Preparing for the Next Storm

Learning from the Man-Made Environmental Disasters that Followed Hurricane Harvey

ENVIRONMENTAL INTEGRITY PROJECT

EMBARGOED FOR RELEASE

AUGUST 16, 2018

ACKNOWLEDGEMENTS

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The Environmental Integrity Project (environmentalintegrity.org) is a nonprofit, nonpartisan organization that empowers communities and protects public health and the environment by investigating polluters, holding them accountable under the law, and strengthening public policy.

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Preparing for the Next Storm:

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Executive Summary

Hurricane Harvey slammed into the Gulf Coast as a category 4 storm on August 25, 2017, dropping over 40 inches of rain across the region—and well over 50 inches in some places. The highest total rainfall in the nation's history—60.58 inches—was recorded near Port Arthur, Texas, about 90 miles east of Houston.[1]

In a region built on petrochemicals and a massive floodplain, industrial facilities were hit hard, and caught off guard. When refineries and other chemical facilities are forced to shut down and restart due to inclement weather, such as was the case with Hurricane Harvey, they release additional harmful pollutants—a result of abnormal operations, equipment malfunctions and failures, and maintenance problems. If they wait too long to cease operations, weather-related impacts, such as power outages, can exacerbate the situation, emitting more pollution and impacting public health. Trouble breathing, rashes, and fatigue are just a few of the symptoms Houston residents living near industrial areas describe when asked about the ways in which Harvey upended their lives.

Hurricane Harvey was more than an historic flooding event. The aftermath was a man-made environmental disaster. We know this because of industry's own reports to the state, which included 8.3 million pounds of unpermitted air pollution[2] and more than 150 million gallons of wastewater released by sewage plants and industry.[3] Air monitoring also detected dangerous plumes of cancer-causing benzene released by industry in a southeast Houston neighborhood while parts of the city were still underwater.[4]

The Houston Ship Channel is lined with refineries and other industrial facilities, many of which waited too long to shut down after receiving warnings about Hurricane Harvey. The delay and poor planning contributed to the release of dangerous air pollutants into nearby communities.

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While some pollution releases during natural disasters may be unavoidable, improvements such as coordinated and staged shutdowns of petrochemical plants, improved maintenance, and equipment better designed to withstand heavy rainfall could help improve the response next time there's a major storm in the region. And there will be a next time: climate change contributed to Harvey's historic rainfall, as warmer air holds more water and record warm water in the Gulf of Mexico helped the storm build strength.[5]

The state of Texas and industry need to better protect workers and neighboring communities from the risks associated with locating massive chemical complexes in low-lying, densely populated coastal areas. This report details ways in which some of the challenges relating to air and water pollution can be addressed in the hopes that in the case of future large storms, taking a deep breath will offer a release of anxiety—not a trip to the emergency room. Texas can do much more to protect vulnerable communities from industrial air and water pollution during natural disasters.

The report by the Environmental Integrity Project relies on reports and data from the Texas Commission on Environmental Quality as well as federal records. This report concerns only unpermitted or illegal air pollution releases – that is, emissions during industrial accidents, startups, shutdowns, and maintenance that companies report to the state as being above and beyond what their state-issued Clean Air Act permits allow during normal operations.

Key Findings:

- After Texas Gov. Greg Abbott declared a "State of Disaster" for coastal Texas counties at 4 pm on August 23, in anticipation of the approaching hurricane, industrial plants in the Houston area took no actions to shut down their facilities – pre-emptively, for reasons of safety and pollution control -- for more than three days. Then, when the heavy rains hit around 6 pm on August 26, eight plants shut down within 24 hours of each other, releasing 1.3 million pounds of pollution. This was part of a cluster of 23 air pollution emissions events over 48 hours that released more than 2.2 million pounds of pollution in the Houston area—much of it triggered by flooding-related mishaps like electrical outages, equipment malfunctions, and the failure of floating roof tanks.

More than 150 million gallons of wastewater overflowed from sewage treatment plants and industries during Hurricane Harvey. Improved engineering could reduce such overflows in the future.

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- In Corpus Christi, near where the storm was forecast to first make landfall, seven refineries and petrochemical facilities shut down pre-emptively before the rains even started to fall after hearing the Governor's disaster declaration. On average, these plants released less air pollution than similar facilities in Houston and Port Arthur, where industries waited longer to shut down and were seemingly caught off guard when power went out.

- Seven industrial plants near the Texas coast– including the Arkema chemical plant in Crosby and the Total Petrochemicals Refinery in Port Arthur -- reported that unexpected electrical outages caused by the storm triggered accidents and shutdowns that released at least 255,598 pounds of air pollution.[6] The Arkema plant burned and exploded when flooding disabled not only the power but also the plant's refrigeration system, igniting chemicals whose fumes sickened emergency responders and forced an evacuation of everyone living within 1.5 miles of the plant.

- At least 45 industrial discharges and 1,500 sanitary sewage overflows released more than 150 million gallons of wastewater during Hurricane Harvey, according to state data.[7] But that figure represents significant underreporting, because at least 24 percent of facilities that reported discharges during the storm failed to enter any estimate of quantity in their reports, instead entering zeros.

Hurricane Harvey caused an estimated $125 billion in damage and left a lot of wreckage – including up to 200 million cubic yards of debris.

- Storage tanks holding crude oil, gasoline, and other hydrocarbons that failed and released toxic pollutants during the storm were often poorly maintained and not designed to withstand heavy rainfall. More than 15 floating roof storage tanks tanks that store hydrocarbon products like gasoline failed during the storm.[8] At least 400 storage tanks in the Houston region have floating roofs, in which the top of the tank floats on the liquid itself.

- About 18.8 million pounds of air pollutants were emitted between August 23 and September 30, 2017, of which 44 percent (8.3 million pounds) were Hurricane Harvey related.

