



# Canary in a Rainstorm - Flood Risk Mitigation in Pinellas County

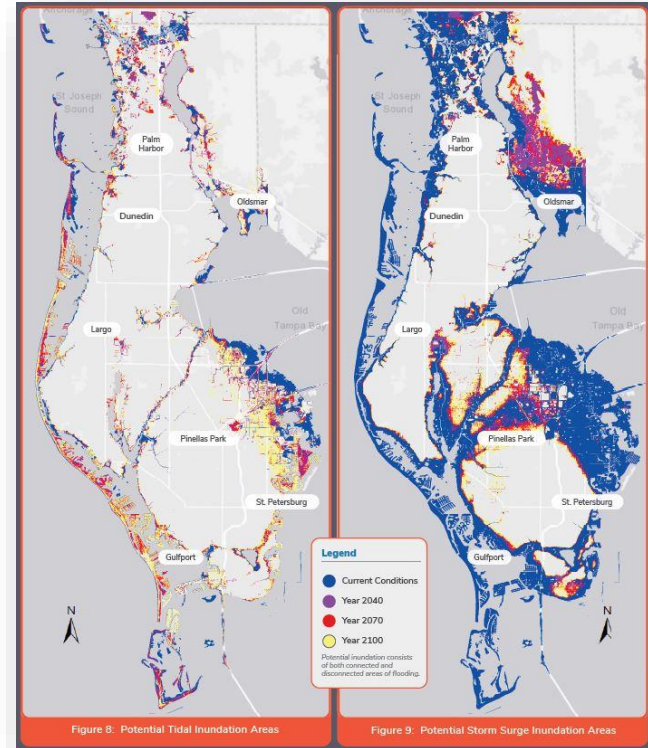
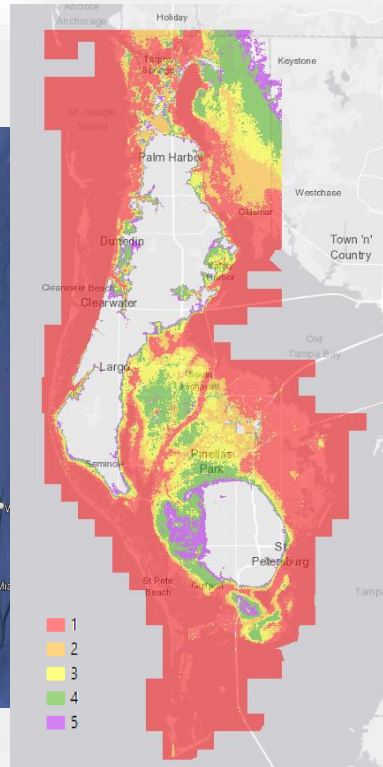
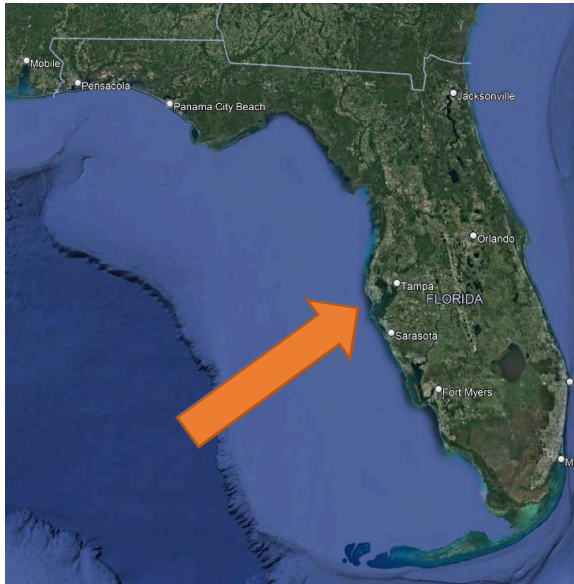
Lisa Foster, CFM, Pinellas County Floodplain Administrator

Paul Miselis, PE, CFM, ENV SP, Land & Water Engineering Science

Kent Boulicault, PE, Singhofen & Associates, Inc.



# Pinellas County



# Pinellas County

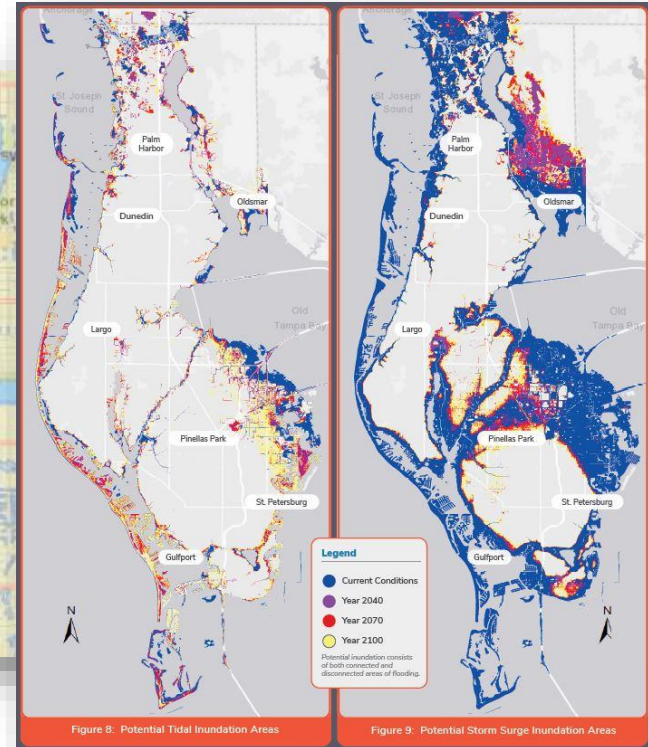
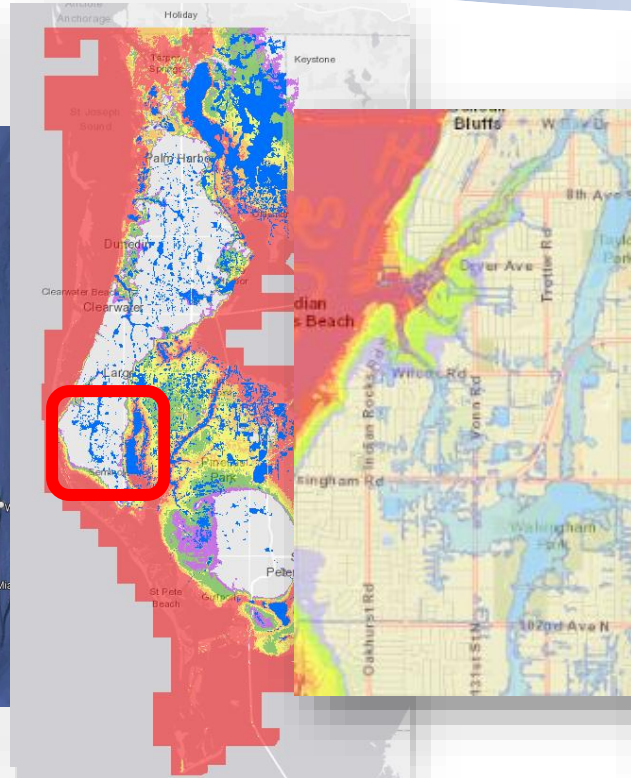
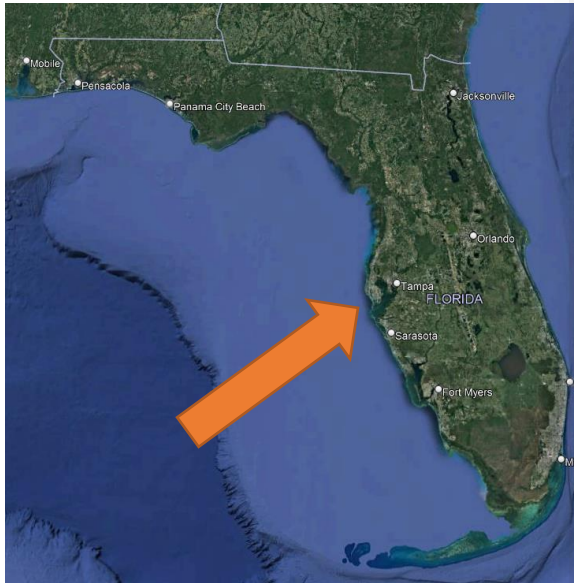


