NATIONAL HURRICANE CENTER TROPICAL CYCLONE REPORT

HURRICANE BARRY

(AL022019)

11–15 July 2019

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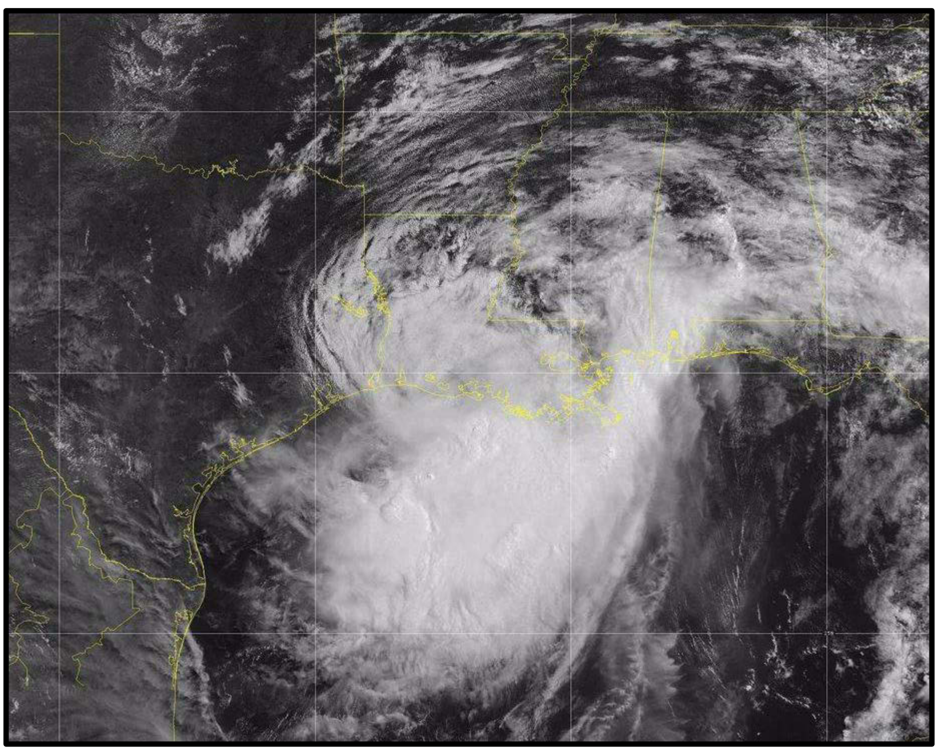

GOES-16 VISIBLE SATELLITE IMAGE AT 1520 UTC 13 JULY OF HURRICANE BARRY AROUND THE TIME IT MADE LANDFALL IN LOUISIANA.

Barry formed over the north-central Gulf of Mexico from a non-tropical origin and moved slowly west-northwestward across the northern Gulf. The cyclone made landfall as a category 1 hurricane (on the Saffir-Simpson Hurricane Wind Scale) over south-central Louisiana and produced a large area of heavy rainfall and flooding along and to the east of its center over the Mississippi Valley.

Hurricane Barry

11–15 JULY 2019

SYNOPTIC HISTORY

The origin of Barry was non-tropical, and the cyclone can be traced back to a mesoscale convective system that formed over the central United States. This thunderstorm complex and area of low pressure was first identifiable in satellite and radar imagery late on 2 July over southwestern Kansas (Fig. 1). The area of disturbed weather moved eastward across the south-central United States during the next several days, and it reached northern Georgia on 7 July. The disturbance slowed down and turned southeastward and then southward over Georgia and the Florida Panhandle on the east side of a low- to mid-level ridge during the next couple of days, with showers and thunderstorms gradually increasing during that time. The elongated low emerged over the far northeastern Gulf of Mexico late on 9 July with a large area of disorganized convection. Once offshore, the low moved southwestward on the southeast side of the ridge and gradually became better defined. Satellite images indicate that the low developed a well-defined center and had sufficiently organized deep convection around 0000 UTC 11 July to mark the formation of a tropical depression when it was located over the northern Gulf of Mexico about 170 n mi south of Mobile, Alabama. After genesis, convective banding continued to increase on the south side of the circulation, and the depression strengthened to Tropical Storm Barry 6 h later. The "best track" chart of Barry's path is given in Fig. 2, with the wind and pressure histories shown in Figs. 3 and 4, respectively. The best track positions and intensities are listed in Table 1[1].

Barry slowly strengthened during the next couple of days with its associated convection increasing in intensity and coverage. However, the thunderstorm pattern remained asymmetric with nearly all of the convection limited to the south of the center due to the combined influences of northerly shear and dry mid-level air. While gaining strength, Barry moved slowly westward to west-northwestward on the south and southwest sides of the above-mentioned ridge. Barry turned northwestward early on 13 July when it began to move toward a weakness in the ridge over the Mississippi Valley, and it strengthened to a category 1 hurricane on the Saffir-Simpson Hurricane Wind Scale around 1200 UTC that day when it was located just offshore of the south-central Louisiana coast. The cyclone maintained that intensity when it made landfall over a remote part of the Louisiana coast, about 10 n mi east-southeast of Pecan Island, around 1500 UTC 13 July. It should be noted that Barry never obtained the classic appearance of a hurricane in satellite imagery (cover image), and the cyclone remained asymmetric through landfall with much of its associated heavy rains occurring well to the south and east of the center (Fig. 5). Figure 6 shows the 34-, 50-, and 64-kt wind radii of Hurricane Barry. It can been seen that the

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[1] A digital record of the complete best track, including wind radii, can be found on line at ftp://ftp.nhc.noaa.gov/atcf. Data for the current year's storms are located in the *btk* directory, while previous years' data are located in the *archive* directory.

sustained hurricane-force-winds are estimated to have occurred over a relatively small area near the Louisiana coast.

After landfall, Barry turned north-northwestward and weakened, falling below hurricane strength by 1800 UTC 13 July when the center passed near Intracoastal City, Louisiana. The tropical storm's center moved across the western portion of Louisiana and Barry weakened to a tropical depression while centered just south of the Arkansas border by 0000 UTC 15 July. While moving northward over western Arkansas, the cyclone continued to weaken and it became a remnant low about 12 h later. Surface observations indicate that the low opened into a trough shortly after 0600 UTC 16 July when the system was located over southern Missouri.

METEOROLOGICAL STATISTICS

Observations in Hurricane Barry (Figs. 3 and 4) include subjective satellite-based Dvorak technique intensity estimates from the Tropical Analysis and Forecast Branch (TAFB) and the Satellite Analysis Branch (SAB), and objective Advanced Dvorak Technique (ADT) estimates and Satellite Consensus (SATCON) estimates from the Cooperative Institute for Meteorological Satellite Studies/University of Wisconsin-Madison. Observations also include flight-level, stepped frequency microwave radiometer (SFMR), and dropwindsonde observations from six flights (14 center fixes) by the 53rd Weather Reconnaissance Squadron of the U.S. Air Force Reserve Command and five flights by the NOAA Aircraft Operations Center. Data and imagery from NOAA polar-orbiting satellites including the Advanced Microwave Sounding Unit (AMSU), the NASA Global Precipitation Mission (GPM), the European Space Agency's Advanced Scatterometer (ASCAT), and Defense Meteorological Satellite Program (DMSP) satellites, among others, were also useful in constructing the best track of Barry. The National Weather Service WSR-88D radar network provided data for tracking Barry across the northern Gulf of Mexico and the south-central United States.

Ship reports of winds of tropical storm force associated with Barry are given in Table 2, and selected surface observations from land stations and data buoys are given in Table 3.

Winds and Pressure

The peak intensity of Barry of 65 kt at 1200 UTC 13 July is based on a combination of a surface observation, aircraft reports, and Doppler radar data. Around 1200 UTC 13 July, a National Ocean Service (NOS) observation site at Eugene Island, Louisiana, reported sustained winds of 62 kt and a gust of 74 kt. Around the same time and location, the Air Force Reserve Hurricane Hunters reported unflagged SFMR winds between 60–63 kt and a peak 850-mb flight-level wind of 73 kt, which corresponds to a surface wind of about 60 kt. In addition, Doppler velocities from the Lake Charles radar suggested that surface winds were in the 60–65 kt range around the same time. Based on these data, there is high confidence that Barry had peak winds around 65 kt from 1200 UTC 13 July through landfall a few hours later.

The highest wind observation over land was recorded at Acadiana Regional Airport in New Iberia, Louisiana, where sustained winds of 43 kt and a gust of 57 kt were reported on 13 July.

Most of Barry's strong winds were confined to the south-central portion of the Louisiana coast (Fig. 6).

The estimated minimum pressure of 993 mb from 1800 UTC 12 July through landfall around 1500 UTC 13 July is based on a combination of aircraft reports and surface observations. It is interesting to note that despite Barry's winds increasing during that time, the minimum pressure held steady, likely because Barry was moving into a region where surrounding pressures were high. The minimum pressure reported on land was 995 mb at Salt Point, Louisiana.

Storm Surge[2]

The highest measured storm surge from Barry was 6.13 ft above normal tide levels at an NOS gauge near Eugene Island, Louisiana, in Atchafalaya Bay. Larger departures from normal tide levels were observed at two gauges closer to shore in Atchafalaya Bay, but water levels at those stations were already higher than normal prior to Barry due to anomalously high freshwater discharge through the Mississippi River system (specifically the Atchafalaya River). With the inclusion of the high river discharge, the NOS gauge at Amerada Pass measured 6.93 ft above normal tide levels, and the gauge at Berwick measured 6.75 ft above normal tide levels.

The combined effect of the surge and tide produced inundation levels of 4 to 6 ft above ground level along the central Louisiana coast in and around Vermilion and Atchafalaya Bays. The NOS gauge near Eugene Island recorded a maximum water level of 5.3 ft above Mean Higher High Water (MHHW). Including the high river discharge, the Amerada Pass and Berwick gauges both measured peak water levels of 6.6 ft MHHW. A United States Geological Survey (USGS) streamflow gauge in Vermilion Bay at Cypremort Point recorded a maximum water level of 7.79 ft above the North American Vertical Datum of 1988 (NAVD88), which converts to about 6.5 ft MHHW. Another USGS gauge in Vermilion Bay near Intracoastal City recorded a water level of 6.84 ft NAVD88, which converts to about 5.6 ft MHHW. Figure 7 shows storm tide observations above MHHW from NOS gauges, which provide rough approximations of inundation above normally dry ground.

