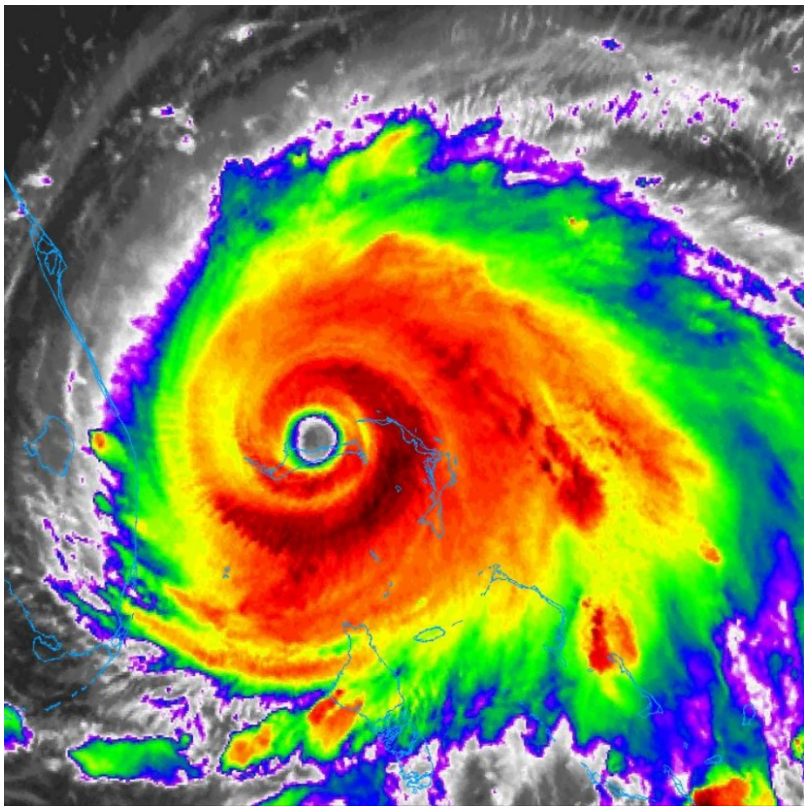
Power Delivery Performance

Hurricane Dorian

Storm Date: September 3, 2019

Report Date: May 8, 2020



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General

This is the Power Delivery Performance Report for Hurricane Dorian. The purpose of this report is to give an overview of the performance and generalized assessment of the system with specific case studies describing conditions, damage, and system performance.

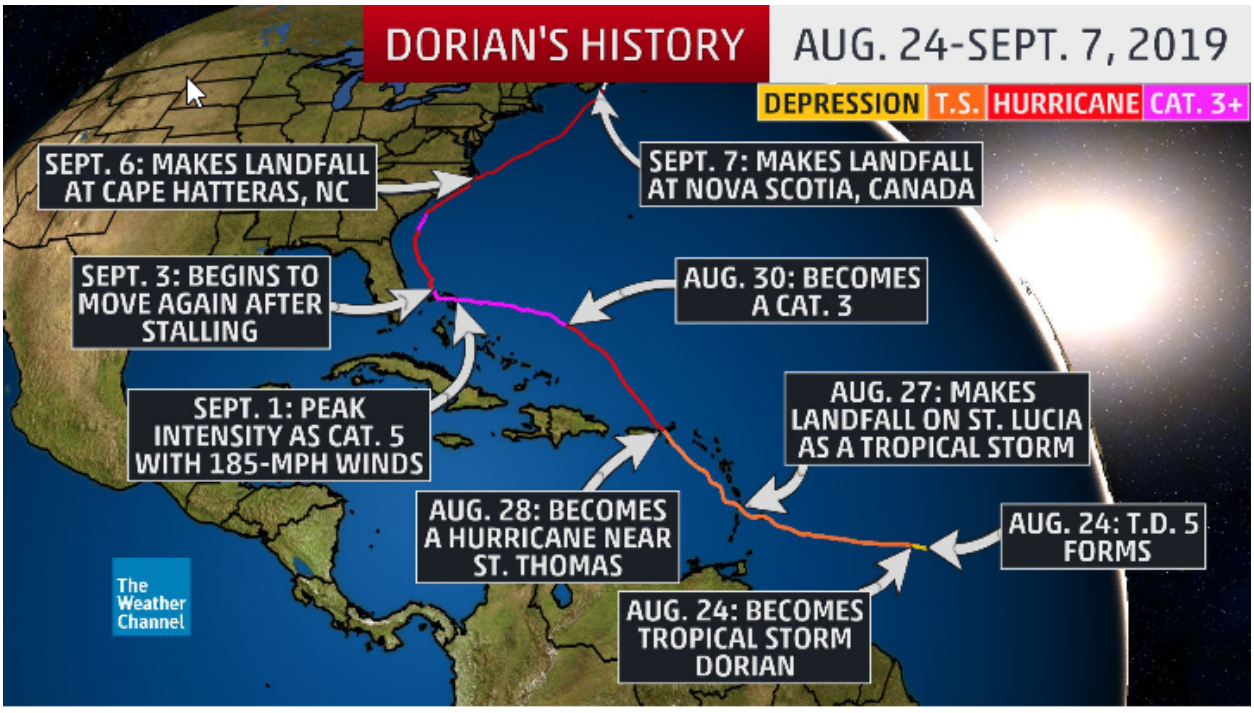
Daytona Speedway Staging Site

Executive Summary

On Monday September 2, 2019, Hurricane Dorian winds started to impact the Florida coastline as it intensified to a Category 5 sitting over the Bahama Islands. After spending two days over the Bahama islands Hurricane Dorian turned north with hurricane force winds impacting the coastline from Palm Beach County to the state of Georgia. Dorian impacted all 35 counties across the 27,000 square miles of FPL's service territory affecting 185K customers. Hurricane Dorian caused limbs and trees to break in addition to some flooding which impacted the area.

Hurricane Dorian was the strongest hurricane in modern records for the Northwestern Bahamas and the 48 hour pre-landfall predictive models included a direct hit for the state of Florida. The timing of the north / northwest turn was very critical in determining how close Dorian would get to the Florida peninsula and based on the size of Hurricane Dorian and the projected path toward Florida. FPL prepared by staging several crews throughout the state to support the restoration efforts for this potentially catastrophic storm.

Based on the movement of the storm and the investments to the FPL Grid since 2006, the winds effectively did not challenge the structural integrity of the system. During Hurricane Dorian, Transmission and Distribution Hardening and Smart Grid worked together to reduce the customer interuptions, severity, amount of damage, and improved situational awareness.



Hurricane Dorian started as a tropical wave before escalating into a Category 5 hurricane (Credit: Weather.com)

Executive Summary (Continued)

Results: 60.9% (112.5K) of customers restored in one day, 100% (184.6K) in three days (impacted). Average customer outage was 78 minutes. This was a three day event, but according to the Carver data, we did not have any customers out longer than 24 hours, so essentially 100% of the customers were restored within one day.

FPL Transmission System and Substations performed well in Dorian with no significant damage to the BES (Bulk Electric System). FPL experienced 0 pole failures and 3 line sections out. In addition, there was no substations out or major substation equipment damages. Protective relay systems and breakers were called on to clear 5 relay events with 0 mis-operations (0%). This is well below the 8% NERC average.

FPL Distribution System performed well in Dorian and demonstrated that the investments in the Distribution Feeder Hardening Program, Pole Inspection Program (PIP) and Smart Grid are providing benefits. The system performed as designed and greatly helped to reduce severe damage, duration of restoration and provided the ability for the grid to self- heal. These investments were key to the speed of storm restoration.

Distribution pole damage was primarily due to vegetation falling into FPL poles or lines with 5 out of the 8 (67%) poles down. In addition, there were no feeder poles down primarily due to the hardening efforts and the inspections of the non-hardened poles. 38% (3 out of 8) of poles down were ATT.

Underground Feeders experienced no outages. Overhead Hardened Feeders performed significantly better than non-Hardened Feeders; however, non-Hardening feeders still benefitted from the Pole Inspection Program (PIP) which has resulted in the replacement of over 87,000 poles and reinforcement of over nearly 57,000 poles since the inspection program began in 2006.

Underground Laterals performed 10.6X better than Overhead Laterals with vegetation (41% of Trouble Tickets) being the leading cause of Overhead Lateral outages. FPL's next step for grid hardening, Storm Secure Lateral Undergrounding program, which began in 2018, experienced no outages.

Smart Grid provided benefits with AFS (Automated Feeder Switches) Self-Healing operations avoiding 37K Customer Interuptions.

Hurricane Dorian Quick Stats

Meteorology

- Dorian did not make landfall, however it did bring hurricane force winds up the east coast and feeder bands that impacted the remaining FPL area from Monday September 2, 2019 through Wednesday September 5, 2019.

Vegetation

- 24% of CI was due to Vegetation
- 28% of all tickets restored required Vegetation work
- 11 feeder outages were due to vegetation

Distribution System Performance

- **Feeders Out 74**
  - UG 0
  - Hardened 22
  - Non-Hardened 52
  - Hardened Feeders performed 1.76 times better than non-Hardened Feeders
  - There were no UG Feeder Outages

- **Laterals Out 789**
  - OH 706
  - UG 83
  - Underground Laterals performed 10.7X better than Overhead Laterals
  - There were no outages on Storm Secure UG Lateral Hardening program

- **Distribution Transformers**
  - Single phase UG Transformers performed 1.5X better than OH Transformers

- **Poles Down ***
  - Hardened Feeder 0
  - Non-Hardened Feeder 0
  - Lateral,Service,Telephone 8

  ** Poles replaced to restore power*

- **Smart Grid**
  - Automatic Feeders Switch (AFS) teams avoided 37K Customer Interruptions

Transmission and Substation System Performance

- Transmission Out 3 line sections
- Transmission Poles Down 0
- Substations Out 0

Other

- Injuries OSHA 1
- Forensics Teams Deployed 42 personnel (trans., sub, dist.)

Customer Outages

- Average customer outage was 78 minutes
- Peak sustained outages was 11,349 / 0.23% of total customer base
- Total outages
    - 162,390 customers were affected at least once.
    - 184,626 customers were impacted with multiple outages.

Carver Tracking

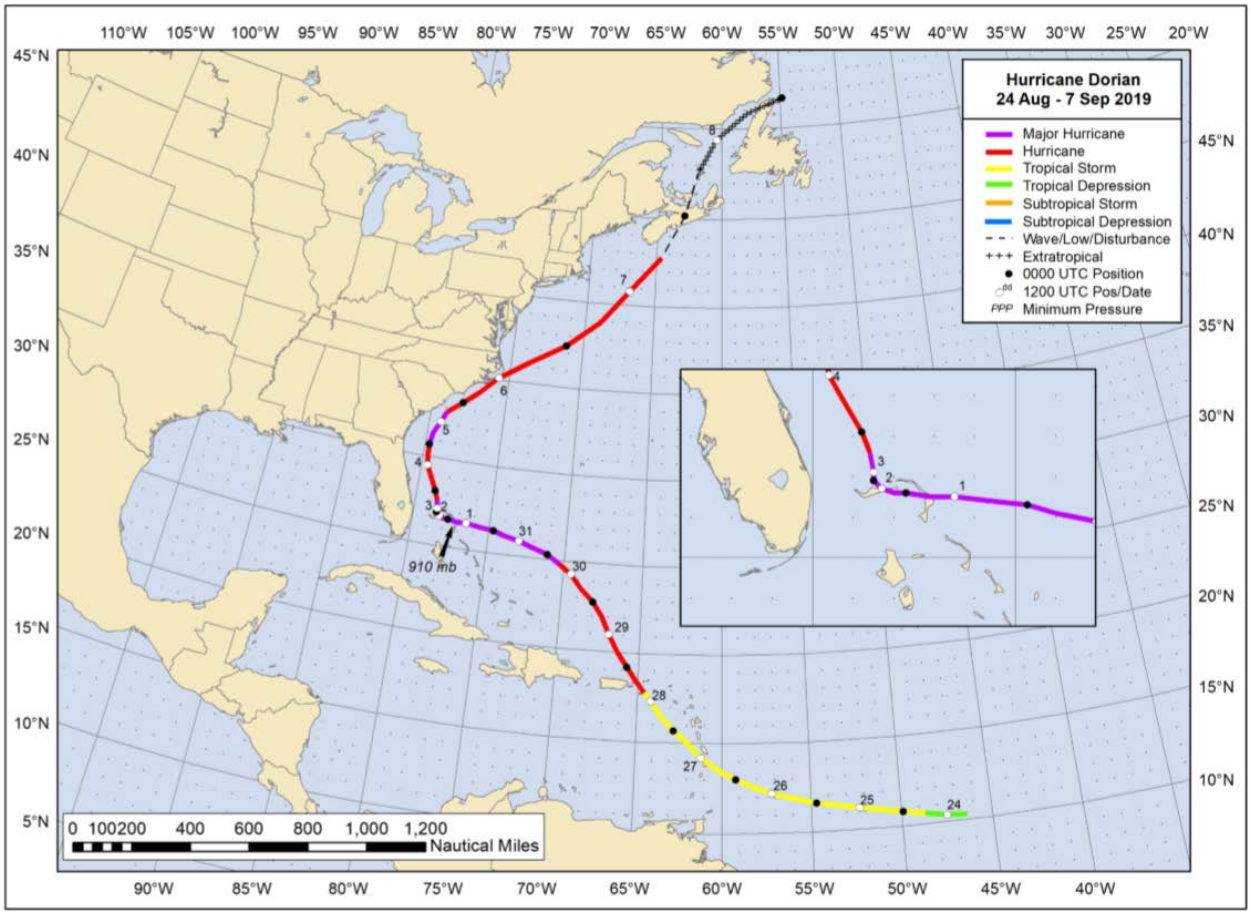
- Start All Areas 9/2/19 @ 12AM
- Stop (Dade, Broward, Palm Beach) 9/4/19 @ 6AM
- Stop (West) 9/4/19 @ 7AM
- Stop (North) 9/5/19 @ 12AM

