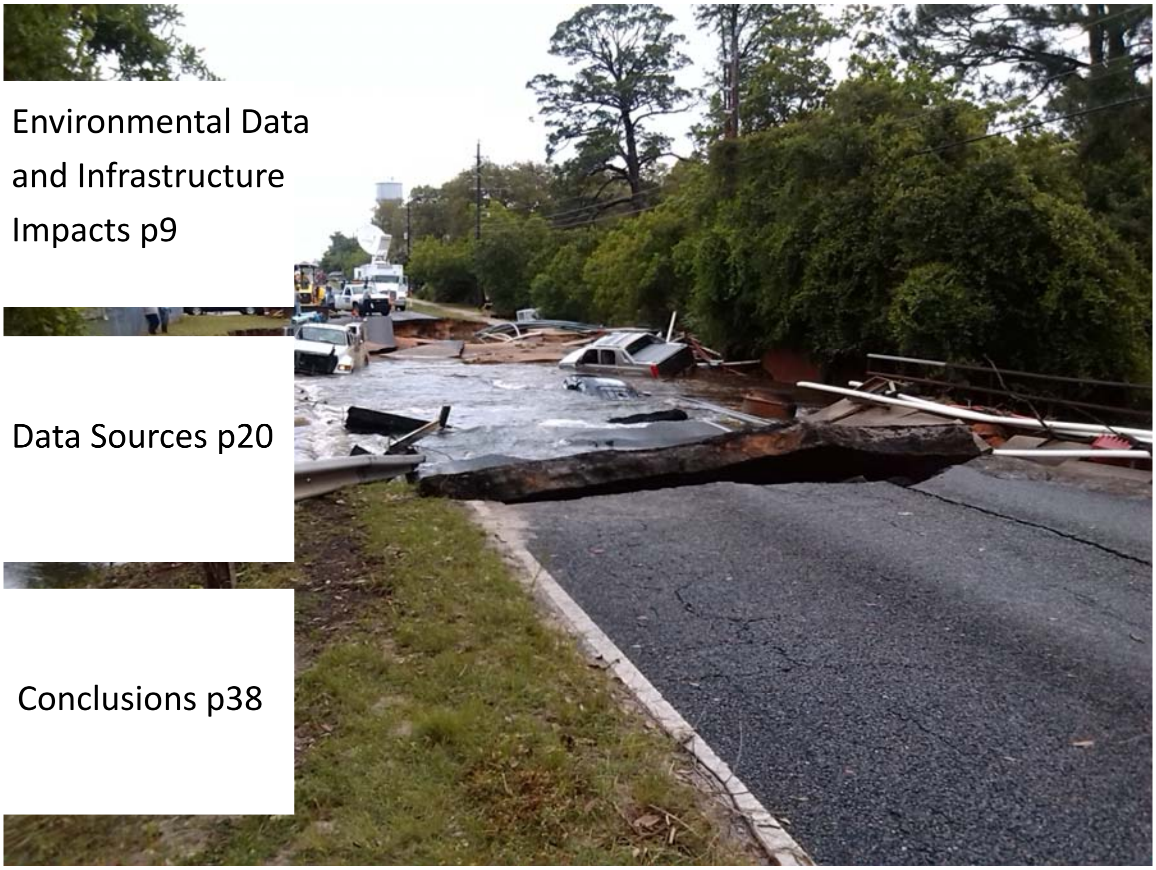

Health Impact Assessment Report on Extreme Flooding in Escambia County, April-May 2014

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Executive Summary

In this report, the Florida Department of Health, Environmental Public Health Tracking (EPHT) Program, in collaboration with the Escambia County Health Department and the University of West Florida, used the Health Impact Assessment (HIA) Framework to examine adverse health outcomes that may be related to an extreme flooding event in Pensacola, Florida (Escambia County) during April 30—May 3, 2014. Natural disasters, such as hurricanes and floods, can cause extensive damage to infrastructure and property, and can sometimes result in injuries and deaths in the affected population. Globally, flooding is the most common natural disaster and the most frequent cause of natural disaster-related mortality. In this 2014 flooding event, portions of Pensacola received more than 15.5 inches of rain in a single day. Infrastructure impacts from this extreme event included destroyed bridges and roads, and the failure of many sewage lift stations. To determine if there were associated increases in injury, illness, and death, data on reportable diseases, hospitalizations, emergency department (ED) visits, and deaths that occurred during the impact period were compared to a control period in 2008. The results of this comparison were mixed, with some Escambia County ZIP Codes showing increased hospitalizations and ED visits, and some ZIP Codes showing a decrease. However, county-wide, there were increases in the proportion of both injury and respiratory related hospitalizations and ED visits during the impact period. This analysis highlighted the difficulty of verifying statistical associations when dealing with low numbers. The end of this report discusses policy changes that might result in fewer health impacts if such a flooding event were to happen in the future. These recommendations include guidance for cleanup activities and a suggestion to raise the electric panels on lift stations above the flood elevation, in order to keep them operational during extreme rainfall events.

This project was supported by Cooperative Agreement Number 5U38EH000941 from the Centers for Disease Control and Prevention. The contents of this document are solely the responsibility of the authors and do not necessarily represent the official views of the Centers for Disease Control and Prevention.

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Background

The Florida Department of Health Environmental Public Health Tracking (EPHT) Program is funded by the U.S. Centers for Disease Control and Prevention (CDC) to look at health outcomes that may be related to environmental hazards. One of the approaches used by the EPHT Program is the Health Impact Assessment (HIA) framework. The HIA framework is a process to evaluate the potential public health impacts of a policy, plan, or project. The HIA process is typically performed before a plan is implemented, but the same steps of assessment, data collection, analysis, interpretation, and recommendations can be applied retroactively to situations like natural disasters. The purpose is to evaluate whether policy adjustments might reduce future impacts.

Natural disasters, such as hurricanes and floods, can cause extensive damage to infrastructure and property, and can sometimes result in injuries and deaths in the affected population. The reason for this study was to attempt to measure the public health impacts from the April-May 2014 flooding event in Escambia County, and then to recommend policy changes that might result in fewer impacts if such a flooding event were to happen again. The flow chart below shows data points that are important in this HIA process.

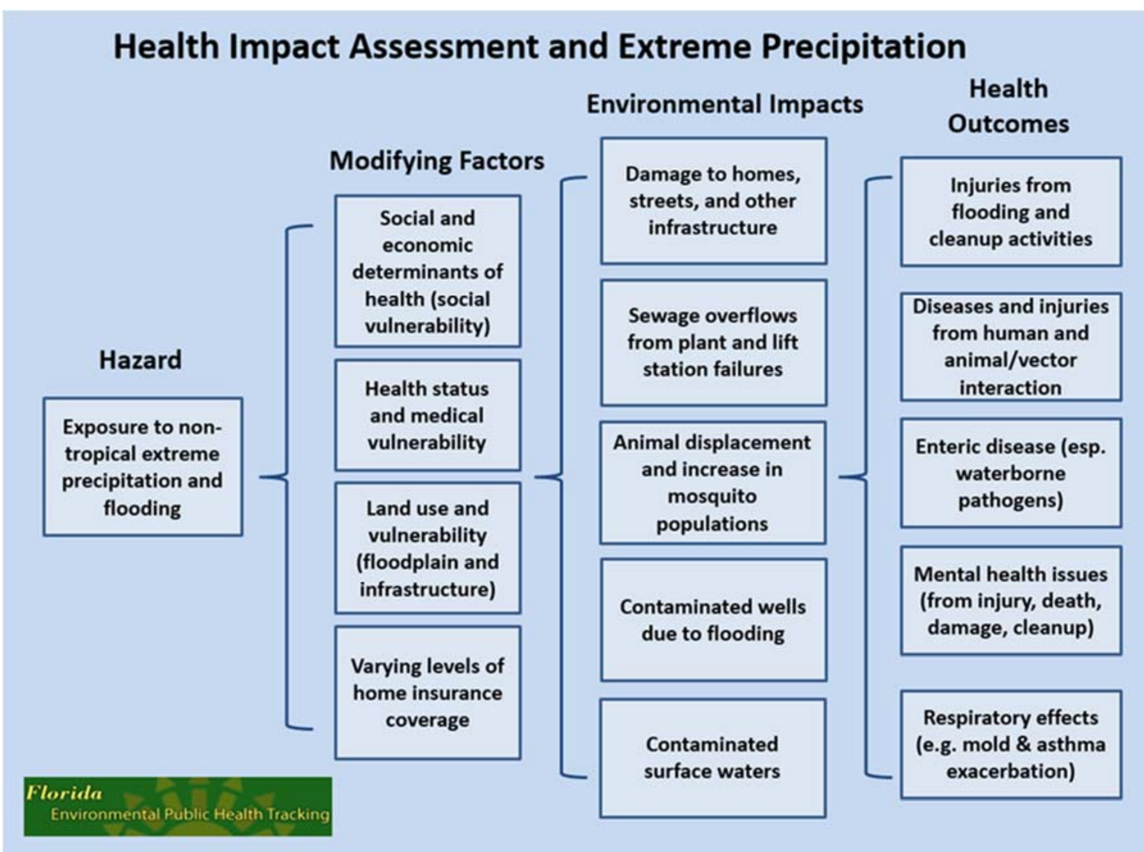


Figure 1. Factors related to an extreme precipitation event in Escambia County, 2014.

PURPOSE OF THIS STUDY

The purpose of this study is to answer the following questions: What types of injuries, deaths, and other health effects may have been associated with a severe non-tropical flooding event in Escambia County, Florida during April 29-May 3, 2014, and how does that compare to a similar period of time without a severe flood? Another important question for this study, and the reason this project is considered a Health Impact Assessment: Are there policy changes that could result in fewer health effects during a similar future flooding event?

BACKGROUND-

Health Impacts from Flooding Events

Globally, flooding is the most common natural disaster and the most frequent cause of natural disaster-related mortality. From 1994-2013, flooding affected 2.4 billion people and caused 750,000 deaths (Centre for Research on the Epidemiology of Disasters [CRED], 2015). The impacts on human health associated with flood events can be direct or indirect. Direct effects include risk of drowning and injury. Indirect effects include increased risk of food-, water-, and vector-borne diseases.

Immediate causes of death during floods include drowning and injury (Doocy, Daniels, Murray, & Kirsch, 2013), with drowning accounting for the majority of flood-related mortality. Between 1980 and 2009, the primary cause of flood-related mortality worldwide was drowning (Doocy et al., 2013). Drowning deaths may occur during the event or after the event, when water levels are higher and rivers and streams are flowing faster than normal. Drowning may also occur when vehicles are caught in floodwaters. A review of 13 flood events in the U.S. and Europe demonstrated that two-thirds of reported deaths were due to drowning (Jonkman & Kelman, 2005). In the U.S., many of these drowning deaths involved vehicles (Jonkman & Kelman, 2005).

Injury is also a significant cause of morbidity and mortality during and after a flood. During an event, the risk of injury is related to a person or vehicle being caught in the floodwaters during evacuation attempts or mitigation efforts. After a flood, injury may occur as a result of clean-up activities. Worldwide, over 360,000 injuries have been reported associated with floods during the period 1980 - 2009 (Doocy et al., 2013).

Flooding may also have negative impacts on health by increasing the risk of certain bacterial and protozoan diseases that are typically associated with fecal-oral transmission or transmission through contaminated food and water. These include illnesses such as salmonellosis, campylobacteriosis, cryptosporidiosis, giardiasis, and vibriosis. Flooding can lead to sewer and septic system overflows. Contaminated floodwaters can spread and expose a large number of people. For example, campylobacter has been detected in floodwaters following urban flooding events (Veldhuis, Clemens, Sterk, & Berends, 2010). Flooding of the home has been shown in international studies to increase the odds of diseases such as cryptosporidiosis and paratyphoid fever by 200% to 350% (Ahern et al., 2005). The risk of these diseases after flood events in the U.S. appears to be lower but is still important to consider. Extreme rainfall events (>90th percentile) preceded 51% of waterborne disease outbreaks in the U.S. from 1948 to 1994 (Curriero, Patz, Rose, & Lele, 2001). Increased risk of gastrointestinal illness with flooded homes or yards has also been demonstrated in more recent U.S.-based studies (Ahern et al., 2005).

