TECHNICAL PUBLICATION SJ2009-5

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PRELIMINARY EVALUATION OF POTENTIAL WEIR SITES FOR WETLAND CONSERVATION IN TIGER BAY AND BENNETT SWAMP,VOLUSIA COUNTY, FLORIDA, PHASE II

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by

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August 7, 2009

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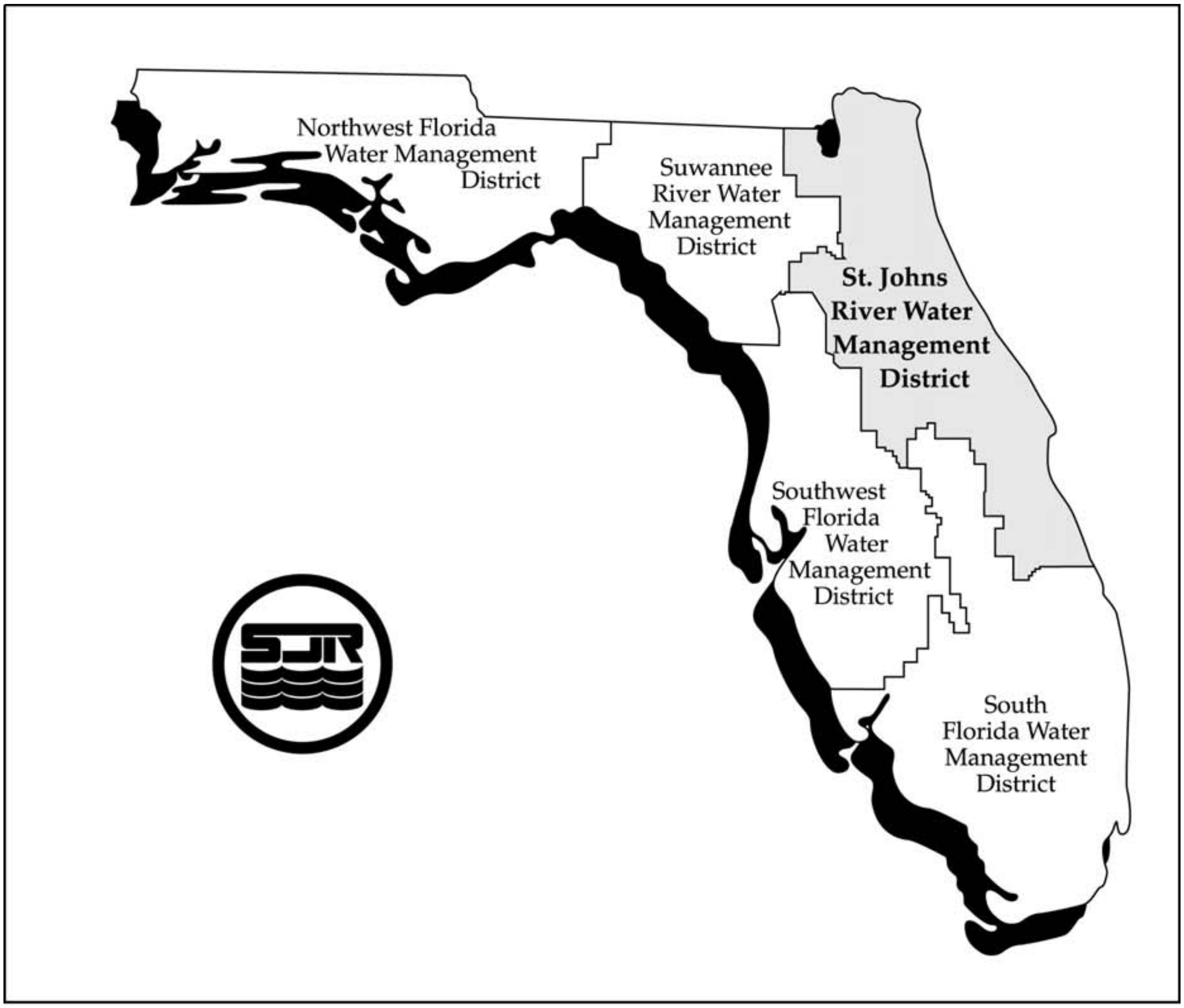
St. Johns River Water Management District
Palatka, Florida

2009



The St. Johns River Water Management District (SJRWMD) was created by the Florida Legislature in 1972 to be one of five water management districts in Florida. It includes all or part of 18 counties in northeast Florida. The mission of SJRWMD is to ensure the sustainable use and protection of water resources for the benefit of the people of the District and the state of Florida. SJRWMD accomplishes its mission through regulation; applied research; assistance to federal, state, and local governments; operation and maintenance of water control works; and land acquisition and management.

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INTRODUCTION

Municipal water demand in Volusia County, Florida, is expected to more than double from 45.7 million gallons per day (mgd) in 1988 to 95 mgd by 2010 (Williams 1997). Most of this increase is from the Daytona Beach metropolitan area. The communities in this area have had to abandon or reduce pumpage from their old wellfields near the coast due to saltwater intrusion and have had to develop new wellfields inland, primarily west of Interstate 95 (I-95) along the Rima Ridge. Tiger Bay lies on the west side of Rima Ridge and Bennett Swamp lies along the east side (Figure 1). St. Johns River Water Management District (SJRWMD) has identified the Daytona Beach wellfield drawdown area as having a moderate-to-high likelihood of harm to native vegetation (Vergara 1994). Tiger Bay also has been identified by the U.S. Geological Survey (USGS) as a potential recharge area in the event that well pumpage lowers the head of the Floridan aquifer (Rutledge 1985). Surface drainage (Tiger Bay Canal and Thayer Canal) has also contributed to the drop in the surficial water table.

