5.2.13 STUDY AREA 13 – ATLANTIC BOULEVARD AND SOUTH RIVERSIDE DRIVE

This study area is located on the east side of the Intracoastal Waterway chiefly along Riverside Drive. The project area extends along Riverside Drive from the intersection with Atlantic Boulevard on the northern limits to the intersection of SE 10th Street on the southern limits. The existing condition stormwater model was used to evaluate the performance of the existing stormwater system during a 5-year, 24-hour design storm event with 7.8 inches of rainfall. Based on the result of the existing conditions stormwater model, the extent of the expected flooding areas is displayed on Figure 5-13B at the end of this section. Based on our analysis, heavy flooding can be expected at the north side of South Riverside Drive between SE 2nd Street to Atlantic Boulevard, which is very low lying.

The topography of the study area is displayed on Figure 5-13A along with the model schematics. The ground surface elevation along the centerline of South Riverside Drive is as low as 1.3 feet NAVD at some locations. Within the stormwater model, the study area is defined by the Sub-basins SE_024_01, SE_025_01, SE_026_01, SE_041_01, and SE_027_01, which are all bounded to the west by the Intracoastal Waterway. Based on the topography, the study area can be divided in two sub-areas by SE 5th Street. There is no exchange of stormwater runoff between these two sub-areas since they are isolated topographically by a small ridge at this intersection. As shown in the topography map, these sub-basins can be expected receive a significant amount of stormwater runoff from sub-basins CE_081_03, SE_030_01, and SE_007_01, which are located to the east and have higher ground surface elevations. Due to the very low elevation of the study area, the expected flooding is also tidally influenced since backflow from the Intracoastal Waterway can occur via the existing outfall pipes.

The City has received resident complaints on the north Side of South Riverside Drive, just north of SE 2nd Street. Site photographs have been provided which show extensive flooding along South Riverside Drive between SE 2nd Street and Atlantic Boulevard as well throughout the vacant property to the west of Riverside Drive. This documented flooding complaint mimics the model results displayed in Figure 5-13B. Various system improvement alternatives to the existing stormwater system were investigated for this study area, which include upgrading the pipe sizes, installing a pump station that discharges to the Intracoastal Waterway through an existing outfall, and installing a pump station with a stormwater retention area. Please note that the installation of exfiltration trench was not considered as a system improvement alternative since the very low elevation of the study area would limit the effectiveness of these options.

Alternative 1: Pipe Size Upgrades

The proposed improvements under Alternative 1 include upgrading the pipe sizes at specific locations increase the conveyance capacity of the stormwater system, which could increase the discharge rate to alleviate the flooding problems within the study area. For this study area, all existing outfalls pipes were analyzed to receive pipe size upgrades. Alternative 1 includes the removal of existing pipes (1,530 linear feet) with diameters between 12 inches and 21 inches. Under Alternative 1, the proposed pipe sizes include 310 linear feet of 24 inch RCP and 1,220 linear feet of 30 inch RCP. The estimated design and construction costs for Alternative 1 are approximately $1,900,000.

Based on the results of our analysis, the reduction of the peak flood stages under Alternative 1 is displayed in Table 5.13.1 below. The model results show the effectiveness of Alternative 1 at improving flooding conditions at different locations around the study area. The average reduction of peak flood stage is approximately 0.42 feet throughout the study area. However, the flooding at Node IN_3353, which is the location of the major flooding concern at the north end of Riverside Drive, is still expected to flood to depth greater than 1 foot under Alternative 1.

Table 5.13.1 – Alternative 1 Peak Flood Stage Summary					
Nodes	Existing Conditions			Alternative 1	
	Peak Stage (feet)	Ground Elevation (feet, NAVD)	Flood Depth (feet)	Peak Stage (feet)	Peak Reduction (feet)
IN_3353	2.53	1.30	1.23	2.40	-0.13
IN_3350	2.96	2.53	0.43	2.62	-0.34
IN_3349	2.96	1.72	1.24	2.40	-0.56
IN_3345	2.96	2.35	0.61	2.43	-0.53
IN_3343	2.96	2.12	0.84	2.43	-0.53

Based on our analysis with the stormwater model, the expected flooding duration within the study area is summarized within Table 5.13.2 below. The model results show the effectiveness of Alternative 1 at improving flooding conditions along South Riverside Drive throughout this study area, which shows a significant reduction in predicted flooding depth. The flood duration within Node IN_3353, which is the location of the major flooding concern, is expected to be reduced from 2.5 hours under the existing conditions to 0.78 hours under Alternative 1.

Table 5.13.2 – Alternative 1 Flood Duration Summary				
Nodes	Reference Roadway Elevation (feet, NAVD)	Flood Duration (hours)		
		Existing Conditions	Alternative 1	Reduction (%)
IN_3353	1.30	2.5	0.78	69
IN_3349	1.72	3.7	0.18	95
IN_3345	2.35	4.2	0	100
IN_3343	2.12	5	0.51	90

Alternative 2: Pump Station

The proposed construction under Alternative 2 includes the installation of two pump stations adjacent to existing outfalls in order to provide additional hydraulic head on the downstream end of the system to increase the system discharge capacity to alleviate the flooding, especially during high tide conditions. The proposed pump stations are located next to the model Node IN_3353 in the north sub-area and model Node IN_3349 in the south sub-area. The assumed components associated with each pump station are listed below. Additional pipe improvements are proposed to efficiently transmit stormwater runoff to the pump stations. The estimated design and construction costs for this pump station alternative are approximately $2,927,000.The model assumptions in regards to the proposed pump station are as follows:

- The existing gravity outfall pipe discharging to the Intracoastal Waterway is to be replaced by a 24-inch discharge pipe.
- Install a backflow prevention flap gate at the point of discharge into the Intracoastal Waterway.
- A wet well with a total footprint of about 150 square feet and depth of 8 feet.
- A proposed pump capacity shall be approximately 20 CFS, which is equivalent to the peak discharge rate of the existing drainage system during low tide conditions.

Based on our analysis with the stormwater model, the reduction of the peak flood stages under Alternative 2 are summarized within Table 5.13.3 below. The model results show a peak stage reduction of 0.21 feet

adjacent to the proposed pump station for the north sub-area at Node IN_3353, which is the location of the major flooding concern at the north end of Riverside Drive. No other portion of the study area receives any benefit in regards peak stage reduction under Alternative 2.