There may also be a link between vector-borne diseases and flooding, though the relationship is complex and not well understood. Mosquito-borne disease transmission is very sensitive to precipitation total and frequency (Shaman & Day, 2007). Increased precipitation and flooding may lead to an increase in standing water and, therefore, mosquito breeding sites. This can lead to an increase in transmission of some mosquito-borne diseases. Furthermore, increased precipitation is associated with higher humidity, which can enhance vector survival. On the other hand, too much precipitation may destroy breeding sites and wash away mosquito larvae and eggs, thereby lowering disease transmission (Morin, Comrie, & Ernst, 2013; Shaman & Day, 2007). The relationship between West Nile Virus (WNV) transmission and precipitation varies regionally across the U.S., with increased WNV incidence associated with higher than average precipitation in the Western U.S. and lower than average precipitation in the Eastern U.S. (Hahn et al., 2015). Flooding in the home after extreme precipitation events was found to be a risk factor for WNV infection (Han et al., 1999). Other mosquito-borne diseases also demonstrated increased transmission after flood events, particularly in urban areas, including malaria (in countries with endemic malaria) (Ahern et al., 2005).

Flooding may also have impacts on the mental health of individuals, both in the short and long term. The flood itself can be a cause of significant stress, and additional stress during the recovery period may also lead to mental health issues. Some of the psychosocial issues that may arise after a flood event include grief or bereavement leading to depression, economic problems, behavioral issues in children, post-traumatic stress, increased substance use or abuse, increased domestic violence, and exacerbation of pre-existing mental health conditions (Stanke, Murray, Amlot, Nurse, & Williams, 2012).

Overall, extreme flooding events have significant impacts on human populations. For this study, we are focused on those impacts in a single Florida county (Escambia). To place the human health impacts in context, it is helpful to understand the magnitude of the environmental impacts of the 2014 flooding event.

Environmental Data and Infrastructure Impacts

The environmental data sets described in this section, and their sources, are as follows:

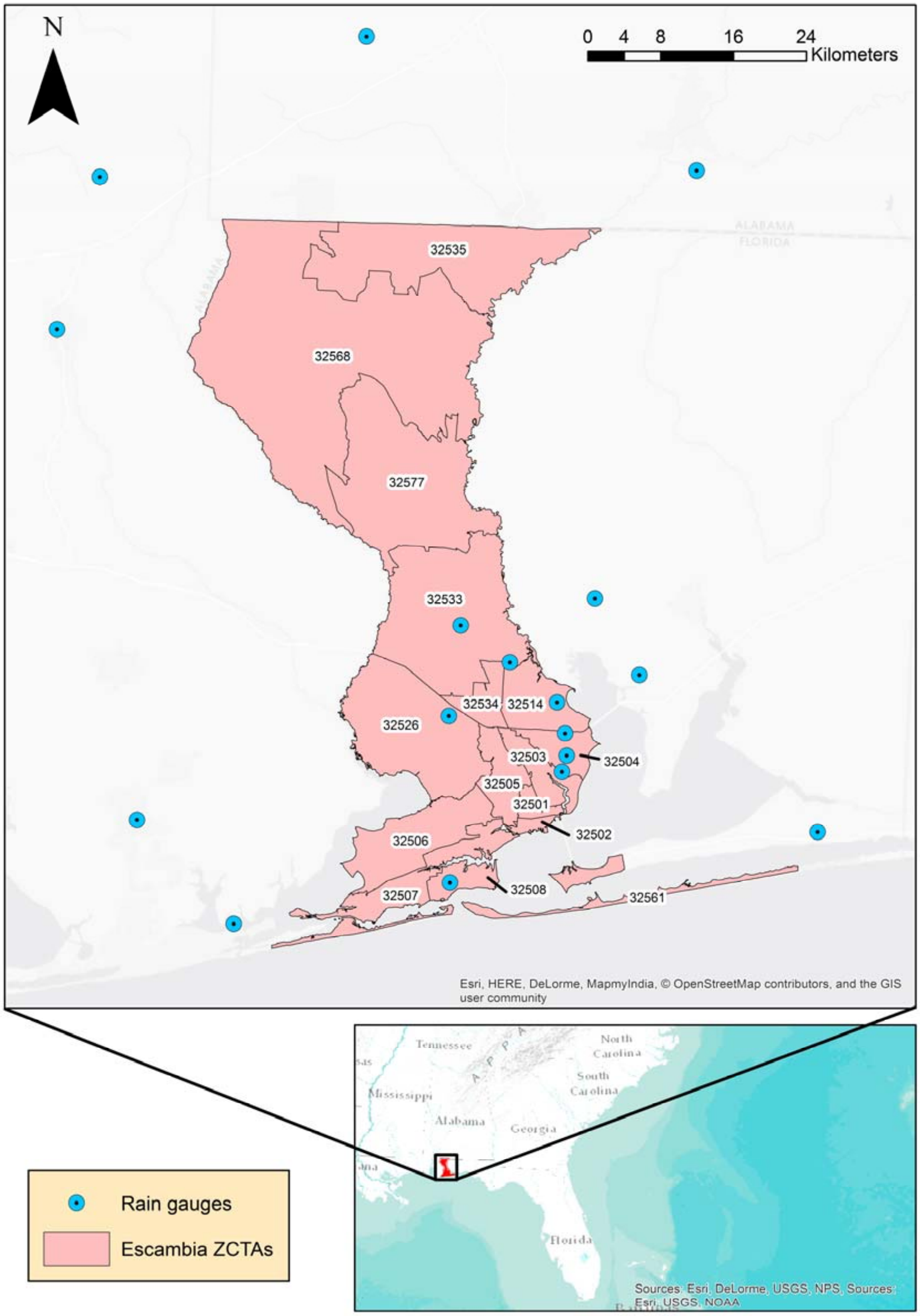
Stream Gauge Data and Hydrographs: (USGS 2015).

Infrastructure data: Road Damages, County Property Damage Report, Sewage Lift Station Failures (Escambia County 2015; Florida Department of Health in Escambia County 2015).

Precipitation Data: daily rainfall totals (NOAA 2015; Weather Underground 2015).

We identified 17 different weather stations with precipitation records for each of the five days in the April-May 2014 event (Figure 2, Table 1). From these 17 data points, we used Inverse Distance Weighting to interpolate a continuous surface of estimated rainfall across the county for each day (Figure 3). For the Pensacola Regional Airport, the longest and most complete precipitation record in the county, we computed long-term (1960 – 2014) descriptive statistics of daily and monthly rainfall totals for only the months of April and May, including mean monthly precipitation, maximum monthly precipitation, and the percentile value of each. This approach allowed us to characterize the historical climatological significance of the 2014 flood. Further, we used these percentiles to select a non-remarkable April-May period in 2008 as our control period
(described below under "Methods").

Figure 2. Map of study area (Escambia County, FL) and locations of rain gauges used in this study. The smaller spatial units within the county are ZIP Code Tabulation Areas (ZCTAs; U.S. Postal Service 2015).



Zip Code Tabulation Areas (ZCTAs) are generalized areal representations of United States Postal Service ZIP Code service areas.

Table 1. Weather station information

Station Name	Station Latitude	Station Longitude	Elev. (m)	Years of Data
Pensacola Regional Airport	30°28’41” N	87°11’13” W	34.1	1960-2014
Pensacola Forest Sherman NAS	30°21’00” N	87°19’01” W	8.5	1960-2014
Pensacola 9.2 NW	30°30’50” N	87°19’23” W	25.0	2013-2014
Pensacola 7 NNE	30°31’52” N	87°12’00” W	34.7	2001-2014
Pensacola 3.8 N	30°30’00” N	87°11’20” W	32.3	2008-2014
Pace 2.4N FL	30°38’02” N	87°09’32” W	57.0	2007-2014
Orange Beach 2.1 NE AL	30°18’11” N	87°33’43” W	1.8	2008-2014
Navarre 2.1 WNW FL	30°24’32” N	86°53’53” W	8.8	2009-2014
Milton 6.0SW FL	30°33’36” N	87°06’22” W	7.0	2011-2014
Gonzalez 2.5 NNW	30°36’14” N	87°18’43” W	48.2	2007-2014
Gonzalez 2.1 E	30°34’08” N	87°15’18” W	21.9	2010-2014
Foley 0.5 ESE AL	30°24’11” N	87°40’37” W	27.1	2007-2014
Brewton 3SSE Al	31°03’29” N	87°03’18” W	25.9	1936-2014
Bay Minette, AL	30°53’02” N	87°47’06” W	82.6	1913-2014
Bay Minette 10.9N AL	31°02’10” N	87°44’28” W	90.5	2012-2014
Atmore AL	31°10’55” N	87°26’20” W	91.4	1940-2014
Cordova Park (KFLPENSA29)	30°27’43” N	87°11’31” W	29.9	2010-2014

Although the estimates in Figure 3 indicate the relative amounts of rainfall across different parts of the county, it is noteworthy that rainfall totals alone do not necessarily reflect the magnitude of localized flooding and flood impacts. The relationship between extreme rainfall and hydrologic flooding is complex, and influenced by several factors including antecedent soil moisture, soil/substrate storage capacity and permeability, specific characteristics of precipitation events (e.g., intensity, duration), and the physical properties of individual drainage basins. Each of these is highly variable in time and space. Thus, no single metric of extreme precipitation is consistently linked with hydrologic flooding in any two places, or in one place at any two times (Kunkel et al. 1999).

From April 29 – May 3, 2014, the Escambia County (Pensacola) area of Florida received an enormous amount of rainfall. For April 29, the maximum estimated rainfall was concentrated in the city of Pensacola near the Airport, and generally in the southeastern part of the county. The peak rainfall estimates range up to 15.5 inches, which is an underestimate, due to the known failure of the Airport rainfall monitoring station for some period of time on the afternoon of April 29th. In spite of this equipment failure, the recorded rainfall at the Airport station for April 29th was 15.5 inches, the highest single-day rainfall total in the Airport station record, nearly 9 inches greater than the second-highest daily total since 1960.

For the same day, rainfall estimates in the central and southwestern parts of the county were less than 3 inches. Thus, the bulk of the severe precipitation on April 29 was spatially confined to a relatively small area around Pensacola and the Airport, including ZIP Codes 32514, 32504, 32503, 32505, 32502, and 32501. On April 30, the highest rainfall totals (ranging to 18.9 inches) were in the extreme southwestern part of the county, and in a belt circling the northern part of Pensacola, including the central portion of the county. Relatively low rainfall totals were recorded in the south-central and far northern parts of the county. Much of the city of Pensacola received less than the center of the county, but rainfall totals in the city still ranged from around 5.5 – 7.5 inches. For this day, the main rainfall was concentrated in ZIP Codes 32533, 32506, and 32507. Rainfall totals on May 1, 2014, were relatively low across the county, with maximum rainfall values of less than ½ inch concentrated in the center of the county, in ZIP Code 32533. Total rainfall decreased in all directions away from the center of the county on this day, with only trace precipitation recorded in the far northwestern and southwestern parts of the county. Maximum rainfall totals on May 2, 2014 reached as high as 1.4 inches, concentrated in the south-central part of the county, primarily impacting ZIP Codes 32526, 32533, 32534, 32503, and 32505. On this day, the remainder of the county received less than 1 inch of total rainfall. Rainfall for May 3, 2014 is nearly identical to the previous day, with maximum rainfall of around 1 inch concentrated in the south-central portion of the county, affecting ZIP Codes 32526, 32533, 32534, 32503, and 32505. The northern, eastern, and southern parts of the county received little or no precipitation on this day.