Tiger Bay Canal was constructed in 1940, when U.S. 92 was four-laned. The purpose was to collect the drainage from U.S. 92 and convey it north then east through Rima Ridge (Figure 2) into the middle of Bennett Swamp. This flow continues east across Bennett Swamp into Thayer Canal (Figure 3), which flows east into the Tomoka River. For more than a decade, Volusia County has wanted to reduce the lowering of the water table caused by Tiger Bay Canal by placing a weir in Tiger Bay Canal. In 1989, the Florida Department of Transportation (FDOT) was seeking sites for wetland mitigation credits when Volusia County proposed Tiger Bay Canal. The FDOT prepared design drawings for a 65-foot weir at the upper end of Tiger Bay Canal, just upstream of a large box culvert under U.S. 92. During the permitting process, the project ran into opposition and FDOT withdrew their application. Volusia County was still interested and entered into a contract with SJRWMD in October 1994 to jointly fund a three-phase study to identify several potential weir sites in the watershed for wetland mitigation and recharge potential. Camp Dresser and McKee Inc. (CDM) was contracted by SJRWMD to conduct phase I, the conceptual stage of the study. Phase II was to improve hydrologic analysis by using better topographic data, identifying other possible weir sites, and preparing preliminary designs of recommended weirs. Phase III would prepare detailed designs and cost estimates and see the project through to construction.

CDM completed phase I in February 1996 (CDM 1996). The report identified four potential weir sites. At public meetings, the public and some governmental agencies again expressed concern that the proposed weirs would cause flood damage to trees on public and private forestlands.

SJRWMD initiated phase II of the investigation (this report) in June 1996, to investigate these concerns and refine the modeling. With the help of highway drawings, soils maps, and new county surveys, the watershed boundaries were refined. This was done with much less topographic data than recommended for the phase II study. Serious questions still existed as to the exact watershed boundaries and flow patterns. The additional surveys and data helped to improve the stormwater management model (SWMM) surface runoff and backwater models. Groundwater was added to the SWMM. Initial modeling identified the best weir site at the upstream end of Thayer Canal, and not Tiger Bay Canal. Emphasis was, therefore, shifted to Bennett Swamp and Thayer Canal. An environmental assessment and weir design for Bennett Swamp was contracted in early 2000 to CH2M HILL. In the fall of 2001, another contract (CDM/DHI 2002) was let—for the creation of an integrated groundwater/surface water model for the Tiger Bay/Bennett Swamp area. The CDM/DHI numerical model development and calibration was to evaluate potential weir sites and their impacts on runoff, water table levels, and recharge, with more accuracy than the SWMM used previously. As a result, further work using the SWMM has been halted. This report summarizes the findings of SJRWMD modeling through December 2002, and we partially fulfill some of the goals set forth in phase II. A detailed technical draft report exists in the library of SJRWMD (Freeman 2003).

Figure 1. Tiger Bay vicinity map

2 0 2 Miles

■ Stream gauge
▲ Rain gauge
▨ Watershed boundary

The St. Johns River Water Management District prepares and uses this information for its own purposes and this information may not be suitable for other purposes. This information is provided "as is." Further documentation of this data can be obtained by contacting St. Johns River Water Management District, Geographic Information System's, Program Management, P.O. Box 1429, Palatka, Florida, 32178-1429 (386) 329-4176.