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- In the nine months after the storm, 18 companies revised their air pollution reports to the state to erase 1.7 million pounds of unpermitted emissions during Hurricane Harvey.[9] Industry often justified their alteration of the numbers by arguing that flexible state permits, and Gov. Abbott's disaster declaration, made the pollution legal. This is questionable, however, because – under the state's program -- such reclassification should only be allowed for planned shutdowns, startups and maintenance, not storms and other emergencies.

- The Houston area suffered a cluster of three high-ozone days following Harvey – including the worst day for smog in Texas in 2017, on September 1, 2017.[10] These unhealthy gh smog days – which can cause asthma attacks and burning lungs -- were in part the result of industry's release of millions of pounds of ozone precursors, with 1.1 million pounds of volatile organic compounds released on August 27 and 2.4 million pounds released on August 31.[11] Releases of nitrogen oxides (another precursor of ozone) totaled about 156,000 pounds during the same period in the Houston region, of which 145,000 pounds were released on August 27.

- Residents of the Houston region were also bombarded with extremely high levels of multiple air toxics, including benzene, a carcinogen. These Harvey-related releases were heavily concentrated in working class and lower-income neighborhoods, which highlights the long-standing environmental injustice of vulnerable communities living adjacent to industry. The pollutants put children, the elderly, people without health insurance, and those living with chronic respiratory conditions like asthma or chronic obstructive pulmonary disease, at increased risk of acute health problems.

- During and after the storm, federal and state regulators provided overly broad statements about air pollution levels, repeatedly telling people that they had no reason to worry despite known releases of benzene and other dangerous pollutants.

Key Recommendations:

- As the lead state agency for environmental emergency response, the Texas Commission on Environmental Quality (TCEQ) should plan, coordinate, and stagger the often complicated shutdowns of major industrial facilities during hurricanes and other disasters, as well as the subsequent restarting of plants, to minimize pollution impacts to nearby communities.

- Refineries and other petrochemical plants need to better prepare in advance of future hurricanes to minimize their emissions and the failures caused by storms, such as power outages. Companies need to invest in more robust backup electrical generation systems.

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- The state needs to be better prepared to monitor air pollution during and immediately after natural disasters. The air quality impacts from the pollution that was released during and after Hurricane Harvey are not fully known, because the region's air monitoring stations were shut down ahead of the storm. While there may be good reason to shutter some expensive equipment to protect it from damage, the state also has an obligation to protect public health during and after a disaster. The state should invest in mobile air monitoring units and create a surveillance plan to seek out and detect pollution hot spots.

- With more intense storms and greater unpredictability forecast along the Texas coast due to climate change, it is imperative that refineries and petrochemical plants invest more in the best available pollution controls. This includes making industrial storage tanks safer and more resilient by improving upon the floating roof design that frequently failed during Hurricane Harvey. More frequent tank inspection and maintenance are also needed, along with enforcement of regulations and penalties for violations.

- The TCEQ should ensure accurate reporting of air pollution releases to the State of Texas Environmental Electronic Reporting System (STEERS) database. The state should require regulated entities to report facility locations using latitude and longitude coordinates and use Chemical Abstracts Service (CAS) registry numbers for chemicals.

- The state should not suspend pollution reporting requirements during future natural disasters – as Texas Gov. Greg Abbott did for nearly eight months after Harvey -- nor should the state allow industrial plants to retract pollution reports based on disaster declarations or questionable interpretations of the state permits. Candid and transparent reporting is necessary to understand the public health impacts of air pollution releases.

- Wastewater treatmenat plants should consider taking precautionary steps to deal with future floods, including by building more protective walls and levees, moving to higher ground, transitioning to smaller plants, or even more creative solutions such as integrating treatment areas with artificial wetlands.

- Industry and municipalities should work together to create detailed emergency response plans that include better risk communication and information for residents on pollution releases and public safety.

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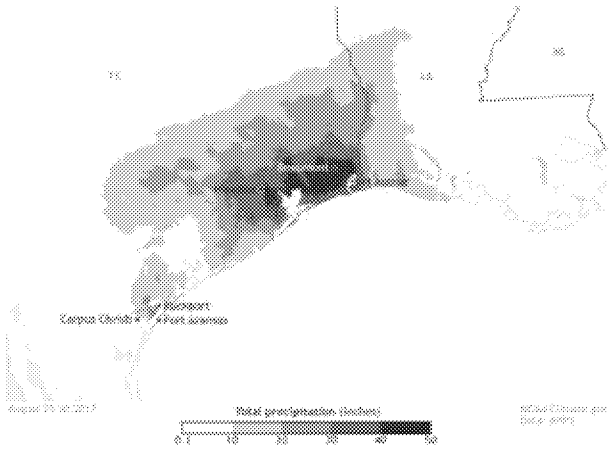
The Magnitude of the Storm

When Hurricane Harvey stalled over southeastern Texas for nearly a week, it dumped roughly 19 trillion gallons of rainwater. According to state officials, more than 270,000 homes were impacted, with nearly 80,000 homes hit with at least 18 inches of floodwater.[12] The storm and ensuing flooding created up to 200 million cubic yards of debris, enough to fill up a football stadium almost 125 times.[13] Hundreds of wastewater treatment facilities overflowed or were not fully operational during the storm, and at least 13 Superfund sites with toxic materials were flooded or otherwise damaged.[14] Thousands of people were left without reliable drinking water for over a week.

Rainfall Totals During Hurricane Harvey



Rainfall estimates from NOAA's Advanced Hydrologic Prediction Service for August 25-30, 2017.