Elsewhere in Louisiana, inundation levels of 2 to 4 ft above ground level occurred along the southeastern Louisiana coast, and west of Vermilion Bay to Calcasieu Lake. The NOS gauge at the I-10 Bonnet Carre Floodway on the western side of Lake Pontchartrain measured a peak water level of 4.3 ft MHHW, while 3.2 ft MHHW was measured at Shell Beach. West of Vermilion Bay, a peak water level of 3.7 ft MHHW was recorded at the Freshwater Canal Locks in Vermilion Parish, and 2.4 ft MHHW was measured at the NOS gauges near Lake Charles.

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[2] Several terms are used to describe water levels due to a storm. **Storm surge** is defined as the abnormal rise of water generated by a storm, over and above the predicted astronomical tide, and is expressed in terms of height above normal tide levels. Because storm surge represents the deviation from normal water levels, it is not referenced to a vertical datum. **Storm tide** is defined as the water level due to the combination of storm surge and the astronomical tide, and is expressed in terms of height above a vertical datum, i.e. the North American Vertical Datum of 1988 (NAVD88) or Mean Lower Low Water (MLLW). **Inundation** is the total water level that occurs on normally dry ground as a result of the storm tide, and is expressed in terms of height above ground level. At the coast, normally dry land is roughly defined as areas higher than the normal high tide line, or Mean Higher High Water (MHHW).

Inundation levels of 2 to 3 ft above ground level occurred along the coasts of Mississippi and Alabama. In Mississippi, the highest measured water level was 3.0 ft MHHW at the NOS gauge at the Bay Waveland Yacht Club, and in Alabama, 2.8 ft MHHW was recorded at the Bayou La Batre Bridge. Inundation levels of 2 ft or less occurred along the Florida Panhandle coast and along the upper Texas coast.

Rainfall and Flooding

Barry produced heavy rainfall mainly along and to the east of the center's track, where strong rain bands set up over the same areas for a few days. The heaviest rainfall occurred over south-central and southwestern Louisiana where accumulations of 10 to 15 inches were widespread. The maximum reported storm-total rainfall was 23.58 inches near Ragley, Louisiana. Farther east in Louisiana, in the Baton Rouge and New Orleans areas, rainfall totals of 4 to 8 inches were common. Similar totals also occurred in southern portions of Mississippi and Alabama. Barry's heavy rains caused additional flooding to occur along the banks of the Atchafalaya River near Morgan City, Louisiana.

Even though Barry was weakening and ultimately became a remnant low as it headed inland, its slow motion resulted in heavy rains well inland into Arkansas. Barry produced a total of 16.59 inches of rain in Dierks, Arkansas, which was the most rain associated with a tropical system in the state's history. Most of that rain, 16.17 inches, occurred in just a 24-h period, which was a record-breaking 1-day rainfall amount in Arkansas.

Tornadoes

There were several reports of funnel clouds in East Baton Rouge and Livingston Parishes in Louisiana, but a survey conducted by the National Weather Service did not find damage indicative of a tornado path.

CASUALTY AND DAMAGE STATISTICS

There were no reports of deaths associated with Hurricane Barry. Damage associated with the storm was primarily due to flooding from a combination of heavy rains and storm surge, and was mostly confined to the state of Louisiana. For example, in Calcasieu Parish, dozens of homes experienced major flooding and more than 20 rescues were conducted. In St. Mary Parish, numerous trees and power lines were downed and many homes and businesses had wind damage. There was no significant damage reported in the metropolitan New Orleans area. Across Louisiana, first responders rescued 93 people from flood waters in 11 parishes. Minor wind damage and flooding from the heavy rains were widespread across much of the southern portion of the state. At one point, more than 300,000 people were without power. In Mississippi, there was minor flooding in beach areas near Biloxi, but no significant damage to homes, roadways, or businesses was reported. Total damage is estimated to be about $600 million according to the NOAA National Centers for Environmental Information.

FORECAST AND WARNING CRITIQUE

Genesis

The genesis of Barry was well anticipated despite its non-classical formation. The disturbance from which Barry developed was introduced into the Tropical Weather Outlook at 1800 UTC 6 July (102 h prior to genesis) with a low chance (<40%) of formation during the next 5 days (Table 4). The 5-day formation chance was raised to the medium category (40–60%) 84 h before genesis, and to the high category 66 h before formation occurred. The 2-day probabilities of formation also well anticipated Barry's development. The system was entered into the 2-day probabilities with a low chance of development 60 h before formation, and it entered the medium and high categories 42 h and 30 h before genesis, respectively. NHC began issuing Potential Tropical Cyclone advisories at 1500 UTC 10 September in order to issue a tropical storm watch for a portion of the northern Gulf Coast (additional details below), providing an additional 24 h of lead time before Barry was declared a tropical cyclone operationally.

Track

A verification of NHC official track forecasts for Barry is given in Table 5a. Official track forecast errors were lower than the mean official errors for the previous 5-yr period for all verifying forecast times. In fact, the NHC mean track errors were up to 45 percent lower than the long-term average errors at 12 and 96 h. The climatology and persistence errors (OCD5) errors were also well below their 5-yr means, indicating that Barry's track was easier to predict than average. A homogeneous comparison of the official track errors with selected guidance models is given in Table 5b. The best-performing models were the simple consensus aids TVCA, TVCX, and TVDG, which beat the official forecasts at all verifying times. AEMI and EMXI were strong performers and also beat the official forecasts at the short lead times. GFSI and HMNI were among the models that had the largest errors. The official forecasts had a slight eastward bias, especially for the portion of Barry's track over the south-central United States (Fig. 8). This bias was present in most of the model guidance as well (not shown).

Intensity

A verification of NHC official intensity forecasts for Barry is given in Table 6a. Official intensity forecast errors were much lower than the mean official errors for the previous 5-yr period at all forecast times. As was the case for track, the OCD5 errors were also well below their 5-yr means, indicating that Barry's intensity was easier to predict than normal. A homogeneous comparison of the official intensity errors with selected guidance models is given in Table 6b. The official intensity forecasts were outstanding from 12 to 48 h, beating all of the guidance. Among the models, the simple consensus models were the best, with IVCN and IVDR having errors slightly above the official forecasts from 12 to 48 h. Several models outperformed the NHC forecasts at 72 h, but the sample was too small to draw meaningful conclusions. The NHC intensity forecasts had little bias overall, but the first couple of forecasts predicted Barry to become slightly stronger than what occurred (Fig. 9).

Storm Surge

NHC's first forecast for maximum storm surge inundation (at 1500 UTC 10 July) was 3 to 5 ft above ground level from Morgan City, Louisiana, to the mouth of the Pearl River. The area expected to receive the highest inundation was expanded from Intracoastal City, Louisiana, to the mouth of the Pearl River the forecast values were raised slightly to 3 to 6 ft above ground level by that afternoon (2100 UTC 10 July). These forecasts verified well since the maximum inundation levels were 4 to 6 ft above ground level between Intracoastal City and Morgan City.

Watches and Warnings

Potential Tropical Cyclone advisories were issued for the disturbance that became Barry beginning at 1500 UTC 10 July, in order to issue a tropical storm watch for a portion of the Louisiana coast (Table 7). This watch was upgraded to a hurricane watch 6 h later. The hurricane watch along the northern Gulf coast was issued a little more than 48 h before the arrival of tropical-storm-force winds along that section of coastline. Hurricane and tropical storm warnings were issued with a little more than 36 h of lead time.

The NWS issued storm surge warnings for portions of the coasts of Louisiana and Mississippi from Intracoastal City, Louisiana, to Biloxi, Mississippi, including the northern and western shores of Lake Pontchartrain. The NWS also issued storm surge watches for portions of southeastern Louisiana inland of the storm surge warnings, and for the coast of Mississippi from Biloxi to the Alabama border (Table 8). Water level observations indicate that up to 3 ft of inundation (which NHC uses as a first-cut threshold for the storm surge watch/warning) occurred along portions of the coast from just west of Vermilion Bay, Louisiana, eastward to the western coast of Mississippi, as well as along the shore of Lake Pontchartrain (Fig. 10). Overall, the storm surge warning verified well, with the endpoints of the warning area being close to the cut-off of areas that received at least 3 ft of inundation.

The NWS issued the initial storm surge watch from the mouth of the Pearl River westward to Morgan City, Louisiana, at 1500 UTC 10 July, which was 48–54 h before sustained tropical-storm-force winds began along that portion of the coast. The initial storm surge warning was issued from the mouth of the Atchafalaya River to Shell Beach at 1500 UTC 11 July, which was 24–30 h before sustained tropical-storm-force winds began along that portion of the coast.

Impact-Based Decision Support Services (IDSS) and Public Communication

The NHC began providing direct support to emergency managers on 9 July, when Barry was a broad low in the northeastern Gulf of Mexico, and this support continued through 14 July, when Barry was inland over Louisiana. The decision support included calls and briefings coordinated through the FEMA Hurricane Liaison Team, embedded at the NHC. These briefings included Federal/State video-teleconferences with Mississippi, Alabama, and Louisiana, FEMA Headquarters, FEMA Region 6, and FEMA Region 4. In addition, the NHC director maintained direct communications with senior state emergency management officials to discuss the evolving threat to the Gulf Coast. NHC's Tropical Analysis and Forecast Branch provided six briefings for the U.S. Coast Guard District 8 in support of their life-saving mission and operations during Hurricane Barry.

Prior to Barry's formation, there was significant run-to-run variability in model guidance as to the eventual track of the system along the Gulf Coast. For example, 7-day forecasts of heavy rainfall that did not materialize a week later across portions of southeast Texas were supported by global deterministic models and their ensemble systems, including the GFS and ECMWF. Within 5 days of landfall, rainfall forecasts from the Weather Prediction Center had correctly shifted east to Louisiana, and while rainfall amounts were still over forecast, the placement of the rainfall was improved. While these forecasts were made before NHC began issuing advisories on what became Barry, they highlight the IDSS challenges associated with messaging storm surge, rainfall, and wind hazard potential for a system that had not yet formed.

The NHC media pool was in operation from 11–13 July, and more than 80 live briefings to national and local television outlets were performed. NHC also conducted 11 Facebook Live broadcasts during the 11–13 July period, and these received more than 400,000 views. The NHC Twitter account received about 20 million impressions during the course of the storm, and the Facebook account reached about 2.4 million people. In addition, more than 50 phone interviews to national and local media outlets were provided during the event. During the six-day threat from Barry, the NHC web site received approximately 472 million web hits with about 27 million page views. The majority of the page views went to the graphical products.

