hillsborough River serves as the primary source of potable water for the City of Tampa. The Tampa Water Department withdraws water from the middle Hillsborough River at the David L. Tippin Water Treatment Facility, which is located approximately 1.4 miles upstream from the City of Tampa Dam. As a requirement of the Safe Drinking Water Act, the Tampa Water Department provides water users with an annual report (*e.g.*, Tampa Water Department 2007) of results from ongoing water quality sampling of finished, *i.e.,* treated potable water.

To support and ensure safe drinking water supply and comply with the federal Safe Drinking Water Act, the Florida Department of Environmental Protection implements a Source Water Assessment and Protection Program (SWAPP). As part of this program, the Department completed Source Water Assessments for the City of Tampa Water Department in 2004, 2006 and 2009; the reports are available from the Department web site at http://www.dep.state.fl.us/swapp/ DisplayPWS.asp?pws_id=6290327. The 2004 and 2006 assessments assigned a concern level of "high" for the middle Hillsborough River as a water supply, based on potential sources of contamination. In contrast, the 2008 assessment identified only a "low" level of concern for the supply. Differences in assessment results could be attributable to use of a different evaluation procedure for the more recent assessment or could reflect improved conditions in the watershed.

Other Studies of Middle River Water Quality

In addition to the evaluations for development of TMDLs for the Hillsborough River conducted by the Florida Department of Environmental Protection and the Unites States Environmental Protection Agency, a number of other studies have included assessments of the water quality of the middle river. The studies have been conducted to evaluate issues such as the use of copper for controlling nuisance algae, reconstruction of historic water quality conditions, nutrient loading to Tampa Bay, and classification of the upper Hillsborough as an Outstanding Florida Water. These studies are briefly summarized in this sub-section to further characterize water quality in the middle river.

Copper is commonly used as an algaecide for controlling cyanobacteria and other phytoplankton populations and reducing taste, odor or public health problems associated with chemical compounds produced by some of these organisms. This heavy metal may also be used to kill molluscan hosts for parasites responsible for swimmers itch. Negative effects of copper use include exposure of non-target organisms, including zooplankton, fish and benthic fauna, to potentially lethal doses of the metal (reviewed by Leslie 1990, 1992 and Cooke *et al.* 1993).

According to Hohman (1992; see also Hohman and Martin 1995), copper has been used to control phytoplankton in the middle Hillsborough River since about 1926. The Tampa Water Department spot-treats areas between the dam and the 40th Street bridge during phytoplankton blooms or population increases that occur from the spring through the fall; daily treatments are common during summer months. Applications are undertaken when phytoplankton cell densities exceed 10,000 cells/L at any of 8 monitoring zones, and if water temperature exceeds 70°F and color ranges from 30 to 400 units. For the four year period from 1987 through 1991, Hohman (1992) reports that 9,460 to 31,720 lbs of copper sulfate pentahydrate was applied annually to the middle river segment, based on information provided by the Tampa Water Department. Hohman sampled near-shore areas of the river segment between the City of Tampa Dam to a point slightly upstream of the Fletcher Avenue bridge in 1991 and 1992, and found no violations of state water quality standards for aqueous copper; copper levels in all samples were below detection limits for the analytical method that was employed for the analyses. In contrast, Goetz *et al.* (1978) reports an aqueous copper concentration of 210 µg/L at the "Tampa Reservoir" dam, however, information on sampling effort for the reported value was not provided.

Although Hohman (1992) did not detect copper in the water column of the middle or lower rivers, appreciable amounts of copper were detected in sediments from both river segments. Copper concentrations in the middle river ranged from 760 to 7,580 µg/kg of dried sediment and highest values, ranging up to 20,910 µg/kg were observed in the lower river at a site near Lowery Park. Leslie (1992) reviewed application of copper to Florida waters, including the middle Hillsborough River, and reports that based on an unspecified number of samples collected by the Florida Department of Natural Resources, copper concentration in middle river sediments ranged from 52 to 1,760 mg/kg. Sediment concentrations based on samples collected by the Department between the City of Tampa Dam and the 40th Street bridge averaged 464 mg/kg. Upstream and downstream concentrations ranged from 1-12 mg/kg and 7-60 mg/kg, respectively.

The sediment copper concentrations reported by Hohman (1992) and Leslie (1992) differ by several orders of magnitude, indicating that additional study is necessary for evaluation of sediment copper levels in the river. State standards for copper levels in aquatic sediments have not been developed. Leslie (1992) reports that a “no effect” to “probable effect” range from 28 to 170 mg/kg was identified as part of an unpublished Department of Environmental Regulation study of the effects of copper on marine and estuarine organisms.

Brenner and Whitmore (1998) also evaluated middle river sediments, examining sediment cores to reconstruct historic trophic state conditions in the basin. Trophic state classifications are used by water managers and scientists to describe the level of biological productivity, and are based on nutrient levels, chlorophyll concentrations and other factors. Brenner and Whitmore found little organic matter accumulation at most of the 18 sites between the City of Tampa Dam and the 40th Street bridge where they collected core samples. Two cores included sufficient organic material for analyses. They found sediment nitrogen and phosphorus levels were comparable to those found in Florida lake sediments. Diatom assemblages within core strata were indicative of eutrophic or highly productive conditions, based on inferred limnetic total phosphorus levels. Interestingly, inferred limnetic phosphorus levels for recently deposited sediments were lower than measured phosphorus concentrations in the sediment core samples, a finding that Brenner and Whitmore considered most likely attributable to nitrogen limitation. They also acknowledge that numerous diatom taxa indicative of flowing water conditions and not typically found in lake sediments were distributed throughout the cores, and that this may have contributed to the differences noted for measured and inferred phosphorus levels. Precise dating of sediment core strata was not possible, but based on core diatom assemblages it appears that during the 10-20 years preceding the study, average Trophic State Index (an index of trophic state or nutrient levels; see Huber *et al.* 1982) values increased approximately 10 units. This implies that nutrient levels in the river segment have increased substantially in recent years.

The Tampa Bay Estuary Program has identified the Hillsborough River as a major source of nitrogen and phosphorus loading to Tampa Bay (Coastal Environmental 1994 as cited in Southwest Florida Water Management District 1999b). In 1999, the District completed a study of nitrogen loading from the upper river, including Crystal Springs, to support Program efforts to improve bay water quality. Total nitrogen discharged from Crystal Springs and across the City of Tampa Dam to the lower Hillsborough River was estimated for 1991, 1994 and 1997. Estimates of total nitrogen loads to the lower river ranged from 120 to 468 tons per year for the three years, with Crystal Springs accounting for 14 to 32% of the annual totals.

In support of the then proposed classification of the Hillsborough River as an Outstanding Florida Water, the Southwest Florida Water Management District (1987) summarized water quality data available from United States Environmental Protection Agency STORET database for the river from the City of Tampa Dam to the Hillsborough River State Park, about 22.7 miles upstream from the dam. Water quality data were summarized for 5 stations, including a site at the City of Tampa Dam. Values reported for selected parameters at the site included: dissolved oxygen (mean = 6.2 mg/L; range = 0 to 11.7 mg/L; n = 114); pH (mean = 7.3 mg/L; range = 6.1 to 8.5 mg/L; n = 101); specific conductance (mean = 449 μS/cm at 25°C; range = 76 to 6,200 μS/cm at 25°C;

n = 136), total alkalinity (mean = 87.4 mg $CaCO_3$; range = 8 to 151 mg $CaCO_3$/L; n = 28) and temperature (mean = 23.5° C; range = 11.5 to 34.0° C; n = 125).

The United States Geological Survey has examined water quality in the middle river as part of several studies of the Hillsborough River. Goetz *et al.* (1978) provide summary water quality data collected by the Survey for the period from 1923 to 1976 at sites near the City of Tampa Dam, 56th Street, the Harney Canal and Fowler Avenue. They note that specific conductance, which is a measure of the ability of water to conduct electric current and reflects concentrations of salt ions, was slightly higher at the site near the dam, as compared to the upstream sampling locations. They attribute this difference to the introduction of relatively mineralized water from Sulphur Springs to the middle river near the dam site. Wolansky and Thompson (1987) report similar observations for specific conductance near the dam as compared to sites at the Morris Bridge and Zephyrhills gauge sites in the upper Hillsborough River. In a report on the hydrology of the Tampa Bypass canal, Knutilla and Corral (1984) provide summary values for selected water quality parameters for a site in Cow House Creek and in the Harney Canal downstream from District structure S-161. Stoker *et al.* (1996) included the middle Hillsborough River in a study of the effects of river discharge and water quality on nutrient loading to Hillsborough Bay. Their study included sampling near the gauge site at the City of Tampa Dam, although samples were collected during only four months in the late spring and summer of 1991. This limited sampling effort precluded evaluation of seasonal trends and the effect of river discharge on water quality in the middle river.

Limno-Tech, Inc. (1997) examined nutrient loading to the middle river in support of identification of pollutant load reduction targets for management of the system. A variety of sources of water quality data were used for their analyses, including a site monitored by the Hillsborough County Environmental Protection Commission near Fowler Avenue and two sites sampled by the City of Tampa. These sites sampled by the City were located at the 40th Street and Bullard Parkway bridges. Based on data collected by the City of Tampa from 1984 through 1995 at the site near 40th Street, Limno-Tech, Inc. report a long-term average total phosphorus concentration of 0.317 mg/L, and note that this concentration is higher than most lakes in the state. Based on data collected at the same site between 1984 and 1986, they report a mean total nitrogen concentration of 1.01 mg/L. Chlorophyll a measurements collected between 1984 and 1995 yielded a mean concentration of 11.4 μg/L. Given the relatively high phosphorus levels, Limno-Tech, Inc. hypothesize that the moderate chlorophyll a concentrations in the river segment likely reflect the use of algaecides for control of phytoplankton populations.

Pillsbury (2004; see also Pillsbury and Byrne 2007) examined spatial and temporal variation of various water quality constituent or parameters for the Hillsborough River from Crystal Springs to downtown Tampa, based on sampling conducted during a two year period from 1999 to 2001. Sites near the 40th Street, Bullard Parkway, Fowler Avenue and Fletcher Avenue bridges were evaluated. She reports that flows from Blackwater Creek and Crystal Springs, respectively exert a strong influence on the phosphate and nitrate composition of water in the river. She also notes that total phosphorus concentrations at the sites near the Fowler Avenue and Bullard Parkway bridges were comparable to average value for the entire river. Interestingly, total phosphorus levels were slightly lower at the site near 40th Street. Pilsbury hypothesizes that this was likely related to the augmentation of the middle river with water from Sulphur Springs, the Tampa Bypass Canal and a sinkhole located near Morris Bridge Road. Increased concentrations of several cations and anions at the 40th Street bridge site, relative to the upstream sites in the middle river provided support for this hypothesis.

Current Summarization of Water Quality Data Collected by the United States Geological Survey and Southwest Florida Water Management District

For the present study of the middle river, water quality for the river segment was characterized using data currently available from the United States Geological Survey and Southwest Florida Water Management District. Water quality data for the middle river may also be available for sites sampled by the Hillsborough Environmental Protection Commission, the City of Tampa Water Department and Florida LAKEWATCH, but these data were not evaluated.

Water quality data for the river, including field measurements and results from laboratory analyses were obtained from the Geological Survey web site for a total of 5 sites (see Table 7-1 and Figure 7-1). Data available for the sites included information presented as “Field/Lab water quality samples” and “Daily data”. Data or results were reported in each data set by site for sporadic sampling events. Field/lab water quality sample results were available for the period from July 20, 1923 through December 10, 2008, although results for only two dates in the 1920s were included. Most records from Field/lab water quality samples data set were associated with sampling events conducted in the 1950s through recent times. Results in the Daily data set were available from September 9, 2002 through January 19, 2009. Water quality data for the middle river were obtained from the District Water Management Information System for 6 sites located between the City of Tampa Dam and Fowler Avenue (Table 7-2 and Figure 7-2). Data included measurements taken in the field and results from analyses completed by the District Chemical Laboratory based on samples collected at irregular intervals between February 13, 1996 and September 8, 2005. For this report these data are referred to as “historic” District data. More recent field measurements of selected water quality parameters at 12 middle river sites by the District (Table 7-3 and Figure 7-3) were also evaluated. These data were available for sampling events conducted from July 17, 2008 through January 15, 2009 and are referred to as “recent” District data.

Table 7-1. United States Geological Survey water quality sampling sites on the middle Hillsborough River.

USGS Site Number	Site name
02304000	Hillsborough River at Fowler near Temple Terrace FL
280212082225200	Hillsborough River Site 1 at Temple Terrace FL
280128082234600	Hillsborough River Site 3 Dnstr 56th St nr Tampa FL
280136082253000	Hillsborough R Site 5 Abv Dam nr Tampa FL
02304500	Hillsborough River near Tampa FL

Figure 7-1. Location of United States Geological Survey water quality sampling sites on the middle Hillsborough River (photographic image source: Fugro EarthData, Inc. 2007).

Table 7-2. Southwest Florida Water Management District "historic" water quality sampling sites on the middle Hillsborough River.

District Identification Number	Site name
19223	Hillsborough River at Fowler
19216	Hillsborough Reservoir 1
19217	Hillsborough Reservoir 2
19212	Hillsborough Reservoir 3
19214	Hillsborough Reservoir 4
19213	Hillsborough River nr Tampa