Houston is a massive city. At 655 square miles, the city's sprawling landmass could contain New York City, Washington, Boston, San Francisco, Seattle, Minneapolis, and Miami. The destruction across the region from Harvey made it the most expensive natural disaster in more than a decade, causing an estimated $125 billion in damage. The storm was the second costliest U.S. natural disaster in history, after 2005's Hurricane Katrina.[15] 2017 was the most expensive year on record for natural disasters, and included other major hurricanes like Maria, which slammed into Puerto Rico, and Irma, which hit Cape Verde.[16]

In the year since Harvey, leaders in Houston and the surrounding region have made some efforts to prepare for a future with even more hurricane-strength storms. Much of the focus is being directed towards housing and infrastructure, with Harris County—which encompasses Houston—voting on a $2.5 billion flood protection bond proposal on August 25, the one-year anniversary of Hurricane Harvey's landfall. Projects would include "drainage improvements, upgraded warning systems, infrastructure repairs, home buyouts, and construction of more detention basins," according to the office of Harris County Judge Ed Emmett.[17]

Residents living in neighborhoods along the Houston Ship Channel, such as Manchester and Pasadena, as well as Port Arthur to the east, experienced the worst of the disaster in many ways. On top of the flooding, they were forced to breathe air that many residents described as a soupy chemical mix of petroleum odors, soot, sulfur dioxide, benzene, and other pollutants.

The EPA recently announced it was opening an internal investigation into how federal and state officials dealt with air quality threats during Hurricane Harvey. The Office of the

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Inspector General will look into whether high-risk areas were appropriately prioritized, whether potential health risks were identified, and whether these concerns were properly communicated to the public.[18]

Coastal communities like Houston need to better prepare for flooding because of climate change: warmer air holds more water, which means storms carry heavier rainfall.

Industries Reported 8.3 Million Pounds of Air Pollution

A review of industry self-reported air pollution incidents ("emissions events") for 2017 on file with the Texas Commission on Environmental Quality (TCEQ) for counties impacted by Hurricane Harvey reveals that the storm was cited as the cause of approximately 8.3 million pounds of unauthorized air pollution. Of this, 5.6 million pounds of pollution was released in the Houston area (Harris, Brazoria, Chambers and Galveston counties). Directly adjacent to the Houston area, much smaller Jefferson County – home to Beaumont and Port Arthur – suffered 2 million pounds of unauthorized air pollution. The biggest releases of air pollution were the result of equipment breakdowns and accidental leaks, according to state records. Facility shutdowns and subsequent startups also account for a large share of the reported pollution.

The 8.3 million pound estimate is based on a review of all industry reports to Texas regulators during the months of August and September of 2017 using key search terms "hurricane," "Harvey," and "flooding" in the description of the causes of the events. This figure represents a rough estimate of Harvey-related pollution, including emissions that were simply discovered by plant operators during post-Harvey startups.[19]

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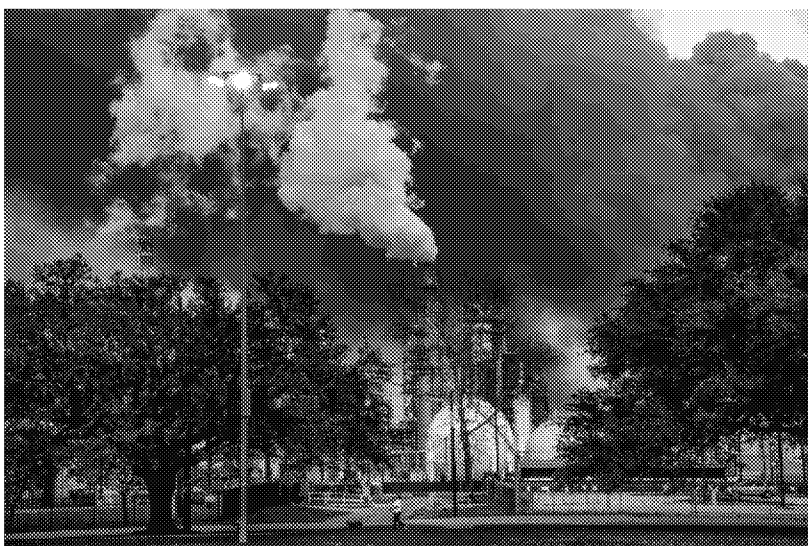
The calculation of all reported Harvey-related air pollution is likely an underestimation. An unknown number of industrial plant operators may have opted not to report emissions based on Gov. Abbott's August 28 proclamation—three days after the storm started—waiving state reporting rules. Gov. Abbott's action inspired widespread confusion, because federal pollution reporting rules remained in place, and many companies continued to report their emissions to the state, despite the state's waiver. The governor did not lift his suspension of reporting requirements for almost eight months.

Shutting down of air monitors: On top of the Governor's suspension of many environmental rules, part of the TCEQ's disaster planning strategy included shutting down air monitors to protect them from damage. Approximately 75 percent of the stationary air monitoring equipment from the Houston, Corpus Christi, and Beaumont-Port Arthur areas was temporarily removed in preparation for Hurricane Harvey, according to state officials.[20] These heavily industrialized areas are home to many of the largest sources of air pollution in the United States. The predominantly lower-income and minority neighborhoods located near these sources bore the brunt of unauthorized air pollution released during Hurricane Harvey. EPA and the TCEQ did not begin using mobile stations to conduct air quality monitoring near industries in the Houston area until September 5. Many significant releases occurred prior to this date, and later monitoring failed to provide those living near major sources with information about the full extent of their exposure to dangerous chemicals, like benzene, during the hurricane.

Increased frequency of storms: Since 2001, the Houston area has been hit by four 500-year flood events, including in 2015, 2016, and 2017.[21] EPA, in line with the established scientific consensus, projects that flooding from extreme rainfall will increase in the coming years and that Texas will lead the nation in the potential for flood-related damage. Given the extent of this risk and potentially disastrous public health consequences of repeated exposures to the pollution spikes that frequently occur during extreme weather events, it is important for the TCEQ to develop a plan and obtain equipment necessary to accurately monitor air quality during these events, and to provide information about potential health risks to affected communities in real time.