Storm Characteristics and Weather

Hurricane Dorian reached Category 5 intensity on September 1 with maximum sustained winds of 185 mph. Hurricane Dorian made landfall in Elbow Cay, Bahamas and again on Grand Bahama several hours later with feeder bands affecting the entire state of Florida. On September 2, Hurricane Dorian stalled just north of Grand Bahama, still as a Catefory 5, for about a day and then on September 3 began to move slowly towards the north-northwest impacting the Florida east coast. On September 5 Hurricane Dorian continued up the eastern US coast exiting the FPL and Florida territory. Summarized from https://www.weather.gov/mhx/Dorian2019

Hurricane Dorian was the strongest hurricane in modern records for the northwestern Bahamas and the 48 hour pre-landfall projected path included a direct hit for the state of Florida. The timing of the northwest or north turn was very critical in determining how close Dorian would get to the Florida peninsula on Tuesday and Wednesday. Based on the size and the multiple projected paths into Florida, FPL prepared by staging several crews to support the restoration efforts. (Source NHC Report)

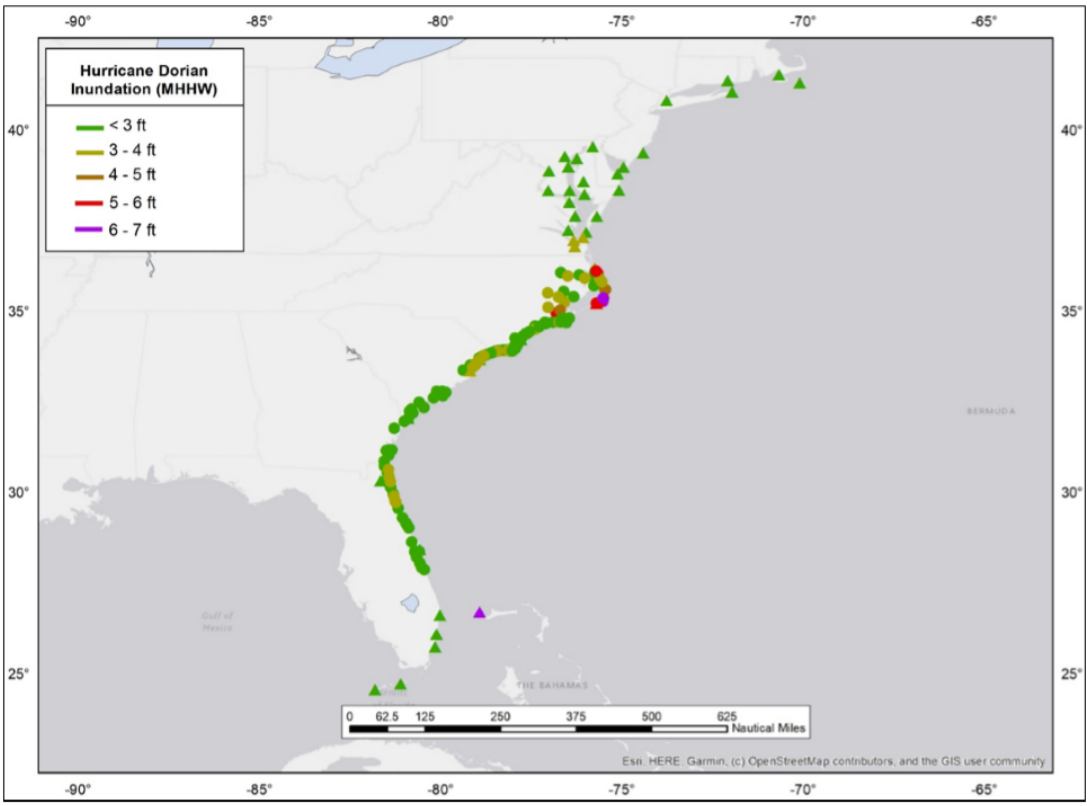
Actual Storm Path



Best track positions for Hurricane Dorian, 24 August – 7 September 2019 (Source NHC)

Storm Surge and Flooding

- Storm surge warnings ultimately extended from Lantana, Florida north to Virginia. Based on NOS tide gauge and USGS pressure sensor data, at least 3 ft of inundation (which NHC uses as a first-cut threshold for the storm surge watch/warning) occurred within some parts of the warning area, particularly portions of northeastern Florida. Although a sizeable portion of the Storm Surge Warning area did not verify, the issuance of the watch and warning was justified given that a slight westward deviation of Dorian's track, or an expansion of its wind field, would have caused significant storm surge flooding to occur along a larger proportion of the coast. The first storm surge forecast for a portion of the U.S. east coast was issued at 1500 UTC 1 September and called for maximum inundation heights of 4 to 7 ft above ground level between Jupiter Inlet and the Volusia/Brevard County Line in Florida. (Source NHC Report)
- Storm surge flooding occurred along portions of the southeastern United States coast from Florida to Virginia. In Florida, inundation heights of 1 to 3 ft above ground level were observed, although a few USGS sensors along the northeastern coast of Florida measured peak water levels slightly over 3 ft MHHW (Fig. 9). A sensor at Jacksonville Beach, Florida, measured a wavefiltered water level of 3.6 ft MHHW. The highest levels sampled by a tide gauge were at Fernandina Beach, Florida, where the NOS instrument measured a storm surge of 4.25 ft above normal tide levels and a storm tide of 2.6 ft MHHW. (Source NHC Report)



Tide gauge and USGS storm tide pressure sensor measurements from the east coast of the United States and the Bahamas from Hurricane Dorian, converted to feet above Mean Higher High Water, which is used as a proxy for inundation. (Source NHC Report)

Storm Surge and Flooding (Pictures)


St. Augustine Bayfront


Lincolnville near St. Augustine


Stuart Salerno Rd

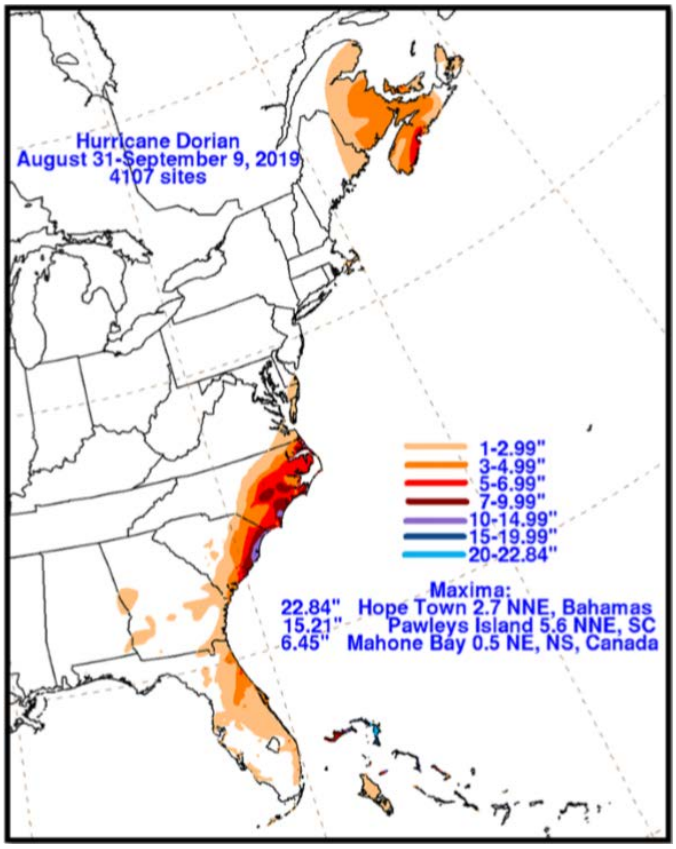

Vilano, St.Johns County


Downtown Miami, 5th and Alton Rd


Miami Beach, 85th St and Byron Ave

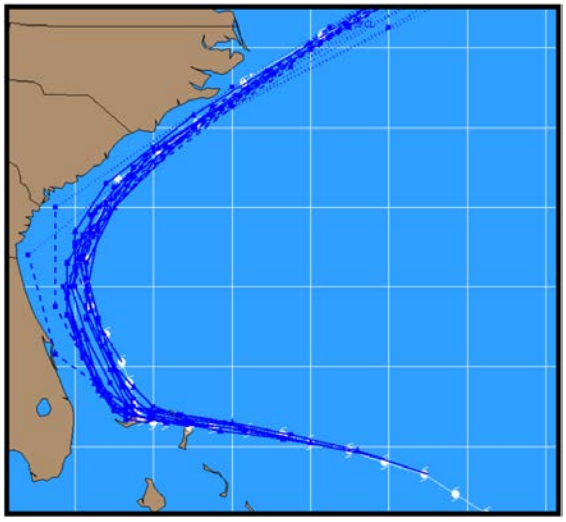
Rainfall

- Hurricane Dorian rainfall analysis (inches) during the period 31 August to 9 September 2019, which includes the extratropical phase. Graphic courtesy of the NOAA Weather Prediction Center.



Forecasts and Warning Critique

- Several NHC forecasts issued on 28–30 August brought the center of Dorian over the Florida peninsula. However, subsequent NHC forecasts turned Dorian northward east of Florida. This resulted in low track forecast errors during a time when many models still indicated a landfall in Florida. (Source NHC Report)



Selected official track forecasts (blue lines, with 0, 12, 24, 36, 48, 72, 96, and 120 h positions indicated) for Hurricane Dorian from 0000 UTC 31 August to 0000 UTC 4 September 2019. The best track is given by the white line with positions shown at 6 h intervals. (Source NHC Report)

Winds and Pressure

- Dorian's center remained offshore the coast of eastern Florida, tropical-storm-force winds occurred north of Broward County, because the hurricane's wind field had expanded considerably by then. The highest observed surface wind speed was a 60-kt gust measured at New Smyrna Beach, Florida, around 0640 UTC 4 September. Some higher gusts were observed, but those occurred at elevated stations. (Source NHC Report)
- Feeder bands impacted the entire state of Florida.

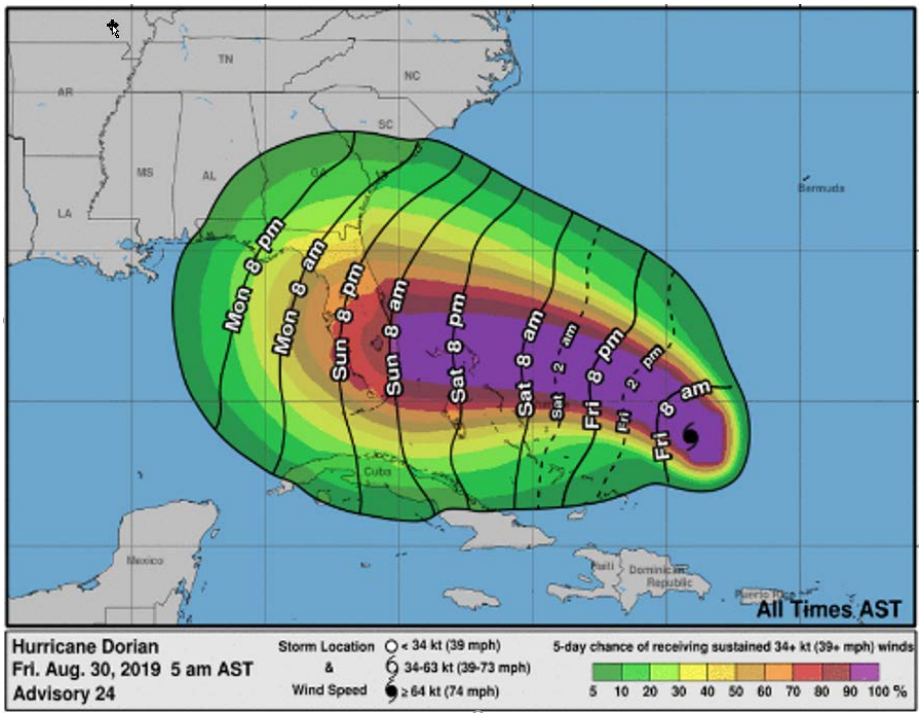
Hurricane Dorian's outer bands are lashing Florida as the storm moves northward along the U.S. coastline.

