2009 GMEC Conference

Date:
Thursday, April 30, 2009
Friday, May 1, 20009

Location:
Hilton at Walt Disney World Resort

Speaker:
Dr. Devo Seereeram, Ph.D., P.E.,
Devo Engineering

Topic:
Major Geotechnical Failures As a Result of Tropical Storm Fay
(With a Focus on DeBary, Orange City, and Rock Springs Localities in Central Florida)

ACKNOWLEDGEMENTS

- All helicopter photos of DeBary failures courtesy Professional Engineering Consultants (PEC)
- Rainfall data and maps compiled from NOAA, Weather Underground, and PEC/Devo Engineering Files
- Fish Memorial Hospital Flooding – Local 6 News
- All other photos compiled from Devo Engineering Files

Main Menu

1

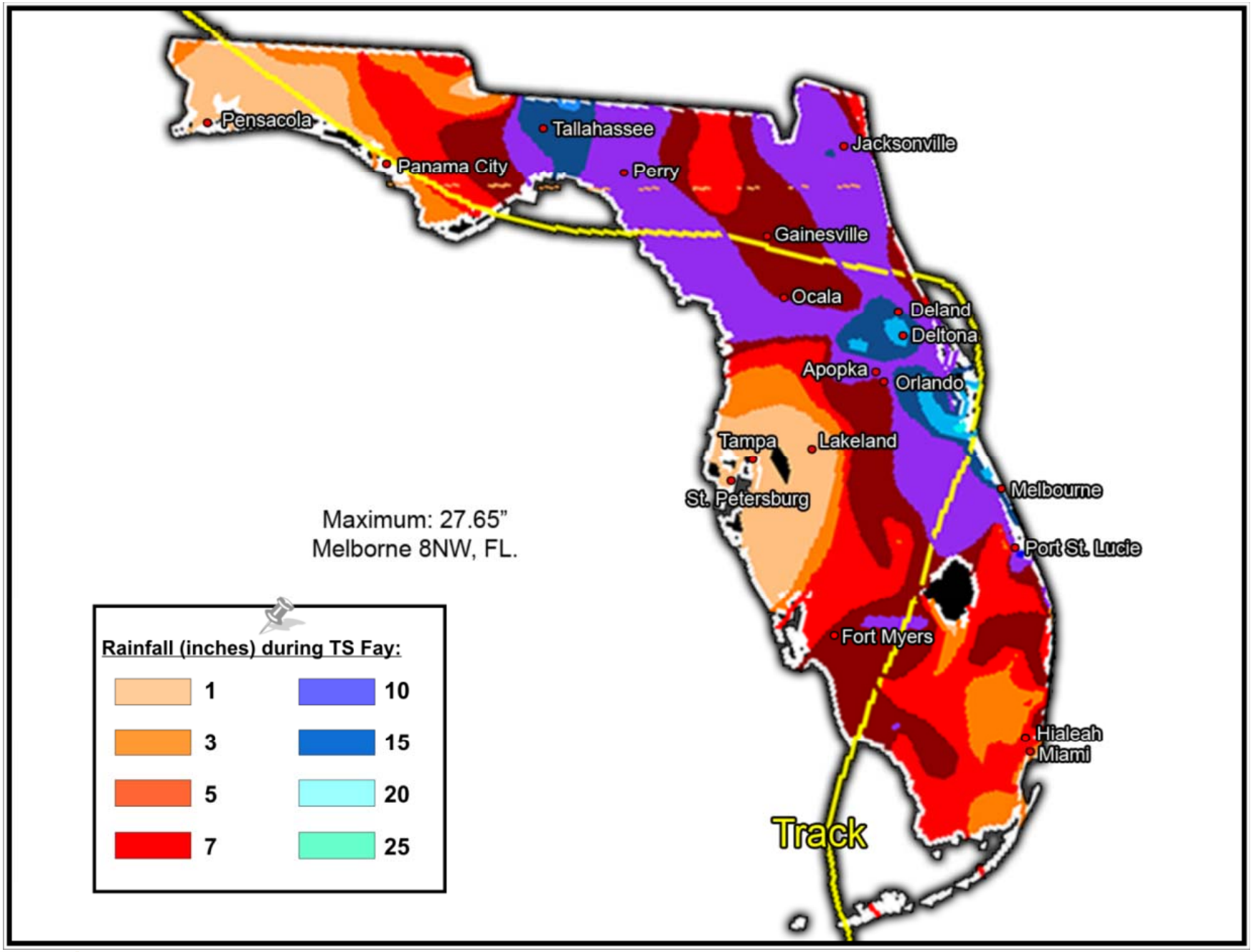
5 Day Rainfall Totals at Various Stations

Bullet points about TS Fay

- During seven days in Florida, August 18th to 24th, 2008, fourteen (14) people died and thousands of homes, and numerous commercial properties and roads were damaged by 60-mph winds and flood waters up to 5 feet deep, as Tropical Storm Fay traveled through the entire state.

- TS Fay made four (4) Florida landfalls, first at Key West in the late afternoon of August 18th, then early the following morning at Cape Romano south of Naples as a 60 mph tropical storm.

Rainfall Totals for TS Fay - NOAA Data

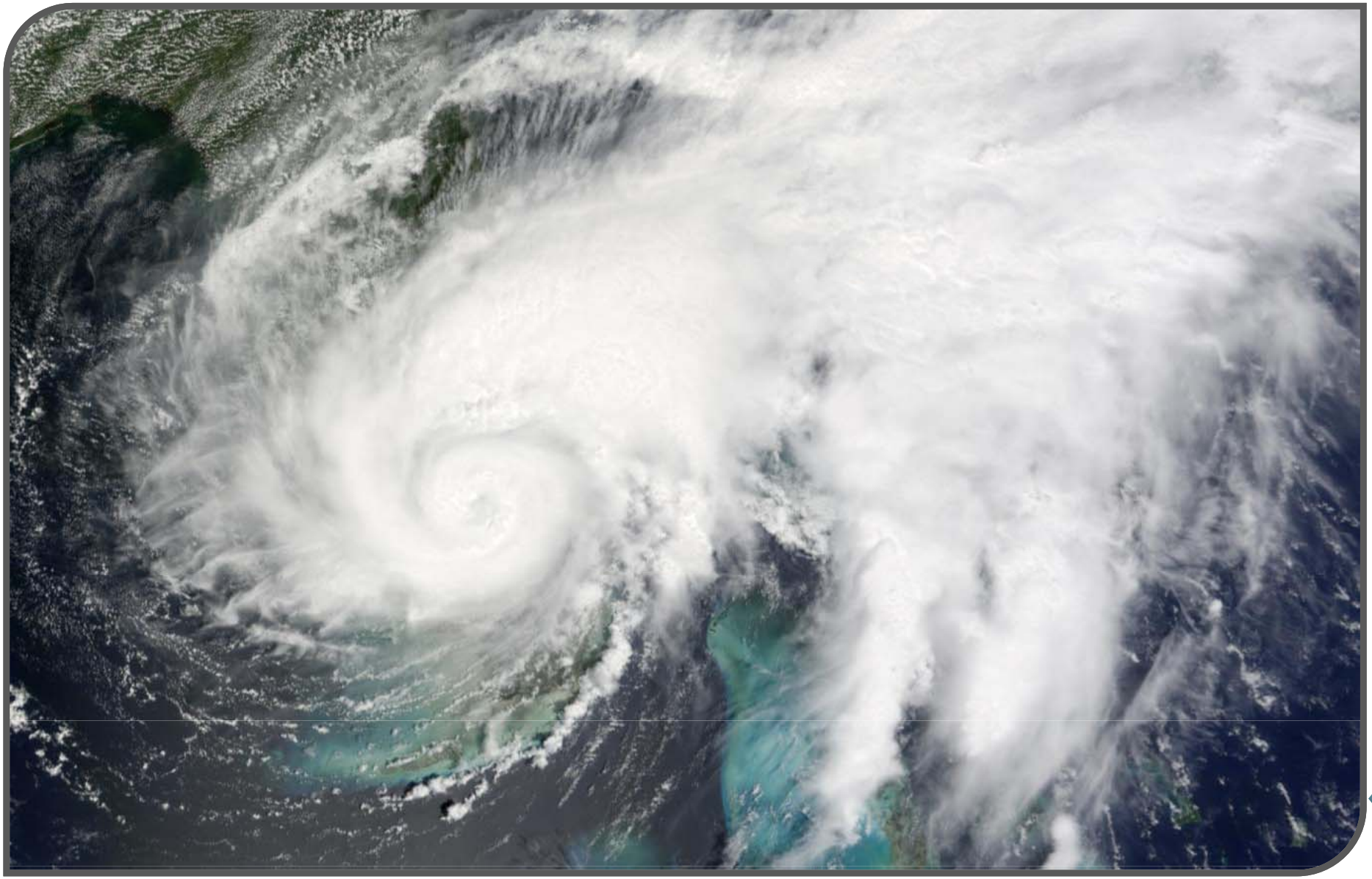


Bullet points about TS Fay (continued)

- Later that day, while crossing central Florida, Fay unexpectedly strengthened to 65 mph over land which is a stronger intensity than Fay achieved over open ocean. The storm developed an eye feature, and continued to hold its strength for the rest of the day. After many hours of land interaction, Fay began to weaken. Fay regained some strength, however, after leaving land at Melbourne and heading northward over the warm Atlantic Ocean waters, only to be deflected westward as it encountered a high pressure ridge.

- The westward deflection resulted in another landfall at Flagler Beach in the afternoon of August 21st. The storm then emerged into the northeastern Gulf of Mexico and made its fourth landfall on the morning of August 23rd near Carrabelle in the Florida Panhandle.

Fay Over Florida (August 19, 2008)



Bullet points about TS Fay (continued)

- Since 1950, only two (2) other storms have done a loop-de-loop through the state:

  ❶Tropical Storm Florence in 1960, and

  ❷Hurricane Gordon in 1994.

- The color-coded generalized rainfall map produced by NOAA shows that areas of the state received up to 25 inches of rain. On August 21st, President George W. Bush declared the entire state of Florida a Federal Disaster Area as many rivers in Central Florida, such as the St. Johns River, jumped their banks.

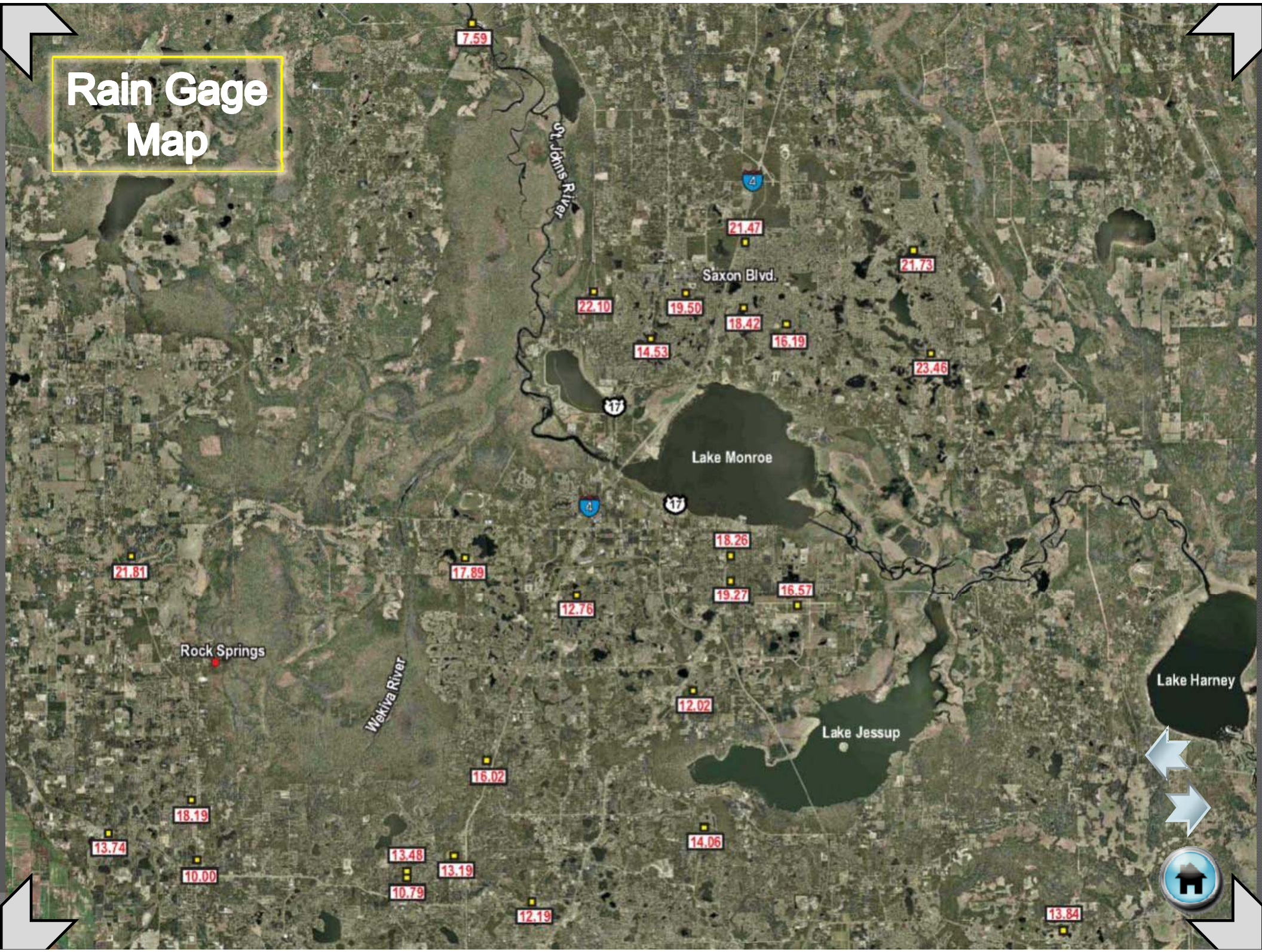
Hurricane Gordon 1994 path

Hurricane Florence 1960 path

Bullet points about TS Fay (continued)

- The NOAA-published rainfall map shows that the Orange City locale (in Volusia County) received about 20 inches of rain during the multi-day storm and the distribution of rainfall was not uniform. Interestingly, the area in the Orange City-DeBary-Deltona triangle was within a zone of heaviest rainfall (20 to 25 inches) while nearby cities such as Deland, Lake Mary, Altamonte Springs, and Sanford were spared such excess rainfall.