Refineries are located adjacent to residential neighborhoods along the Houston Ship Channel and often suffer from their air emissions.

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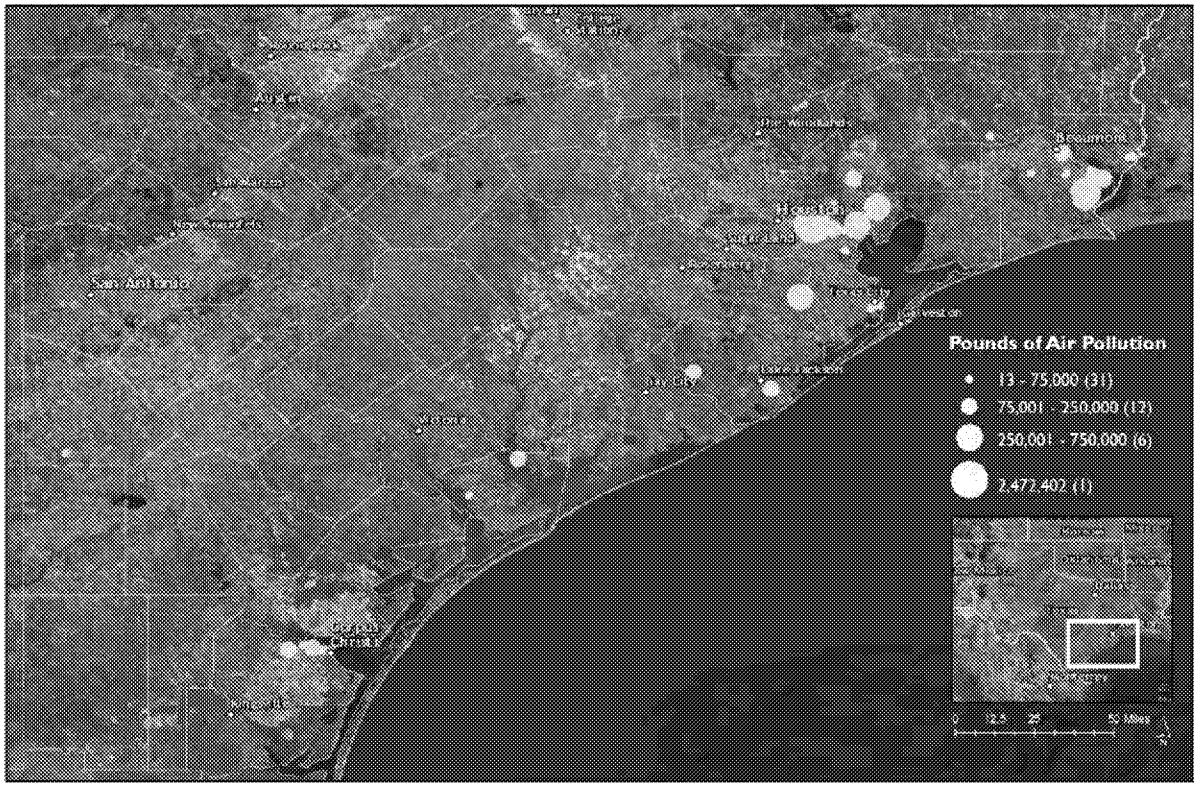
MAP OF AIR POLLUTION RELEASED DURING HARVEY



Comparing Air Pollution Incidents Across Regions

Comparing the air pollution releases in three Texas industrial hubs—Corpus Christi/Port Aransas, the Houston region, and Beaumont/Port Arthur—offers some insight into how industry reacted to Hurricane Harvey. All three regions were hit hard by the storm, experiencing multiple days of rain and flooding. However, Corpus Christi's facilities shut down before the weather turned for the worse, and thus were able to limit harmful emissions.

For example, in Corpus Christi, the Flint Hills refinery shut down even before the storm made landfall at 10 pm on August 25, illustrating that it was preparing in advance to minimize emissions and the chance of an accidental release. As the storm zigzagged east along the Gulf Coast from Corpus Christi toward Houston and the upper Texas coast, industrial facilities failed to demonstrate the same foresight. In these areas, shutdowns and other emissions events happened only after heavy rain, flooding, and sometimes power outages had already descended upon the area, with some plants caught off guard when their power went out. This chaos caused clusters of facilities to release large amounts of pollution all at once, as a result of equipment failures and flood damage, increasing the concentration of pollutants that local residents had to inhale.

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By the time Hurricane Harvey dumped over two feet of rain on Jefferson County, where Beaumont and Port Arthur are located, on August 29, it was clear that the storm was causing catastrophic damage across Texas's upper coastal region. There was ample time for oil refineries and chemical complexes to shut down in the preceeding days to avoid excess emissions caused by the storm, but these plants did not take action early. It would seem that there was either a reluctance to shut down among the industrial operators until it was absolutely unavoidable, or a lack of action caused by the absence of state guidance or protocol.

The Breakdown by Coastal Region:

Corpus Christi (Nueces County): On August 24, the day after Gov. Abbott declared a "State of Disaster" -- and before rain reached the area – industry reported seven intentional shutdowns that released a total of 136,485 pounds of air pollution. Rain did not begin until midnight on August 24, with Harvey making landfall nearby at Port Aransas around 10 pm on August 25.

Houston Region (Brazoria, Chambers, Galveston, and Harris counties): In the Houston area, the first plant shutdown happened at 11 pm on August 26, when the LyondellBasell company's Chocolate Bayou Plant in Brazoria County shut down -- more than three days after Gov. Abbott's "State of Disaster" declaration on August 23. Heavy rain hit in the region around 6 pm on August 26. In the next 24 hours, eight plants shut down in a cluster – including the ExxonMobil Baytown Refinery, Chevron Phillips Cedar Bayou Plant, and Pasadena Refining -- releasing 1.3 million pounds of air pollution. In the 48 hours after the heavy rainfall started, a total of 23 emissions incidents were reported that eventally released 2.2 million pounds of pollution. Of these 23 incidents, 9 were the result of tank roof failures, two were caused by power outages, at least two were triggered by flooding, one by a lightning strike, one by an equipment malfunction, and the others by general storm-related issues or unidentified causes, according to state records.

