

**PRELIMINARY ENGINEERING REPORT  
EVALUATION OF JASMINE STREET  
TIDE BARRIER ALTERNATIVES,  
EGANS CREEK  
NASSAU COUNTY, FLORIDA**

**February 16, 2007**

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EVALUATION OF JASMINE STREET TIDE BARRIER ALTERNATIVES,  
EGANS CREEK  
NASSAU COUNTY, FLORIDA**

**FOR  
FLORIDA DEPARTMENT OF TRANSPORTATION  
DISTRICT 2**

**PREPARED BY**

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**February 2007  
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## EXECUTIVE SUMMARY

Prompted by vegetation changes south of Jasmine Street after the construction of the Egans Creek self regulating tide (SRT) gate at Atlantic Avenue (SR200), this evaluation addresses alternatives that would either promote saltwater vegetation south of Jasmine Street, or inhibit (effectively preclude) tide and saltwater propagation south of Jasmine Street in order to maintain or re-establish freshwater vegetation there. In either case, the evaluation's objective strives to minimize the effects on flood levels both north and south of Jasmine Street. Through model applications, Taylor Engineering evaluated several alternatives to meet this objective, including gravity tide flap gates and valves. This modeling effort builds upon Taylor Engineering's hydrologic and hydraulic modeling performed for the Egans Creek salt marsh restoration project which included the replacement of a failing tide flap gate at Atlantic Avenue with the SRT gate to restore tidal (saline) flow to the creek to generate salt marsh regrowth.

Taylor Engineering applied HEC-RAS 3.1, converted from the previous UNET model, for a typical tide (no rainfall) as well as two rainfall events — the 25- and 100-year storms — with and without tide barriers in place. The evaluation considered two types of tide barriers — flap gates and valves — attached to a box weir structure on either the south or north end of the existing Jasmine Street culverts. The gates and valves would allow rainfall runoff to flow downstream (north) but inhibit, with proper operation, tide from propagating upstream. For all alternatives, the top of the box would remain open to serve as flood relief should storm water levels exceed +1.6 ft NGVD. Alternatives included both two and three openings in the box (for both flap gates and valves) of different sizes equivalent to two 3x3 ft square, two 4 ft diameter circular, two 4x7 ft elliptical, and three 4 ft diameter circular openings. Generally, the results indicate all alternatives would inhibit tide propagation south of Jasmine Street and maintain existing levels of flood protection. The barriers would affect tides north of Jasmine Street (high tide would increase and low tide would decrease). Also, salinity levels would likely decrease at least periodically for some distance north of Jasmine Street.

Without a tide barrier at Jasmine Street, tides will continue to propagate through the large culverts and into the system south of Jasmine Street where they will promote a return to the historical salt marsh environment. Simulated tides indicate minimal tide attenuation for a considerable distance south of Jasmine Street with high tide reaching about +1.2 ft NGVD. Recently observed freshwater vegetation loss south of Jasmine Street suggests saltwater vegetation will cover approximately 50 acres (roughly equal to the recently observed area of stressed and damaged freshwater vegetation). However, a more detailed model setup based on topographic surveys south of Jasmine Street is necessary to refine the expected areas/limits of salt marsh creation. The more detailed model is beyond the scope of this evaluation.

Saltwater marsh is more ecologically productive than freshwater wetlands. Thus, Federal agencies generally prefer saltwater marsh to freshwater wetlands and often require greater mitigation for saltwater marsh impacts compared to freshwater wetland impacts. Furthermore, agencies generally prefer a natural system over an engineered system that maintains the system in an unnatural (not historical) condition. With no tide barrier, restoration of Egans Creek south of Jasmine Street to its historical salt marsh environment would likely occur naturally. Clearing of freshwater vegetation (estimated at \$375,000) would not be necessary for successful salt marsh restoration.

Long-term preservation of certain freshwater vegetation south of Jasmine Street is virtually impossible without the construction of major, expensive surge flood control structures. A 25-year hurricane surge would overtop Atlantic Avenue and flood the entire Egans Creek system. Such an event would kill nearly all the freshwater flora, including red maple trees. By definition, the 25-year surge has almost a 90% chance of occurrence over a 50-year design life. Thus, long-term costs of maintaining the area south of Jasmine Street as a freshwater system should realistically include replanting every 50 years (and vegetation removal if desired). This cost, at present day rates, is \$593,000 for 50 acres, but the total cost would depend on the area inundated by surge and could exceed several million dollars. In contrast, a salt marsh (virtually unaffected by surges) should remain permanently.

If a tide barrier is installed, a valve-type barrier (with three independent valves in case one-valve fails) on the south side of Jasmine Street is recommended. The design life (50-year) cost for this structure exceeds \$2,000,000 (including initial construction and average annualized maintenance costs at about \$316,000 and \$38,000, respectively, assuming 4% annual escalation, and excluding recommended routine inspection costs). Re-establishment of freshwater vegetation south of Jasmine Street should occur over time without replanting. The time required for re-establishment of freshwater vegetation is unknown and depends on the time required for rainfall to flush the brackish water from the soil. If replanting is preferred, soil salinity tests should be performed before replanting. Soil salinity has not been assessed at this time. An analysis of the soil salinity flushing time was beyond the scope of this study. The table below summarizes costs for salt/freshwater systems south of Jasmine Street.

Cost Summary for Jasmine Street Alternatives

<b>Cost Item</b>	<b>Tide Barrier<sup>1</sup>/Freshwater System South of Jasmine</b>	<b>Saltwater System South of Jasmine</b>
Initial Structure Construction	\$316,000	Not Applicable
Annual Structure Maintenance <sup>2</sup>	\$38,000	Not Applicable
Tree Clearing/Grubbing <sup>3</sup>	\$375,000	\$375,000

<sup>1</sup> Valves on 3, 4-ft diameter circular openings in box on south side of Jasmine Street

<sup>2</sup> Average over 50-year design life with 4% annual escalation.

<sup>3</sup> 50 acres assumed; not required for freshwater or saltwater system re-establishment.

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## 1.0 INTRODUCTION

Prompted by vegetation changes south of Jasmine Street after the construction of the Egans Creek self regulating tide (SRT) gate at Atlantic Avenue, the Florida Department of Transportation directed Earth Tech Consulting, Inc. (Earth Tech), the Department's General Engineering Consultant, to identify and evaluate feasible alternatives that would either promote saltwater vegetation south of Jasmine Street or inhibit (effectively preclude) tide and saltwater propagation south of Jasmine in order to maintain or reestablish freshwater vegetation there. In either case, the evaluation's objective strives for minimal effects on flood levels both north and south of Jasmine Street. This evaluation builds upon previous work performed for the Egans Creek salt marsh restoration project which included the replacement of a failing tide flap gate at Atlantic Avenue with the SRT gate to restore tidal (saline) flow to the creek to generate salt marsh regrowth.