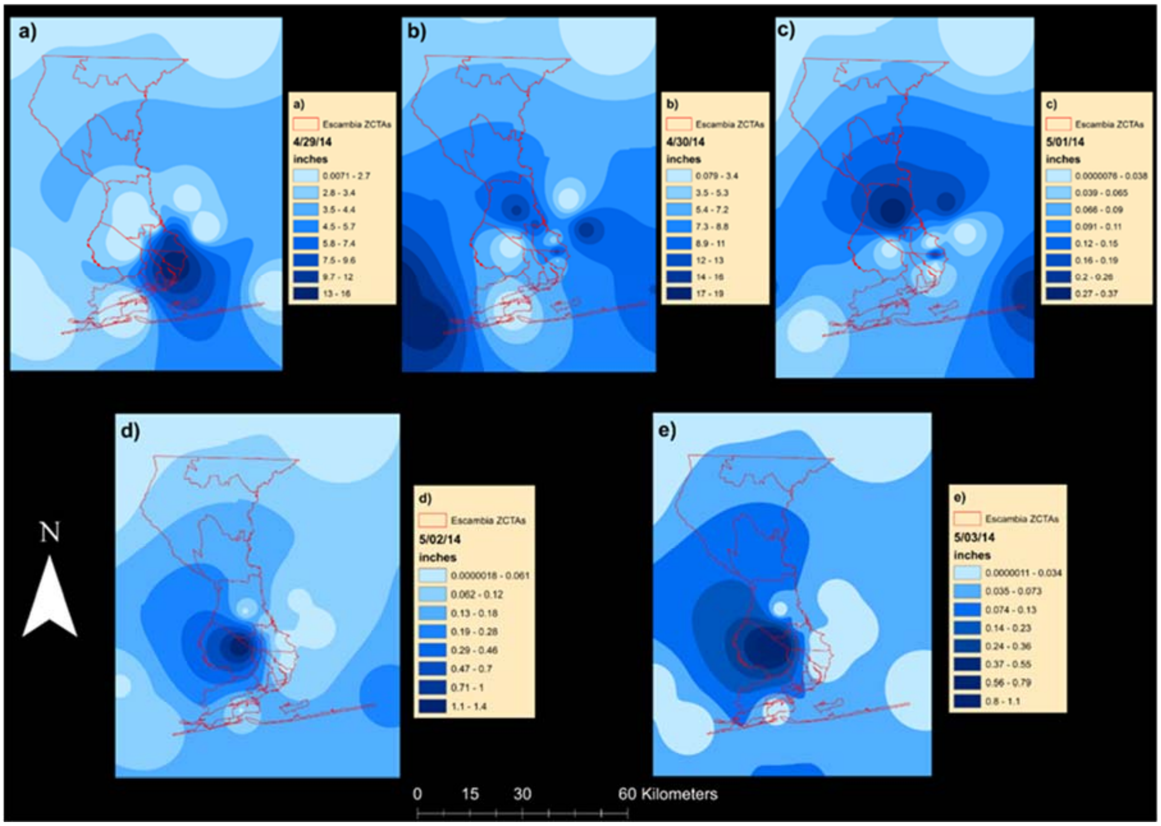


Figure 3. Estimated rainfall totals for (a) April 29, 2014, (b) April 30, 2014, (c) May 1, 2014, (d) May 2, 2014, and (e) May 3, 2014. The rainfall estimates were interpolated from the available rain gauge data using Inverse Distance Weighting.

For the purpose of this study, the extreme rainfall event is defined as April 29 – May 3, 2014. This multi-day event resulted in the wettest April-May period in the historical record, and was nearly 11 inches greater than the second highest total (2005), in spite of the reported failure of the Airport rain gauge for some period of time during the peak rainfall day of April 29, 2014. At the Airport station, two consecutive days (April 29 and 30) in 2014 rank in the top 10 single-day rainfall totals since 1960 (Table 2).

Table 2. Ten highest April-May daily rainfall totals at the Airport Station, 1960-2014

Year	Month	Day	Precipitation (inches)
2014	April	29	15.55*
2005	April	6	6.87
2005	April	1	6.48
1987	May	10	4.94
2014	April	30	4.92
1995	May	10	4.79
1983	April	7	4.32
1970	May	31	4.25
1973	April	26	4.24
1995	April	11	4.06

*The April 29, 2014 value is an underestimate due to equipment malfunction during the storm.

The relationship between extreme rainfall and hydrologic flooding is complex, and influenced by several factors including antecedent soil moisture, soil/substrate storage capacity and permeability, specific characteristics of precipitation events (e.g. intensity, duration), and the physical properties of individual drainage basins.

Road and Bridge Damage

In total, 392 road damage reports and 15 bridge damage reports were filed with Escambia County (Figure 4). Much like the rainfall totals, damages to roads and bridges were abundant and widespread in the southern part of the county. Conversely, roads and bridges in the central and northern parts of the county were essentially unaffected. Major reported transportation failures included the partial or total destruction of a 2-mile stretch of U.S. 90 (Scenic Highway) in the southeastern part of the county and the destruction of Old Corry Road bridge over Jones Swamp in West Pensacola (south-central part of the county).

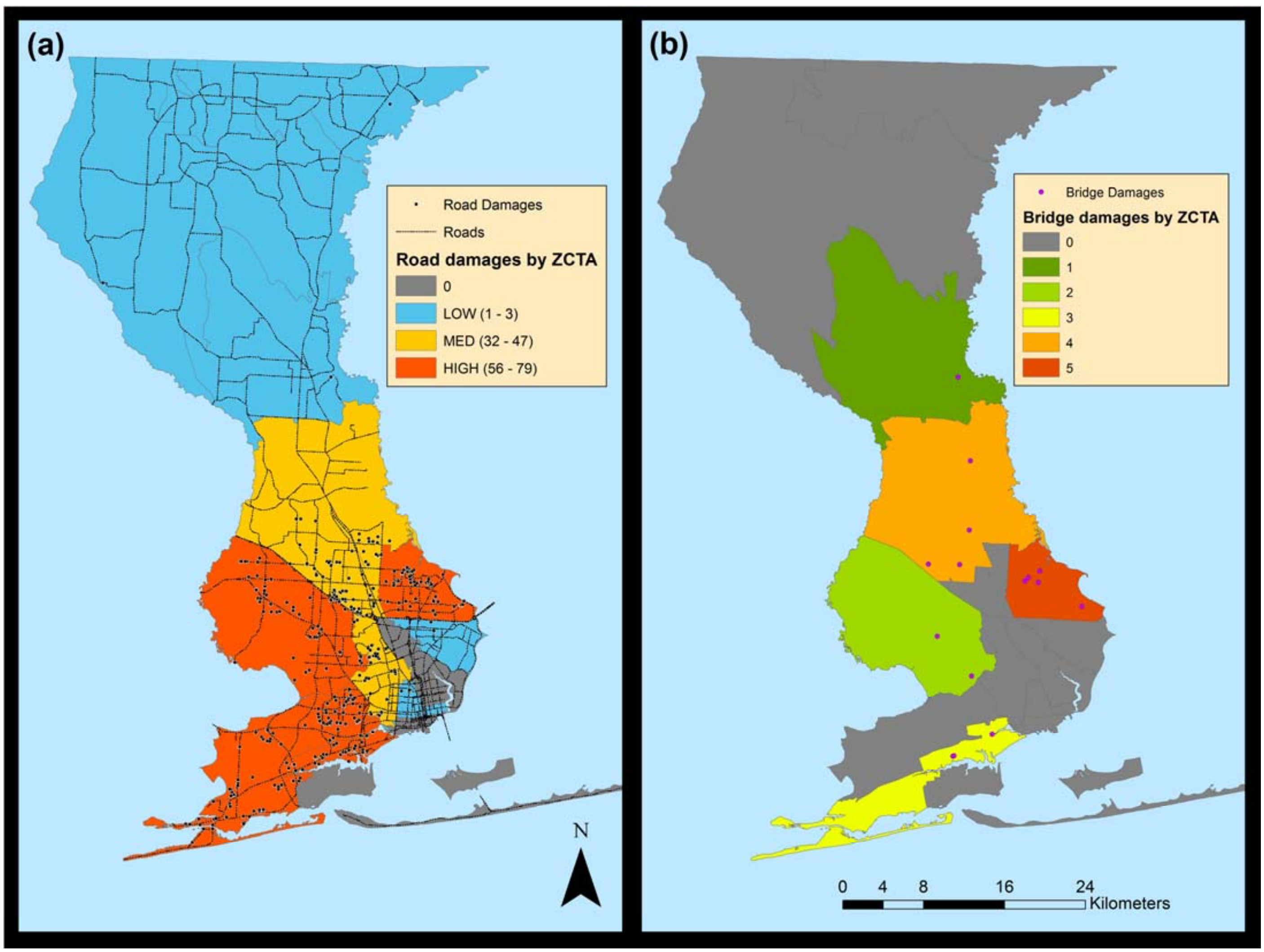


Figure 4. Reported structural damages to (a) roads and (b) bridges during the 5-day event period (April 29 – May 3, 2014) by ZCTA

Sanitary Sewage Lift Station Failures

The failure of a sanitary sewage lift station is normally an unusual event, but flooding emergencies create conditions where such stations can be inundated with flood waters and subsequently stop pumping. In the Escambia County area, some sewage lift stations failed as a result of this flooding event. In some cases, the electrical panel for the sewage lift station was flooded, which led to a loss of power and pumping ability. This created a sewage backup that led to many overflows from surrounding manholes and other connections. For this study, we obtained records for a total of 357 individual sewage lift stations in Escambia County. These include primarily public (Emerald Coast Utilities Authority) lift stations, with the exception of one private lift station for which we obtained data (Department of Health [DOH]-Escambia, 2015). No lift stations were located in ZIP Codes 32535, 32568, or 32577 (northern half of the county). Thus, by definition, all lift station failures and related impacts are concentrated in the southern half of the county. Of the 357 stations, a total of 31 failed at some point during the 5-day period of analysis, giving a county-wide lift station failure rate of 8.7% (Figure 5).

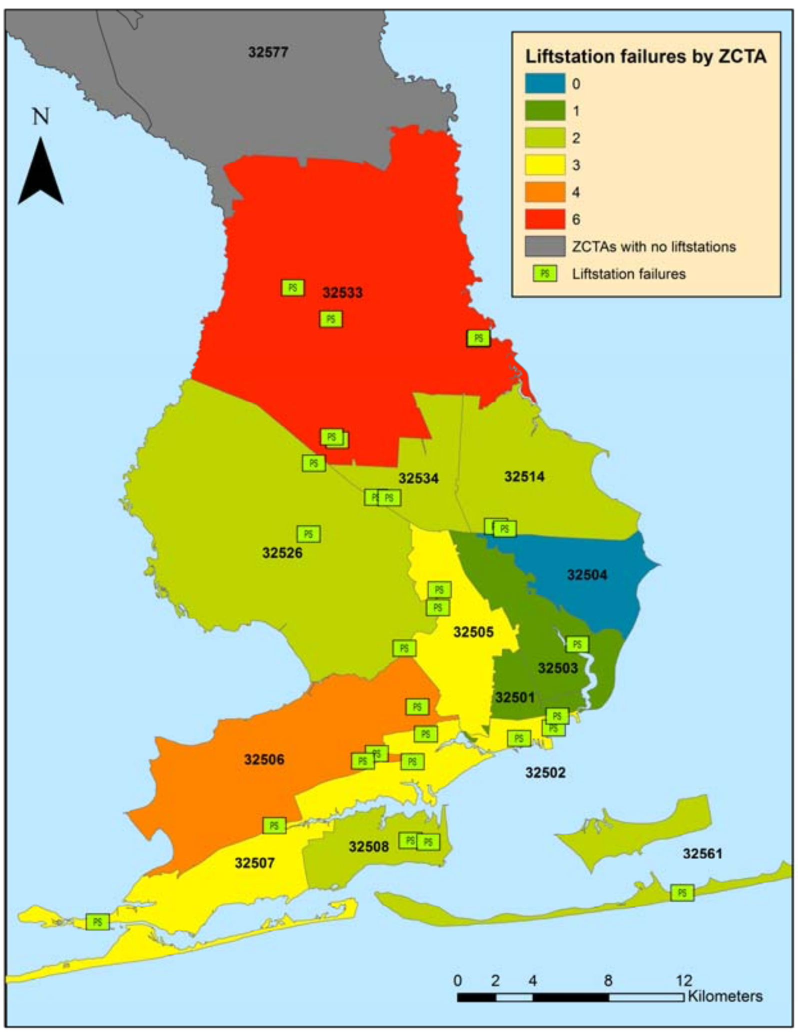


Figure 5. Locations of all individual sewage lift station failures during the 5-day event and total lift station failure counts by ZCTA.