Figure 8: Potential Tidal Inundation Areas

Figure 9: Potential Storm Surge Inundation Areas



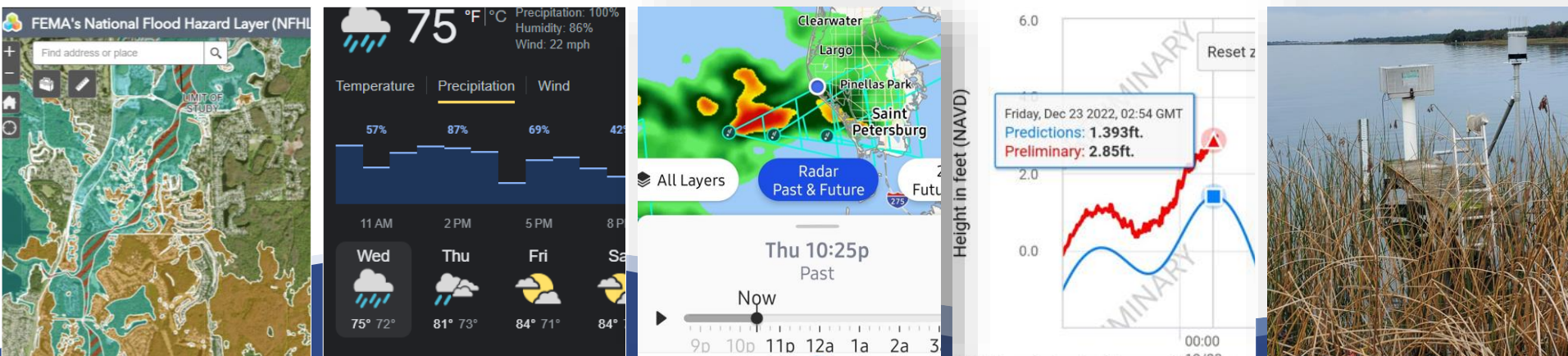
**Rain is on the way**



# Maps, Forecasts & Data



## Now What???



# Flood Warning Notifications



## When?? Where?? How??



### Brooker Creek USGS Gage reading

Public Information from Pinellas County Government · 30 Aug

4

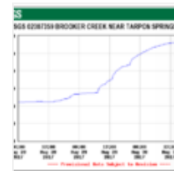
Dear Tarpon Woods Residents-

As of 3 p.m., the water level of Brooker Creek is at 11.83 feet according to USGS Gage 02307359, which is located in the Tarpon Woods neighborhood. Water levels in Brooker Creek are elevated after approximately 6 inches of rain over the last two days. Water levels appear to be cresting, as indicated in the attached plot diagram, and drier weather is forecast with a 20-30% probability of rain through Thursday. Based on past observations, the Tarpon Woods neighborhood becomes susceptible to street flooding at stages above 12.2 feet, with some roads impassable. Based on current gage trends, flooding does not appear imminent, but residents should be vigilant and monitor the weather and gage levels, especially in the event of additional heavy rainfall.

Pinellas County Public Works

Edited 30 Aug · Posted Aug 30, 2017 · Subscribers of Pinellas County Government in 1 neighborhood in Crime Safety

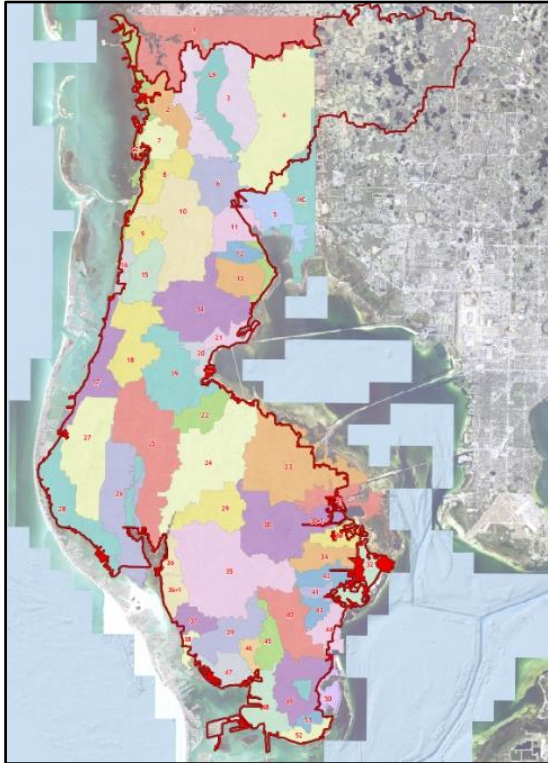
THANK | E | REPLY





# Flood Forecasting Tools

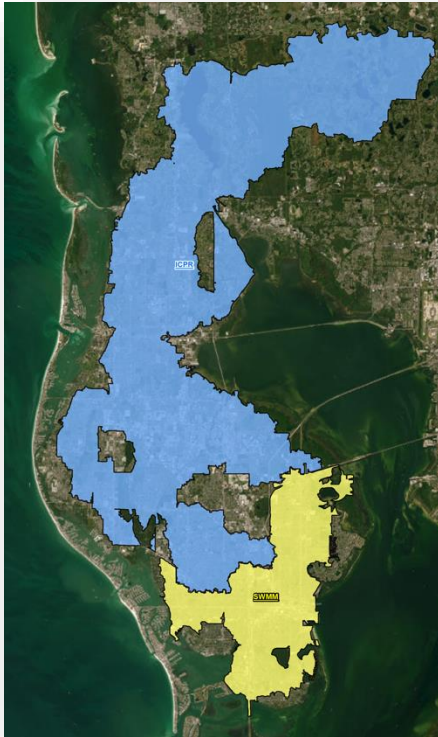
# Countywide Model Development



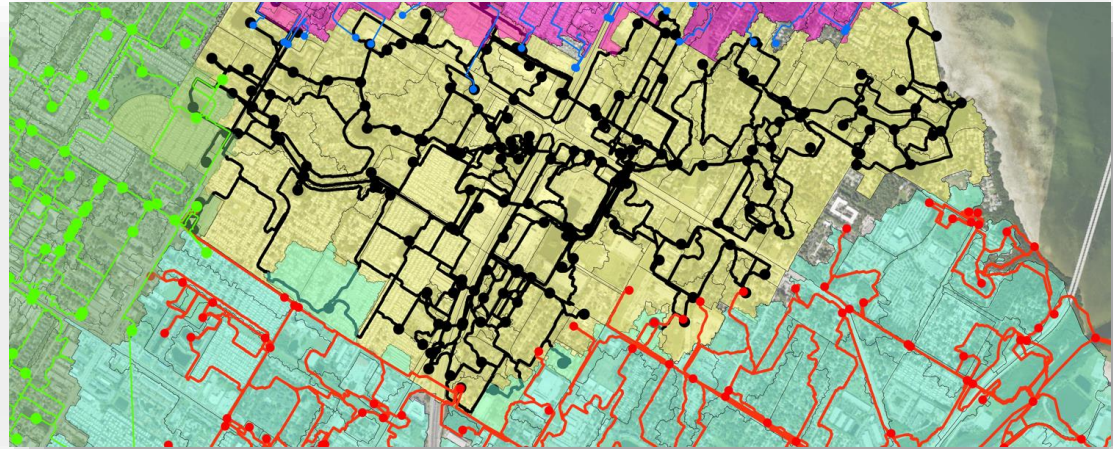
- **270 mi<sup>2</sup>**
- **52 watersheds**
- **Modeled: 206 mi<sup>2</sup>** (extends outside county)
  - **14 ICPR models**
  - **15 SWMM models**
- **Unmodeled: 78 mi<sup>2</sup>**