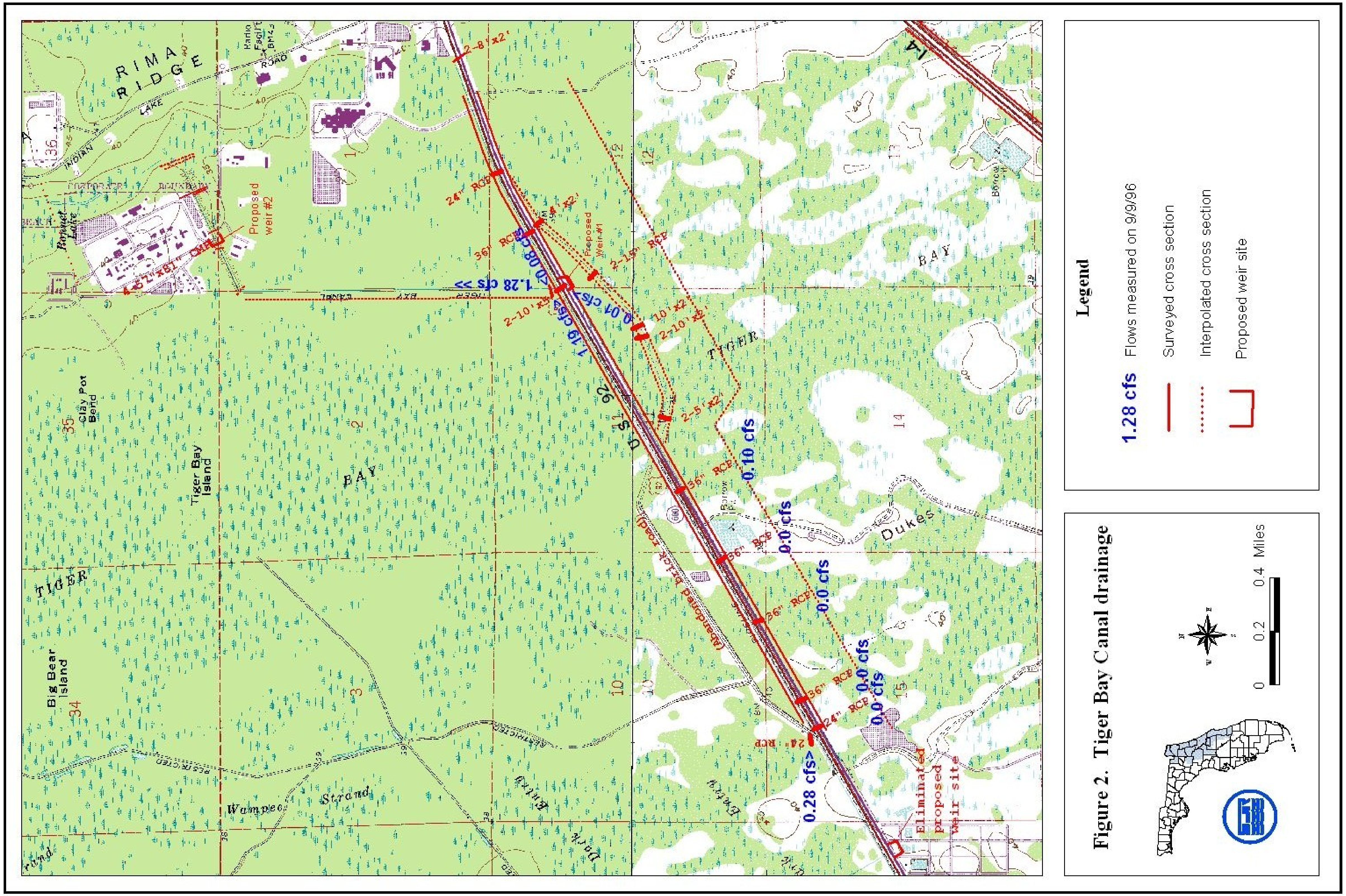

Figure 2. Tiger Bay Canal drainage

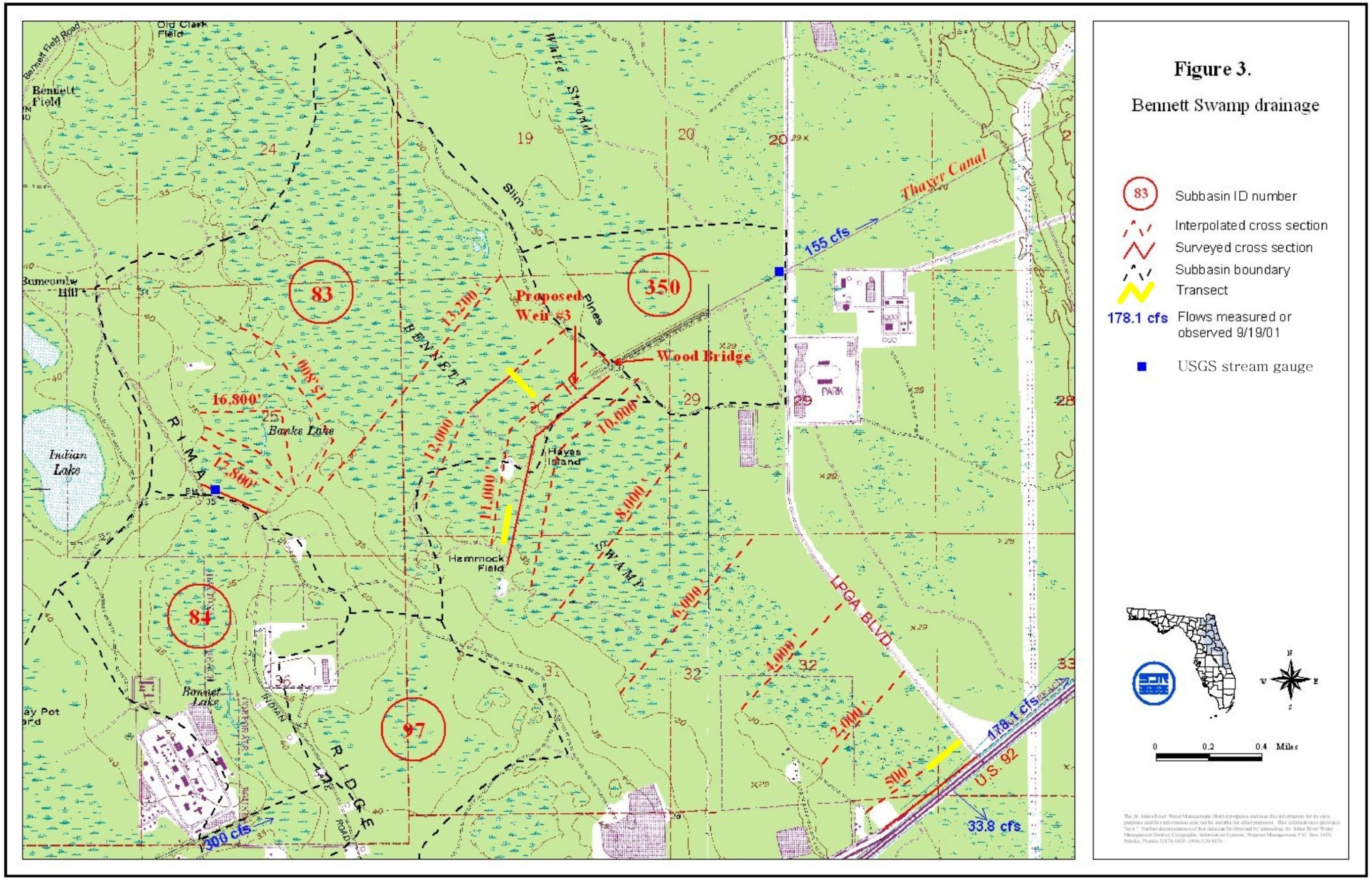

Figure 3. Bennett Swamp drainage

PHASE I REPORT RECOMMENDATIONS

The phase I report identified four potential weir sites: (1) on the south edge of U.S. 92, at the upstream end of Tiger Bay Canal; (2) approximately 2.4 miles to the west, also on the south edge of U.S. 92; (3) at the downstream end of the Tiger Bay Canal canalization; and (4) on Thayer Canal, approximately 1,000 feet (ft) downstream from the Bennett Swamp outlet to Thayer Canal. The highest-ranked weir location was the original FDOT site at the upstream end of Tiger Bay Canal. The CDM phase I report also addressed the needs and tasks for a phase II study. Among the recommendations was the need for 1-ft contour interval maps based on aerial photogrammetry. The report recommended extensive survey and data collection, with the possibility of identifying up to seven potential weir sites. Phase II would improve upon the existing models. At the same time, it was anticipated that the SJRWMD Floridan aquifer MODFLOW model (modular, three-dimensional, finite-difference, groundwater flow model) would also be improved and used to evaluate groundwater impacts from the weirs. The conceptual capital cost was $1,246,000, with $540,000 designated as land acquisition costs for the additional 540 acres of average annual flooded area. The total cost for maintenance and operation of four to seven weirs was estimated at $23,000 to $29,000, annually. The data collection and analysis cost for the phase II portion of the study was estimated at $625,000, of which $308,000 was for aerial photogrammetry and $170,000 was for preliminary engineering and analysis.

STUDY AREA

AREA DESCRIPTION

Tiger Bay swamp begins just north of State Road (SR) 44 (Figure 1) at an elevation of 40 ft and runs north for about 10 miles (mi) to an elevation of 35 ft. However, the northern 2.0 mi of Tiger Bay drains north into Middle Haw Creek, which empties into the St. Johns River. Tiger Bay Island marks the northern limits of Tiger Bay Canal watershed (Figure 2). The east side of the swamp is bordered by narrow Rima Ridge, which has elevations up to 45 ft or more. The western boundary, about 3.5 mi west of Rima Ridge, is just over 40 ft in elevation but is extremely flat. A natural break in the Rima Ridge occurs 1.0 mi east of Tiger Bay Island at a 36-ft elevation. It is through this natural break that the last leg of Tiger Bay Canal runs. Tiger Bay Canal (Figure 2) collects the drainage along U.S. 92 and conveys it north for 6,200 ft before turning east 2,600 ft through part of Rima Ridge. The canal ends in a narrow slough that continues another 9,000 ft north, through the remainder of Rima Ridge, before discharging into the middle of Bennett Swamp (Figure 3). Flow continues east another 6,000 ft, across Bennett Swamp, where it enters Thayer Canal.