Earth Tech tasked Taylor Engineering, having previously setup and applied a hydrologic and hydraulic model of the Egans Creek system, to perform the modeling component of this evaluation and, with input from Earth Tech and Environmental Resource Solutions, to develop rough cost comparisons for feasible alternatives. Through model applications, Taylor Engineering evaluated several alternatives to inhibit saltwater propagation south of Jasmine Street and provide flood control. Alternatives included gravity tide flap gates and valves. Model applications also addressed the expected tide conditions south of Jasmine Street without tide barrier installation.

This report provides model results and rough cost comparisons for the alternatives. Chapter 2 describes the model setup. Chapter 3 describes the results of model applications for storm events with various tide barriers in place. Chapter 4 provides cost estimates for tide barrier alternatives addressed in Chapter 3. Chapter 5 describes expected tidal conditions without tide barriers (do nothing alternative). Chapter 6 addresses other effects and issues the Department should consider before it selects an alternative. Finally, Chapter 7 provides a summary and conclusion.

Appendices provide backup information. Appendix A includes samples of vendor specifications for a variety of tide barriers. Appendix B includes the HEC-RAS model schematization, and model input and output.

## 2.0 MODEL SETUP

This modeling effort builds upon the hydrologic and hydraulic modeling performed for the Egans Creek salt marsh restoration project (Dompe, et al., 2000; Taylor Engineering, Inc., 2001). For that project, Taylor Engineering applied UNET (U.S. Army Corps of Engineers [USACE], 1995), a one-dimensional, dynamic hydraulic model that can simulate flow in a complex network of open channels. Because of its capability to include off-channel storage, overbank storage areas, and multiple channels, UNET resembles a quasi two-dimensional model. The UNET model simulated the SRT gates at Atlantic Avenue and predicted tide levels, duration of tide inundation, hurricane storm surge flooding, and rainfall runoff flooding within Egans Creek including south of Jasmine Street. Described in Dompe, et al. (2000), application of a separate model provided the rainfall runoff rates within UNET.

Taylor Engineering applied the UNET model to design the Egans Creek salt marsh restoration with specific emphasis on the mitigation area between Atlantic Avenue and Jasmine Street. Thus, the model detail focuses on the area between Atlantic Avenue and Jasmine Street, inclusive of the culverts at Atlantic and Jasmine. With a simulated tide range near 3 ft immediately north of Jasmine Street, the model predicted tide propagation with minimal head loss (attenuation) through the two large (4-ft x 7-ft) elliptical culverts under Jasmine Street and into the system (canals and low-lying terrain) south of Jasmine Street. However, because Taylor Engineering designed the model setup to quantify marsh creation north (and not south) of Jasmine Street per the scope of work, the model only represented the system south of Jasmine Street in limited detail.

For the current evaluation, Taylor Engineering converted the UNET model to HEC-RAS 3.1 (USACE, 2002). Run in dynamic mode, HEC-RAS represents USACE's updated version of UNET and provides a visual, dynamic gate operation and water level output that aid quality assurance. A comparison of the HEC-RAS model results to the UNET model results ensured adequate conversion; differences in simulated water level results fell under 0.03 ft at all checked locations within the models. Without calibration, the HEC-RAS (and UNET) model simulates observed, general tidal conditions within the system (north and south of Jasmine Street) very well. At the time of this evaluation, concurrent water elevations throughout the system with all three SRT gates open were unavailable for a detailed model calibration effort. However, limited water level readings describing the head loss across the SRT gates did allow a minor model adjustment to the gates' coefficient of discharge parameters and the culverts' entrance and exit losses. Taylor Engineering then applied the adjusted HEC-RAS model to evaluate Jasmine Street tide barrier alternatives and their effect on flooding as described below.

### 3.0 MODEL RESULTS FOR TIDE BARRIER ALTERNATIVES

The adjusted HEC-RAS model, described above, was applied to a typical, mean tide (no rainfall) condition as well as two rainfall events — the 25-year storm and the 100-year storm (1% chance of occurrence in any given year). The results from these model applications established the baseline conditions (water levels) for comparison with tide barrier alternatives. Thus, comparing model results from the simulations of a Jasmine Street tide barrier with model results for baseline (existing) conditions established the expected effects of the tide barriers on tide elevations and storm water (flooding) elevations north and south of Jasmine Street.

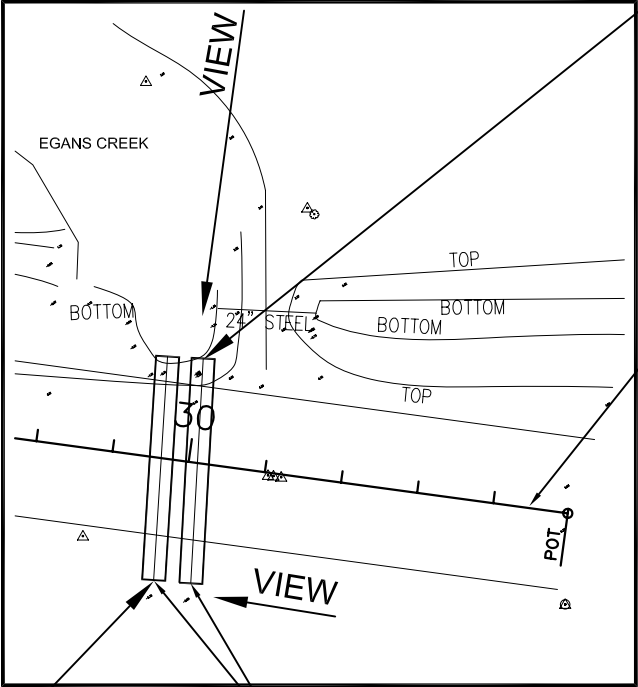
Taylor Engineering simulated two types of tide barriers — flap gates and valves — attached to a box weir structure on either the upstream (south) or downstream (north) end of the existing Jasmine Street culverts. Figure 3.1 shows photographs demonstrating the existing conditions at the north and south culvert ends. Figures 3.2 – 3.3 provide conceptual drawings for the two water control box locations and show a flap gate type barrier with two openings. (Appendix A includes typical gate and valve descriptions, drawings, specifications, and photos.) The gates and valves allow rainfall runoff to flow downstream (north) but inhibit, with proper operation, tide from propagating upstream. For all alternatives, the top of the box remains open, as would a drop structure, to allow stormwater flow over the top of the box as a flood relief if storm water levels exceed +1.6 ft NGVD. This elevation would preclude normal tides and salinity from propagating south of Jasmine Street.