Beaumont/Port Arthur (Jefferson and Orange counties): Heavy rain began in this area around 12 pm on August 26. Six air pollution incidents, totaling 311,481 pounds, occurred almost three days later on August 29—the day the area received a record-breaking two feet of rain. Four of these events were shutdowns and one was related to a power outage.

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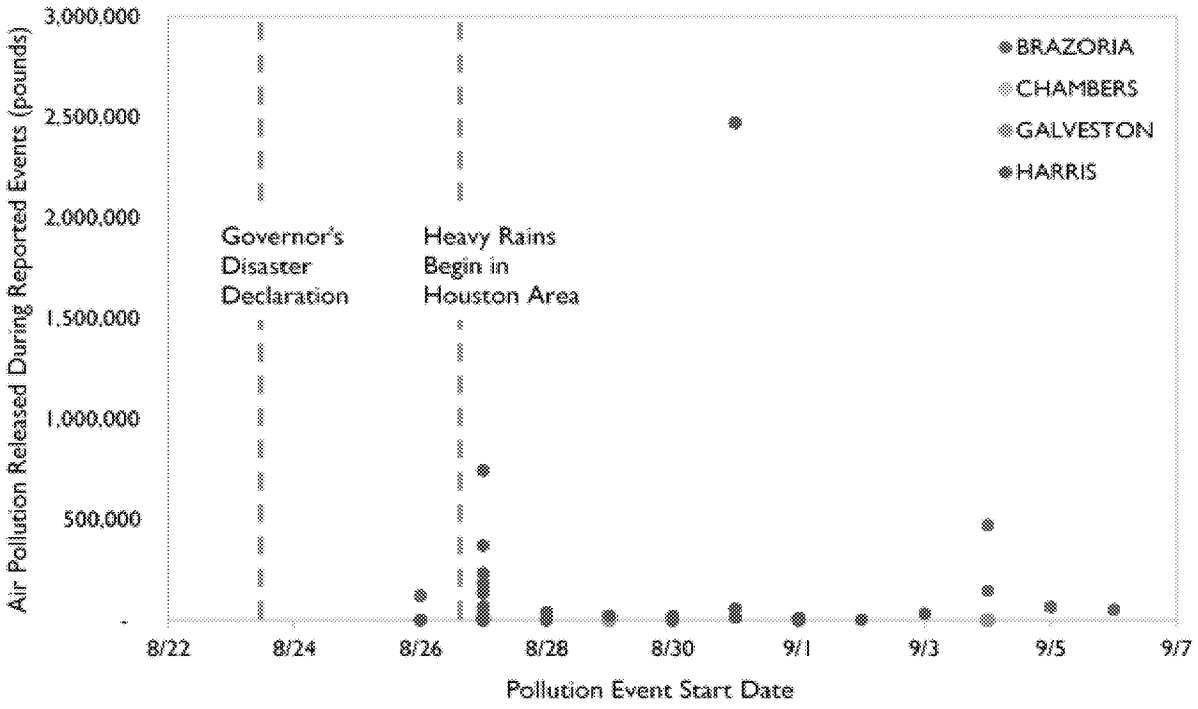
TIMING OF INDUSTRIAL SHUTDOWNS AND AIR POLLUTION RELEASES IN HOUSTON AREA



Power Outages: Across the whole Texas coastal region, a total of seven industrial plants – including the Arkema chemical plant in Harris County, and the Total Petrochemicals Refinery in Port Arthur -- reported that unexpected electrical outages caused by the storm triggered accidents and shutdowns that released at least 255,598 pounds of air pollution, according to state records. The Arkema plant exploded and burned when flooding from the hurricane disabled not only the power but the plant's refrigeration system. The fires released air pollution that sickened emergency responders and forced an evacuation of nearby homeowners.

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Plants that Released the Most Storm-Related Pollution in Houston Area

Rank	Company	Facility	Amount Reported (lbs)
1	Magellan Terminals Holdings	Galena Park Terminal	2,472,402
2	Chevron Phillips Chemical Company	Chevron Phillips Chemical Cedar Bayou Plant	745,472
3	INEOS USA	Chocolate Bayou Plant	715,457
4	ExxonMobil Corporation	ExxonMobil Baytown Refinery	561,240
5	Valero Energy Partners	Valero Houston Refinery	235,412
6	Phillips 66 Company	Sweeny Refinery	177,076
7	KM Liquids Terminals	Pasadena Terminal	166,059
8	The Dow Chemical Company	Dow Texas Operations Freeport	133,141
9	Shell Chemical Company	Shell Oil Deer Park	112,096
10	Arkema	Arkema Crosby Plant	86,002

Incidents reported between August 23, 2017 and September 30, 2017. Compiled using STEERS database from TCEQ, obtained on 2/21/2018 in response to a public information request. Houston area is Harris, Brazoria, Chambers and Galveston counties.

Gasoline spill: A gasoline tank leak at Magellan Midstream's Galena Park Terminal east of Houston was the largest reported spill of chemicals or petroleum products caused by Hurricane Harvey in the region. Flooding caused two storage tanks to overflow and release around 11,000 barrels—more than 460,000 gallons—of gasoline into the surrounding standing water. Vapors with a hydrocarbon odor (volatile organic compounds) were also reported, according to a state investigation report.[22]

Impact on Neighbors

Juan Flores, who works with the nonprofit organization Air Alliance Houston, was in his hometown of Galena Park, on the city's East End, during the storm. Flores said he started seeing people on Facebook posting about a very strong petrochemical smell, the intensity of which they had not experienced before. Even though it takes a lot for Flores to smell something—having grown so accustomed to the soupy chemical atmosphere of the area—he said he was hit by it, too, and the odor was so

Juan Flores of Galena Park, in Houston, and his neighbors were exposed to air pollution from petrochemical plants during the storm.