Bennett Swamp is about 9.0 mi long and lies midway between Tiger Bay and Tomoka River to the east. The northern 4.0 mi of Bennett Swamp drains north-northwest, before it turns east, out Priest Branch and into the Tomoka River. The southern 5.0 mi, which once carried most of the discharge from Tiger Bay Canal, historically drained southeast before converging with the upper Tomoka River. Only a small fraction of Tiger Bay Canal flows north. The construction of Thayer Canal now diverts over half the runoff due east into the Tomoka River. Not until flow in Thayer Canal reaches about 15 cubic feet per second (cfs), does water begin to spill south around Hayes Island (Figure 3). The U.S. 92 drainage ditch, another 2.0 mi southeast, intercepts most of this spill and conveys it directly east to Tomoka River. During major floods, Bennett Swamp can spill its eastern boundaries at several locations.

This study relied upon USGS topographic quadrangle maps, SJRWMD geographic information system (GIS) data, soils maps, FDOT drainage maps for I-4 and U.S. 92, and field investigations to delineate watershed and subbasin boundaries shown in Figure 4. The revised watershed boundary for Tiger Bay Swamp resulted in a drainage area of 26.19 square miles (sq mi) at the USGS gauge at Indian Lake Road (Figure 2). The USGS estimate is 29.0 sq mi at the gauge. The USGS lists the drainage area (Tiger Bay and Bennett Swamps) at their Thayer Canal gauge at LPGA Boulevard as 33.0 sq mi. This study estimated 29.51 sq mi. CDM estimated 44.48 sq mi. because they extended the drainage area north and west of Tiger Bay Island (Figure 2) and they extended the southern boundary to SR 44 (Figure 1).

SUBBASIN DELINEATION AND LAND USE

The watershed is divided into 11 subbasins, as shown in Figure 4, and is closely patterned after CDM's subbasins in the phase I report. Two of CDM's northern subbasins were eliminated because they belonged to the Middle Haw Creek watershed, and most of the remaining subbasins were altered somewhat based on sources previously sited. The larger subbasins have wide hardwood and cypress wetland swamps bordered by pine flatwood forests. Subbasins bordering Rima Ridge contain well-drained upland forests. Table 1 lists the drainage areas of each subbasin, classified by forest type (in total acres). Included in the forest coverage are about 200 acres of county facilities, including the Tomoka Correctional Institute, along with their surface water runoff detention ponds just west of Indian Lake Road and north of U.S. 92.

Table 1. Subbasin drainage areas, classified by forest type (in total acres)

Subbasin*	Wetlands	Pine Flatwoods	Uplands	Total Acres
7	54.50	73.77	28.44	156.71
84	168.85	170.83	146.28	485.96
85	1,593.59	775.51	25.51	2,394.61
88	667.56	719.72	0.00	1,387.28
89	287.86	494.21	0.00	782.07
91	2,339.68	1,401.29	0.00	3,740.97
92	453.45	821.33	0.00	1,274.78
93	4,382.18	2158.39	0.00	6,540.57
Total acres—Tiger Bay Canal gauge	9,947.67	6,615.05	200.23	16,762.95
83	823.00	355.45	221.60	1400.05
97	89.92	246.98	95.43	432.33
350	151.60	141.10	0.00	292.70
Total acres—Thayer Canal gauge	11,540.99	7,549.13	517.26	18,888.08