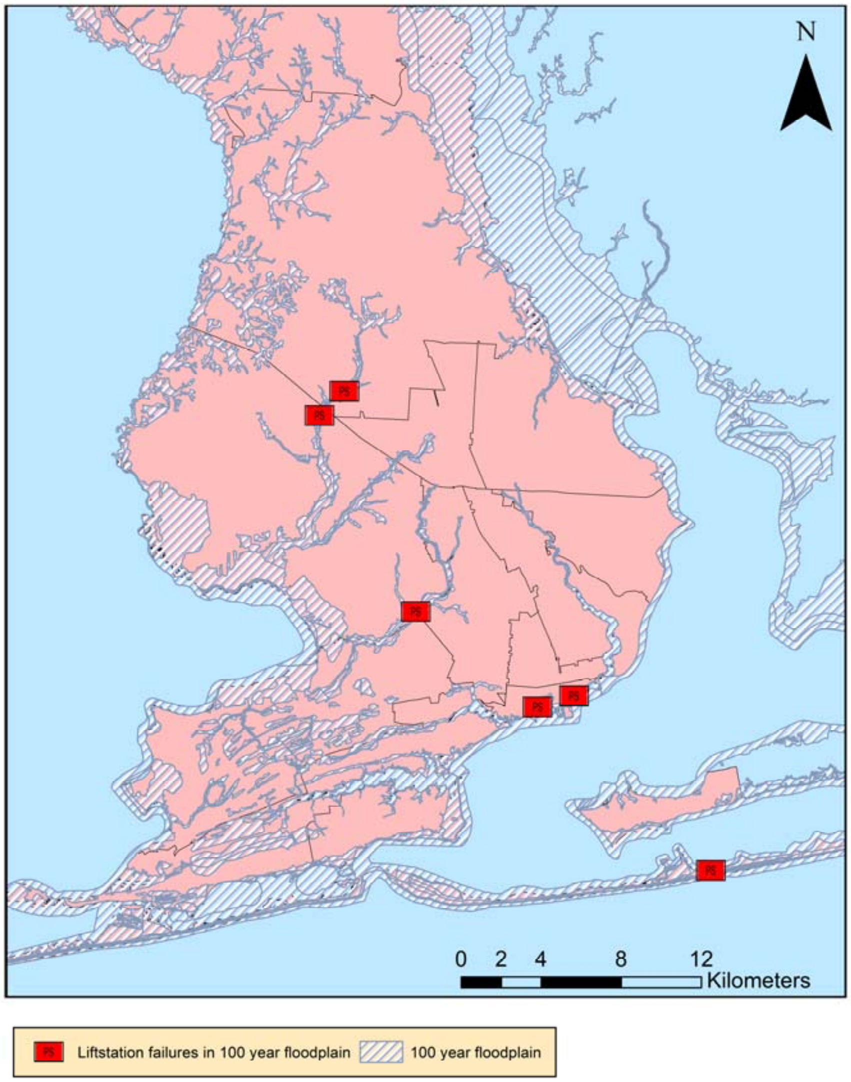
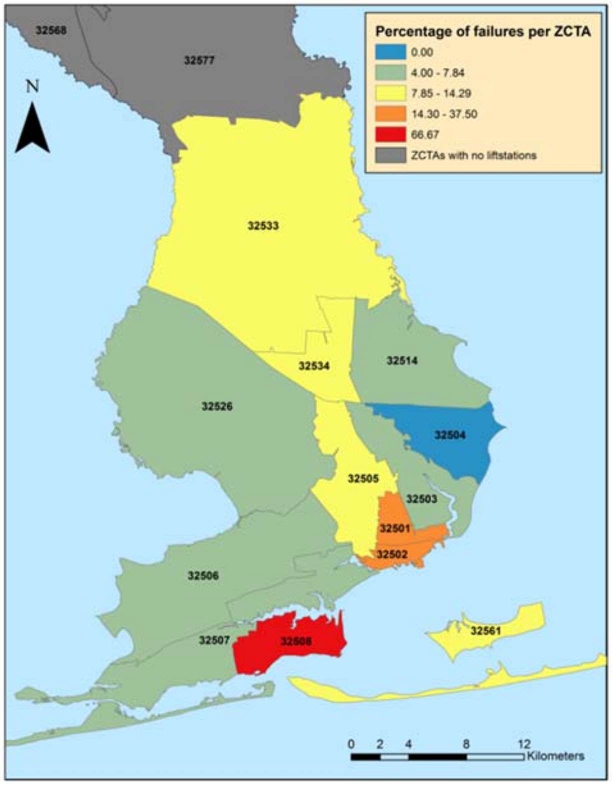


Figure 6. Locations of individual sewage lift station failures within the 100-yr floodplain.

To determine lift station failure rates relative to the 100-yr floodplain, we identified the total number of lift stations located within the 100-yr floodplain (n = 67; 19% of all lift stations) and the number of those that failed (n=7), giving a lift station failure rate of 10.4% within the 100-yr floodplain boundary (Figure 6). Alternatively, 290 (81% of the total) lift stations in the county are outside (above) the 100-yr floodplain. Of these, 24 failed, for a lift station failure rate of only 8.3% outside the floodplain. Although the small sample sizes preclude traditional significance testing, these varying failure rates support the common-sense notion that lift stations within the floodplain are more susceptible to failure during extreme precipitation events.

Sewage lift/pump stations are used for pumping wastewater or sewage from a lower to higher elevation, particularly where the elevation of the source is not sufficient for gravity flow and/or when the use of gravity conveyance will result in excessive excavation and higher construction costs

Figure 7. Sewage lift station failures as a percent of all lift stations by ZCTA.



Alternatively, the relative abundance of failures outside of the floodplain (in raw numbers of failures) emphasizes that under conditions of extreme rainfall and runoff, even the stations above the floodplain are susceptible. We also examined the spatial patterns of lift station failures by ZIP Code using raw numbers of failures, failure rates (failures/total lift stations by ZIP Code), and failures per square mile. The ZIP Codes with the greatest number of total failures include 32533 (center of the county) and 32506 (southwest part of the county), while ZIP Code 32504 in the southeastern portion of the county had zero failures (Figure 7).

The highest lift station failure rates were in Pensacola (ZIP Codes 32501 and 32502) and in the southernmost portion of the county, where as many as two-thirds of all lift stations failed; Figure 8).

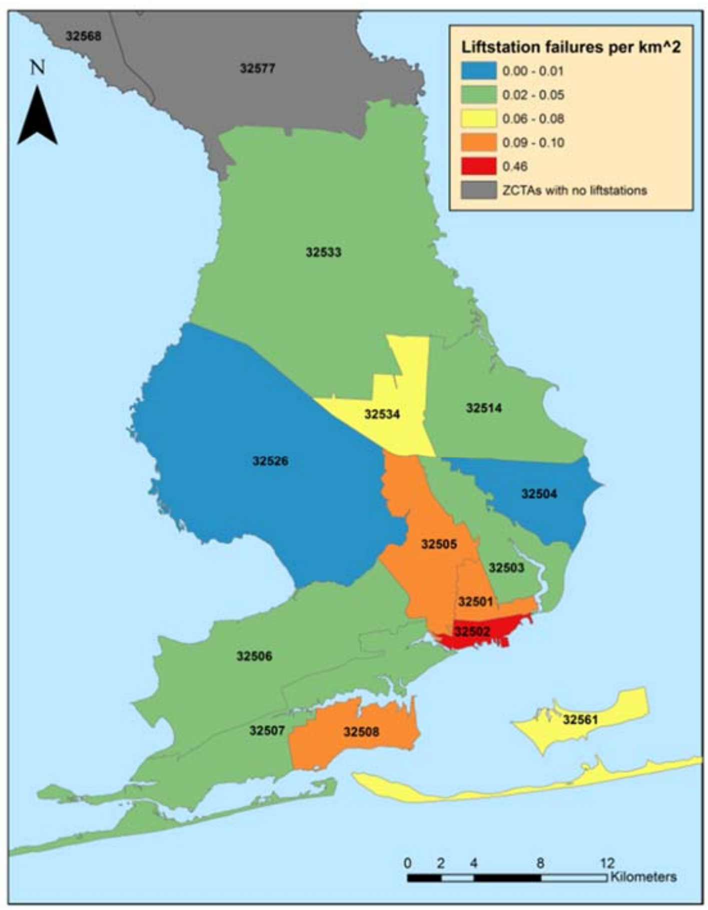
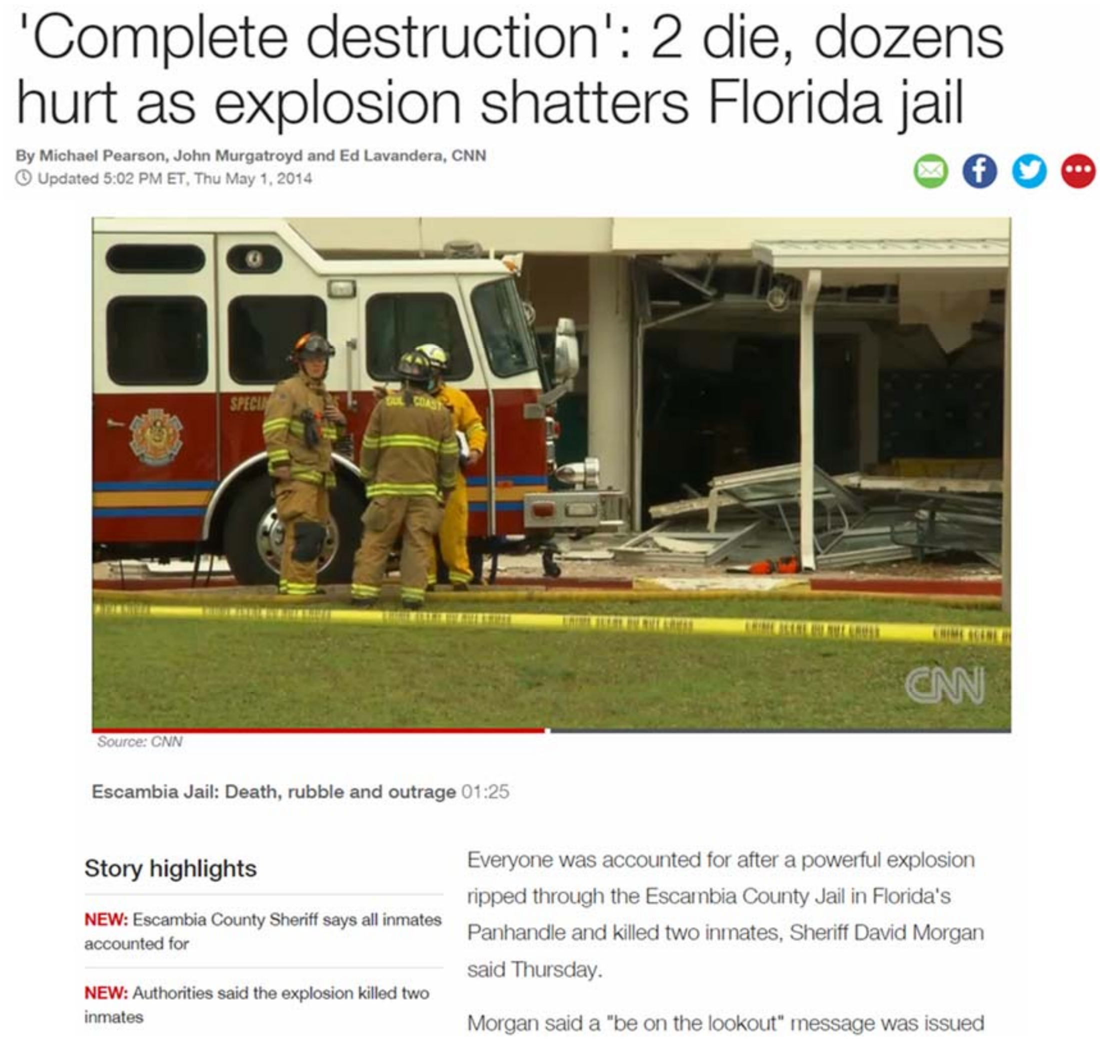


Figure 8. Sewage lift station failures per square kilometer by ZCTA.

Local Reporting of Flood Impacts



'Complete destruction': 2 die, dozens hurt as explosion shatters Florida jail

By Michael Pearson, John Murgatroyd and Ed Lavandera, CNN
Updated 5:02 PM ET, Thu May 1, 2014

Source: CNN

Escambia Jail: Death, rubble and outrage 01:25

Story highlights

NEW: Escambia County Sheriff says all inmates accounted for

NEW: Authorities said the explosion killed two inmates

Everyone was accounted for after a powerful explosion ripped through the Escambia County Jail in Florida's Panhandle and killed two inmates, Sheriff David Morgan said Thursday.