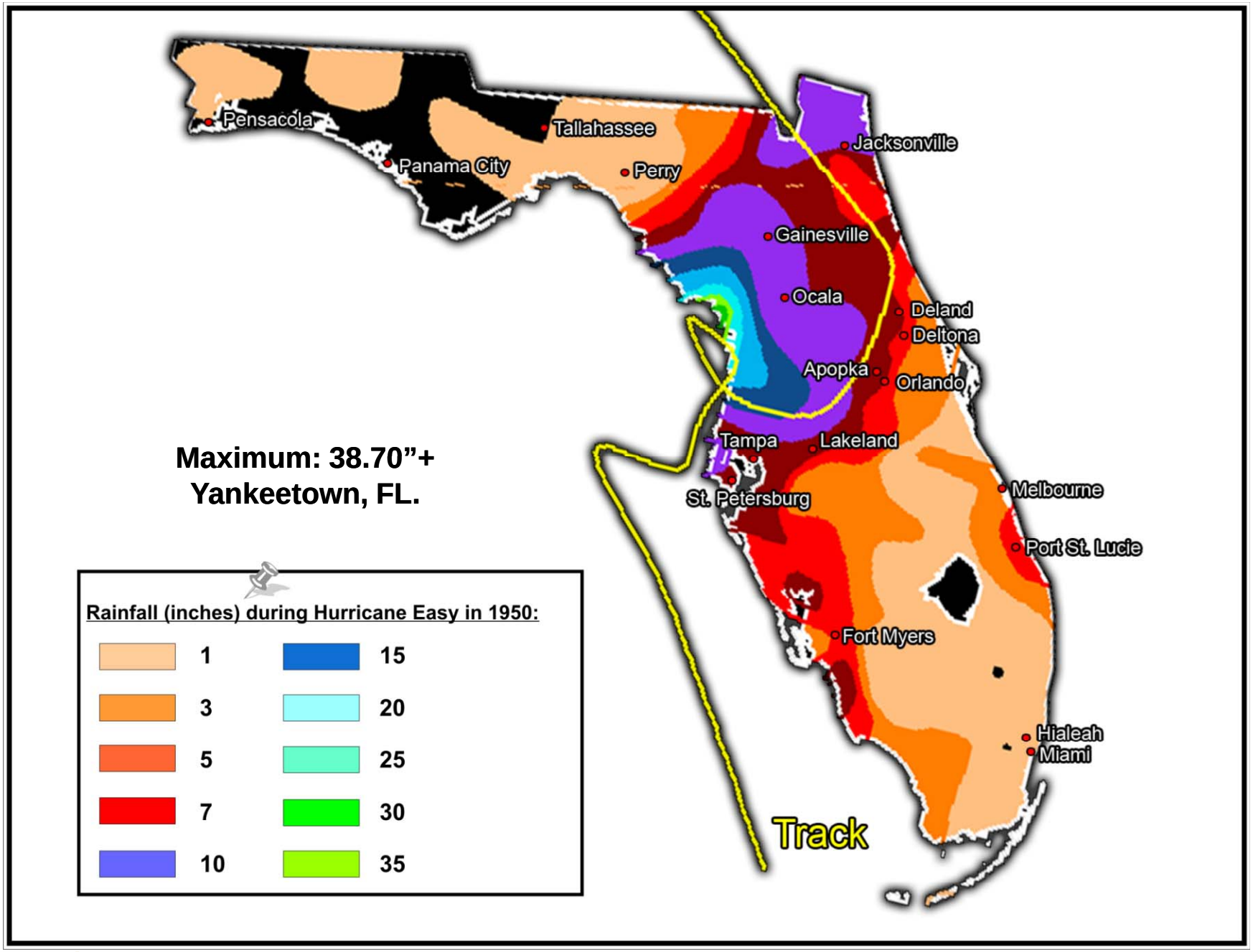
- TS Fay rainfall measurements at several rain gages in the vicinity of Debary/Orange City confirm that the magnitude of rainfall was generally between 21 and 22 inches during the storm (Aug 18-23, 2008). About 45 to 60% of this precipitation occurred on a single day: Thursday August 21st in this area. The spot measurements also confirm that the neighboring cities to the north and to the south did not receive the abnormally high rainfall totals.


Rain Gage Map
7.59
St. Johns River
21.47
21.73
Saxon Blvd.
22.10
19.50
18.42
16.19
14.53
23.46
Lake Monroe
18.26
21.81
17.89
19.27
16.57
12.76
Rock Springs
Wekiva River
Lake Harney
12.02
Lake Jessup
16.02
18.19
13.74
14.06
13.48
13.19
10.00
10.79
12.19
13.84

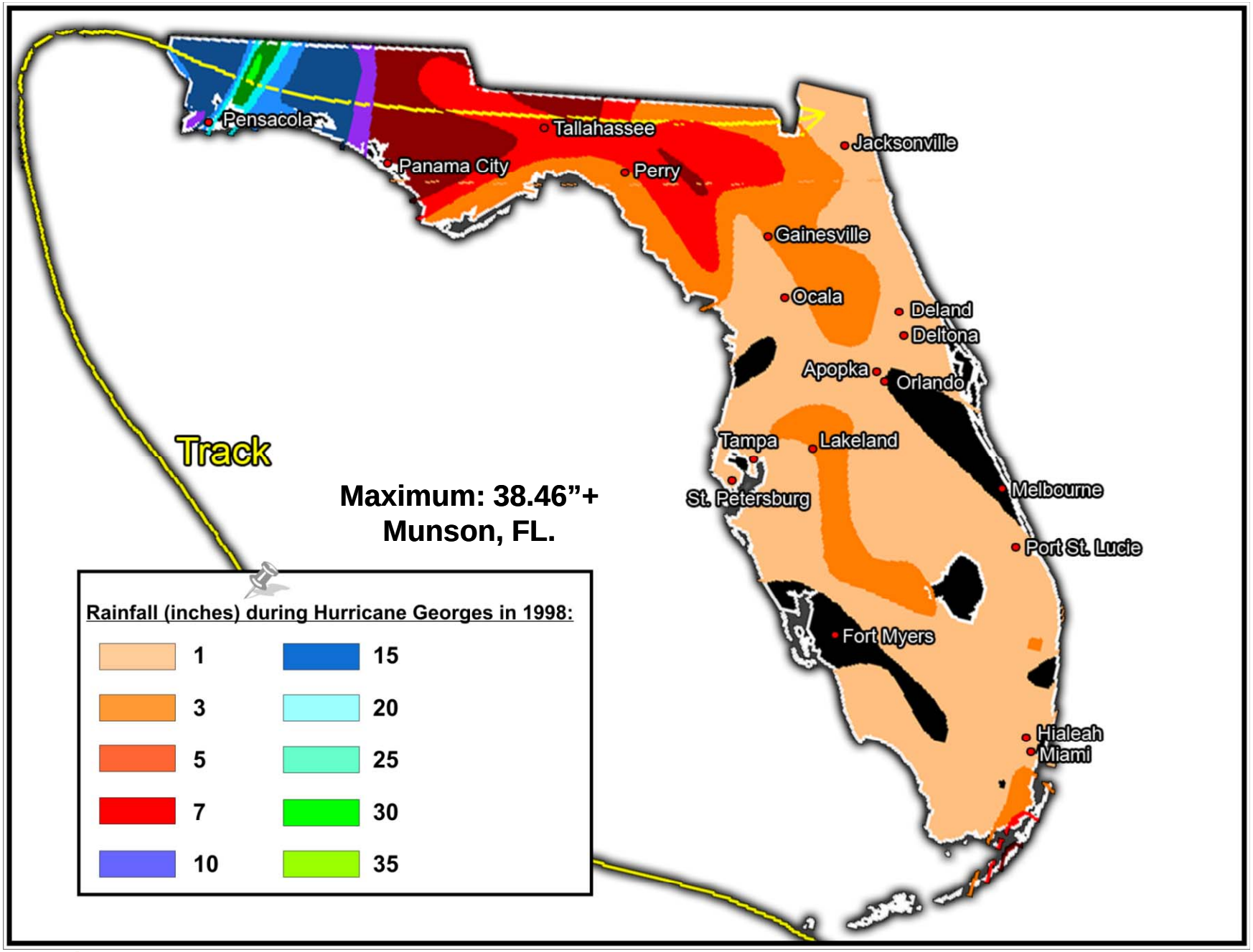
Bullet points about TS Fay (continued)

- The record-breaking rainfall from Fay was amazing, but it didn't come near one record for Florida that has stood since 1950. In September of 1950, Hurricane Easy dumped 38.70" of rain in a 24-hour period in Yankeetown, FL. That record stood as the all time 24-hour rainfall maximum for the United States, until Tropical Storm Claudette drenched the town of Alvin, TX with 42.00" in a 24-hour period in 1978.

Hurricane Easy in 1950



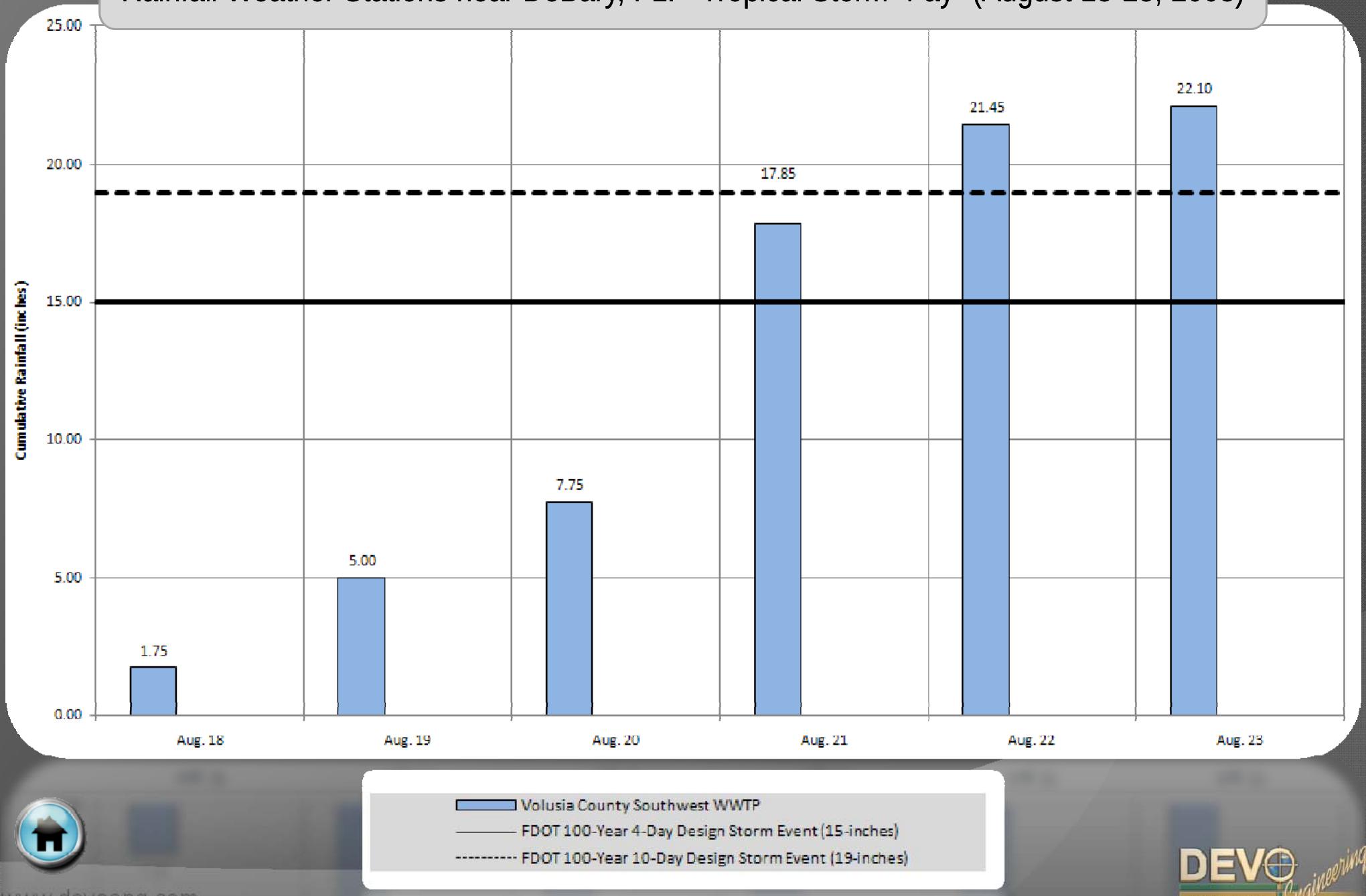
Hurricane Georges in 1998



2

Comparison of Actual Rainfall to 100 year - 10 day storm

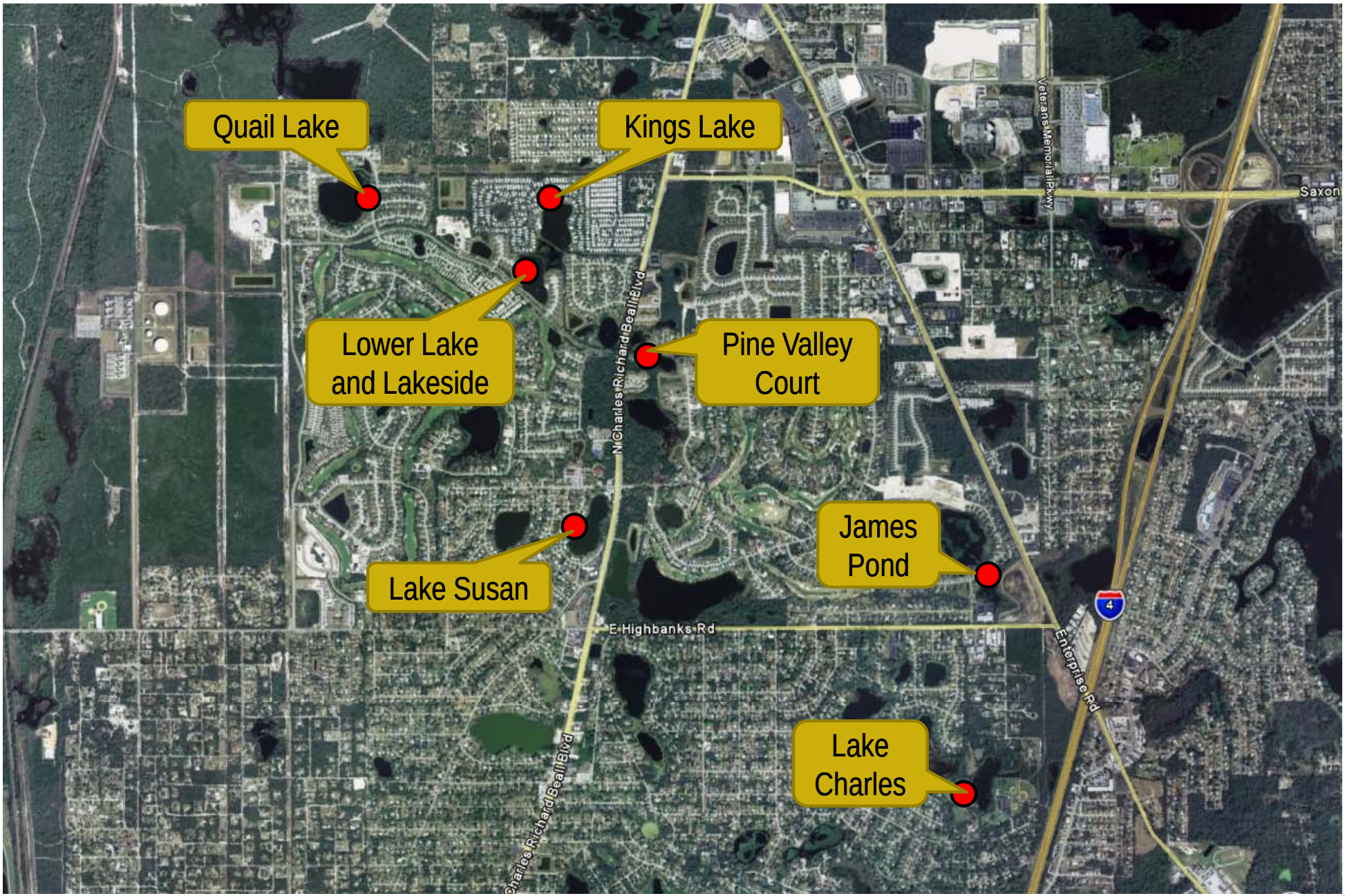
Rainfall Weather Stations near DeBary, FL. - Tropical Storm “Fay” (August 18-23, 2008)