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powerful it made his eyes water. Relying on his past experiences, Flores turned off his air conditioner, to protect not only himself but his toddler from the noxious fumes.

It turns out what Flores and those in his neighborhood were experiencing were the effects of the biggest reported spill in the Houston region from Hurricane Harvey. The source of the debilitating stench wasn't revealed for days after the storm, leaving Flores and other Galena Park residents to attempt futile efforts to escape the odor without even knowing how concerned they should be—or when it might subside.

"People were having a hard time, some people felt nauseous," said Flores. "We were basically on an island, all people could do was wait it out." His experience is an example of why better air pollution monitirong and notification systems are needed.

Storage Tank Failures

As torrential rains pummeled the Houston region during Hurricane Harvey, industrial storage tanks took a battering. The flooding and breakdown of more than two dozen tanks in the storm led to the release of more than 600,000 gallons of fuel and associated toxic pollutants.[23]

Storage tanks proved to be one of the most vulnerable pieces of industrial infrastructure during Hurricane Harvey, with more than two dozen tanks leaking toxins into the air and water.

Often, it was the roofs of the tanks that failed. According to a Houston Chronicle analysis of reports filed after the storm, more than 15 floating roof storage tanks failed during Harvey. At Valero Energy's Houston refinery, the rain caused one of the tank roofs to collapse sideways, releasing more than 235,000 pounds of pollutants into the atmosphere. Overall, these 15 failures allowed some 3.1 million pounds of chemicals to escape their tanks.[24]

At least 400 storage tanks in the Houston region have floating roofs, in which the top of the tank floats on the liquid itself.[25] The design is meant to curtail the buildup of toxic vapors above the liquids. The tanks, which have drainage systems meant to prevent the accumulation of water, are typically designed to take on approximately 10 inches of rain over 24 hours.[26] Hurricane Harvey's rainfall totaled four or five times this much.

At the Marathon Petroleum Texas City Refinery, the roof of Tank 112 was observed to be tilting due to the excessive rainfall, causing "roof integrity concerns" on a tank filled with

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gasoline, according to state reports.[27] At the Pasadena Terminal, torrential downpours caused Tank 150-8's external floating roof to partially submerge, allowing "product to spill from roof drains onto the ground between tank and dike walls."[28]

Texas industries often avoid having to meet the most stringent and protective tank designs because the state and EPA have allowed lax environmental permitting to become the norm in Texas. With more intense storms and greater unpredictability forecast along the Texas coast due to climate change, more resilient tank designs and increased inspection and maintenance are needed, as well as stricter enforcement. Strict enforcement of tank inspection and maintenance requirements is important, even in cases where violations do not result in illegal emissions, to prevent releases from rundown tanks when the next extreme weather event hits.

Poorly maintained equipment is less likely to withstand storms. For example, the state investigation report for the Valero Houston Refinery tank failure makes it clear that the tank was not well maintained, that Valero was aware of problems with that tank since 1996, and that an internal tank inspection was two years overdue at the time Harvey hit. The investigation concluded that the leak could have been prevented by better maintenance.[29]

Facilities that Reported Largest Storm-Related VOC Pollution Events in Houston Area

Rank	Company	Facility	Amount Reported (lbs)
1	Magellan Terminals Holdings	Galena Park Terminal	2,372,280
2	Chevron Phillips Chemical Company	Chevron Phillips Chemical Cedar Bayou Plant	312,191
3	Valero Energy Partners	Valero Houston Refinery	235,357
4	ExxonMobil Corporation	ExxonMobil Baytown Refinery	234,565
5	KM Liquids Terminals	Pasadena Terminal	165,628
6	INEOS USA	Chocolate Bayou Plant	104,900
7	Shell Chemical Company	Shell Oil Deer Park	67,943
8	The Dow Chemical Company	Dow Texas Operations Freeport	65,567
9	Seaway Pipeline	Galena Park Terminal	56,821
10	Arkema	Arkema Crosby Plant	50,902

Incidents reported between August 23, 2017 through September 30, 2017. Compiled using STEERS database from TCEQ, obtained on 2/21/2018 in response to a public information request.

Volatile Organic Compounds (VOCs) are a class of chemicals that includes many different hazardous air pollutants and known carcinogens, like benzene. The primary sources of VOC are petroleum refineries, chemical plants, and oil and gas extraction and processing operations. The pollutants are often released from flares and leaking tanks and pipes during malfunction and maintenance events at industrial sources in Texas and elsewhere.[30]

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According to the National Institutes of Health, "short-term exposure to volatile organic compounds can cause eye and respiratory tract irritation, headaches, dizziness, visual disorders, fatigue, loss of coordination, allergic skin reactions, nausea, and memory impairment," while "long-term exposure to volatile organic compounds can cause damage to the liver, kidneys, and central nervous system." VOCs are also a component of smog, which can trigger asthma attacks and other heath problems.

Companies with the Largest Reported Storm-Related Benzene Pollution Releases in the Houston Area

Rank	Company	Facility	Amount Reported (lbs)
1	Chevron Phillips Chemical Company	Chevron Phillips Chemical Cedar Bayou Plant	28,505
2	Magellan Terminals Holdings	Galena Park Terminal	12,735
3	The Dow Chemical Company	Dow Texas Operations Freeport	7,835
4	Shell Oil Company	Shell Oil Deer Park	2,989
5	Valero Energy Partners	Valero Houston Refinery	1,881
6	Shell Chemical Company	Shell Oil Deer Park	605
7	KM Liquids Terminals	Pasadena Terminal	487
8	Formosa Plastics Corporation, Texas	Formosa Point Comfort Plant	340
9	Pasadena Refining System	Pasadena Refining System	142
10	Equistar Chemicals	Equistar Chemicals Channelview Complex	123

Incidents reported between August 23, 2017 through September 30, 2017. Compiled using STEERS database from TCEQ, obtained on 2/21/2018 in response to a public information request.