Morgan said a "be on the lookout" message was issued

Figure 9. CNN article from May 1, 2014 about Escambia County Jail Explosion.

As early as April 30, one drowning fatality near Cantonment had been reported. University Parkway at 9-Mile Road was underwater, along with the Scenic Hills North neighborhood, most of Palafox Street in downtown Pensacola, an area near Fairfield Avenue at Pace Blvd. Additionally, a storm retention pond had failed, flooding the Woodbridge subdivision on University Parkway. At least 1,700 homes were without power in an area from Panama City, FL, to Orange Beach, AL (PNJ April 30, 2014).

By May 3, millions of gallons of raw sewage overflowed from the ECUA Central Water Reclamation Facility into the Escambia River near Gonzalez, along with 35 reported domestic wastewater spills in Escambia and Santa Rosa counties combined. Flooding was reported at the Forest Creek apartment complex in Warrington, and major flooding affected the Cordova Park neighborhood near Piedmont Road and Summit Avenue in Pensacola, as well as in the Bristol Park neighborhood in Cantonment. Flooding also was blamed for a natural gas explosion at the Escambia County Jail in Pensacola, killing at least two inmates (PNJ May 3, 2014) . (Figure 9). News coverage of the flood and the impacts was limited on May 4 to concerns about mold problems during the "drying-out" process (PNJ May 4, 2014).

Surface Water Sampling and Beach Advisories

Based on conversations with Escambia County Government's Environmental Section, little to no surface water samples were taken immediately after the flooding event. This is because county staff members were heavily involved in response and clean-up efforts. With a flooding event of this magnitude (many infrastructure impacts), the emphasis was on ensuring public safety and restoring needed services. Likewise, there was a limited amount of sampling done at permitted beaches (places where recreational waters are routinely monitored). However, DOH-Escambia did issue precautionary warnings that urged people to avoid beach waters (and all flood waters) during and after the flooding event. Data obtained from Escambia County government indicated fecal coliform elevations several weeks after the flooding event, but this data did not correspond to our defined impact (study) period.

Florida Data Sources Used to Characterize Health Impacts

A variety of data sources are readily available in Florida to study the effects of extreme weather events on human health outcomes. Using existing data sources is beneficial for several reasons. First, they provide immediate access to data to understand historical (baseline) trends and potential associations between weather and public health. They also collect information statewide on a variety of health outcomes and diseases that is standardized using common classification schemes. However, using these data sources is not without limitations. For example, these data sources were mostly created for billing, surveillance, or quality assurance purposes and were not originally intended for research in general or to specifically study the effects of weather hazards on health outcomes.

Agency for Health Care Administration (AHCA):

AHCA, managed by the Executive Branch of the Florida state government, is the main health policy and planning entity responsible for managing the state's Medicaid program, licensing the 41,000 state health care facilities, and centralizing/sharing associated health care data (http://ahca.myflorida.com). AHCA has been collecting hospital discharge and emergency department (ED) data since 1988 and 2005, respectively. These data sources contain a detailed record of each hospitalization and ED visit, and each record lists the primary and contributing diagnoses, patient demographics, and billing information (such as ZIP Code). Hospital discharge data also contain information on primary and secondary procedures. Some of the strengths of using AHCA data include: they provide comprehensive statewide coverage and have many years of historical data; hospital discharge and ED data provide for the ability to study non-notifiable diseases and injuries; they provide additional data to augment and evaluate notifiable disease information; and they provide overall and categorical health care charges that can be used to estimate costs. Limitations of AHCA data include the absence of data from federal facilities, a six-month to one-year lag in access to data due to internal reporting and validation processes, limited available personal identifiers, and questionable clinical accuracy. This last limitation is true with any study relying solely on *International Classification of Diseases, 9th Revision, Clinical Modification* (ICD-9-CM) codes. AHCA data were used for the following health conditions: injuries from flooding and clean-up activities, asthma and other respiratory diseases, mental health conditions, and carbon monoxide poisoning. We included primary and all secondary diagnoses among Florida residents for the health condition(s) of interest.

AHCA, MERLIN, and Vital Statistics data were all used to identify health conditions that were caused or worsened by the flood event

Florida's Notifiable Disease Surveillance System (Merlin):

Merlin is a web-based surveillance system that is maintained by the DOH, Division of Disease Control and Health Protection, Bureau of Epidemiology, Surveillance Systems Section (http://www.doh.state.fl.us/disease_ctrl/epi/Acute/systems.html). It is used for notifiable disease reporting by all of Florida's 67 counties. Data are collected and entered primarily by DOH staff located in the counties. Merlin is a single, statewide database with real-time web access for entering patient demographic and geographic information, case data (e.g., symptoms and exposures), laboratory results, health care visit information, extended case report form data, and control measures and outbreak information, where applicable. There are several strengths of the Merlin system that should be noted. Merlin is a flexible system that can be adapted to meet the unique needs for reporting of specific diseases through the Merlin Outbreak Module or Extended Data screens. Having statewide data on reportable diseases in Florida over the past two decades (since 1992) provides easily accessed essential background information, clinical data, and a means to view disease rates and other trends over time. The limitations of Merlin include variation in training and expertise of county staff, variable completeness and timeliness of case reporting, differing priorities for case follow-up, and differences in clinical and surveillance case definitions. It is important to note that Merlin is a passive surveillance system placing the burden of reporting notifiable diseases to the county health department on healthcare providers. Because of this, incomplete reporting of cases is an important limitation. The relatively mild nature of many infections and the availability of over-the-counter medications means that many cases of such illness will not be reported to the Merlin system. It is believed that is the case in this study. However, Merlin data were still used for the following health conditions: vectorborne disease (e.g., West Nile Virus) and enteric diseases (i.e., *Campylobacter*, *Giardia*, and *Salmonella* infections). For all health conditions of interest in Merlin, we include all case classifications (confirmed, probable, and suspect) and only cases that were acquired in Florida among Florida residents.

Florida Poison Information Center Network (FPICN):

The FPICN is coordinated through DOH Division of Children's Medical Services, and includes three centers (Jacksonville, Tampa, and Miami) (http://www.fpicn.org). Each center is certified by the American Association of Poison Control Centers and is located on the campus of a major teaching hospital. Patient exposures are assessed, managed, and coded by specialists in poison information, including pharmacists, nurses, physicians, or physician assistants who are trained and certified to operate the hotline. Data collected on each call includes demographic and geographic information, date and site of exposure, exposure reason, case management information, ingested substances, symptoms, and outcome. FPICN has been taking calls from Florida's public since 1998, and data is available in real-time, 24 hours per day and seven days per week. The following limitations should be noted. FPICN has follow-up protocols to ensure accuracy and completeness of data, but missing information can still be a problem. Also, the poison centers rely heavily on self-reported information, rather than on validated clinical information, in some instances. FPICN data were used for carbon monoxide poisoning. We included only exposure-related calls that were determined to have effects related to an unintentional exposure.

Vital Statistics:

The Bureau of Vital Statistics at DOH collects Florida mortality data using the Electronic Death Record System (EDRS). Currently, about 97% of all death records in Florida are filed using the EDRS, which was implemented in 2011 and 2012. However, death certificate data in Florida are available back to 1917. Death certificates are completed by the attending physician or one of their office representatives, a local medical examiner, or the funeral home director. This data system collects a variety of data on all deaths, including the underlying and contributing causes of death based on ICD-10 coding with up to 20 contributing causes of death currently available (http://www.flpublichealth.com/VSBOOK/VSBOOK.aspx). Limitations to using vital statistics data include lag in availability up to the fourth quarter (fall) of previous year, incomplete data, poor data quality due to the variability in clinical training of persons completing the forms, and limited demographic or risk factor information. In this study, vital statistics data were used for assessing unintentional deaths related to the flood event.

Health Conditions/Indicators Definitions

Most of the morbidity and mortality considered in relation to flooding in this report are acute in nature, and we are more concerned with the short-term health effects. However, the risk period of interest for each of these health outcomes is variable. For injury and carbon monoxide (CO) poisoning, we were interested in an impact period that encompassed post-storm clean-up activities (up to 14 days after the end of the event). For enteric diseases, the time period of interest included only a longer post-storm period (up to 30 days after the end of the event) to account for variable incubation periods for our outcomes of interest. For mental health conditions, the impact period was up to 30 days post-event to capture the mental health effects associated with loss of property, displacement, injury, and death of loved ones. Similarly, for all-cause mortality, we chose a 30-day period post-event to capture deaths considered both directly and indirectly related to the flood event. Finally, for asthma and other respiratory diseases and vectorborne diseases, we included up to 60 days post-event in our analysis. For respiratory disease, we are interested in the respiratory effects primarily from mold. This longer timeframe will allow for the mold to develop and for people to be exposed and then develop symptoms associated with this exposure. The longer timeframe for vectorborne diseases also accounts for the mosquito life cycle and disease transmission cycle of most of these diseases.

All-cause injury:

This report focuses on all-cause injury among Florida residents, where both the primary or secondary diagnoses are indicative of an injury and the cause is listed as unintentional or undetermined. The definition of all-cause injury matches that of the Centers for Disease Control and Prevention (CDC), with additional exclusions of codes that are unlikely to be related to weather hazards (e.g., late effects of injury, poisoning).

ICD-9 and E-codes used for defining injuries included:
800-904
910-929
940-957
959
995.55
E800-E848
E850-E869
E880-E929

This definition excludes intentional injury (E950-E979, E990-E999), late effects (905-909), foreign body entering orifice (930-939), traumatic complications (958), poisoning and toxic effects of substances (960-989), and other or unspecified effects (990-995). Both hospital and ED visits were utilized to assess this indicator.

All-cause mortality:

All-cause mortality was considered as an indicator for this weather-related event. All death certificates where the manner of death code was not listed as suicide, homicide, or pending investigation were included regardless of the listed underlying or contributing causes of death. We further classified deaths using the underlying cause of death based on *International Classification of Diseases, 10th Revision* (ICD-10) codes into the following sub-categories: cardiovascular disease, intestinal infections, other infections, cancer, diabetes, respiratory disease, kidney/liver disease, injury, and other diseases.

Asthma and other respiratory effects:

Because chronic respiratory disease can often be controlled with proper education, clinical treatment, medication regimen, and environmental management, ED visits may be considered indicators of poorly controlled disease rather than of total prevalence or incidence. The change in rate of ED visits and hospitalizations, however, can be used as a proxy to track changes in the severity of these diseases over time. Adhering to proper medication regimens can be more difficult during times of natural disaster. For the purpose of this report, ED visits for the health outcomes of interest were based on either a primary or a secondary diagnosis of the following ICD-9 codes for respiratory diseases (460 to 519). Both hospital and ED visits were utilized to assess these indicators.

Carbon monoxide (CO) poisoning:

We used FPICN exposure calls, hospitalization, and ED data to assess the burden of CO poisoning among Florida residents. We included only unintentional cases of exposure or poisoning, and excluded cases associated with fire, when possible. Note that some cases of CO exposures or poisonings may be documented in more than one of the data sets used in this report; however, de-duplication was not possible due to the lack of personal identifiers available in these data sources. For hospitalization and ED data, this indicator was based on the following ICD-9 codes: 986 , E952.0, E952.1, E868.2, E868.3, E868.8, E868.9, E982.0, and E982.1

This definition excluded visits with ICD-9 codes for intentional poisonings (E952.0, E952.1, E950-E979.9, and E990-E999). For FPICN data, calls related to CO exposure, indicated as such by the Specialist in Poison Information, were included. We excluded "information-only" calls and calls judged as non-toxic exposure, unrelated effect, confirmed as a non-exposure, or intentional.

Enteric diseases:

The foodborne and waterborne diseases chosen as health indicators for this study are notifiable diseases in Florida. Campylobacteriosis and salmonellosis are bacterial diseases more commonly associated with foodborne transmission. Giardiasis is a protozoan disease and is more commonly associated with waterborne transmission and contamination of water sources. For some of these diseases, there are other modes of transmission besides foodborne or waterborne, such as environmental exposure and zoonotic or person-to-person transmission. Affected individuals often have mild or asymptomatic infections, and many cases do not seek treatment and are not reported.