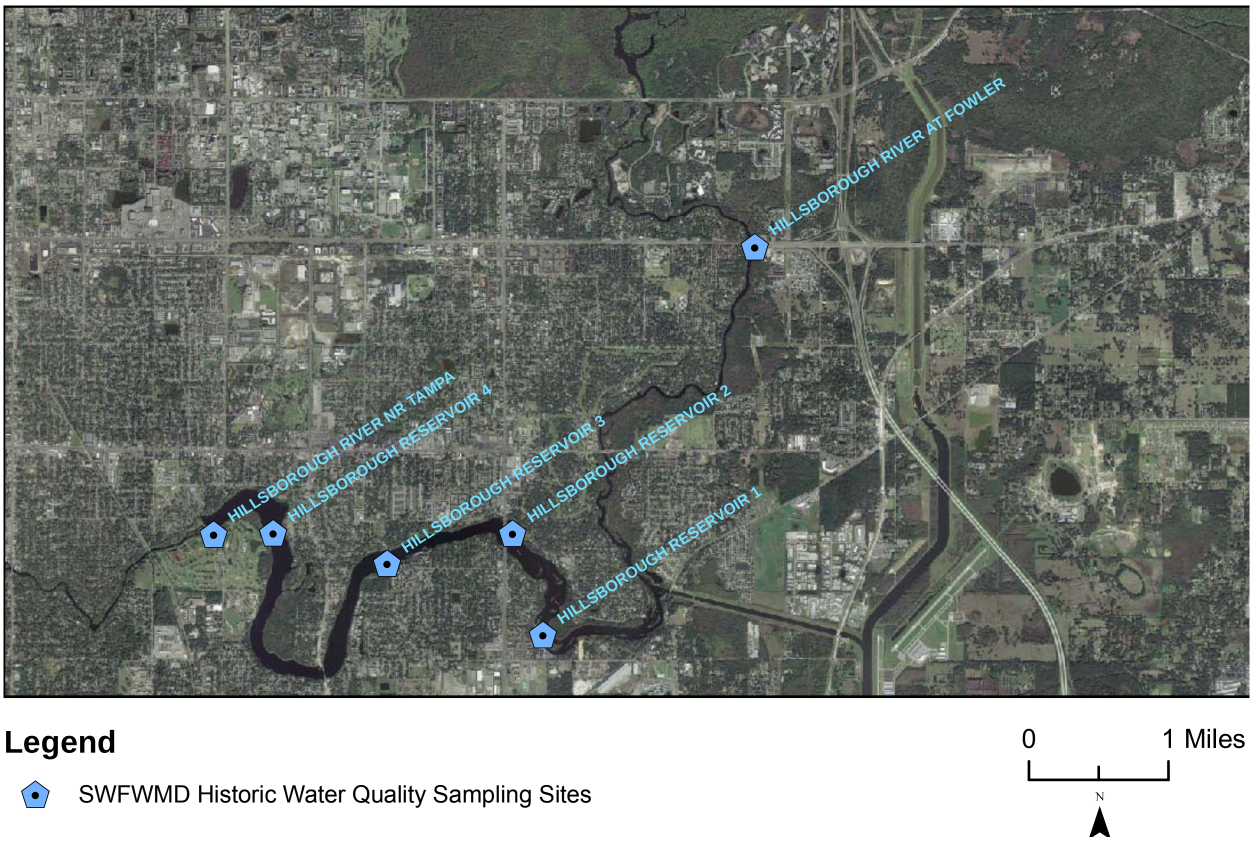
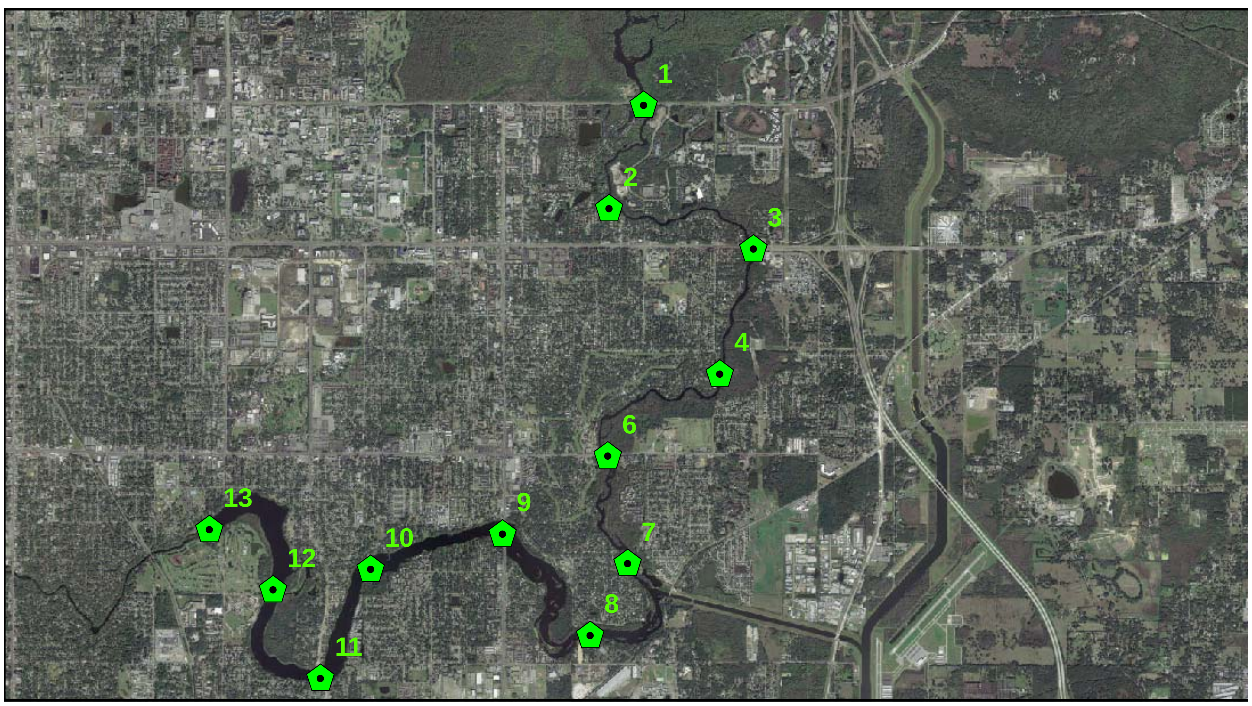


Figure 7-2. Location of sites with "historic" water quality for the middle Hillsborough River available from the Southwest Florida Water Management District Water Management Information System (photographic image source: Fugro EarthData, Inc. 2007).

Table 7-3. Southwest Florida Water Management District "recent" water quality sampling sites on the middle Hillsborough River.

District Site Number	Site Location/Description
1	Downstream side of the Fletcher Avenue Bridge/Under the bridge
2	Between Fletcher Avenue and Fowler Avenue bridges
3	Upstream of Fowler Avenue bridge/Near boat ramp at Rotary Park
4	Between Fowler Avenue and Bullard Parkway bridges
6	Upstream side of Bullard Parkway Bridge
7	Upstream from Harney Canal
8	Downstream from Harney Canal
9	56th Street bridge/Under the bridge
10	Between 56th Street and 40th Street bridges
11	40th Street bridge/Under the bridge
12	Upstream from David L. Tippin Water Treatment Facility
13	Upstream from the City of Tampa Dam



Legend

SWFWMD Recent Water Quality Sampling Sites

0 1 Miles

N

Figure 7-3. Location of sites with "recent" water quality for the middle Hillsborough River available from the Southwest Florida Water Management District Water Environmental Section (photographic image source: Fugro EarthData, Inc. 2007).

Water quality constituent or parameter values for the middle Hillsborough River were relatively comparable among the four data sets examined. Summary statistics for water quality data classified by the United States Geological Survey as Field/Lab water quality samples and Daily data are listed in Tables 7-4 and 7-5. Summary statistics for historic and recent water quality measurements and analyses conducted by the District are provided in Tables 7-6 and 7-7, respectively. Although the tables contain summary values for a large number of water quality constituents or parameters, only a few, including temperature, pH, specific conductance, nitrogen, phosphorus, chlorophyll, transparency, color and dissolved oxygen, were examined further for this report. This information was reviewed to provide a brief characterization of water quality in the river segment based on existing data, and to provide a preliminary examination of results from the recent monitoring of middle river water quality that the District is conducting in support of the minimum flows recovery strategies being implemented for the lower river.

Reported water temperatures in the four data sets examined for the middle river ranged from 5.2 to 34.0° C or 41 to 93° F. Mean pH values for the individual data sets ranged from 7.1 to 7.4, indicating that water in the impounded river segment is slightly basic. This likely reflects the substantial groundwater contributions from the upper river and the water sources used for augmentation of the river. Individual pH measurements less than 7.0, reflecting more acidic conditions, were not uncommon in the data sets, and in part, reflect the levels of organic acids and other molecules in the water that are derived from decomposition of plant material derived from the river floodplain. Mean specific conductance values for the river ranged from 212 to 385 µS/cm at 25° C, a range indicative of moderate levels of dissolved salts. For comparative purposes, Friedemann and Hand (1989) report median specific conductance values of 188, 366, and 37,125 µS/cm at 25° C, respectively, for Florida lakes, streams and estuaries.

Phosphorus is an element that is often identified as a limiting nutrient for the growth of algae and aquatic plants. Phosphorus is found in water bodies in dissolved and particulate form and often cycles rapidly between these two states. Total phosphorus, the sum of dissolved and particulate forms, is often quantified and used to characterize the trophic state, or level of biological productivity, of water bodies. The data sets available for the middle river include concentrations of phosphorus reported as orthophosphate, phosphate, phosphorus, and total phosphorus and are expressed as mg/L, mg/L as P, or mg/L as PO_4. The mean total phosphorus value of 0.20 mg/L derived from the "historic" District data set and the range of other means calculated for values reported as mg/L or mg/L as P (0.15 to 1.11 mg/L) in the District and United States Geological Survey data suggests that the middle river may be classified as hypereutrophic based on the trophic-state classification system of Forsberg and Ryding (1980). A hypereutrophic water body is a system with very high levels of biological productivity.

Friedemann and Hand's (1989) report on typical water quality values for Florida water bodies and a Florida LAKEWATCH (2000a) report on nutrients in Florida lakes include comparative information that is useful for evaluating the phosphorus concentrations reported for the middle river. Based on data contained in the United States

Environmental Protection STORET database, Friedemann and Hand report that 80% of Florida lakes have total phosphorus concentrations less than 0.15 mg/L and 90% have concentrations less than 0.29 mg/L. The mean total phosphorus concentration calculated for the middle river, 0.20 mg/L, exceeds the levels reported for 60 to 70% of the rivers sites examined by Friedemann and Hand. Summary information provided by Florida LAKEWATCH (2000a) also indicates that phosphorus levels are relatively high in the middle river. Based on data available in the Florida LAKEWATCH database for the period prior to January 1998, only 8% of Florida lakes exhibited total phosphorus levels in excess of 0.1 mg/L.

Nitrogen is another essential element for the growth of algae and aquatic plants. It occurs in a wide variety of organic or inorganic forms in water and different forms of the element are often measured for assessments of water quality. This was the case for the water quality data sets evaluated for the middle river, with concentrations of ammonia, nitrite, nitrate, organic nitrogen, total nitrogen and total Kjeldahl nitrogen reported. Total nitrogen, which is the sum of nitrate, nitrite, ammonia and organic nitrogen, is commonly used for trophic-state evaluations. The mean total nitrogen values of 0.97 and 1.15 mg/L calculated for the middle river based on the historic District data set and the United States Geological Survey Field/lab water quality samples are indicative of eutrophic conditions, based on criteria developed by Forsberg and Ryding (1980). Mean values reported for other forms of nitrogen that may be combined to obtain total nitrogen estimates for the middle river were also indicative of eutrophic conditions. Eutrophic water bodies are those considered to have a high level of biological productivity.

Relative concentrations of nitrogen in the middle river, as compared to other Florida water bodies, are not as high as the observed relative concentrations of phosphorus. Friedemann and Hand (1989) report that 60 to 70% of the lakes they examined have higher total nitrogen levels than the mean values of 0.97 and 1.15 mg/L calculated for the middle river. Similarly, between 50 to 70% of the river sites they examined had higher total nitrogen levels.

Chlorophyll, which is used by plants and algae for photosynthesis, is another water quality parameter that is typically assessed when evaluating or describing trophic-state conditions in a water body. Summarization of historic District data yielded a mean total chlorophyll value of 8.2 μg/L, based on 147 samples and a mean chlorophyll a value of 18.5 μg/L based on 79 samples. These chlorophyll levels provide additional support for classification of the middle river as a eutrophic water body based on the Forsberg and Ryding (1980) classification system.

Mean water transparency or clarity values ranged from 2.3 to 3.8 feet, based on Secchi depth values. This range is indicative of eutrophic to hypereutrophic conditions, according to the Forsberg and Ryding (1980) trophic-state classification system. Friedemann and Hand (1989) report, however, that many lakes in Florida exhibit relatively low transparency values. The range in mean transparency values for the middle river corresponds to the values of between 40 to 70% of the lakes and stream sites examined by Friedemann and Hand. Based on an analysis of 500 lakes, Florida LAKEWATCH (2001b) reports that 45% percent of the lakes had mean Secchi depths between 3 and 8 feet, while 25% had Secchi depths less than 3 feet.

Transparency values for the river may be influenced by seasonal variation in water color. Water color is a function of the dissolved organic matter content and is measured by comparing water samples against a spectrum of standard colors with assigned platinum-cobalt unit (PCU) values. Reported color levels averaged 89 and 118 PCU in the available District and United States Geological Survey data and were quite variable in both data sets. Highly colored water may limit growth of algae and aquatic plants and confound determination of trophic state based on transparency values and chlorophyll concentrations.

Concentrations of dissolved oxygen often vary widely within an aquatic systems, based on variation in temperature, atmospheric pressure, photosynthesis, respiration and chemical oxidation/reduction reactions not associated with living organisms. The parameter is of importance to aquatic ecosystem management because many organisms cannot tolerate extended periods of concentrations less than about 1 or 2 mg/L (Florida LAKEWATCH 2003). Dissolved oxygen concentrations in the District and United States Geological Survey data examined for the middle river ranged from 0 to 14.85 mg/L. Mean values for the individual data sets ranged from 3.48 to 5.82 mg/L.

The Florida criterion for dissolved oxygen in Class I water bodies requires that dissolved oxygen concentrations shall not be less than 5.0 mg/L and requires that “[n]ormal daily and seasonal fluctuations above this level shall be maintained” (Rule 62-302.530, F.A.C.). This standard is commonly violated in the middle river (Table 5-8), as was noted in the discussion of the State list of impaired water bodies and total maximum daily loads presented in the first sub-section of this chapter. From 38 to 78% of the reported dissolved oxygen concentrations in each middle river data sets were less than 5.0 mg/L. Based on the total of 4,690 dissolved oxygen concentration values reported in the combined data sets, approximately 70% of the 4,690 values were below the state standard. The Daily data set reported by the United States Geological Survey includes daily maxima and minima subsets – even the reported maxima subset included daily values that were less than 5.0 mg/L.

Low dissolved oxygen concentrations are not uncommon in Florida water bodies. The most recent statewide integrated assessment of water quality indicates that 19% of the 1,294 river segments that have been examined are classified as impaired due to low dissolved oxygen concentrations (Florida Department of Environmental Protection 2008). Impairment associated with low dissolved oxygen levels is also reported for 6% of the 654 lakes and 15% of the 546 estuarine river segments that have been evaluated. Many of these water bodies may be impaired as a result of pollutants derived from anthropogenic activities that have reduced oxygen levels. It is possible, however, that dissolved oxygen concentrations at some of the sites naturally fall below the 5.0 mg/L state standard. Dissolved oxygen in discharge from Florida springs, for example, may contain less than 1 mg/L dissolved oxygen (McKinsey and Chapman

1998). Similarly, although stable thermal stratification of the water column is not common in central Florida lakes, water column temperature gradients may develop on a daily or seasonal basis in some systems, and these gradients may be associated with depleted oxygen levels in deeper waters (Yount 1961, Shannon and Brezonik 1972, Attardi 1983).

Department of Environmental Protection rules provide for establishment of Site Specific Alternative Criteria for situations where violation of water quality standards are due to natural background conditions or anthropogenic conditions that cannot be controlled or abated. To date, the only alternative criterion associated with dissolved oxygen concentrations has been established for a portion of the lower St. Johns River and its tributaries, where a minimum of 4 mg/L dissolved oxygen is required (Rule 62-303.800(5)(a), F.A.C.). Approximately 53% of the 4,690 dissolved oxygen concentrations reported in the data sets examined for the middle river were below 4.0 mg/L.

Examination of dissolved oxygen concentrations for the middle river included in the recent Southwest Florida Water Management District data set is useful for illustrating some of the issues associated with standard compliance determinations for this water quality constituent. Although the mean dissolved oxygen concentration of 5.8 mg/L for the 301 measurements in the data set was higher than the 5.0 mg/L state criterion, mean concentrations calculated for some sampling events and at some sample sites were lower than the standard. Relatively low mean oxygen levels were calculated for sampling events conducted in late July and early August 2008 (see Table 7-9, which also includes summary information for water temperature, specific conductance, pH and transparency). These episodes of low oxygen concentrations may have been related to the effects of weather conditions on photosynthesis (the July event was conducted on a cloudy, rainy day), increased organic matter concentrations, which would increase oxygen demand and potentially reduce photosynthesis rates, or influx of oxygen-depleted water from the upper river or middle river floodplain swamps. When examined by sampling site, mean concentrations of dissolved oxygen exceeded the state standard at all but two of the sites (Table 7-10). Low oxygen levels at the site located at Fletcher Avenue, which was the most upstream of the sampled sites, were possibly related to factors associated with flooplain-channel interactions, including increased organic matter content. The low mean oxygen concentration at the other site that failed to meet the state standard, site 12, was likely related to depletion of oxygen in lower portions of the water column. Examination of a water-column profile of dissolved oxygen and temperature measurements for the site collected on October 2, 2008 (Figure 7-4) illustrates the magnitude of potential variation in dissolved oxygen levels that may exist at a single site. Concentrations of dissolved oxygen ranged from 9.4 mg/L near the water surface to 0.5 mg/L at a depth of 19.7 feet. Variation in oxygen concentrations between surficial and deeper waters was evident at most of the sites in the middle river and was expectedly more pronounced at the deeper downstream sites (Figure 7-5).