Table 5.13.3 – Alternative 2 Peak Stage Summary					
Nodes	Existing Conditions			Alternative 2	
	Peak Stage (feet)	Ground Elevation (feet, NAVD)	Flood Depth (feet)	Peak Stage (feet)	Peak Reduction (feet)
IN_3353	2.53	1.30	1.23	2.32	-0.21
IN_3350	2.96	2.53	0.43	2.96	0.00
IN_3349	2.96	1.72	1.24	2.96	0.00
IN_3345	2.96	2.35	0.61	2.96	0.00
IN_3343	2.96	2.12	0.84	2.97	+0.01

Based on our analysis with the stormwater model, the reduction of flood duration within the study area under Alternative 2 is summarized in Table 5.13.4 below. The estimated reduction in flood duration under Alternative 2 is relatively insignificant when compared to Alternative 1. The flood duration within Node IN_3353, which is the location of the major flooding concern at the north side of Riverside Drive, is expected to be reduced from 2.5 hours under the existing conditions to 1.25 hours under Alternative 1.

Table 5.13.4 – Alternative 2 Flood Duration Summary				
Nodes	Reference Street Elevation (feet, NAVD)	Flood Duration (hours)		
		Existing Conditions	Alternative 2	Reduction (%)
IN_3353	1.30	2.5	1.25	50
IN_3349	1.72	3.7	2.85	23
IN_3345	2.35	4.2	4.05	4
IN_3343	2.12	5	4.90	2

Alternative 3/4: Pump Station and Storage

The proposed construction under Alternative 3 includes the installation of a pump station, which connects to potential stormwater retention area(s) at an undetermined location within the study area. The proposed stormwater retention area was assumed encompasses a total area of 1.0 acres. The proposed retention area was assumed to have a perimeter berm at +8.0 feet NAVD with a 3:1 internal side slope to the bottom elevation of +3.5 feet NAVD. The bottom of the retention area is set to be 1 foot higher than the seasonal high water table, which is expected to be around the site at +2.5 feet NAVD. The areas of the stormwater retention area were estimated to be 0.67 acres at the top of the berm and 0.44 acres at the bottom of the retention area. Overflow from this stormwater retention area would need to be connected back to the existing system through a weir-type control structure. The weir elevation within the control structure was assumed at +7.5 feet NAVD, which would provide a total storage volume of 1.93 acre-feet. The estimated design and construction costs for this pump station and storage alternative are approximately $4,375,000.

The stormwater model was used to analyze Alternative 3 with the existing stormwater pipe remaining in place and Alternative 4 with increasing the existing pipe diameters to 30 inch RCP. The reduction of the peak flood stages under Alternative 3/4 are summarized within Table 5.13.5 below. This simulation showed an additional reduction in peak flood stages at Node IN_3353, which is the location of the major

flooding concern at the north end of Riverside Drive. There is no flood reduction benefit in other areas under Alternative 3.

Table 5.13.5 – Alternative 3/4 Peak Flood Stage Summary							
Nodes	Existing Conditions			Alternative 3 (Existing Pipes)		Alternative 4 (30-inch RCP)	
	Peak Stage (feet)	Ground Elevation (feet, NAVD)	Flood Depth (feet)	Peak Stage (feet)	Peak Reduction (feet)	Peak Stage (feet)	Peak Reduction (feet)
IN_3353	2.53	1.30	1.23	2.31	-0.22	1.88	-0.65
IN_3350	2.96	2.53	0.43	2.96	0.00	2.96	0.00
IN_3349	2.96	1.72	1.24	2.96	0.00	2.96	0.00
IN_3345	2.96	2.35	0.61	2.96	0.00	2.96	0.00
IN_3343	2.96	2.12	0.84	2.96	0.00	2.96	0.00

Based on our analysis with the stormwater model, the reduction in flood duration in the study area is summarized below in Table 5.13.6 for Alternative 3 and in Table 5.13.7 for Alternative 4. The stormwater model predicts a reduction in flood duration of 50% under Alternative 3 and 76% under Alternative 4 at Node IN_3353, which corresponds to the north end of Riverside Drive. There is no reduction in expected flood durations in other areas along Riverside Drive under either Alternative 3 or Alternative 4.

Table 5.13.6 – Alternative 3 (with Existing Pipes) Flood Duration Summary				
Nodes	Reference Roadway Elevation (feet, NAVD)	Flood Duration (hours)		
		Existing Conditions	Alternative 3 (Existing Pipe)	Reduction (%)
IN_3353	1.30	2.5	1.26	50
IN_3349	1.72	3.7	3.7	0
IN_3345	2.35	4.2	4.2	0
IN_3343	2.12	5	5	0

Table 5.13.7 – Alternative 4 (with 30-inch RCP) Flood Duration Summary				
Nodes	Reference Roadway Elevation (feet, NAVD)	Flood Duration (hours)		
		Existing Conditions	Alternative 4 (30-inch RCP)	Reduction (%)
IN_3353	1.30	2.5	0.59	76
IN_3349	1.72	3.7	3.7	0
IN_3345	2.35	4.2	4.2	0
IN_3343	2.12	5	5	0

Alternative 5: Pumped Drainage Well

The stormwater model was used to conduct several simulations of various proposed pump stations within the study area. The purpose of this system improvement alternative is to increase conveyance capacity of the stormwater management system to alleviate the existing flooding issues quicker. The proposed construction under Alternative 5 includes the installation of three pumped drainage well near the existing

outfalls on South Riverside Drive. The estimated design and construction costs for this pump station alternative are approximately $1,947,000. The components associated to the pumped drainage well are listed below.

* Existing discharge pipe to outfall into Intracoastal Waterway to remain the same size.
* Install new flap gates at existing outfalls for backflow prevention.
* Install new pumped drainage well, maximum pump capacity of 9 CFS, which is equivalent to the peak discharge of the existing drainage system during low tide conditions.

Based on the results of our analysis with the stormwater model, the reduction in peak flood stages under Alternative 5 are summarized in Table 5.12.8 below. According to the stormwater model, Alternative 5 results in minimal reductions in the peak flood stage throughout the study area. Within the critical model node, Node IN_3353, the peak flood depth is reduced from 1.23 feet under the existing conditions to 1.11 feet under Alternative 5.