ACKNOWLEDGMENTS

Data in Table 3 were compiled from Post Tropical Cyclone (PSH) Reports issued by the NWS Weather Forecast Offices (WFOs) in New Orleans and Lake Charles. Additional data were used from reports sent by the National Data Buoy Center and the NOS Center for Oceanographic Products and Services. Reports from the Mobile WFO provided information on rainfall and flooding in Alabama and portions of the Florida Panhandle, and data from the Little Rock WFO was also used in this report. Tiffany Hersey, Dennis Feltgen, and Matt Onderlinde contributed to the IDSS section. Figures 7 and 10 were provided by NHC's Storm Surge Unit.

Table 1. Best track for Hurricane Barry, 11–15 July 2019.

Date/Time (UTC)	Latitude (°N)	Longitude (°W)	Pressure (mb)	Wind Speed (kt)	Stage
10 / 1200	28.5	86.5	1009	25	disturbance
10 / 1800	28.1	87.1	1009	30	"
11 / 0000	27.8	87.6	1008	30	tropical depression
11 / 0600	27.7	88.0	1007	35	tropical storm
11 / 1200	27.7	88.4	1005	35	"
11 / 1800	27.7	88.8	1005	40	"
12 / 0000	27.8	89.2	1001	45	"
12 / 0600	27.9	89.7	1001	45	"
12 / 1200	28.1	90.2	998	50	"
12 / 1800	28.4	90.7	993	55	"
13 / 0000	28.6	91.1	993	60	"
13 / 0600	28.9	91.5	993	60	"
13 / 1200	29.3	91.9	993	65	hurricane
13 / 1500	29.6	92.2	993	65	"
13 / 1800	29.9	92.4	996	60	tropical storm
14 / 0000	30.4	92.8	999	50	"
14 / 0600	31.0	93.2	1003	40	"
14 / 1200	31.6	93.5	1005	35	"
14 / 1800	32.3	93.6	1007	35	"
15 / 0000	33.0	93.6	1008	25	tropical depression
15 / 0600	33.9	93.6	1008	25	"
15 / 1200	34.7	93.6	1008	20	low
15 / 1800	35.5	93.5	1008	20	"
16 / 0000	36.3	93.3	1009	15	"
16 / 0600	37.2	92.9	1010	15	"
16 / 1200					dissipated
13 / 1200	29.3	91.9	993	65	maximum wind
13 / 1500	29.6	92.2	993	65	Landfall about 10 n mi east-southeast of Pecan Island, LA

Table 2. Selected ship reports with winds of at least 34 kt for Hurricane Barry, 11–15 July 2019. Note that many wind observations are taken from anemometers located well above the standard 10 m observation height.

Date/Time (UTC)	Ship call sign	Latitude (°N)	Longitude (°W)	Wind dir/speed (kt)	Pressure (mb)
11 / 1200	2AKI3	28.4	87.9	190 / 49	1010.2
11 / 1800	A8AK7	21.6	85.8	270 / 39	1010.3
11 / 2000	V7IY4	27.2	87.3	140 / 38	1009.0
11 / 2000	BGCF1	26.4	81.9	220 / 37	1015.4
11 / 2136	RLOT2	29.5	94.5	060 / 38	1010.6
11 / 2300	2AKI3	25.8	87.4	200 / 49	1009.2
12 / 0100	V7IY4	27.3	87.0	180 / 39	1009.0
12 / 0500	3FOB5	26.1	83.7	180 / 35	1014.8
12 / 0500	V7IY4	27.2	87.3	150 / 37	1010.0
12 / 0600	3FOB5	25.9	83.9	180 / 35	1014.1
12 / 0600	WDF476	26.0	89.4	240 / 35	1008.3
12 / 0700	3FOB5	25.7	84.0	180 / 35	1013.6
12 / 0800	V7IY4	27.2	87.1	150 / 38	1010.0
12 / 1000	H3VR	28.7	87.5	180 / 40	1006.8
12 / 1200	WDF476	26.0	88.9	240 / 38	1009.1
12 / 1300	V7IY4	27.1	87.1	190 / 50	1011.0
12 / 1300	DPIA1	30.2	88.1	150 / 35	1009.7
12 / 1500	WHDV	26.5	90.8	220 / 48	
12 / 1500	HSDA	28.8	89.3	160 / 53	
12 / 1700	A8ZQ7	28.8	89.1	160 / 53	1005.0
12 / 1800	H3VR	26.7	87.4	240 / 38	1007.2
12 / 1800	KPSJ	27.0	90.0	240 / 45	1013.0
12 / 1900	HSDK	28.7	89.2	160 / 55	1002.0
12 / 2000	WNFQ	28.1	87.3	190 / 36	1012.3
13 / 0100	V7IY4	27.0	87.2	180 / 39	1012.0
13 / 0700	C6FZ7	27.5	92.2	240 / 50	1004.1

Table 3. Selected surface observations for Hurricane Barry, 11–15 July 2019.

Location	Minimum Sea Level Pressure		Maximum Surface Wind Speed			Storm surge (ft)[c]	Storm tide (ft)[d]	Estimated Inundation (ft)[e]	Total rain (in)
	Date/ time (UTC)	Press. (mb)	Date/ time (UTC)[a]	Sustained (kt)[b]	Gust (kt)				
Offshore Oil Platforms									
KMDJ- MS Canyon 311A (28.64N 89.79W)			12/1715	66 (90 m/2-min)	78				
KMIS-MP 140B (29.30N 88.84W)			13/0935	44 (85 m/2-min	54				
KVKY- Main Pass 289C (29.25N 88.84W)			12/0055	39 (115 m/2-min	43				
Buoys									
KEIR-Eugene Island 215 (28.63N 91.49W)		994.4	13/1054	62 (25 m)	79				
Other									
SPLL1- S Pelto Block (28.87N 90.48W)			13/0300	59 (10 m/2-min)	69				
United States									
Florida									
National Ocean Service (NOS) Sites									
Panama City Beach (PCBF1) (30.21N 85.88W)	12/0830	1010.9	11/1948	31 (17 m)	36	1.97	2.83	1.9	
Pensacola (PCLF1) (30.40N 87.21W)	12/0936	1009.2	12/1348	21 (10 m)	26	1.86	2.60	1.7	
Apalachicola (APCF1) (29.72N 84.98W)	12/0912	1011.9	12/0812	25 (9 m)	29	1.60	2.42	1.6	
Panama City (PACF1) (30.15N 85.67W)			12/0912	21 (12 m)	30	1.40	2.21	1.4	
Cedar Key (CDRF1) (29.14N 83.03W)	12/0848	1012.4	12/1936	23 (10 m)	31	1.77	2.67	1.1	
Alabama									
NOS Sites									
Bayou La Batre Bridge (BLBA1) (30.41N 88.25W)						2.67	3.75	2.8	
Coast Guard Sector Mobile (MCGA1) (30.65N 88.06W)	12/0912	1008.5	13/1224	25 (9 m)	32	2.83	3.84	2.7	
West Fowl River Bridge (WFRA1) (30.38N 88.16W)						2.64	3.43	2.5	
Weeks Bay, Mobile Bay (WBYA1) (30.42N 87.83W)						2.49		2.5	
Mobile State Docks (OBLA1) (30.70N 88.04W)	12/0912	1008.6				2.19	3.47	2.3	
Dog River Bridge (BYSA1) (30.55N 88.09W)						2.31		2.3	
Chickasaw Creek (CIKA1) (30.78N 88.07W)						2.28		2.1	
East Fowl River Bridge (EFRA1) (30.44N 88.11W)						2.07	3.10	2.3	

Location	Minimum Sea Level Pressure		Maximum Surface Wind Speed			Storm surge (ft)[c]	Storm tide (ft)[d]	Estimated Inundation (ft)[e]	Total rain (in)
	Date/ time (UTC)	Press. (mb)	Date/ time (UTC)[a]	Sustained (kt)[b]	Gust (kt)				
Dauphin Island (DILA1) (30.25N 88.08W)	12/0824	1008.3	12/1300	33 (11 m)	46	2.00	2.92	2.2	
Fort Morgan (FMOA1) (30.23N 88.02W)	12/0824	1007.7	13/1148	38 (38 m)	47				
Mississippi									
NOS Sites									
Bay Waveland Yacht Club (WYCM6) (30.33N 89.33W)	12/1118	1006.5	12/2142	29 (10 m)	37	3.16	4.05	3.0	
Pascagoula NOAA Lab (PNLM6) (30.37N 88.56W)						2.15	3.31	2.4	
Petit Bois Island, Port of Pascagoula (PTBM6) (30.21N 88.51W)	12/0912	1007.0	13/0742	31 (5 m)	44				
National Estuarine Research Reserve System (NERRS) Sites									
Grand Bay, Mississippi Sound (GBRM6) (30.41N 88.40W)						2.65	3.63	2.6	
United States Geological Survey (USGS) Streamflow Gauges									
East Pearl River at CSX Railroad near Claiborne (EPCM6) (30.19N 89.53W)							4.37		
Back Bay of Biloxi near Biloxi (BBBM6) (30.42N 88.98W)							3.45		
Louisiana									
NOS Sites									
Grand Isle (GISL1) (29.26N 89.96W)	12/2306	999.3	12/2312		45				
SW Pass (BURL1) (28.90N 89.43W)	12/0900	1005.0	12/1510	50 (38 m/10-min)	60				
National Ocean Service (NOS) Sites									
Amerada Pass (ARML1) (29.45N 91.34W)	13/0818	995.3	13/1024	31 (11 m)	53	6.93*	7.43*	6.6*	
Berwick (TESL1) (29.67N 91.24W)	13/0836	996.7	13/1712	40 (12.5 m)	55	6.75*		6.6*	
Calcasieu Pass (CAPL1) (29.77N 93.34W)	13/1024	1000.4	14/1500	40 (12 m)	48	2.27		1.9	
Freshwater Canal Locks (FRWL1) (29.55N 92.31W)	13/1042	996.5	14/0506	41 (17 m)	55	5.66		3.7	
New Canal (NWCL1) (30.03N 90.11W)	12/1300	1003.0	12/1306	31 (10 m/2-min)	39	3.51		3.1	
Pilottown (PILL1) (29.18N 89.26W)	12/1030	1000.9	12/1524	37 (9.5 m/2-min	46	2.51		2.5	
Shell Beach (SHBL1) (29.87N 89.67W)	12/1130	1003.9	12/1424	35 (16 m/2-min)	41	3.54	3.94	3.2	