Statistical evaluations of the recent water quality data collected by the District in comparison to middle river water levels or flows at upstream gauging stations was not undertaken due to the limited number of sampling events for the data. Continued data collection may permit additional uses of these data for evaluation and management of the middle river and the greater Hillsborough River watershed.

Table 7-4. Summary statistics for water quality parameter or constituent data for the middle Hillsborough River available from the United States Geological Survey (USGS) as "Field/Lab water quality samples" data. Field measurement or sample collection for each constituent/parameter (number = N) was conducted between July 20, 1923 and December 10, 2008 at the 5 fixed stations located between the City of Tampa Dam and the Fowler Avenue bridge (see Figure 7-1). Not all constituents/parameters were sampled at all 5 stations. USGS Code specifies constituent/parameter and analysis procedure.

Constituent or Parameter	Units	USGS Code	N	Mean	Standard Deviation	Minimum	Maximum
Acid Neutralizing Capacity - Unfiltered, Fixed End Point, Field	mg/L as CaCO3	-410	56	99.39	34.64	8.00	151.00
Bicarbonate - Unfiltered, Fixed End Point, Field	mg/L	-440	55	121.40	42.35	10.00	184.00
Aluminum - Unfiltered Recoverable	µg/L	-1105	9	104.44	59.61	40.00	200.00
Aluminum - Filtered	µg/L	-1106	2	135.00	162.63	20.00	250.00
Arsenic - Unfiltered	µg/L	-1002	23	2.30	2.77	0.00	11.00
Arsenic - Filtered	µg/L	-1000	4	10.00	8.16	0.00	20.00
Cadmium - Unfiltered	µg/L	-1027	5	0.40	0.55	0.00	1.00
Cadmium - Filtered	µg/L	-1025	2	0.00	0.00	0.00	0.00
Calcium - Filtered	mg/L	-915	149	38.69	14.12	4.00	128.00
Carbonate - Unfiltered, Fixed End Point, Field	mg/L	-445	31	0.26	1.44	0.00	8.00
Carbon							
Inorganic Carbon Unfiltered	mg/L	-685	43	25.79	7.87	10.00	37.00
Organic Carbon - Unfiltered	mg/L	-680	173	16.55	7.69	0.00	35.00
Organic Carbon – Filtered	mg/L	-681	6	20.83	6.59	10.00	28.00
Total Carbon - Unfiltered	mg/L	-690	43	37.53	7.73	18.00	52.00
Chloride - Filtered	mg/L	-940	156	26.47	137.47	3.00	1720.00
Chlorophyll							
Chlorophyll a – Phytoplankton, Uncorrected	µg/L	-32230	6	8.70	7.04	1.60	17.00
Chlorophyll b – Phytoplankton, Uncorrected	µg/L	-32231	6	0.72	0.57	0.20	1.40
Chlorophyll a Phytoplankton –	µg/L	-70953	20	7.78	7.53	1.60	31.00

Constituent or Parameter	Units	USGS Code	N	Mean	Standard Deviation	Minimum	Maximum
Fluorometry							
Chromium - Unfiltered Recoverable	µg/L	-1034	2	15.00	21.21	0.00	30.00
Color - Filtered	PCU	-80	141	118	73	0	280
Coliforms							
E Coli - m-TEC, MF	col/100 mL	-31633	41	94.24	85.63	23.00	420.00
Entererococci - mEI MF	col/100 mL	-90909	39	74.95	60.60	20.00	250.00
Fecal Coliform - M-FC 0.45 µMF	col/100 mL	-31616	4	295.00	407.96	50.00	900.00
Fecal Coliform- M-FC, 0.7µ MF	col/100 mL	-31625	40	90.83	89.79	25.00	390.00
Fecal Streptococci - m-enterococcus	col/100 mL	-31679	4	211.50	201.47	34.00	460.00
Total Coliform - M-Endo, Immed.	col/100 mL	-31501	70	549.47	740.94	44.00	3200.00
Copper - Unfiltered Recoverable	µg/L	-1042	5	7.04	12.86	0.00	30.00
Copper - Filtered	µg/L	-1040	20	91.25	225.78	0.00	940.00
Dissolved Oxygen [A]	mg/L	-300	3,338	3.48	1.99	0.00	11.70
Dissolved Oxygen Percent Saturation	%	-301	65	57.32	27.87	8.00	130.00
Fluoride - Filtered	mg/L	-950	143	0.26	0.10	0.10	0.90
Hardness	mg/L as $CaCO_3$	-900	149	115.04	67.30	20.00	810.00
Iron - Unfiltered Recoverable	µg/L	-1045	42	232.86	149.59	50.00	640.00
Iron - Filtered	µg/L	-1046	55	106.78	111.57	0.00	480.00
Iron - Suspended Sediment Recoverable	µg/L	-1044	6	118.33	54.92	30.00	200.00
Lead - Unfiltered Recoverable	µg/L	-1051	2	3.00	1.41	2.00	4.00
Lead - Filtered	ug/L	-1049	2	2.50	3.54	0.00	5.00
Lead - Suspended Sediment Recoverable	ug/L	-1050	15	7.00	10.80	0.00	36.00
Magnesium - Filtered	mg/L	-925	149	4.40	9.50	0.70	118.00
Manganese - Unfiltered Recoverable	µg/L	-1055	23	19.57	7.67	10.00	40.00
Manganese - Filtered	µg/L	-1056	22	11.82	8.64	0.00	31.00
Manganese - Suspended Sediment Recoverable	µg/L	-1054	16	6.63	7.73	0.00	30.00
Mercury - Unfiltered Recoverable	µg/L	-71900	11	1.04	1.61	0.00	4.60
Nickel - Unfitlered Recoverable	µg/L	-1067	6	1.33	1.37	0.00	4.00
Nitrogen							
Ammonia - Unfiltered	mg/L	-71845	158	0.10	0.39	0.00	4.76
Ammonia - Unfiltered	mg/L as N	-610	158	0.08	0.30	0.00	3.70
Ammonia - Filtered	mg/L	-71846	70	0.06	0.03	0.01	0.18
Ammonia - Filtered	mg/L as	-608	80	0.04	0.02	0.01	0.11

Constituent or Parameter	Units	USGS Code	N	Mean	Standard Deviation	Minimum	Maximum
	N						
Ammonia + Organic Nitrogen - Filtered	mg/L as N	-623	14	0.57	0.32	0.36	1.50
Ammonia + Organic Nitrogen - Unfiltered	mg/L as N	-625	207	0.90	0.51	0.10	4.10
Nitrate - Unfiltered	mg/L as N	-620	145	0.31	0.53	0.00	3.90
Nitrate - Filtered	mg/L	-71851	65	0.70	0.76	0.00	2.70
Nitrate + Nitrite – Unfiltered	mg/L as N	-630	129	0.33	0.49	0.02	4.30
Nitrate + Nitrite – Filtered	mg/L as N	-631	71	0.14	0.14	0.03	0.61
Nitrate - Filtered	mg/L as N	-618	70	0.15	0.17	0.00	0.60
Nitrite - Unfiltered	mg/L as N	-615	132	0.02	0.04	0.00	0.40
Nitrite - Filtered	mg/L	-71856	41	0.03	0.01	0.01	0.07
Nitrite - Filtered	mg/L as N	-613	37	0.01	0.00	0.00	0.02
Organic Nitrogen – Unfiltered	mg/L	-605	223	0.83	0.46	0.06	3.90
Organic Nitrogen – Filtered	mg/L	-607	14	0.53	0.33	0.32	1.50
Total Nitrogen - Unfiltered	mg/L	-600	190	1.15	0.73	0.13	8.40
Total Nitrogen – Unfiltered	mg/L as NO_3	-71887	128	5.09	3.83	0.60	37.00
Total Nitrogen – Filtered	mg/L	-602	13	0.89	0.27	0.62	1.60
pH -Unfiltered, Field	SU	-400	3,078	7.08	0.27	5.20	8.50
Phosphorus							
Orthophosphate – Unfiltered	mg/L as P	-70507	164	0.37	0.19	0.05	1.30
Orthophosphate – Filtered	mg/L	-660	111	0.80	0.41	0.00	3.20
Orthophosphate – Filtered	mg/L as P	-671	86	0.25	0.09	0.03	0.44
Phosphate - Unfiltered	mg/L	-650	172	1.11	0.57	0.15	3.99
Phosphorus – Unfiltered	mg/L as P	-665	236	0.37	0.19	0.09	1.50
Phosphorus - Unfiltered	mg/L as PO4	-71886	10	1.57	0.76	0.70	3.40
Phosphorus - Filtered	mg/L as P	-666	3	0.33	0.07	0.25	0.38
Potassium - Filtered	mg/L	-935	132	2.57	3.13	0.00	37.00
Sodium - Filtered	mg/L	-930	137	16.48	82.59	3.50	970.00
Solids							
Residue - Filtered, Sum of Constituents	mg/L	-70301	100	183.80	326.78	40.00	3360.00
Loss on Ignition from Residual on Evaporation –	mg/L	-505	6	49.83	24.51	29.00	94.00

Constituent or Parameter	Units	USGS Code	N	Mean	Standard Deviation	Minimum	Maximum
Unfiltered							
Residue on Evaporation at 105 Degr. C - Unfiltered	mg/L	-500	6	260.33	130.83	195.00	526.00
Residue on Evaporation at 105 Degr. C - Filtered	mg/L	-515	2	320.00	169.71	200.00	440.00
Residue on Evaporation at 180 Degr. C. - Filtered	mg/L	-70300	85	188.91	66.88	40.00	544.00
Residue Total - Non-filterable	mg/L	-530	8	3.75	4.74	1.00	15.00
Suspended Solids – Dried at 110 Degr. C	mg/L	-70299	25	3.64	2.20	0.00	8.00
Silica - Filtered	mg/L as SiO_2	-955	95	6.81	2.40	0.52	13.00
Specific Conductance - Unfiltered	µS/cm at 25 Degr. C	-95	3,374	244	168	48	6,200
Sulfate - Filtered	mg/L	-945	160	15.46	23.94	4.00	285.00
Temperature	Degr. C	-10	3,363	22.7	5.2	10.5	34.0
Transparency - Secchi Disc Depth	feet	-49701	32	2.3	0.4	1.6	3.0
Turbidity	NTU	-76	87	1.88	1.18	0.62	10.00
Zinc - Filtered	µg/L	-1090	20	27.05	27.97	0.00	120.00
Zinc - Filtered	µg/L	-1090	20	27.05	27.97	0.00	120.00

Unit codes: PCU = platinum cobalt units; col = colonies; SU = standard units; NTU = nephelometric turbidity units

[A] *Summary statistics for dissolved oxygen include 5 values of 0.2 mg/L that were reported as "<0.2 mg/L"*

Table 7-5. Summary statistics for water quality parameter or constituent data available as for the middle Hillsborough River available from the United States Geological Survey (USGS) as "Daily Data". Field measurements (number = N) were conducted between September 9, 2002 and January 19, 2009 at 4 fixed stations located between the City of Tampa Dam and the Fowler Avenue bridge (see Figure 6-7 – "Daily Data" not available for the Hillsborough River near Tampa, FL site). Samples at 3 of the sites include measurements from the top and bottom of the water column and sampling at Hillsborough River Site 3 Downstream from 56th St Near Tampa FL was limited to measurement of pH on 3 dates. USGS Code specifies constituent/parameter and analysis procedure.

Constituent or Parameter	Units	N	Mean	Standard Deviation	Minimum	Maximum
Temperature - Maximum	Degr. C	388	23.4	4.9	12.9	31.2
Temperature - Minimum	Degr. C	388	22.3	4.8	12.0	29.4
Specific Conductance - Maximum - Unfiltered	µS/cm at 25 Degr. C	388	322	82	139	469
Specific Conductance - Minimum - Unfiltered	µS/cm at 25 Degr. C	388	313	82	131	448
Dissolved Oxygen – Maximum	mg/L	385	5.53	3.15	0.90	13.80
Dissolved Oxygen – Minimum	mg/L	385	4.30	2.54	0.70	10.20
pH - Field - Maximum – Unfiltered	SU	115	7.16	0.26	6.70	8.40
pH - Field - Minimum - Unfiltered	SU	161	7.05	0.18	6.70	7.70

Unit codes: SU = standard units

Table 7-6. Summary statistics for "historic" water quality parameter or constituent data for the middle Hillsborough River available from the Southwest Florida Water Management District Water Management Information System. Field measurement or sample collection for each constituent/parameter (number = N) was conducted between February 13, 1996 and September 8, 2005 at 6 sites located between the City of Tampa Dam and the Fowler Avenue bridge (see Figure 7-2). Not all constituents/parameters were sampled at all 6 stations.

Constituent or Parameter	Units	N	Mean	Standard Deviation	Minimum	Maximum
Alkalinity	mg/L	160	114.50	32.71	0	163
Calcium	mg/L	162	57.03	18.63	13.9	114
Carbon						
Carbon - Total Organic	mg/L	170	13.73	10.91	0.3	37.1
Chloride	mg/L	158	23.55	25.61	6.5	187
Chlorophyll and Phaeophytin						
Chlorophyll - Total	µg/L	147	8.22	9.57	0.85	54.5
Chlorophyll a	µg/L	79	18.45	13.29	0.35	67.3
Chlorophyll b	µg/L	78	1.47	0.99	0	5.45
Chlorophyll c	µg/L	78	2.64	1.62	0.1	6.78
Phaeophytin	µg/L	148	6.14	6.33	0	25.3
Color	PCU	169	89	84	5	300
Dissolved Oxygen	mg/L	281	4.97	3.32	0.04	14.85
Fluoride	mg/L	167	0.19	0.09	0.02	0.446
Magnesium	mg/L	164	6.13	5.84	1.4	70.7
Nitrogen						
Ammonia (N)	mg/L	170	0.05	0.06	0.006	0.258
Nitrate - Nitrite (N)	mg/L	159	0.18	0.25	0.002	1.2
Nitrogen - Total	mg/L	17	0.97	0.36	0.1	1.47
Nitrogen - Total Kjeldahl	mg/L	142	0.89	0.54	0.11	2.31
pH	SU	285	7.38	0.54	6.46	8.67
Phosphorus						
Orthophosphate (P) (Dissolved)	mg/L	160	0.15	0.14	0.004	0.54
Phosphorus - Total	mg/L	170	0.20	0.14	0.022	0.57
Potassium	mg/L	164	2.55	1.73	0.55	21.5
Sodium	mg/L	164	17.29	45.72	4.13	572
Solids						
Residues- Filterable (TDS) (Dissolved)	mg/L	159	258.46	164.17	83	2009
Residues - Nonfilterable (TSS)	mg/L	165	5.16	4.57	1	43
Specific Conductance	µS/cm at 25 Degr. C	367	379	186	104	1,783
Sulfate	mg/L	158	41.36	34.78	3.2	150
Temperature	Deg. C	285	22.8	4.8	12.1	31.1
Total Depth	feet	147	7.4	4.2	1.3	20.7
Transparency - Secchi Disc Depth	feet	144	3.4	1.8	0	10.8
Turbidity	NTU	170	2.09	1.17	0.4	9.5

Unit codes: PCU = platinum cobalt units; SU = standard units; NTU = nephelometric turbidity units

Table 7-7. Summary statistics for "recent" water quality parameter or constituent data for the middle Hillsborough River collected by the Southwest Florida Water Management District. Field measurements (number = N) were obtained for 8 sampling events between July 17, 2008 and January 15, 2009 at up to 12 fixed sites located between the City of Tampa Dam and the Fletcher Avenue bridge (see Figure 7-3).