Table 5.13.8 – Alternative 5 Peak Stage Summary

Nodes	Existing Conditions			Alternative 5	
	Peak Stage (feet)	Ground Elevation (feet, NAVD)	Flood Depth (feet)	Peak Stage (feet)	Peak Reduction (feet)
IN_3353	2.53	1.30	1.23	2.41	-0.12
IN_3350	2.96	2.53	0.43	2.86	-0.10
IN_3349	2.96	1.72	1.24	2.85	-0.11
IN_3345	2.96	2.35	0.61	2.87	-0.09
IN_3343	2.96	2.12	0.84	2.88	-0.08

Based on our analysis with the stormwater model, the reduction of flood duration within the study area under Alternative 5 is summarized in Table 5.13.9 below. The estimated reduction in flood duration under Alternative 5 is relatively insignificant when compared to Alternative 1. The flood duration within Node IN_3353, which is the location of the major flooding concern at the north side of Riverside Drive, is expected to be reduced from 2.5 hours under the existing conditions to 1.80 hours under Alternative 5.

Table 5.13.9 – Alternative 5 Flood Duration Summary

Nodes	Reference Roadway Elevation (feet, NAVD)	Flood Duration (hours)		
		Existing Conditions	Alternative 5	Reduction (%)
IN_3353	1.30	2.5	1.8	28
IN_3349	1.72	3.7	1.7	54
IN_3345	2.35	4.2	1.8	57
IN_3343	2.12	5	3	40

Alternative 6: Pumped Drainage Well and Pipe Size Upgrades

The stormwater model was used to conduct several simulations of various proposed pump stations within the study area. The purpose of this system improvement alternative is to increase conveyance capacity of the stormwater management system to alleviate the existing flooding issues quicker. The proposed construction under Alternative 6 includes the installation of three pumped drainage wells with the same characteristics of Alternative 5 and the installation of upsized outfall pipes with same characteristics as

noted in Alternative 1. The estimated design and construction costs for this alternative are approximately $2,870,000.

Based on the results of our analysis with the stormwater model, the reduction in peak flood stages under Alternative 6 are summarized in Table 5.12.10 below. According to the stormwater model, Alternative 6 results in the most significant reductions in the peak flood stage throughout the study area. Within the critical model node, Node IN_3353, the peak flood depth is reduced from 1.23 feet under the existing conditions to 1.10 feet under Alternative 6.

Table 5.13.10 – Alternative 6 Peak Stage Summary					
Nodes	Existing Conditions			Alternative 6	
	Peak Stage (feet)	Ground Elevation (feet, NAVD)	Flood Depth (feet)	Peak Stage (feet)	Peak Reduction (feet)
IN_3353	2.53	1.30	1.23	2.40	-0.13
IN_3350	2.96	2.53	0.43	2.62	-0.34
IN_3349	2.96	1.72	1.24	2.40	-0.56
IN_3345	2.96	2.35	0.61	2.40	-0.56
IN_3343	2.96	2.12	0.84	2.40	-0.56

Based on our analysis with the stormwater model, the reduction of flood duration within the study area under Alternative 6 is summarized in Table 5.13.11 below. The estimated reduction in flood duration under Alternative 6 is the most significant reductions when compared to the previous listed alternatives. The flood duration within Node IN_3353, which is the location of the major flooding concern at the north side of Riverside Drive, is expected to be reduced from 2.5 hours under the existing conditions to 0.60 hours under Alternative 6.

Table 5.13.11 – Alternative 6 Flood Duration Summary				
Nodes	Reference Roadway Elevation (feet, NAVD)	Flood Duration (hours)		
		Existing Conditions	Alternative 6	Reduction (%)
IN_3353	1.30	2.5	0.6	76
IN_3349	1.72	3.7	0.14	96
IN_3345	2.35	4.2	0	100
IN_3343	2.12	5	0.4	92

Alternative Comparison

Refer to Table 5.13.12 below for a comparison of the various system improvement alternatives for this study area. Please note the peak flood stage and flood reduction results within Table 5.13.12 refer to the critical problem area of the study area, which corresponds to Node IN_3353 within the stormwater model. Based on our analysis with the stormwater model, all system improvement alternatives can be considered to be an effective option for reducing the peak flood stages and reducing the expected flood duration within the study area. However, Alternative 3 and Alternative 4 should likely be eliminated from consideration since using valuable private property in this study area for stormwater retention is not feasible from a cost standpoint. Alternative 1 provides similar flood control benefits as Alternative 2 and is significantly more cost effective, yet does not assist with discharge capacity during high tides. Alternative 6 should be implemented for this study area since it provides flood control throughout the

study area and supplemental discharge capacity during high tide periods within the Intracoastal Waterway. Although Alternative 6 does not provide enough additional flood protection to meet the level of service criteria for all public roadways within the study area, Alternative 6 does provide significant benefits which alleviate the flooding problems within the study area.

Table 5.13.12 – Alternative Comparison			
Alternative	**Peak Flood Stage Reduction (feet)**	**Flood Duration Reduction (hours)**	**Implementation Costs ($)**
Alternative 1	0.13	1.72	$1,900,000
Alternative 2	0.21	1.25	$2,927,000
Alternative 3	0.22	1.24	$4,375,000
Alternative 4	0.65	1.91	$4,493,000
Alternative 5	0.12	0.90	$1,947,000
Alternative 6	0.13	1.90	$2,870,000

The recommended stormwater improvements for this study area include the replacement of six existing outfall pipes with 24-inch or 30-inch diameter pipe, which will significantly reduce flooding within South Riverside Drive during low tide within the Intracoastal Waterway. Due to the extremely low ground surface elevations along South Riverside Drive, the upsized outfall pipes will not assist with the gravity discharge during high tide within the Intracoastal Waterway. The installation of the pumped drainage wells are intended to reduce flooding within North Riverside Drive during high tide periods within the Intracoastal Waterway. Due to the negative impacts of high tide on the performance of the stormwater system in this study area, the proposed improvements include the installation of backflow prevention devices at all six existing outfalls from South Riverside Drive. The swale areas should also be regraded throughout the study area to provide additional storage volume for stormwater runoff. For the recommended stormwater improvements for this study area, CMA has prepared a conceptual layout, which is enclosed within Appendix A-1 and a preliminary cost estimate, which is enclosed within Appendix A-2. During the detailed design phase, Alternative 6 will encounter various constructability concerns related to the replacement of outfall pipe within utility easements on private property and regulatory limitations on the peak discharge via the upsized outfall pipes.