Modeled alternatives included both two and three openings in the control box (for both flap gates and valves) of different sizes equivalent to two 3x3 ft square openings, two 4 ft diameter circular openings, two 4x7 ft elliptical openings, and three 4 ft diameter circular openings. Simulations also considered the addition of a 4x7 ft elliptical culvert under Jasmine Street with three 4x7 ft elliptical openings in the box (ultimately found unnecessary for achieving adequate flood control). Given the creek bottom elevation (near -3 ft NGVD) and low road elevation, 4 ft high openings in the box were the maximum considered. Note that a single tide gate can serve a large opening, say 4x10 ft; however, Taylor Engineering recommends multiple, lighter weight flap gates or multiple valves as a safety factor should one gate or valve become inoperable (unable to open or close). In this case, the other gates or valves ideally should function properly to allow some level of flood protection and maintain some level of tide obstruction.

The model setup for flap gates and valves comprise similar configurations. Within the model, multiple vertical sluice gate structures about the box structures. Depending on the simulated water surface elevation difference (water pressure gradient) across the gates (north vs. south of the gates), the model



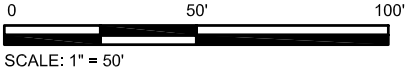
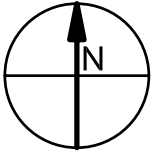
NORTH END  
(FROM NORTH)



JASMINE STREET (CENTER LINE)

EXISTING 7' x 4' CULVERTS

SOUTH END  
(FROM EAST)

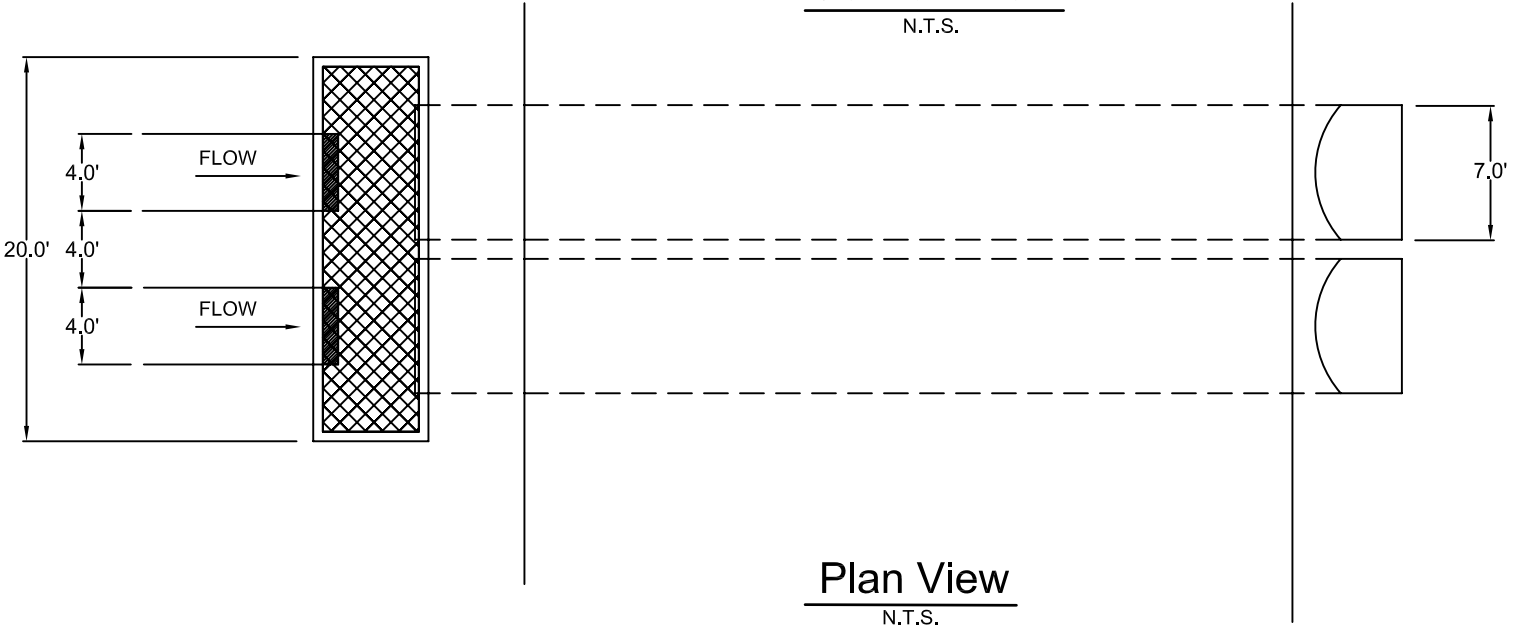


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FIGURE 3.1  
 JASMINE STREET CULVERTS,  
 EGANS CREEK  
 NASSAU COUNTY, FLORIDA

PROJECT	C2000-010
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SHEET	1 of 3
DATE	JAN. 2007