Location	Minimum Sea Level Pressure		Maximum Surface Wind Speed			Storm surge (ft)[c]	Storm tide (ft)[d]	Estimated Inundation (ft)[e]	Total rain (in)
	Date/ time (UTC)	Press. (mb)	Date/ time (UTC)[a]	Sustained (kt)[b]	Gust (kt)				
SW Pass- Pilots Station E (PSTL1) (28.93N 89.41W)	12/1018	1001.1	12/2242	45 (20 m/2-min)	57				
Pilottown (PILL1) (29.18N 89.26W)	12/1030	1000.9	12/1524	37 (12 m)	46	2.51		2.5	
Lake Charles Bulk Terminal (BKTL1) (30.19N 93.30W)						2.63		2.4	
Lake Charles (LCLL1) (30.22N 93.22W)	13/2212	1001.2				2.60		2.4	
Pilots Station East, SW Pass (PSTL1) (28.93N 89.41W)	12/1018	1001.1	12/2242	45 (24 m)	57	2.28		2.2	
Port Fourchon, Belle Pass (PTFL1) (29.11N 90.20W)						2.42		2.1	
Grand Isle (GISL1) (29.26N 89.96W)	12/2306	999.3	12/0306	28 (9 m)	45	3.08		2.0	
Frenier Landing (FREL1) (30.11N 90.42W)	12/2118	1003.1	13/0154	30 (10 m)	39				
Advanced Hydrological Prediction Service (AHPS) Sites									
Cypremort Point (VCPL1) (29.71N 91.88W)			13/2330		64				
5 WNW Moss Bluff (CWFL1) (30.34N 93.28W)									13.72
4 NW Moss Bluff (CIBL1) (30.34N 93.25W)									10.76
Weatherflow									
Bayou Bienvenue (30.00N 89.90W)			12/1251	38 (27 m/1-min)	47				
Dulac (29.35N 90.73W)			13/0739	42 (10 m/1-min)	59				
East Bay Tower (29.06N 89.30W)			12/1504	43 (15 m/1-min)	56				
Mandeville (30.36N 90.09W)	12/2145	1003.6	13/0945	34 (10 m/1-min)	44				
Midlake (30.20N 90.12W)	12/2249	1004.1	13/0429	35 (12.5 m/1-min)	45				
USGS Streamflow Gauges									
Vermilion Bay near Cypremort Point (VCPL1) (29.71N 91.88W)							7.79	6.5	
Vermilion Bay near Intracoastal City (ICCL1) (29.67N 92.14W)							6.84	5.6	
Caillou Bay SW of Cocodrie (CCOL1) (29.08N 90.87W)							6.55	5.6	
Barataria Pass at Grand Isle (EGIL1) (29.27N 89.95W)							4.01	3.2	
Caminada Pass NW of Grand Isle (CPGL1) (29.23N 90.05W)							3.61	2.8	

Location	Minimum Sea Level Pressure		Maximum Surface Wind Speed			Storm surge (ft)[c]	Storm tide (ft)[d]	Estimated Inundation (ft)[e]	Total rain (in)
	Date/ time (UTC)	Press. (mb)	Date/ time (UTC)[a]	Sustained (kt)[b]	Gust (kt)				
Black Bay near Snake Island near Pointe-a-la-Hache (PSIL1) (29.63N 89.56W)							5.56		
Tchefuncte River at Madisonville (MSVL1) (30.40N 90.15W)							4.79		
Rigolets at Hwy 90 near Slidell (RFPL1) (30.17N 89.74W)							4.00		
Empire Waterway south of Empire (EWEL1) (29.30N 89.60W)							3.77		
Other Marine									
LOPL1- Louisiana Offshore Oil Port (28.89N 90.03W)	12/2242	997.1	12/2142	51 (58 m/2-min)	59				
COOP									
1 NE Bunkie (BNKL1) (30.96N 92.18W)									11.80
1 SSW Oberlin (OBEL1) (30.60N 92.77W)									18.16
CWOP									
4 WSW Gillis (D3319) (30.36N 93.27W)									12.19
Community Collaborative Rain, Hail and Snow Network (CoCoRaHS) Sites									
Bunkie (LA-AV-1) (30.95N 92.19W)									12.44
1 NW Oberlin (30.62N 92.77W)									14.70
5 SE Ragley (LA-BG-2) (30.46N 93.17W)									15.74
Other									
Port Fourchon Heliport (KXPY) (29.12N 90.20W)			12/1815	33 (10 m/1-min)	54				
1 NE Bordelonville (30.11N 91.90W)									12.98
2 E Buhler (CLBL1) (30.33N 93.33W)									13.40
1 WSW Bunkie (30.95N 92.20W)									12.29
1 ESE Cottonport (30.98N 92.03W)									17.12
1 NW Dupont (30.94N 91.96W)									11.72
De Quincy (30.45N 93.44W)									12.86
5 SSW De Quincy (CGEL1) (30.38N 93.46W)									11.64
2 SSE De Quincy (CBUL1) (30.42N 93.42W)									10.92
2 ESE De Quincy (CRGL1) (30.44N 93.42W)									10.20
3 WNW Gillis (CIHL1) (30.39N 93.25W)									14.96

Location	Minimum Sea Level Pressure		Maximum Surface Wind Speed			Storm surge (ft)[c]	Storm tide (ft)[d]	Estimated Inundation (ft)[e]	Total rain (in)
	Date/ time (UTC)	Press. (mb)	Date/ time (UTC)[a]	Sustained (kt)[b]	Gust (kt)				
1 S Gillis (CSGL1) (30.35N 93.20W)									10.88
2 SW Gillis (CIPL1) (30.35N 93.23W)									10.16
3 NW Grand Prairie (30.71N 92.18W)									10.60
2 W Mansura (31.06N 92.08W)									16.08
4 SSW Marksville (31.07N 92.08W)									16.08
1 E Morgan City (29.70N 91.18W)									10.60
4 NW Moss Bluff (30.34N 93.26W)									11.94
4 S Ragley (30.46N 93.23W)									23.58
2 SSW Ragley (30.49N 93.24W)									18.78
1 E Simmesport (SMAL1) (30.98N 91.80W)									11.12
2 WSW Topsy (CMBL1) (30.40N 93.15W)									11.51
6 ENE Ville Platte (30.71N 92.19W)									10.60
Texas									
NOS Sites									
Rainbow Bridge (8770520) (29.98N 93.88W)						2.07	2.34	1.7	
Texas Point, Sabine Pass (TXPT2) (29.69N 93.84W)	13/0848	1002.3	14/1648	36 (13 m)	49	2.08		1.3	
Sabine Pass North (SBPT2) (29.73N 93.87W)	13/0848	1004.9	14/2142	26 (6 m)	38	2.21		1.3	
Eagle Point (EPTT2) (29.48N 94.92W)	13/0836	1004.4				1.49		1.1	
Texas Coastal Ocean Observing Network (TCOON) Sites									
Port Arthur (PORT2) (29.87N 93.93W)	13/2112	1003.4	14/2230	23 (11 m)	32	2.02	2.11	1.5	
High Island (HIST2) (29.59N 94.39W)	13/0842	1003.6				1.96		1.2	
Rollover Pass (RLOT2) (29.52N 94.51W)	13/0830	1004.1				1.65		1.1	

Table 4. Number of hours in advance of formation associated with the first NHC Tropical Weather Outlook forecast in the indicated likelihood category. Note that the timings for the "Low" category do not include forecasts of a 0% chance of genesis.

	Hours Before Genesis	
	48-Hour Outlook	**120-Hour Outlook**
Low (<40%)	60	102
Medium (40%-60%)	42	84
High (>60%)	30	66

Table 5a. NHC official (OFCL) and climatology-persistence skill baseline (OCD5) track forecast errors (n mi) for Hurricane Barry, 11–15 July 2019. Mean errors for the previous 5-yr period are shown for comparison. Official errors that are smaller than the 5-yr means are shown in boldface type.

	Forecast Period (h)						
	12	24	36	48	72	96	120
OFCL	**13.3**	**21.6**	**30.4**	**41.1**	**70.6**	**75.0**	
OCD5	22.7	39.8	64.9	92.4	136.4	128.7	
Forecasts	16	14	12	10	6	2	
OFCL (2014-18)	23.6	35.5	47.0	61.8	96.0	136.0	179.6
OCD5 (2014-18)	44.8	97.6	157.4	220.1	340.7	446.6	536.6

Table 5b. Homogeneous comparison of selected track forecast guidance models (in n mi) for Hurricane Barry, 11–15 July 2019. Errors smaller than the NHC official forecast are shown in boldface type. The number of official forecasts shown here will generally be smaller than that shown in Table 5a due to the homogeneity requirement.

Model ID	Forecast Period (h)						
	12	24	36	48	72	96	120
OFCL	17.3	26.5	35.6	49.1	68.2		
OCD5	22.6	41.9	68.1	105.9	174.5		
GFSI	19.2	33.0	50.2	69.2	116.2		
HMNI	22.0	37.5	60.8	78.2	96.2		
HWFI	19.4	26.8	37.4	53.4	69.6		
EGRI	18.9	28.9	**34.7**	49.7	142.7		
EMXI	**15.6**	**20.9**	**33.5**	54.1	94.0		
CMCI	24.5	44.5	73.8	84.6	79.7		
NVGI	19.2	31.1	46.4	57.5	69.4		
CTCI	21.5	33.8	41.9	60.9	73.6		
AEMI	**11.2**	**16.8**	**28.5**	**43.8**	95.0		
HCCA	17.6	28.4	37.2	**45.9**	**54.1**		
FSSE	**16.9**	**23.0**	37.0	**47.2**	**40.0**		
TVCA	**15.6**	**21.1**	**26.2**	**33.0**	**41.2**		
TVCX	**14.7**	**20.3**	**26.3**	**36.7**	**46.0**		
TVDG	**14.9**	**19.6**	**23.8**	**30.2**	**31.2**		
GFEX	**15.4**	26.7	41.1	60.0	100.7		
TABD	27.2	61.6	102.9	141.3	243.3		
TABM	17.3	**24.3**	**35.4**	52.6	149.0		
TABS	46.9	99.7	133.2	154.4	204.6		
Forecasts	9	9	8	6	2		

Table 6a. NHC official (OFCL) and climatology-persistence skill baseline (OCD5) intensity forecast errors (kt) for Hurricane Barry, 11–15 July 2019. Mean errors for the previous 5-yr period are shown for comparison. Official errors that are smaller than the 5-yr means are shown in boldface type.