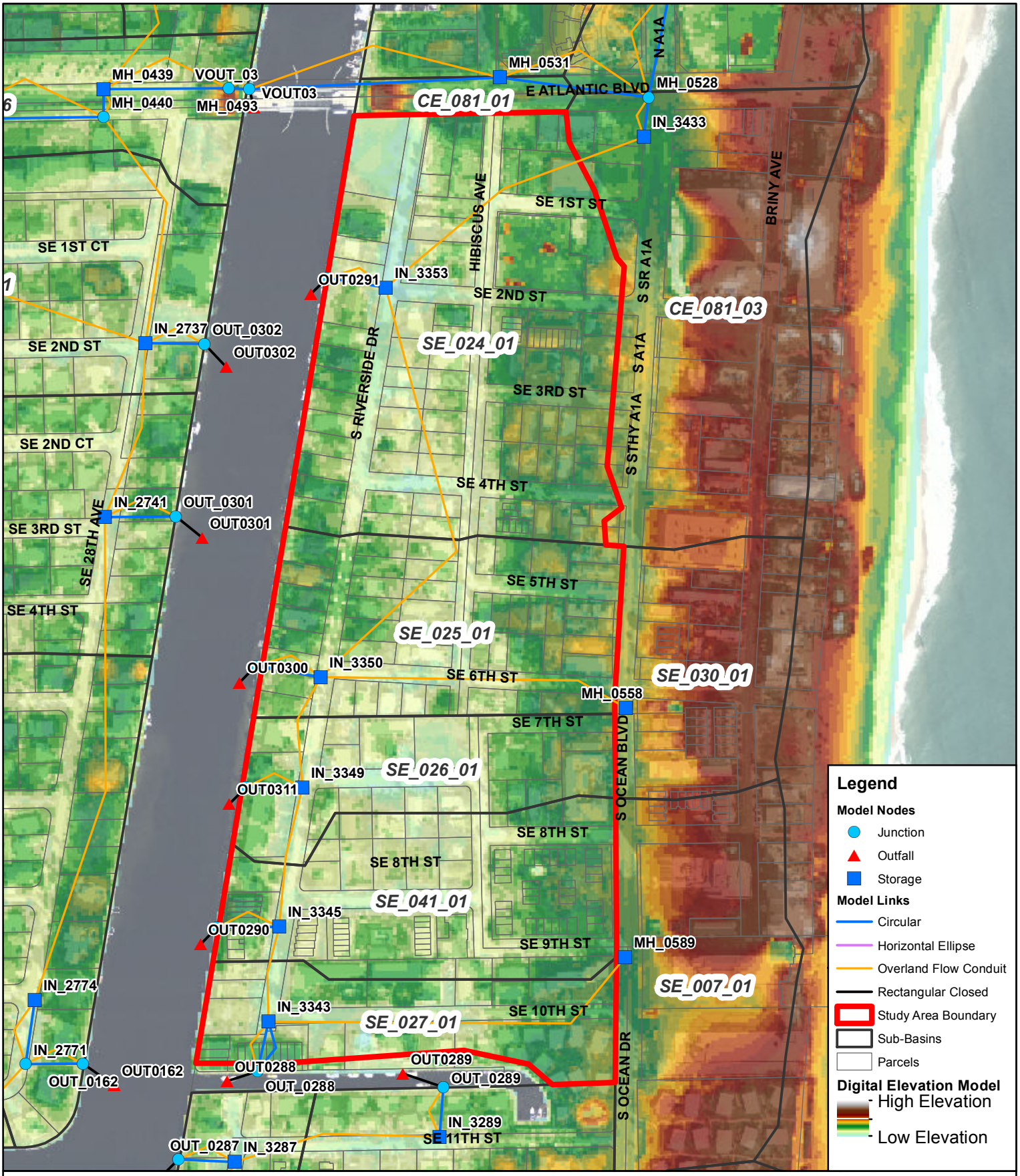

Figure 5-13A
Atlantic Blvd & South Riverside Drive
Existing Topography & Model Schematics