SEAL	
ENGINEER OF RECORD	
DATE	



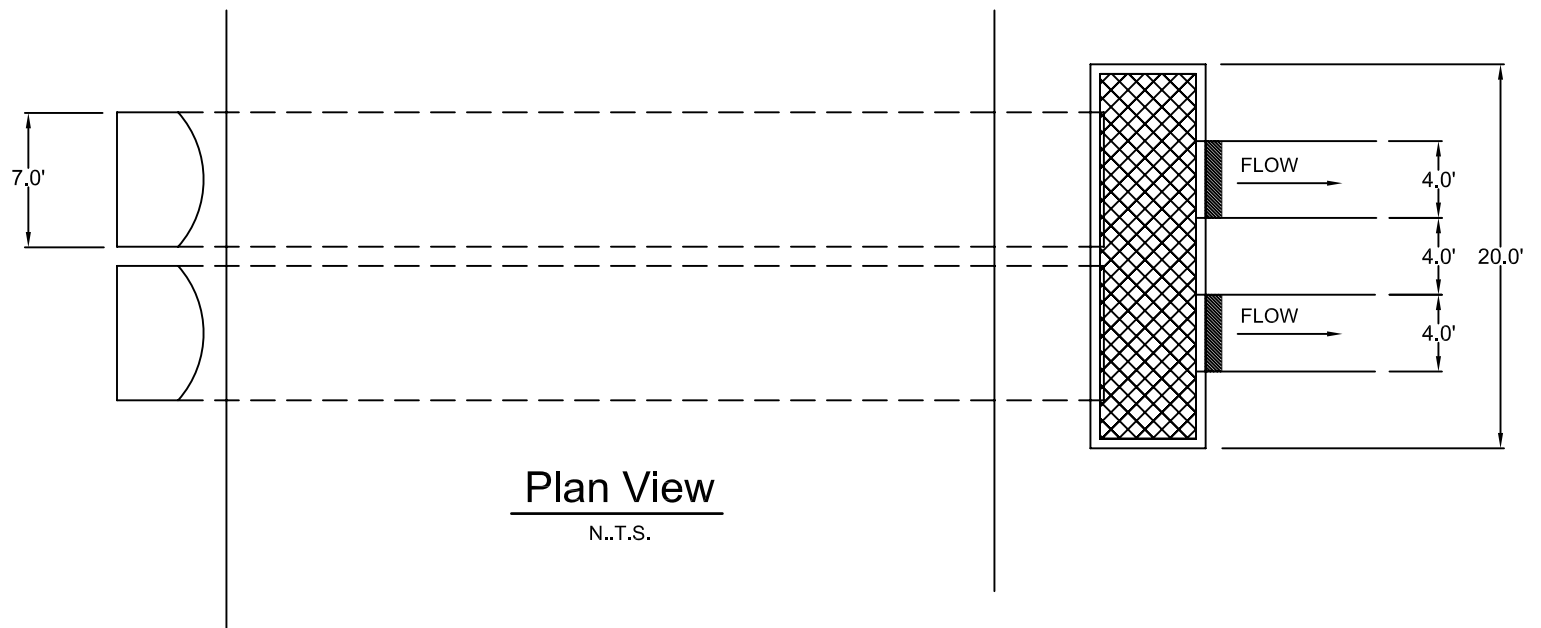
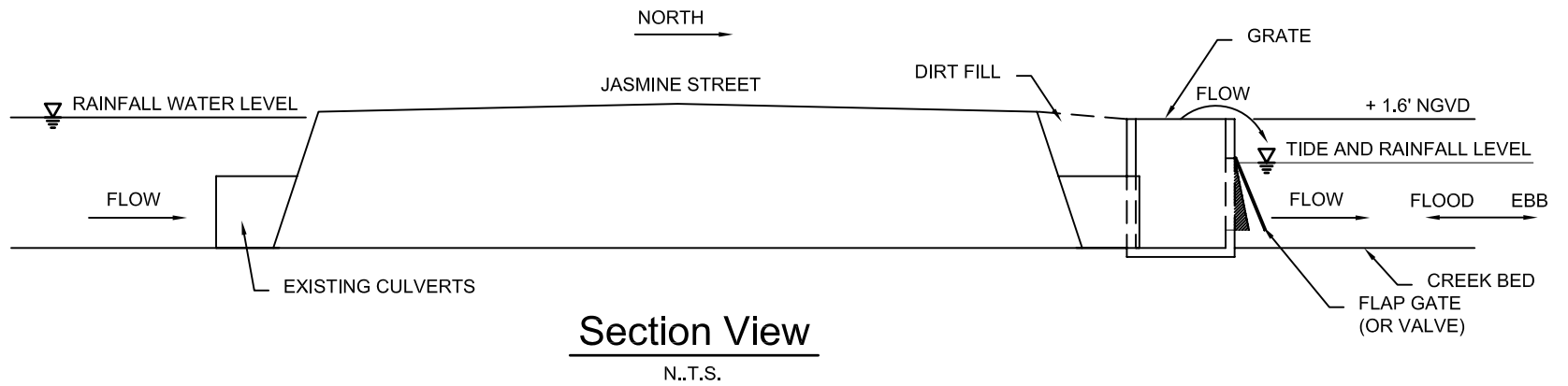
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FIGURE 3.2  
 CONCEPTUAL TIDE BARRIER ON  
 SOUTH SIDE OF JASMINE STREET

PROJECT	C2000-010	SEAL
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FIGURE 3.3  
CONCEPTUAL TIDE BARRIER ON  
NORTH SIDE OF JASMINE STREET

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DATE	JAN. 2007

SEAL

ENGINEER OF RECORD

DATE

opens and closes the gates. For example, given a higher elevation on the south (freshwater) side of the gates, the gates open to allow stormwater runoff to flow north through the culverts. Given a higher water elevation on the north side of the gates, the gates close to inhibit tidal flow (salt water) south.

Although the model setup appears similar for both flap gate and valve alternatives, the hydraulic losses through a flap gate versus a valve represent important differences between the two types of barriers. Neither apparatus type opens completely to allow unobstructed flow — as such, each apparatus poses a different degree of obstruction as water passes through the opening. Thus, the gates' discharge coefficient ( $C_d$ ) were adjusted within the model to represent the different hydraulic losses for the flap gate and valve. The model simulated three different coefficient values — low: 0.2, medium: 0.4, and high: 0.7 — to represent a range that would encompass the hydraulic losses expected for the different barrier types (the lower the coefficient, the greater the hydraulic loss or flow reduction). Also, examining the model results for this range provides an understanding of the model sensitivity to discharge coefficients. Notably, a coefficient of 0.7 represents a typical value for a gate opening without a tide flap gate or valve attached.

Model results for a typical tide (without rainfall) indicate the barrier would slightly change tidal conditions north of Jasmine Street. High tide levels would likely rise about 0.1 ft and low tide levels would likely drop about 0.3 ft. The resulting tide range would increase about 0.4 ft. As a result, periods of inundation north of Jasmine Street could change slightly.

Tables 3.1 – 3.4 provide selected model results for rainfall flood events. Tables 3.1 and 3.2 provide the 25- and 100-year flood elevation effects caused by a tide barrier on the north side of Jasmine Street. Tables 3.3 and 3.4 provide the 25- and 100-year flood elevation effects caused by a tide barrier on the south side of Jasmine Street. Communication with gate and valve vendors indicates a low to medium  $C_d$  corresponds approximately to valve-type barriers, and a medium – high  $C_d$  corresponds to a typical flap gate barrier.