3

Residential Structure Flooding

Residential Structure Flooding



DGCC Lower Lake and Lakeside (40 structures flooded)

DGCC Lower Lake and Lakeside (40 structures flooded)

Photo 1 of 4

DGCC Lower Lake and Lakeside (40 structures flooded)

Photo 2 of 4

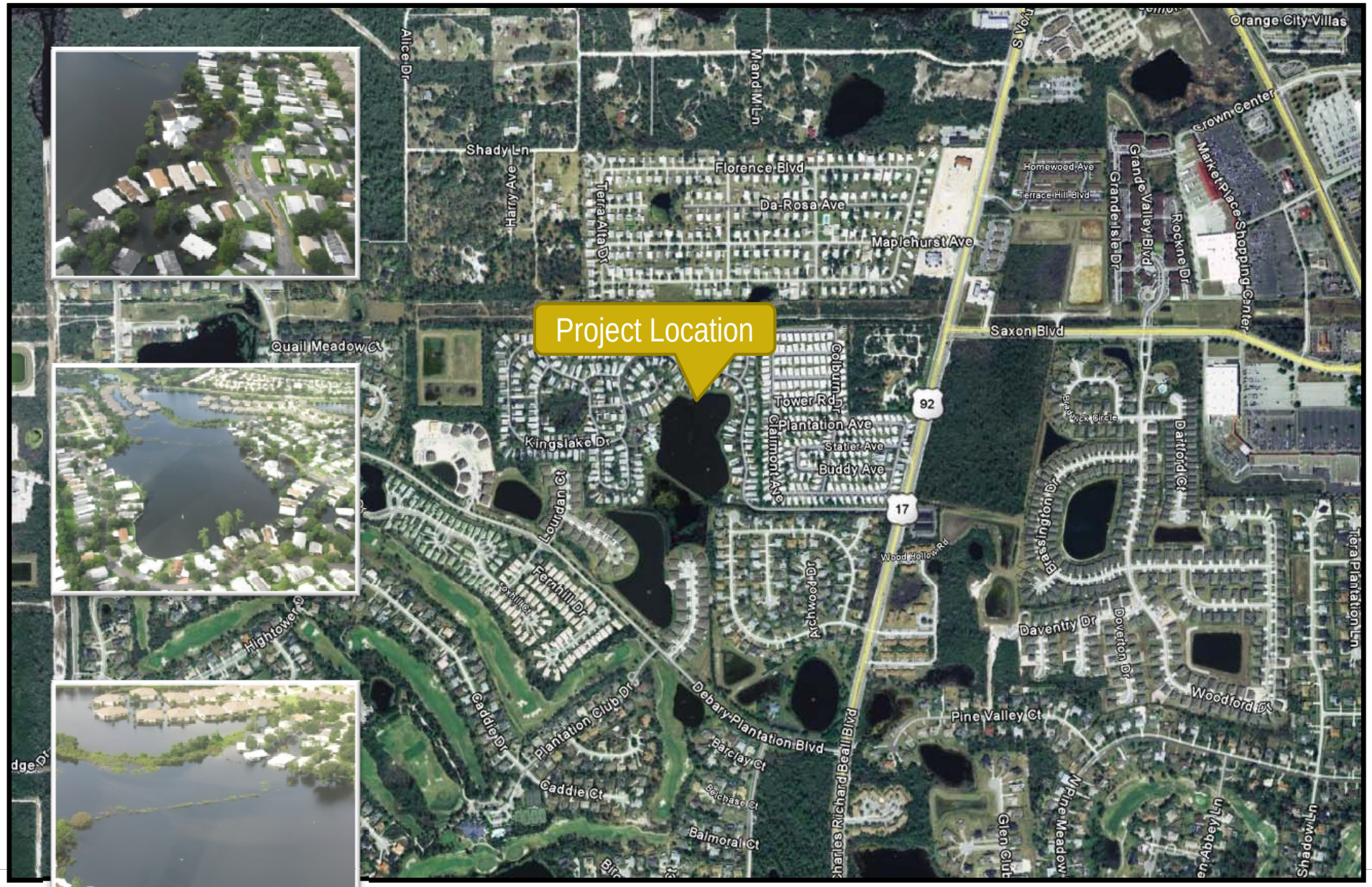
DGCC Lower Lake and Lakeside (40 structures flooded)

Photo 3 of 4

DGCC Lower Lake and Lakeside (40 structures flooded)

Photo 4 of 4

Kings Lake (16 structures flooded)



Kings Lake (16 structures flooded)

Photo 1 of 3

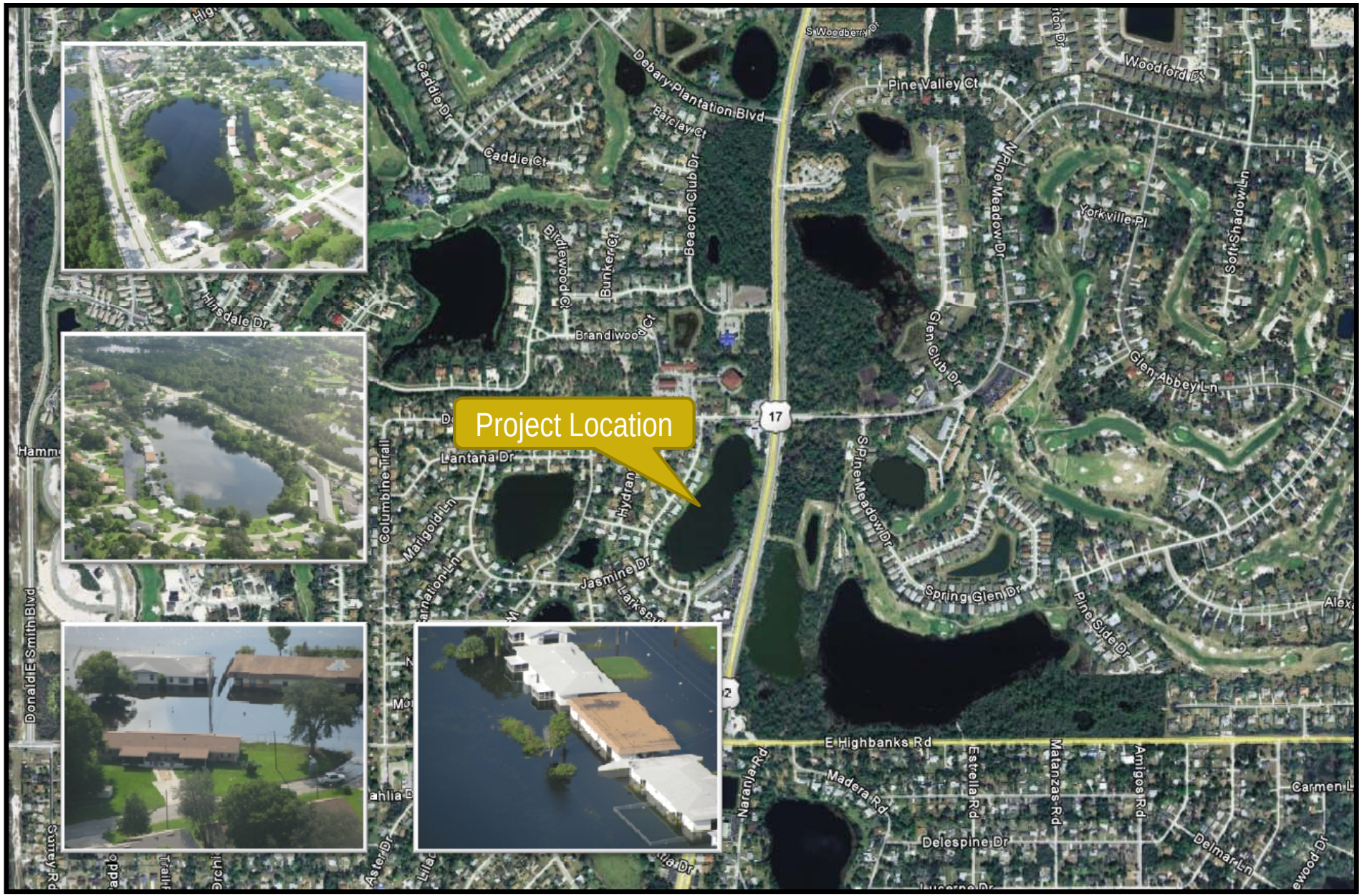
Kings Lake (16 structures flooded)

Photo 2 of 3

Kings Lake (16 structures flooded)

Photo 3 of 3

Lake Susan (12 structures flooded)



Lake Susan (12 structures flooded)

Photo 1 of 4

Lake Susan (12 structures flooded)

Photo 2 of 4

Lake Susan (12 structures flooded)

Photo 3 of 4

Lake Susan (12 structures flooded)

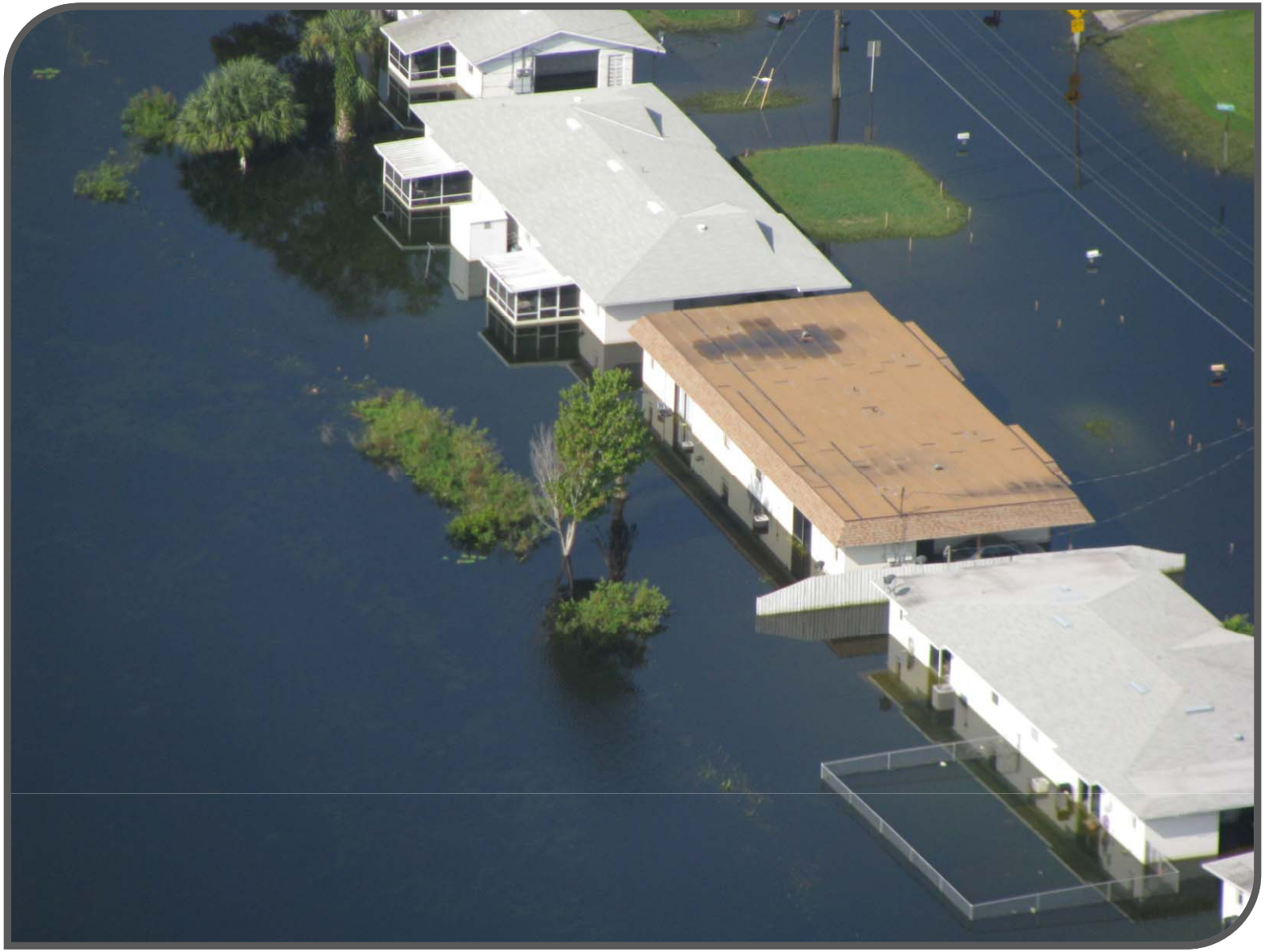
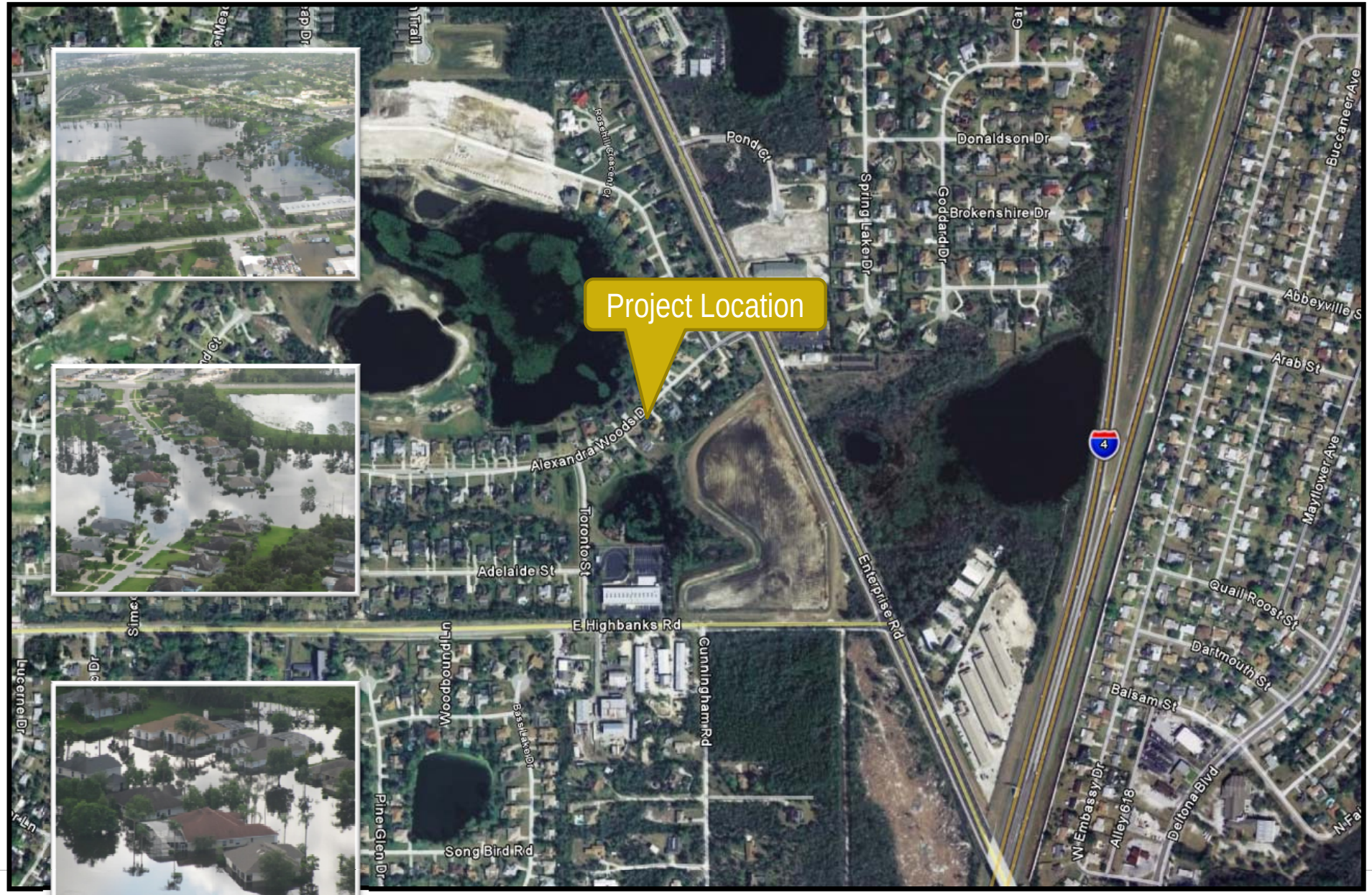