	Forecast Period (h)						
	12	24	36	48	72	96	120
OFCL	**2.8**	**2.9**	**3.9**	**3.0**	**5.0**	**7.5**	
OCD5	3.9	4.0	7.6	10.5	4.0	3.5	
Forecasts	16	14	12	10	6	2	
OFCL (2014-18)	5.3	7.9	9.9	11.2	13.3	14.4	14.2
OCD5 (2014-18)	6.9	10.9	14.3	17.4	20.9	22.0	22.8

Table 6b. Homogeneous comparison of selected intensity forecast guidance models (in kt) for Hurricane Barry, 11–15 July 2019. Errors smaller than the NHC official forecast are shown in boldface type. The number of official forecasts shown here will generally be smaller than that shown in Table 6a due to the homogeneity requirement.

Model ID	Forecast Period (h)						
	12	24	36	48	72	96	120
OFCL	2.0	2.5	4.4	2.9	3.3		
OCD5	2.7	3.4	5.4	6.9	4.0		
HMNI	4.5	5.8	7.4	5.6	8.3		
HWFI	3.4	4.7	6.6	3.1	**3.0**		
GFSI	4.7	4.3	6.0	4.0	3.3		
EMXI	6.3	6.4	8.1	6.1	3.3		
CTCI	4.3	5.0	6.8	6.1	7.3		
HCCA	2.6	4.7	6.2	3.0	**1.3**		
IVCN	3.5	4.2	5.3	4.9	**2.7**		
IVDR	3.3	3.6	5.0	3.9	**2.3**		
DSHP	4.6	6.4	7.9	6.7	**3.0**		
LGEM	4.3	6.6	8.7	8.0	3.7		
FSSE	2.9	4.4	6.1	4.7	13.3		
Forecasts	10	10	9	7	3		

Table 7. Hurricane and tropical storm watch and warning summary for Hurricane Barry, 11–15 July 2019.

Date/Time (UTC)	Action	Location
10 / 1500	Tropical Storm Watch issued	Morgan City to Mississippi River
10 / 2100	Tropical Storm Watch modified to	Mississippi River to Pearl River
10 / 2100	Hurricane Watch issued	Cameron to Mississippi River
11 / 1500	Tropical Storm Watch modified to	Pearl River to AL/MS border
11 / 1500	Tropical Storm Watch issued	Lake Pontchartrain
11 / 1500	Tropical Storm Watch issued	Lake Maurepas
11 / 1500	Tropical Storm Warning issued	Morgan City to Pearl River
11 / 2100	Tropical Storm Watch changed to Tropical Storm Warning	Lake Pontchartrain
11 / 2100	Tropical Storm Watch changed to Tropical Storm Warning	Lake Maurepas
11 / 2100	Tropical Storm Warning modified to	Grand Isle to Pearl River
11 / 2100	Tropical Storm Warning issued	Cameron to Intracoastal City
11 / 2100	Hurricane Watch modified to	Cameron to Intracoastal City
11 / 2100	Hurricane Warning issued	Intracoastal City to Grand Isle
13 / 1500	Tropical Storm Warning changed to Hurricane Watch	Cameron to Intracoastal City
13 / 1500	Tropical Storm Watch discontinued	All
13 / 1500	Tropical Storm Warning issued	Sabine Pass to Intracoastal City
13 / 1500	Hurricane Watch discontinued	Grand Isle to Mississippi River
13 / 1800	Hurricane Watch discontinued	All
13 / 2100	Tropical Storm Warning modified to	Sabine Pass to Mississippi River
13 / 2100	Tropical Storm Warning discontinued	Grand Isle to Pearl River
13 / 2100	Hurricane Warning discontinued	All
14 / 0000	Tropical Storm Warning modified to	Cameron to Mississippi River
14 / 0300	Tropical Storm Warning modified to	Cameron to Grand Isle
14 / 0600	Tropical Storm Warning modified to	Cameron to Morgan City
14 / 0600	Tropical Storm Warning discontinued	Lake Pontchartrain

Date/Time (UTC)	Action	Location
14 / 0600	Tropical Storm Warning discontinued	Lake Maurepas
14 / 2100	Tropical Storm Warning discontinued	All

Table 8. Storm Surge watch and warning summary for Hurricane Barry, 11–15 July 2019.

Date/Time (UTC)	Action	Location
10 / 1500	Storm Surge Watch issued	Morgan City to Pearl River
10 / 2100	Storm Surge Watch modified to	Intracoastal City to Pearl River
11 / 1500	Storm Surge Warning issued	Shell Beach to Atchafalaya River
11 / 1500	Storm Surge Watch issued	Pearl River to Mississippi-Alabama border
11 / 2100	Storm Surge Watch issued	Lake Pontchartrain
12 / 0300	Storm Surge Warning modified to	Intracoastal City to Shell Beach
12 / 0300	Storm Surge Watch modified to	Shell Beach to Mississippi-Alabama border
12 / 1500	Storm Surge Watch changed to Storm Surge Warning	Lake Pontchartrain
12 / 1500	Storm Surge Warning modified to	Intracoastal City to Biloxi
12 / 1500	Storm Surge Watch modified to	Biloxi to Mississippi-Alabama border
13 / 2100	Storm Surge Watch discontinued	Biloxi to Mississippi-Alabama border
14 / 0600	Storm Surge Watch discontinued	All
14 / 0600	Storm Surge Warning discontinued	Atchafalaya River to Biloxi
14 / 0600	Storm Surge Warning discontinued	Lake Pontchartrain
14 / 1500	Storm Surge Warning discontinued	All

Figure 1. GOES-16 visible satellite image of a mesoscale convective system (red star) at 1930 UTC 2 July that led to the formation of Hurricane Barry. The red line depicts the track of the system.

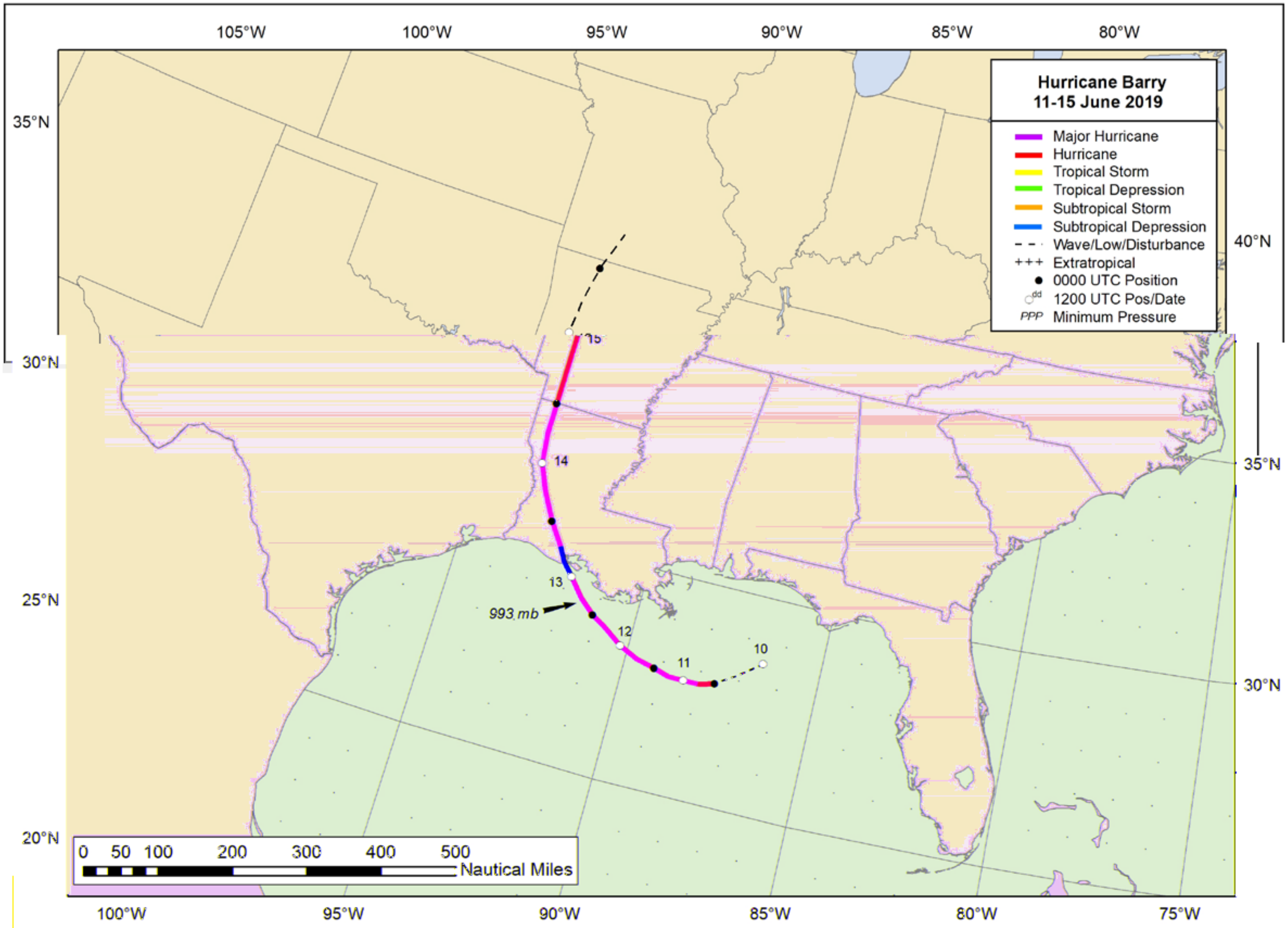

Figure 2. Best track positions for Hurricane Barry, 11–15 July 2019. The track over the United States is partially based on analyses from the NOAA Weather Prediction Center.