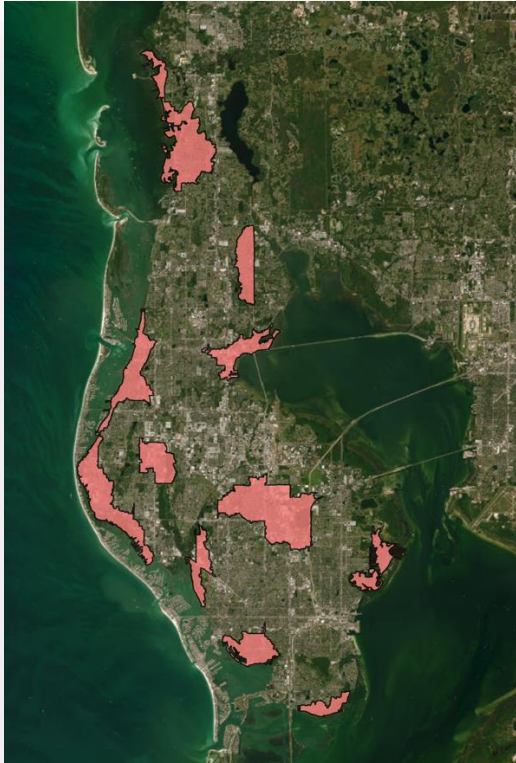
# Existing Watershed Models



- **ICPR and SWMM**
  - St. Pete was developing citywide in ICPR
- **Gaps and Overlaps – Addressed in GIS**



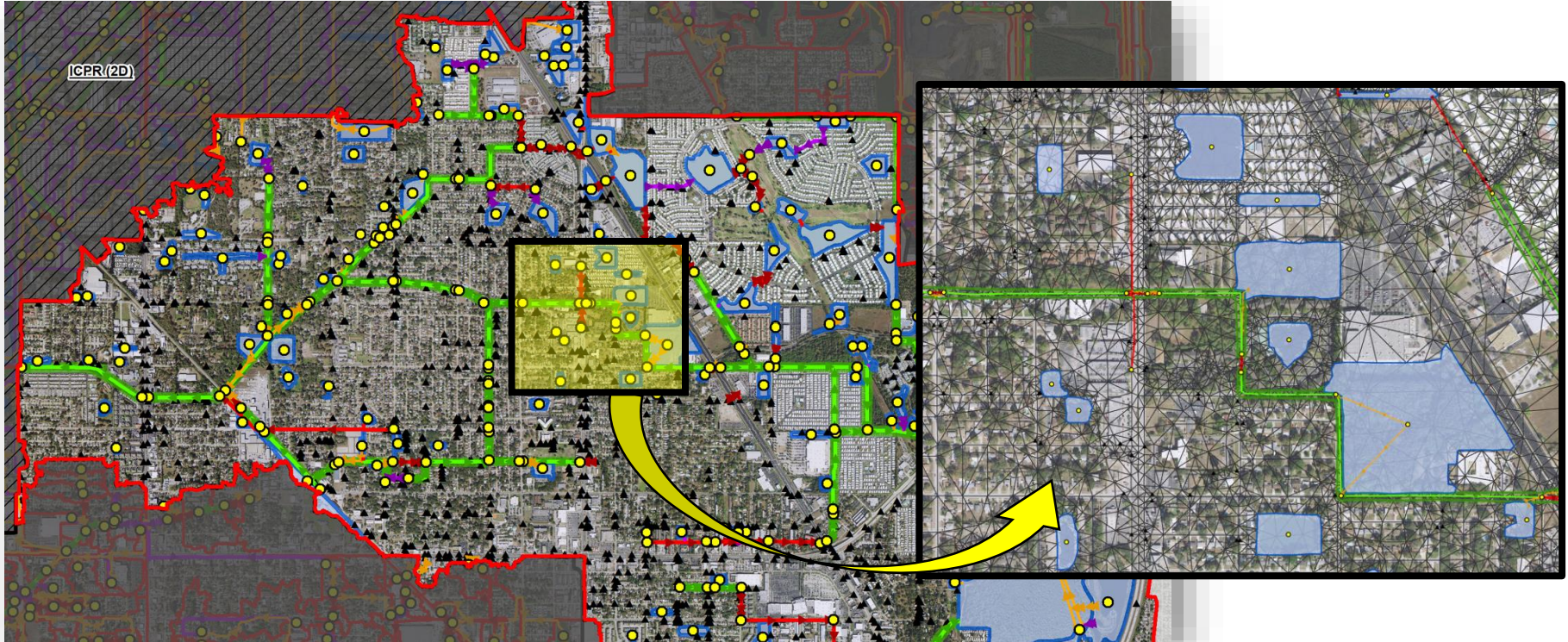
# Unmodeled Areas



- **Rapid Flood Hazard Assessment Approach**
  - **2D Features**
  - **Used road centerlines to breaklines roads**
- **Modified to make more robust**
  - **Initial floodplain review**
  - **Added major channel features (1D)**
  - **Added pipes (major xings; from infrastructure)**
  - **Added interpolated breaklines (swales & side drains)**
  - **Added ponds and assumed outfalls**
  - **Weirs to ponds at roadway sags**



# RFHA Approach



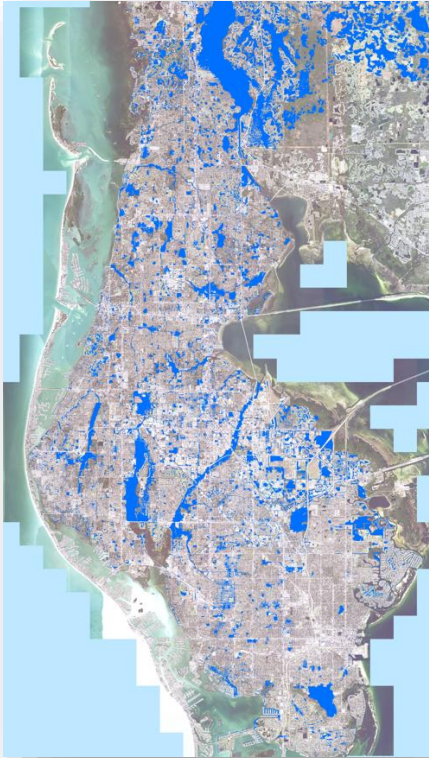
# Simulations



Return Period and Duration	FLMOD Rainfall Distribution				FDOT Rainfall Distribution												SWFWMD Rainfall Distribution				
	Simulation	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
<b>Storm Return Period</b>																					
25	X				X	X							X				X				
50		X					X	X						X				X			
100			X						X	X					X				X		
500				X							X	X				X					X
<b>Storm Duration</b>																					
4-Hours					X		X		X		X										
24-Hours	X	X	X	X									X	X	X	X					
3-Days						X		X		X		X									
5-Days (SWF)																	X	X	X	X	