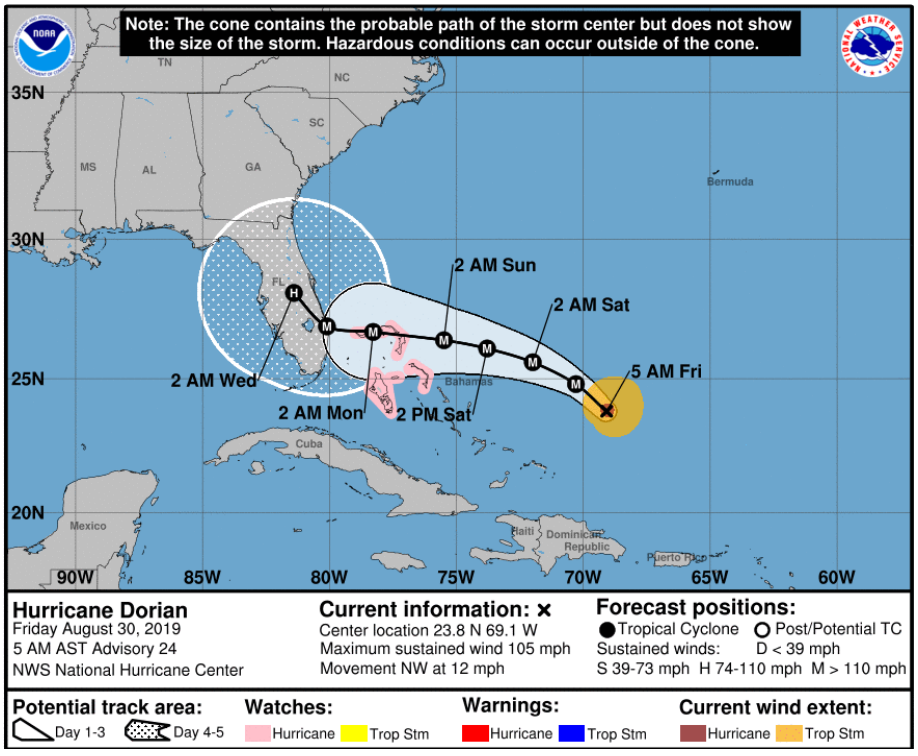
NOAA/NESDIS/STAR/GOES-East

Pre-Landfall Storm Path

72 Hour Pre-Landfall

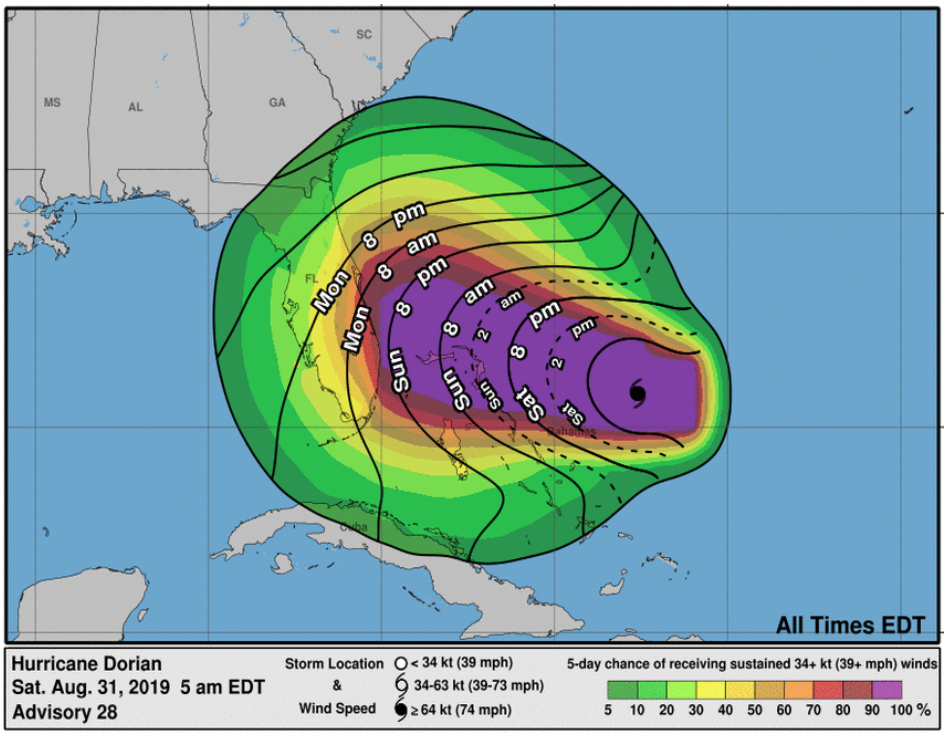
- NHC Track 8/30/2019 5:00AM Advisory

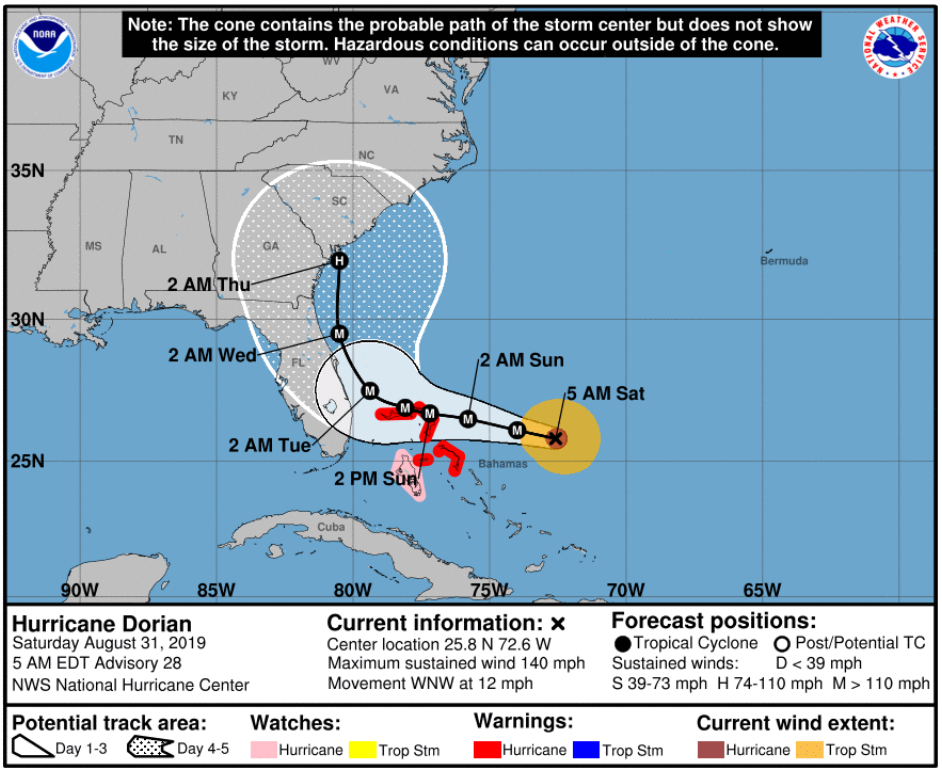




48 Hour Pre-Landfall

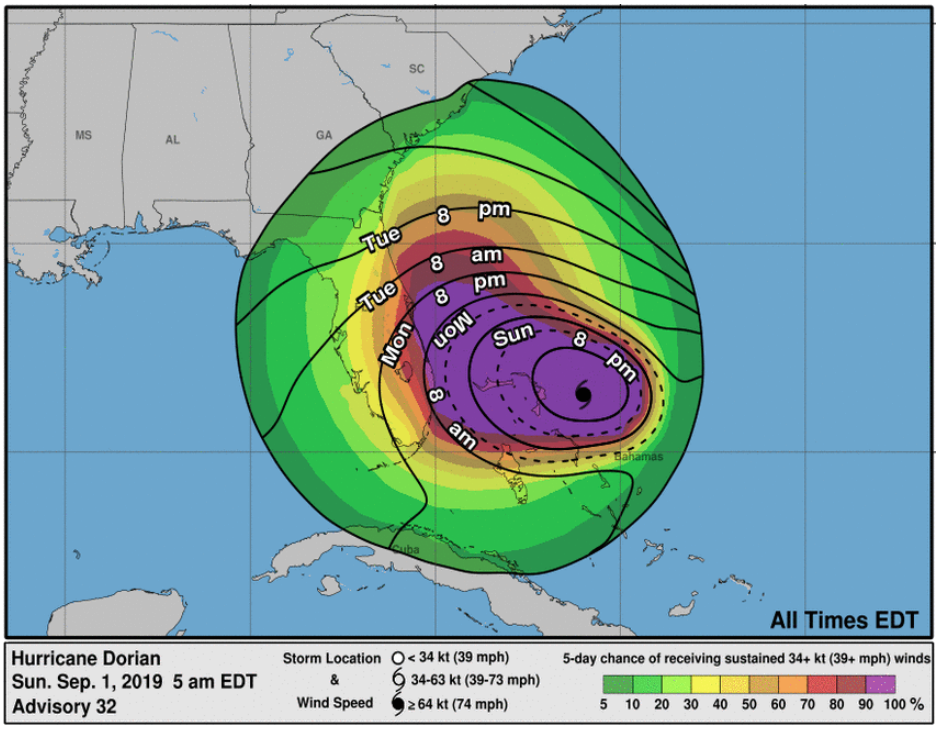
- NHC 8/31/2019 5:00AM Advisory

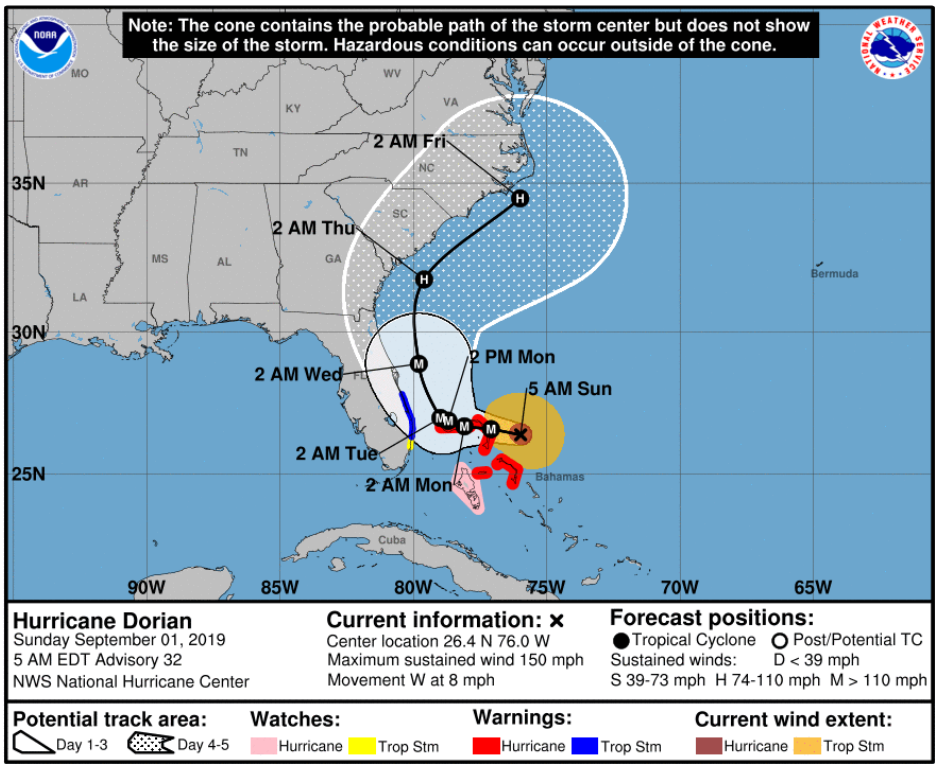




24 Hour Pre-Landfall

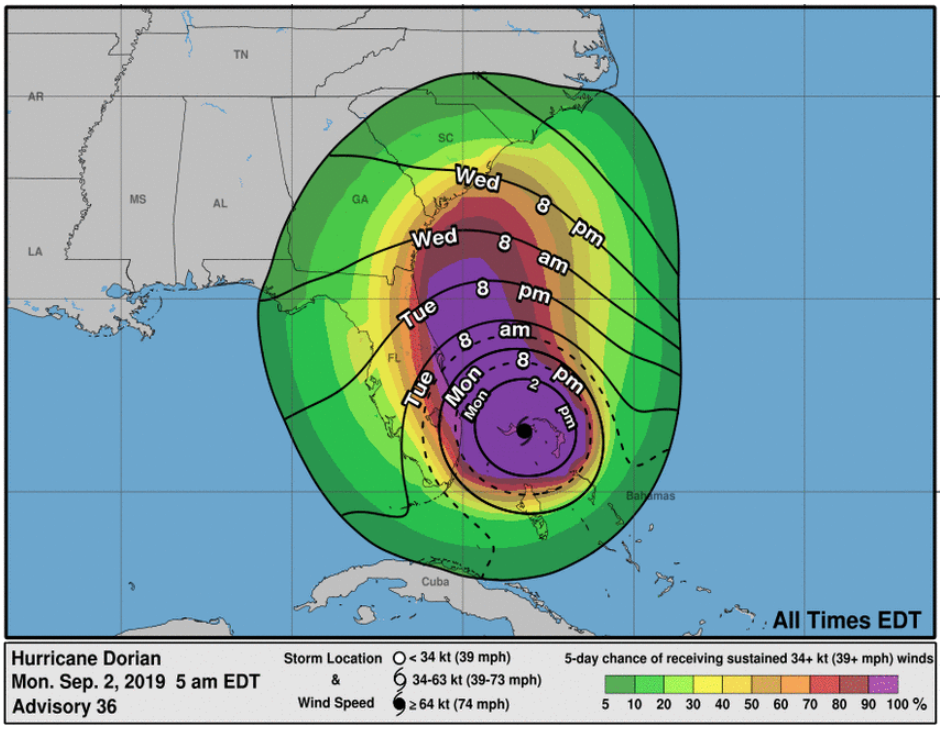
- NHC 9/1/2019 5:00AM Advisory

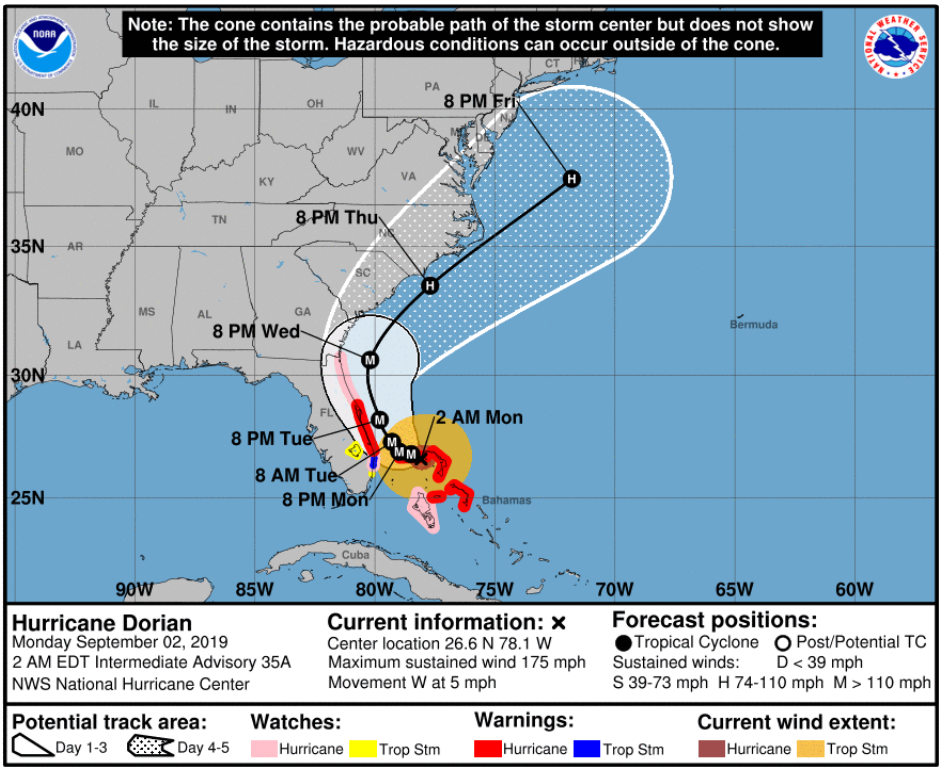




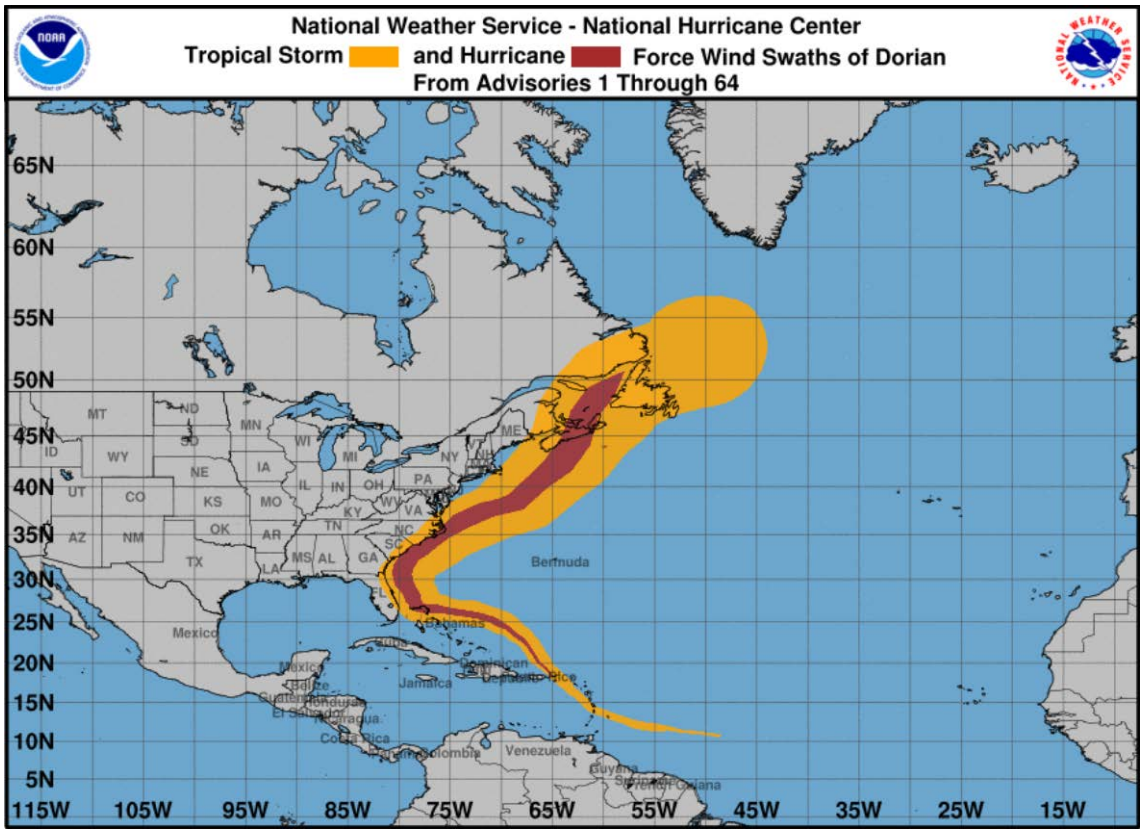
Final Hour Pre-Landfall

- NHC 9/2/2019 2:00AM Advisory





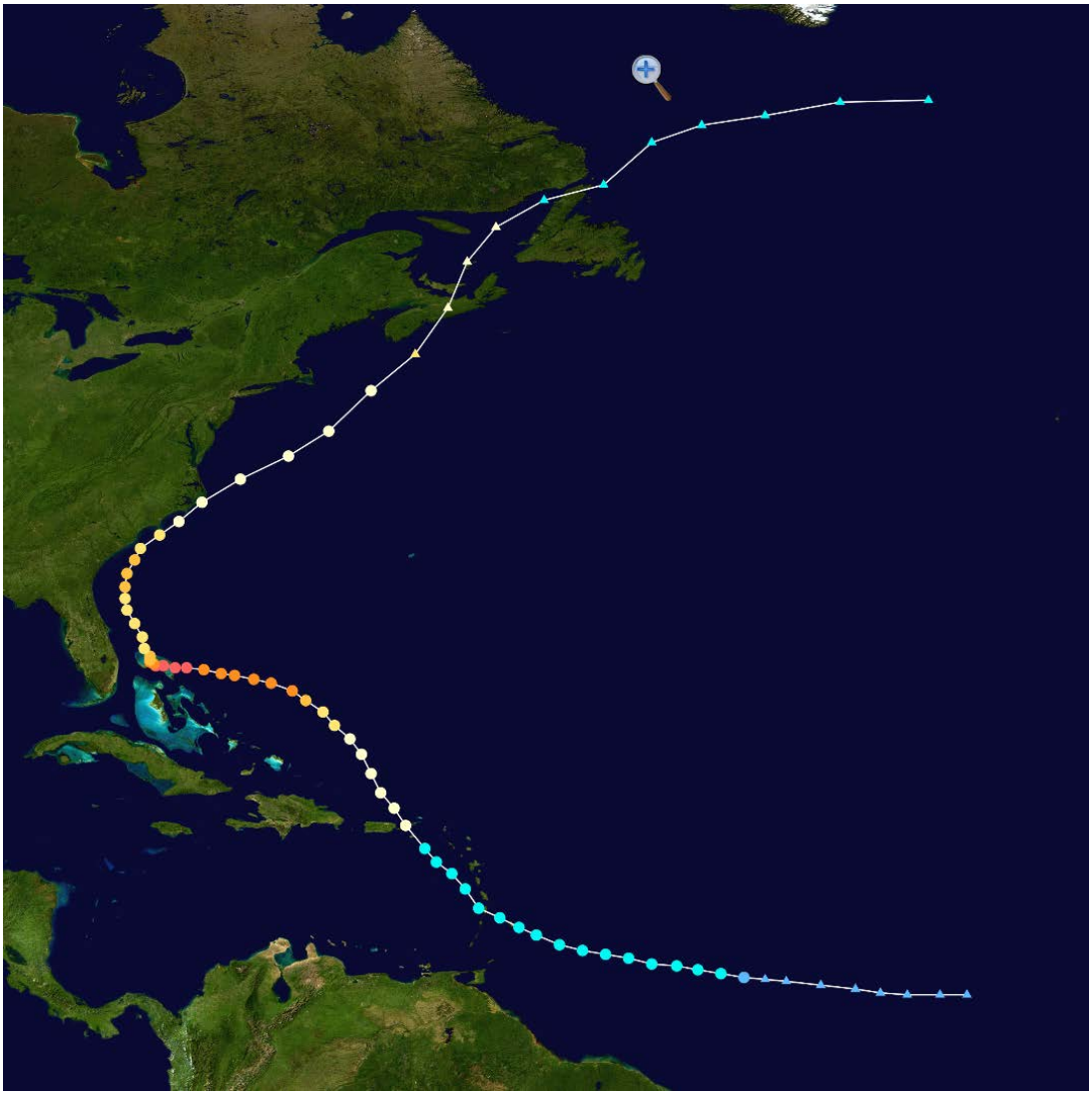
Actual Storm Path (Source: NHC)



Actual Storm Path

Saffir–Simpson scale

Category	Wind speeds (for 1-minute maximum sustained winds)			
	m/s	knots (kn)	mph	km/h
Five	≥ 70 m/s	≥ 137 kn	≥ 157 mph	≥ 252 km/h
Four	58–70 m/s	113–136 kn	130–156 mph	209–251 km/h
Three	50–58 m/s	96–112 kn	111–129 mph	178–208 km/h
Two	43–49 m/s	83–95 kn	96–110 mph	154–177 km/h
One	33–42 m/s	64–82 kn	74–95 mph	119–153 km/h
Tropical storm	18–32 m/s	34–63 kn	39–73 mph	63–118 km/h
Tropical depression	≤ 17 m/s	≤ 33 kn	≤ 38 mph	≤ 62 km/h



Transmission and Substation Performance

Summary

Overall, the Transmission System performed well during the storm event. Conductor damage was minimal.

Transmission poles down: 0

Transmission lines out: 0

Transmission line sections out: 3
- Voltage class: 115kV

Substations out: 0

Protection System Performance:
- There were 5 transmission relay events and 0 mis-operation for a 0% mis-operation rate (NERC goal is 8.0%, FPL 12 month average is 6%)
- Calculation based on NERC PRC-004

Major Equipment Damage:

Transmission Lines and Substations
- No major equipment damage identified

Distribution Substations
- No major equipment damage identified

Transmission Line Performance

Overall Transmission Performance was good during the storm event. Conductor damage was minimal. Approximately 45% of lines were patrolled after the storm. The boundaries of the storm included Central and North Management Areas.