Constituent or Parameter	Units	N	Mean	Standard Deviation	Minimum	Maximum
Dissolved Oxygen	mg/L	301	5.82	2.82	0.34	12.60
pH	SU	301	7.06	0.59	6.08	8.27
Sample Depth	Degr. C	301	6.5	5.3	1.0	24.3
Specific Conductance	μS/cm at 25 Degr. C	301	385	65	224	546
Temperature	Degr. C	301	24.3	4.4	14.0	29.4
Transparency – Secchi Disc Depth	feet	62	3.8	1.4	1.6	10.2

Unit code: SU = standard units

Table 7-8. Summary of the total number of dissolved oxygen concentration values and the number with values <5.0 mg/L reported in the United States Geological Survey (USGS) and Southwest Florida Water Management District (SWFWMD) data sets examined for the middle river.

Source or Total	Data Set	N	N Less than 5 mg/L	Percentage Less than 5 mg/L
USGS	Field/lab water quality samples	3,338	2,586	77.5
USGS	Daily data – Minimum	385	235	61.0
USGS	Daily data – Maximum	385	183	47.5
SWFWMD	Historic	281	151	53.7
SWFWMD	Recent	301	114	37.9
Total	Combined	4,690	3,269	69.7

Table 7-9. Summary statistics by sampling event for "recent" water quality parameter or constituent data for the middle Hillsborough River collected by the Southwest Florida Water Management District. Field measurements (number = N) were conducted at up to 12 fixed sites located between the City of Tampa Dam and the Fletcher Avenue bridge (see Figure 7-3).

Sampling Event Dates	N	Temperature (Degr. C)	Dissolved Oxygen (mg/L)	Specific Conductance (µS/Cm at 25 Degr. C)	pH (SU)	N for Trans-parency	Trans-parency (Secchi Disc Depth in feet)
07/17&18/08	63	27.3 ± 1.3	5.4 ± 1.4	383 ± 55	6.78 ± 0.47	12	2.8 ± 0.6
07/30/08	33	27.1 ± 1.0	2.5 ± 2.1	291 ± 16	6.65 ± 0.19	4	3.2 ± 0.1
08/25/08	54	26.6 ± 0.5	2.9 ± 1.2	317 ± 13	6.45 ± 0.25	11	4.0 ± 0.8
10/02/08	44	26.1 ± 0.6	6.9 ± 2.4	406 ± 22	7.11 ± 0.32	10	4.3 ± 2.2
10/17/08	40	25.6 ± 0.4	6.6 ± 1.3	423 ± 23	7.31 ± 0.36	10	4.1 ± 1.5
12/03/08	30	16.3 ± 0.8	9.5 ± 1.1	456 ± 35	7.80 ± 0.15	7	4.2 ± 1.7
01/15/09	37	16.3 ± 0.9	8.6 ± 1.4	445 ± 47	7.90 ± 0.21	8	4.0 ± 1.4

Unit code: SU = standard units

Table 7-10. Summary statistics by site for "recent" water quality parameter or constituent site for the middle Hillsborough River collected by the Southwest Florida Water Management District. Field measurements (number = N) were conducted between July 17, 2008 and January 15, 2009 at up to 12 fixed sites located between the City of Tampa Dam and the Fletcher Avenue bridge (see Figure 7-3; note there is no site 5).

Site Number	N	Temperature (Degr. C)	Dissolved Oxygen (mg/L)	Specific Conductance (µS/Cm at 25 Degr. C)	pH (SU)	N for Trans-parency	Transparency (Secchi Disc Depth in feet)
1	13	22.3 ± 5.8	4.7 ± 2.3	353 ± 49	6.63 ± 0.57	2	4.1 ± 0.7
2	28	25.6 ± 0.4	5.2 ± 2.1	380 ± 44	6.58 ± 0.29	4	6.3 ± 3.5
3	15	23.9 ± 4.4	5.7 ± 3.7	367 ± 51	6.73 ± 0.58	5	3.2 ± 1.1
4	11	26.0 ± 0.5	5.0 ± 2.1	376 ± 41	6.55 ± 0.24	4	3.9 ± 0.9
6	30	23.2 ± 4.8	6.0 ± 3.2	367 ± 45	6.93 ± 0.61	1	3.3
7	20	23.1 ± 4.8	6.9 ± 2.9	376 ± 30	7.09 ± 0.61	6	5.1 ± 1.3
8	37	23.1 ± 4.8	6.2 ± 2.7	423 ± 53	7.19 ± 0.56	6	4.3 ± 1.3
9	28	25.0 ± 4.2	5.8 ± 3.2	383 ± 75	7.10 ± 0.57	6	3.9 ± 0.9
10	21	25.1 ± 4.8	6.8 ± 2.8	393 ± 69	7.39 ± 0.59	7	3.0 ± 0.8
11	23	24.7 ± 4.8	6.5 ± 3.0	396 ± 71	7.41 ± 0.58	7	3.2 ± 0.3
12	44	24.8 ± 4.4	4.8 ± 2.9	392 ± 76	7.13 ± 0.54	7	3.3 ± 0.5
13	37	24.6 ± 4.6	6.1 ± 2.3	367 ± 91	7.38 ± 0.46	7	3.2 ± 0.7

Unit code: SU = standard units

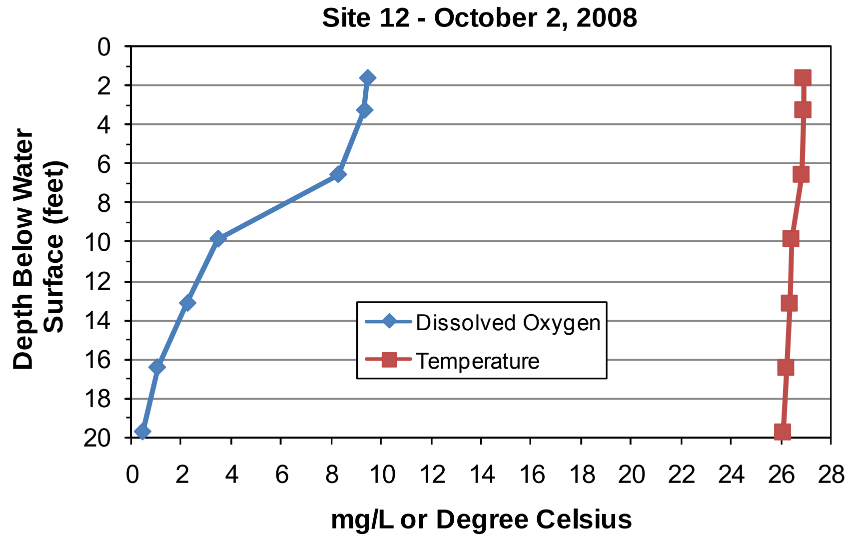


Figure 7-4. Dissolved oxygen concentration and temperature profile for the water column of the middle river on October 2, 2008 at Site 12 near the David L. Tippin Water Treatment Facility.

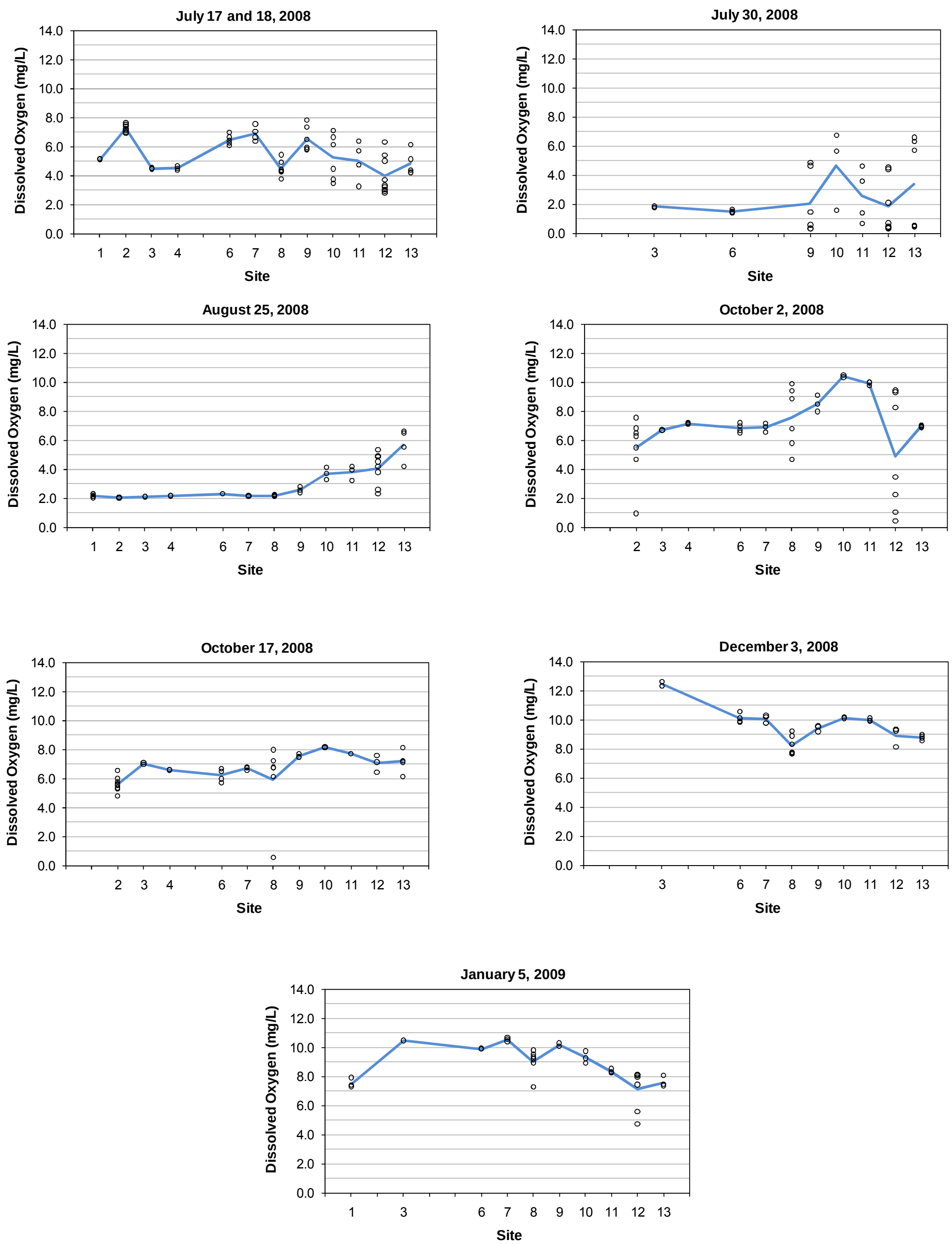


Figure 7-5. Dissolved oxygen concentrations in the middle Hillsborough River at up to 12 sites based on seven "recent" Southwest Florida Water Management District sampling events. Symbols show discrete measurements from ~1 foot below the water surface to ~ 1 foot above the river bed. Line connects mean values for each site. Site numbers correspond to locations shown in Figure 7-3; missing site labels indicate sites that were not sampled (note that there is no site 5).

Highlights of Chapter 7

All surface waters in Florida are classified according to present and future most beneficial uses and associated with class-specific water quality standards for selected physical and chemical parameters. Because the middle Hillsborough River is used as a drinking water source, the river segment from the City of Tampa Dam upstream to Flint Creek, and Cow House Creek are classified as a Class I waters, *i.e.*, potable water supplies. With regard to compliance with water quality standards, Section 303(d) of the Federal Clean Water Act requires each state to identify and list "impaired" waters where applicable water quality criteria are not being met after implementation of technology-based effluent limitations, and also requires development of Total Maximum Daily Loads (TMDLs) for the water bodies. Total Maximum Daily Loads are the amount of pollutant that a receiving water body can assimilate without causing violation of a pollutant-specific water quality standard.

Based on recent, draft 2008 updates to the list of impaired water bodied proposed by the Florida Department of Environmental Protection, the middle river, which is identified on the list as the “Hillsborough Reservoir” is impaired due to low dissolved oxygen concentrations and fish mercury levels. Cow House Creek is identified on the draft list as impaired because of low dissolved oxygen concentrations. Total phosphorus is also identified as a pollutant of concern for Cow House Creek. Upon development of TMDLs for the middle Hillsborough River, the Department will develop a Basin Management Action Plan (BMAP) for meeting the identified TMDLs. The BMAP will represent a set of strategies that address the activities, timeline and funding necessary for restoration of the impaired waters.

A number of studies have included assessments of the water quality of the middle river. The studies have been conducted to evaluate issues such as the use of copper for controlling nuisance algae, reconstruction of historic water quality conditions, nutrient loading to Tampa Bay, and classification of the upper Hillsborough as an Outstanding Florida Water. These studies were briefly summarized in this sub-section to further characterize water quality in the middle river.

Water quality for the river segment was characterized for the current study of the middle river using data available from the United States Geological Survey and Southwest Florida Water Management District. Mean pH values for the individual data sets examined ranged from 7.1 to 7.4, indicating that water in the impounded river segment is slightly basic. This likely reflects the substantial groundwater contributions from the upper river and the water sources used for augmentation of the river. Individual pH measurements less than 7.0, reflecting more acidic conditions, were not uncommon in the data examined, and in part, reflect the levels of organic acids and other molecules in the water that are derived from decomposition of plant material derived from the river floodplain. Phosphorus, nitrogen and chlorophyll concentrations, as well as measures of water transparency were indicative of eutrophic or hypereutrophic conditions in the middle river. Eutrophic and hypereutrophic water bodies are systems that are considered to have high or very high levels of biological productivity.

The Florida criterion for dissolved oxygen in Class I water bodies requires that dissolved oxygen concentrations shall not be less than 5.0 mg/L. This standard was commonly violated in the middle river. Based on the total of 4,690 dissolved oxygen concentration values reported in the combined data sets, approximately 70% of the 4,690 values were below the state standard. Examination of dissolved oxygen concentrations for the middle river included in the recent Southwest Florida Water Management District data set is useful for illustrating some of the issues associated with standard compliance determinations for this water quality constituent. Although the mean dissolved oxygen concentration of 5.8 mg/L for the 301 measurements in the data set was higher than the 5.0 mg/L state criterion, mean concentrations calculated for some sampling events and at some sample sites were lower than the standard. Dissolved oxygen concentrations lower than the state standard were likely the result of the effects of weather conditions on photosynthesis (a sampling event was conducted on a cloudy, rainy day), increased organic matter concentrations, which would increase oxygen demand and potentially reduce photosynthesis rates, or influx of oxygen-depleted water from the upper river or middle river floodplain swamps. Low dissolved oxygen levels at most sites were also evident in deeper waters, a common phenomenon associated with water density gradients that develop as a result of differential heating of the water column.

Chapter 8

Summary Findings and Management of the Middle Hillsborough River

Summary Findings – Middle Hillsborough River Setting and Description

As defined for this report, the "middle" river consists of an approximate 12.1 mile segment of the Hillsborough River from the City of Tampa Dam upstream to point where Fletcher Avenue crosses the river, the portion of the Harney Canal between the river and District water control Structure S-161, as well as the portion of Cow House Creek downstream from District Structure S-163. The City of Tampa Dam can be used to impound water in the river segment to an elevation of 22.5 feet above NGVD29. At water levels higher than this elevation, water spills over the dam to the lower Hillsborough River.

To support the current District study of the middle river, an updated bathymetric/ topographic data set was developed for the river segment. The data set was based on survey data collected in 2008 and elevation data from historic District aerial photography with contours maps. Analysis of the bathymetric/topographic data indicated that when the water level at the City of Tampa Dam is at 22.5 feet above NGVD29, the middle river extends over 734 acres and contains approximately 1.613 billion gallons of water.

Survey data from 231 cross-sections across Hillsborough River channel that were used for development of the new bathymetric/topographic data set were also used to develop an updated elevation profile of the river bottom or bed from the City of Tampa Dam to District Structure S-155, which is located upstream from the middle river. The survey data indicate that the lowest bed elevations for cross sections for much of the first few miles upstream from the dam range in elevation from 0 to 5 feet above NGVD29, although several cross-sections in this stretch of the river include minimum that were lower than 0 feet above NGVD29. One are included a river bed elevation 35.15 feet below NGVD29.