# Countywide Inundation Maps

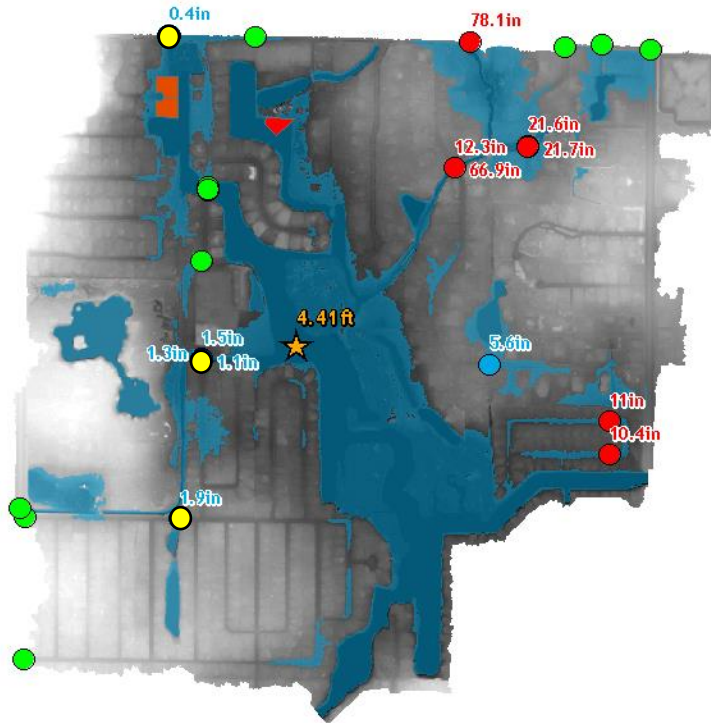


- **Level-pool floodplains**





# Flood Risk Identification



- Risk Points

- Symbolization

● = No Flooding

● = Less than 3" Flooding

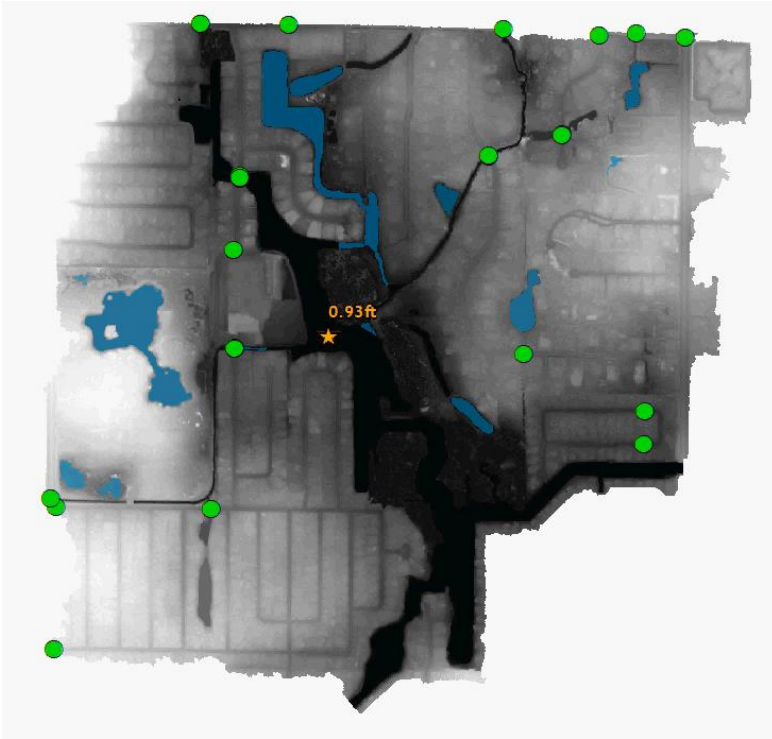
● = Greater than 3" but less than 6"





● = Greater than 6"

- Flood Depths

- Gage locations and stage

# Flood Risk Identification



- **Risk Points**
- **Symbolization**
  -  = No Flooding
  -  = Less than 3" Flooding
  -  = Greater than 3" but less than 6"
  -  = Greater than 6"
- **Flood Depths**
- **Gage locations and stage**
- **Animations**



# Stream Gauge Monitoring

# Standard Operating Guidelines (SOG)



## Develop standard operating guidelines

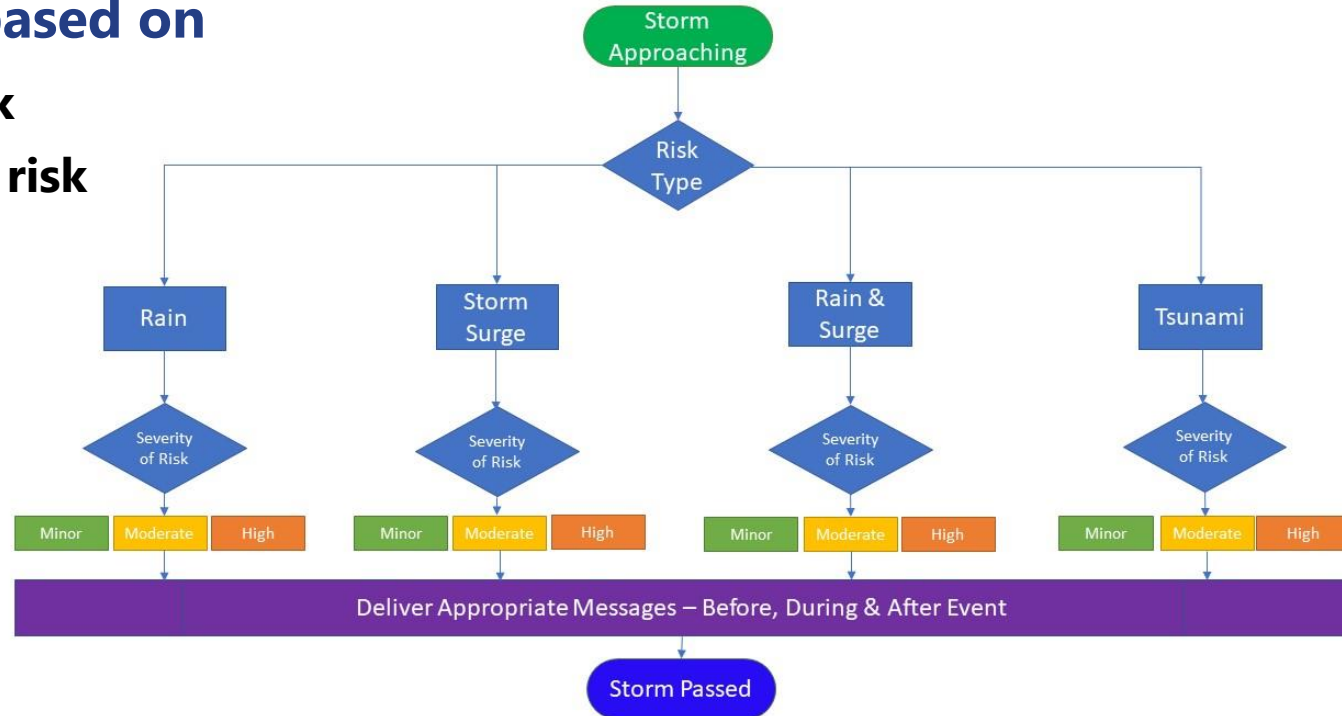
- **Public safety is paramount**
- **Easily understandable SOG for use by anyone**
- **Consistent methodology**
- **Consistent and timely public notifications**
- **Targeted notifications at neighborhood level**
- **Before, during and after the storm**