Transmission System Performance

- 5 out of 235 Transmission lines experienced 5 Relay Operations
- 3 out of 486 Line Sections out

Damage / Component Failures

- 0 poles down
- 2 spans with phases down
- 1 OHGW failures
- 0 spans replaced

Line Events

Transmission Line	Line Section	Cause	Structure
Deland - Putnam 115kV	Como Tap – Crescent City	Debris - Spanish moss at structure	64G5
Cape Canaveral - South Cape 115kV	Courtenay – South Cape	OHGW down due to corrosion at the pole bond connection	91F12
Laurderdale-McArthur 138kV	All	Bird Streamer *Momentary*	9T2A
Andytown – Nobhill 230 kV	All	Palm Frond blew into feeder 6262 and flashed up into transmission *Momentary*	85S9 to 85S10
Millcreek - St Johns #2 115kV	Gator – St Augustine	Conductor down	115H10

Substation Performance

Overall Substation Performance was good during the storm event. All events that included an entire substation were identified as momentaries.

- 0 Distribution Substations of 622 total Substations were out
- 5 BES Relay Operations with 0 relay mis-operations (0% mis-operations)
- 0 Major Equipment Damage
- No flooded substations
  - St. Augustine incorporated the AquaDam which performed as expected.
- No substation communications were completely lost. The following outages did occur:
  - TELCO: 6 stations
  - Wireless: 8 stations
  - Both wired and wireless: 0 stations
- System protection operated as expected.
- No stations experienced battery loss due to extended outage.
- No mobile equipment was deployed.

Post Storm Events

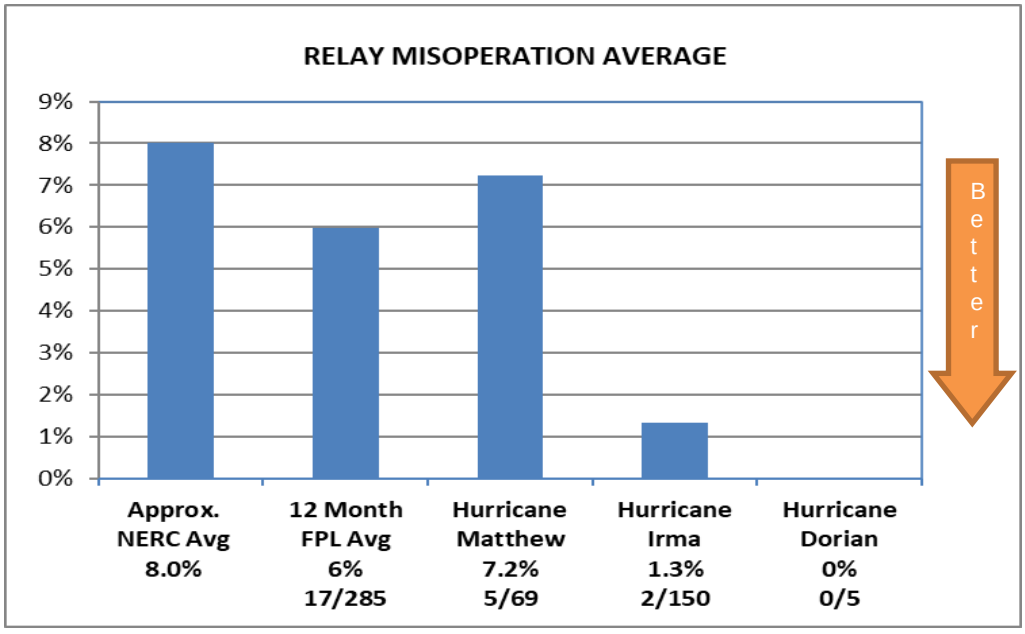
- No significant post storm events to date

Protective Relay Performance

- A Relay Mis-operation is a failure to trip or tripping unnecessarily further defined by NERC PRC-004
- Relay Misoperation Comparisons is shown below

Relay Misoperation Details

- No Mis-operations occurred



Case Study - St. Augustine AquaDam

What is the AquaDam?

- The AquaDam is a tempoary water-filled barrier which can control and divert water. It consists of two flexible watertight inner tubes, side by side, contained within a woven outer sleeve. The inner tubes are filled with water, giving form to the AquaDam, and creating a temporary, highly-effective water barrier.
- Installation time for water-filled AquaDam mainly depends on available pumping power. Most AquaDams are installed in a single day and removal is similar. AquaDams can be guided through turns, to conform to nearly any designed path alignment.
- The AquaDam was designed to conform to all the requirements of the Clean Water Act. By eliminating the use of dirt/earth fill material, the potential for earth fill discharges into the waterway is dramatically reduced, if not eliminated. (Source: www.AquaDam.net)

The AquaDam installed for Dorian prevented storm surge from entering yard.

- St. Augustine has experienced three significant storm surge events in the last four years.
- The AquaDam maximum protection level 7.6FT.
- Surge levels would have likely not caused equipment damage without the AquaDam.

St. Augustine AquaDam Pre-Storm

Case Study - St. Augustine AquaDam (Continued)

- Table to the right identifies key NAVD88 elevations
- The below table compares the last three major storms affecting the St. Augustine Substation.

Description / Event	NAVD88 Elevations
FEMA 100 Year Flood	8.0 ft
AquaDam	**7.6 ft**
Other Yard Equip. Cabinets	~7.3 ft
Hurricane Matthew Surge	**~7.0 ft**
Hurricane Irma Surge	**~6.7 ft**
Motor Operator Cabinets	~6.1 ft
Yard Flood Warning Alarm	5.7 ft
Hurricane Dorian Surge	**~5.1 ft**
Avg. Yard Grade	~4.5 ft
Avg. Grade Outside Yard	~4.4 ft
Typical Sea level	0 to 3 ft

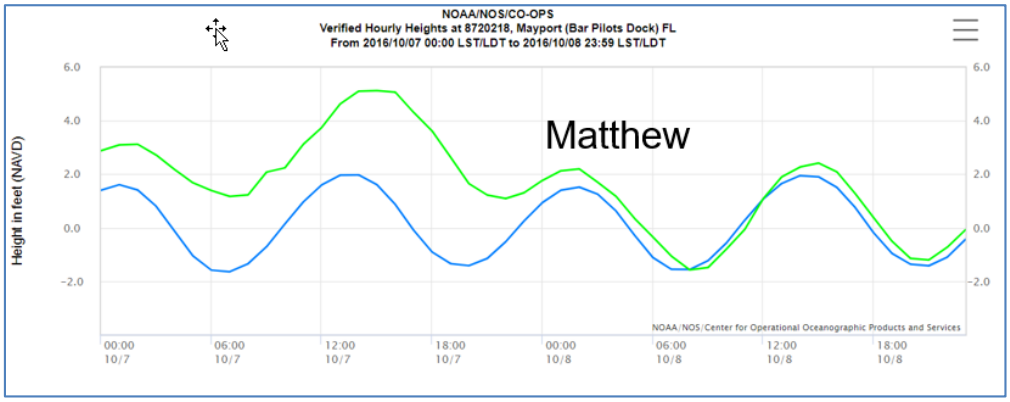
	Hurricane Matthew	Hurricane Irma	Hurricane Dorian
Date	10/7/2016	9/11/2017	9/04/2019
Warning Flood Alarmed		12:26 AM	
Flood Alarm		1:00 AM	
Storm Surge NAVD 88	~7.0 Feet	~6.7 Feet	5.1 Feet
Surge Level above Yard	~33 inches	~30 inches	~12 inches
Equipment Damaged/ Replaced	Four Switch Cabinets	Feeder Breaker, One Switch Cabinet	No Damage

AquaDam held back storm surge and an interior pump kept rain from accumulating

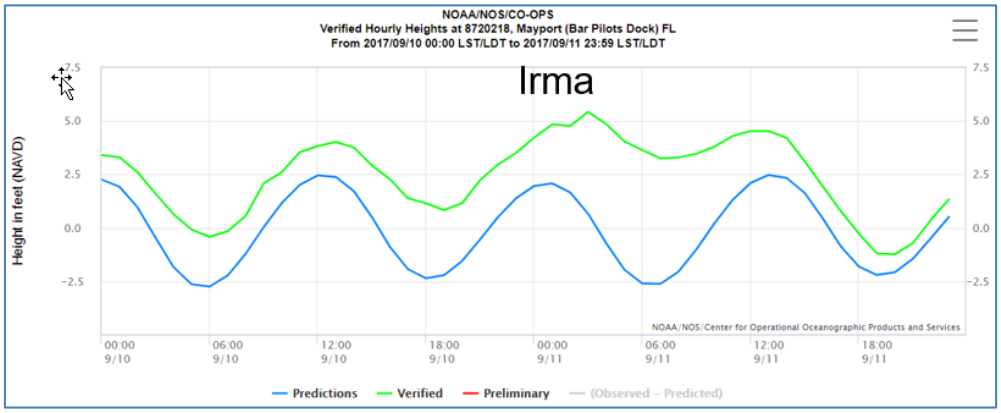
Case Study - St. Augustine AquaDam (Continued)

Actual Storm Surge at Jacksonville

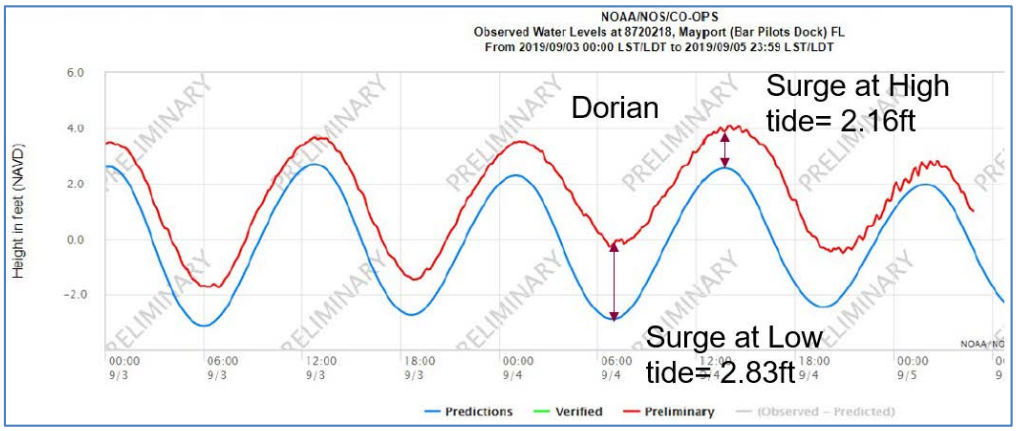
- Less than 50 miles from St. Augustine
- 3' storm surge at Jacksonville and 5' storm surge at St. Augustine
- Flood waters recede in about 6 hours



Hurricane Matthew surge hit just after high tide as tides were starting to go down



Hurricane Irma surge hit just after high tide as tides were starting to go down



Hurricane Dorian maximum storm surge occurred at low tide which minimized worst case surge

Case Study - St. Augustine AquaDam (Continued)

St. Augustine AquaDam during hurricane at high tide

St. Augustine AquaDam during hurricane at high tide

Distribution Performance

Distribution System performed well in Dorian and demonstrated the investments in the Distribution Hardening Program, Pole Inspection Program (PIP) and Smart Grid have helped to reduce the number and severity of outages during Hurricane Dorian. This was key to improved speed of restoration.

Pole Down Summary

- Hardened Feeder 0
- Non-Hardened Feeder 0
- Lateral, Service, Telephone 8

Feeder Summary

	Affected	% Affected
Feeders Out	**76**	**2%**
o UG	0	0%
o Hardened	21	2%
o Non-Hardened	55	3%

Excludes outages caused by Transmission and Substation

- No Hardened Feeder Poles down out of 175,576 poles on 1198 Hardened Feeders
- Hardened Feeders performed 1.76 times better than non-Hardened Feeders
- The primary objective of hardening is to reduce restoration times by minimizing the number of pole failures during extreme wind weather events.

Lateral Summary

	Affected	% Affected
Laterals Out	**789**	**0.41%**
o OH	706	0.82%
o UG	83	0.08%

- Underground Laterals perform 10.7X times better than Overhead Laterals.
- Vegetation is the leading cause of Overhead Lateral outages
- No Hardened Laterals experienced an outage.
- Excludes outages caused by Feeder, Substation or Transmission outages

Smart Grid Summary

- Self-Healing AFS (Automated Feeder Switch) operations avoided 37K Customer Interruptions (CI) during the storm.

Pole Performance

Distribution Poles performed well in Dorian. Hardened poles performed better than non-Hardened poles. The investments in the distribution hardening program, pole inspection program (PIP) and smart grid have helped reduce the number and severity of outages during storm events. The severity of damage was minimized and the speed of restoration was faster due to the efforts of the hardening programs that FPL has employed. Pole damage was primarily due to vegetation.