Photo 4 of 4

James Pond (9 structures flooded)



James Pond (9 structures flooded)

Photo 1 of 3

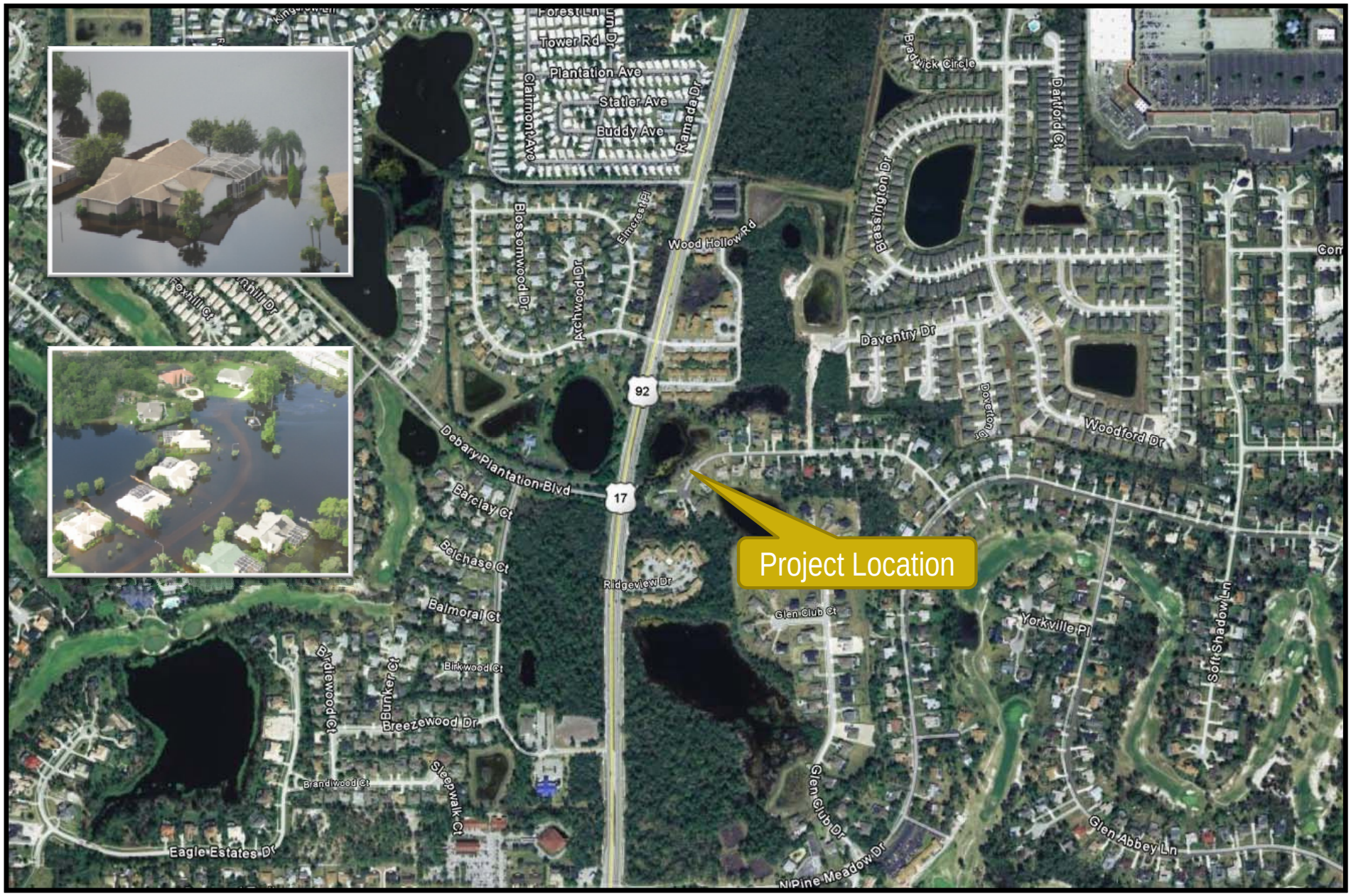
James Pond (9 structures flooded)

Photo 2 of 3

James Pond (9 structures flooded)

Photo 3 of 3

Pine Valley Court (6 structures flooded)



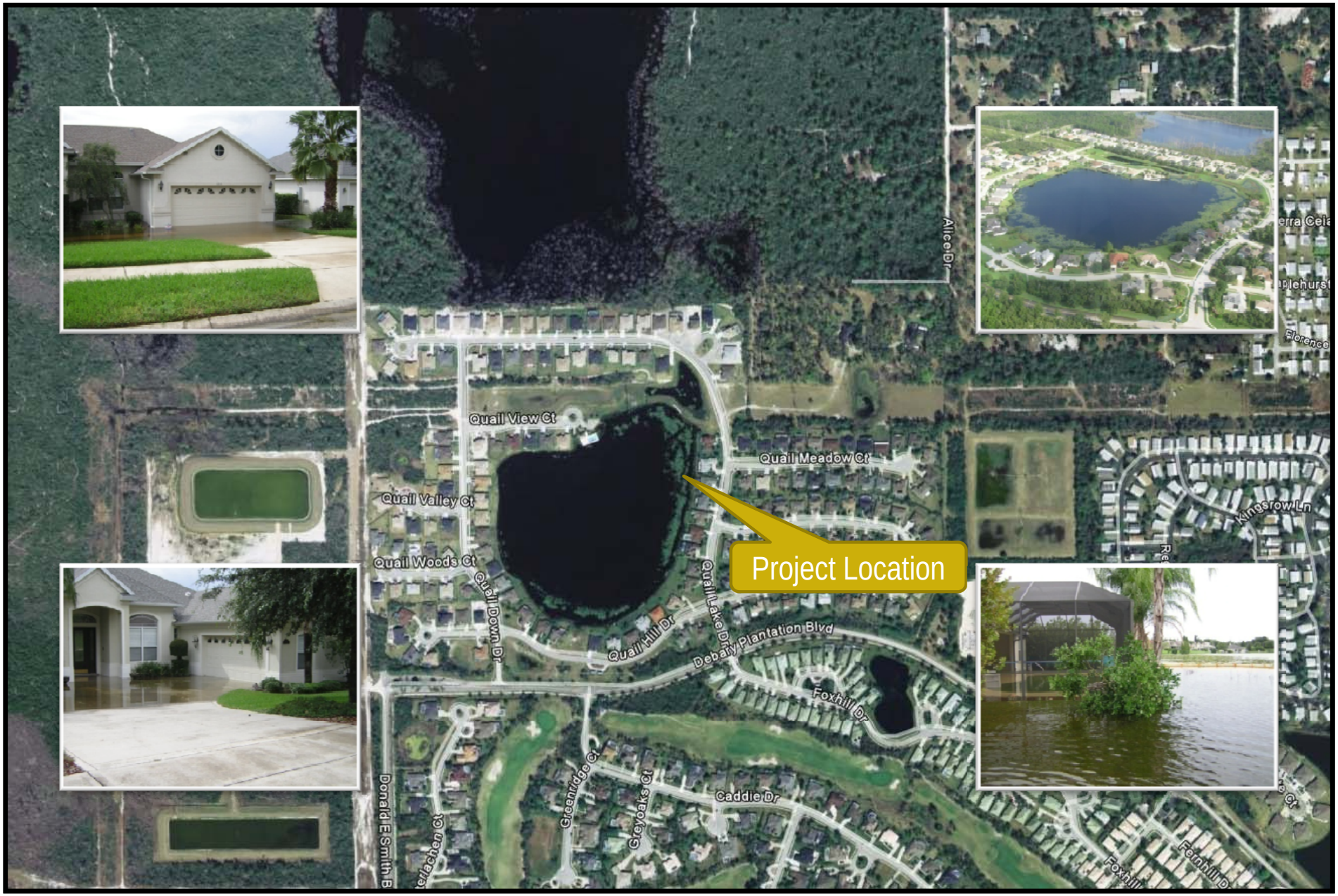
Pine Valley Court (6 structures flooded)

Photo 1 of 2

Pine Valley Court (6 structures flooded)

Photo 2 of 2

Quail Lake (2 structures flooded)



Quail Lake (2 structures flooded)

Photo 1 of 4

Quail Lake (2 structures flooded)

Photo 2 of 4

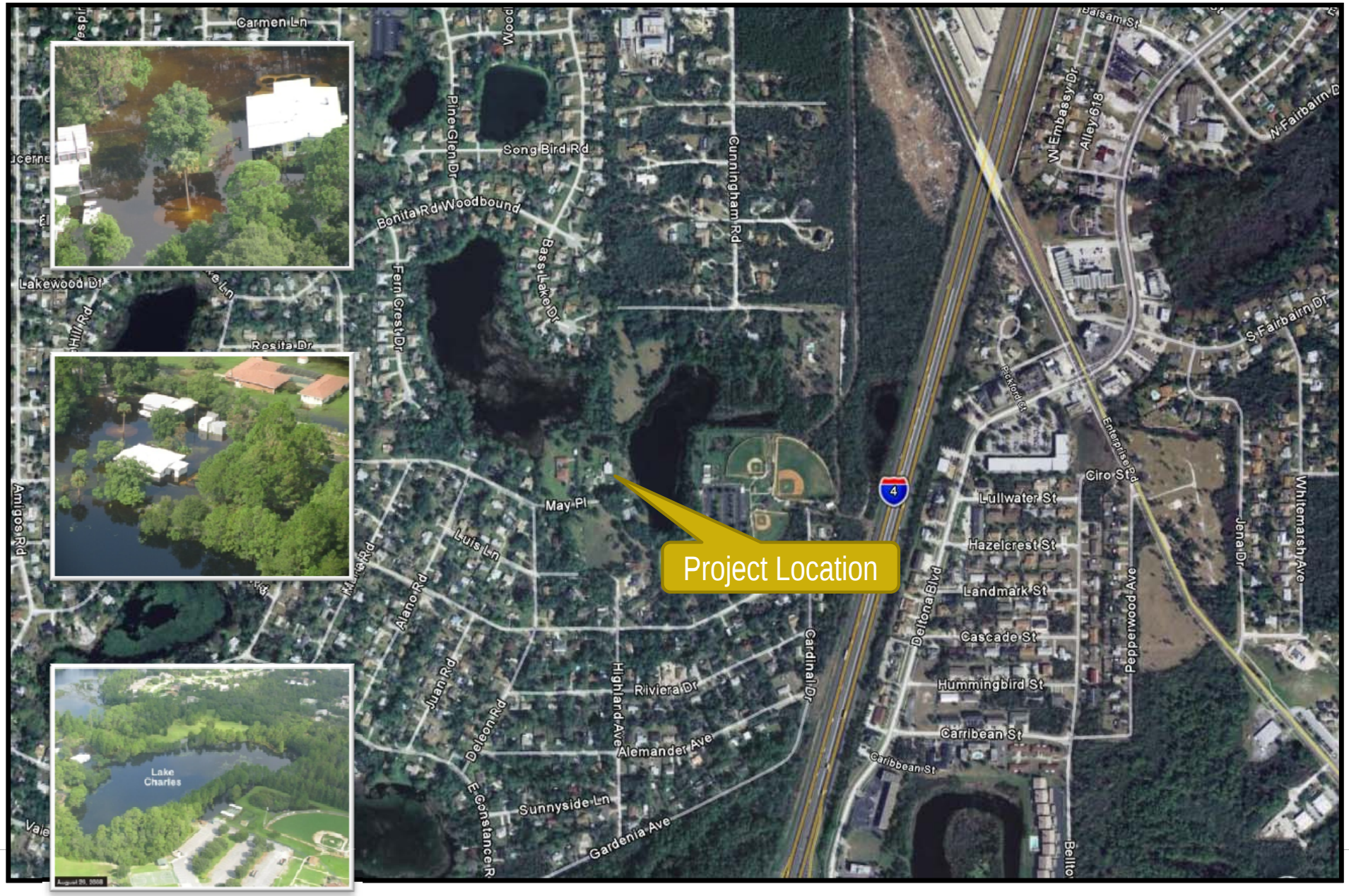
Quail Lake (2 structures flooded)

Photo 3 of 4

Quail Lake (2 structures flooded)

Photo 4 of 4

Lake Charles (1 structure flooded)



Lake Charles (1 structure flooded)

Photo 1 of 3

Lake Charles (1 structure flooded)

Photo 2 of 3

Lake Charles (1 structure flooded)