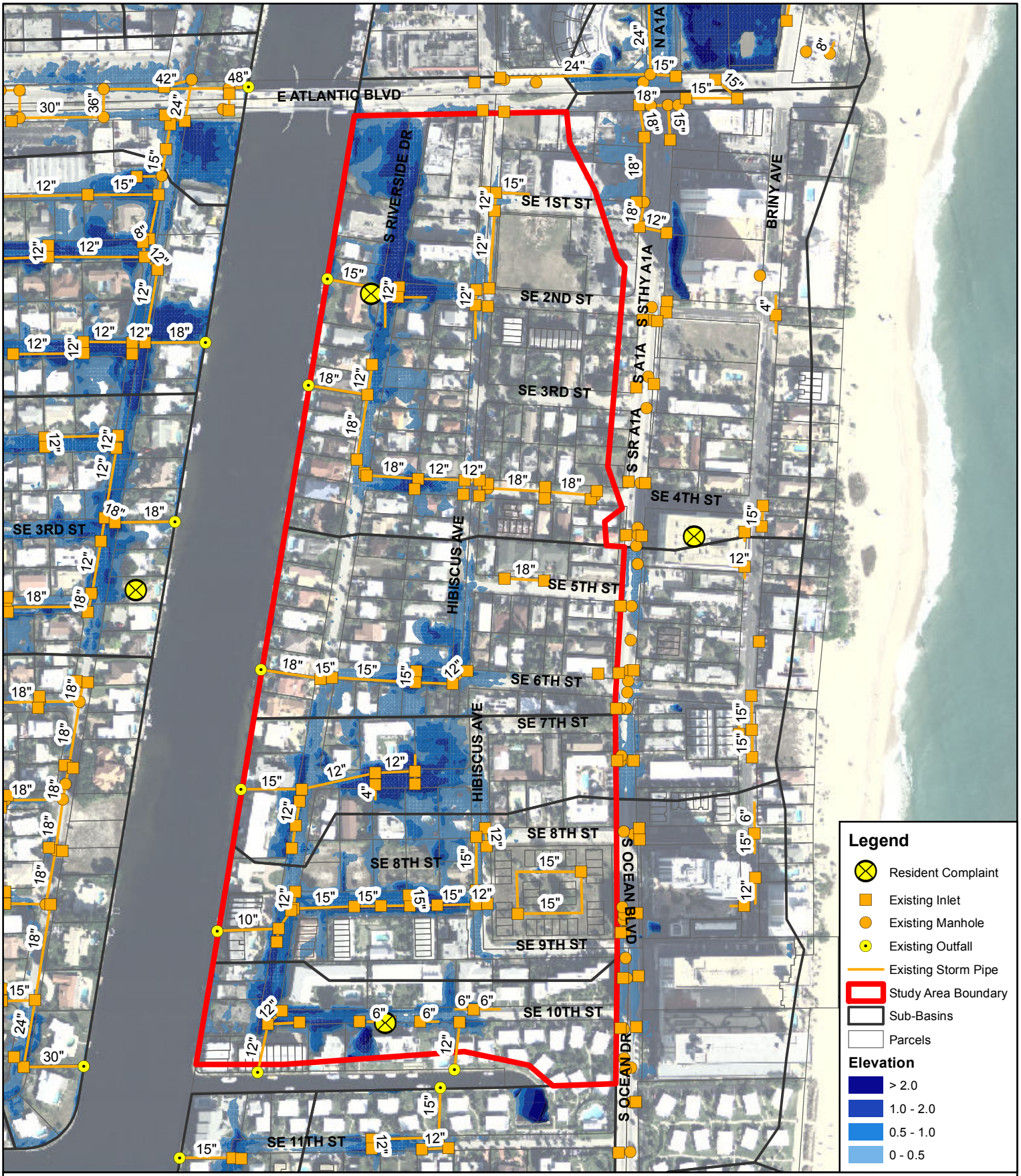

Figure 5-13B
Atlantic Blvd & South Riverside Drive
Potential Flooding Depth

N
W E
S

0 200 400
Feet

5.2.14 STUDY AREA 14 – NE 27TH AVENUE AND NE 16TH STREET

This study area is bounded by US-1 on the west, NE 22nd Street on the north, NE 28th Avenue on the east, and NE 16th Street on the south. This study area consists of primarily single family residential properties with a limited existing drainage system serving the roadways. The existing drainage system within the study area consists of two independent drainage systems that collect stormwater runoff from the public right-of-way and discharges via existing 24-inch outfalls into tidal canals, which are directly connected to the Intracoastal Waterway. An existing outfall is located at the north end along NE 22nd Court while the other existing outfall is located at the south side end of NE 16th Street.

The existing conditions stormwater model was used to evaluate the potential flooding within the study area during a 5-year, 24-hour design storm event with 7.8 inches of rainfall. The study area is defined by the sub-basins CE_032_01 and CE_038_01 within the stormwater model. The topography of the study area along with the model schematics are displayed within Figure 5-14A at the end of this section. According to the topography, stormwater runoff can be expected to flow from the north to the south along NE 27th Avenue before collecting in low lying areas in the right-of-way. The lowest elevations within the study area directly correlate to the flooding problems. Based on the results of the existing conditions stormwater model, the extent of potential flooding within the study area is displayed on Figure 5-14B at the end of this section. The significant portions of the public right-of-way areas within this study area display flooding greater than one inch. The worst flooding is expected primarily along NE 27th Avenue and the east section of NE 16th Street and NE 17th Street.

The stormwater model was used to evaluate effectiveness of various system improvement alternatives, such as exfiltration trenches, drainage wells, or pump stations, in reducing the existing flooding problems. The system improvement alternatives which were evaluated with the stormwater model are summarized below.

Alternative 1: Exfiltration Trench

The stormwater model was used to conduct several simulations of the installation of proposed exfiltration trench within the study area not currently served by the existing stormwater system. The purpose of this system improvement alternative is to provide additional storage and infiltration capacity to alleviate the existing flooding issues quicker. Under Alternative 1, the proposed construction includes a total of 8,022 LF of exfiltration trench, which were aligned along right-of-way areas with ground surface elevations greater than +5.0 feet NAVD. The general location of the proposed exfiltration trench is summarized by sub-basin within Table 5.14.1 below. The estimated design and construction costs for this exfiltration trench alternative are approximately $3,390,000.

Table 5.14.1 – Alternative 1 Proposed Exfiltration Trench Summary

Sub-Basin	Exfiltration Trench (LF)	Mean Ground Surface Elevation (feet NAVD)
CE_032_01	5,044	+5.6
CE_036_01	598	+6.1
CE_038_01	2,380	+4.9
Total	**8,022**	**+5.53**

CMA conducted an analysis with the stormwater model of Alternative 1 to estimate the maximum potential reduction in peak flood stage and flood duration due to an exfiltration trench system within this

study area. During the evaluation of Alternative 1, the design parameters for the proposed exfiltration trench are assumed within the stormwater model to be as follows:

- Trench Width: 4 feet
- Trench Height: 4 feet
- Perforated pipe diameter: 18-inch
- Hydraulic conductivity: 9.8×10^{-4} CFS/ft^2-ft head

Based on our analysis with the stormwater model, the reduction in peak flood stage under Alternative 1 is summarized within Table 5.14.2 below. The model results for Alternative 1 show a reduction in peak flood stage of -0.13 feet at the critical model node (Node IN_3013). The peak flood depth is expected to be reduced from 1.79 feet under the existing conditions to 1.66 feet under Alternative 1.

Table 5.14.2 – Alternative 1 Peak Flood Stage Summary

	Existing Conditions			Alternative 1	
Nodes	Peak Stage (feet, NAVD)	Ground Elevation (feet, NAVD)	Flood Depth (feet)	Peak Stage (feet, NAVD)	Peak Stage Reduction (feet)
IN_3013	4.89	3.1	1.79	4.76	-0.13
IN_3043	4.97	3.3	1.67	4.85	-0.12
IN_3003	2.45	1.5	0.95	2.45	0.00
MH_0484	4.58	5.6	N/A	4.58	N/A

Based on our analysis with the stormwater model, the reduction of flooding duration within the study area under Alternative 1 is summarized in Table 5.14.3 below. The reduction in flood duration under Alternative 1 is moderate with a maximum reduction of 34% from the existing conditions. At the critical model node (Node IN_3013), the flood duration is expected to be reduced from 7.7 hours under the existing conditions to 6.4 hours under Alternative 1.

Table 5.14.3 – Alternative 1 Flood Duration Summary

Nodes	Reference Roadway Elevation (feet, NAVD)	Flood Duration (hours)		
		Existing Conditions	Alternative 1	Reduction (%)
IN_3013	3.10	7.7	6.4	16
IN_3043	3.30	5.0	3.3	34

Alternative 2: Pipe Size Upgrades

The proposed improvements under Alternative 2 include upgrading the pipe size at the outfall to increase the conveyance capacity of the stormwater system, which could increase the discharge rate to alleviate the flooding problems within the study area. Alternative 2 includes replacing the existing 12-inch pipe and 24-inch pipe with approximately 600 linear feet of new 36-inch RCP. The estimated design and construction costs for Alternative 2 are approximately $338,000.