Benzene is a dangerous volatile organic compound released into the air from industries that use, store, or produce petroleum products, including fuel, chemicals, plastics, and pesticides. Short-term exposure to benzene can lead to dizziness, rapid or irregular heartbeat, tremors, unconsciousness and at high levels even death.[31] Longer-term exposure to benzene can cause leukemia, birth defects, low birth weight, and bone marrow damage. A 2010 study by University of Texas School of Public Health and Texas Department of State Health Services found that women living in neighborhoods with higher than average levels of benzene are more likely to give birth to babies with serious neurological defects.[32] The World Health Organization warns that there is no safe level of benzene exposure. But, despite the significant health impacts posed by benzene, industrial facilities routinely and illegally release large amounts of this cancer-causing chemical during malfunctions and maintenance.[33]

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Above and below are charts listing the largest releases air pollutants, including benzene, in the Houston, Corpus Christi and Port Arthur areas that were linked to Hurricane Harvey in company reports to the Texas Commission on Environmental Quality.

Plants with the Most Harvey-Related Air Pollution in the Corpus Christi Area

Rank	Company	Facility	Amount Reported (lbs)
1	Equistar Chemicals	Equistar Corpus Christi Plant	104,938
2	Valero Refining-Texas	Valero Corpus Christi Refinery West	88,809
3	CITGO Refining and Chemical Co.	CITGO Corpus Christi Refinery East	44,417
4	MarkWest Javelina Co.	Javelina Gas Processing Facility	33,885
5	CITGO Refining and Chemical Co.	CITGO Corpus Christi Refinery West	31,893

Incidents reported between August 23, 2017 and September 30, 2017. Includes all reported air pollutants. Compiled using STEERS database from TCEQ, obtained on 2/21/2018 in response to a public information request. Includes Nueces County.

Plants with the Most Harvey-Related Air Pollution in the Beaumont-Port Arthur Area

Rank	Company	Facility	Amount Reported (lbs)
1	The Premcor Refining Group	Valero Port Arthur Refinery	691,117
2	Flint Hills Resources Port Arthur	Flint Hills Resources Port Arthur Facility	518,594
3	Motiva Enterprises	Port Arthur Refinery	439,239
4	Total Petrochemicals and Refining	Port Arthur Refinery	184,956
5	ExxonMobil Oil Corp.	ExxonMobil Beaumont Refinery	129,352

Incidents reported between August 23, 2017 and September 30, 2017. Compiled using STEERS database from TCEQ, obtained on 2/21/2018 in response to a public information request. Includes Jefferson and Orange Counties.

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Unpermitted Emissions in all Counties Hit by Storm

A total of approximately 18.8 million pounds of air pollutants were emitted by Texas industry in unpermitted incidents reported between August 23 and September 30, 2017, according to state records. Of this, 8.3 million pounds (or 44 percent) were reported to be caused by Hurricane Harvey. The following numbers are for the Texas counties impacted by the storm.

More than 8 million pounds of air pollution were emitted by industrial sources in the Houston region during Hurricane Harvey.

County	Total Air Pollution Released (lbs)	Number of Events
Harris*	4,478,281	27
Jefferson	2,098,201	27
Brazoria*	1,071,326	10
Nueces	327,508	15
Calhoun	160,707	6
Hardin	57,991	2
Atascosa	37,873	4
Galveston*	30,478	4
Chambers*	14,230	8
Washington	14,086	2
Orange	3,815	3
Dewitt	10	1
Total	**8,294,506**	**109**

** Houston Area. Note: numbers self-reported by industry to the TCEQ August 23, 2017 to September 30, 2017*

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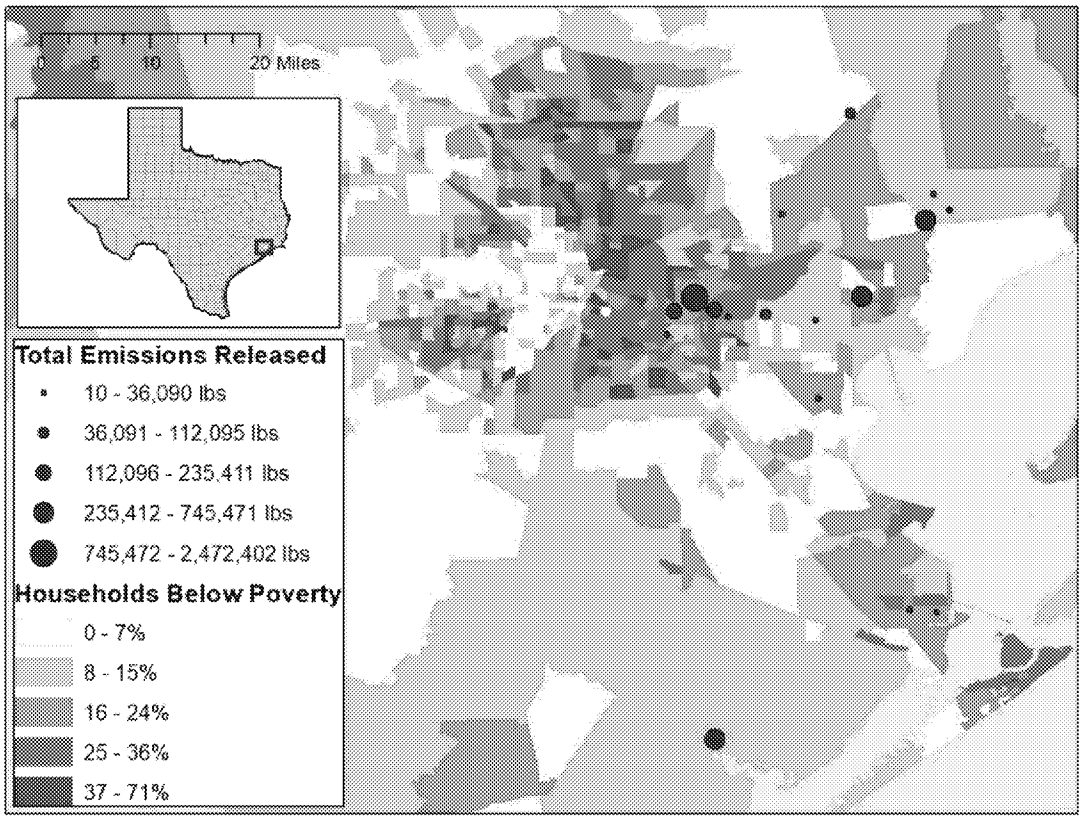
Air Pollution and Percentage of Households in Poverty in Houston Area