Photo 3 of 3

4

Commercial Structure Flooding

Commercial Structure Flooding

Fish Memorial Hospital

Fish Memorial Hospital

Photo 1 of 1

Orange City Medical Office

Orange City Medical Office

Shows the Main Point of Entry of Water onto Prrperty

Orange City Medical Office

Shows scoured Landscape in North Carpark

Orange City Medical Office

Field Notes

Orange City Medical Office

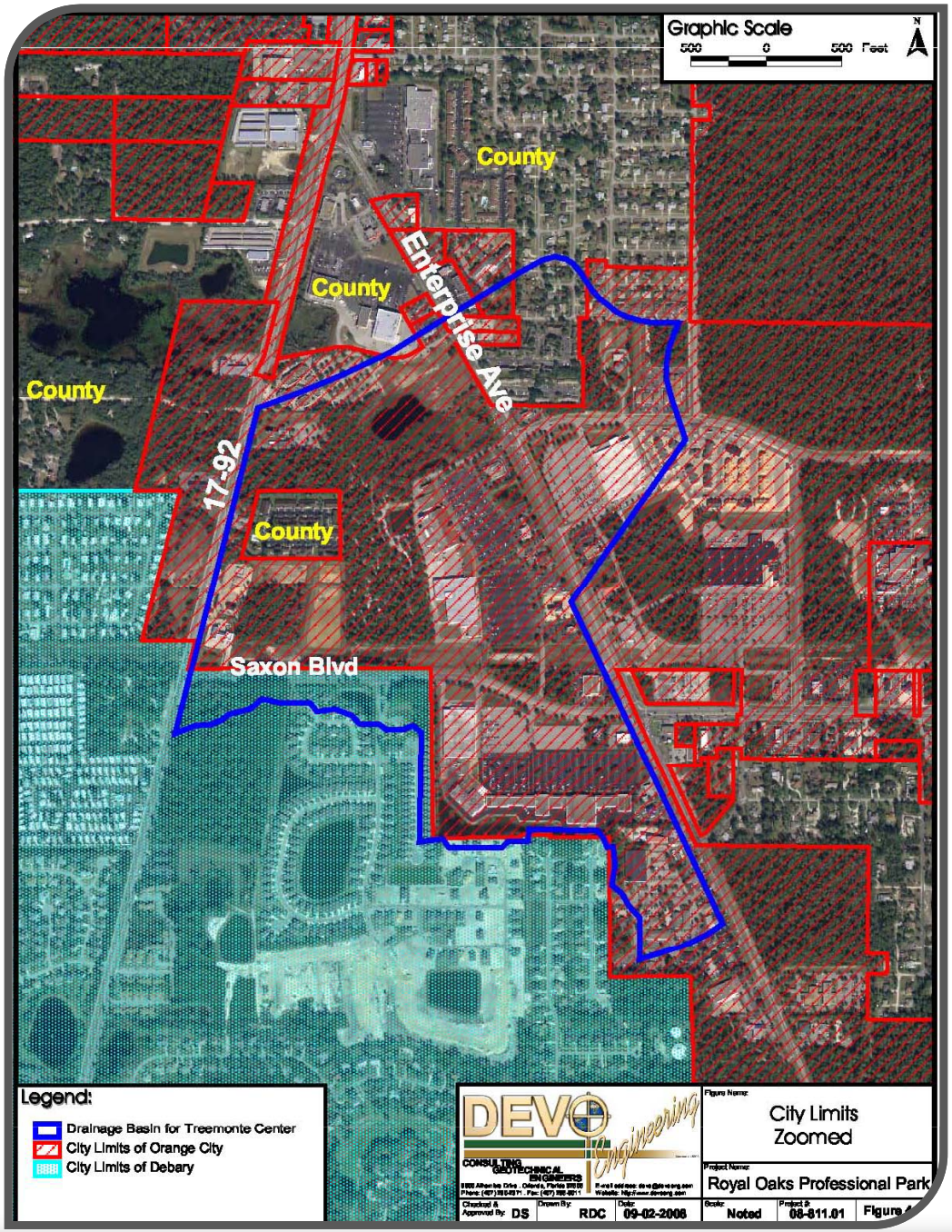
Shows Water Stains 8 Inches High At Main Entrance

Orange City Medical Office

Shows up to 2 ft of Scour Along Front Landscape Area

Royal Oaks Professional Center

Royal Oaks Professional Center



Royal Oaks Professional Center

Shows Water Flowing Onto Treemont Drive in Front of the Building

Royal Oaks Professional Center

Shows Sandbags Stacked Against Entrance Door

Royal Oaks Professional Center

Shows the Entire Carpark Under Water

Royal Oaks Professional Center

Shows Water Waist Deep in the Carpark

5

Infrastructure Flooding

Infrastructure Flooding

Debary Plantation Blvd

Debary Plantation Blvd

Photo 1 of 5

Debary Plantation Blvd

Photo 2 of 5

Debary Plantation Blvd

Photo 3 of 5

Debary Plantation Blvd

Photo 4 of 5

Debary Plantation Blvd

Photo 5 of 5

US 17-92 at Big Lots Pond

US 17-92 at Big Lots Pond

Photo 1 of 2

US 17-92 at Big Lots Pond

Photo 2 of 2

6

Major Cover Collapse Sinkholes

Major Cover Collapse Sinkholes

Deroose Nursery - Rock Springs

Deroose Nursery - Rock Springs

Photo 1 of 7

Deroose Nursery - Rock Springs

Photo 2 of 7

Deroose Nursery - Rock Springs

Photo 3 of 7

Deroose Nursery - Rock Springs

Photo 4 of 7

Deroose Nursery - Rock Springs

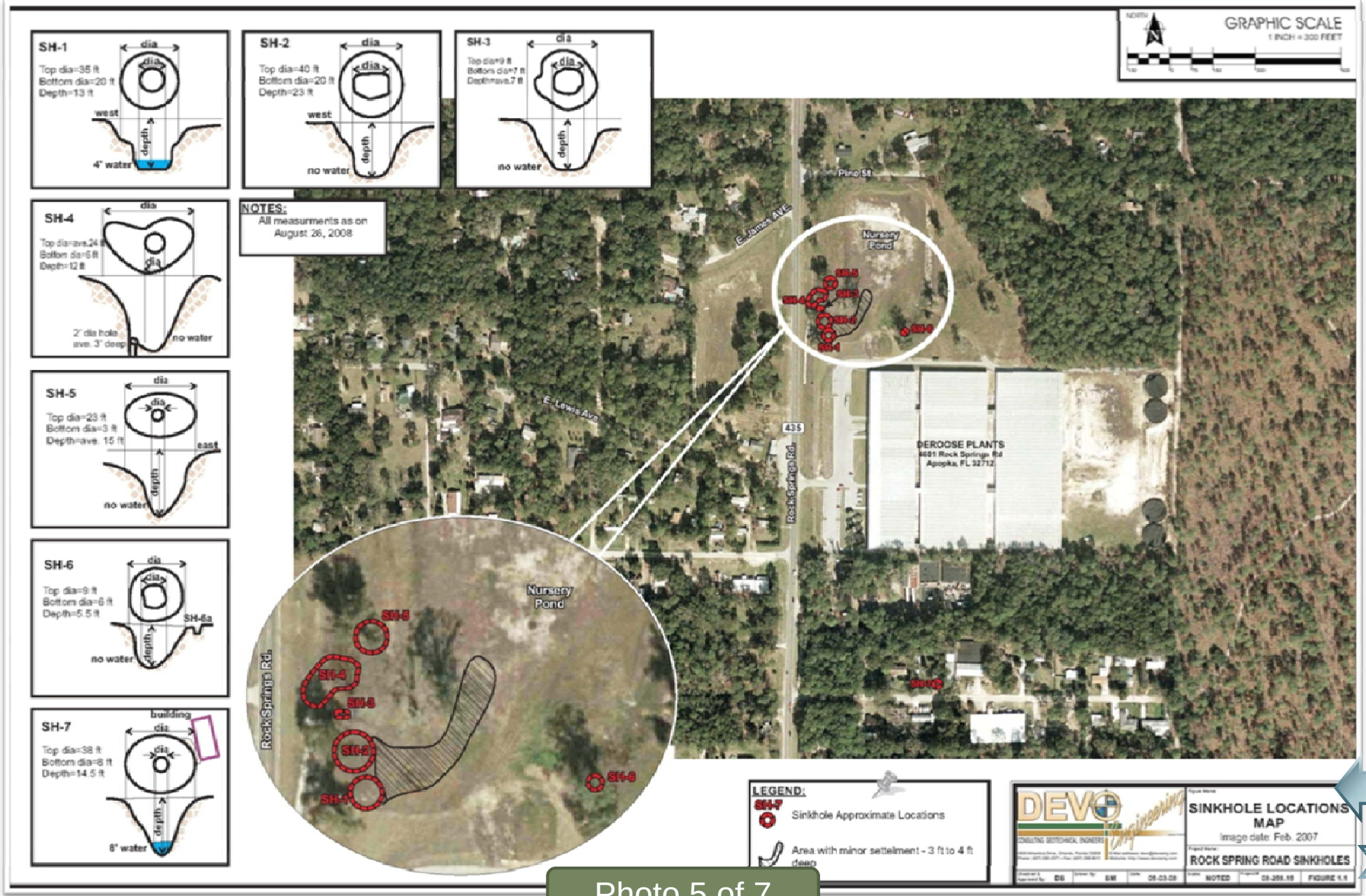


Photo 5 of 7

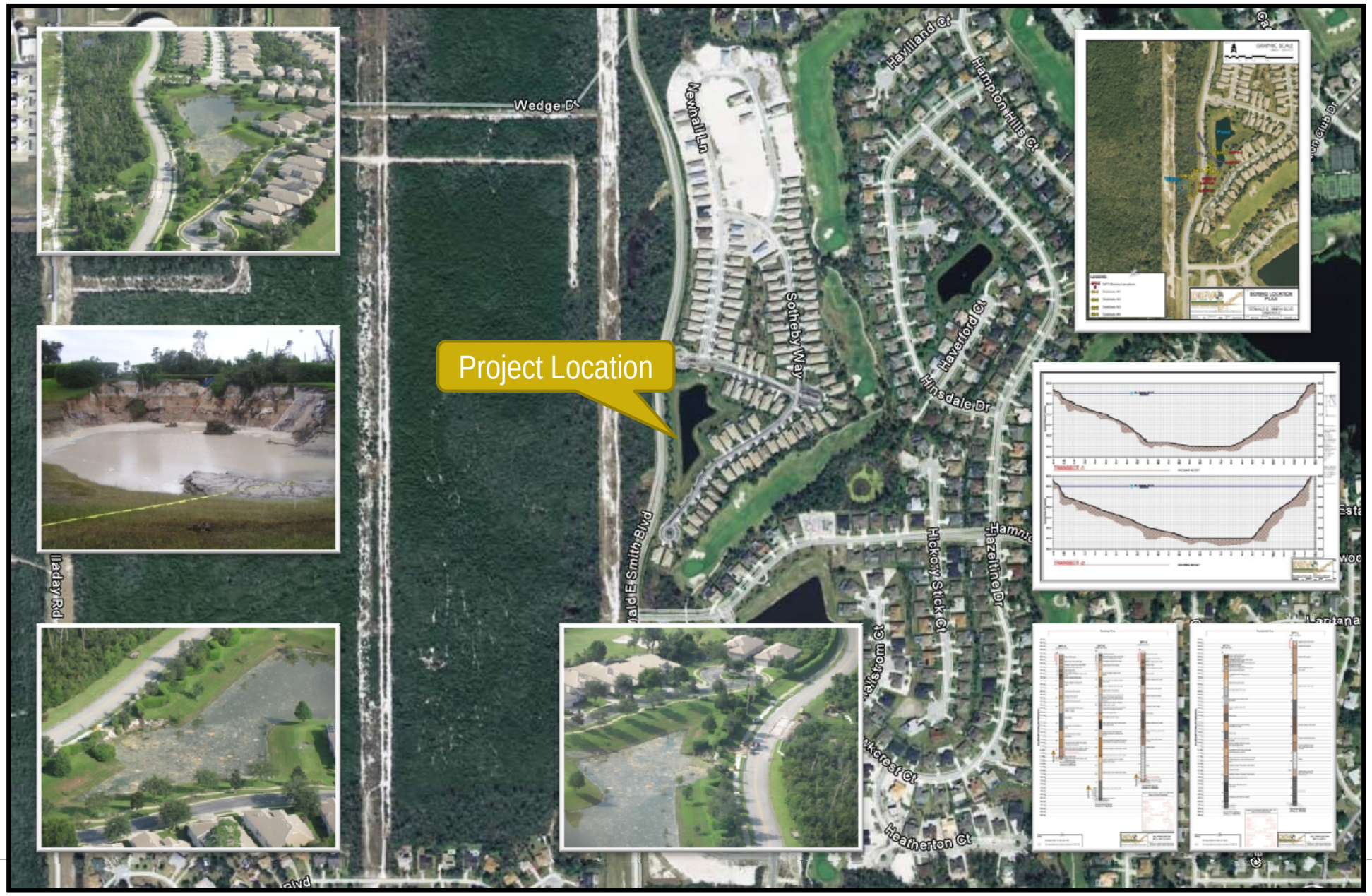
Deroose Nursery - Rock Springs

Photo 6 of 7

Deroose Nursery - Rock Springs

Photo 7 of 7

Donald E. Smith Blvd



Donald E. Smith Blvd

Photo 1 of 7

Donald E. Smith Blvd

Photo 2 of 7

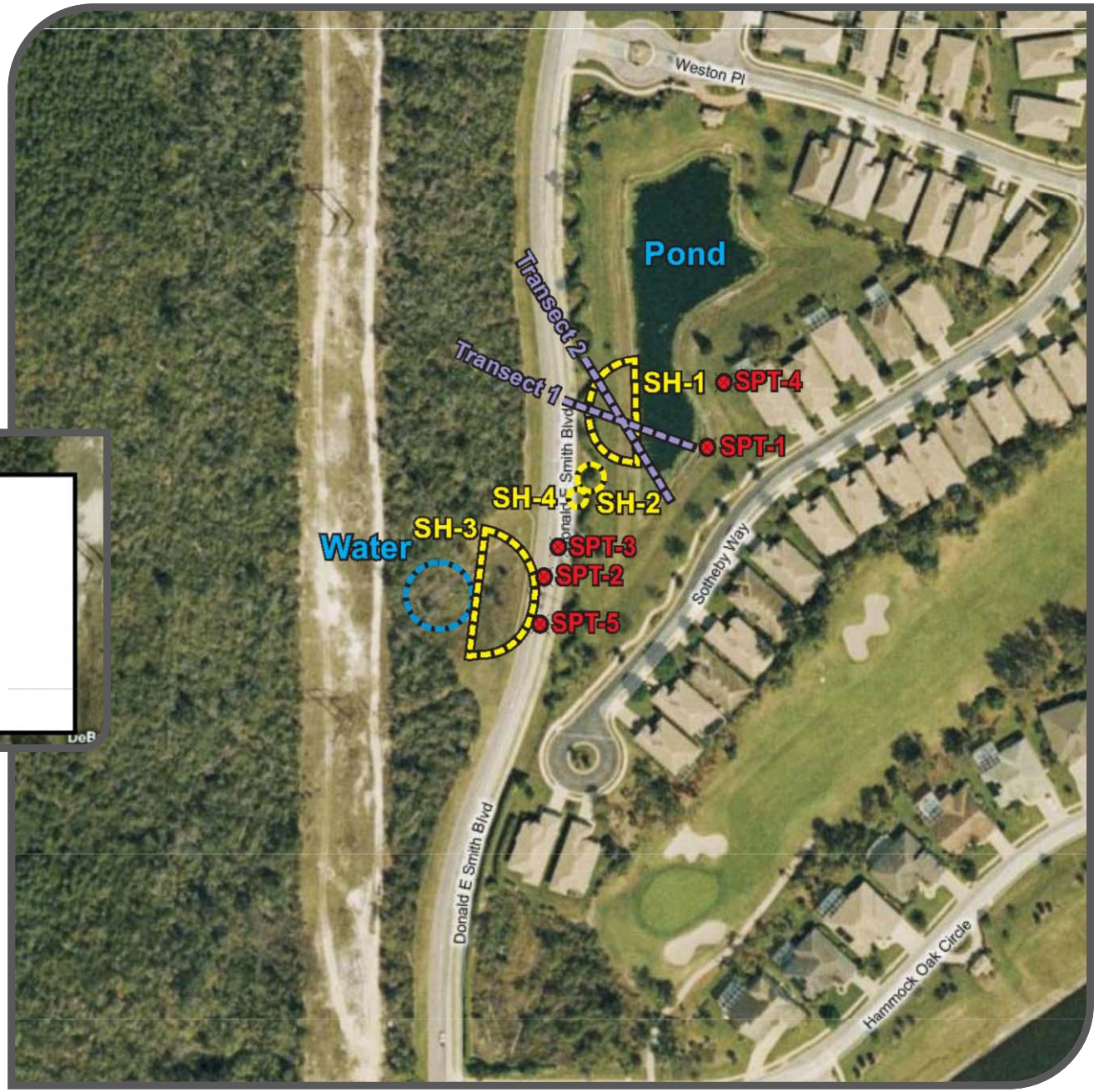
Donald E. Smith Blvd

Photo 3 of 7

Donald E. Smith Blvd

Photo 4 of 7

Donald E. Smith Blvd



LEGEND:

SPT-5	SPT Boring Locations
SH-1	Sinkhole #1
SH-2	Sinkhole #2
SH-3	Sinkhole #3
SH-4	Sinkhole #4

Photo 5 of 7

Donald E. Smith Blvd

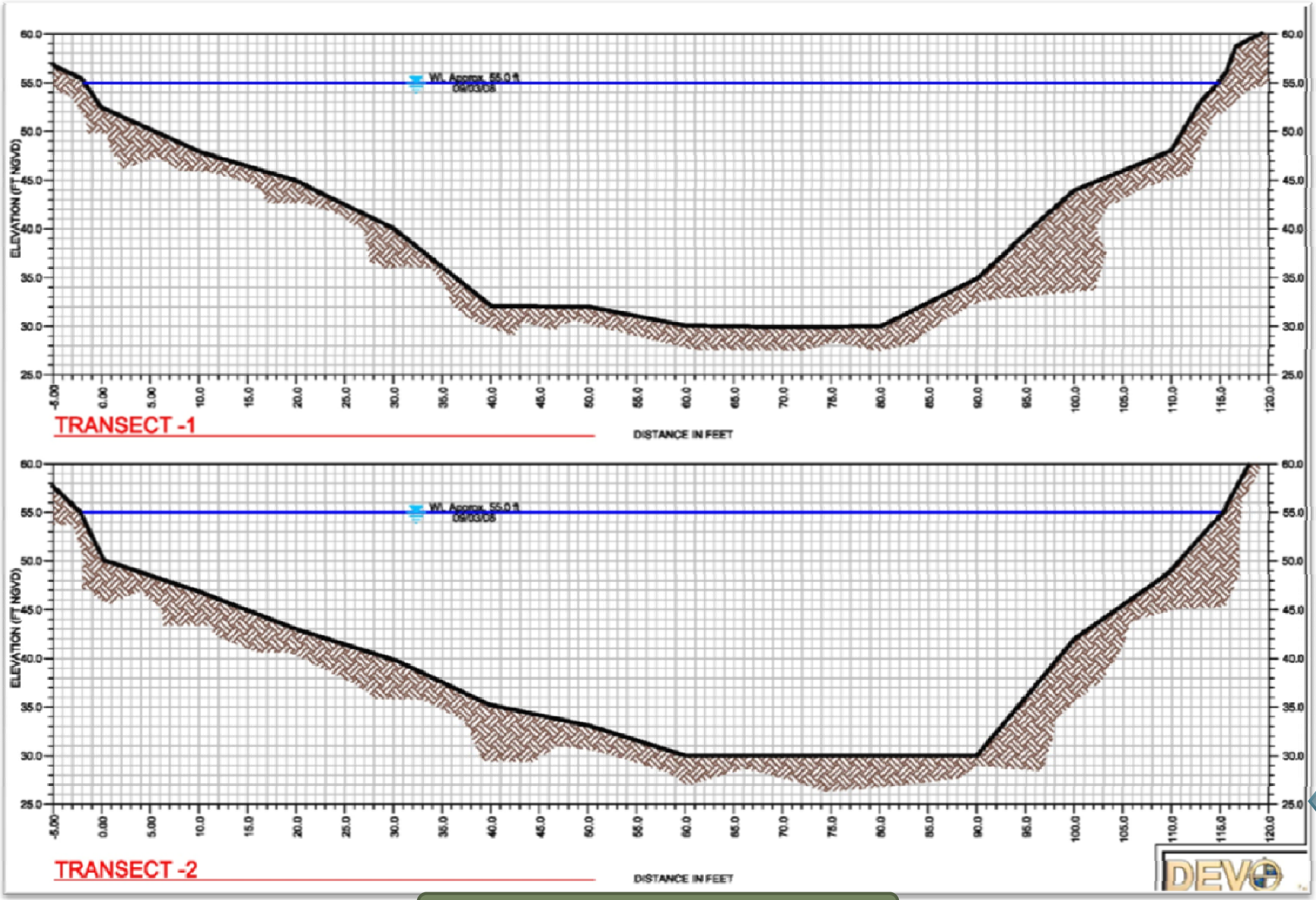
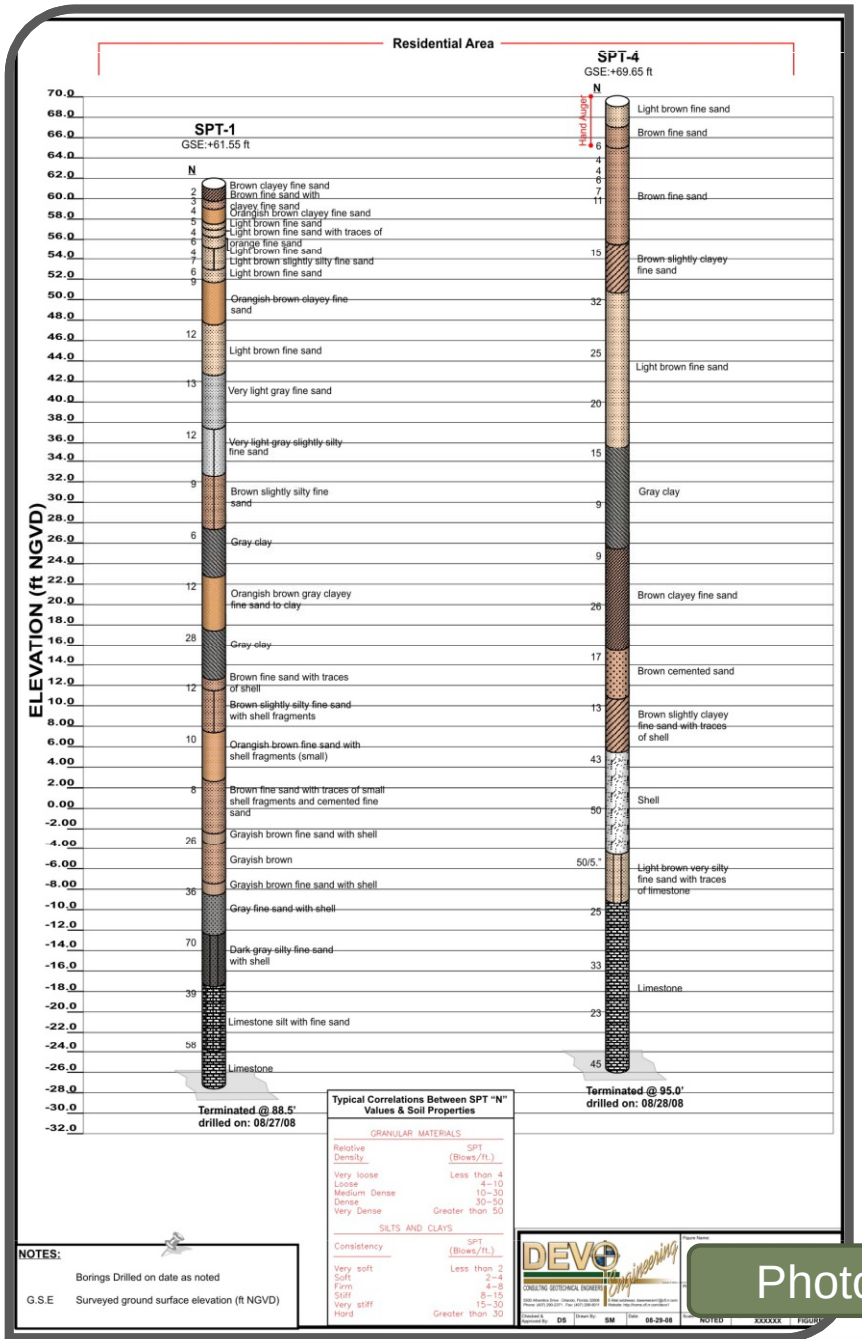