# Flood Warning & Response Toolkit



- Responses based on

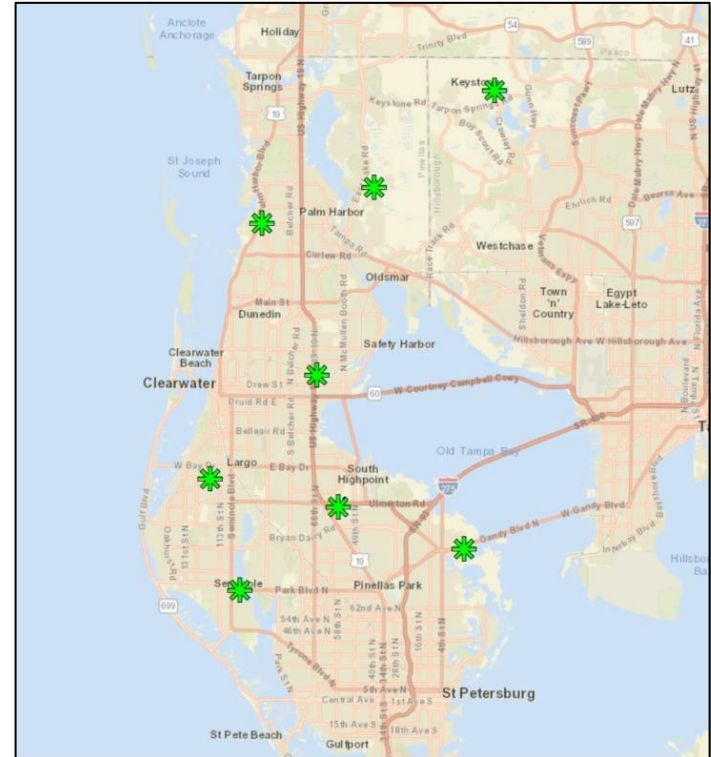
- Type of risk
- Severity of risk





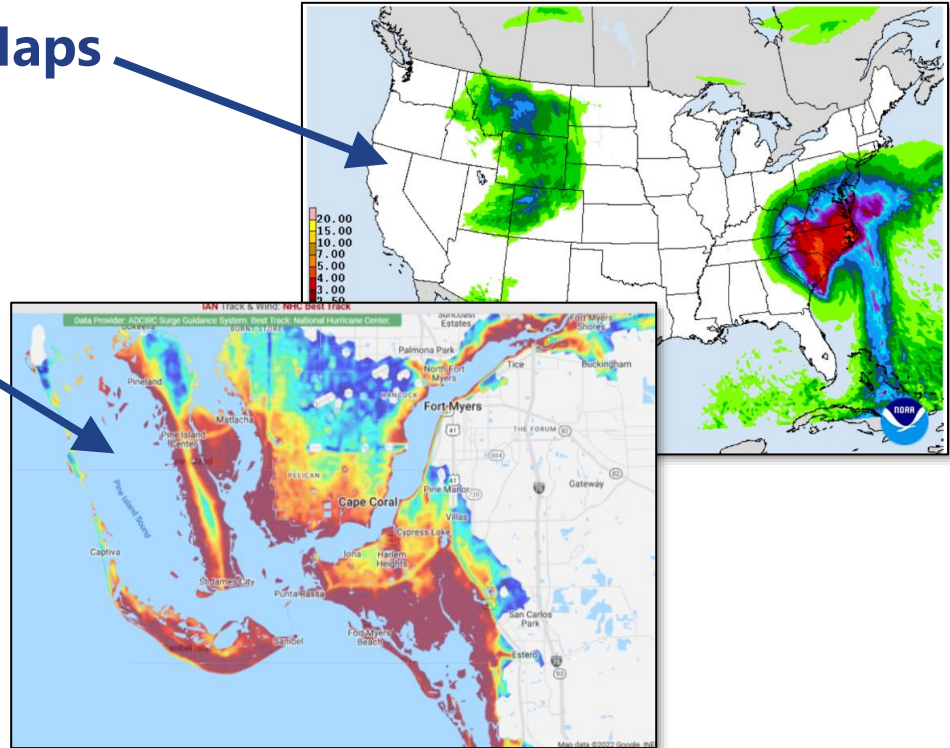
# Key Flood Monitoring Areas

- **Assess current & forecast conditions**
- **Consult SOG**
- **Coordinate with PIO**
- **Issue appropriate local notices**



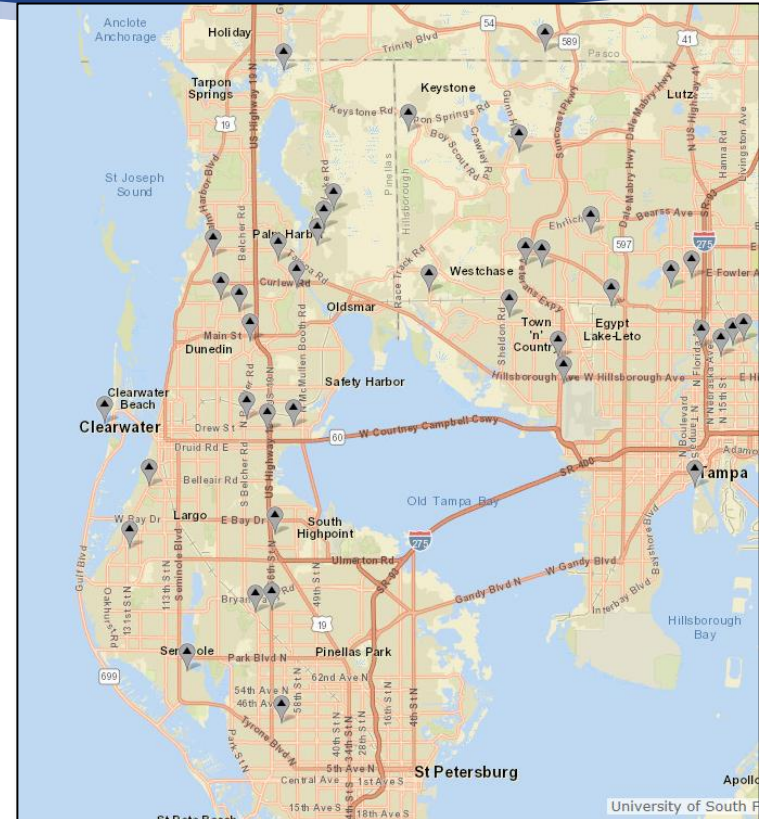
# Data to Inform Decisions

- Rainfall forecasts & QPF Maps
- Flood forecasting tool
- National Hurricane Center
- Storm surge forecasts
- Stream and lake levels
- SWFWMD Structures Dashboard
- NOAA Tides & Currents



# Gauges to Inform Messages

- **Stream water levels**
  - **Current stage**
  - **Trends**
- **Lake levels**
- **Tide gauges**
- **Rainfall**
  - **Measured**
  - **Anticipated (from other sources)**