Based on the results of our analysis, the reduction of the peak flood stages under Alternative 2 is displayed in Table 5.14.4 below. Alternative 2 results in a reduction in only the critical model node (Node

IN_3013) with a peak flood depth reduced from 1.79 feet under the existing conditions to 1.30 feet under Alternative 2.

Table 5.14.4 – Alternative 2 Peak Flood Stage Summary					
	Existing Conditions			Alternative 2	
Nodes	Peak Stage (feet, NAVD)	Ground Elevation (feet, NAVD)	Flood Depth (feet)	Peak Stage (feet, NAVD)	Peak Stage Reduction (feet)
IN_3013	4.89	3.1	1.79	4.40	-0.49
IN_3043	4.97	3.3	1.67	4.97	0.00
IN_3003	2.45	1.5	0.95	2.45	0.00
MH_0484	4.58	5.6	N/A	4.58	0.00

Based on our analysis with the stormwater model, the expected flooding duration within the study area is summarized within Table 5.14.5 below. The model results show the effectiveness of Alternative 2 at improving flooding conditions throughout this study area, which shows a significant reduction in predicted flooding depth. The flood duration within Node IN_3013, which is the location of the major flooding concern, is expected to be reduced 7.7 hours under the existing conditions to 2.5 hours under Alternative 2.

Table 5.14.5 – Alternative 2 Flood Duration Summary				
Nodes	Reference Roadway Elevation (feet, NAVD)	Flood Duration (hours)		
		Existing Conditions	Alternative 2	Reduction (%)
IN_3013	3.10	7.7	2.5	67
IN_3043	3.30	5.0	4.4	12

Alternative 3: Pump Station

The stormwater model was used to conduct several simulations of various proposed pump stations within the study area. The purpose of this system improvement alternative is to increase conveyance capacity of the stormwater management system to alleviate the existing flooding issues quicker. The proposed construction under Alternative 3 includes the installation of one pump station near the existing outfall at model Node: IN_3013. The estimated design and construction costs for this pump station alternative are approximately $2,198,000. The components associated to the pump station are listed below.

- Install a 24-inch discharge pipe from pump station to outfall location.
- Install a flap gate at the point of discharge for backflow prevention.
- Wet well with a total footprint of about 150 square feet and depth of 8 feet.
- Maximum pump capacity shall be 33 CFS, which is equivalent to peak discharge rate from existing drainage system during low tide conditions.

Based on our analysis with the stormwater model, the reduction in peak flood stages under Alternative 3 is summarized within Table 5.14.6 below. The model results for Alternative 3 show a minimal reduction in peak flood stage at Node IN_3013 adjacent to the proposed pump station. The remainder of the study area receives no benefit from Alternative 3.

Table 5.14.6 – Alternative 3 Peak Flood Stage Summary					
	Existing Conditions			Alternative 3	
Nodes	Peak Stage (feet, NAVD)	Ground Elevation (feet, NAVD)	Flood Depth (feet)	Peak Stage (feet, NAVD)	Peak Stage Reduction (feet)
IN_3013	4.89	3.1	1.79	4.81	-0.08
IN_3043	4.97	3.3	1.67	4.97	0.00
IN_3003	2.45	1.5	0.95	2.45	0.00
MH_0484	4.58	5.6	N/A	4.58	N/A

Based on our analysis with the stormwater model, the reduction in expected flooding duration is summarized within Table 5.14.7 below. The model results show a limited reduction in flood duration under Alternative 3. At the critical model node (Node IN_3013), the flood duration is expected to be reduced from 7.7 hours under the existing conditions to 6.5 hours under Alternative 3.

Table 5.14.7 – Alternative 3 Flood Duration Summary				
Nodes	Reference Street Elevation (feet, NAVD)	Flood Duration (hours)		
		Existing Conditions	Alternative 3	Reduction (%)
IN_3013	3.10	7.7	6.5	15
IN_3043	3.30	5.0	4.5	9

Alternative 4: Drainage Wells

The stormwater model was used to conduct several simulations of the installation of proposed drainage wells within problem areas of the study area. The purpose of this system improvement alternative is to intercept stormwater runoff before it reaches the existing outfalls and to provide additional discharge capacity at the problem area to alleviate the existing flooding issues quicker. The expected construction includes a total of seven drainage wells along NE 16th Street and NE 17th Street within the study area. Within the stormwater model, a minimum driving head of 1.5 feet above the SHWT was assumed prior to activating discharge via the proposed drainage wells. Based on the historical information for the area, the discharge rate of each drainage well was assumed to be 450 GPM per foot of head within the stormwater model, which is approximately equivalent to 1.0 CFS per foot of head. All proposed drainage wells will be interconnected to maintain the same driving head to each drainage well. The estimated design and construction costs for this drainage well alternative are approximately $1,098,000.

Based on our analysis with the stormwater model, the reduction in peak flood stages under Alternative 4 is summarized within Table 5.14.8 below. The model results for Alternative 4 show a reduction in peak flood stage of 0.18 feet at Node IN_3013 adjacent to the proposed pump station. The remainder of the study area receives no benefit from Alternative 4.

Table 5.14.8 – Alternative 4 Peak Flood Stage Summary					
	Existing Conditions			Alternative 4	
Nodes	Peak Stage (feet, NAVD)	Ground Elevation (feet, NAVD)	Flood Depth (feet)	Peak Stage (feet, NAVD)	Peak Stage Reduction (feet)
IN_3013	4.89	3.1	1.79	4.71	-0.18
IN_3043	4.97	3.3	1.67	4.97	0.00
IN_3003	2.45	1.5	0.95	2.45	0.00
MH_0484	4.58	5.6	N/A	4.58	N/A

Based on our analysis with the stormwater model, the reduction in expected flooding duration is summarized within Table 5.14.9 below. According to the model results, Alternative 4 shows a limited reduction in flood duration of up to 37% from the existing conditions. Alterative 4 reduces the expected flooding duration to less than 5 hours within the study area. At the critical model node (Node IN_3013), the flood duration is expected to be reduced from 7.7 hours under the existing conditions to 4.8 hours under Alternative 4.