Campylobacteriosis is an enteric disease caused by bacteria from the genus *Campylobacter*. We included confirmed (*Campylobacter* isolated using culture techniques), suspect (*Campylobacter* isolated using non-culture techniques), and probable (has clinical symptoms and is linked to a confirmed case) case definitions.

Salmonellosis is an enteric disease caused by bacteria from the genus *Salmonella*. We included confirmed (*Salmonella* isolated using culture techniques), suspect (*Salmonella* isolated using non-culture techniques), and probable (has clinical symptoms and is linked to a confirmed case) case definitions.

Giardiasis is a protozoan diarrheal disease caused by *Giardia lamblia*. We included only confirmed (evidence of *G. lamblia* cysts, trophozoites, antigen, or DNA) and probable (has clinical symptoms and is linked to a confirmed case) case definitions.

Mental health referrals:

Because there is no surveillance system available for mental health visits nor good estimates of the prevalence of these conditions, we relied on ED visits for mental health and behavioral disorders for these indicators. Only principal diagnoses were considered to improve our specificity for this group of health outcomes. We considered the following conditions that may be associated with weather-related impacts.

Codes for mental health conditions included:

Organic psychotic conditions (ICD-9: 290-294)

Depression (ICD-9: 311)

Stress-related disorders (ICD-9: 308-309)

Substance-related disorders (ICD-9: 291-292, 303-305)

Neuroses (ICD-9: 300)

Other psychoses (ICD-9: 295-299)

All mental health conditions (ICD-9: 290-319)

Some important limitations specifically related to mental health conditions are worth mentioning. We are missing individuals who are receiving mental health services outside of an ED setting, whether at temporary clinics or outside of health care settings (e.g., church or community organizations). However, ED visit data currently represents the best available statewide data source to examine such associations. EDs may also be the best source of health care available immediately after impact, barring structural damage, as available resources are often targeted towards emergency services. We also recognize that the effects of such extreme weather events on mental health may be long-term and outside of our impact period of interest. However, evidence suggests that most individuals with initial symptoms of stress or trauma associated with natural disasters tend to return to normal functioning over time.

Vectorborne diseases:

The following vectorborne diseases were originally assessed using Merlin data for the time periods of interest: West Nile virus, Eastern Equine encephalitis, St. Louis encephalitis, and other arboviral diseases. No locally-acquired cases of any of these vectorborne diseases were identified or reported during the time periods of interest in Escambia County. Because these are dependent on the life cycle of the vector (i.e., mosquito), the incidence for these diseases, like West Nile Virus, peak in Florida in the wet summer months, typically between July and September, which is later than our periods of interest (Florida Department of Health, Florida Morbidity Statistics Report 2013) . Therefore, no vectorborne disease results are presented in this report.

Methods

The method used to examine the health impacts associated with this flood event was a Case-Control Study, comparing counts of our health outcomes of interest that occurred in Escambia County during and after the flood event (impact period) to counts in a period without a flood event (control period). The unit of analysis was the count of health care visits or disease reports related to a specific health condition during the impact or control period of interest. Counts were assessed for the county as a whole, and separately for each ZIP Code in Escambia County.

Using daily precipitation data for the months of April and May covering the period 1960 – 2014, we calculated the descriptive statistics including mean, median, and standard deviation. We also computed percentile values for daily observations and for running five-day sums. For both the daily observations and the five-day totals, the April-May 2014 event ranked first (April 30, and April 28 – May 2) among all April and May days since 1960.

To identify a baseline period for comparison, we examined the daily and five-day running totals for only the period April 15 – May 15, and for only the most recent 10 years (2005-2014; this time frame is limited by the availability of the health data), using the percentiles computed from the entire April – May observed precipitation record (1960-2014).

We selected the year 2008 as the most appropriate control period. The April 15 - May 15, 2008 precipitation record from the Regional Airport (for example) is unremarkable (less than the 80th percentile of all comparable periods since 1960) and also is non-zero (whereas the overwhelming majority (~70%) of all daily observations in the full record are zeroes).

Proportions were compared between the impact and control periods for a select group of conditions, including the proportion of ED visits and hospitalizations that were coded as respiratory, injury, and carbon monoxide poisoning. All of these are types of health impacts that could be caused by flooding impacts and/or cleanup activities. The 2008 proportion for these types of health outcomes was compared to the 2014 proportion, to look for any increases from the earlier year to the latter. For ED visits and hospitalizations, the denominator was the total count of ED visits or hospitalizations during that same period and in that same geographic area. This was done to reduce the bias caused by increased utilization of EDs and hospitals over time.

This study examined sub-county differences in flooding impacts at the ZIP Code level. While this study examined health outcomes by ZIP Code area, it is very difficult to find meaningful statistical relationships in sub-populations when there are very low numbers of associated health outcomes, as in this study. No formal statistical testing was conducted based on the limitations in sample size and the comparison of only two time periods.

An important caveat is that each of these health outcome types has a slightly different exposure window (time period of concern). Please see Table 3 below for a list of the relevant exposure windows by health outcome. These time periods are based on the literature for each health outcome. So, the number of respiratory visits during the 60-day exposure window was counted, and then converted to a proportion of all of the ED and Hospitalizations for the same time period.

Table 3. Exposure windows for impact and control periods and data sources for each health indicator considered for the health impact assessment

Health Outcome	Data Source	Exposure Windows*	Dates
All-cause injury	AHCA	Event + 14 days	4/29 – 5/17
All-cause mortality	Vital Statistics	Event + 30 days	4/29 – 6/2
Asthma and other respiratory effects	AHCA	Event + 60 days	4/29 – 7/2
Carbon monoxide poisoning	AHCA, FPICN	Event + 14 days	4/29 – 5/17
Enteric diseases	Merlin	Event + 30 days	4/29 – 6/2
Mental health conditions	AHCA (ED only)	Event + 30 days	4/29 – 6/2
Vectorborne diseases	Merlin	Event + 60 days	4/29 – 7/2

*Period of interest includes the 5-day event period (4/29-5/3) plus the additional days in the exposure window. The control period used the same calendar dates for the year 2008. Note—vectorborne diseases not included in final analysis due to very low numbers. AHCA = Agency for Health Care Administration, FPICN = Florida Poison Information Centers Network, ED = emergency department

The use of ED and Hospitalization data to characterize widespread public health impacts is imperfect because it only captures a portion of the burden (typically the most severe cases). Further, the ZIP Codes used in this analysis were collected by AHCA for billing purposes and may not represent where the persons were actually exposed.

Results

Here, we present descriptive and comparative results for the impact period (2014) and control period (2008) for each of the health outcomes considered in this assessment. For some health outcomes, few to no cases were reported during the time periods considered, so no proportions were calculated. In these instances, only raw numbers of cases are reported and described.

All-cause injury: During the impact period (the 5-day flooding event plus the 14-day exposure window), there were 231 hospitalizations and 1,970 ED visits related to injury in Escambia County. These visits accounted for 10.9% of all hospitalizations and 24.3% of all ED visits during the exposure window. During the control period, there were 166 hospitalizations and 1,665 ED visits, accounting for 8.2% of hospitalizations and 24.0% of ED visits during the window. Table 4 presents the proportions of visits by ZIP code during the periods of interest, and Figure 10 shows the percent change in proportions from 2008 to 2014 for all-cause injury hospitalizations and ED visits. Figure 11 displays the percent change in proportions for all hospital and ED visits combined. The ED and hospitalization data for all-cause injury showed increased visits when 2008 (control year) is compared to 2014 (flooding year) for the entire county and for many of the ZIP Codes.

Table 4. Proportion of hospitalizations and ED visits for all-cause injury during the periods of interest by ZIP Code and county total

	Hospitalizations		ED Visits	
	Control Period	Event + 14 Day Period	Control Period	Event + 14 Day Period
ZIP Code*	2008	2014	2008	2014
32501	6.0%	7.3%	20.4%	27.5%
32502	11.1%	12.5%	16.7%	24.4%
32503	9.8%	11.3%	22.5%	26.1%
32504	3.3%	10.8%	28.2%	25.7%
32505	5.9%	8.6%	21.8%	21.5%
32506	4.3%	12.3%	24.3%	20.8%
32507	7.1%	9.7%	25.7%	24.1%
32508	13.3%	0.0%	33.3%	25.0%
32514	9.4%	14.5%	25.2%	24.5%
32526	11.6%	8.9%	27.0%	26.8%
32533	15.8%	12.6%	26.0%	25.2%
32534	4.7%	14.6%	19.5%	25.1%
32535	13.0%	12.5%	18.3%	26.0%
32568	8.3%	0.0%	35.9%	20.9%
32577	6.7%	2.9%	25.3%	36.0%
Escambia County (overall)	8.2%	10.9%	24.0%	24.3%

*ZIP Codes not listed did not have health reports matching our study definition

There were 231 hospitalizations and 1,970 ED visits related to injury in Escambia County during the flood event. These visits accounted for 10.9% of all hospitalizations and 24.3% of all ED visits during the exposure window.

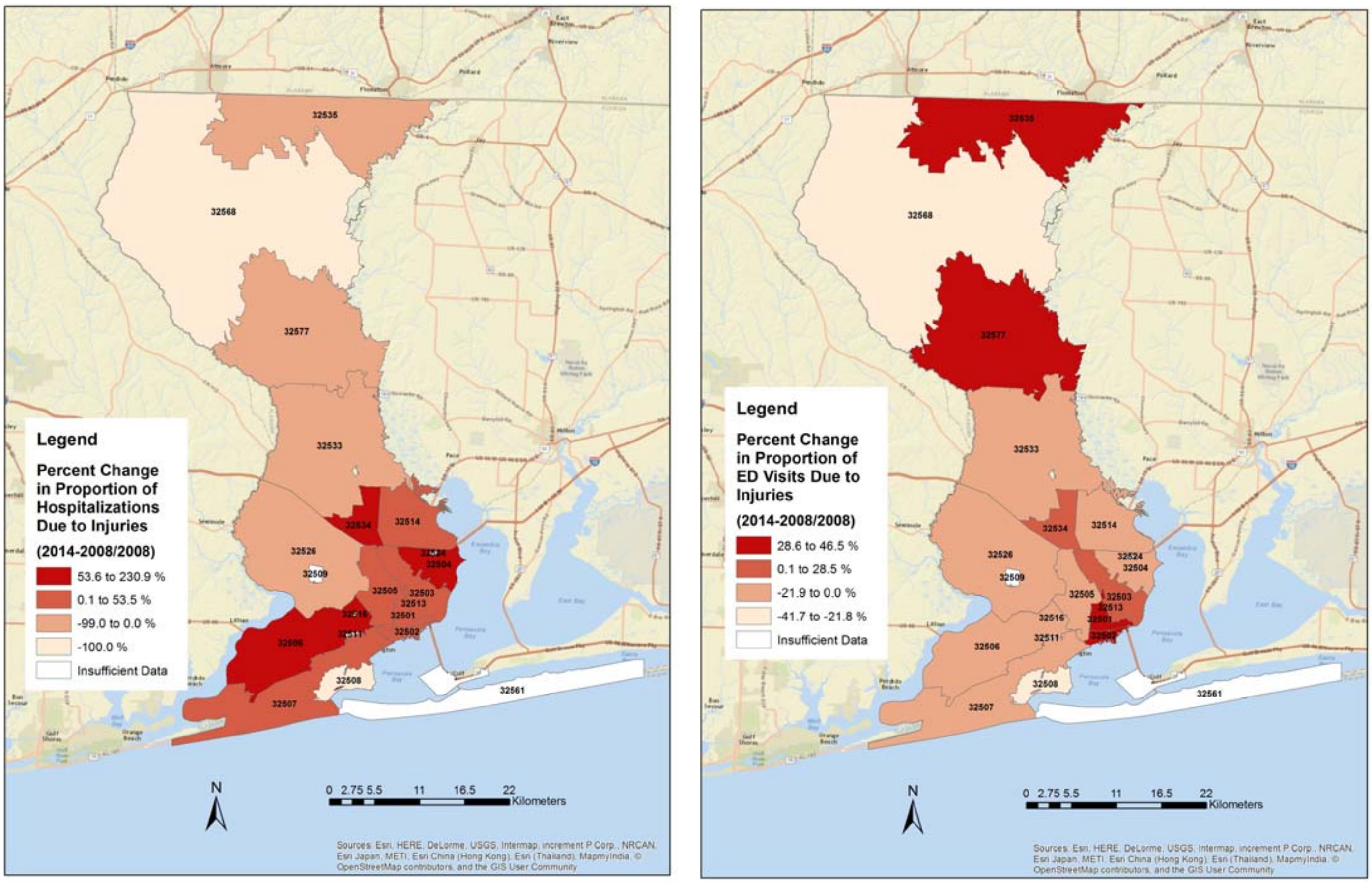


Figure 10. Difference in a) Injury Hospitalizations as a Proportion of All Hospitalizations and b) Injury ED Visits as a Proportion of All ED Visits (% change, 2014 minus 2008, divided by 2008) During Exposure Window by ZIP Code