The highest bed cross-section minimum in the middle river was observed at a site approximately 400 feet upstream from the Fowler Avenue bridge. Higher cross-section minima were measured upstream from the middle river. The highest minimum, 19.11 feet above NGVD29, was measured at a cross-section approximately 1.5 miles upstream from the Fletcher Avenue bridge. The measured cross-section elevation minima suggest there is the potential for a backwater effect from the City of Tampa Dam to cause the pooling of water upstream to Structure S-155, given that all bed elevations were lower than the 22.5 feet above NGVD29 dam crest elevation.

Summary Findings – History of the Impounded Hillsborough River, Tampa Bypass Canal and Sulphur Springs

The segment of the Hillsborough River corresponding to the middle river has been impounded since the late 1890s. The impoundment created by previous dams or the currently existing dam was historically used for electricity generation and since the 1920s as a water supply. Flooding in 1933 led to the collapse of the then existing dam and in 1945 construction of the currently existing dam by the City of Tampa was completed.

Flooding in the Hillsborough River basin in 1960 precipitated construction of the Lower Hillsborough Flood Detention Area, Tampa Bypass Canal, Harney Canal and water control structures associated with these facilities. Construction of these flood control systems was initiated in the mid-1960s and continued through the early 1980s. They allow diversion of flood waters from the upper Hillsborough River away from the City of Temple Terrace and the City of Tampa for discharge to Tampa Bay.

The Lower Hillsborough Flood Detention Area, Tampa Bypass Canal, Harney Canal and associated structures were originally developed for flood control purposes, although management goals for the systems have expanded to include water storage and supply, natural system protection and recreational use. Water from the Tampa Bypass Canal and Harney Canal is used to augment the middle river for water supply purposes. Water pumped from Sulphur Springs, an artesian spring located downstream from the middle river is also used to augment the middle river.

Summary Findings – Water Budget Concepts and Parameters for the Middle River

Inflow to the middle river was conservatively estimated by summing discharge records available for three upstream gauge sites ranged from 41 to 602 million gallons per day from 1975 through 2008. Annual outflow from the middle river at the City of Tampa Dam ranged from 6.2 million gallons per day up to 1.13 billion gallons per day and averaged 227.3 million gallons per day for the period from 1939 through 2008, indicating that inflows to the middle river higher than observed from 1975 through 2008 were likely to have occurred.

The middle river has been augmented with water from Sulphur Springs since the mid-1960s and from the Tampa Bypass Canal/Harney Canal system since the mid-1980s (although some water was pumped from the canal to the river in the early 1980s). District regulation of augmentation with water from Sulphur Springs began in 1983 following issuance of a Consumptive Use Permit to the City of Tampa. Regulation of augmentation with water from the Tampa Bypass Canal/Harney Canal system was authorized beginning in 1983 when a Consumptive Use Permit was issued to the West Coast Regional Water Supply Authority (now known as Tampa Bay Water). For the period from 1984 through 2007 the combined volume of water pumped from Sulphur Springs and the Tampa Bypass Canal/Harney Canal system ranged from 0 to 32.5 million gallons per day and averaged 9.5 million gallons per day. Augmentation of the middle river with water pumped from Sulphur Springs and the Tampa Bypass Canal has increased water levels in the middle river by approximately 1.1 to 1.7 feet.

Use of the middle river as a water supply by the City of Tampa was initiated in the 1920s, but the District did not begin regulating withdrawals from the river until 1976, shortly after the Florida Legislature identified the need for state-wide water use permitting. The original Consumptive Use Permit (Number 2062) allowed withdrawal of an annual average volume of 67.1 million gallons per day from the impounded river. The current permit limits daily withdrawals on an annual average to 82 million gallons per day. From 1946 through 2007, daily withdrawals on an annual basis have ranged from 15 million gallons per day to 79.4 million gallons per day. Pumpage records available through November 2008 indicate that approximately 71.7 million gallons per day was withdrawn from the river last year.

Since 1999, Tampa Bay Water has been authorized to divert up to 194 million gallons per day from the middle Hillsborough River to the Tampa Bypass Canal through the Harney Canal and Structure S-161, and also allows the withdrawal of up to 258 million gallons per day from the Middle and Lower pools of the canal for regional use. Diversions from the river to the canal system area limited to periods when discharge at the City of Tampa Dam exceeds 65 million gallons per day. Daily average discharge from the middle river for 2002 through 2007 ranged from 4.7 to 110.4 million gallons per day.

Relatively long-term sets of water level records are available for three gauge sites on the middle river; at the dam, near the Harney Canal and at Fowler Avenue. Water level records are also available for a shorter time period at a site just upstream from the middle river, near Fletcher Avenue. Comparison of water level measurements made on the same day indicated that water levels at the dam upstream to the Harney Canal area are relatively comparable indicating the surface of the pooled water in this segment of the middle river is typically relatively “flat”. Comparisons of water levels at the dam and at the gauge sites at Fowler Avenue and near Fletcher Avenue indicate that during periods of high inflow from the upper river, water levels at the upstream gauges may be substantially higher than at the dam. The data also indicate that under certain conditions, *e.g.,* during periods of low to moderate inflows from the upper river, the water surface of the middle river is relatively “flat” from the dam upstream to Fletcher Avenue. Review of water level records and recently collected cross-section survey data indicated that when the water level at the dam recedes below 18 to 18.2 feet above NGVD29 water levels at the upstream sites may deviate from the water level at the dam.

Summary Findings – Comparison of Water Level Fluctuations in the Middle River and Other Florida Water Bodies

Review of time-series plots of water surface elevations in the middle Hillsborough River at the City of Tampa Dam and at other river gauge sites in west-central Florida indicated substantial differences between the hydrologic regime of the middle river and the other sites. Water levels at all of the river gauge sites except the middle river site exhibited spikes or rapid increases and decreases above a relatively flat or stable lower water level. The hydrograph for the middle river site appeared to be a mirror-image of the hydrographs for the other river gauge sites. In contrast to the relatively stable base-flow condition evident for the lower water levels in the other hydrographs examined, the middle river site exhibited a relatively stable high-water condition. This phenomenon is, of course, a function of the elevation at which water is discharged over or across the City of Tampa dam and the augmentation of the river segment. The fluctuation range defined by the difference between maximum and minimum daily water levels for the middle river site was 7.09 feet, and was lower than the range (9.06 to 19.35 feet) observed at each of the other 15 river gauge sites.

The time-series plot of middle river water levels was much more similar to that of reservoirs located throughout the state. The range between maximum and minimum monthly mean water levels in the middle Hillsborough River during an evaluation period from January 1985 through May 2008 was 5.03 feet and was less than the median fluctuation range calculated for 14 Florida reservoirs evaluated (6.37 feet) and was also less than the fluctuation range calculated for the 8 reservoirs that are used for water supply purposes (6.02 feet).

Concordance between water level fluctuations in the middle river at the City of Tampa Dam and at fluctuations at twelve area lakes was intermediate between that of the middle river fluctuations and the various river gauge sites and reservoirs within the state Rising and falling water levels, presumably reflecting rainfall patterns, were clearly evident in the lake and middle river hydrographs, although the stability of peak levels in for the middle river which was associated with discharge across the City of Tampa Dam, was not evident in the lake level time-series plots. The range between maximum and minimum monthly mean water levels in the middle Hillsborough River (5.03 feet), was less than the median fluctuation range calculated for the full set of lakes, 6.5 feet, and was also less than the median of 6.05 feet calculated for the lakes when the two lakes that are known to be impacted by water withdrawals excluded.

Similarities in the hydrographs of the middle Hillsborough River, Florida reservoirs and area lakes indicated that it may be appropriate to consider water level fluctuations in the middle river analogous to those occurring in lakes.

Summary Findings – Minimum Flows and Levels Criteria and the Middle River

The District has established minimum flows and levels for numerous water bodies in the Hillsborough River watershed, including 21 cypress wetlands, 9 lakes, a portion of the Upper Floridan Aquifer system, the upper Hillsborough River, Crystal Springs and the lower Hillsborough River. Because minimum flows or levels are not being met in some of these systems, a regional recovery strategy for the northern Tampa Bay area and a site-specific recovery strategy for the lower Hillsborough River are currently being implemented to achieve compliance with the minimum flows and levels.

State law pertaining to establishment of minimum flows and levels and the District's Water Levels and Rates of Flow rules include sections that are relevant to determining whether minimum flows and levels rules are applicable to the middle Hillsborough River. State law includes provisions for excluding certain water bodies from the minimum flows and levels establishment requirement. In addition District rules state that no guidance levels shall be prescribed for the "City of Tampa Reservoir" and several other regional impoundments used for water supply purposes. Based on these sections of state law and District rules, the District has not pursued adoption of minimum flows and levels for the middle Hillsborough River. This management decision was and is based on: 1) the stipulation in previous versions of District rules that management levels were not to be developed for the middle river and other impoundments used for water supply purposes; 2) the stipulation in current District rules that guidance levels are not to be developed for the middle river and other impoundments used for water supply purposes; 3) consideration of the river segment as a water body constructed prior to the requirement for a permit; and 4) judgment that the system is not expected to experience adverse impacts or significant harm associated with water withdrawals.

Review of District rules that may be relevant to the middle Hillsborough River led to identification of a few potential rule changes that could be implemented to improve clarity and therefore improve regulatory activities associated with the rules. First, it would be useful to clarify District intent regarding establishment of minimum flows and levels for the middle river and other impoundments used for water supply purposes. To accomplish this goal, Rule 40D-8.031(2), F.A.C., which currently indicates that no guidance levels be established for several water bodies, including the City of Tampa Reservoir, could be amended to indicate that no minimum flows, minimum levels or guidance levels should be established for the middle river and the other impoundments identified in the rule. Also to more clearly identify the middle Hillsborough River, the reference in the rule to the "City of Tampa Reservoir on the Hillsborough River in Hillsborough County" could be changed to the "City of Tampa Reservoir on the Middle Hillsborough River". Another potential rule change concerning the middle river would involve revision of the definition of the lower Hillsborough River included in Rule 40D-80.041(1)(a), F.A.C. The segment is currently defined in the rule as the river downstream of Fletcher Avenue. This reference could be changed to indicate that the lower Hillsborough River is the river segment downstream from the dam on the City of Tampa's Reservoir.

Although unrelated to the middle river, it may also be appropriate to amend District rules to include Shell Creek Reservoir in Charlotte County among the impoundments for which minimum flows, minimum levels and guidance levels are not to be developed. This action would require inclusion of the Shell Creek Reservoir in Rule 40D-8.031(2), F.A.C. Also unrelated to the middle river, but potentially useful for regulatory activities, would be an amendment to Rule 40D-8.031(1) to indicate that no minimum flows, minimum levels or guidance levels be established for reservoirs or other artificial structures located entirely on lands owned, leased, or otherwise controlled by a user.

The applicability of District methods for establishing minimum flows and levels was evaluated with respect to the middle river and application of the method used for establishing minimum levels for lakes with fringing cypress wetlands was found to be the most appropriate. Following development of a provisional significant change standard for the river based on protecting the integrity of cypress wetlands, the appropriate methods were applied and permitted identification of two provisional minimum levels; a High Minimum Lake Level at 22.3 feet above NGVD29 and a Minimum Lake Level at 20.9 feet above NGVD29. The Minimum Lake Level is an elevation that a lake's water levels must equal or exceed 50% of the time, on a long-term basis. The High Minimum Lake Level is the elevation that must be equaled or exceeded 10% of the time. Comparison of these provisional levels with measured water surface elevations recorded at the City of Tampa Dam indicated that the levels have been met for an evaluation period of 1985 through 2008.

Significant change standards that are developed when establishing minimum levels for lakes that lack fringing cypress wetlands were also examined for the middle river. Provisional standards were developed to identify median water levels that protect species richness, ensure natural patterns of water column mixing, maintain connectivity within the basin, protect aesthetics, preserve recreational use of the lake for waterskiing, maintain specified water depths at the end of docks, and protect herbaceous wetlands. In all cases except the provisional standard developed for dock-use, measured water levels in the middle river from 1985 through 2008 exceeded the elevations associated with the provisional standards more than 50% of the time.

The provisional dock-use standard was not considered appropriate for consideration for the middle river because the elevation associated with the standard, 24.4 feet above NGVD29, was higher than the monthly mean water surface elevations determined for the middle river and used for the minimum lake level analyses. Although the dock-use standard was not considered appropriate for the middle river, an analysis of mean river bed elevations at the end of existing docks for various sub-segments of the middle river indicated that a two-foot water depth requirement at the end of the docks was met over 86% of the time for the period from 1985 through 2008.

Summary Finding – Water Quality of the Middle River

All surface waters in Florida are classified according to present and future most beneficial uses and associated with class-specific water quality standards for selected physical and chemical parameters. Because the middle Hillsborough River is used as a drinking water source, the river segment from the City of Tampa Dam upstream to Flint Creek, and Cow House Creek are classified as a Class I waters, *i.e.*, potable water supplies. With regard to compliance with water quality standards, Section 303(d) of the Federal Clean Water Act requires each state to identify and list "impaired" waters where applicable water quality criteria are not being met after implementation of technology-based effluent limitations, and also requires development of Total Maximum Daily Loads (TMDLs) for the water bodies. Total Maximum Daily Loads are the amount of pollutant that a receiving water body can assimilate without causing violation of a pollutant-specific water quality standard.

Based on recent, draft 2008 updates to the list of impaired water bodied proposed by the Florida Department of Environmental Protection, the middle river, which is identified on the list as the "Hillsborough Reservoir" is impaired due to low dissolved oxygen concentrations and fish mercury levels. Cow House Creek is identified on the draft list as impaired because of low dissolved oxygen concentrations. Total phosphorus is also identified as a pollutant of concern for Cow House Creek. Upon development of TMDLs for the middle Hillsborough River, the Department will develop a Basin Management Action Plan (BMAP) for meeting the identified TMDLs. The BMAP will represent a set of strategies that address the activities, timeline and funding necessary for restoration of the impaired waters.

A number of studies have included assessments of the water quality of the middle river. The studies have been conducted to evaluate issues such as the use of copper for controlling nuisance algae, reconstruction of historic water quality conditions, nutrient loading to Tampa Bay, and classification of the upper Hillsborough as an Outstanding Florida Water. These studies were briefly summarized in this sub-section to further characterize water quality in the middle river.

Water quality for the river segment was characterized for the current study of the middle river using data available from the United States Geological Survey and Southwest Florida Water Management District. Mean pH values for the individual data sets examined ranged from 7.1 to 7.4, indicating that water in the impounded river segment is slightly basic. This likely reflects the substantial groundwater contributions from the upper river and the water sources used for augmentation of the river. Individual pH measurements less than 7.0, reflecting more acidic conditions, were not uncommon in the data examined, and in part, reflect the levels of organic acids and other molecules in the water that are derived from decomposition of plant material derived from the river floodplain. Phosphorus, nitrogen and chlorophyll concentrations, as well as measures of water transparency were indicative of eutrophic or hypereutrophic conditions in the middle river. Eutrophic and hypereutrophic water bodies are systems that are considered to have high or very high levels of biological productivity.

The Florida criterion for dissolved oxygen in Class I water bodies requires that dissolved oxygen concentrations shall not be less than 5.0 mg/L. This standard was commonly violated in the middle river. Based on the total of 4,690 dissolved oxygen concentration values reported in the combined data sets, approximately 70% of the 4,690 values were below the state standard. Examination of dissolved oxygen concentrations for the middle river included in the recent Southwest Florida Water Management District data set is useful for illustrating some of the issues associated with standard compliance determinations for this water quality constituent. Although the mean dissolved oxygen concentration of 5.8 mg/L for the 301 measurements in the data set was higher than the 5.0 mg/L state criterion, mean concentrations calculated for some sampling events and at some sample sites were lower than the standard. Dissolved oxygen concentrations lower than the state standard were likely the result of the effects of weather conditions on photosynthesis (a sampling event was conducted on a cloudy, rainy day), increased organic matter concentrations, which would increase oxygen demand and potentially reduce photosynthesis rates, or influx of oxygen-depleted water from the upper river or middle river floodplain swamps. Low dissolved oxygen levels at most sites were also evident in deeper waters, a common phenomenon associated with water density gradients that develop as a result of differential heating of the water column.