Photo 6 of 7

Donald E. Smith Blvd



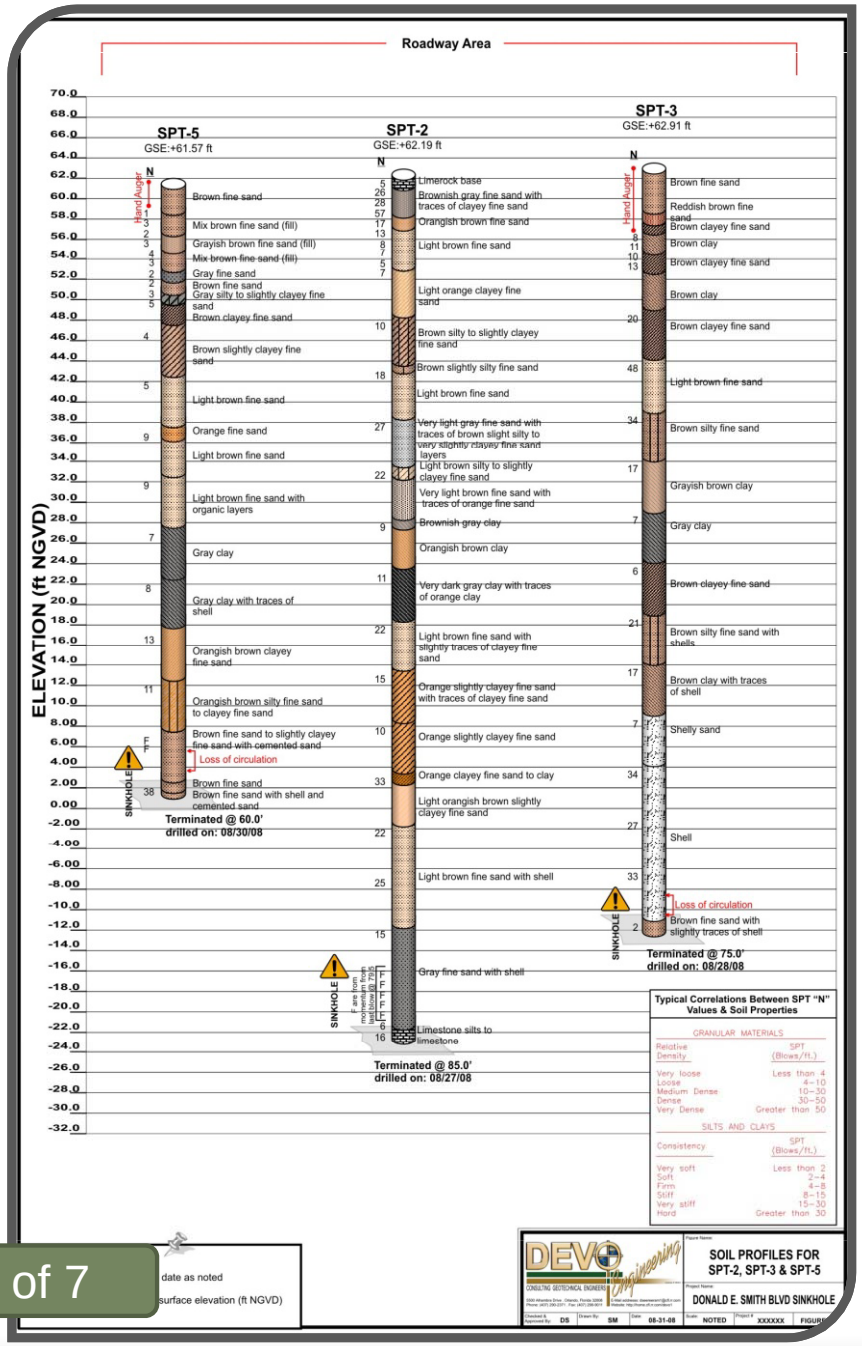


Photo 7 of 7

Fox Lake Drive Sinkholes - Rock Springs

Fox Lake Drive Sinkholes - Rock Springs

Photo 1 of 3

Fox Lake Drive Sinkholes - Rock Springs

Photo 2 of 3

Fox Lake Drive Sinkholes - Rock Springs

Photo 3 of 3

Integrated Court

Integrated Court

Photo 1 of 5

Integrated Court

Photo 2 of 5

Integrated Court

Photo 3 of 5

Integrated Court

Photo 4 of 5

Integrated Court

Photo 5 of 5

7

Pond Berms Failures

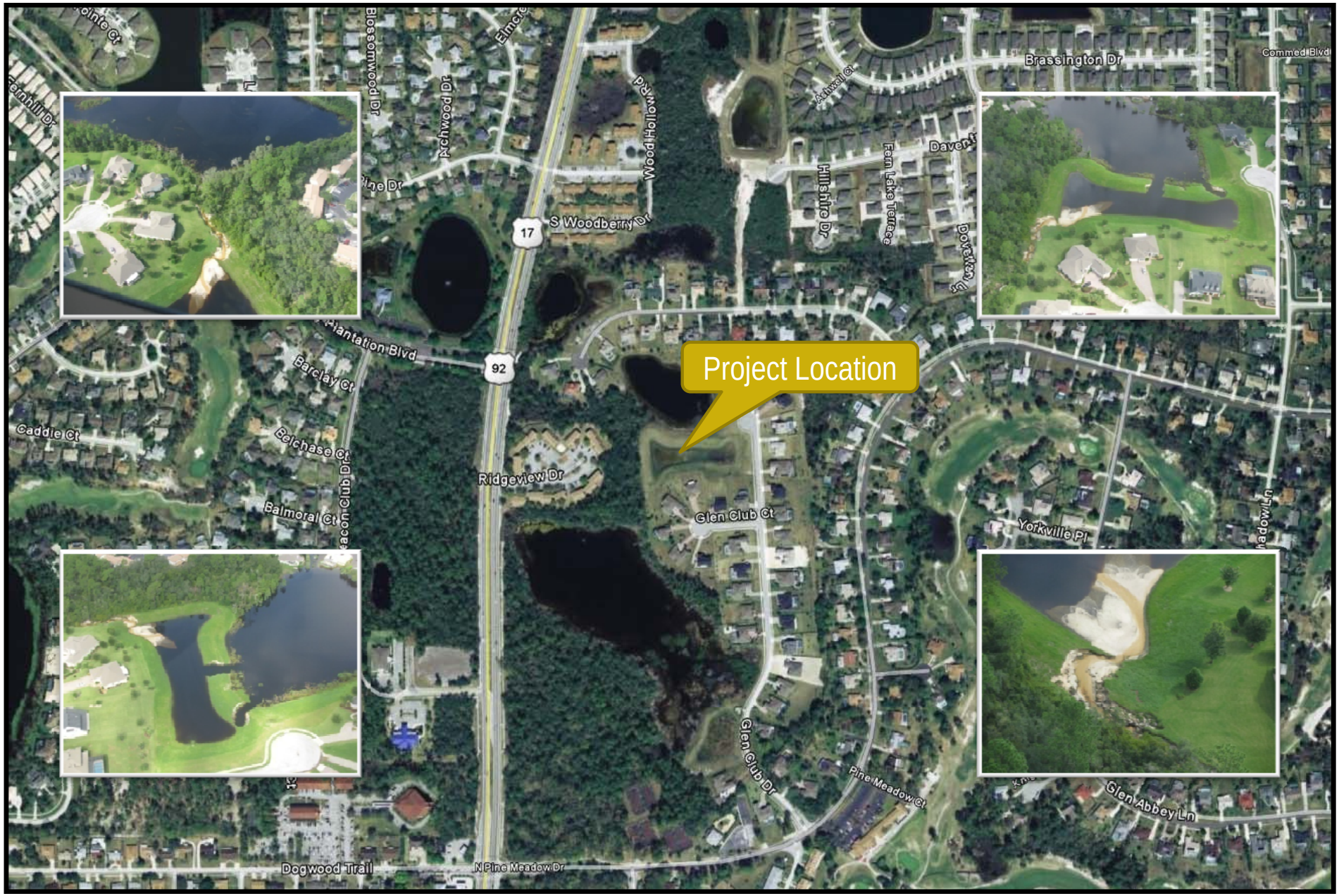
Pond Berms Failures

Miller Road Pond Outfall

Miller Road Pond Outfall

Photo 1 of 1

Glen Club Drive Pond Berm Failure



Glen Club Drive Pond Berm Failure

Photo 1 of 4

Glen Club Drive Pond Berm Failure

Photo 2 of 4

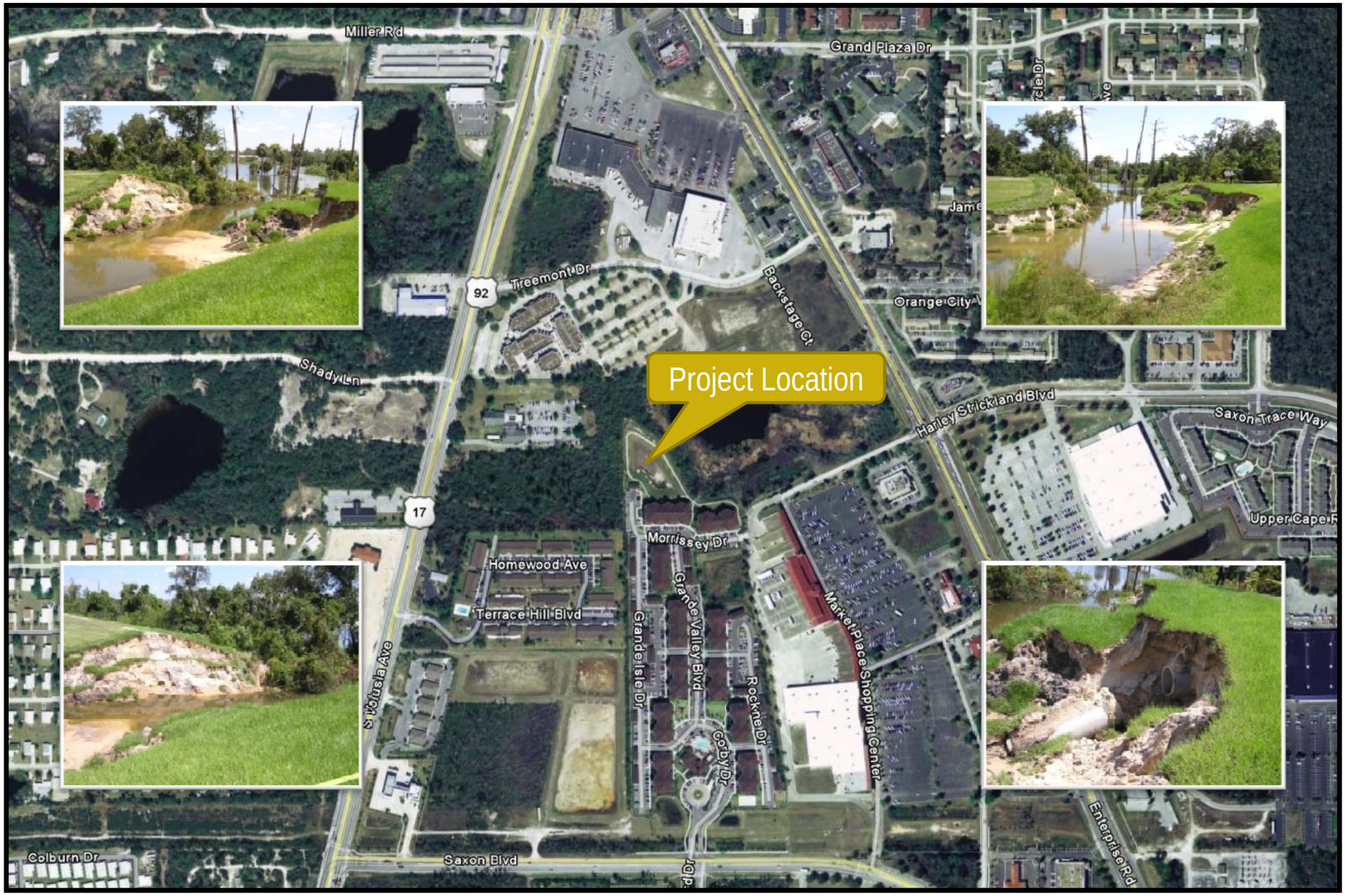
Glen Club Drive Pond Berm Failure

Photo 3 of 4

Glen Club Drive Pond Berm Failure

Photo 4 of 4

Grande Ville Apartments



Grande Ville Apartments

Photo 1 of 4

Grande Ville Apartments

Photo 2 of 4

Grande Ville Apartments

Photo 3 of 4

Grande Ville Apartments

Photo 4 of 4

Lowes Pond


Project Location
Saxon Trace Way
Enterprise Rd
Bloxham Ave
Threadgill Pl
Medical Center Dr
Veterans Memorial Pkwy
Broward Ave
Grande Valley Blvd

Lowes Pond

Photo 1 of 3

Lowes Pond

Photo 2 of 3

Lowes Pond

Photo 3 of 3

Saxon Trace Apartments

Saxon Trace Apartments

Photo 1 of 6

Saxon Trace Apartments

Photo 2 of 6

Saxon Trace Apartments

Photo 3 of 6

Saxon Trace Apartments

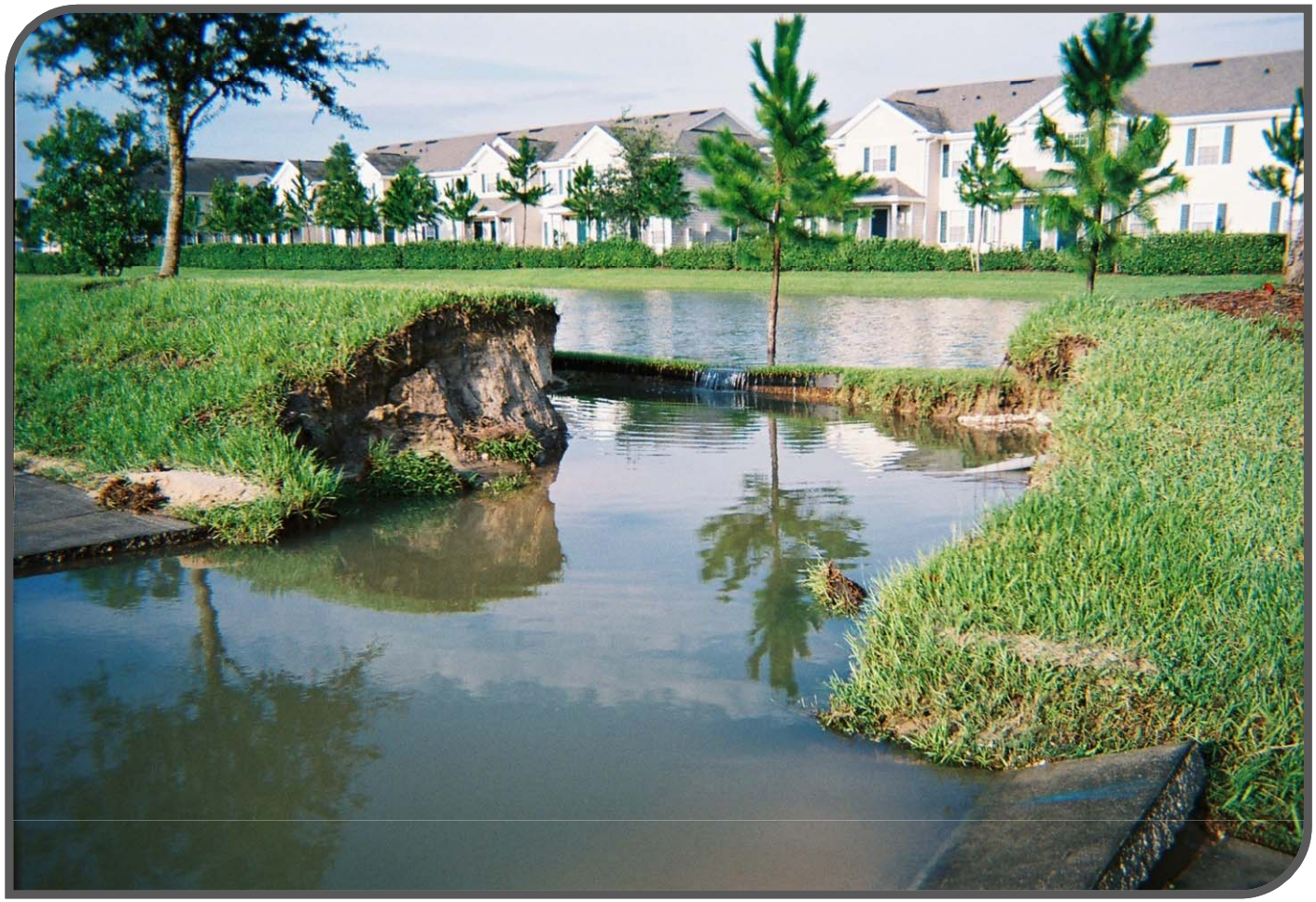


Photo 4 of 6

Saxon Trace Apartments

Photo 5 of 6

Saxon Trace Apartments

Photo 6 of 6

Saxon Woods


Project Location
Florence Blvd
Saxon Blvd
N Charles Richard Beall Blvd
Bittersweet Dr
Forest Ln
Tower Rd
Colburn Dr
Plantation Ave
Statler Ave
Buddy Ave
Claimont Ave
Bradwick Circle
Dartford Ct
Brassington Dr
Ashwell Ct
Daventry Dr
Hillshire Dr
Doveton Dr
Woodford Dr
Pine Valley Ct
N Pine Meadow Dr
Soft Shadow Ln
Wood Hollow Rd
Blossomwood Dr
Archwood Dr
Elmcrest Pl
92
17

Saxon Woods

Photo 1 of 3

Saxon Woods

Photo 2 of 3

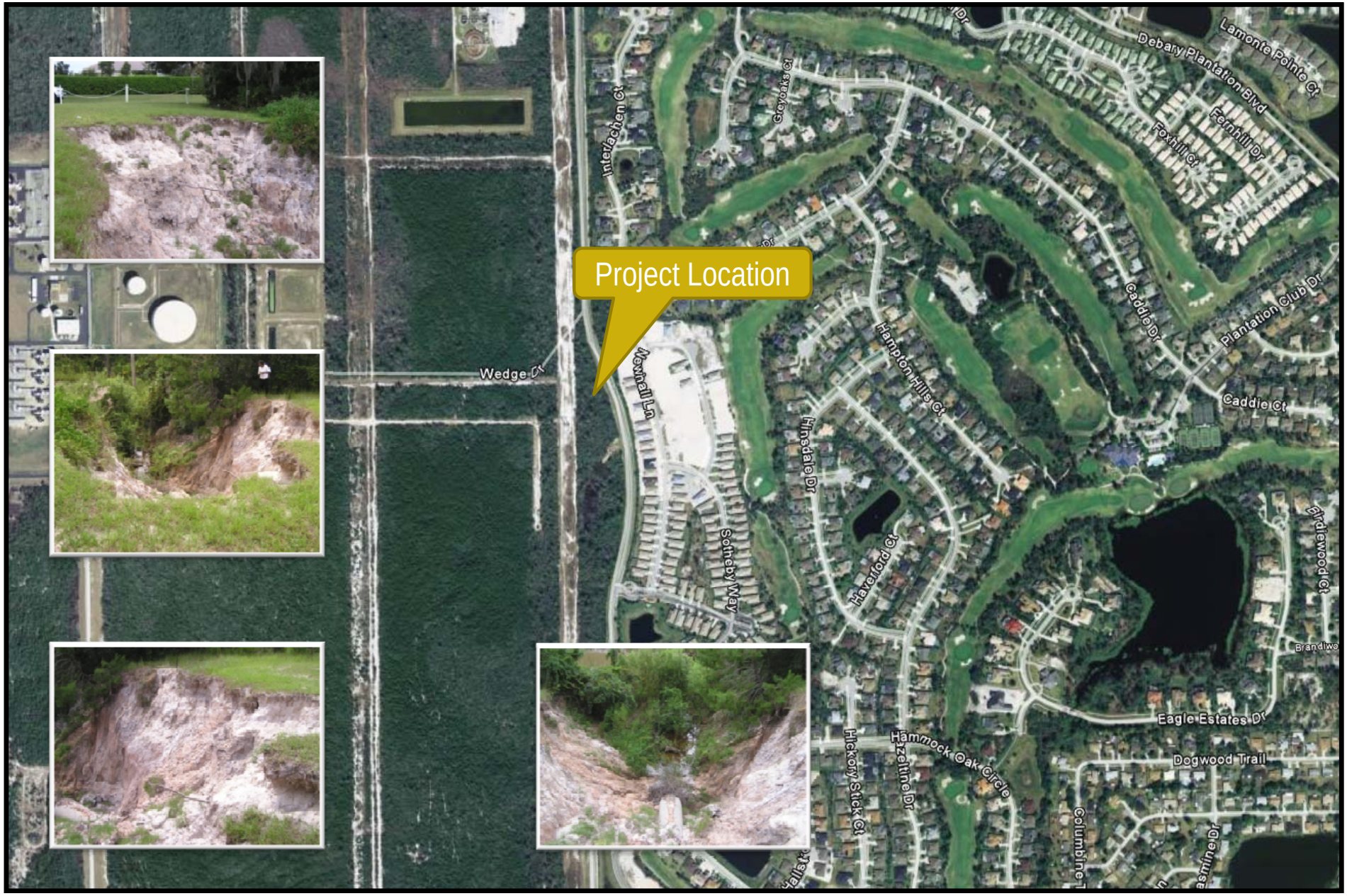
Saxon Woods

Photo 3 of 3

8

Erosional Washouts

Donald E. Smith Blvd



Donald E. Smith Blvd

Photo 1 of 4

Donald E. Smith Blvd

Photo 2 of 4

Donald E. Smith Blvd

Photo 3 of 4

Donald E. Smith Blvd

Photo 4 of 4

Lester Road Canal Improvements

Lester Road Canal Improvements

Photo 1 of 8

Lester Road Canal Improvements

Photo 2 of 8

Lester Road Canal Improvements

Photo 3 of 8

Lester Road Canal Improvements

Photo 4 of 8

Lester Road Canal Improvements

Photo 5 of 8

Lester Road Canal Improvements

Photo 6 of 8

Lester Road Canal Improvements

Photo 7 of 8

Lester Road Canal Improvements

Photo 8 of 8

Lester Road Canal Improvements

Table 1. Rainfall Data at Weather Station at SW Corner of Rock Springs Road and Welch Road Lat: N 28 ° 42 ' 17 " (28.705 °); Long: W 81 ° 30 ' 44 " (-81.512 °)		
Date	Rainfall (inches)	Tropical Storm Fay (inches)
August 20, 2008	0.79	17.4
August 21, 2008	7.28	
August 22, 2008	6.35	
August 23, 2008	2.98	