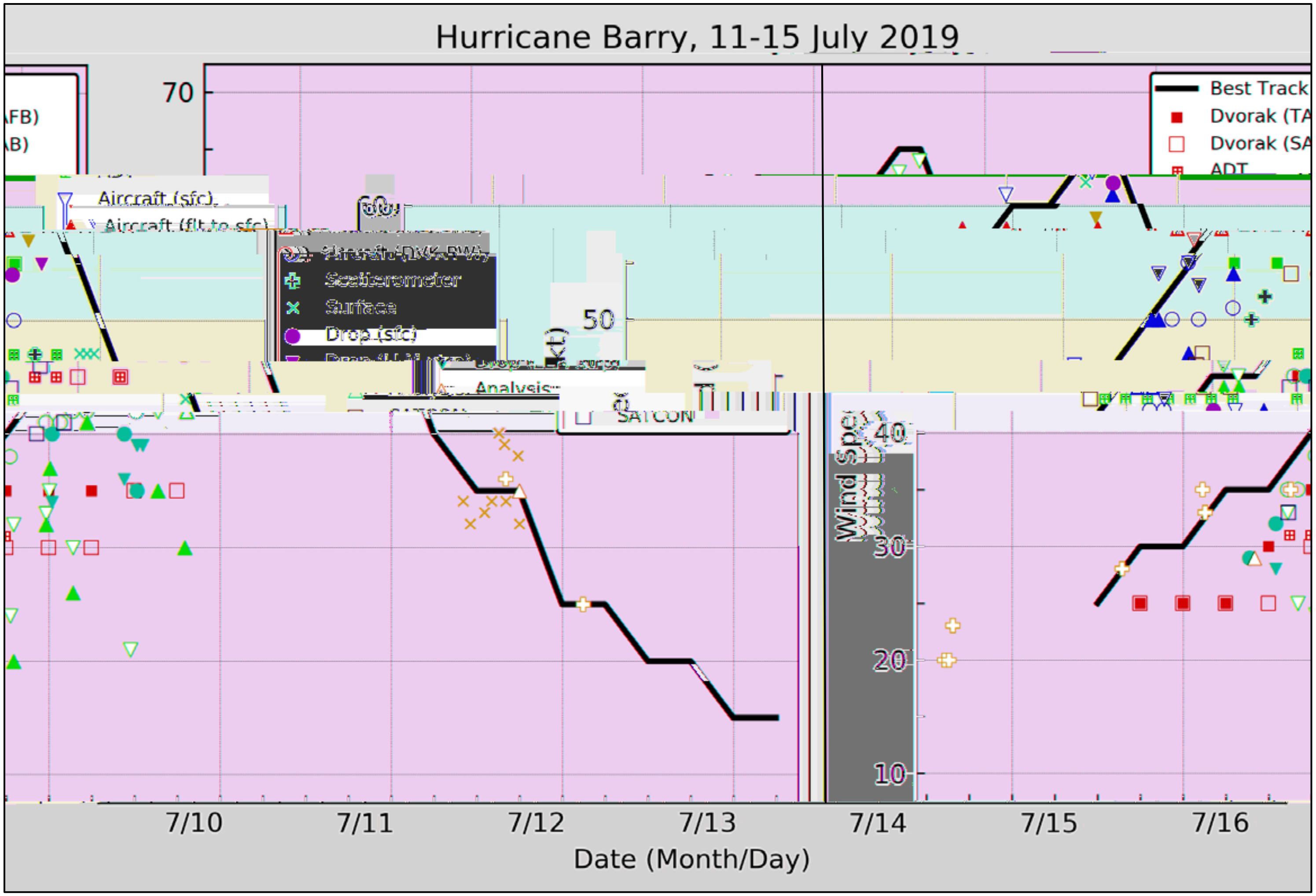

Figure 3. Selected wind observations and best track maximum sustained surface wind speed curve for Hurricane Barry, 11–15 July 2019. Aircraft observations have been adjusted for elevation using 90%, 80%, and 80% adjustment factors for observations from 700 mb, 850 mb, and 1500 ft., respectively. Advanced Dvorak Technique estimates represent the Current Intensity at the nominal observation time. SATCON intensity estimates are from the Cooperative Institute for Meteorological Satellite Studies. Dashed vertical lines correspond to 0000 UTC, and the solid vertical line corresponds to landfall.

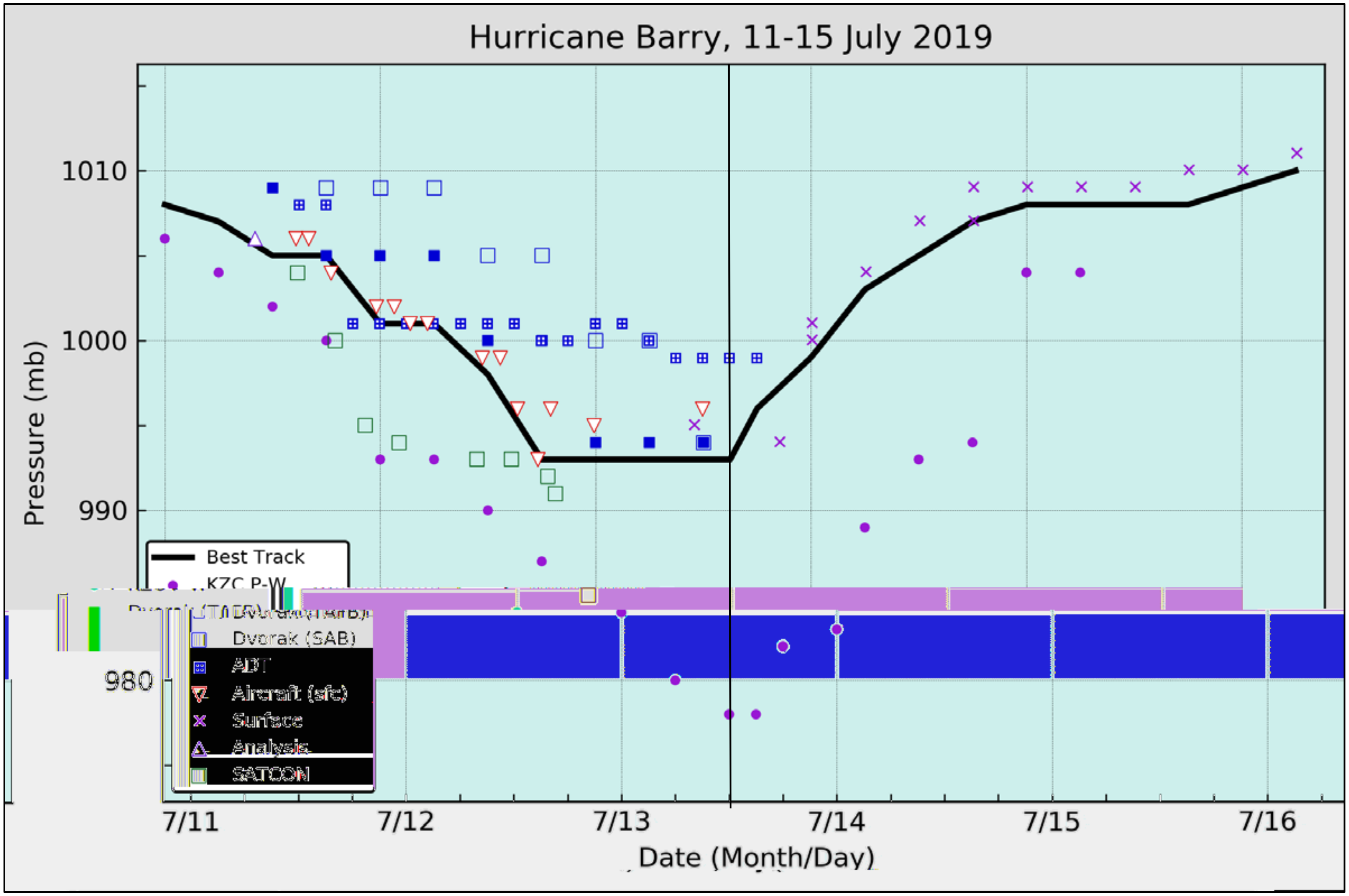

Figure 4. Selected pressure observations and best track minimum central pressure curve for Hurricane Barry, 11–15 July 2019. Advanced Dvorak Technique estimates represent the Current Intensity at the nominal observation time. The one SATCON intensity estimate is from the Cooperative Institute for Meteorological Satellite Studies. KZC P-W refers to pressure estimates derived using the Knaff-Zehr-Courtney pressure-wind relationship. Dashed vertical lines correspond to 0000 UTC, and the solid vertical line corresponds to landfall.

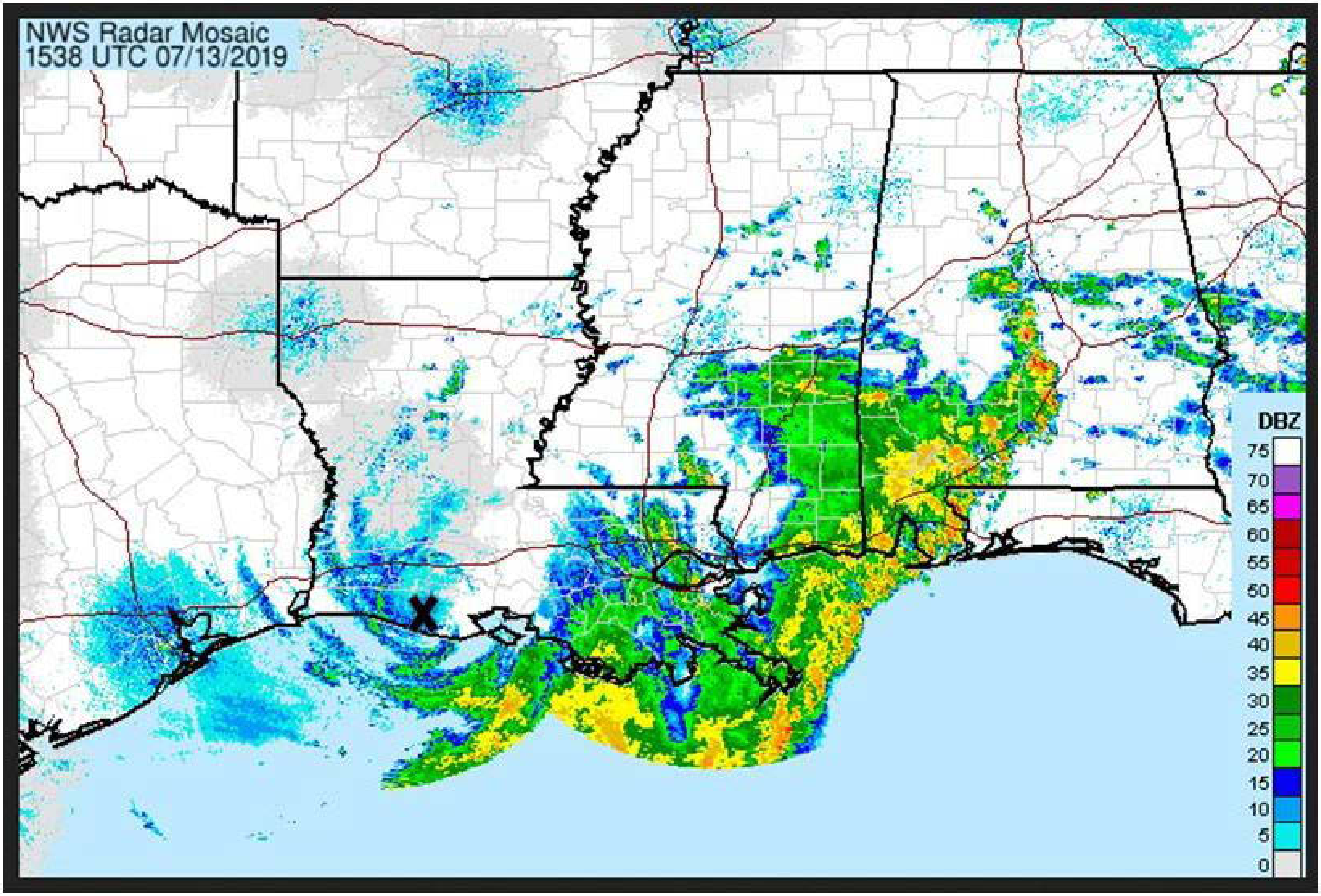

Figure 5. National Weather Service regional radar reflectivity mosaic at 1538 UTC 13 July 2019 showing Hurricane Barry over southwestern Louisiana. The black 'X' depicts the estimated center position.