*Numbering system taken from CDM 1996

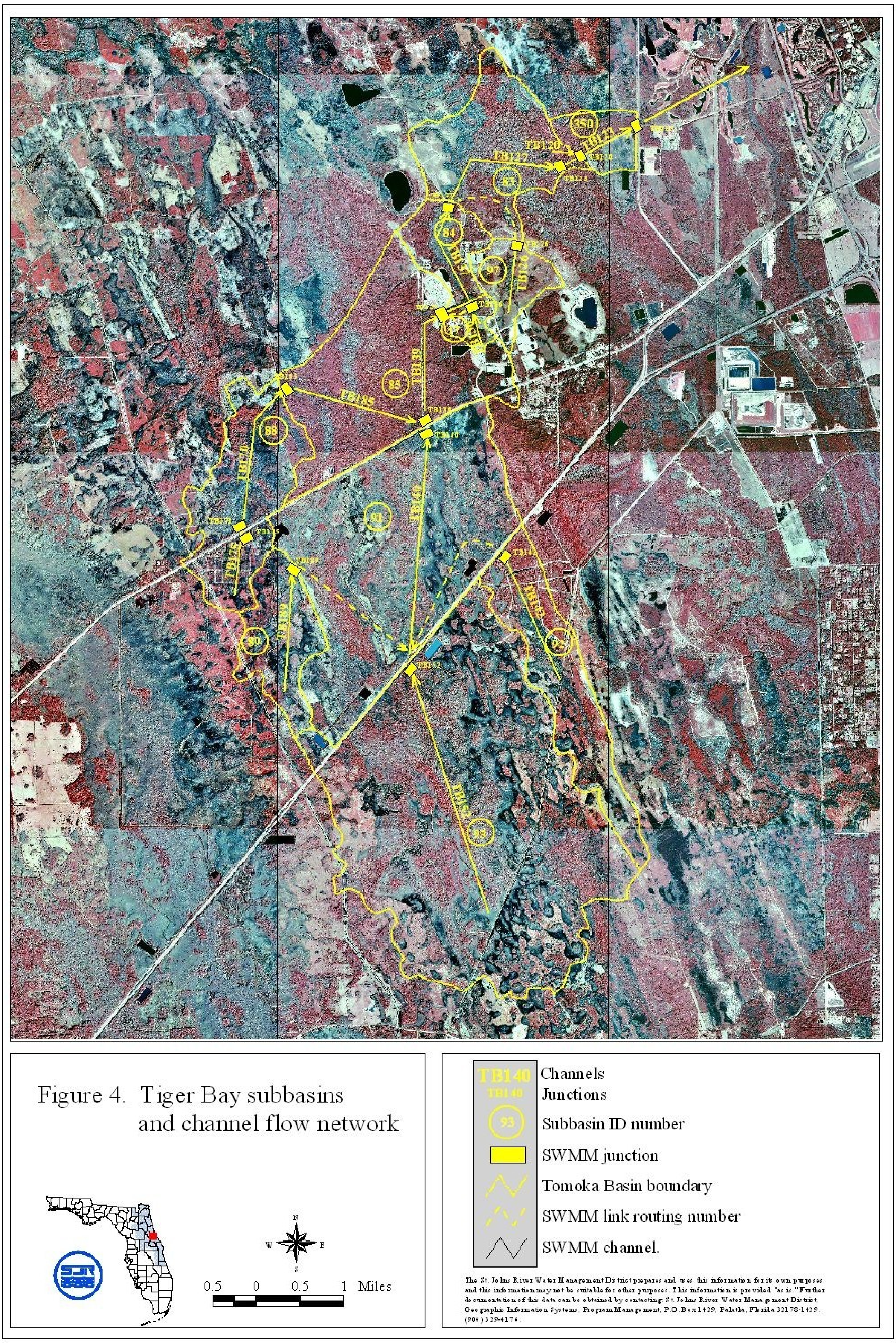

Figure 4. Tiger Bay subbasins and channel flow network

MODELING STRATEGY

Considerable data already existed for performing hydrologic modeling of the watershed. CDM had modeled Tiger Bay and the entire Tomoka River watershed using the U.S. Environmental Protection Agency's approved stormwater management model (SWMM) and its hydrodynamic routing block, EXTRAN (Huber and Dickinson 1988). Much of this information was retained. The strategy was to build upon the previous work by refining the watershed boundaries, cross-section data, rainfall data, and SWMM. To compute water table levels, groundwater seepage, and recharge to the Floridan aquifer, the groundwater option of SWMM was activated.

The discharges generated by SWMM were converted to stages based on stage-discharge relationships developed using the U.S. Army Corps of Engineers (USACE) one-dimensional HEC-2 and HEC-RAS simulation programs. Three separate backwater calculations were made: one for Thayer Canal; one for Bennett Swamp; and one for Tiger Bay Canal and Tiger Bay, up to I-4. Backwater stage-discharge relationships were also used to size pseudo-weirs at the downstream end of conduits draining subbasins 83, 84, 85, and 9 of the SWMM. These dummy weirs improved calibration by controlling runoff rates and volumes. For the remaining upstream subbasins, the stage-discharge data from CDM's EXTRAN modeling was used to size these pseudo-weirs.

In the phase I report, the original FDOT site had three times as many benefits as the next best site at the downstream end of Tiger Bay Canal. The phase II study, therefore, began by concentrating most of the effort on this site, in the hope that construction could soon begin. The county did additional surveys in the vicinities of the U.S. 92 box culverts and the Tiger Bay Road culverts on Tiger Bay Canal and of all the culverts under the LPGA Boulevard east of Bennett Swamp between U.S. 92 and Thayer Canal. SJRWMD made discharge measurements at several locations along U.S. 92 and Tiger Bay Canal. Bennett Swamp was modeled by using only the 5-ft contour maps available. After some initial modeling, the ranking of the weirs was reversed. The Thayer Canal site became the highest-ranked site, with the weir at the downstream end of Tiger Bay Canal ranking close behind. New surveys of Bennett Swamp and Thayer Canal were obtained, and an environmental assessment study was initiated. The modeling effort was now directed towards Bennett Swamp and Thayer Canal weir, as reflected in this report.

MODELING RESULTS

MODELING RESULTS FOR PRE-WELLFIELD-, 1988-, AND 2010 CONDITIONS

To better visualize impact and be in accord with earlier groundwater modeling efforts by SJRWMD, the SWMM was set up to predict runoff for predevelopment, existing (1988), and projected (2010) wellfield pumpage by using piezometric contour levels predicted by MODFLOW (modular, three-dimensional, finite-difference, groundwater flow model) established by USGS. SJRWMD simulated 50 years of runoff to determine the impact of wellfield pumpage on runoff and recharge. Table 2 shows wellfields have a great impact on runoff volume, with most of the impact occurring to low-to-moderate flows in terms of duration. Overall, the reduction in runoff from pre-wellfield to 2010 conditions is 52.7% at U.S. 92 and 53.7% at Bennett Swamp outlet. The groundwater seepage portion of the runoff is very small—overall, only 2.3% at Bennett Swamp, for 2010 conditions. All of this seepage was assumed to originate from the Tiger Bay Canal segment between U.S. 92 and Tiger Bay Road, about 7,400 ft downstream. To reduce groundwater seepage loss into the canal would require a weir near the downstream end of Tiger Bay Canal. Much of this seepage is not technically "lost" but would infiltrate into Bennett Swamp. (SWMM does not compute seepage from the channel back into the shallow aquifer.) The reduction in evapotranspiration (ET) is small, only 6%. The increased recharge to the Floridan aquifer (deep percolation) is 217% above U.S. 92 and 230% above Bennett Swamp due to the lowering of the Floridan aquifer head with increased pumpage. Moving downstream, the recharge rate, in inches per year (in./yr), decreases due to the sharp reduction in the leakage rate in the Hawthorne Formation, extending east through Rima Ridge.

MODELING CHANGES AND RESULTS WITH PROPOSED WEIRS

The weirs were modeled using the piezometric contours for 2010-projected pumpage rates, because 1988 conditions were no longer applicable. The initial runs with SWMM and the backwater models, using the recommended phase I weir widths and crest elevations, which were approximated in SWMM, showed no significant change in runoff or flood levels. As a result, one weir was eliminated and the other three were raised in elevation. The model was rerun with the changes. The models, primarily HEC-RAS, were updated each time new information became available. The weir-modeling process and results are as follows.