Hurricane Charley (total = 5.07 inches):

- Aug 13, 2004 = 5.07 inches

Hurricane Jeanne (total = 9.0 inches):

- Sept 26, 2004 = 9.0 inches

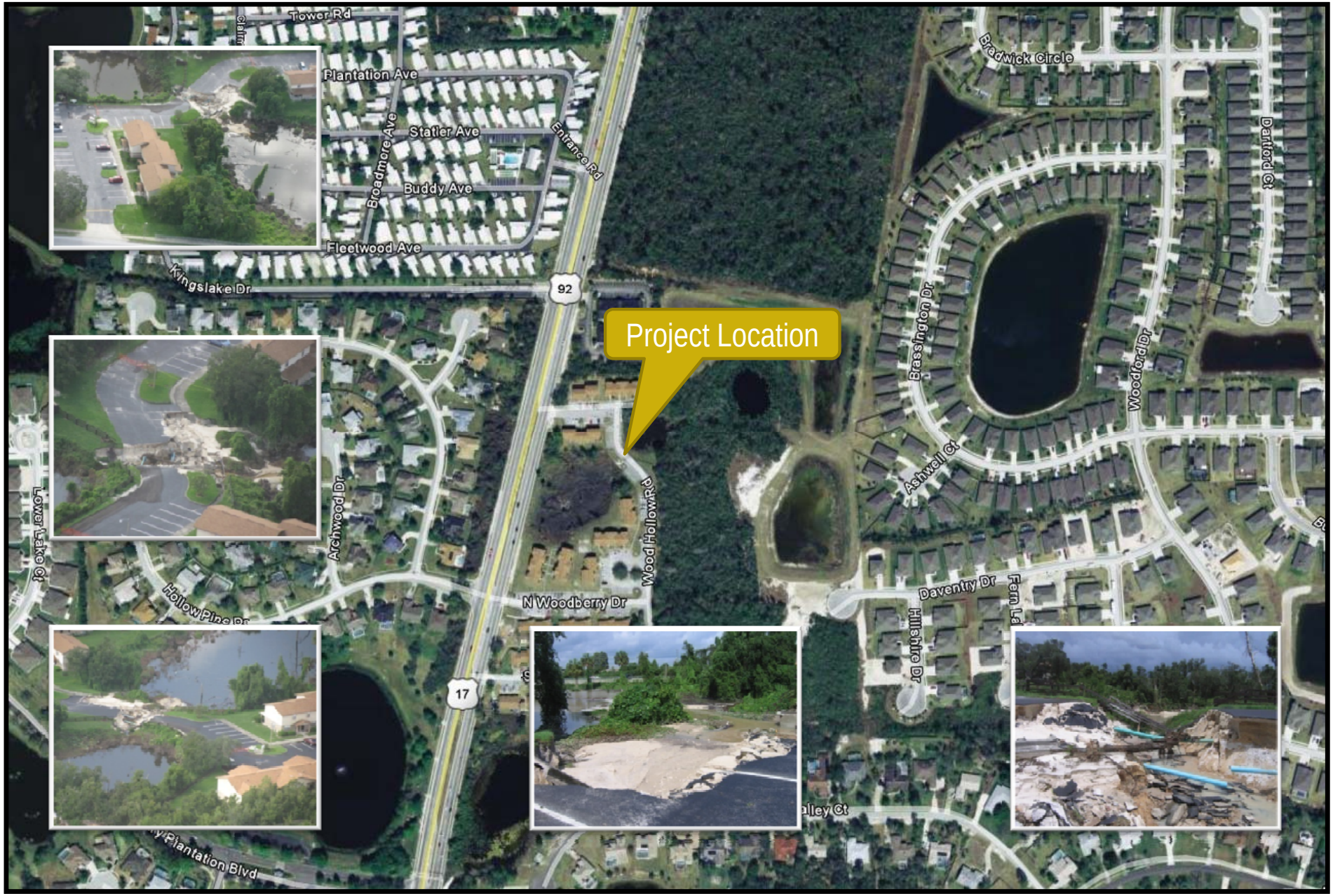
Hurricane Frances (total = 13.11 inches):

- Sept 4, 2004 = 1.05 inches
- Sept 5, 2004 = 9.59 inches
- Sept 6, 2004 = 2.47 inches

9

Failure of Conveyance Systems

Debary Villas



Debary Villas

Photo 1 of 5

Debary Villas

Photo 2 of 5

Debary Villas

Photo 3 of 5

Debary Villas

Photo 4 of 5

Debary Villas

Photo 5 of 5

10

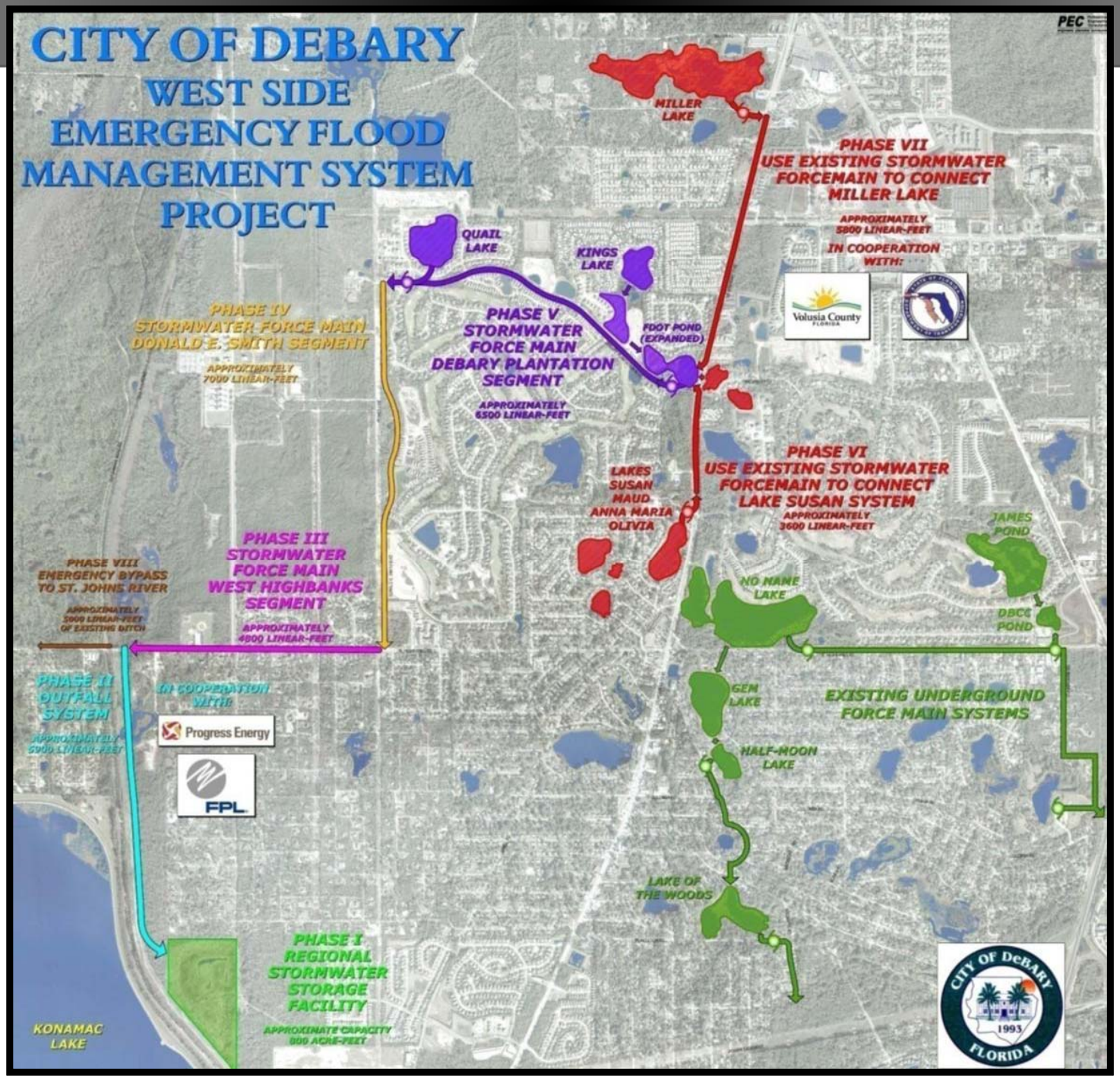
Lessons Learned and Future Direction

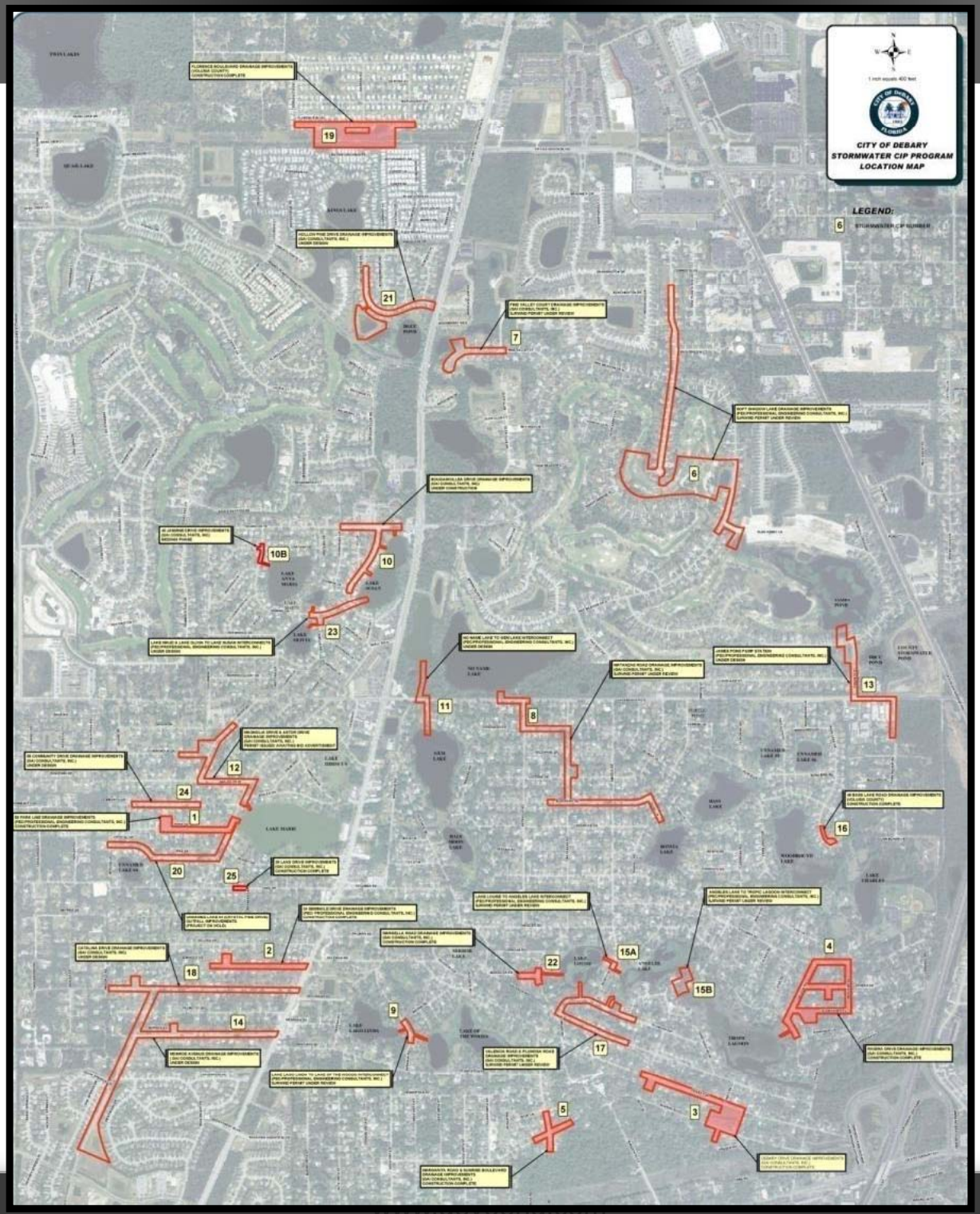
Technical Summary

1. The modes of stormwater pond berm failures were similar in all instances.
2. The pond slope failures were not due to conventional slope stability but overtopping and then washing out of the weak spot in the fill section.
3. The sinkhole collapses, as is typical, occurred when the surficial aquifer water level or pond head rose and aggravated internal erosion, exposing the buried karstic cavities. The Rock Springs Sinkholes were classic cover collapse features which we only see in thinly mantled karst.
4. A “dam breach” analysis is sometimes needed to assess impact to downstream conveyance systems which can potentially impact structures.

Technical Summary (continued)

5. In terms of regulations, water quantity storage in land-locked ponds - reiterate my earlier recommendation to regulate the FDOT 100 yr/10 day storms for these land-locked systems.
6. Properties at bottom of land-locked basin suffers most long-term impact; uphill ponds within the land-locked basins are only temporarily inconvenienced. All should share the burden, not just the land owner at the lowest point in the trough.
7. Urbanized areas with numerous land-locked basins are most susceptible to this type of damage and there is need for regional pumping system or revisiting drainage wells.


CITY OF DEBARY
WEST SIDE
EMERGENCY FLOOD
MANAGEMENT SYSTEM
PROJECT
PEC
MILLER LAKE
PHASE VII
USE EXISTING STORMWATER
FORCEMAIN TO CONNECT
MILLER LAKE
APPROXIMATELY
5800 LINEAR-FEET
IN COOPERATION
WITH:
Volusia County
FLORIDA
QUAIL LAKE
KINGS LAKE
FDOT POND
(EXPANDED)
PHASE IV
STORMWATER FORCE MAIN
DONALD E. SMITH SEGMENT
APPROXIMATELY
7000 LINEAR-FEET
PHASE V
STORMWATER
FORCE MAIN
DEBARY PLANTATION
SEGMENT
APPROXIMATELY
6500 LINEAR-FEET
PHASE VI
USE EXISTING STORMWATER
FORCEMAIN TO CONNECT
LAKE SUSAN SYSTEM
APPROXIMATELY
3600 LINEAR-FEET
LAKES
SUSAN
MAUD
ANNA MARIA
OLIVIA
JAMES
POND
NO NAME
LAKE
DBCC
POND
PHASE VIII
EMERGENCY BYPASS
TO ST. JOHNS RIVER
APPROXIMATELY
5000 LINEAR-FEET
OF EXISTING DITCH
PHASE III
STORMWATER
FORCE MAIN
WEST HIGHBANKS
SEGMENT
APPROXIMATELY
4800 LINEAR-FEET
PHASE II
OUTFALL
SYSTEM
APPROXIMATELY
6900 LINEAR-FEET
IN COOPERATION
WITH:
Progress Energy
FPL
GEM
LAKE
EXISTING UNDERGROUND
FORCE MAIN SYSTEMS
HALF-MOON
LAKE
LAKE OF
THE WOODS
PHASE I
REGIONAL
STORMWATER
STORAGE
FACILITY
APPROXIMATE CAPACITY
800 ACRE-FEET
KONAMAC
LAKE
CITY OF DEBARY
1993
FLORIDA


CITY OF DEBARY
STORMWATER CIP PROGRAM
LOCATION MAP
LEGEND:
6 STORMWATER CIP NUMBER
19
21
7
6
10B
10
23
11
8
13
12
24
1
16
20
25
2
18
22
15A
15B
4
14
9
17
5
3