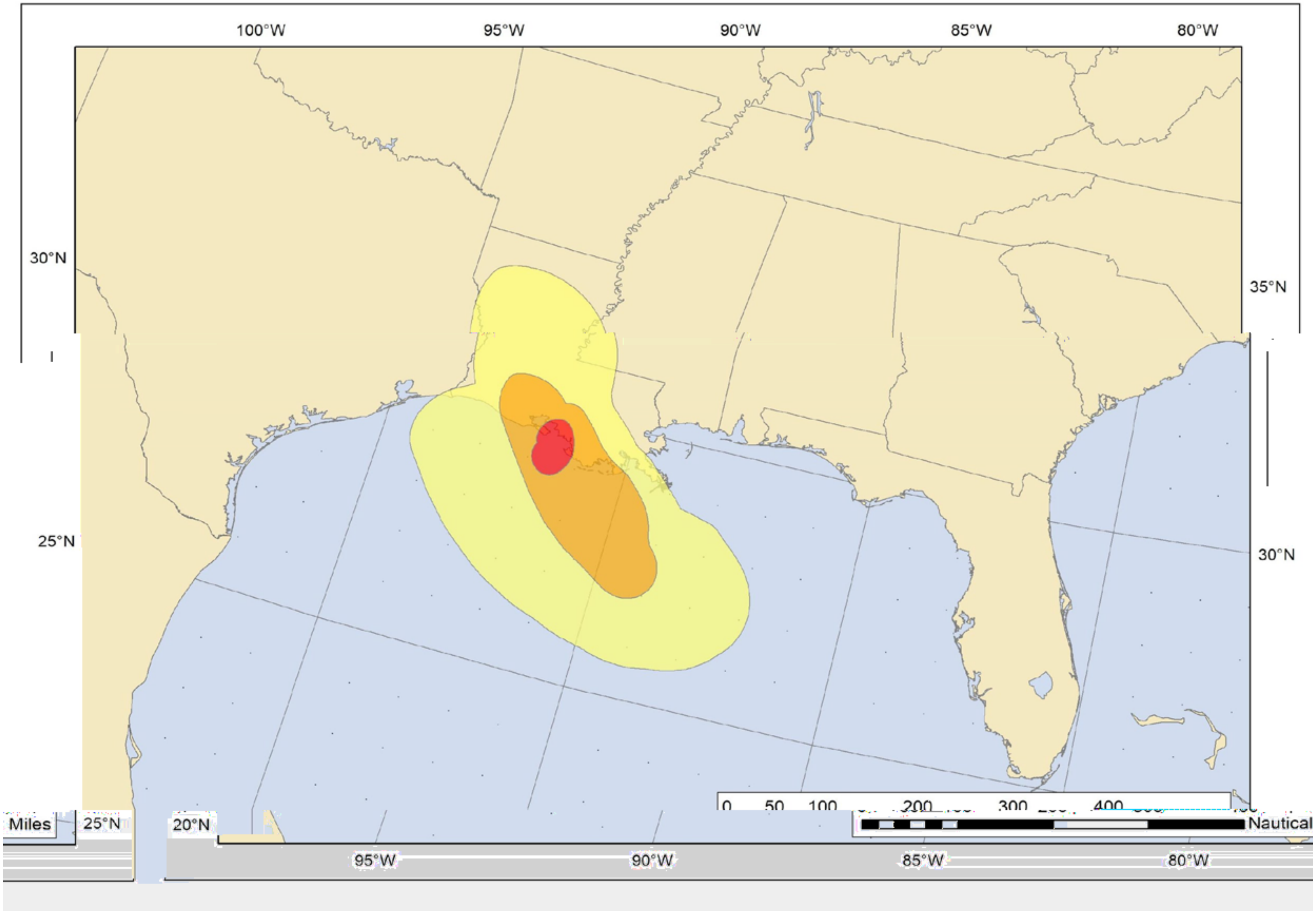

Figure 6. Wind swath depicting the radius of 34-kt (yellow), 50-kt (orange), and 64-kt (red) winds for Hurricane Barry, 11–15 July 2019. This swath represents the maximum extent of the winds in each quadrant, and is not necessarily an analysis of the observed wind.

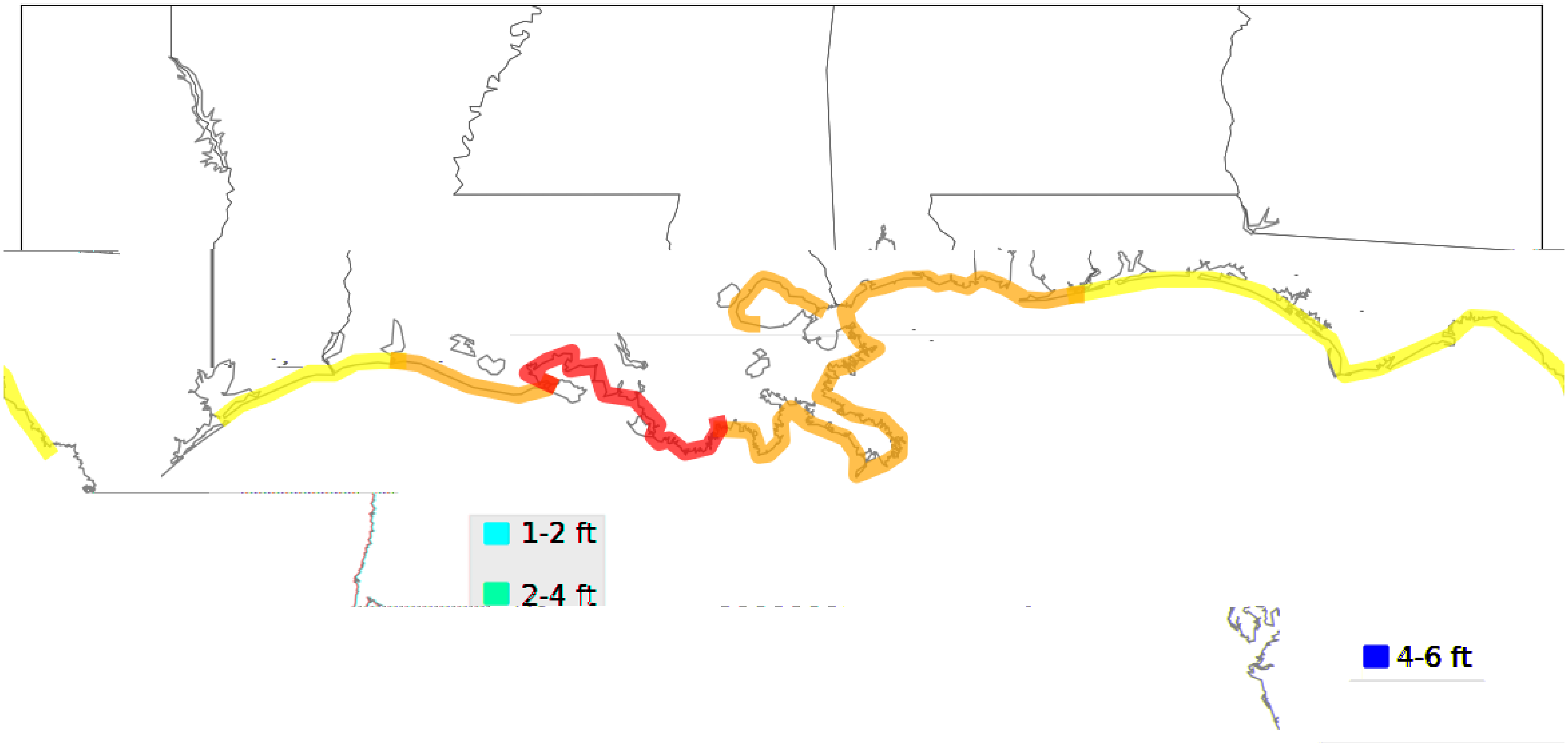

Figure 7. Estimated maximum storm surge inundation levels (ft. above ground) along the northern Gulf coast during Hurricane Barry. Estimates are based on NOS tide station data above Mean Higher High Water, USGS streamflow gauges, and a SLOSH hindcast. Image courtesy of the NHC Storm Surge Unit.

