

= Hurricane Isabel =

Hurricane Isabel was the costliest , deadliest , and strongest hurricane in the 2003 Atlantic hurricane season . The ninth named storm , fifth hurricane , and second major hurricane of the season , Isabel formed near the Cape Verde Islands from a tropical wave on September 6 in the tropical Atlantic Ocean . It moved northwestward , and within an environment of light wind shear and warm waters it steadily strengthened to reach peak winds of 165 mph (265 km / h) on September 11 . After fluctuating in intensity for four days , Isabel gradually weakened and made landfall on the Outer Banks of North Carolina with winds of 105 mph (165 km / h) on September 18 . It quickly weakened over land and became extratropical over western Pennsylvania the next day .

In North Carolina , the storm surge from Isabel washed out a portion of Hatteras Island to form what was unofficially known as Isabel Inlet . Damage was greatest along the Outer Banks , where thousands of homes were damaged or even destroyed . The worst of the effects of Isabel occurred in Virginia , especially in the Hampton Roads area and along the shores of rivers as far west and north as Richmond and Washington , DC . Virginia reported the most deaths and damage from the hurricane . About 64 % of the damage and 68 % of the deaths occurred in North Carolina and Virginia . Electric service was disrupted in areas of Virginia for several days , some more rural areas were without electricity for weeks , and local flooding caused thousands of dollars in damage .

Moderate to severe damage extended up the Atlantic coastline and as far inland as West Virginia . Roughly six million people were left without electric service in the eastern United States from the strong winds of Isabel . Rainfall from the storm extended from South Carolina to Maine , and westward to Michigan . Throughout the path of Isabel , damage totalled about \$ 5 @. @ 7 billion (2003 USD , \$ 7 @. @ 33 billion 2016 USD) . 16 deaths in seven U.S. states were directly related to the hurricane , with 35 deaths in six states and one Canadian province indirectly related to the hurricane .

= = Meteorological history = =

A tropical wave moved off the coast of Africa on September 1 . An area of low pressure associated with the wave moved slowly westward , and its convection initially appeared to become better organized . On September 3 , as it passed to the south of the Cape Verde islands , organization within the system degraded , though convection increased the next day . The system gradually became better organized , and Dvorak classifications began early on September 5 . Based on the development of a closed surface circulation , it is estimated the system developed into Tropical Depression Thirteen early on September 6 . Hours later , it intensified into Tropical Storm Isabel , though operationally the National Hurricane Center did not begin issuing advisories until 13 hours after it first developed .

Located within an area of light wind shear and warm waters , Isabel gradually organized as curved bands developed around a circular area of deep convection near the center . It steadily strengthened as it moved to the west @-@ northwest , and Isabel strengthened to a hurricane on September 7 subsequent to the development of a large , yet ragged eye located near the deepest convection . The eye , overall convective pattern , and outflow steadily improved in organization , and deep convection quickly surrounded the 40 @-@ mile (60 km) -wide eye . Isabel intensified on September 8 to reach major hurricane status while located 1 @, @ 300 miles (2 @, @ 100 km) east @-@ northeast of Barbuda . On September 9 , Isabel reached a primary peak intensity of 135 mph (215 km / h) for around 24 hours , a minimal Category 4 hurricane on the Saffir ? Simpson Hurricane Scale .

Early on September 10 , the eyewall became less defined , the convection near the eye became eroded , and northeasterly outflow became slightly restricted . As a result , Isabel weakened slightly to a Category 3 hurricane . The hurricane turned more to the west due to the influence of the Bermuda @-@ Azores High . Later on September 10 , Isabel restrengthened to a Category 4 hurricane after convection deepened near the increasingly organizing eyewall . The hurricane continued to intensify , and Isabel reached its peak intensity of 165 mph (270 km / h) on