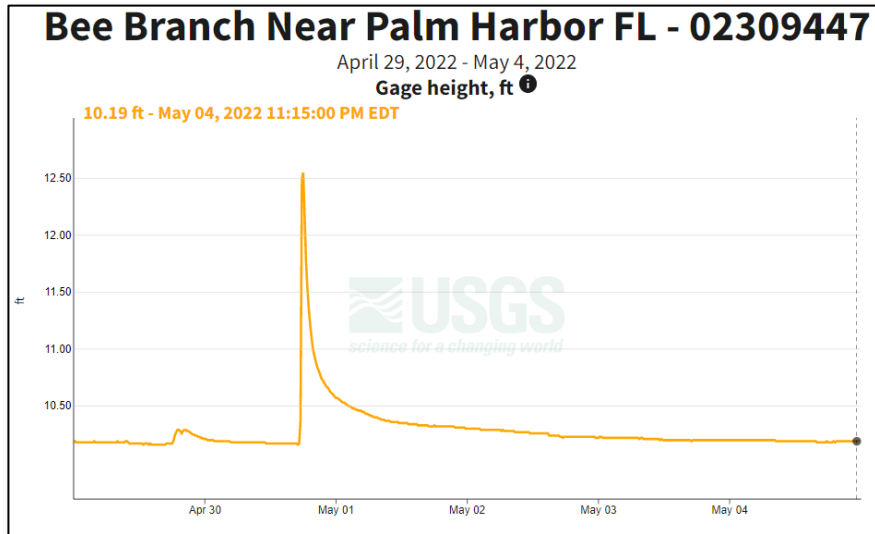
# Lake Level Control Structures

- Taylor Lake gates
- Lake Seminole gates
- Keystone Chain of Lakes  
SWFWMD gates

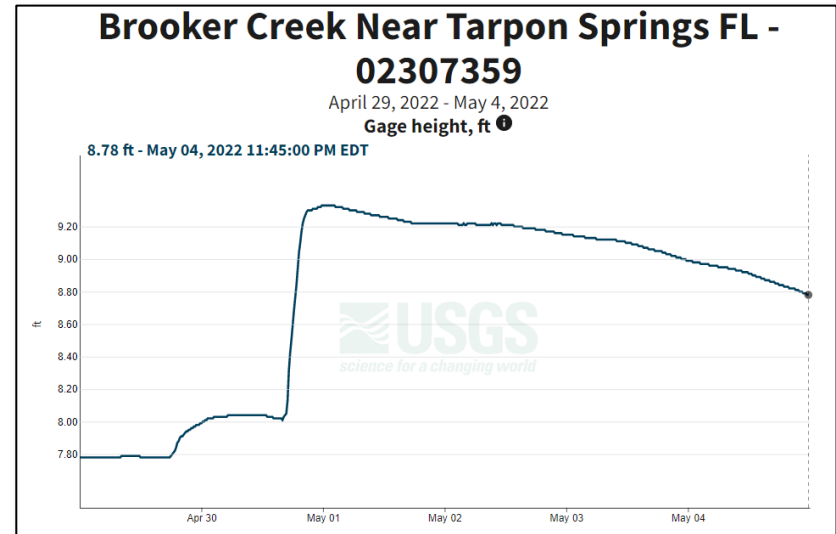


# Not all Gauges are Useful

- Urban stream response vs. natural stream response



Urban Character → Fast Response



Rural Character → Slow Response



# Generalized Storm Severity



Minor Hazard

$\leq 7''$  rainfall  $\rightarrow$  isolated ponding of water

Moderate Hazard

7" to 9" rainfall  $\rightarrow$  localized flooding in low-lying areas

High Hazard

$> 9''$  rainfall  $\rightarrow$  widespread flooding

# Response & Action Types



- **Public Works Department to:**
  - **Storm prep – Clear channels**
  - **Lower lake levels – May take several days to do**
  - **Deploy high water signage**
  - **Stage / start / stop pumps**
  - **Move equipment out of flood zones**
  - **Post-storm recovery**
- **Coordinate with SWFWMD, Hillsborough County & others**
- **Issue public notices in coordination with Emergency Management & PIO**

# Example Scenario – Cross Bayou



<b>Stage (Feet, NAVD88)</b>	<b>Moderate Hazard (e.g., 7" to 9" rainfall, localized flooding in low-lying areas, or storm surge from 3 to 4 feet)</b>
~2.5 feet	<ul style="list-style-type: none"> <li>If gauge is rising and expecting more rain or if king tide is expected to exceed 2.5 feet:</li> <li>Alert EM / Communications / residents of possible development of flood conditions.</li> </ul>
3.0 to 4.0 feet	<ul style="list-style-type: none"> <li>If rainfall is increasing or anticipated to continue, or if tides are expected to exceed ~4.0 feet:</li> <li>Consider starting evacuations in Mariners Cove.</li> </ul>
4.0 feet	<ul style="list-style-type: none"> <li>Evacuations ongoing</li> </ul>
~4.5 to 5.0 feet	<ul style="list-style-type: none"> <li>Mariners Cover evacuation should be nearing completion.</li> </ul>
5.5 feet	<ul style="list-style-type: none"> <li>If rainfall is increasing or anticipated to continue, or if tides / storm surge are expected to exceed ~5.5 feet:</li> <li>Alert EM, Communications and residents / property owners along Cross Bayou of possible development of flood conditions.</li> </ul>
7.1 feet to 7.4 feet	<ul style="list-style-type: none"> <li>Broader Countywide flood messaging will be needed.</li> </ul>

# Example Scenario – Cross Bayou

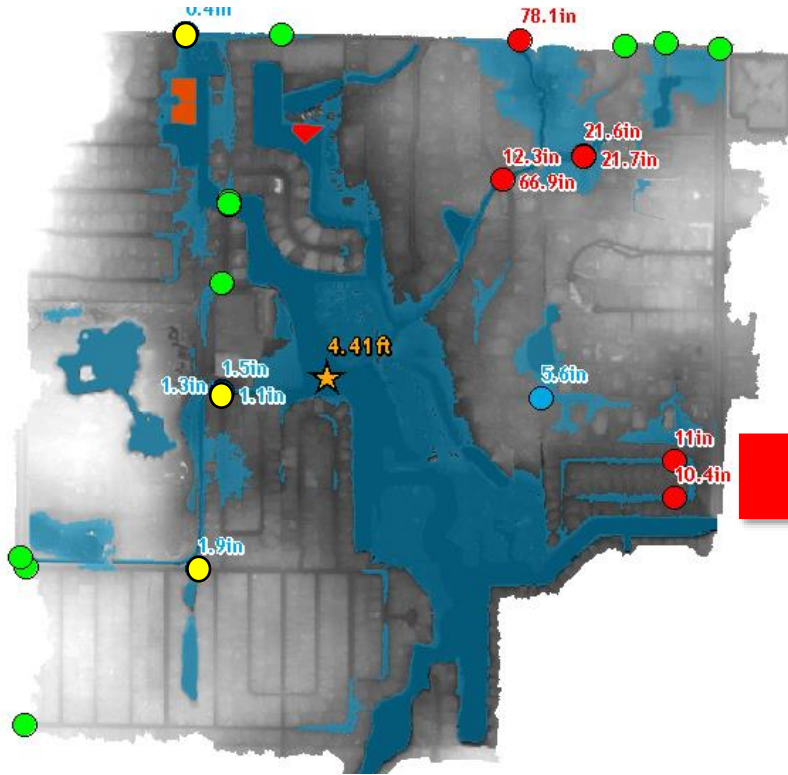


Stage (Feet, NAVD88)	(e.g.,		ing areas, or storm surge
~2.5 feet	<ul style="list-style-type: none"> <li>If g</li> <li>ex</li> <li>• Ale</li> <li>co</li> </ul>		<p>ng tide is expected to</p> <p>the development of flood</p>
3.0 to 4.0 feet	<ul style="list-style-type: none"> <li>• If r</li> <li>ex</li> <li>• Co</li> </ul>		<p>or if tides are expected to</p>
4.0 feet	<ul style="list-style-type: none"> <li>• Ev</li> </ul>		
~4.5 to 5.0 feet	<ul style="list-style-type: none"> <li>• Ma</li> </ul>		<p>ompletion.</p>
5.5 feet	<ul style="list-style-type: none"> <li>• If</li> <li>ex</li> <li>• Ale</li> <li>• Ba</li> </ul>		<p>or if tides / storm surge are</p> <p>erty owners along Cross</p> <p>ns.</p>
7.1 feet to 7.4 feet	<ul style="list-style-type: none"> <li>• Br</li> </ul>		<p>eded.</p>