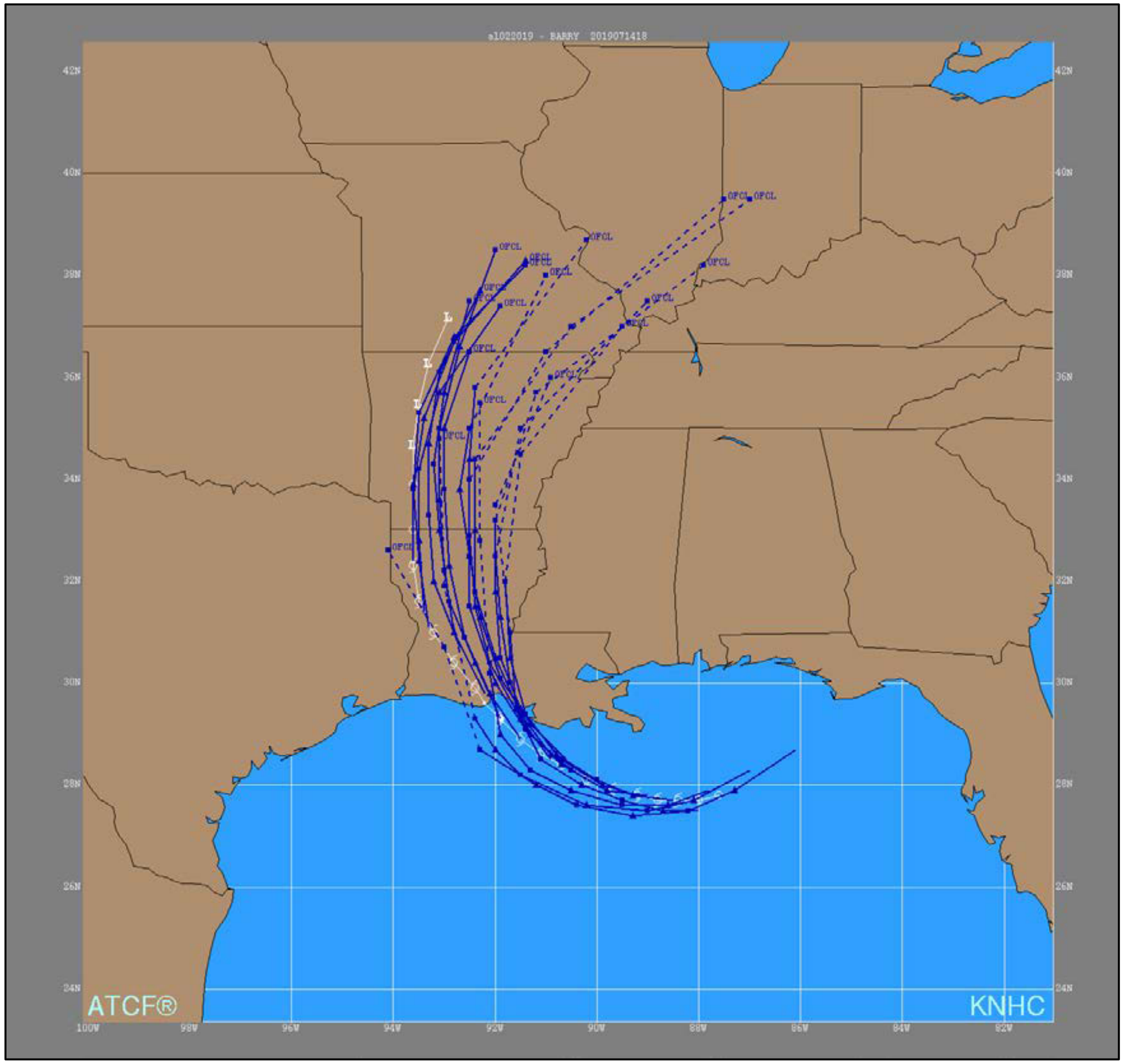

Figure 8: Selected official track forecasts (blue lines, with 0, 12, 24, 36, 48, 72, 96, and 120 h positions indicated) for Hurricane Barry from 1200 UTC 10 July to 1800 UTC 14 July. The best track is given by the white line with positions shown at 6 h intervals.

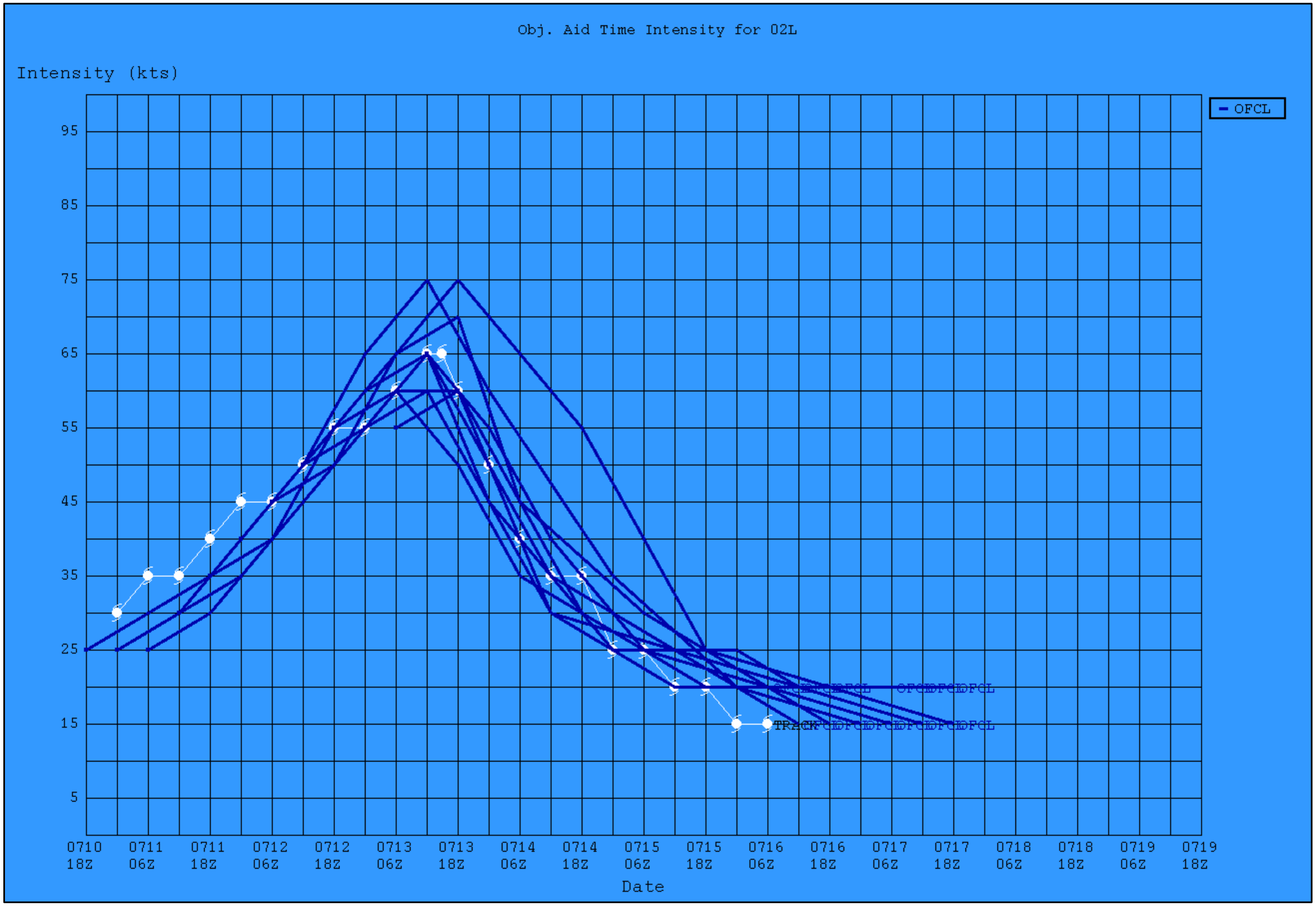

Figure 9. NHC official intensity forecasts (kt, blue lines) from 1200 UTC 10 July to 1800 UTC 14 July 2019 for Hurricane Barry. The verifying intensity is shown in white.

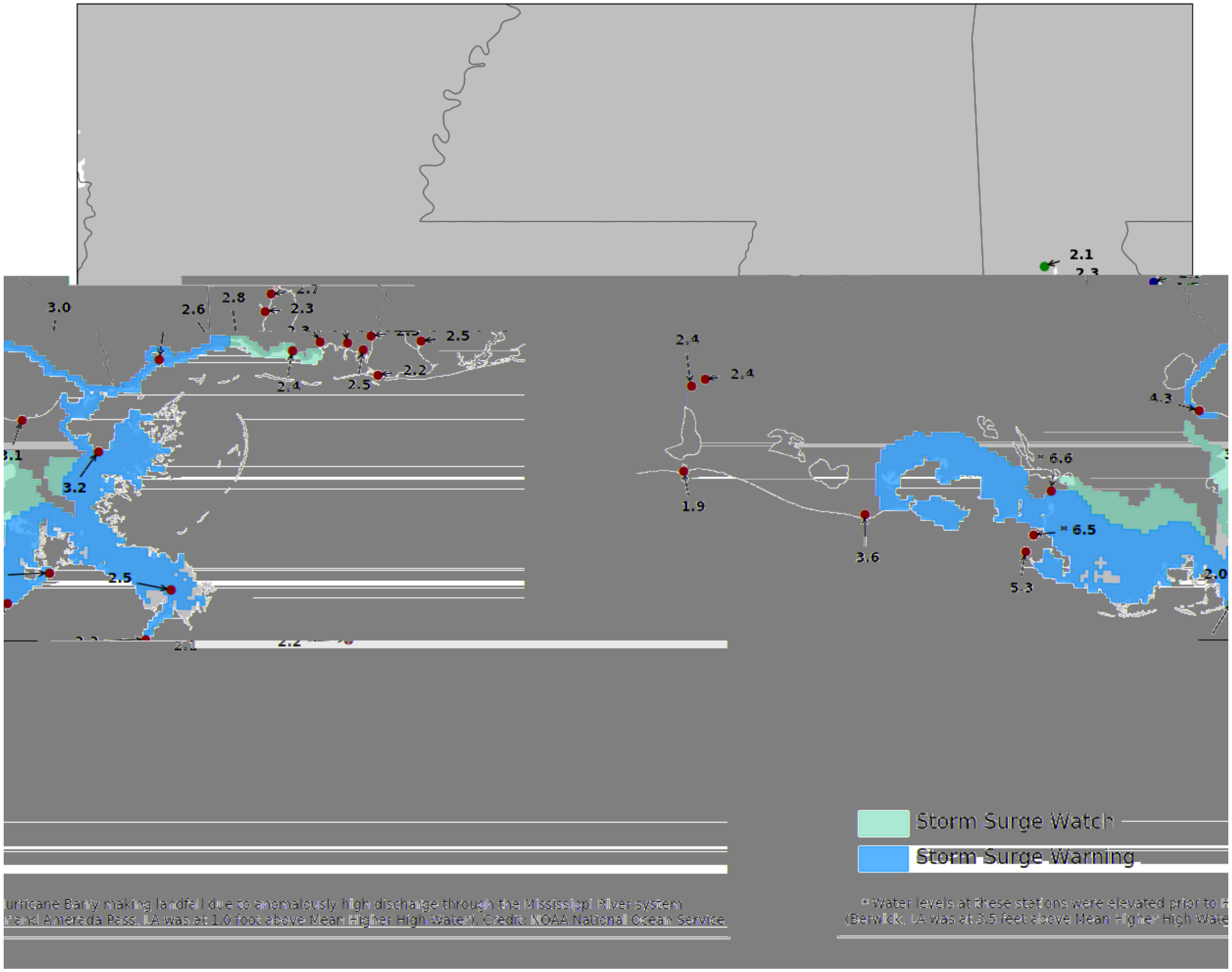

Figure 10. Maximum water levels measured from tide gauges along the central Gulf Coast during Hurricane Barry and storm surge warnings (magenta) and watches (lavender). Water levels are referenced above Mean Higher High Water, which is used as a proxy for inundation (above ground level) on normally dry ground along the immediate coastline. Image courtesy of the NHC Storm Surge Unit.