September 11 , a Category 5 hurricane on the Saffir ? Simpson Hurricane Scale . Due to an eyewall replacement cycle , Isabel weakened slightly , though it retained Category 5 status for 24 hours . As Isabel underwent another eyewall replacement cycle , outflow degraded in appearance and convection around the eye weakened , and early on September 13 Isabel weakened to a strong Category 4 hurricane . A weakness in the ridge to its north allowed the hurricane to turn to the west @-@ northwest . After completing the replacement cycle , the hurricane 's large 40 mile (65 km) wide eye became better defined , and late on the 13th Isabel re @-@ attained Category 5 status . A NOAA Hurricane Hunter Reconnaissance Aircraft flying into the hurricane launched a dropsonde which measured an instantaneous wind speed of 233 mph (375 km / h) , the strongest instantaneous wind speed recorded in an Atlantic hurricane . Cloud tops warmed again shortly thereafter , and Isabel weakened to a strong Category 4 hurricane early on September 14 . Later that day , it re @-@ organized , and for the third time it attained Category 5 status while located 400 miles (650 km) north of San Juan , Puerto Rico .

Cloud tops around the center warmed again early on September 15 and Isabel weakened to a Category 4 hurricane . Later that day , the inner core of deep convection began to deteriorate while the eye decayed in appearance . As a ridge to its northwest build southeastward , it resulted in Isabel decelerating as it turned to the north @-@ northwest . Increasing vertical wind shear contributed in weakening the hurricane further , and Isabel weakened to a Category 2 hurricane on September 16 while located 645 miles (1035 km) southeast of Cape Hatteras , North Carolina . Convection remained minimal , though outflow retained excellent organization , and Isabel remained a Category 2 hurricane for two days until making landfall between Cape Lookout and Ocracoke Island on September 18 with winds of 105 mph (165 km / h) . It weakened after it made landfall , though due to its fast forward motion Isabel remained a hurricane until reaching western Virginia early on September 19 . After passing through West Virginia as a tropical storm , Isabel became extratropical over Western Pennsylvania including Pittsburgh . The system crossed Lake Erie into Canada . Early on September 20 , the extratropical remnant of Isabel was absorbed by a larger extratropical storm over the Cochrane District of Ontario .

= = Preparations = =

Two days before Isabel made landfall , the National Hurricane Center issued a hurricane watch from Little River , South Carolina to Chincoteague , Virginia , including the Pamlico and Albemarle Sounds and the lower Chesapeake Bay . The NHC also issued a tropical storm watch south of Little River , South Carolina to the mouth of the Santee River , as well as from Chincoteague , Virginia northward to Little Egg Inlet , New Jersey . Hurricane and tropical storm warnings were gradually issued for portions of the East Coast of the United States . By the time Isabel made landfall , a tropical storm warning existed from Chincoteague , Virginia to Fire Island , New York and from Cape Fear , North Carolina to the mouth of the Santee River in South Carolina , and a hurricane warning existed from Chincoteague , Virginia to Cape Fear . Landfall forecasts were very accurate ; from three days prior , the average track forecast error for its landfall was only 36 miles (58 km) , and for 48 hours in advance the average track error was 18 miles (29 km) .

Officials declared mandatory evacuations for 24 counties in North Carolina , Virginia , and Maryland , though in general not many left . According to a survey conducted by the United States Department of Commerce , evacuation rates were estimated as follows ; 45 % in the Outer Banks , 23 % in the area around the Pamlico Sound , 23 % in Virginia , and about 15 % in Maryland . The threat of Isabel resulted in the evacuation of hundreds of thousands of residents , primarily in North Carolina and Virginia , and included more than 12 @, @ 000 residents staying in emergency shelters .

19 major airports along the East Coast of the United States were closed , with more than 1 @, @ 500 flights canceled . The Washington Metro and Metrobus system closed prior to the arrival of the storm , and Amtrak canceled nearly all trains south of the nation 's capital . Schools and businesses throughout its path closed prior to Isabel 's arrival to allow time to prepare ; hardware and home improvement stores reported brisk business of plywood , flashlights , batteries , and portable

generators , as residents prepared for the storm 's potential impact . The federal government was closed excluding emergency staff members . The United States Navy ordered the removal of 40 ships and submarines and dozens of aircraft from naval sites near Norfolk , Virginia .

A contingency plan was established at the Tomb of the Unknowns at Arlington National Cemetery that , should the winds exceed 120MPH , the guards could take positions in the trophy room (above the Tomb Plaza and providing continual sight of the Tomb) but the plan was never implemented . However , it spawned an urban legend that the Third Infantry sent orders to seek shelter , orders that were deliberately disobeyed .