After the initial SWMM run, Weir 1 at the upstream end of Tiger Bay Canal was downgraded to last place. There is no evidence this weir would reduce groundwater seepage since there is no natural channel or sign of groundwater seepage upstream of

Table 2. Simulated water budgets for pre-wellfield-, 1988-, and 2010 conditions at the three proposed weir sites

	Pre-wellfield		1988		2010	
	(in./yr)	(cfs)	(in./yr)	(cfs)	(in./yr)	(cfs)
(Tiger Bay Canal at U.S. 92 for 1946–1995 DeLand rainfall. Drainage area (DA) = 12,338.5 ac.)						
Rainfall	54.84	77.83	54.84	77.83	54.84	77.83
Evaporation	3.77	5.35	3.02	4.29	2.50	3.55
Evapotranspiration	36.28	51.49	35.23	50.00	34.20	48.54
Deep percolation	6.92	9.82	11.67	16.56	15.03	21.33
Runoff	9.73	13.81	6.85	9.72	5.13	7.28
(Tiger Bay Canal at Tiger Bay Road for 1946–1995 DeLand rainfall. DA = 16,763.1 ac.)						
Rainfall	54.84	105.74	54.84	105.74	54.84	105.74
Evaporation	3.67	7.08	3.17	6.11	2.76	5.32
Evapotranspiration	36.29	69.98	35.42	68.30	34.12	65.79
Deep percolation	6.44	12.42	11.59	22.35	14.63	28.21
Runoff	10.56	20.36	7.02	13.54	5.46	10.53
(seepage portion)	0.20	0.39	0.17	0.33	0.14	0.27
(Bennett Swamp to Hayes Island for 1949–1995 DeLand/Daytona Bch rainfall. DA = 18,595.5 ac.)						
Rainfall	54.38	116.32	54.38	116.32	54.38	116.32
Evaporation	3.59	7.68	3.07	6.57	2.67	5.71
Evapotranspiration	36.18	77.39	35.06	74.99	34.01	72.75
Deep percolation	6.03	12.90	11.14	23.83	13.90	29.73
Runoff	10.66	22.80	7.16	15.32	5.72	12.24
(seepage portion)	0.21	0.45	0.16	0.34	0.13	0.28

Note: Seepages for pre-wellfield conditions are estimated.
Measurements provided in inches per year (in./yr) and cubic feet per second (cfs); ac = acres.

U.S. 92. The weir crest elevation had to be elevated 2.4 ft to an elevation of 37 ft to impound 10 acres before the SWMM showed any benefit in the form of slower runoff rates. HEC-RAS backwaters indicated the backwater effect of the weir beyond the ponded area was minimal and would probably not affect any pine trees. Average annual flooded area would be increased by 10 acres. However, one serious problem with the crest at 37 ft is that it may be too high for a four-lane primary road, which calls for a 2- to 3-ft clearance above the designed, 24-hour high water level to protect the subgrade. The pavement elevation on the upstream (eastbound) side of the divided highway is 41 ft. The downstream (westbound) side is 1.5 ft lower. (The FDOT had a 64-ft weir with the crest at 37.5 ft, except for two 6-ft-wide slots. One slot had a fixed crest of 36.2 ft; the other had removable stop logs with settings anywhere from 33.2 to 37.5 ft.) For SWMM to show some kind of benefit, the minimum 2-ft clearance was chosen. If the 3-ft clearance had been required, the weir would have had to have been lowered by a foot. Stop logs would be required since the subgrade criterion would be violated by nearly every flood event. The weir crest should be lower than modeled to avoid removing stop logs all of the time.

Weir 2, the proposed weir site at the downstream end of Tiger Bay Canal (Figure 2), was moved upstream 1,600 ft and the crest elevation increased 3 ft from the phase I-recommended elevation. It would not impound any water, but would increase the average annual flooded area from about 73 acres to 166 acres. It would reduce groundwater seepage into the canal, but only by 0.17 cfs. However, this groundwater seepage is also needed downstream in Bennett Swamp, where wellfield impact and over-drainage are more severe. The weir crest elevation is also too high, for the same reasons stated as for Weir 1; that is, its backwaters affect the westbound lane of U.S. 92 to the same degree as Weir 1 does for the eastbound lane.

Weir 3, the proposed weir site at the upstream end of Thayer Canal (Figure 3), was clearly the much better site. This became apparent after determining that Thayer Canal was removing nearly all of the water from Bennett Swamp below ~15 cfs, diverting it directly to Tomoka River, before the water could travel its 5-mi historic course to the upper end of Tomoka River. Emphasis was, therefore, shifted to Bennett Swamp. SJRWMD contracted CH2M HILL in early 2000 to do some baseline monitoring and data collection of Bennett Swamp's existing ecological and hydrological conditions and to prepare a preliminary design for a weir to mitigate damages. CH2M HILL obtained three transects in the swamp (CH2M HILL 2000). SJRWMD obtained discharge measurements on three different occasions following Hurricane Gabriel in September 2001, the flood of record (Figure 3). At the same time, three additional cross sections of Bennett Swamp and three cross sections on Thayer Canal were obtained. These discharge measurements and new cross sections proved vital for recalibrating all of the backwater profiles done before the September 2001 flood. SWMM for the Bennett Swamp portion of the model was refined and a special reservoir routing program was developed for the purpose of routing flows through Bennett Swamp. The weir crest was raised a foot to 28.5 ft from the phase I report level. About 80 acres would be impounded by the weir but at a lower elevation than 27.6 ft, the elevation at about which water begins to spill south around Hayes Island. The average water level in the middle of Bennett Swamp would be raised from 28.06 ft to 28.34 ft, under 2010 conditions. This represents an increase in average annual flooded area from 265 acres to 341 acres for the area between Hayes Island and 7,500 ft to the northwest. The average annual flooded area between Hayes Island and U.S. 92 would be increased about 30 acres. Average annual flows south around Hayes Island would increase from about 3.8 to 6.8 cfs. Before the construction of Thayer Canal, average annual flow was 20 cfs around Hayes Island. Nothing spilled east, except during extreme flood events. An undetermined, small increase in flow leading into the north half of Bennett Swamp was not modeled. Table 3 compares the phase II weir characteristics and impacts with those of the phase I report.