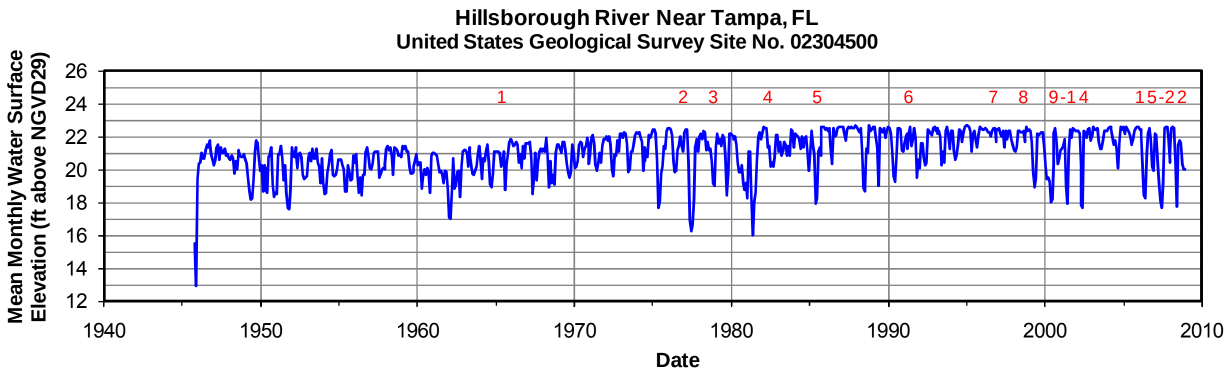
Water Management Activities and Middle River Water Levels

As described throughout this report, the middle Hillsborough River has been managed to meet societal needs for more than a century. Figure 8-1 highlights actions that have been undertaken by the District or other governmental organizations during the past forty plus years to promote higher water levels and storage of water in the river segment.

From the mid-1960s when water was first pumped from Sulphur Springs to the river upstream from the City of Tampa Dam, through 2008, when an Executive Director Order was issued to allow increased pumping of water from the Tampa Bypass Canal / Harney Canal system to the river, augmentation has been used to increase water levels in the middle river. Sources used for augmentation have not been limited to Sulphur Springs and the Tampa Bypass / Harney Canal system – in 2000, water from Morris Bridge Sink was also used to augment the middle river.

The District's issuance of the first water-use permit to the City of Tampa in 1976 for withdrawals from the middle river marked a milestone in regulatory activities that affect water levels in the river. Revisions to this permit and the subsequent permitting of withdrawals from Morris Bridge Well Field and the storage of water in aquifer storage and recovery wells by the City of Tampa have also had a direct impact on maintaining water levels in the river segment.

Establishment of minimum flows and levels for the Hillsborough River has also played a role in enhancing water levels in the middle river. Adoption of minimum flows for the lower Hillsborough River, Sulphur Springs and the Tampa Bypass Canal in 2007 and the adoption of a recovery strategy for the lower Hillsborough River initiated development of a number of projects that will increase flows to the lower river and in some cases enhance water levels in the middle river. The adoption of minimum flows for the upper Hillsborough River and Crystal Springs in 2007 also afforded protection to the middle river. Compliance with the required flows in the upper watershed will ensure flows to the middle river and thereby promote increased water levels in the impounded river segment. Although not noted in Figure 8-1, establishment of minimum flows and levels for the underlying aquifer system and numerous lakes and wetland in or within the vicinity of the Hillsborough River watershed also enhances water levels in the middle river by establishing limits on water use in the region. Similarly, the regional recovery strategy being implemented to recovery flows and levels in some of these systems promotes increased ground water levels which may be directly associated with increased flows and levels in all segments of the Hillsborough River.



1	1964 or 65	Augmentation of the middle river with water from Sulphur Springs initiated
2	1976-Dec	First water-use permit issued to City of Tampa for middle river withdrawals
3	1978	Morris Bridge Well Field becomes operational
4	1982	Tampa Bypass Canal system completed
5	1985	Augmentation initiated with water from the Tampa Bypass Canal system
6	1991	Permanent pumping facility constructed for augmentation with water from the Tampa Bypass Canal system
7	1996-Sep	Aquifer Storage and Recovery system initiated by City of Tampa
8	1998-May	Tampa Bay Water formed; Parternship Agreement capped withdrawals from middle river at 82 million gallons per day
9	2000-Apr	Executive Director Order No. SWF 00-16 authorized increased augmentation with water from the Tampa Bypass Canal system
10	2000-Apr	Executive Director Order No. SWF 00-17 authorized increased augmentation with water from Sulphur Springs
11	2000-May	Executive Director Order No. SWF 00-26 authorized augmentation with water from Morris Bridge Sink
12	2000-Aug	Minimum levels and recovery strategy adopted for lower Hillsborough River
13	2000-Nov	Executive Director Order No. SWF 00-57 authorized augmentation with water from Morris Bridge Sink
14	2000-Nov	Executive Director Order No. SWF 01-22 authorized increased augmentation with water from Sulphur Springs
15	2006-May	Executive Director Order No. SWF 06-31 authorized increased augmentation with water from Tampa Bypass Canal system
16	2006-May	Executive Director Order No. SWF 07-3 authorized increased augmentation with water from Tampa Bypass Canal system
17	2007-Aug	Revised minimum flows adopted for lower Hillsborough River; minimum flows adopted for Sulphur Springs, Tampa Bypass Canal; Recovery Strategy for lower river also adopted
18	2007-Dec	Minimum flows adopted for upper Hillsborough River and Crystal Springs
19	2008-Jan	Pumping from Tampa Bypass Canal initiated as part of Lower Hillsborough River Recovery Strategy
20	2008-Oct	Executive Director Order No. SWF 08-043 authorized increased augmentation with water from the Tampa Bypass Canal system
21	2008-Oct	Tampa Bypass Canal Middle Pool pipeline study completed
22	2008-Dec	Executive Director Order No. SWF 08-043 amended for increased augmentation with water from Tampa Bypass Canal system

Figure 8-1. Timeline of major management activities concerning the middle Hillsborough River shown with mean monthly water levels of the river at the City of Tampa Dam.

Chapter 9

Recommendations

Based on review of previous studies and the new results presented in this report, a few recommendations were developed to enhance District management activities associated with the middle Hillsborough River. The recommendations include modifications to exiting rules concerning the middle and lower segments of the Hillsborough River and evaluation of management activities that may be implemented to allow increased augmentation of the river with water from the Tampa Bypass Canal / Harney Canal system. Recommendations are listed below.

1. Modify selected sections of the District's Water Levels and Rates of Flow rules to clarify references to the impounded river upstream of the City of Tampa Dam and to revise the definition of the lower Hillsborough River.

   Rule 40D-8.031(2), F.A.C., which addresses implementation of minimum flows and levels, stipulates that the District shall not prescribe guidance levels for the 'City of Tampa Reservoir on the Hillsborough River in Hillsborough County" and several other impoundments used for water supply purposes. It is recommended that the rule be amended to replace the phrase 'City of Tampa Reservoir on the Hillsborough River in Hillsborough County" with the "City of Tampa Reservoir on the Middle Hillsborough River".

   Rule 40D-8.041(1)(a), F.A.C, which addresses minimum flows for the lower Hillsborough River, defines the lower river as the river segment downstream from Fletcher Avenue. It is recommended that language in this rule be modified to indicate that the lower Hillsborough River is the segment of the river downstream from the City of Tampa Dam.

   Rule 40D-8.041(3)(a), F.A.C., which addressed minimum flows for Sulphur Springs includes a reference to the "Hillsborough River reservoir". It is recommended that this phrase be changed to "City of Tampa Reservoir on the Middle Hillsborough River".

2. Modify existing language in the District's Water Levels and Rates of Flow rules to indicate that minimum flows, minimum levels or guidance levels will not be established for the middle Hillsborough River.

   Rule 40D-8.031(2), F.A.C. currently stipulates that the District shall not prescribe guidance levels for the "City of Tampa Reservoir on the Hillsborough River in Hillsborough County" and several other impoundments used for water supply purposes. It is recommended that Rule 40D-8.031(2), F.A.C. be amended to indicate that no minimum levels, guidance levels or minimum flows shall be prescribed for the "City of Tampa Reservoir on the Hillsborough River" and the other water bodies identified in the rule.

Although unrelated to the middle Hillsborough River, it may also be appropriate to amend District rules to include Shell Creek Reservoir in Charlotte County among the impoundments for which minimum flows, minimum levels and guidance levels are not to be developed. It may also be useful to amend the rule section pertaining to establishment of guidance levels for reservoirs or other artificial structures located entirely on lands owned, leased, or otherwise controlled by a user. Based on these goals, it is recommended that Rule 40D-8.031(2), F.A.C. be amended to include Shell Creek Reservoir in Charlotte County. It is also recommended that Rule 40D-8.031(1) be amended to indicate that no minimum flows, minimum levels or guidance levels shall be prescribed for any reservoir or other artificial structure meeting the requirements specified in the rule.

3. Review permit conditions or limits placed on augmentation of the middle river with water from the Tampa Bypass Canal / Harney Canal system to determine whether additional augmentation may be possible.

Water Use Individual Permit (Number 20006675.005) issued to Tampa Bay Water authorizes augmentation of the middle river with water from the Tampa Bypass Canal. The permit allows an annual average withdrawal of up to 20 million gallons per day and a peak monthly rate of 40 million gallons per day from the canal system for augmentation of the river. Augmentation is permitted when the middle river water surface is below 22.50 feet above NGVD29, the crest gates and the two Tainter gates on the City of Tampa Dam are closed and the flow in the Hillsborough River at the Morris Bridge gauge site is less than the withdrawal rate from the middle river at the City of Tampa's David L. Tippin Water Treatment Facility. Augmentation must cease when the water surface elevation in the Harney Canal at Structure S-161 is at or below 12 feet above NGVD29; or the difference in water surface elevation on either side of the S-161 structure is 10 feet or greater; or the water level in the middle river equals or exceeds 22.5 feet above NGVD29.

In response to recent drought conditions, Executive Orders have been issued to temporarily modify permit conditions and allow for additional augmentation of the middle river. Modifications have included allowing daily withdrawals of up to 40 million gallons per day, and allowing augmentation to proceed when the difference in water levels on either side of Structure S-161 and the water surface elevation in the canal system exceed conditions or limits identified in the permit.

It is recommended that staff investigate the potential for continued or additional modification of permit conditions associated with augmentation of the middle river with water from the Tampa Bypass Canal / Harney Canal system. For example, it may be reasonable to review the requirement that augmentation may commence only when the river flow at the Morris Bridge gauge is less than the withdrawal from the middle river at the City's water treatment facility. Additional ground water modeling for the area may also be undertaken to further evaluate permit requirements or limits associated with required water surface elevations in the canal system.

4. Continue to monitor water levels and other physical or chemical attributes of the middle Hillsborough River.

   Rule 40D-80.073(4)(h), F.A.C., requires the District to monitor and evaluate the effect of the lower Hillsborough River recovery strategy on water levels in the river upstream from the City of Tampa Dam to at least Fletcher Avenue. It is recommended that the District continue to monitor water levels in the middle river and to also continue collection or measurement of selected water quality parameters or constituents, including dissolved oxygen concentrations, specific conductance, pH, and water transparency.

5. Institute field-verification efforts regarding bathymetric/topographic data for the middle Hillsborough River.

   Recent survey data for river bottom elevations in the middle Hillsborough River identified several relatively deep depressions. It is recommended that these sites be visited for verification of reported elevation values. For improvement of bathymetric/topographic data sets developed for the middle river, it is also recommended that spot elevations be obtained for some areas where data are sparse. For example, it may be reasonable to make additional elevation measurements in wetland areas at various points along the river segment.

Chapter 10

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Appendix A

Minimum Flows and Levels Recovery and Prevention Strategies for the Northern Tampa Bay Area

RULES OF THE
SOUTHWEST FLORIDA WATER MANAGEMENT DISTRICT
CHAPTER 40D-80
RECOVERY AND PREVENTION STRATEGIES
FOR MINIMUM FLOWS AND LEVELS

40D-80.011 Policy and Purpose.
40D-80.073 Regulatory Portion of Recovery Strategy for Pasco, Northern Hillsborough and Pinellas Counties.
40D-80.074 Regulatory Portion of Recovery Strategy for the Southern Water Use Caution Area

40D-80.011 Policy and Purpose.
This Chapter sets forth the regulatory portions of the recovery or prevention strategies to achieve or protect, as applicable, the Minimum Flows and Levels established for rivers, lakes, wetlands and aquifers in Chapter 40D-8, F.A.C., as required by Section 373.0421(2), Florida Statutes, (1997). The complete prevention or recovery strategy for a given area will be set forth in the District Water Management Plan. The complete prevention or recovery strategy may include, but not be limited to, water resource supply and development projects and funding assistance, environmental restoration projects, conservation programs and water shortage plans. In areas where existing flows or levels are below, or projected to fall within 20 years below, the applicable Minimum Flow or Level, the District is expeditiously implementing a prevention or recovery strategy for those waters with the intent to prevent water flows and levels from falling below, or to achieve recovery to the established Minimum Flow or Level as soon as practicable, whichever is applicable. This Chapter comprises a portion of that strategy.

Specific Authority 373.0361, 373.044, 373.113, 373.171 F.S. Law Implemented 373.0361, 373.0395, 373.042, 373.0421, 373.171 F.S. History – New 8-3-00.

40D-80.073 Regulatory Portion of Recovery Strategy For Pasco, Northern Hillsborough and Pinellas Counties.
(1) Background.
Chapter 96-339, Laws of Florida, requires the District to establish Minimum Flows and Levels for priority waters within Pasco, Hillsborough and Pinellas Counties by October 1, 1997. The District has so established Minimum Flows and Levels within Pasco, Hillsborough North of State Road 60, and Pinellas Counties (the "Northern Tampa Bay Area" or "Area"). Those Minimum Flows and Levels are contained within Chapter 40D-8, F.A.C. In establishing those Flows and Levels, the District has determined that the existing water levels in many of the priority waters are below the Minimum Flows or Levels. This section sets forth the regulatory portion of the first phase of the Recovery Strategy for the Area.

(2) Objective of Recovery Strategy.

(a) All water use permittees within the Area are addressed by this Rule 40D-80.073, F.A.C. However, Tampa Bay Water (formerly known as the West Coast Regional Water Supply Authority), Pinellas County, Pasco County, the City of New Port Richey, Hillsborough County, the City of Tampa, and the City of St. Petersburg, the last six listed referred to as "Member Governments," water supply facilities account for the majority of water withdrawals within the Area. For this reason, these facilities are the primary focus of the portion of the recovery strategy encompassed by this Rule 40D-80.073, F.A.C. Those facilities are the following wellfields: Cosme-Odessa, Eldridge-Wilde, Section 21, South Pasco, Cypress Creek, Cross Bar Ranch, Starkey, Morris Bridge, Northwest Hillsborough Regional, Cypress Bridge, and North Pasco, (the "Central System Facilities"). Other users' water withdrawals result in relatively minimal water resource impacts, and they are addressed in 40D-80.073(5), F.A.C.

(b) While the Area has recently seen cyclical low levels of precipitation, the predominant cause of the lowered surficial water table in the vicinity of the Central System Facilities is the ground water withdrawals from the Central System Facilities. As a result, in the vicinity of the Central System Facilities, wetlands and lakes have been and continued to be impacted by reduced water levels, including wetlands and lakes for which minimum wetlands and lake levels have been established. Recovery to Wetland and Lake Minimum Levels for wetlands and lakes described in and established in 40D-8.623(3), Table 8-1 and 40D-8.624(12), Table 8-2, F.A.C., is the objective of this Rule 40D-80.073, F.A.C. This portion of the Recovery Strategy for the Area is effective through December 31, 2010.