On September 18 , the Canadian Hurricane Centre issued heavy rainfall and wind warnings for portions of southern Ontario . A gale warning was also issued for Lake Ontario , eastern Lake Erie , the Saint Lawrence River and Georgian Bay . A news report on September 14 warned conditions could be similar to the disaster caused by Hurricane Hazel 49 years prior , resulting in widespread media coverage on the hurricane . Researchers on a Convair 580 flight studied the structure of Isabel transitioning into an extratropical storm , after two similar studies for Hurricane Michael in 2000 and Tropical Storm Karen in 2001 . While flying in a thunderstorm , ice build forced the plane to descend .

= = Impact = =

Strong winds from Isabel extended from North Carolina to New England and westward to West Virginia . The winds , combined with previous rainfall which moistened the soil , downed many trees and power lines across its path , leaving about 6 million electricity customers without power at some point . Parts of coastal Virginia , especially in the Hampton Roads and Northeast North Carolina areas , were without electricity for almost a month . Coastal areas suffered from waves and its powerful storm surge , with areas in eastern North Carolina and southeast Virginia reporting severe damage from both winds and the storm surge . Throughout its path , Isabel resulted in \$ 3 @. @ 6 billion in damage (2003 USD , \$ 4 @. @ 63 billion 2016 USD) and 51 deaths , of which 16 were directly related to the storm 's effects .

The governors of Pennsylvania , West Virginia , Maryland , New Jersey , and Delaware declared states of emergency . Isabel was the first major hurricane to threaten the Mid @- @ Atlantic States and the Upper South since Hurricane Floyd in September 1999 . Isabel 's greatest effect was due to flood damage , the worst in some areas of Virginia since 1972 's Hurricane Agnes . More than 60 million people were affected to some degree ? a similar number to Floyd but more than any other hurricane in recent memory .

= = = Caribbean and Southeast United States = = =

Powerful surf affected the northern coastlines of the islands in the Greater Antilles . Strong swells also lashed the Bahamas . During most hurricanes , the location of the Bahamas prevents powerful swells of Atlantic hurricanes from striking southeast Florida . However , the combination of the location , forward speed , and strength of Isabel produced strong swells through the Providence Channel onto a narrow 10 mile (16 km) stretch of the southeastern Florida coastline ; wave heights peaked at 14 feet (4 @. @ 3 m) at Delray Beach . The swells capsized a watercraft and injured its two passengers at Boynton Beach , and a swimmer required assistance to be rescued near Juno Beach . Minor beach erosion was reported in Palm Beach County . In the northern portion of the state , waves reached up to 15 feet (4 @. @ 5 m) in height at Flagler Beach , causing the Flagler Beach Pier to be closed due to damaged boards from the waves . Rip currents from Isabel killed a surfer at an unguarded beach in Nassau County , with an additional six people requiring rescue from the currents . The beaches were later closed during the worst of the rough surf .

In northeastern South Carolina , the outer rainbands produced moderate winds reaching 45 mph (72 km / h) at Myrtle Beach . Rainfall was light , peaking at 1 @. @ 34 inches (34 mm) in Loris .

= = = North Carolina = = =

Isabel produced moderate to heavy damage across eastern North Carolina , totaling \$ 450 million (2003 USD , \$ 579 million 2016 USD) . Damage was heaviest in Dare County , where storm surge flooding and strong winds damaged thousands of houses . The storm surge produced a 2 @, @ 000 foot (600 m) wide inlet on Hatteras Island , unofficially known as Isabel Inlet , isolating Hatteras by road for two months . Strong winds downed hundreds of trees of across the state , leaving up to 700 @, @ 000 residents without power . Most areas with power outages had power restored within a few days . The hurricane directly killed one person and indirectly killed two in the state .