- 0 Hardened Feeder poles down
- 8 Total poles replaced to restore power
  - 3 ATT Poles
  - 5 FPL Poles

Hardening Pole Programs

- Storm Hardening Plan:
  - Hardened 175,576 poles
- Pole Inspection Program:
  - Replaced 87,246 poles
  - Reinforced 57,595 poles

Region	FPL Concrete	FPL Wood	FPL Total	Third Party	Total	Broken Poles in TCMS	Pole Failure Rate
Broward	24,732	78,218	102,951	46,206	149,157	2	0.0013%
Dade	28,057	122,638	150,695	60,961	211,656	1	0.0005%
East	20,601	137,992	158,593	42,719	201,312	-	0.0000%
North*	23,986	442,589	466,575	75,113	541,688	5	0.0009%
West	13,560	307,824	321,384	7,000	328,384	-	0.0000%
Total	107,064	1,082,593	1,189,657	231,999	1,432,196	8	0.0006%

*includes Vero Beach

Distribution Pole Failure %			
Pole Type	Failures	Total # of Poles	Failure Rate
Hardened Feeders	0	175,576	0%
non-Hardened Feeder	0	245,424 **	0%
3rd Party*	3	232,000	0.0004%
Lateral / Service	5	779,196 **	0.0006%
Overall	8	1,432,196	0.0006%

* 3rd Party Poles replaced by FPL
** Estimated

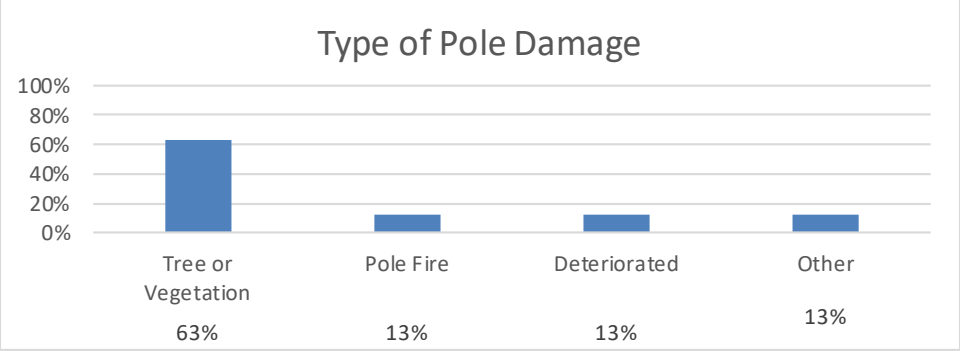
Pole Damage Details

- No Hardened Feeder Pole down
- 3 ATT poles down
  - 2 vegetation and 1 deteriorated pole failure
- 5 FPL poles down
  - 3 vegetation, 1 pole fire, and 1 no cause identified
- Vegetation was the primary cause for pole damage

Pole Damage Details from TCMS and Other Sources

FDR#	Sub	MA	FPL or ATT	TT#	Date	LLN#/FPL ID	Detail Comments of outage
803038	TROPICAL	WD	ATT	666	9/2/2019	8-6253-9852	Deteriorated AT&T pole - West Dade - need replace badly broken tx pole..40/3 pole.. 1 phs lat..tx 50 kv 7620/13 strt 120/240 tx..oil spill crew.. 1/p/s broken ptp.. rs open pull off lat. r/o 1431 sw 93 ct.. pole & tx r/o 1320 sw 92 pl.. no truck access.. RS Interruption Category Code - OCA
704463	FASHION	NB	FPL	247	9/3/2019	8-8090-0428	Pole broke 5' from the top just above the transformer. Pics on sharepoint site. Per the ticket comments wire was against pole and caught the pole on fire
706465	HOLMBERG	NB	ATT	1241	9/3/2019	8-7093-5593	Tree took out lateral and broke pole. Need to get pole location downstream of TLN 8-7093-5593-0-7
404132	SATELLITE	BV	ATT	1674	9/3/2019	268117844	Trees took out lateral conductor and pole, rear of 290 Ocean Spay Ave at FPL ID# 268117844
105832	ELKTON	NF	FPL	1235	9/4/2019	3-4451-8546	Trees took out lateral and broke dead end 40'/4 pole at tln# 3-4451-8546-0-1
105832	ELKTON	NF	FPL	1449	9/4/2019	3-4848-8397	TCMS details - 7 poles s/o packing house need tree to clear so line crew can repl 40/4 corner pole / 2 phase's & neut / & put up 2 spans #2 al pri & neut / access / abandon 2 pot bank does not need to be put back up
?	?	?	FPL	NA	?	?	No cause identified (Pictures from Crew)
104832	Taylor	CF	FPL	255	9/4/2019	?	Tree took out lateral and broke pole.

Type of Pole Damage



Case Study – Pole Analysis

Details

- FPL
- Tree / Vegetation
- TT# 255 on 9/4/19
- CF / Taylor / 104832 (Daytona)

Case Study – Pole Analysis

Details

- FPL
- No cause identified (Other)
- No Ticket information (Pictures from Crew)
- St.Augustine on 9/4/19

Case Study – Pole Analysis

Details

- FPL
- Tree / Vegetation
- TT# 1449
- NF / Elkton / 105832 (St. Augustine)

Case Study – Pole Analysis

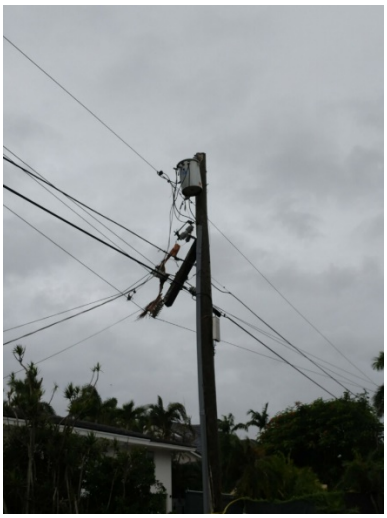
Details

- FPL
- Tree fell on line breaking pole
- TT# 1235
- NF / Elkton / 105832 (St. Augustine)

Case Study – Pole Analysis

Details

- FPL
- Vegetation (Palm Frond) wrapped around stinger and caused a pole fire
- TT# 247
- NB / Fashion / 704463 (Pompano / Ft.Lauderdale)



Case Study – Pole Analysis

Details

- ATT
- Tree fell into lateral and broke pole
- TT# 1241
- NB / Holmberg / 706465 (Parkland / Boca Raton)
- No pictures were taken due to quick restoration and cleanup.

Case Study – Pole Analysis

Details

- ATT
- Deteriorated
- TT# 666
- WD / Tropical / 803038 (Miami)

Case Study – Pole Analysis

Details

- ATT
- Tree fell into lateral and broke pole
- TT# 1674
- BV / Satellite / 404132 (Melbourne / Cape Canaveral)

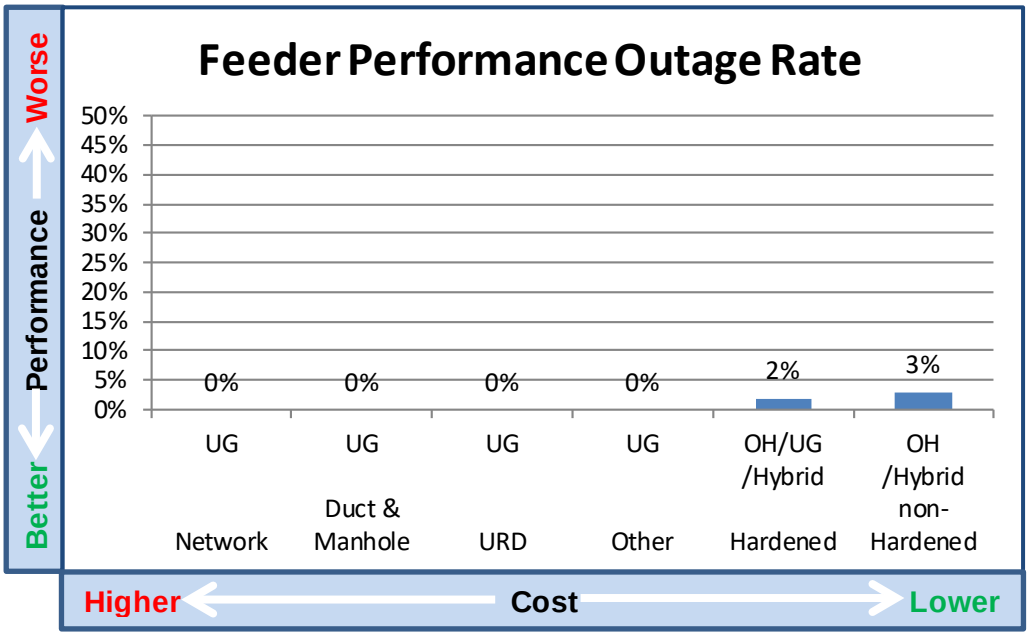
Feeder Performance

- Underground Feeders performed better than Overhead Feeders.

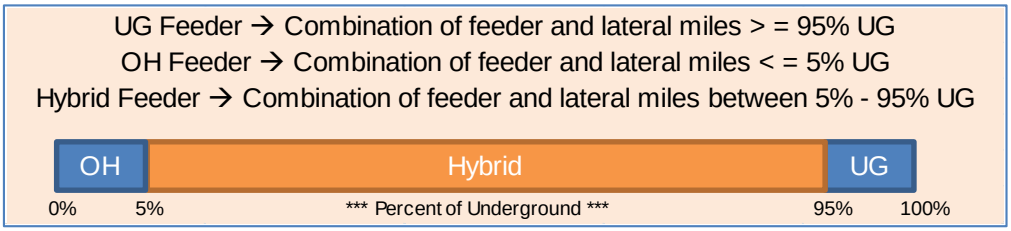
Feeder Performance by Feeder Type

- Excludes Transmission and Substation Outages
- OH Hardened Feeder includes OH-to-UG conversions as a part of Hardening
- Data based on Adjusted Carver Report, 9-5-19 @ 6AM

Feeder	Type	Affected	Population	% Affected
UG	Network	0	11	0%
UG	Duct / Manhole	0	331	0%
UG	Other	0	136	0%
UG	URD	0	79	0%
OH / UG / Hybrid	Hardened	22	1198	2%
OH / Hybrid	non-Hardened	52	1721	3%
Total		74	3,476	2%



Definition of Purely Overhead (OH), Purely Underground(UG) and Hybrid Feeders



Hardened vs non-Hardened Feeder Performance

- Hardened Feeders make up 35% of the Feeder population.
- No feeder poles were broken or down during this event.
- Hardened Feeders performed 1.64 times better than non-Hardened Feeders
- Forensic teams inspected 21 Hardened Feeders experiencing an outage
- Data based on Adjusted Carver Report, 9-5-19 @ 6AM

$$\text{Hardened Feeder Performance Ratio} = \frac{\text{Number of Non-Hardened Feeders Out*}}{\text{Total Number of Non- Hardened Feeders}} \text{ to } \frac{\text{Number of Hardened Feeders Out*}}{\text{Total Number of Hardened Feeders}}$$

* Affected = Feeders out at least one time

$$\frac{52 / 1{,}721}{22 / 1{,}198} = \frac{3\%}{2\%} = 1.64 \text{ X Better}$$

Feeder Outage Causes

- Data based on TCMS tickets
- Vegetation accounted for 19% of the feeder tickets
- Due to the large number of resources available during this storm restoration was performed quickly and additional cause analysis was unable to be performed.

Cause Code	Count of Tickets	Percentage
188 - Equip Failed OH	24	27%
2,6,14 - Hurricane/Storm	22	25%
20, 21 - Vegetation	17	19%
190 - Unknown	8	9%
197 - Other	8	9%
200 - Transmission related	5	6%
Balance of outages	5	6%
Total	89	100%

Feeder Outages by Area		
Area	Hardened	nonHardened
North (NF, CF, BV)	13	19
East (TC, WB, BR)	7	23
South (NB,CB,SB,ND,CD,WD,SD)	2	8
West (TB,MS,NA)	0	2

Lateral Performance

- Underground Laterals performed better than Overhead Laterals.
- While UG Laterals make up 56% of the Lateral population, UG Laterals sustained less outages accounting for only 0.08% of the Laterals out.
- Based on the assessment of outage performance UG Laterals performed 10.7 times better than OH Laterals.
- Lateral outages do not include outages caused by Feeder, Substation or Transmission
- Storm Control Laterals (SCL) were not created for this event
- Data based on Adjusted Carver Report, 9-5-19 @ 6AM

Laterals Out	Affected	Population	% Affected
OH	706	86,047	0.82%
UG	83	108,255	0.08%
Total	789	194,302	0.41%

$$\frac{706 / 86{,}047}{83 / 108{,}255} = \frac{0.82\%}{0.08\%} = 10.7$$

Underground Laterals performed 10.7 X better than Overhead Laterals

$$\text{UG Lateral Performance Ratio} = \frac{\text{Number of OH Laterals Out*}}{\text{Total Number of OH Laterals}} \text{ to } \frac{\text{Number UG Laterals Out*}}{\text{Total Number of UG Laterals}}$$

* Affected = Laterals out at least one time

Lateral Outage Causes

- Data based on TCMS tickets
- Vegetation accounted for 41% of the lateral tickets
- Due to the large number of resources available during this storm restoration was performed quickly and additional cause analysis was unable to be performed.