(3) Recovery Strategy Elements for Tampa Bay Water and Member Governments.

(a) The District and Tampa Bay Water ("TBW") and Member Governments have entered into the Northern Tampa Bay New Water Supply and Ground Water Withdrawal Reduction Agreement (the "Agreement"). The Agreement constitutes that portion of the District's recovery strategy that is specifically applicable to the Central System Facilities as provided for in Sections 373.036, 373.0361, 373.0421(2), 373.0831 and 373.1963, Florida Statutes. The Agreement governs the development of new water supplies, reduction of pumpage, litigation and administrative hearings between the District, TBW and its Member Governments and the District's financial assistance to the TBW to achieve new water supplies and reduction of pumpage at the Central System Facilities all of which contribute to the attainment of the objective of this portion of the recovery strategy. The Agreement makes available to TBW from the District $183,000,000.00 to be used for new water supply development projects excluding ground water sources and including alternative sources of potable water and regionally significant transmission pipelines. Independently, the Tampa Bay Water Master Water Plan provides for the development of at least 85 million gallons per day (mgd) annual average daily quantity of additional water supply sources and partially offsets additional water supply needs for growth by increased conservation and demand management.

(b) Recovery Management.

The pumping reductions required under the Agreement shall be implemented by the TBW and Member Governments as specified below as the principal means of achieving the objective of this Rule 40D-80.073, F.A.C. Additionally, the Floridan Aquifer Recovery Management Levels set forth in Table 80-1 below shall be used as long-term guidelines for allocating withdrawals within the Operations Plan, submitted to the District by TBW pursuant to the Agreement, and shall be reevaluated in 2010. The Floridan Aquifer Recovery Management Levels are based on the hydrogeologic properties and environmental conditions in the Northern Tampa Bay Area, and are set to advise and guide in determining planned ground water withdrawal rates in 2007, but not as the sole basis by which the District will approve or disapprove the operations plan and its amendments.

Table 80-1 Floridan Aquifer Recovery Management Levels			
Well Name	Latitude	Longitude	Recovery Management Levels (feet NGVD)
1. RMP8D1	280342	823256	26.8
2. PZ-3	281446	823342	40.5
3. Cosme 3	280608	823529	27.6
4. SR 52 and 581	281926	822129	73.3
5. Morris Bridge 1	280652	822042	28.2
6. James 11	280653	823415	33.1
7. Morris Bridge 13	280656	821751	30.1
8. Berger	280700	822942	44.5
9. Hillsborough 13	280703	823027	40.3
10. Wolfe	282305	823015	52.0
11. Debuel	280741	822709	55.4
12. DGW-4	280829	822008	43.7
13. Calm 33A	280834	823435	33.2
14. EW11	280905	823905	16.2
15. Lutz Park	280913	822832	56.8
16. Lutz Lake Fern	280921	822230	43.4
17. EW N4	280945	823804	27.6
18. EW 2N	281011	823905	18.9
19. MW2-1000	281019	822114	58.7
20. SP42	281036	823056	47.7
21. Matts	281102	822924	60.1
22. Starkey 707	281454	823802	27.6
23. SR54	281144	823046	49.6
24. DMW500	281204	822238	51.0
25. Starkey Regional	281312	823616	32.6
26. MW1	281447	823542	31.6
27. Pasco 13	281559	822645	72.5
28. NPMW-11	281631	823411	41.0
29. TMR4D	281650	822444	58.3
30. TMR1D	281719	822246	61.1
31. TMR3D	281745	822342	59.5
32. NPMW-7	281825	823405	44.1
33. TMR-2	281845	822240	68.5
34. SR52 East	281918	822645	73.1
35. SR52 West	282010	823737	51.9
36. SRW	282035	822839	69.3
37. CB1SED	282100	822628	71.3
38. SERW	282206	822711	63.7
39. CB3ED	282221	822419	69.1
40. Citrus Park	280437	823426	29.4

(c) Periodic Review of Recovery Strategy.

1. The District shall review the recovery strategy periodically to assess the progress of strategy elements. The District will evaluate the water resource recovery attained in light of the reductions in quantities withdrawn achieved based on an evaluation of whether wetland and lake stage-frequency data indicate that wetland and lake water levels are improving.

2. These reviews shall consider reports generated by the TBW and the Member Governments describing the status of all additional sources either developed or in development to offset water withdrawals from Central System Facilities as well as any other water supply and water resource information available to the District.

3. The information considered by the District pursuant to subparagraphs (c)1. and 2. above is intended to be also considered during preparation of the update pursuant to Section 373.036, F.S., which is due in 2003, of the District's Water Management Plan as it relates to the water supply assessment for the West-Central Planning Region.

(4) Hillsborough River Strategy.

Beginning November 25, 2007, the Minimum Flow for the Lower Hillsborough River shall be as provided in 40D-8.041(1), F.A.C., to be achieved on the time schedule as set forth below. The District and the City of Tampa (City) shall measure the delivery of water to the base of the dam relative to their respective elements as described below. The City shall report this information to the District monthly on the 15th day of the following month. In addition, the City shall submit a quarterly written report of all activities and all progress towards timely completion of its elements of the recovery strategy. Such reports will be submitted to the District within 15 calendar days after each calendar year quarter.

(a) The District and the City have entered into the Joint Funding Agreement Between The Southwest Florida Water Management District and The City of Tampa For Implementation of Recovery Projects To Meet Minimum Flows Of The Lower Hillsborough River (the "Agreement"). The Agreement and 40D-80.073(4), F.A.C., constitute the District's recovery strategy for the Lower Hillsborough River required by Section 373.0421(2), F.S., and shall not compromise public health, safety and welfare.

(b) The schedule to achieve the Minimum Flows for the Lower Hillsborough River is as follows:

1. Sulphur Springs - Beginning on November 25, 2007, the City shall be required to provide 10 cubic feet per second (cfs) of water to the base of the City's dam each day provided such use will not compromise public health, safety and welfare.

2. Tampa Bypass Canal Diversions - By January 1, 2008, provided that any permit that may be required is approved, the District shall divert up to 7.1 million gallons of water on any given day from the District's Tampa Bypass Canal ("TBC") to the Hillsborough River at the District's Structure 161. The District shall then deliver water from the Hillsborough River immediately above the City's dam to the base of the City's dam to help meet the minimum flow requirements of the Lower Hillsborough River. Such diversions shall not occur if public health, safety and welfare will be compromised.

a. The District shall complete a comprehensive analysis of these diversions within 90 days of the first year of operation to identify and subsequently make any mechanical or efficiency adjustments that may be necessary. The District shall use its best efforts to expedite obtaining any permit that may be needed to undertake these actions.

b. By October 1, 2013, provided that the transmission pipeline has been constructed and is operational, all of the water diverted from the TBC middle pool under this provision to help meet the minimum flow shall be provided to the Lower Hillsborough River per subparagraph 40D-80.073(4)(b)7., F.A.C.

c. These diversions shall be prioritized as follows:

(i) Priority Source One – Diversions From the TBC Middle Pool When the TBC Middle Pool is Above 12.0 feet NGVD (1929 or its 1988 equivalent), and There is Flow of at Least 11 cfs Over the District's Structure 162 – On days when the TBC middle pool is above 12.0 feet NGVD (1929 or its 1988 equivalent), as measured by the downstream gauge at the District's Structure 161, and there is flow of at least 11 cfs over the District's Structure 162, the District shall divert water from the TBC middle pool to the Hillsborough River.

A. The District shall then deliver 75 percent of any water diverted from the TBC to the Hillsborough River under this provision to the Lower Hillsborough River. Delivery of 75 percent of the water diverted from the TBC addresses concerns about potential losses due to subsurface leakage, evaporation and transpiration. This delivery shall be from the Hillsborough River just above the City's dam to the base of the City's dam, and shall supplement diversions from Sulphur Springs, Blue Sink and Morris Bridge Sink, as they are implemented, and as described in 40D-80.073(4)(b)1., 3., 6. and 8., F.A.C.

B. The TBC middle pool diversions will be limited to the quantity needed to achieve the minimum flow requirements of the Lower Hillsborough River set forth in 40D-8.041(1), F.A.C., but will not exceed 7.1 million gallons on any given day.

C. Such diversions shall cease from the TBC middle pool if the elevation difference between the TBC middle and lower pools exceeds 7.0 feet.

D. On days when flow over the Hillsborough River Dam naturally exceeds 20 cfs during the months of July through March or 24 cfs during the months of April through June and when diversions from the TBC middle pool are not needed to replenish the supply from Storage Projects described in 40D-80.073(4)(c) and (d), F.A.C., diversions from the TBC middle pool shall not occur, and any flows in the TBC lower pool above elevation 9.0 feet NGVD (1929 or its 1988 equivalent), shall be available for water supply.

E. Prior to October 1, 2013, and during the months of March through June, on days when some water is needed from the TBC middle pool to help meet the minimum flow for the Lower Hillsborough River, all available water from the TBC middle pool not needed to be diverted in accordance with SWFWMD Water Use Permit No. 20006675 but not exceeding 7.1 million gallons on any given day will be diverted to the Hillsborough River. Water delivered to the Hillsborough River in excess of that needed to help meet the minimum flow of the Lower Hillsborough River shall remain in the Hillsborough River above the dam. Keeping this water in the Hillsborough River above the dam will reduce the time and quantities of supplemental flow needed to help meet the minimum flow requirements.

F. During the months of July through February, on days when water is needed from the TBC middle pool to help meet the minimum flow of the Lower Hillsborough River, only that amount of water needed to help meet the minimum flow but not in excess of 7.1 million gallons on any given day shall be diverted from the TBC middle pool to the Hillsborough River, and any water in the TBC middle and lower pools above elevations 12.0 and 9.0 feet NGVD (1929 or its 1988 equivalent), respectively, shall be available for water supply.

(ii) Priority Source Two – Diversions When the TBC Middle Pool is above 12.0 feet NGVD (1929 or its 1988 equivalent), and the Flow Over the District's Structure 162 is Less Than 11 cfs - On days when the TBC middle pool is above 12.0 feet NGVD (1929 or its 1988 equivalent), as measured by the downstream gauge at the District's Structure 161, and the flow over the District's Structure 162 is less than 11 cfs, the District shall divert water from the TBC middle pool to the Hillsborough River.

A. The District shall then deliver 75 percent of any water diverted from the TBC middle pool to the Hillsborough River under this provision to the Lower Hillsborough River. Delivery of 75 percent of the water diverted from the TBC addresses concerns about potential losses due to subsurface leakage, evaporation and transpiration. This delivery shall be from the Hillsborough River just above the City's dam to immediately below the City's dam, and shall supplement diversions from Sulphur Springs, Blue Sink and Morris Bridge Sink, as they are implemented, and as described in 40D-80.073(4)(b)1., 3., 6. and 8., F.A.C.

B. The TBC middle pool diversions will be limited to the quantity needed to achieve the minimum flow requirements of the Lower Hillsborough River, but will not exceed 7.1 million gallons on any given day.

I. On days such diversions occur, the District will divert from the TBC lower pool to the TBC middle pool quantity equivalent to that diverted by the District from the TBC middle pool to the Hillsborough River.

II. Such diversions shall cease from both the TBC middle and lower pool when the stage of the TBC lower pool reaches 6.0 feet NGVD (1929 or its 1988 equivalent), as measured by the gauge at the District's Structure 160, or the elevation difference between the TBC middle and lower pools exceeds 7.0 feet.

C. Once the stage in the TBC lower pool is below 8.7 feet NGVD (1929 or its 1988 equivalent), withdrawals from this priority source to help meet the minimum flow for the lower Hillsborough River are considered withdrawals from the storage of the TBC lower pool. When the stage in the TBC lower pool is below 8.7 feet NGVD (1929 or its 1988 equivalent), the following restrictions apply:

I. At no time shall withdrawals from the lower pool to help meet the minimum flow for the lower Hillsborough River cause the stage in the lower pool to go below 6.0 feet NGVD (1929 or its 1988 equivalent), or cause the elevation difference between the TBC middle and lower pools to exceed 7.0 feet, as measured on either side of the District's Structure 162.

II. If supplemental flows are required to help meet the lower Hillsborough River minimum flow from this Priority Source, once withdrawals begin from storage they will continue until the TBC lower pool reaches an elevation of 6.0 feet NGVD (1929 or its 1988 equivalent). At such time as either of the conditions set forth in 40D-80.073(4)(b)2.(ii)C.I., F.A.C., above, are met, the District shall cease withdrawals from the TBC lower pool. The District shall only reinitiate withdrawals from the TBC lower pool when its elevation equals or exceeds 9.0 feet NGVD (1929 or its 1988 equivalent), for 20 consecutive days, which is defined as the TBC lower pool replenishment.

III. The total withdrawn from storage shall not exceed 7.1 million gallons on any given day.

IV. Withdrawals from storage will be limited to the quantity needed to help achieve the minimum flow requirements of the Lower Hillsborough River after utilizing the quantity diverted from all other sources, as they are implemented, and as described in 40D-80.073(4)(b), (c) and (d), F.A.C.

(iii) Priority Source Three – Diversions When TBC Middle Pool Elevations are Between 10.0 and 12.0 Feet NGVD (1929 or its 1988 equivalent) - The District will make all reasonable efforts to obtain authorization from the United States Army Corps of Engineers to allow the withdrawals of up to 7.1 million gallons on any given day from the TBC middle pool to aid in the Lower Hillsborough River minimum flow requirements when the TBC middle pool is below 12.0 feet and above 10.0 feet NGVD (1929 or its 1988 equivalent).

A. These diversions will only occur when the stage of the TBC lower pool has reached 6.0 feet NGVD (1929 or its 1988 equivalent), or the TBC lower pool is in a state of replenishment as described in 40D-80.073(4)(b)2.(ii)C.II., F.A.C. These diversions will be limited to the quantity needed to help achieve the minimum flow requirements of the Lower Hillsborough River after utilizing the quantity diverted from all other sources, as they are implemented, and as described in 40D-80.073(4)(b) , (c) and (d), F.A.C., but will not exceed 7.1 million gallons on any given day.

B. These diversions shall cease if the elevation difference between the Hillsborough River and TBC middle pool exceeds 9.5 feet, if approved by the United States Army Corps of Engineers, as measured on either side of the District's Structure 161, or if the elevation difference between the TBC middle and lower pools exceeds 7.0 feet, as measured on either side of the District's Structure 162.

C. Diversions associated with this provision will not occur until the water transmission pipeline as set forth in 40D-80.073(4)(b)7., F.A.C., is completed or by October 1, 2013, whichever is sooner. Once the stage in the TBC middle pool is below 12.0 feet NGVD (1929 or its 1988 equivalent), withdrawals to help meet the minimum flow for the Lower Hillsborough River are considered withdrawals from the storage of the TBC middle pool. When the stage is below 12.0 feet NGVD (1929 or its 1988 equivalent), the following restrictions apply:

I. At no time shall withdrawals from the TBC middle pool to help meet the minimum flow for the Lower Hillsborough River cause the stage in the middle pool to go below 10.0 feet NGVD (1929 or 1988 equivalent), or cause the elevation difference between the TBC middle pool and Hillsborough River to exceed 9.5 feet, as measured on either side of the District's Structure 161, or cause the elevation difference between the TBC middle and lower pools to exceed 7.0 feet, as measured on either side of the District's Structure 162.