= = = Virginia = = =

The storm surge assailed much of southeastern Virginia causing the worst flooding seen in the area since the 1933 Chesapeake ? Potomac hurricane , peaking at an estimated 9 feet (2 @. @ 7 m) in Richmond along the James River . The surge caused significant damage to homes along river ways , especially along the middle reaches of the James River basin . The strong storm surge surpassed the floodgate to the Midtown Tunnel while workers attempted to close the gate ; about 44 million US gallons (170 @, @ 000 m3) of water flooded the tunnel entirely in just 40 minutes , with the workers barely able to escape . The damage to the electrical grid and flooding kept Old Dominion University , Norfolk State University , Virginia Commonwealth University and many of the region 's other major educational institutions closed for almost a week . Further inland , heavy rainfall was reported , peaking at 20 @. @ 2 inches (513 mm) in Sherando , Virginia , causing damage and severe flash flooding . Winds from the hurricane destroyed over 1 @, @ 000 houses and damaged 9 @, @ 000 more ; damage in the state totaled about \$ 1 @. @ 85 billion (2003 USD , \$ 2 @. @ 38 billion 2016 USD) , among the costliest tropical cyclones in Virginia history . The passage of Isabel also resulted in 32 deaths in the state , 10 directly from the storm 's effects and 22 indirectly related .

= = = Mid @-@ Atlantic = = =

About 1 @. @ 24 million people lost power throughout Maryland and Washington , D.C. The worst of Isabel 's effects came from its storm surge , which inundated areas along the coast and resulted in severe beach erosion . In Eastern Maryland , hundreds of buildings were damaged or destroyed by the storm surge and related tidal flooding . The most severe flooding occurred in the southern portions of Dorchester and Somerset counties and on Kent Island in Queen Anne 's County . Thousands of houses were affected in Central Maryland , with severe storm surge flooding reported in Baltimore and Annapolis . Washington , D.C. sustained moderate damage , primarily from the winds . Throughout Maryland and Washington , damage totaled about \$ 945 million (2003 USD , \$ 1 @. @ 22 billion 2016 USD) , with only one direct fatality due to flooding .

The effects of the hurricane in Delaware were compounded by flooding caused by the remnants of Tropical Storm Henri days before . Moderate winds of up to 62 mph (100 km / h) in Lewes downed numerous trees , tree limbs , and power lines across the state , leaving at least 15 @, @ 300 without power . Numerous low @-@ lying areas were flooded due to high surf , strong storm surge , or run @-@ off from flooding further inland . The passage of Hurricane Isabel resulted in \$ 40 million in damage (2003 USD , \$ 51 @. @ 5 million 2016 USD) and no casualties in the state .

= = = Northeast United States = = =

The winds from Isabel downed hundreds of trees and power lines across New Jersey , leaving hundreds of thousands without power ; a falling tree killed one person . Rough waves and a moderate storm surge along the coastline caused moderate to severe beach erosion , and one person was killed from the rough waves . Damage in the state totaled \$ 50 million (2003 USD , \$ 64 @. @ 3 million 2016 USD) .

The passage of Hurricane Isabel in Pennsylvania resulted in \$ 160 million in damage (2003 USD , \$ 206 million 2016 USD) and 2 indirect deaths in Pennsylvania . One person suffered from carbon

monoxide poisoning , believed to be caused due to improperly ventilated generators in an area affected by the power outages . Moderate winds left about 1 @. @ 4 million customers without power across the state as a result of trees falling into power lines , with dozens of houses and cars damaged by the trees .

Damage in New York totaled \$ 90 million (2003 USD , \$ 116 million 2016 USD) , with Vermont reporting about \$ 100 @, @ 000 in damage (2003 USD , \$ 129 @, @ 000 2016 USD) . Falling trees from moderate winds downed power lines across the region , causing sporadic power outages . Two people died in the region as a result of the hurricane , both due to the rough surf from Isabel .

= = = Elsewhere = = =

In West Virginia , the storm produced moderate rainfall across the state that peaked at 6 @. @ 88 in (175 mm) near Sugar Grove . The rainfall resulted in mudslides and flash flooding , covering several roads and washing away two bridges . The South Branch Potomac River crested at 24 @. @ 7 feet (7 @. @ 5 m) , 9 @. @ 3 feet (2 @. @ 8 m) above flood state near Springfield . The flooding broke a levee at Michael Field , and in Mineral County one school and 14 basements were flooded . In Jefferson County , two people required rescue after a car drove into floodwaters . Although sustained winds were weak in the state , wind gusts reached 46 mph (74 km / h) at Martinsburg . With the wet grounds , the wind gusts toppled thousands of trees , which fell onto homes , roads , and power lines . About 1 @. @ 4 million residents across the state were left without power . Damage in the state totaled \$ 20 million (2003 USD , \$ 25 @. @ 7 million 2016 USD) . No deaths were reported , and three were injured from the hurricane .