**Table 3.1** 25-year Rainfall Flooding Effects North and South of Jasmine Street for Tide Barrier Alternatives Located on the North Side of Jasmine Street

Tide Barrier Alternative	Peak	Stage	Effect (ft)
	Low Cd	Medium Cd	High Cd
Gate/valve on 2, 3-ft x 3-ft square openings (with 2, 4-ft x 7-ft elliptical culverts)	N: 0.00 S: 0.00	N: 0.00 S: 0.00	N: 0.00 S: 0.00
Gate/valve on 2, 4-ft dia circular openings (with 2, 4-ft x 7-ft elliptical culverts)	N: 0.00 S: 0.00	N: 0.01 S: 0.00	N: 0.00 S: 0.00
Gate/valve on 3, 4-ft dia circular openings (with 2, 4-ft x 7-ft elliptical culverts)	N: 0.00 S: 0.00	N: 0.00 S: 0.00	N: 0.00 S: 0.00
Gate/valve on 2, 4-ft x 7-ft elliptical openings (with 2, 4-ft x 7-ft elliptical culverts)	N: 0.00 S: 0.00	N: 0.00 S: 0.00	N: 0.00 S: -0.01

N: Change in Peak Flood Level on the North Side of Jasmine Street; existing HWL +2.88 ft-NGVD  
S: Change in Peak Flood Level on the South Side of Jasmine Street; existing HWL +2.90 ft-NGVD

**Table 3.2** 100-year Rainfall Flooding Effects North and South of Jasmine Street for Tide Barrier Alternatives Located on the North Side of Jasmine Street

Tide Barrier Alternative	Peak	Stage	Effect (ft)
	Low Cd	Medium Cd	High Cd
Gate/valve on 2, 3-ft x 3-ft square openings (with 2, 4-ft x 7-ft elliptical culverts)	N: -0.01 S: +0.01	N: -0.01 S: 0.00	N: -0.01 S: 0.00
Gate/valve on 2, 4-ft dia circular openings (with 2, 4-ft x 7-ft elliptical culverts)	N: -0.01 S: +0.01	N: -0.01 S: 0.00	N: -0.01 S: 0.00
Gate/valve on 3, 4-ft dia circular openings (with 2, 4-ft x 7-ft elliptical culverts)	N: -0.01 S: 0.00	N: -0.01 S: 0.00	N: -0.01 S: 0.00
Gate/valve on 2, 4-ft x 7-ft elliptical openings (with 2, 4-ft x 7-ft elliptical culverts)	N: -0.01 S: 0.00	N: -0.01 S: 0.00	N: -0.01 S: 0.00

N: Change in Peak Flood Level on the North Side of Jasmine Street; existing HWL +3.40 ft-NGVD  
S: Change in Peak Flood Level on the South Side of Jasmine Street; existing HWL +3.49 ft-NGVD

**Table 3.3** 25-year Rainfall Flooding Effects North and South of Jasmine Street for Tide Barrier Alternatives Located on the South Side of Jasmine Street

Tide Barrier Alternative	Peak	Stage	Effect (ft)
	Low Cd	Medium Cd	High Cd
Gate/valve on 2, 3-ft x 3-ft square openings (with 2, 4-ft x 7-ft elliptical culverts)	N: 0.00 S: 0.00	N: 0.00 S: 0.00	N: -0.01 S: 0.01
Gate/valve on 2, 4-ft dia circular openings (with 2, 4-ft x 7-ft elliptical culverts)	N: 0.00 S: 0.00	N: 0.00 S: 0.00	N: 0.00 S: 0.00
Gate/valve on 3, 4-ft dia circular openings (with 2, 4-ft x 7-ft elliptical culverts)	N: -0.01 S: 0.00	N: 0.00 S: 0.00	N: -0.01 S: -0.01
Gate/valve on 2, 4-ft x 7-ft elliptical openings (with 2, 4-ft x 7-ft elliptical culverts)	N: 0.00 S: 0.00	N: 0.00 S: 0.00	N: -0.01 S: -0.01

N: Change in Peak Flood Level on the North Side of Jasmine Street; existing HWL +2.88 ft-NGVD  
S: Change in Peak Flood Level on the South Side of Jasmine Street; existing HWL +2.90 ft-NGVD

**Table 3.4** 100-year Rainfall Flooding Effects North and South of Jasmine Street for Tide Barrier Alternatives Located on the South Side of Jasmine Street

Tide Barrier Alternative	Peak	Stage	Effect (ft)
	Low Cd	Medium Cd	High Cd
Gate/valve on 2, 3-ft x 3-ft square openings (with 2, 4-ft x 7-ft elliptical culverts)	N: -0.01 S: +0.01	N: -0.02 S: +0.01	N: -0.02 S: 0.00
Gate/valve on 2, 4-ft dia circular openings (with 2, 4-ft x 7-ft elliptical culverts)	N: -0.01 S: +0.01	N: -0.02 S: 0.00	N: -0.02 S: 0.00
Gate/valve on 3, 4-ft dia circular openings (with 2, 4-ft x 7-ft elliptical culverts)	N: -0.02 S: 0.00	N: -0.02 S: -0.01	N: -0.02 S: -0.01
Gate/valve on 2, 4-ft x 7-ft elliptical openings (with 2, 4-ft x 7-ft elliptical culverts)	N: -0.02 S: +0.01	N: -0.02 S: 0.00	N: -0.02 S: 0.00

N: Change in Peak Flood Level on the North Side of Jasmine Street; existing HWL +3.40 ft-NGVD

S: Change in Peak Flood Level on the South Side of Jasmine Street; existing HWL +3.49 ft-NGVD

Generally, model results indicate the alternatives would inhibit tide propagation south of Jasmine Street and maintain existing flood protection levels (minimal to no effect on flood levels both north and south of Jasmine Street). Note the tide barriers, by impeding tide propagation upstream, would create additional flood storage volume available for rainfall runoff. Because high tide does not propagate south of Jasmine Street, the water level upstream of Jasmine Street is lower at the beginning of the storm event. Thus, with a tide gate alternative, the volume of water in the system is less at the beginning of the storm event. This condition allows more rainfall runoff to store in the system without causing flooding. Thus, the tide barriers generally tend to maintain flood protection.

Although peak flood elevations are not expected to increase, rainfall runoff would pond behind the tide barrier and drain through the barrier when the upstream water level exceeds the downstream tide level. A slower release could result in longer durations of freshwater inundation upstream (south) of Jasmine Street. Preliminary modeling indicates daily water levels will likely rise 0.5 ft, assuming 1 ft<sup>3</sup>/sec of base flow, above the typical daily conditions that existed before the SRT gate construction at Atlantic Avenue. Model setup south of Jasmine Street remains insufficient to examine daily inundation conditions in detail.