II. If supplemental flows are required to help meet the Lower Hillsborough River minimum flow from this Priority Source, once withdrawals begin from storage they will continue until the TBC middle pool reaches an elevation of 10.0 feet NGVD (1929 or its 1988 equivalent). At such time as either of the conditions set forth in 40D-80.073(4)b.2.c.(iii)C.I., F.A.C., above, are met, the District shall cease withdrawals from the TBC middle pool. The District shall only reinitiate withdrawals from the TBC middle pool when its elevation equals or exceeds 12.0 feet NGVD (1929 or its 1988 equivalent), for 20 consecutive days, which is defined as the TBC Pool Replenishment, and there is less than 11 cfs of flow over the District's Structure 162.

III. The total withdrawn from storage on any one day shall not exceed 7.1 million gallons.

IV. Withdrawals from storage will be limited to the quantity needed to help achieve the minimum flow requirements of the Lower Hillsborough River after utilizing the quantity diverted from all other sources, as they are implemented, and as described in 40D-80.073(4)(b) , (c) and (d), F.A.C.

3. Sulphur Springs Project

a. By October 1, 2009, and as specified in the Agreement, the City shall complete the modification of the lower weir to provide to the base of the dam all available flow from Sulphur Springs not needed to maintain the minimum flow for manatees as set forth in 40D-8.041(2)(b), F.A.C.

b. By October 1, 2010, the City shall complete the construction of the upper gates and the pump station to provide to the base of the dam all available flow from Sulphur Springs not needed to maintain the minimum flow for manatees as set forth in 40D-8.041(2)(b), F.A.C.

c. By October 1, 2012, and as specified in the Agreement, the City is to provide to the base of the dam all available flow, from Sulphur Springs not needed to maintain the minimum flow for Sulphur Springs as set forth in 40D-8.041(2)(a), F.A.C.

(i) These diversions shall not exceed 11.6 million gallons on any given day.

(ii) The City is authorized to use any remaining quantities at Sulphur Springs for water supply purposes consistent with SWFWMD Water Use Permit No. 20002062.

d. Additionally, beginning on October 1, 2010, on days when the minimum flow requirements are being adjusted for the Lower Hillsborough River, as described in 40D-8.041(1)(b), F.A.C., and there is flow at Sulphur Springs in excess of the quantity needed to help meet the adjusted flow as described in 40D-8.041(1)(b), F.A.C., and the minimum flow requirements in 40D-8041(2)(b), F.A.C., and the City is not using such flow to augment the Hillsborough River above the dam, the City shall move such quantity to the base of the City's dam up to the unadjusted quantities described in 40D-8.041(1)(b), F.A.C.

4. Blue Sink Analysis - By October 1, 2010, and as specified in the Agreement, the City in cooperation with the District shall complete a thorough cost/benefit analysis to divert all available flow from Blue Sink in north Tampa to a location to help meet the minimum flow or to the base of the City's dam.

5. Transmission Pipeline Evaluation - By October 1, 2010, and as specified in the Agreement, the City shall complete a thorough design development evaluation to construct a water transmission pipeline from the TBC middle pool to the City's David L. Tippin Water Treatment Facility, including a spur to just below the City's dam.

6. Blue Sink Project - By October 1, 2011, and as specified in the Agreement, the City will provide all available flow from Blue Sink project to help meet the minimum flow provided that all required permits are approved, and it is determined that the project is feasible. Once developed, all water from this source shall be used to the extent that flow is available to help meet the minimum flow for the Lower Hillsborough River.

7. Transmission Pipeline Project - By October 1, 2013, and as specified in the Agreement, the City shall complete the water transmission pipeline described in 40D-80.073(4)(b)5., F.A.C., and move the water the District will move as specified in 40D-80.073(4)(b)2. and 8., F.A.C., to the Lower Hillsborough River directly below the dam as needed to help meet the minimum flow or to transport water in accordance with SWFWMD Water Use Permit No. 20006675.

a. This transmission line will eliminate all adjustment for losses described in 40D-80.073(4)(b)2. and 8., F.A.C.

b. Additionally, the City will provide an additional flow of 1.9 million gallons each day to the base of the dam from the TBC middle pool provided that water is being transported in accordance with SWFWMD Water Use Permit No. 20006675. This additional 1.9 million gallons each day is anticipated to be part of the water savings associated with this transmission pipeline.

c. Once the pipeline is completed, the 1.9 million gallons each day of additional flow provided by the City as part of the water savings associated with the pipeline will be used in preference to all other sources except Sulphur Springs and Blue Sink to the help meet the minimum flow for the Lower Hillsborough River.

d. In the event that this pipeline is not substantially completed by October 1, 2013, or that the City did not provide the District with a minimum ninety (90) days notice prior to October 1, 2013, of the delay of completion of the pipe due to circumstances beyond its control, then, the City will be responsible for delivering the flows the District was previously obligated to divert from the TBC middle pool to the Hillsborough River and then to immediately below the City's dam under 40D-80.073(4)(b)2. and 8., F.A.C.; except that the District shall continue to be responsible to pump water from the TBC lower pool to the middle pool as described in 40D-80.073(4)(b)2.b., F.A.C., and from Morris Bridge Sink to the TBC middle pool as described in 40D-80.073(4)(b)8., F.A.C.

e. The City shall also provide the 1.9 million gallons each day if needed to help meet the flow described in this provision, from some other permitable source and is obligated to do so pursuant to d. above.

8. Morris Bridge Sink Project

a. By October 1, 2012, or earlier, and upon completion of the project, provided that any permit that may be required is approved, the District shall divert up to 3.9 million gallons of water on any given day from the Morris Bridge Sink to the TBC middle pool.

(i) The Morris Bridge Sink diversions will be limited to the quantity needed to achieve the minimum flow requirements of the Lower Hillsborough River, after utilizing the quantity diverted from Sulphur Springs, Blue Sink and the 1.9 million gallons of water savings each day anticipated from the transmission pipeline, as they are implemented, and as described in 40D-80.073(4)(b)1., 3., 6. and 7., F.A.C.

(ii) However, on days when TBW does not draw the TBC lower pool down to 9.0 feet NGVD (1929 or its 1988 equivalent) for water supply purposes, and supplemental flow is needed for the Lower Hillsborough River minimum flow requirements beyond water that can be delivered from Sulphur Springs, Blue Sink and the 1.9 million gallons of water savings each day anticipated from the transmission pipeline described in 40D-80.073(4)(b)1., 3., 6. and 7., F.A.C., the District shall divert up to 7.1 million gallons on any given day from the TBC lower pool to the TBC middle pool prior to diverting flows from the Morris Bridge Sink to the TBC middle pool.

(iii) The District shall cease to divert water from the TBC lower pool under this provision once the elevation of the TBC lower pool reaches 9.0 feet NGVD (1929 or its 1988 equivalent).

b. Prior to the completion of the pipeline described in 40D-80.073(4)(b)7., F.A.C., the District shall transfer any water delivered to the TBC middle pool from the Morris Bridge Sink or the TBC lower pool under this provision to the Hillsborough River near the District's Structure 161.

(i) These deliveries shall be made on the same day the District delivers water from the Morris Bridge Sink or the TBC lower pool.

(ii) The District shall then deliver 75 percent of any water diverted to the Hillsborough River under this provision to the Lower Hillsborough River. This delivery shall be from the Hillsborough River just above the City's dam to immediately below the City's dam.

(iii) The deliveries of the water from the Morris Bridge Sink to the TBC middle pool then on to the Hillsborough River are in addition to any other diversions from the TBC middle pool to the Hillsborough River described in 40D-80.073(4)(b)2. and 8., F.A.C.

c. Once the City completes the water transmission pipeline described in 40D-80.073(4)(b)5. and 7., F.A.C., or as may be otherwise responsible for delivering the flows the District was previously obligated to divert pursuant to 40D-80.073(4)(b)7., F.A.C., the City shall move any water the District delivers to the TBC middle pool from Morris Bridge Sink or the TBC lower pool under this provision to the Lower Hillsborough River directly below the dam. Such delivery by the City will occur on the same day the District delivers the water from the Morris Bridge Sink or the TBC lower pool to the TBC middle pool.

d. At no time shall withdrawals from the TBC under this provision cause:

(i) The elevation difference between the TBC middle pool and Hillsborough River to exceed 9.5 feet as measured on either side of the District's Structure 161; or

(ii) The elevation difference between the TBC middle and lower pools to exceed 7.0 feet as measured on either side of the District's Structure 162.

9. Beginning October 1, 2017, the City shall be required to meet the minimum flows at the base of the dam as set forth in 40D-8.041(1), F.A.C.

(c) The City and the District shall, as specified in the Agreement, cooperate in the evaluation of options for storage of water ("Storage Projects") such as aquifer storage and recovery (ASR), and additional source options (e.g., diversions from Morris Bridge Sink greater than those described in 40D-80.073(4)(b)8., F.A.C.), in sufficient permitable quantities, that upon discharge to the base of the dam, together with the other sources of flow described in 40D-80.073(4)(b), F.A.C., will meet the minimum flows beginning October 1, 2017, or earlier.

(d) The City may propose for District approval additional source or storage projects that when completed may be used in lieu of all or part of one or more sources described in 40D-80.073(4)(b)2. – 8., F.A.C.

(e) Any District sponsored project, which shall include evaluation of up to 3.9 million gallons per day of additional quantities other than those identified in 40D-80.073(4)(b)8., F.A.C., from the Morris Bridge Sink, shall be implemented by the District no later than October 1, 2017, provided that it is deemed feasible by the District, to eliminate or reduce the need to divert water from the TBC middle and lower pool storage as described in 40D-80.073(4)(b)2., F.A.C. Such projects shall be implemented only after receiving any required permits.

(f) Each spring, beginning in 2008, the District shall review the recovery strategy to assess the progress of implementation of the recovery strategy and report that progress to the Governing Board. This annual review and report shall include identification of the Storage Projects or other additional sources options that will be operational by October 1, 2017. If and when developed, Storage Projects or other additional source options to supply supplemental flows to meet the minimum flow will be used in preference to removal of water from storage in either the middle or lower pools of the TBC as described in 40D-80.073(4)(b), F.A.C.

(g) The City and the District shall continue the existing monitoring and analysis of the water resources within the Lower Hillsborough River and the District shall provide this information to the Governing Board as part of the its annual review and report described in subsection (4)(d), above.

(h) In 2013, and for each five year period through 2023, the District shall evaluate the hydrology, dissolved oxygen, salinity, temperature, pH and biologic results achieved from implementation of the recovery strategy for the prior five years, including the duration, frequency and impacts of the adjusted minimum flow as described in 40D-8.041(1)(b), F.A.C. As part of the evaluation the District will assess the recording systems used to monitor these parameters. The District shall also monitor and evaluate the effect the Recovery Strategy is having on water levels in the Hillsborough River above the City's dam to at least Fletcher Avenue. The District will evaluate all projects described in this Recovery Strategy relative to their potential to cause unacceptable adverse impacts prior to their implementation.

(i) In conjunction with recovery of the Lower Hillsborough River and to enhance restoration of McKay Bay and Palm River estuary, the District intends to undertake a wetland restoration project adjacent to McKay Bay. The City agrees to contribute to the project by providing up to 7.1 million gallons on any given day of reclaimed water, as needed for the project. Within five years of completion of this wetland project, and for two subsequent five year periods thereafter, the District shall review the hydrologic, dissolved oxygen, salinity, temperature, pH and biologic results achieved from the implementation of the restoration project and other similar District projects that may occur.

(5) Recovery Strategy Elements Relating to Other Existing Water Use Permittees.
In conjunction with the development of a recovery strategy developed pursuant to Section 373.0421(2), F.S., and in addition to applicable permitting requirements contained in 40D-2.301,

F.A.C., existing permittees whose water withdrawals impact Minimum Flows or Levels will be evaluated upon permit renewal to determine the permittee's practical ability to implement measures to reduce its impacts on the Flow or Level during the period of recovery. For purposes of this Chapter, in areas where the existing level is below the Minimum Level, any measurable drawdown at a location where a Minimum Level is established is deemed to be a water withdrawal impact. The items that shall be considered in determining the permittee's responsibility to implement measures to reduce impacts are:

(a) The proportionate amount of impact that the permittee's water withdrawals have on the Minimum Flow or Level;

(b) The cost to the permittee to implement the measures;

(c) The time that it will take the permittee to fully implement the measures;

(d) Any unavoidable public health, safety or welfare emergency that would be caused by implementation of the measures;

(e) Whether the water resources benefits gained from implementation of the permittee's measures to attain the Minimum Flow or Level outweigh water resources impacts that may result from the measures; and

(f) Alternative actions or programs in lieu of or in combination with reductions in withdrawals that will contribute to the attainment of the Minimum Flow or Level and will optimize the net positive effect on the impacted water resources.

(6) Supplemental Hydration of Wetlands and Lakes.
In addition to the reduction of pumpage, the development of new water supplies and wellfield operational changes addressed by the recovery strategy provisions of this Rule 40D-80.073, supplemental hydration of wetlands and lakes that are below their established Minimum Levels through the use of ground water in appropriate circumstances will contribute to the attainment of the objective of the recovery strategy. The circumstances under which supplemental hydration using ground water will be considered an appropriate recovery mechanism are set forth in Section 4.3 A.1.a.ii.(4) and 4.3 A.1.b. of the Basis of Review For Water Use Permit Applications which is incorporated by reference in Rule 40D-2.091, F.A.C., and is available upon request to the District.

(7) Applications for New Quantities.
Requests for withdrawals of new quantities of water that are projected to impact a water body which is below its Minimum Flow or Level shall not be approved unless they contribute to the attainment of the objective set forth in the recovery strategy in Rule 40D-80.073, F.A.C.

(8) 2010 Evaluation of Recovery Strategy.
This recovery strategy is in keeping with the District's legislative mandate pursuant to Sections 373.036, 373.0361, 373.0421, 373.0831, 373.1962 and 373.1963, F.S., to resolve the water supply and water resource impact concerns of the Northern Tampa Bay Area in a cooperative manner with the water suppliers and interested parties. The portion of the District's recovery strategy embodied within this Rule 40D-80.073, F.A.C., is the first regulatory phase of a long-term approach toward eventual attainment of the minimum flows and levels established in Chapter 40D-8, F.A.C., for priority waters in the Northern Tampa Bay Area. Except as to 40D-80.073(4), F.A.C., this phase of the recovery strategy is through the year 2010 based on the current knowledge of the state of the water resources of the Area, the technology for water supply development including alternative sources and conservation and existing and future reasonable-beneficial uses. In addition, it is possible that this phase will achieve recovery to the minimum flows and levels but it is impossible to determine whether this will occur given that it is unknown which recovery management mechanisms will be utilized by water use permittees. Except as to the Lower Hillsborough River, Sulphur Springs and the Tampa Bypass Canal, the

District will evaluate the state of knowledge of these matters in 2010, including analysis of all information and reports submitted pursuant to Rule 40D-80.073(3)(c), F.A.C., data collected and analyzed and relationships determined pursuant to Rule 40D-8.011(5), F.A.C., regarding the minimum flows and levels for the priority waters in the area (The "MFLs") and the Central System Facilities permit(s). Based on that analysis and evaluation, on or before December 31, 2010, except as to the Lower Hillsborough River, Sulphur Springs and the Tampa Bypass Canal, the District will initiate rulemaking to 1) revise the MFLs (the "New MFLs"), as necessary; 2) adopt rules to implement the existing or the New MFLs (The "Implementation Rules"); and 3) revise this Rule 40D-80.073, F.A.C., to incorporate a second phase to this Recovery Strategy ("Recovery Strategy Rules"), as necessary, consistent with Subsection 373.0421(2), F.S. In the event that the District determines that it is not necessary to initiate rulemaking to adopt New MFLs, and a substantially affected person is granted an administrative hearing to challenge the Implementation Rules or the Recovery Strategy Rules, and the MFL Rules, the District will not object to a motion to consolidate the hearings.

Specific Authority 373.044, 373.113, 373.171 F.S. Law Implemented 373.036, 373.0361, 373.171, 373.0421, F.S. History – New 8-3-00, Amended 11-25-07.

40D-80.074 NOT SHOWN