Table 3. Comparison of phase II proposed weirs and phase I proposed weirs

Phase II Interim Report						Phase I Report				
Weir Number	Location (Figure 4)	Width (ft)	Crest Elev. (ft NGVD)	Increase in Avg Annual Flooded Area (acres)	Increased Recharge (ac-ft/day)	Location (Figure 4)	Width (ft)	Crest Elev. (ft NGVD)	Increase in Avg. Annual Flooded Area (acres)	Increased Recharge (ac-ft/day)
Weir 1	TB140	64	37.0	10*	0.05*	TB140	60	34.6	328	N/A.
Weir 2	TB137	38	35.5	93*	0.39*	TB135	50	32.5	93	N/A.
Weir 3	TB123	30	28.5	106	0.15	TB120	30	27.5	119	N/A.
none	TB175	Eliminated				TB175	60	41.0	0.1	N/A
Totals				209	0.59				540	3.68**

*To obtain these benefits, the subgrade of U.S. 92 would be threatened. The increase in 24-hour flood stage duration violated Florida Department of Transportation criterion for a four-lane highway.
**Phase I report did not provide a breakdown of increased recharge resulting from each proposed weir site.
N/A = not applicable
ac-ft/day = acre-feet per day
ft NGVD = feet National Geodetic Vertical Datum

Bennett Swamp Environmental Benefits

Figure 5 depicts the simulated stage-duration curves and how they compare with the historic stage-duration curve based on soil indicators and some short- to medium-term biologic indicators at the CH2M HILL vegetative transect “Thayer Canal” (yellow line in Figure 3), 1,000 ft north of Hayes Island in Bennett Swamp (CH2M HILL 2001). The moss lower limits serve as a short-term indicator, reflecting existing conditions. The stage-duration curve for 1988 pumpage rates falls within the moss lower limits range, but only 0.1 ft higher than for the 2010 pumpage rate. The difference becomes greater for longer exceedence frequencies. The weir, under 2010 conditions, would increase the stage 0.3–0.4 ft over existing conditions (1998 pumpage rate). The initial target level is to meet water levels for pre-wellfield conditions, which it exceeds by 0.1–0.2 ft.

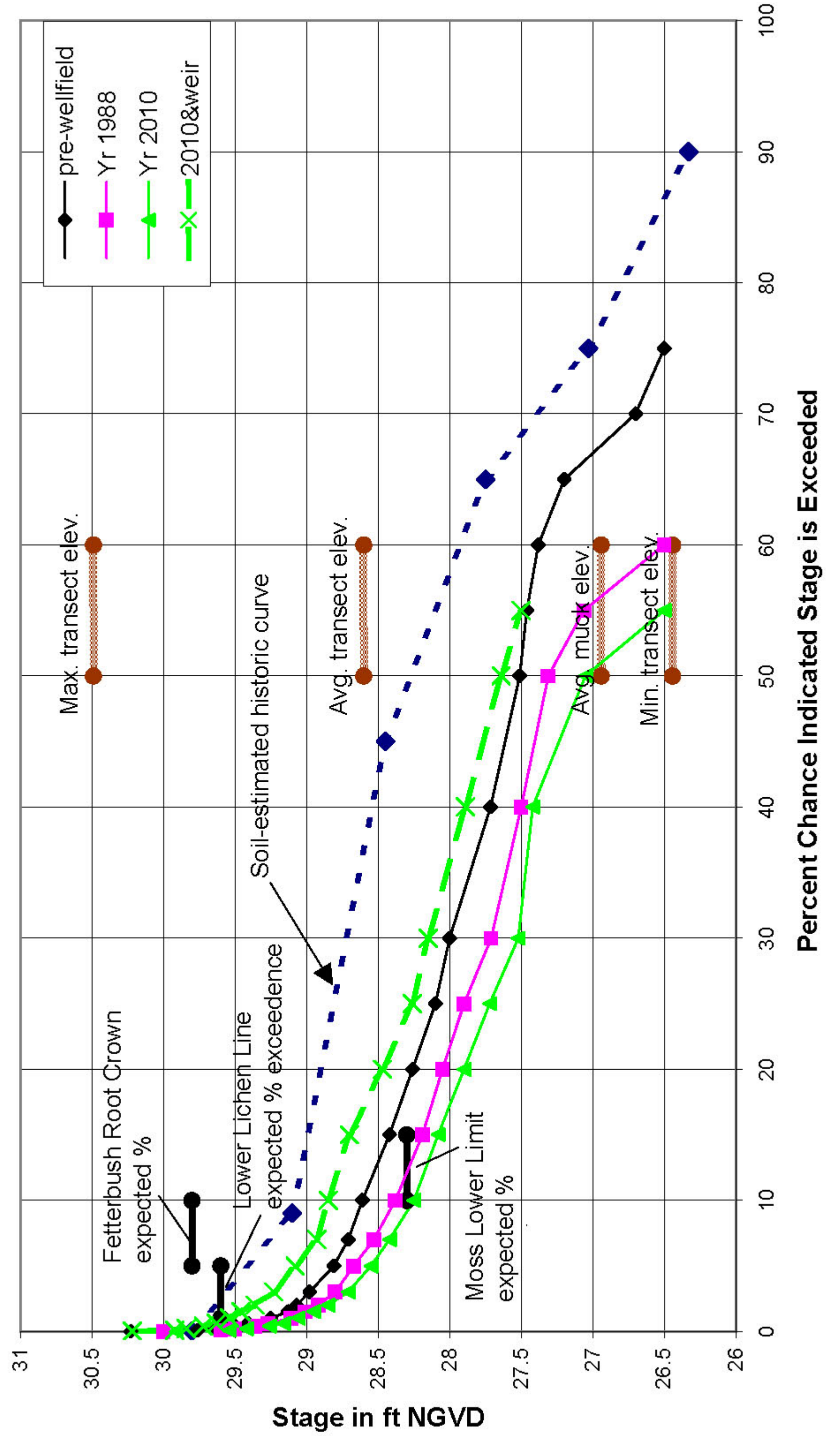

Figure 5. Bennett Swamp simulated 1949–1995 stage duration at Thayer Canal transect

CONCLUSIONS AND RECOMMENDATIONS

Based on the expected increase in average annual flooded area in Table 3 and (to a lesser extent) on increased recharge and on severity of drawdown and endangerment to highway subgrade, the three potential weir sites are ranked as follows, in descending order.

1.) Weir 3, located at Thayer Canal, shows the largest improvement in flooded area, with a 106-acre increase in annual flooded area and a 0.15 acre-feet per day (ac ft/day) increase in recharge. This includes the Bennett Swamp area between Hayes Island and U.S. 92. Despite having less recharge potential, the Thayer Canal weir gets priority status, for the following reasons: (1) Bennett Swamp has been the most adversely affected wetland area as a result of the combination Thayer Canal diversion and wellfield drawdown; (2) no roads are adversely impacted; (3) the reduction in runoff caused by any upstream weir requires the construction of Weir 3 to compensate for the reduced discharge and damages to Bennett Swamp; and (4) the primary purpose of the weirs is wetland augmentation. Increased recharge is of secondary importance.