#### 4.0 COST ESTIMATES FOR TIDE BARRIER ALTERNATIVES

Table 4.1 summarizes approximate cost estimates for 12 different configurations of selected tide barriers — square or circular openings fitted with gates or valves on a control box structure located either north or south of Jasmine Street. The purpose of these estimates is to evaluate alternative feasibility, not to provide detailed construction cost estimates or to identify the most cost-effective alternative. Initial cost estimates consider installed costs related to excavation and back fill; shore stabilization (including rip rap, bedding stone, and filter fabric); cast-in-place, pile-supported concrete boxes; steel traffic-load grates; stainless steel on gates/valves; surveying; engineering design; permitting; mitigation (\$96,000/acre); dust control; construction administration; utility exploration; bonding; and a 25% contingency. Costs exclude maintenance-of-traffic.

**Table 4.1** Approximate Cost Estimates for Jasmine Street Tide Barrier Alternatives

Tide Barrier Alternative	Structure on North Side			Structure on South Side		
	Initial <sup>1</sup>	Annual Maintenance <sup>2</sup>	Replacement <sup>3</sup>	Initial <sup>1</sup>	Annual Maintenance <sup>2</sup>	Replacement <sup>3</sup>
Flap Gates on 2 , 3-ft x 3-ft square openings	\$256,000	\$9,000	\$30,000	\$250,000	\$9,000	\$30,000
Flap Gates on 2, 4-ft dia circular openings	\$256,000	\$9,000	\$30,000	\$250,000	\$9,000	\$30,000
Flap Gates on 3, 4-ft dia circular openings	\$279,000	\$9,000	\$45,000	\$272,000	\$9,000	\$45,000
Valves on 2 , 3-ft x 3-ft square openings	\$284,000	\$9,000	\$50,000	\$279,000	\$9,000	\$50,000
Valves on 2, 4-ft dia circular openings	\$284,000	\$9,000	\$50,000	\$279,000	\$9,000	\$50,000
Valves on 3, 4-ft dia circular openings	\$321,000	\$9,000	\$75,000	\$316,000	\$9,000	\$75,000

<sup>1</sup> Initial construction cost

<sup>2</sup> Anticipated annual maintenance costs *without cost escalation*.

<sup>3</sup> Gate or valve replacement cost every 20 years *without cost escalation*

Maintenance items include gate/valve replacement (gates and valves have a 20-year life), sediment removal, and other miscellaneous maintenance items. Evidenced by the old flap gate at Atlantic Avenue, flap gates (and valves) can require considerable maintenance and inspection. Given Jasmine

Street's location in a more wooded, remote area (compared to Atlantic Avenue) with more debris potential, maintenance could become a considerable expense. Costs do not include routine inspection.

Notably, any of the tide barrier alternatives will promote sedimentation within the culvert. During stormwater events, the discharge through the culverts will likely contain a relatively high sediment concentration. When the gate or valve shuts (due to high tide), water velocity in the culvert diminishes (to zero) and thus allows sediment to settle in the culvert. Even if the tide barrier is positioned on the south side of Jasmine Street, semi-diurnal tides will flood the culverts with high concentrations of sediment that will tend to settle in the culverts due to low (near zero) tidal velocities. The Department should budget for periodic inspection and expect to vacuum the culverts regularly. The above costs consider sediment removal twice per year for either alternative location (north or south side); however, a detailed analysis of sediment rates was beyond the scope of this evaluation. A detailed analysis could change the assumption of sediment removal frequencies including a difference in sedimentation for the north side versus south side of Jasmine Street.

Generally, the cost for a valve-type barrier exceeds the cost for a flap gate due to the expense of the valve itself (about \$25,000/valve compared to \$15,000/gate). Valves do provide the advantage of sealing better in case of obstruction. Unlike a flap gate, a valve (made from flexible material) tends to form a seal around the obstacle.

The cost for a box structure on the north side of Jasmine Street exceeds the cost for one on the south side. The difference primarily results from the need for more erosion control on the north side, because the flow through the gate/valve discharges directly into the creek bed.

Vendors manufacture gates and valves designed with collars to fit directly on the ends of culverts, even elliptical culverts. However, the age and deteriorated condition of the existing culverts make the feasibility of this alternative poor. Replacing the culverts would add considerable expense and probably would require an extended closure of Jasmine Street. Without the need for culvert replacement, the box structure not only serves as a foundation to attach the flap gates or valves, but also allows easier access to the culverts for sediment cleaning and allows for overflow of floodwaters in case the gates/valves do not operate properly due to blockage. If necessary, culvert replacement will cost approximately \$120,000 (excluding maintenance-of-traffic).

Re-establishment of freshwater vegetation south of Jasmine Street should occur over time without replanting. If replanting is preferred, soil salinity tests should be performed before replanting. An analysis of the soil salinity flushing time was beyond the scope of this study.

Costs described above do not include annual escalation. If a 4% annual escalation is factored into the long-term maintenance costs over the 50-year design life, the average annual maintenance cost for the last alternative in the table (3, 4 ft diameter valves on the south side of Jasmine Street) rises to \$38,000.

Costs also do not include routine inspection of the valves or gates to ensure proper operation. Any prolonged obstruction, either keeping the barrier open or closed, could have significant impacts. If the barrier cannot close properly, saltwater can propagate into the system south of Jasmine Street and quickly damage freshwater vegetation. If the barrier cannot open properly due to an obstruction, flooding south of Jasmine Street can result.

## **5.0 EXPECTED TIDE CONDITIONS SOUTH OF JASMINE WITHOUT BARRIER**

Without a tide barrier at Jasmine Street, tide will continue to propagate through the large Jasmine Street culverts and into the system south of Jasmine Street. The model setup does not currently allow a detailed evaluation of tide conditions south of Jasmine Street due primarily to the lack of available topographic survey data. However, simulated tides indicate minimal tide attenuation for a considerable distance south of Jasmine Street, with high tide reaching about +1.2 ft NGVD. Periods of inundation during one high tide reach about seven hours for tide elevation above 0 ft NGVD, and about four hours for tide elevation above elevation +1 ft NGVD. Tide appears to diminish near Sadler Road.

Recently observed freshwater vegetation loss and distress south of Jasmine Street suggest saltwater vegetation will cover approximately 50 acres (roughly equal to the freshwater vegetation loss) without a tide barrier. However, a more detailed model setup based on topographic surveys south of Jasmine Street is necessary to refine the expected limits of salt marsh creation.