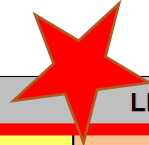
# Summary

# Forecast + Maps to Action




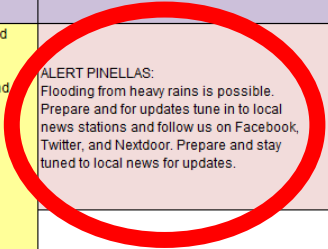


# Flood Notifications



FLOOD HAZARD	LEVEL OF RISK OR IMPACT EXPECTED		
	Minor - Expected Roadway and Yard Flooding	Moderate - Expected Structure Flooding	High - Expected Evacuation / Life Threat
<b>Above Normal Tides / Surge Flooding</b>	Up to Three Feet (<3 ft) of Tides / Surge Predicted Coastal Flood Advisory Issued Roadway / Yard Flooding Possible <b>EXAMPLE: Strong Cold Front (April 18, 2019) with Minor Coastal Road Flooding</b>	Over Three Feet (3+ ft) of Tides / Surge Predicted Storm Surge Watch Issued / Coastal Flood Watch Issued Isolated Evacuations Possible Community Shelters On Standby / Open <b>EXAMPLE: Hurricane Hermine (2016), Community Shelters Opened</b>	Life Threatening Tides / Surge Predicted Storm Surge Warning Issued / Coastal Flood Warning Issued Mandatory Evacuations Expected Due to Tides / Surge Multiple Shelters Opened <b>EXAMPLE: Hurricane Irma (2017), Mandatory Evacu</b>
<b>Extended / Heavy Rainfall Flooding</b>	Flash Flood Watch / Flood Watch Issued No Significant Overflow of Waterways Expected Few to No Evacuations Expected <b>EXAMPLE: Area of Rain with 2" - 4" expected, with isolated ponding of water.</b>	Flash Flood Warnings / Flood Warnings Issued Expected Overflow of Some Waterways Possible Evacuation and Sheltering of Some Residents (Tens to Hundreds) <b>EXAMPLE: Tropical Storm Debby (2012), Tarpon Woods and Mariner's Cover Severely Flooded. One Community Shelter Opened in Pinellas County.</b>	Flash Flood Warnings / Flood Warnings Issued Expected Overflow of Numerous Waterways Expected Evacuation and Sheltering of Residents (Hund <b>EXAMPLE: Hurricane Harvey (2017), Widespread Lif</b>
<b>Extended / Heavy Rainfall AND Above Normal Tide / Surge Flooding</b>	Up to Three Feet (<3 ft) of Tides / Surge Predicted Coastal Flood Advisory Issued Roadway / Yard Flooding Possible Flash Flood Watch / Flood Watch Issued No Significant Overflow of Waterways Expected Few to No Evacuations Expected <b>EXAMPLE: Area of Low Pressure with Minor Coastal Road Flooding and a Flood Watch issued.</b>	Over Three Feet (3+ ft) of Tides / Surge Predicted Storm Surge Watch Issued / Coastal Flood Watch Issued Isolated Evacuations Possible Community Shelters On Standby / Open Flash Flood Warnings / Flood Warnings Issued Expected Overflow of Some Waterways Possible Evacuation and Sheltering of Some Residents (Tens to Hundreds) <b>EXAMPLE: Tropical Storm Colin (2016), Significant Rainfall (10" - 15") and Surge of 3 - 4 ft. One Community Shelter opened.</b>	Life Threatening Tides / Surge Predicted Storm Surge Warning Issued / Coastal Flood Warning Issued Mandatory Evacuations Expected Due to Tides / Surge Multiple Shelters Opened Flash Flood Warnings / Flood Warnings Issued Expected Overflow of Numerous Waterways Expected Evacuation and Sheltering of Residents (Hund <b>EXAMPLE: Hurricane Florence (2018), Life Threater</b>
<b>Tsunami</b>			

# Flood Notifications

Before	During	After	All		
<b>Citizen Information Center (CIC)</b> Pinellas County Emergency Management <i>[Emergency Management Coordinator]</i>	 <b>Alert Pinellas - Opt In Text</b> Pinellas County Emergency Management <i>[Emergency Management Coordinator]</i>	<b>Alert Pinellas - Opt In Email</b> Pinellas County Emergency Management <i>[Emergency Management Coordinator]</i>	<b>Flash Report / Situation Report</b> Pinellas County Emergency Management <i>[Emergency Management Coordinator]</i>	<b>Intelligent Transportation System (ITS)</b> Pinellas County Public Works - Traffic <i>[Traffic Operations Center]</i>	<b>Social Media - F</b> Pinellas County Marketing & <i>[Social Media Sp</i>
The Citizen Information Center (CIC) would activate for this incident and risk level.  See CIC SOG for additional information and activation procedure.	 <b>ALERT PINELLAS:</b> Flooding from heavy rains is possible. Prepare and for updates tune in to local news stations and follow us on Facebook, Twitter, and Nextdoor. Prepare and stay tuned to local news for updates.	Flooding from heavy rains is possible. Prepare and for updates tune in to local news stations and follow us on Facebook, Twitter, and Nextdoor.	Complete template with current conditions	FLOODING POSSIBLE TODAY	Due to the possibility of he are advised to use extrem encountering flooded inter other roadway structures i waters. Drivers are advise "turn around, don't drown!" presented with flood water
		Be aware of flooding and be prepared to take action. Remember - never drive or walk through flooded areas - whether coastal flooding or rainfall flooding.		HEAVY RAIN POSSIBLE TODAY	Heavy wind and rain will ir [TIME] and could cause flo in coastal areas. Resident advised to anticipate the fc conditions this [TIME]:  - [LIST CONDITIONS]
		Due to the possibility of heavy rain, drivers are advised to use extreme caution when encountering flooded intersections and other roadway structures impeded by flood waters. Drivers are advised to employ the "turn around, don't drown!" motto when presented with flood water conditions.		DO NOT DRIVE THROUGH FLOODED ROADWAYS	Pinellas County is checking structures and responding due to flooding, as well as local jurisdictions, and will monitor the situation and p as they become available.

...
Tides & Surge - Minor
Tides & Surge - Moderate
Tides & Surge - High
Rainfall Flooding - Minor
Rainfall Flooding - Moderate
Rainfall Flooding ...