2.) Weir 2, located at Tiger Bay Road, is almost equally as good in terms of increase in average annual flooded area (+94 ac) and is better than Weir 3 in increased recharge (+0.35 ac ft/day). However, the increase in stage-duration exceeds the FDOT criterion for subgrade protection of U.S. 92. Tiger Bay Swamp also has been less severely impacted from over drainage and wellfield pumpage than Bennett Swamp. In addition, the flooded area data and estimates are the least refined among the three potential weir sites.

3.) Weir 1, located at the upstream end of Tiger Bay Canal, is the least favorable because of the much smaller increase in average flooded area (+10 ac) and recharge (+0.05 ac ft/day) and because it requires the largest size and number of weirs (one large weir and 7 small weirs). It also exceeds FDOT criterion for subgrade protection of U.S. 92.

Some of the recommendations proposed during the study have been largely accomplished. An environmental assessment and weir design for Bennett Swamp was contracted in early 2000 to CH2M HILL. Final design and construction was carried out and completed in May 2003 by CH2M HILL, and they are now monitoring and collecting data. The need for more accurate modeling of the shallow aquifer water table levels was recognized early in the study. The result of this was SJRWMD's contract with CDM/DHI in fall 2001 to develop an integrated groundwater/surface water model of Tiger Bay/Bennett Swamp area. Camp Dresser and McKee Inc.

(CDM) and their subcontractor Danish Hydrological Institute (DHI) use the MIKE SHE model for infiltration/runoff and groundwater and the MIKE 11 model for routing surface runoff downstream. The combination of these two models will do a much better job of estimating the shallow water table levels, groundwater seepage, and recharge to the Floridan aquifer and will have application to other watersheds in the District. Future modeling will likely use this set of models. This contract has since been extended to include two more watersheds and two more wellfields to the southeast of Tiger Bay, plus it includes the recently constructed weir at the upper end of Thayer canal. Doppler rainfall data is also being used to supplement the few rainfall gauges in the area. This second contract was scheduled for completion in September 2004.

Remaining recommendations are that Weir 2 at Tiger Bay Road be given serious consideration for possible construction. Tiger Bay has a better recharge rate than Bennett Swamp. However, the weir crest elevation should be lower than that modeled in this report or else have some type of automatic gate opening devise that could cancel most of the backwater effects of the weir. More detailed modeling of this site and any other sites should wait until additional surveys are taken, better topographic data are obtained, and the integrated global system model (IGSM) is refined. The IGSM can also be used to evaluate different operation methods for any weir.

The need for additional surveys and 1-ft contour maps specified in the phase I report still apply. A cross section is needed across Tiger Bay swamp at Tiger Bay Island. Another is needed 1,000–2,000 ft south of this. A north-south ground profile 2,000–4,000 ft long around Tiger Bay Island is necessary to make certain which way, north or south, water tends to flow. The phase I study assumed drainage was from north to south. This phase II report assumed no exchange of water takes place. Most likely, large floods in Tiger Bay could potentially spill north around Tiger Bay Island, but the opposite might occur if the storm is centered over the north end of Tiger Bay.

Weir 3 at the upstream end of Tiger Bay Canal has comparatively few benefits for the expense involved, and it should be dropped from consideration unless future modeling with the integrated groundwater/surface water model proves otherwise.

POST-PROJECT UPDATE: JUNE 2007

The Thayer Canal weir (Weir 3) was completed in January 2004. The stop logs were installed January 14 and initially set at 27.0 ft. In April 2004, an additional stop log was added to bring the weir crest to 27.5 ft, where it has remained up to the present. Eventually it will be set at the design level of 28.5 ft. Raising water levels upstream 1.0 ft above normal has only a limited impact on the immediate surroundings. It does not cause less water to flow out Thayer Canal, nor does it send more water south around Hayes Island. When the stop logs are set at 28.5 ft, more water should be diverted south around Hayes Island and less would be lost out Thayer Canal, especially at low flows. During larger floods, the weir is completely flooded and there is no difference in flow distribution with or without the weir.

The weir is constructed about 800 ft upstream of the wooden bridge, located on the ridgeline trail that runs along the eastern edge of Bennett Swamp. The water level recorder for the weir is the wetland observation well on Thayer Canal Transect located about 1,000 ft west of the weir. The observed stage-discharge curve prior to construction of the weir is generally within 0.1 ft of the computed stage using HEC-RAS. This is an excellent verification of the modeling, which is based on only three high water marks at the wooden bridge 1,700 ft downstream of the gauge. The observed upstream stage data after the weir was installed accurately reflects the discharge expected.

An important new finding following further examination of the discharge records shows that in the early 1980s, more water spilled south around Hayes Creek than presently occurs. This is based on the assumption that the Tiger Bay Canal discharge into Bennett Swamp represents total inflow and that what does not exit Thayer Canal spills south around Hayes Island, eventually entering the Tomoka River. For example in 1982–1985, if Tiger Bay Canal was discharging 100 cfs into Bennett Swamp, 45 cfs exited Thayer Canal and the remaining 55 cfs went south around Hayes Island. In recent years, this has changed to 70 cfs flowing out Thayer Canal and 30 cfs spilling south around Hayes Island. Past records of aerial photographs were reviewed to provide a possible explanation. Changes were noted in the trail crossing Bennett Swamp at Hayes Island. In aerial photos dated 1984, the break in the forest canopy was only 10 ft wide in and around Hayes Island. In a 1992, it was 10–25 ft wide. By 2004, it was 60 ft wide. A field trip disclosed that the overburden from clearing the 60-ft-wide pathway was bulldozed, mostly to the southeast side of the trail, leaving a 3-foot-high mound of dirt concealed in the underbrush along the southeast edge of the clearing. Only the portion of the trail east of Hayes Island was inspected. Assuming this is true for the whole length of the trail, a series of openings should be made along this row of dirt to improve flow southward. Some openings probably exist, but more are needed. The area bordering the north side of the trail is also disturbed, but consists of a series of excavations 3–5 ft deep and several yards across that apparently were a source of fill material for the trail to make up for the losses bulldozed to the south side.

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