Egans Creek restoration (to the historical salt marsh environment) south of Jasmine Street will likely occur naturally without a tide barrier. Tidally influenced brackish areas will become vegetated through natural colonization by marsh plants. Agencies may require clearing of freshwater vegetation at a cost of \$7,500/acre, or \$375,000; however, neither saltwater vegetation planting nor clearing and grubbing are necessary for the re-establishment of salt marsh.

## 6.0 OTHER CONSIDERATIONS

The decision to select a tide barrier alternative or leave the system open to tidal propagation should consider other factors as well. Some considerations follow.

### *Long-term Maintenance of Freshwater System*

A freshwater system south of Jasmine Street will likely require considerable long-term costs. Some of these are addressed above. Others, discussed below, are less well-defined but nevertheless deserve consideration due to their potential magnitude and likelihood.

Tide barriers will require considerable maintenance, as evidenced by the old flap gate at Atlantic Avenue. At Jasmine Street, more wooded and remote than Atlantic Avenue with more debris potential, inspection and maintenance could become a major expense. Inspection costs are not addressed in Chapter 4. Maintenance costs addressed in Chapter 4 could be considerably higher.

Notably, preservation of certain freshwater vegetation south of Jasmine Street is virtually impossible without the construction of major, expensive surge flood control structures. As described in previous reports, a 25-year surge (as defined by FEMA and the State of Florida) will likely overtop Atlantic Avenue and flood the entire Egans Creek system (well beyond Sadler Road). Such an event would inundate and saturate the low-lying areas currently supporting both freshwater and saltwater vegetation. Such an event would kill nearly all the freshwater flora, including red maple trees. By definition, the 25-year surge has greater than a 60% chance of occurrence over 25 years and almost a 90% chance over the 50-year design life. Thus, long-term costs of maintaining the area south of Jasmine Street as a freshwater system should realistically consider replanting every 50 years. This cost, at present day rates, is \$4,360/acre for the purchase, delivery, and installation of 3-gallon trees, and \$7,500/acre for tree removal (if desired, but not necessary). The total cost would depend on the area inundated by surge but could easily exceed several million dollars. By contrast, the Department could expect a salt marsh to withstand hurricane surge inundation and remain permanently.

### *Potential Impacts of a Freshwater System*

In addition to rainfall flooding (if gates become inoperable), the tide barrier could possibly produce other impacts. These impacts, discussed below, include tide and salinity changes north of Jasmine Street, and duration and stagnation of freshwater inundation south of Jasmine Street.

As discussed in Chapter 3, modeling results for a typical tide, without a rainfall event, indicate the barrier would change tidal conditions north of Jasmine Street. High tide levels would likely rise about 0.1 ft and low tide levels would likely drop about 0.3 ft resulting in a tide range increase of about 0.4 ft. Thus, periods of inundation north of Jasmine Street could change slightly. A change could have a negative effect on the successful salt marsh mitigation project north of Jasmine Street.

By design, the tide barrier at Jasmine Street would create a tidal flow node at the barrier. A tidal node represents a location where tidal flow falls to zero (or minimal) even though a considerable tide range can exist. However, occasional rainfall runoff flowing north through the culvert will introduce fresh water to the area north of Jasmine Street. Thus, with essentially no tidal flow and occasional rainfall runoff flow, salinity concentrations adjacent to and north of Jasmine Street would likely decrease. Although the duration of inundation should only change slightly, decreases in salinity could reduce the positive effects of the mitigation project. A quantitative prediction of the expected decrease in salinity goes beyond the scope of this study.

### *Feasibility of a Freshwater System*

The preliminary engineering analyses presented in this report indicate a freshwater system is feasible, with considerable expense, south of Jasmine Street without exacerbating flood conditions. However, the make-up of the freshwater plant species is uncertain. As mentioned in Chapter 3, rainfall runoff will pond behind the tide barrier at times and create longer durations of freshwater inundation upstream (south) of Jasmine Street. Preliminary modeling indicates daily water levels may rise 0.5 ft assuming 1 ft<sup>3</sup>/sec of base flow, above the typical daily conditions that existed before the SRT gate construction at Atlantic Avenue. This condition will likely impact freshwater vegetation, as described below, and/or create water quality problems or increase mosquito production.

According to Environmental Resource Solutions (Allan Hooker, personal communication), mature red maple (*Acer rubrum*) dominated the wetland south of Jasmine Street before the Egans Creek restoration project. The State of Florida has indexed red maple as “facultative wet”, and the U.S. Fish and

Wildlife Service indexes it as “facultative.” Thus, under normal conditions, the species is adapted to seasonally saturated soil conditions, but is not adapted to long periods of flooding or long-term periods of fully saturated soils. The red maple dominance suggests the hydrologic conditions, while significantly altered from the historical salt marsh conditions, had been ideal for this particular species for a number of decades. The construction of a salinity barrier at Jasmine Street will cause hydroperiod changes (based on preliminary modeling) that would prove deleterious to red maple viability south of the barrier. Even subtle changes in the hydroperiod could endanger any replanted red maples, re-creating the current condition. For example, a slight hydroperiod increase could result in conditions conducive to “obligate wet” species, with a “deeper” wetland, dominated by cypress (*Taxodium* spp.) and similarly wet species, corresponding to a red maple dye-off.

### *Saltwater System Benefits*

Many experts, including Federal regulatory agencies, consider saltwater marsh more ecologically productive than freshwater wetlands. In fact, agencies generally require greater mitigation for saltwater marsh impacts compared to freshwater wetland impacts. Furthermore, the conversion of the freshwater system to a saltwater marsh constitutes a restoration of the system to its original condition prior to the installation of the Atlantic Avenue tide flap gate that blocked tide propagation into the system.

A structure, along with its required inspection and maintenance, is not required to restore Egans Creek south of Jasmine Street to its historical salt marsh condition. Regulatory agencies generally prefer a non-engineered solution that allows a system to exist in its natural (historical) condition as opposed to a structural system that maintains a non-historical condition.

### *Planting vs. Natural Revegetation*

Re-establishment of either freshwater or saltwater vegetation (depending on the alternative chosen) south of Jasmine Street should occur over time without replanting. The time required for re-establishment of freshwater vegetation is unknown and depends on the time required for rainfall to flush the brackish water from the soil. If replanting is preferred, soil salinity tests should be performed before replanting. An analysis of the soil salinity flushing time was beyond the scope of this study.