Table 5.14.9 – Alternative 4 Flood Duration Summary				
Nodes	Reference Roadway Elevation (feet, NAVD)	Flood Duration (hours)		
		Existing Conditions	Alternative 4	Reduction (%)
IN_3013	3.10	7.7	4.8	37
IN_3043	3.30	5.0	4.5	9

Alternative 5: Exfiltration Trench & Pipe Size Upgrades

This alternative combines the exfiltration trench of alternative 1 and pipe size upgrades of alternative 2. Under Alternative 1, the proposed construction includes a total of 8,022 LF of exfiltration trench, which were aligned along right-of-way areas with ground surface elevations greater than +5.0 feet NAVD. The proposed improvements under Alternative 2 includes replacing the existing 12-inch pipe and 24-inch pipe with approximately 600 linear feet of new 36-inch RCP. The estimated design and construction costs for Alternative 5 are approximately $2,486,000.

Based on our analysis with the stormwater model, the reduction in peak flood stage under Alternative 1 is summarized within Table 5.14.10 below. The model results for Alternative 5 show a reduction in peak flood stage of -0.72 feet at the critical model node (Node IN_3013). The peak flood depth is expected to be reduced from 1.79 feet under the existing conditions to 1.07 feet under Alternative 5.

Table 5.14.10 – Alternative 5 Peak Flood Stage Summary					
	Existing Conditions			Alternative 5	
Nodes	Peak Stage (feet, NAVD)	Ground Elevation (feet, NAVD)	Flood Depth (feet)	Peak Stage (feet, NAVD)	Peak Stage Reduction (feet)
IN_3013	4.89	3.1	1.79	4.17	-0.72
IN_3043	4.97	3.3	1.67	4.85	-0.12
IN_3003	2.45	1.5	0.95	2.45	0.00
MH_0484	4.58	5.6	N/A	4.58	N/A

Based on our analysis with the stormwater model, the reduction of flooding duration within the study area under Alternative 5 is summarized in Table 5.14.11 below. At the critical model node (Node IN_3013), the flood duration is expected to be reduced from 7.7 hours under the existing conditions to 2.0 hours under Alternative 5.

Table 5.14.11 – Alternative 5 Flood Duration Summary				
Nodes	Reference Roadway Elevation (feet, NAVD)	Flood Duration (hours)		
		Existing Conditions	Alternative 5	Reduction (%)
IN_3013	3.10	7.7	2.0	74
IN_3043	3.30	5.0	2.5	49

Alternative Comparison

Refer to the Table 5.14.12 below for a comparison of the various system improvement alternatives for this study area. Please note the peak flood stage and flood duration results within Table 5.14.12 refer to the critical problem area within the study area, which corresponds to Node IN_3013 within the stormwater model. Based on our analysis with the stormwater model, all system improvement alternatives provide similar flood control benefits to the study area, which are limited. Under all five alternatives, the reduction in peak flood stage ranges from 0.08 feet to 0.49 feet while the reduction in expected flood duration ranges from 1.2 hours to 5.2 hours. Based on the model results, Alternative 5 is slightly more effective than all of the other alternatives at providing additional flood control to the study area. Alternative 5 has the less potential concern that could arise during the detailed design phase which could restrict the complete implementation. Alternative 5 should be implemented for this study area since it provides the best potential flood control benefits. Although Alternative 5 does not provide enough additional flood protection to meet the level of service criteria for all public roadways within the study area, Alternative 5 does provide significant benefits which alleviate the flooding problems within the study area.

Table 5.14.12 – Alternative Comparison			
Alternative	**Peak Flood Stage Reduction (feet)**	**Flood Duration Reduction (hours)**	**Implementation Costs ($)**
Alternative 1	0.13	1.3	$3,390,000
Alternative 2	0.49	5.2	$338,000
Alternative 3	0.08	1.2	$2,198,000
Alternative 4	0.18	2.9	$1,098,000
Alternative 5	0.72	5.7	$2,486,000

CMA recommends the installation of exfiltration trench within City right-of-ways throughout the study area which provide additional storage and infiltration capacity for stormwater runoff. The recommended stormwater improvements for this study area include the installation of new exfiltration trench along NE 18th Street, NE 19th Street, NE 21st Street, NE 22nd Street and NE 27th Avenue to collect stormwater runoff from these areas. The proposed exfiltration system should be interconnected to existing drainage systems, which will allow drawdown via the existing outfalls. The recommended stormwater improvements also include upsizing the existing 24-inch outfall to a 36-inch outfall. The swale areas should also be regraded throughout the study area to provide additional storage volume for stormwater runoff. For the recommended stormwater improvements for this study area, CMA has prepared a conceptual layout, which is enclosed within Appendix A-1 and a preliminary cost estimate, which is enclosed within Appendix A-2. During the detailed design phase, the proposed construction will encounter various constructability concerns related to potential utility conflicts with other underground utilities within the public right-of-way area, which could reduce the extent of the exfiltration trench installed. These items will need to be evaluated in more detail during the design phase of the proposed project.