Cause Code	Count of Tickets	Percentage
20,21,25 - Vegetation	318	41%
2,6,14 - Hurricane/Storm	155	20%
197 - Other	139	18%
188 - Equip Failed OH	88	11%
190 - Unknown	27	4%
Balance of Outages	43	6%
Total	**770**	**100%**

Storm Secure Lateral Undergrounding Program

- No Laterals that have been Hardened experienced an outage.

Region	MA	SUBSTATION	FEEDER #	LATERAL # (DDB/TLN)	FRANCHISE NAME	OH MILES	UG MILES
Broward	CB	HOLY CROSS	701931	87785280703	Fort Lauderdale	0.17	0.69
Dade	ND	IVES	806733	87268336410	Miami Gardens	0.09	0.13
East/North	TC	ADAMS	408461	65874402803	St. Lucie	0.92	3.08
East/North	TC	ADAMS	408461	65874411519	St. Lucie	0.95	3.08
East/North	BR	ATLANTIC	403231	87797866309	Boca Raton	0.37	1.64
East/North	BR	HILLSBORO	404733	87895343609	Boca Raton	0.56	0.63
East/North	BR	HILLSBORO	404736	88095571204	Boca Raton	0.05	0.21
East/North	TC	OLYMPIA	401762	67649207405W	Martin	0.19	0.89
East/North	TC	OLYMPIA	401764	67351874001	Martin	0.53	0.59
East/North	TC	PORT SEWALL	404933	67255685001	Martin	0.21	0.68
West	MS	TUTTLE	504532	51768423396	Sarasota	0.19	0.52
West	NA	ALLIGATOR	503566	76782883501	Collier	0.23	0.73
West	MS	PAYNE	502834	51370975802	Sarasota	0.18	0.38
West	MS	PROCTOR	505166	52163301703	Sarasota	0.27	0.79
West	NA	NAPLES	501239	76280874902	Naples	0.09	0.12

Distribution Transformer and Padmounted Switch Performance

Single phase pad mount transformers performed 1.5 times better than aerial transformers. Although pad mount transformers usually perform 3 to 4 times better than aerial transformers under storm conditions, this was not the case for this storm due to the following:

- Storm did not make landfall and produced less wind (less impact to aerial transformers)
- Off-shore storm still produced rain and surge (affecting pad mount transformers)

Transformer Analytics

- There are over 938,147 distribution transformers in service
- Based on ISC (Integrated Supply Chain) issued material
- UG performed 1.5X better than OH transformers
    - (0.009/0.006)=1.5X
    - 58 of 621,288 aerial transformers = 0.009 % failure rate
    - 16 of 267,803 single phase pads = 0.006 % failure rate
    - 3 of 49,056 three phase pads

Transformer Interruptions

- Source Carver file 9/19 @ 6am and AMG

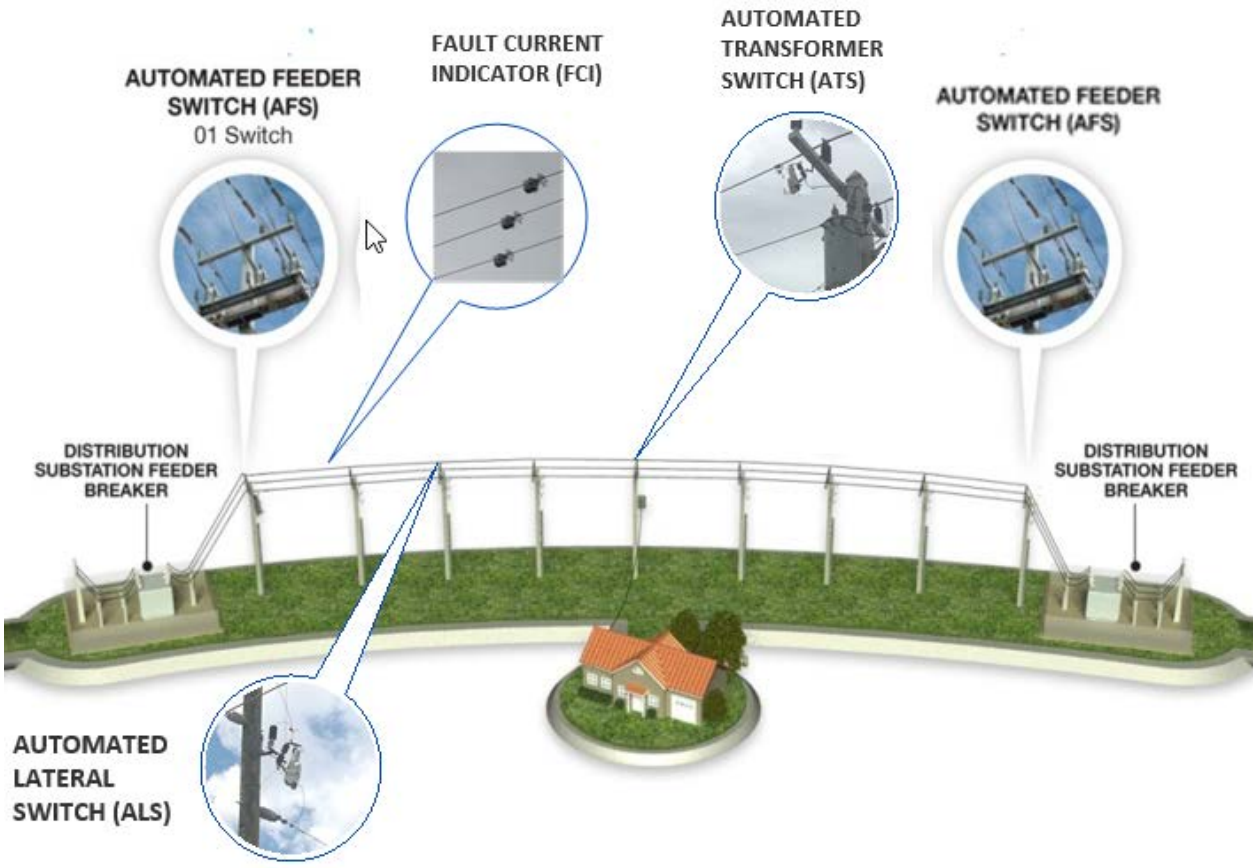
	TX Total	OH TX	UG TX
Interruptions	1,355	1,299	56
# of TX	938,147	621,288	316,859
% Interuptions	0.1%	0.2%	0.02%

Pad Mounted Switches

- There was no pad-mount switch failures related to the storm
- This information is based on teams reviewing trouble tickets, materials that were issued, and reports from the areas
- No failed switches were sent to the Reliability Assurance Center for RCA (Root Cause Analysis)

Smart Grid

- In 2014, FPL began to accellerate its expansion of Smart Grid Devices.
- By incorportating Smart Grid strategy it allows our feeders to prevent and mitigate outages, in addition to speeding up restoration efforts.
- Installation of more than 114,000 intelligent devices have been completed.
- Over 5 million smart meters have been installed to residential and business customers.



AFS (Automated Feeder Switch)

Automatic Feeder Switches (AFS) isolate, transfer load, interrupt faults and have pulse close capabilities. They automatically reroute electricity to reduce the amount of customers affected when an adverse condition affects the power lines.

AFS Performance:

- 37K Customer Interruptions (CI) avoided during the storm

AFS Availability

- AFS units may become disabled or show "Offline/Not Available" due to:
  - **Natural causes: 28 units**
    - Lost communications due to loss of power
    - Damage to switches
    - Switches reconfigured in the field
    - Initial assessments did not indicate any AFS being visually damaged
    - 63 AFS to be field checked identifying any AFS failures.
  - **Planned: 0 units**
    - Storm process which disables AFS team operations for winds greater than 74mph.
    - Disabling of "Normal Open" switches in those areas to avoid automatic throw-over to alternate feeder.

AFS Team Success Rate

- Success Rate indicates self-healing from primary circuits to backup circuit
- Data does not include feeders as AFS feeders if they have only an "01" AFS or only a "NO" AFS (a.k.a. Support Feeder)
- Due to the low number of tickets it is normal to have 0% and 100% success rates

Management Areas	CI Avoided	Interrupted on Original Feeder Ticket	Feeder Tickets with CI Avoided	Number of Feeders with AFS Devices	Success Rate
Broward	**2590**	**2673**	**2**	**3**	**67%**
CB	0	1348	0	1	0%
NB	2590	1325	2	2	100%
Dade	**632**	**4941**	**1**	**3**	**33%**
CD	0	2321	0	1	0%
ND	0	2049	0	1	0%
SD	632	571	1	1	100%
East	**16027**	**24449**	**14**	**21**	**67%**
BR	3210	3084	3	3	100%
TC	9910	10813	8	11	73%
WB	2907	10552	3	7	43%
North	**16767**	**27669**	**17**	**26**	**65%**
BV	1139	4619	2	4	50%
CF	7994	11666	6	10	60%
NF	7634	11384	9	12	75%
West	**1197**	**710**	**1**	**1**	**100%**
MS	1197	710	1	1	100%
Grand Total	37213	60442	35	54	65%

ALS (Automated Lateral Switch)

Automatic Lateral Switches (ALS) clear temporary faults, provides enhanced protection and coordination. During storm events with extreme winds for extended period of time, ALS performance is similar to a fuse.

ALS Forensics

- 379 laterals were patrolled
  - 20% (75) locations were missing at least one ALS unit
  - Based on 417 ALS tickets

ALS vs non-ALS lateral Performance

OH ALS Performance	
Count of **NON-ALS Laterals**	26,321
Number of Outages	355
Percent Outage	1.3%
Count of **ALS Laterals**	54,679
Number of Outages	417
Percent Outage	0.8%

Vegetation

- Vegetation on laterals was the leading cause of Customer Interuptions (CI)
- Vegetation pre-sweeps minimized CIF feeder outages
- Branches growing and blowing into secondary conductors created most of the tree work
- There were 3252 pre-staged Vegetation crews from outside FPL

Pre-storm Activities

- FPL was preparing for a Category 3 event
- 4452 vegetation line clearing personnel were deployed pre-storm
- Pre-storm sweeps to clear CIF (Critical Infrastructure Feeders) of vegetation were completed over 3684 miles within 3 days.
- Vegetation that was cleared included high risk trees (new dead or leaning), palms, bamboo, vines, or fast growing vegetation (cycle busters)

	# Feeders	Total Miles	Miles Swept	%
Dade	236	516	516	100%
East	304	936	877	94%
North	225	1402	1402	100%
West	133	889	889	100%
Grand Total	898	3743	3684	98%

CI related to Vegetation

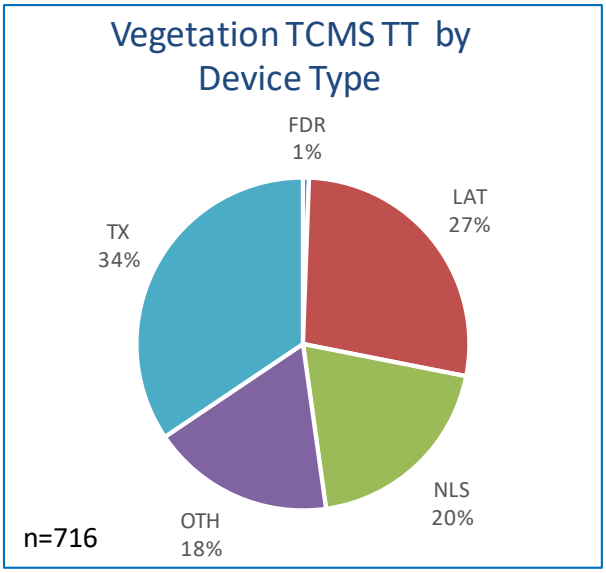
- 24% of CI (Customer Interuptions) was VEG cause codes (42,678 tcms /180,337 Carver)
  - 4% was due to Vines (1,752/42,678)
  - 96% was due to Trees and other vegetation (40,926/42,678)
- TCMS tickets issued from 9/2/19 to 9/4/19

11 Tree related Feeder Outages (all in North Region)

- 9 were Non –preventable from trees outside the Right of way.
- 2 were Palm related

Vegetation TCMS Trouble Tickets (TT)

- 28% of all TT restored needed Tree Work (849/2,976)
- Tickets to vegetation crews during restoration
  - 72% were secondary or service wire
  - 28% were Lateral or Feeder
- Legend
  - Other – location ticket not called in by customer and FPL created TCMS ticket
  - NLS – No Loss of Service
  - FDR – Feeder
  - LAT – Lateral
  - TX – Transformer, Secondary, Service



Case Study: Change Detection in Vegetation using LiDAR

The use of Drones began in Hurricane IRMA capturing pictures and videos. In this storm, the innovation team and Vegetation piloted the use of Drones and lidar to compare pre and post storm imagery. One of the goals for this storm was to determine processing time after the storm, which on average was 6 hours per feeder. This pilot was completed on two feeders and the results of the pilot are noted below.