During the control period, there were 166 hospitalizations and 1,665 ED visits, accounting for 8.2% of hospitalizations and 24.0% of ED visits during the window

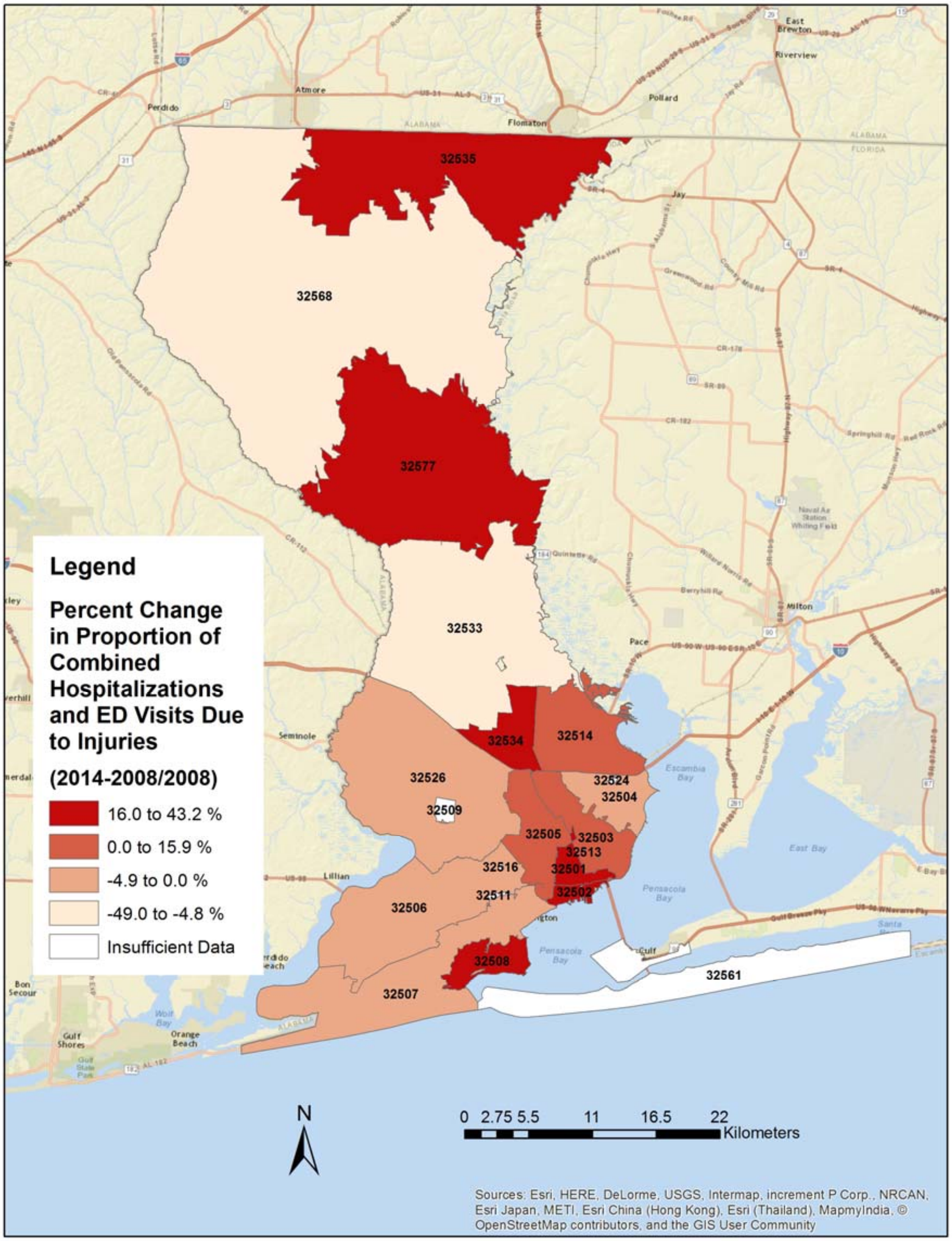


Figure 11. Difference in Combined Injury Hospitalizations and ED Visits as a Proportion of All Hospitalizations and ED Visits (% change, 2014 minus 2008, divided by 2008) During Exposure Window by ZIP Code

All-cause mortality:

During the 5-day flooding event and the 30-day exposure window, 254 deaths were reported in the impact period and 300 in the control period county-wide. This yielded a lower crude mortality rate during the impact (84.0 deaths per 100,000) compared to the control period (110.1 per 100,000). Few differences in underlying causes of death were noted during the two periods, except that there was a greater proportion of deaths due to injury during the impact than control period (7.4% vs. 4.0%). Due to the small numbers, differences in all-cause mortality were not assessed by ZIP Code.

Asthma and other respiratory effects:

For respiratory diseases, we were interested in the 5-day flooding event and a 60-day exposure window. For the entire county, 2,285 (30.7%) respiratory hospitalizations and 5,163 (18.3%) ED visits occurred during the impact period; while 1,909 (28.3%) hospitalizations and 3,953 (16.6%) ED visits occurred during the control period. County-wide, both ED visits and hospitalizations were greater after the flood event than during a non-flood control period. This same trend held true for many of the individual ZIP Codes in Escambia County, especially for respiratory-related ED visits (Table 5, Figures 12 & 13).

Table 5. Proportion of hospitalizations and ED visits for respiratory diseases during the periods of interest by ZIP Code and county total

	Hospitalizations		ED Visits	
		Event + 60-Day Period		Event + 60-Day Period
ZIP Code*	2008	2014	2008	2014
32501	29.2%	29.4%	15.4%	19.2%
32502	30.6%	28.2%	16.9%	16.2%
32503	25.1%	29.2%	18.0%	18.1%
32504	29.3%	29.5%	15.5%	16.1%
32505	28.1%	29.9%	17.6%	20.4%
32506	25.3%	32.4%	17.9%	18.9%
32507	26.8%	30.3%	14.8%	17.8%
32508	11.1%	5.6%	13.3%	15.6%
32514	29.8%	30.8%	15.3%	17.5%
32526	29.4%	31.8%	16.5%	18.0%
32533	28.7%	31.3%	14.5%	15.8%
32534	32.2%	31.3%	19.3%	18.4%
32535	38.2%	42.6%	16.6%	18.6%
32568	20.5%	28.1%	16.1%	16.3%
32577	29.7%	28.7%	16.6%	18.3%
Escambia County (overall)	28.3%	30.7%	16.6%	18.3%

ZIP Codes not listed did not have health reports matching our study definition.

For the entire county, 2,285 (30.7%) respiratory hospitalizations and 5,163 (18.3%) ED visits occurred during the impact period

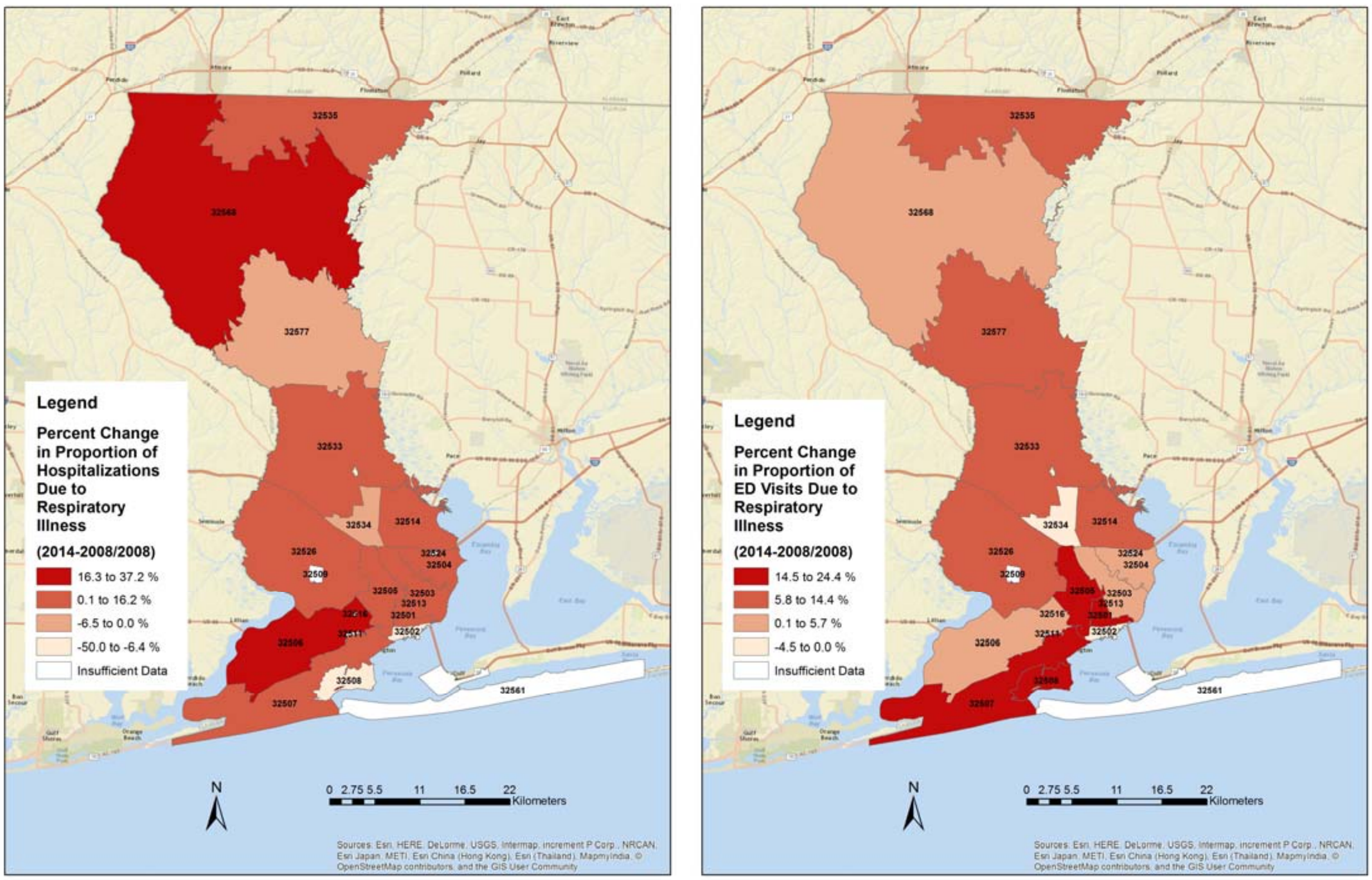


Figure 12. Difference in a) Respiratory Hospitalizations as a Proportion of All Hospitalizations by ZIP Code and b) Respiratory ED Visits as a Proportion of All ED Visits by ZIP Code (% change = 2014 minus 2008, divided by 2008)

County-wide, both ED visits and hospitalizations were greater after the flood event than during a non-flood control period.