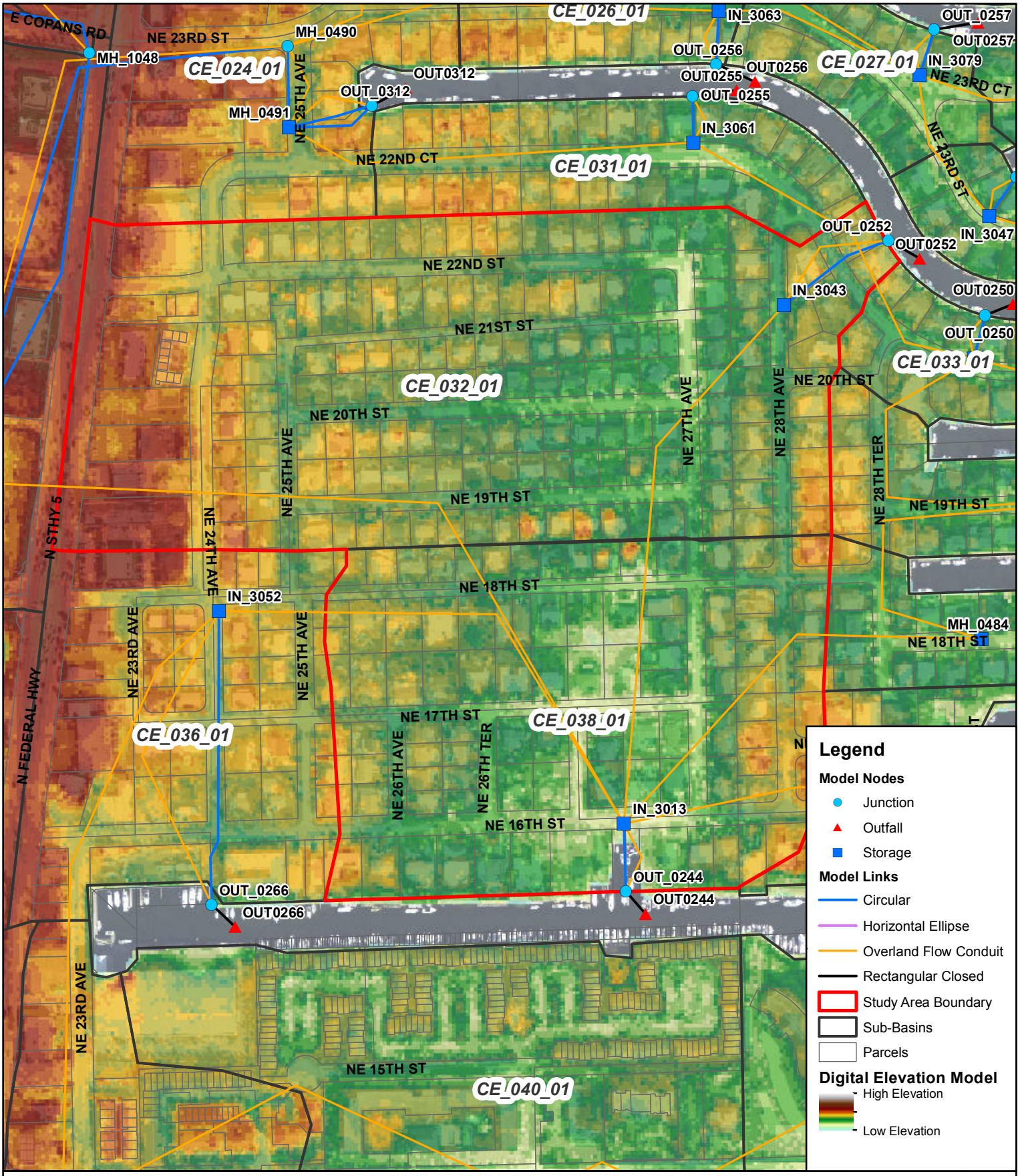

Figure 5-14A
NE 27th Avenue & NE 16th Street
Existing Topography & Model Schematics

N
W E
S

0 200 400
Feet

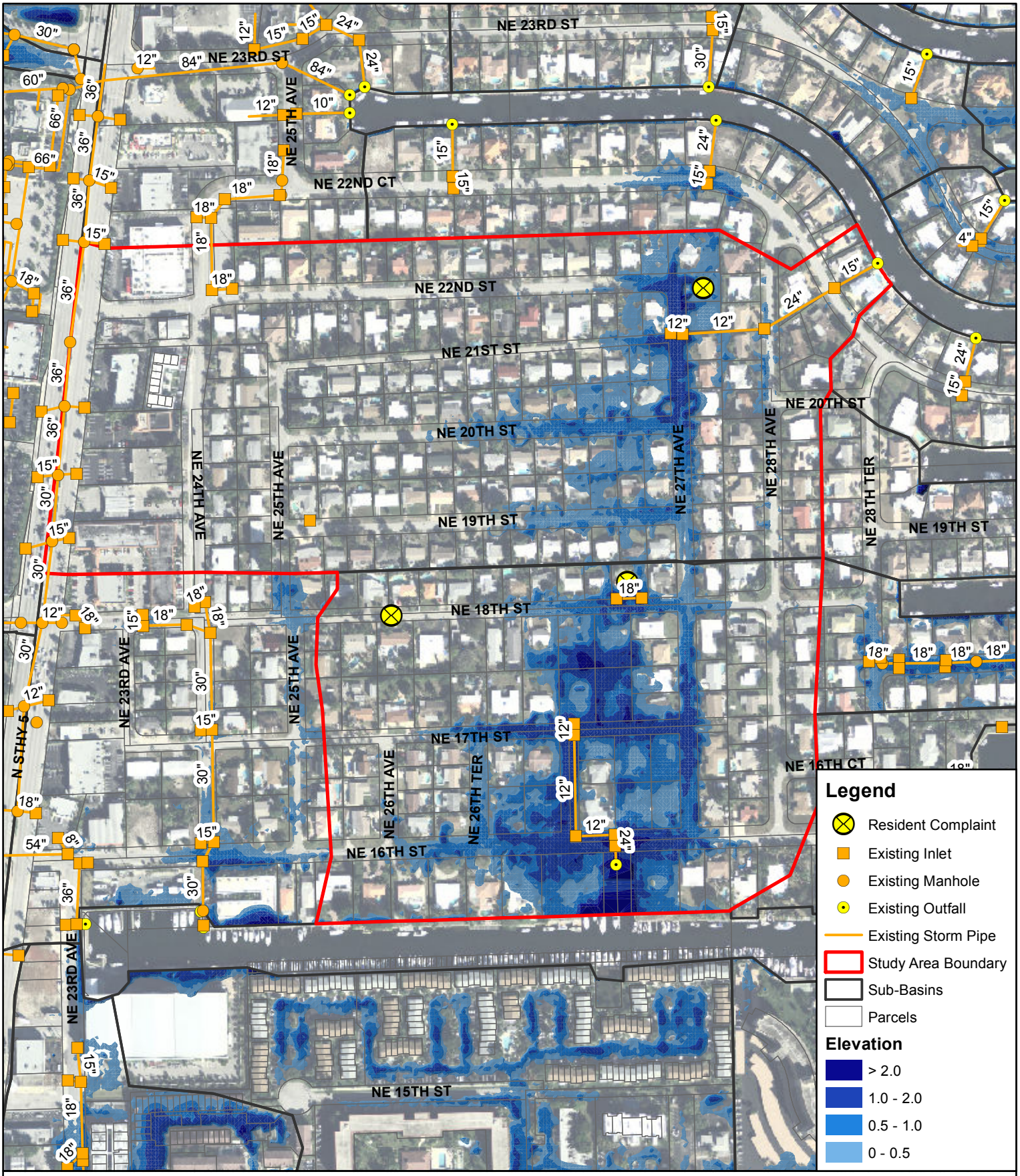

Figure 5-14B
NE 27th Avenue & NE 16th Street
Potential Flooding Depth