# Targeted Flood Notifications



1:44



## ALERT PINELLAS: Coastal Flooding Possible Tonight in Some Areas

Message

Message

Vecinos de MARINERS COVE: Es posible que haya inundaciones esta noche en su vecindario

Vecinos de MARINERS COVE: Es posible que haya inundaciones esta noche en su vecindario. Tenga cuidado al conducir por el area. Nunca conduzca por carreteras inundadas. Mueva automobiles a terrenos mas altos. El nivel de agua actual en Cross Bayou es de sobre 4 pies. Monitoree el nivel en: <https://on.doi.gov/3xzEj0z>

ALERT  
ATTEN  
02307  
Hurric  
your e  
quest

# Next Steps



## Current Follow-on Efforts

- **Model refinements**
- **FMAP support**
- **Countywide vulnerability assessment**
- **Additional gages (repetitive loss areas)**



# Next Steps



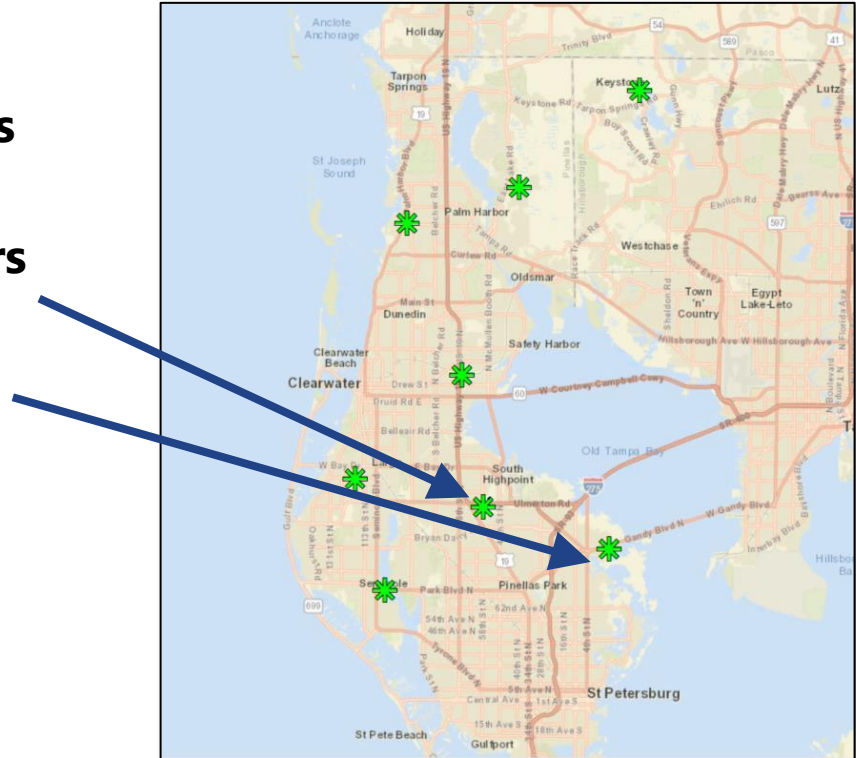
## Real-Time Flood Forecasting

- Automated early warning system
- Simple dashboard interface
- Users: Non-engineer, non-modelers
- What-if scenarios

# Next Steps

## Install Additional Stream Gauges

- **New stream gauges at key locations for better coverage**
- **Cross Bayou gauges x 2 for Mariners Cove MHP**
- **Twin City MHP south of Gandy**



# Next Steps



Stage (Feet, NAVD88)	Minor Hazard (e.g., ≤ 7" rainfall, isolated ponding of water)	Moderate Hazard (e.g., 7" to 9" rainfall, localized flooding in low-lying areas)	High Hazard (e.g., >9" rainfall, widespread flooding)	Comments
11.0 feet	<p>As the water approaches 11' and rising:</p> <p>Ensure that any dewatering pumps and hoses are pre-staged in the event that the creek overflows its banks.</p> <p>Dispatch staff (with a pump, slide gates and MOT) to the site.</p> <p>Continue monitoring Brooker Creek gauges and potential rainfall amounts.</p> <p>Monitor upstream gauges in Hillsborough County. A rising or falling stage may indicate that the Tarpon Woods stages will likely start to rise or fall, respectively, within 6 to 8 hours. Local rainfall patterns may completely obscure or change the timing of the flood wave from upstream as observed at Tarpon Woods.</p>	<p>As the water approaches 11' and rising:</p> <p>Ensure that any dewatering pumps and hoses are pre-staged in the event that the creek overflows its banks.</p> <p>Dispatch staff (with a pump, slide gates and MOT) to the site.</p> <p>If stream gauges rising and continuing or increasing rainfall:</p> <p>Monitor SWFWMD gates. Request that SWFWMD monitor frequently their gates at Island Ford, Crescent Lake and Keystone Lake and, control discharges closely to limit the effect of downstream water surface levels.</p> <p>Patrick Casey E-mail: patrick.casey@swfwmd.state.fl.us Phone: 352-316-7480 or 352-796-7211 Job Title: Structure Controls Analyst, Lead Office Location: Brooksville Section Name: Structure Operations Department Name: Operations Mail Code: BKV-6-OPS</p>	<p>As the water approaches 11' and rising:</p> <p>Ensure that any dewatering pumps and hoses are pre-staged in the event that the creek overflows its banks.</p> <p>Dispatch staff (with a pump, slide gates and MOT) to the site.</p> <p>If stream gauges rising and continuing or increasing rainfall:</p> <p>Monitor SWFWMD gates. Request that SWFWMD monitor frequently their gates at Island Ford, Crescent Lake and Keystone Lake and, control discharges closely to limit the effect of downstream water surface levels.</p> <p>Patrick Casey E-mail: patrick.casey@swfwmd.state.fl.us Phone: 352-316-7480 or 352-796-7211 Job Title: Structure Controls Analyst, Lead Office Location: Brooksville Section Name: Structure Operations Department Name: Operations Mail Code: BKV-6-OPS</p>	<p><a href="https://hdsc.nws.noaa.gov/pfds_map_cont.html">https://hdsc.nws.noaa.gov/pfds_map_cont.html</a></p> <p><a href="https://swfwmd.maps/webappviewer/index/f0669f4f6b94740ad9">https://swfwmd.maps/webappviewer/index/f0669f4f6b94740ad9</a></p>
11.2 feet	<p>Install slide gates / inspect and clean check valves in designated structures per "Tarpon Woods Stormwater System Operations Storm Event Procedures" (Aug 2009). Chain gates to the headwalls.</p> <p>Continue monitoring Brooker Creek gauges and potential rainfall amounts. Brooker Creek levels may rise within on day but typically take more than one week to return back to normal water levels. Therefore, continue monitoring the gauges until a return to normal water levels.</p> <p>Monitor upstream gauges in Hillsborough County. A rising or falling stage may indicate that the Tarpon Woods stages will likely start to rise or fall, respectively, within 6 to 8 hours. Local rainfall patterns may completely obscure or change the timing of the floodwave from upstream as observed at Tarpon Woods.</p>	<p>Install slide gates / inspect and clean check valves in designated structures per "Tarpon Woods Stormwater System Operations Storm Event Procedures" (Aug 2009). Chain gates to the headwalls.</p> <p>Continue monitoring Brooker Creek gauges and potential rainfall amounts.</p> <p>Monitor upstream gauges in Hillsborough County. A rising or falling stage may indicate that the Tarpon Woods stages will likely start to rise or fall, respectively, within 6 to 8 hours. Local rainfall patterns may completely obscure or change the timing of the floodwave from upstream as observed at Tarpon Woods.</p>	<p>Install slide gates / inspect and clean check valves in designated structures per "Tarpon Woods Stormwater System Operations Storm Event Procedures" (Aug 2009). Chain gates to the headwalls.</p> <p>Continue monitoring Brooker Creek gauges and potential rainfall amounts.</p> <p>Monitor upstream gauges in Hillsborough County. A rising or falling stage may indicate that the Tarpon Woods stages will likely start to rise or fall, respectively, within 6 to 8 hours. Local rainfall patterns may completely obscure or change the timing of the floodwave from upstream as observed at Tarpon Woods.</p>	<p><a href="https://dashboard.wa/api/gwis/2.0/service/e=USGS&amp;siteNumber=32168">https://dashboard.wa/api/gwis/2.0/service/e=USGS&amp;siteNumber=32168</a></p>

Questions?