## 7.0 SUMMARY AND CONCLUSIONS

This evaluation addressed alternatives that either promote saltwater vegetation south of Jasmine Street or inhibit (effectively preclude) tide and saltwater propagation south of Jasmine Street for the purpose of maintaining or reestablishing freshwater vegetation there. In either case, the evaluation's objective strives to minimize effects on flood levels both north and south of Jasmine Street. Through model applications, Taylor Engineering evaluated several alternatives including gravity tide flap gates and valves. This modeling effort builds upon Taylor Engineering's hydrologic and hydraulic modeling performed for the Egans Creek salt marsh restoration project. Taylor Engineering converted the previous UNET model to HEC-RAS 3.1 and performed a limited model calibration before applying the model to evaluate alternatives.

Taylor Engineering applied the HEC-RAS model to a typical tide (no rainfall) condition as well as two rainfall events — the 25- and 100-year storms — with and without tide barriers in place. The evaluation considered two types of tide barriers — flap gates and valves — attached to a box weir structure on either the south or north end of the existing Jasmine Street culverts. The gates and valves allow rainfall runoff to flow downstream (north) but inhibit, with proper operation, tide from propagating upstream. For all alternatives, the top of the box remains open to allow stormwater flow over the top as a flood relief if storm water levels exceed +1.6 ft NGVD. Alternatives included both two and three openings in the box (for both flap gates and valves) of different sizes equivalent to two 3x3 ft square, two 4 ft diameter circular, two 4x7 ft elliptical, and three 4 ft diameter circular openings. The following summarizes model results, cost analyses, and other considerations for evaluating freshwater and saltwater systems south of Jasmine Street.

### *Freshwater System (with a Tide Barrier)*

A freshwater system south of Jasmine Street will require a tide barrier structure. Generally, the model results indicate all evaluated tide barrier alternatives inhibit tide propagation south of Jasmine Street and maintain existing levels of flood protection (have virtually no effect on flood levels both north and south of Jasmine). The barriers do affect tide conditions north of Jasmine Street. High tide increases and low tide decreases. Also, salinity levels will likely decrease for some distance north of Jasmine Street as freshwater pulses through the tide barrier during rainfall events. This condition could have a negative effect on the existing, successful saltwater mitigation project.

Rough construction cost estimates vary from \$250,000 for two flap gates on the south side of Jasmine Street to \$321,000 for three valves on the north side, with annual maintenance costs around \$9,000 and gate/valve replacement costs (every 20 years) ranging from \$30,000 to \$75,000 without considering annual cost escalation. These costs do not include labor for necessary routine inspection for sedimentation within the culvert and barrier blockage. Maintenance on tide barriers can be extensive with no guarantee of success.

If a tide barrier is installed, a valve-type barrier (with three independent valves in case one valve fails) on the south side of Jasmine Street is recommended. The valve size should be 3 – 4 ft in diameter. The design life (50-year) cost for this structure exceeds \$2,000,000 (including initial construction and average annualized maintenance costs at about \$316,000 and \$38,000, respectively, assuming 4% annual escalation, and excluding recommended inspection costs).

Long-term preservation of freshwater vegetation south of Jasmine Street is virtually impossible without the construction of major, expensive surge flood control structures. A 25-year hurricane surge will overtop Atlantic Avenue and flood the entire Egans Creek system (well south of Sadler Road). Such an event will kill many freshwater species such as maple trees. By definition, the 25-year surge has almost a 90% chance of occurrence over a 50-year design life. Thus, long-term costs of maintaining the area south of Jasmine Street as a freshwater system should realistically consider replanting every 50 years. This cost, at present day rates, will likely reach several million dollars. By contrast, the Department could expect a salt marsh to remain permanently.

Re-establishment of freshwater vegetation south of Jasmine Street should occur over time without replanting. However, a Jasmine Street tide barrier will likely change the hydroperiod somewhat. Thus, different freshwater species will likely occupy the area. The existing primarily facultative freshwater species (red maples) opportunistically occupied the area due to the unique hydroperiod created by the poorly performing tide gate at Atlantic Avenue. Replication of those unique conditions would be very difficult if not impossible. Efforts to restore the previous facultative freshwater species through planting may fail. Also, the freshwater system hydroperiod may promote mosquito breeding.

The time required for re-establishment of freshwater vegetation is unknown and depends on the time required for rainfall to flush the brackish water from the soil. If replanting is preferred, soil salinity tests should be performed before replanting. An analysis of the soil salinity flushing time was beyond the scope of this study.

*Saltwater System (without a Tide Barrier)*

With no tide barrier, restoration of Egans Creek south of Jasmine Street to the historical salt marsh environment would very likely occur naturally (without replanting). This alternative requires no structure, maintenance, or other cost items. Brackish tide will continue to propagate through the large Jasmine Street culverts and into the system south of Jasmine Street where it will promote salt marsh growth. Simulated tides indicate minimal tide attenuation for a considerable distance south of Jasmine Street with high tide reaching about +1.2 ft NGVD. Recently observed freshwater vegetation loss south of Jasmine Street suggests saltwater vegetation will cover approximately 50 acres (roughly equal to the area of observed vegetation distress/loss). However, a more detailed model setup based on topographic surveys south of Jasmine is necessary to better define the expected limits of salt marsh restoration. Clearing of freshwater vegetation (estimated at \$375,000) would not be necessary for successful salt marsh restoration.

Saltwater marsh is more ecologically productive than freshwater wetlands. Thus, Federal agencies generally prefer saltwater marsh to freshwater wetlands and require greater mitigation for saltwater marsh impacts compared to freshwater wetland impacts. Furthermore, agencies generally prefer a natural system over an engineered system that maintains the system in an unnatural (not historical) condition. The salt marsh would reduce mosquito production.

Table 7.1 summarizes costs for salt and freshwater systems south of Jasmine Street.

**Table 7.1** Cost Summary for Jasmine Street Alternatives

<b>Cost Item</b>	<b>Tide Barrier<sup>1</sup>/Freshwater System South of Jasmine</b>	<b>Saltwater System South of Jasmine</b>
Initial Structure Construction	\$316,000	Not Applicable
Annual Structure Maintenance <sup>2</sup>	\$38,000	Not Applicable
Tree Clearing/Grubbing <sup>3</sup>	\$375,000	\$375,000

<sup>1</sup> Valves on 3, 4-ft diameter circular openings in box on south side of Jasmine Street

<sup>2</sup> Average over 50-year design life with 4% annual escalation.

<sup>3</sup> 50 acres assumed; not required for freshwater or saltwater system re-establishment.

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