Isabel dropped light to moderate precipitation across the eastern half of Ohio , with isolated locations reporting over 3 in (75 mm) . Moisture from Isabel dropped light rainfall across eastern Michigan and peaked at 1 @. @ 55 inches (39 mm) at Mount Clemens . Additionally , Doppler weather radar estimated rainfall approached 2 @. @ 5 inches (64 mm) in St. Clair County . No damage was reported from Isabel in the region .

Swells from Isabel produced moderate surf along the Atlantic coast of Nova Scotia , particularly in the Gulf of Maine . Isabel also produced rough surf in Lake Ontario , with waves reaching 4 m (13 ft) along the western portion . At Hamilton , the waves surpassed seawalls and produced spray onto coastal streets . Rainfall peaked at 59 mm (2 @. @ 3 in) , which caused minor flooding and led to one traffic fatality . About 27 @, @ 000 people lost power , mostly near Toronto . The strong pressure gradient between Isabel and a high pressure system over eastern Canada produced strong easterly winds across lakes Ontario and Erie . A buoy in Lake Ontario reported a peak gust of 78 km / h (49 mph) , and gusts reached as strong as 81 km / h (51 mph) at Port Colborne , Ontario .

= = Aftermath = =

By about a week after the passage of the hurricane , President George W. Bush declared disaster areas for 36 North Carolina counties , 77 counties and independent cities in Virginia , the entire state of Maryland , all three counties in Delaware and six West Virginia counties . The disaster declaration allocated the use of federal funds for rebuilding and providing aid in the aftermath of hurricane Isabel . By about four months after the passage of the hurricane , disaster aid totaled about \$ 516 million (2003 USD , \$ 664 million 2016 USD) , primarily in North Carolina and Virginia . Over 166 @, @ 000 residents applied for individual assistance , with about \$ 117 million (2003 USD , \$ 151 million 2016 USD) approved for residents to assist with temporary housing and home repairs . About 50 @, @ 000 business owners applied for Small Business Administration loans , with about \$ 178 million (2003 USD , \$ 229 million 2016 USD) approved for the assistance loans . About 40 @, @ 000 people visited local disaster recovery centers , designed to provide additional information regarding the aftermath of the hurricane .

In North Carolina , hundreds of residents were stranded in Hatteras following the formation of Isabel Inlet . People who were not residents were not allowed to be on the Outer Banks for two weeks after

the hurricane due to damaged road conditions . When visitors were allowed to return , many ventured to see the new inlet , despite a 1 @-@ mile (1 @.@ 6 @-@ km) walk from the nearest road . Initially , long term solutions to the Isabel Inlet such as building a bridge or a ferry system were considered , though they were ultimately canceled in favor of pumping sand and filling the inlet . Coastal geologists were opposed to the solution , stating the evolution of the Outer Banks is dependent on inlets from hurricanes . Dredging operations began on October 17 , about a month after the hurricane struck . The United States Geological Survey used sand from the ferry channel to the southwest of Hatteras Island , a choice made to minimize the impact to submerged aquatic vegetation and due to the channel being filled somewhat during the hurricane . On November 22 , about two months after the hurricane struck , North Carolina Highway 12 and Hatteras Island were reopened to public access . On the same day , the ferry between Hatteras and Ocracoke was reopened .

In West Virginia , the power outages were restored within a week . Power workers throughout Canada assisted the severely affected power companies from Maryland to North Carolina . Hydro @-@ Québec sent 25 teams to the New York City area to assist in power outages .

Because of widespread property damage and extensive death tolls the name " Isabel " was retired after the 2003 season , and will not be used for future Atlantic hurricanes . It was replaced by " Ida " for the naming list for the 2009 season . The names Ina and Ivy were also suggested as possible replacement names .