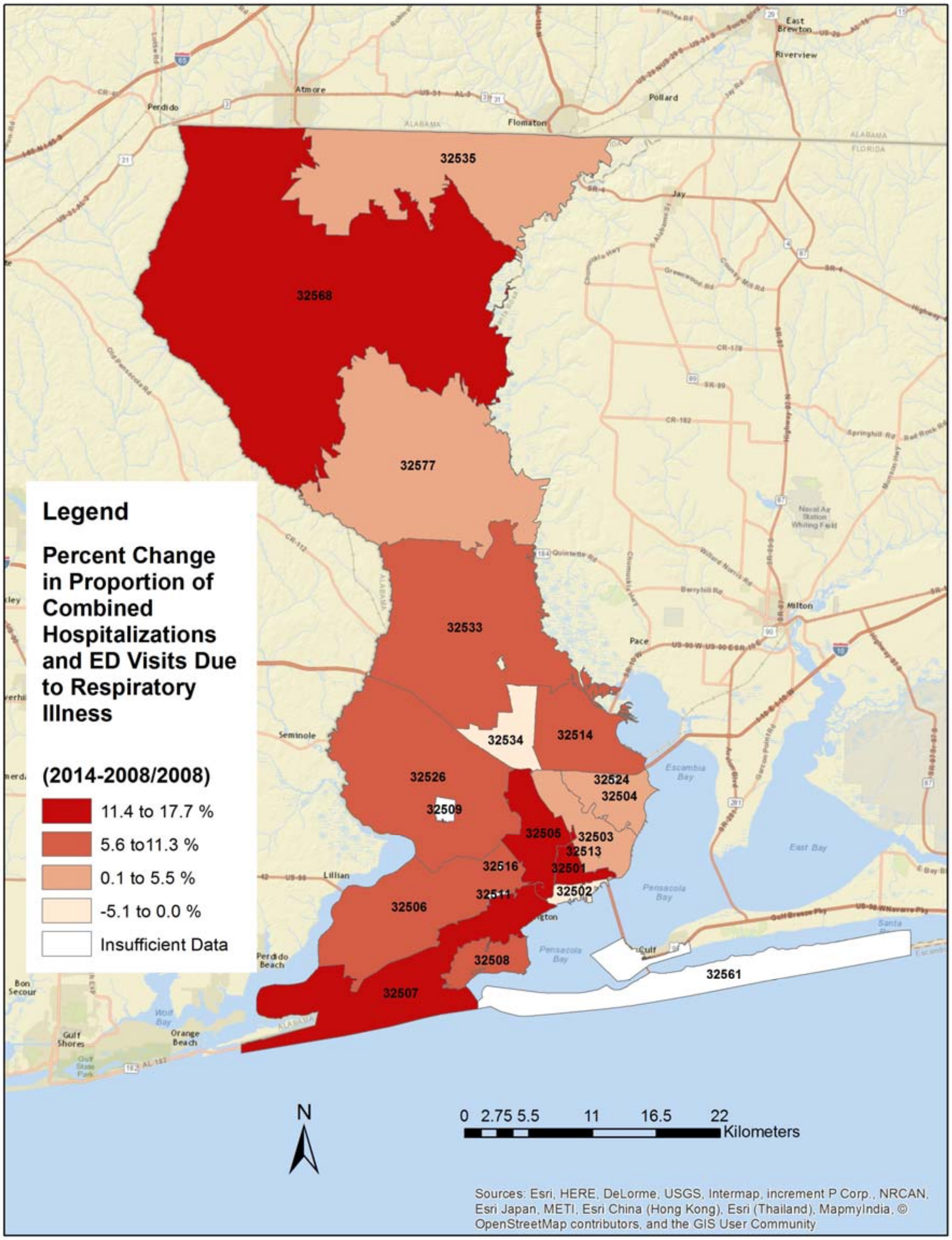


Figure 13. Difference in Combined Respiratory Disease Hospitalizations and ED Visits as a Proportion of All Hospitalizations and ED Visits by ZCTA (% change, 2014 minus 2008 divided by 2008).

Carbon monoxide poisoning:

Very few carbon monoxide poisoning cases or exposure calls were reported during the time periods of interest. In fact, during the impact period (5-day event plus 14-day exposure window), only one hospitalization related to carbon monoxide was reported (no ED visits or poison center calls). During the control period, only one exposure-related call to the poison centers occurred (no ED visits or hospitalizations).

Enteric diseases:

Few cases of the enteric diseases of interest were reported during our periods of interest; 17 cases during the impact and 10 cases during the control period. Among all cases, 55.6% were salmonellosis, 40.7% were campylobacteriosis, and 3.7% were giardiasis.

27 cases of enteric disease were reported during the flood event impact and control periods, which was likely under-reported

Mental health referrals:

For mental-health related ED visits, 340 (2.2% of all ED visits) occurred during the impact period and 295 (2.3% of all ED visits) occurred during the control period. The majority of ED visits for both impact and control periods were for substance-related disorders (28.7%) and neuroses (23.8%).

Vectorborne diseases:

There were no cases of any of the notifiable vectorborne diseases reported during either the impact or control periods.

Overall, this data shows an increase in the proportion of ED visits and hospitalizations that could be flood related (based on the type of health impact reported). The next section of this paper will discuss policy recommendations that, if adopted, would be expected to lead to reduced health impacts in any future flooding events. While this policy section draws on lessons learned from the Escambia County event, the recommendations could also be beneficial to other Florida communities. It is our hope that other Florida counties and cities can learn from the extreme flooding event that impacted the Pensacola area, and that they will take measures designed to reduce the public health burden from such natural disasters.

Policy Recommendations

In this context, policy recommendations include measures to reduce illness, injury, and deaths that can occur from severe flooding. They also include considerations for waste cleanup activities.

Sewage Lift Stations

To reduce the number of sewage lift stations that fail (stop pumping) during extreme flooding events, it is recommended that electrical panels be lifted as high as reasonably possible on the structures that house the lift stations. It is not known how many of the failures during this event could have been prevented by such actions, as that would depend on the height of the flood waters relative to the location of the electrical panel. However, it is reasonable to assume that raising the electrical panels will result in a reduced likelihood of inundation during future flooding events, and this could potentially result in continued operation of lift stations during such natural disasters. The benefits to the community are reduced exposure to human sewage on the ground and reduced sewage in the surrounding environment (which also has benefits for wildlife and potential recreational activities).

Environmental Sampling

In order to understand how flood waters are impacting surface and ground water, additional environmental sampling should be conducted where feasible. The Florida Department of Health will look for grant opportunities that can be used for public health preparedness and response efforts. A shortage of available staff is one of the biggest limitations to gathering data during a disaster, but strike teams from Environmental Health may be available to assist, and such teams should use protocols developed by the CDC during natural disasters.

Cleanup Activities and Personal Protective Equipment

After the flood waters have receded, the cleanup stage can begin. Unfortunately, cleanup activities involve a substantial risk of death and injury. Direct injuries (e.g., broken bones) are common, but CO poisoning and asthma are also issues that can impact human health. To safely engage in cleanup activities, follow these steps from the U.S. Centers for Disease Control and Prevention:

When returning to your home after a hurricane or flood, be aware that flood water may contain sewage.

Inside the Home

- Keep children and pets out of the affected area until cleanup has been completed.
- Wear rubber boots, rubber gloves, and goggles during cleanup of affected area.
- Remove and discard items that cannot be washed and disinfected (such as, mattresses, carpeting, carpet padding, rugs, upholstered furniture, cosmetics, stuffed animals, baby toys, pillows, foam-rubber items, books, wall coverings, and most paper products).
- Remove and discard drywall and insulation that has been contaminated with sewage or flood waters.
- Thoroughly clean all hard surfaces (such as flooring, concrete, molding, wood and metal furniture, countertops, appliances, sinks, and other plumbing fixtures) with hot water and laundry or dish detergent.
- Help the drying process by using fans, air conditioning units, and dehumidifiers.
- After completing the cleanup, wash your hands with soap and warm water. Use water that has been boiled for 1 minute (allow the water to cool before washing your hands).
- Or you may use water that has been disinfected for personal hygiene use (solution of ⅛ teaspoon [~0.75 milliliters] of household bleach per 1 gallon of water). Let it stand for 30 minutes. If the water is cloudy, use a solution of ¼ teaspoon (~1.5 milliliters) of household bleach per 1 gallon of water.
- Wash all clothes worn during the cleanup in hot water and detergent. These clothes should be washed separately from uncontaminated clothes and linens.
- Wash clothes contaminated with flood or sewage water in hot water and detergent. It is recommended that a laundromat be used for washing large quantities of clothes and linens until your onsite waste-water system has been professionally inspected and serviced.
- Seek immediate medical attention if you become injured or ill.

Outside the Home

- Keep children and pets out of the affected area until cleanup has been completed.
- Wear rubber boots, rubber gloves, and goggles during cleanup of affected area.
- Have your onsite waste-water system professionally inspected and serviced if you suspect damage.
- Wash all clothes worn during the cleanup in hot water and detergent. These clothes should be washed separately from uncontaminated clothes and linens.
- After completing the cleanup, wash your hands with soap and warm water. Use water that has been

boiled for 1 minute (allow the water to cool before washing your hands).

- Or you may use water that has been disinfected for personal hygiene use (solution of ⅛ teaspoon [~0.75 milliliters] of household bleach per 1 gallon of water). Let it stand for 30 minutes. If the water is cloudy, use solution of ¼ teaspoon (~1.5 milliliters) of household bleach per 1 gallon of water.
- Seek immediate medical attention if you become injured or ill.

See also Reentering Your Flooded Home, Mold after a Disaster, and Cleaning and Sanitizing with Bleach after an Emergency.

Avoidance of Carbon Monoxide (CO) Poisoning

- Install a CO alarm in your home if you have combustion appliances or an attached garage.
- Be sure all appliances are properly installed and used according to the manufacturer's instructions.
- Have fireplace, combustion heating, and ventilation systems, including chimneys, flues, and vents, professionally inspected every year.
- Do not burn charcoal inside a house, garage, vehicle, tent, or fireplace.
- Always use generators outside, more than 20 feet away from home, doors, and windows.
- Do not use un-vented combustion heaters in enclosed spaces, especially sleeping areas.
- Never leave an automobile running in a closed garage or in a garage attached to the house - even with the garage door open.
- While driving, keep the rear window or tailgate of a vehicle closed, as CO from the exhaust can be pulled inside.
- If you suspect you are experiencing any symptoms of CO poisoning, open doors and windows, turn off gas appliances, and go outside.

In cases of severe CO poisoning, call 911 emergency services or call the Florida Poison Information Center at 1-800-222-1222.

Waste Disposal Considerations

As mentioned previously, the cleanup of flooding damage and the renovation of affected properties generates large amounts of construction and demolition debris. Some of this material is relatively inert and harmless (e.g., wood), and some of it has the potential to cause human health effects if not handled and disposed of properly. In particular, the decomposition of gypsum wall board (sheet rock) can generate Hydrogen Sulfide gas that smells like rotten eggs and can be a health concern at elevated levels. After the flooding event in Escambia County in 2014, some of the damaged building materials were transported to the Rolling Hills construction and demolition landfill, located in ZIP Code 32505. The huge amount of this material made it challenging to manage properly. As a result, the surrounding community of Wedgewood experienced adverse effects from Hydrogen Sulfide emissions. The Florida Department of Health addressed this issue in a June 2015 report, which can be found at http://www.floridahealth.gov/environmental-health/hazardous-waste-sites/_documents/r/rollinghills060215.pdf . Environmental sampling efforts in the Wedgwood community are ongoing at this time.

Conclusions

This was a historic flooding event, with severe impacts for the Pensacola area that lasted many months. The flooding overwhelmed public and private infrastructure, resulting in environmental and public health impacts. The data on hospitalization and emergency department visits for multiple health outcomes showed mixed results. Some Escambia County ZIP Codes showed an increased proportion of the types of hospitalizations and emergency department visits that may have been associated with impacts from the extreme flooding event, and other ZIP Codes showed a decrease in this proportion. That conclusion is based on a descriptive analysis comparing the time period of the flood to the same days during a control year (2008). For the county as a whole, there was a slight increase in the proportion of emergency department visits and hospitalizations due to respiratory problems and injuries. For other health impacts that could be caused by flooding, there were simply not enough cases reported in Escambia County to determine if there was a measurable change when the time period in 2014 was compared to the same period in 2008. The health outcomes with insufficient data included food and waterborne illness, vector-borne (mosquito-related) disease, and carbon monoxide poisoning. However, if future flooding occurs in a larger metropolitan area, then it may be feasible to include such impacts in future analyses. Even with the aforementioned limitations in mind, it is clear that the April 2014 flooding resulted in serious impacts to Escambia County. The policy steps listed in this document may reduce such impacts from any future flooding events, and will help to minimize adverse health outcomes from natural disasters in Florida.