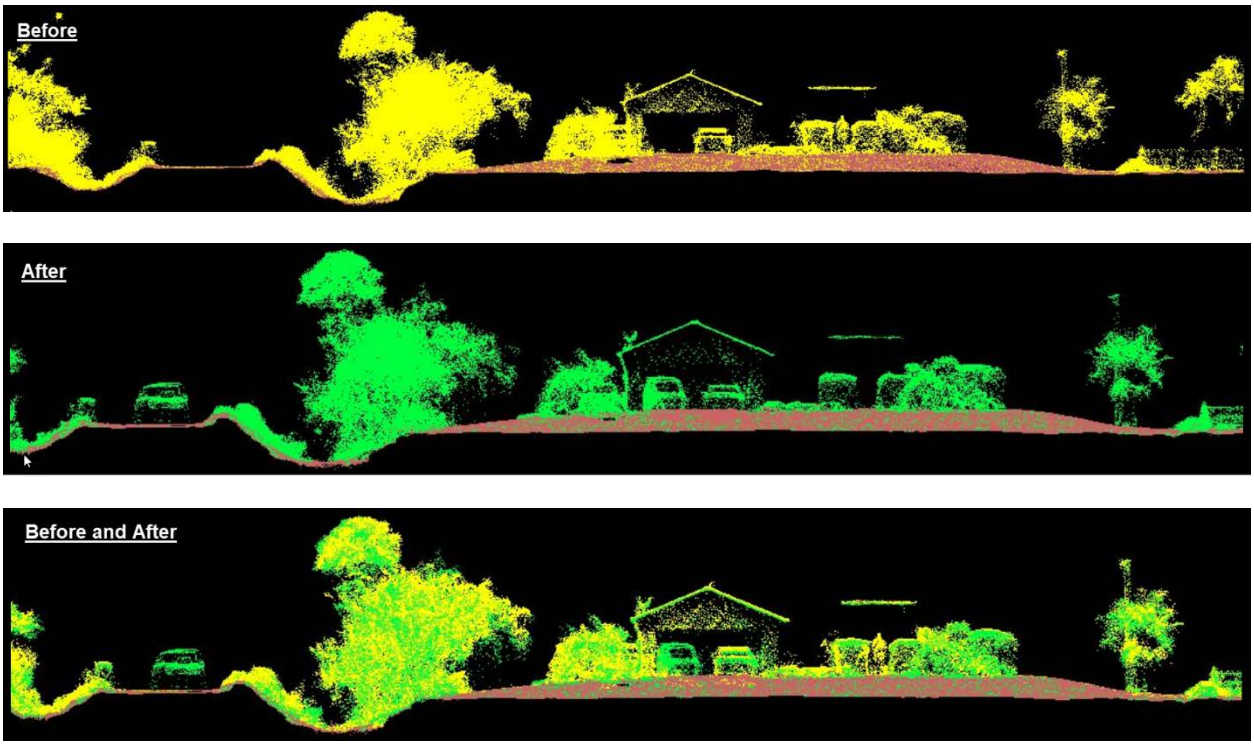
Vero Feeder

- No changes were found with broken poles or vegetation.

Edgewater Feeder

- No changes were found with broken poles or vegetation.

Below is an example of pre and post storm imagery:



Vegetation Pictures

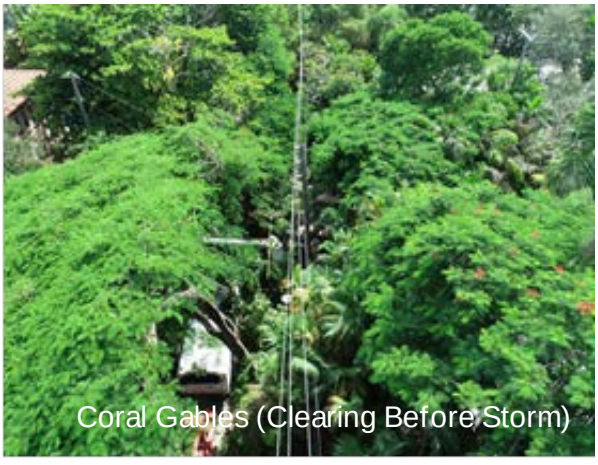

Daytona


Daytona


Melbourne

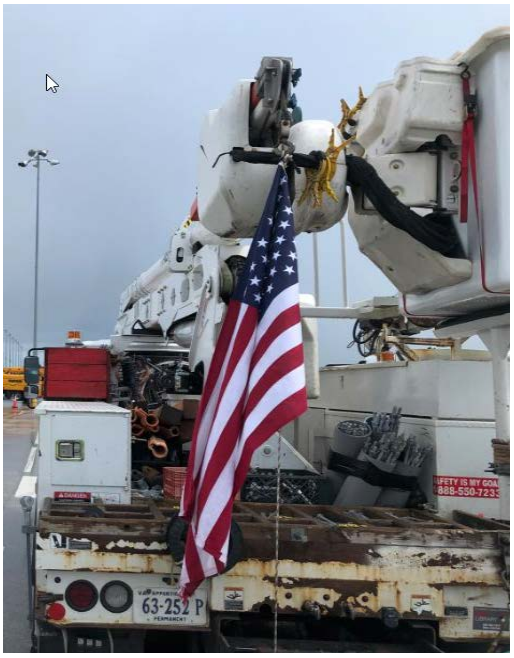

Vero Beach


St.Augustine


Coral Gables (Clearing Before Storm)

Staging Sites

Lake City staging site



Daytona Speedway staging site

St. Lucie Fairgrounds staging site

Jacksonville staging site

St. Augustine staging site

Forensics

Data Collection Findings / Number of Patrols

- Forensic (ESDA data collection) 10 Findings / 21 Patrols
- ALS Patrol (Findings reported back to team lead) 75 Findings / 379 Patrols
    - ALS (Automated Lateral Switch) identified ALS damaged and missing units

Background and Philosophy

FPL's Storm Forensic Organization was formed after the 2004-2005 active storm seasons to help evaluate Distribution infrastructure performance during extreme wind weather events. The data collected serves to meet FPL commitments to the FPSC which include annual summary reporting of infrastructure performance during hurricane events.

The field forensic teams were created to investigate affected areas and collect damage information to analyze performance of:

- Hardened Feeders
- Overhead Feeders
- Overhead vs. Underground Laterals

Note: Forensic investigations exclude locations under safety, property damage or other special investigation teams

Dorian Activation

Based on the projected path and intensity of Hurricane Dorian the Forensics Team was pre-activated, but not pre-positioned. As the storm approached Florida and turned North up the coast, the teams were deployed as conditions improved and were acceptable to begin patrol.

ESDA

Since communications were not down, FPL incorporated the use of the ESDA (Emergency Storm Damage Assessment) App on their smart device to collect data on the impacted Hardened Feeders. All Hardened Feeders affected, that were not related to substation or transmission outages, were patrolled using ESDA

Hardened Feeders

The primary objective of hardening is to reduce restoration times by minimizing the number of pole failures during extreme wind weather events. Pole failures typically lead to extended restoration times and longer outages. As a result, FPL forensic investigators use pole failure rates as the primary measurement criteria to evaluate performance of Hardened vs. non-Hardened Feeders within the impacted areas. Feeder field forensic data was collected to conduct root cause analysis and failure mode of previously Hardened Feeders that locked out during the storm. All calculations are based on field data collected from ESDA patrols.

Overhead Feeders

Investigation of selected Overhead Feeders impacted by extreme wind events is an annual reporting requirement to the FPSC. Inspection locations are defined based on selected routes within the path of the storm. The objective of inspections is to collect sample data on selected Feeder locations in order to evaluate infrastructure performance during extreme wind events. Field data from ESDA patrols, TCMS and other sources will be utilized.

Overhead vs. Underground Performance

The investigation and performance of Overhead vs. Underground infrastructure during extreme wind events is an annual reporting requirement to the FPSC. Forensic investigators examine selected Underground or Overhead Lateral facilities that were affected within the path of the storm. The objective of these inspections is to collect sample data from Overhead or Underground damage locations in order to evaluate and compare infrastructure performance of Overhead and Underground facilities during extreme wind event. Field data from ESDA patrols, TCMS and other sources will be utilized.

Defining Storm Affected Areas

The emergency preparedness department performs the storm tracking activities from forecast to actual storm path. This information is available to the GIS group Technology Coordinator and is used to identify the storm affected area. Prior to a storm event, the Forensic Leads and the Technology Coordinator will be in close contact to execute the below plan based on the latest possible forecast or pre-storm plan. After the storm has passed, the Forensics Team executes the pre-storm plan unless the actual event was significantly different, at which time a new plan based on the actual storm path will be developed.

Dorian affected FPL's entire service area including:

<u>Southeast Areas:</u>

Central Dade	North Dade	South Dade
West Dade	Central Broward	North Broward
South Broward	Boca Raton	West Palm

<u>North Management Areas:</u>

Treasure Coast	Brevard	Central Florida
North Florida		

<u>West Management Areas:</u>

Manasota	Naples	Toledo Blade

Distribution Hardening Programs

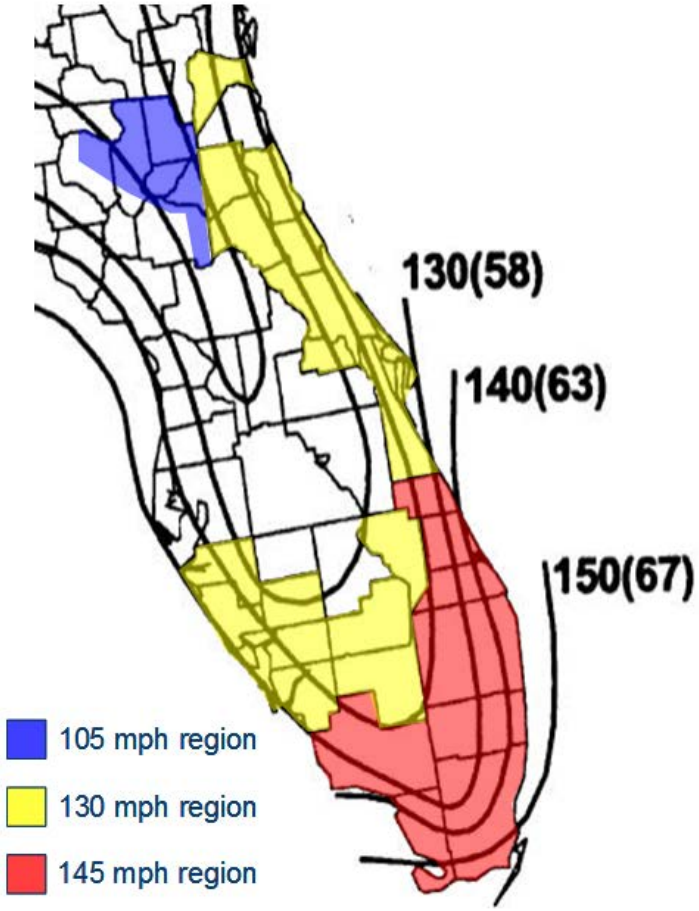
Storm Hardening Plan

- The Storm Hardening Plan started in 2006 and FPL has:
  - Hardened 170K poles through August 2019
- FPL's Storm Hardening Plan is filed with the PSC

PIP (Pole Inspection Program)

- The Pole Inspection Program started in 2006 and FPL has:
  - Replaced 87,246 through August 2019
  - Reinforced 57,595 through August 2019
- FPL's Pole Inspection Program is filed with the PSC.

Distribution Design Gust Wind Speeds



General Definitions / Acronyms

Affected - include only one interruption per device (for feeder, lateral, transformer, etc) if the device goes out multiple times

ALS – Automated Lateral Switch

AFS – Automated Feeder Switch

Broken or Downed Pole – Cannot carry electricity

Customers Affected - Customers that experienced an outage

CI - Customers Impacted which are customers that may have gone out more than once or nested outages.

CI Avoided – Customer Interruptions Avoided

CMH – Construction Man Hours (Labor)

DA – Distribution Automation

D&A – Design and Applications which coordinate the forensic operations and forensic patrols

ESDA - Electric Storm Damage Assessment is a mobile app and primary tool that facilitated the collection and characterization of the major types of damage on the Distribution system.

Hybrid Feeder - Combination of Feeder and Lateral miles between 5% - 95% UG

Interruptions - Total number of customer outages

Mean Higher High Water (MHHW) – An average of higher high water heights over time. Numbers are reported as the value above that regions value.

NHC – National Hurricane Center

NOS – National Ocean Service

OH Feeder - Combination of Feeder and Lateral miles < = 5% UG

RCA – Root Cause Analysis

TCMS – Trouble Call Management System

UG Feeder - Combination of Feeder and Lateral miles > = 95% UG