The majority of the reported Harvey-related unpermitted emissions were along the upper Texas coast, with high amounts reported in the Houston area. Many of the high levels of Harvey-related pollution occurred in working class and lower-income areas.



Total amount of unpermitted air pollution released due to Hurricane Harvey between August 23-September 30, 2017 in the Houston area (as reported in the Texas Commission on Environmental Quality STEERS database) and percent of households with income below poverty level by census tract (from American Community Survey 2011-2015)

Hazardous Air Pollutants

Roughly 771,000 pounds of sixteen different hazardous air pollutants were released into Houston air as a result of Harvey, according to state data. Benzene, ethylbenzene, toluene, and xylene made up the majority of the releases, totaling 554,000 pounds. Benzene, a known carcinogen and leukemia-causing agent even at relatively low concentrations, is the most hazardous.[34] Approximately 56,000 pounds of benzene were released due to the storm, along with 25,000 pounds of 1,3-butadiene, another carcinogen.

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Harvey-Related Hazardous Air Pollutants Released in the Houston Region

Hazardous Air Poullutant	Total (lbs)
1,3 Butadiene	25,151
2,2,4 Trimethyl Pentane	67,999
Acetophenone	2,673
Acrylic Acid	193
Benzene	55,728
Butadiene	365
Carbon Disulfide	19
Carbonyl Sulfide	28
Dichloro Ethylene	149
Ethyl Acrylate	2,120
Ethyl Benzene	53,508
Ethylene Oxide	4
Hexane	116,451
Hydrogen Chloride	5
Hydrogen Cyanide	113
Methanol	244
Napthalene	560
Toluene	218,515
Vinyl Acetate	514
Vinyl Chloride	3

Health Survey Results

A survey of 41 Hurricane Harvey survivors by researchers at the University of Texas School of Public Health found that 44 percent reported that they believed they were exposed to chemicals or toxins; 39 percent said they were exposed to contaminated flood water; 27 percent to sewage; 24 percent to mold; and 12 percent to oil leaks.[35] Fifty-four percent reported having their homes damaged by the flood, the same percentage experienced anxiety symptoms, 39 percent said they suffered from depression, and 46 percent met the threshold for probable symptoms of Post Traumatic Stress Disorder (PTSD), according to the survey.

Ozone

Following Hurricane Harvey, ozone concentrations far exceeded national standards in parts of the Gulf Coast. On Sept. 1, the Houston area suffered the smoggiest day – with the worst ground-level ozone levels -- in all of Texas for 2017. This was part of a three-day cluster of high ozone levels in the region. Ozone is formed when air pollutants like volatile organic

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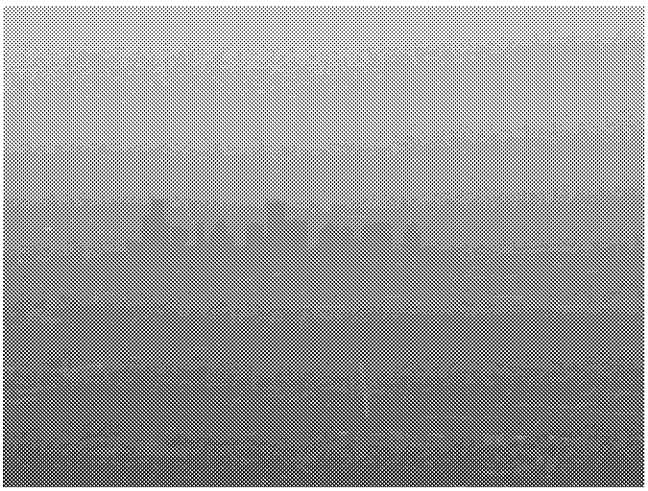
compounds (VOC's) and nitrogen oxides (NOx) mix in sunlight in hot temperatures. A study by Rice University scientists found that that the risk of an asthma attacks and other health impacts increases when people are exposed to multiple days of high exposure – such as happened after Hurricane Harvey.[36] Health effects from ozone exposure include constricted airways, asthma attacks, exacerbated respiratory problems, cardiovascular events, chronic obstructive pulmonary disease, and even death.[37]



An extremely smoggy day in Houston in 2006. Ground-level ozone pollution was especially high during Hurricane Harvey, excacerbating health risks.

From August 23 to September 1, 2017, approximately 3.9 million pounds of VOCs were released into the Houston/Galveston/Brazoria region by surrounding industries. August 27 and August 31 were days of highest VOC releases in response to Harvey, totaling 1.3 and 2.5 million pounds, respectively. Nitrogen oxides totaled about 154,000 pounds during the same period in the Houston region, of which 143,000 pounds were released on August 27.[38]

Once the rain ceased, there were perfect conditions for high ozone days due to the weather and the large releases of NOx and VOCs. Eleven of 44 ozone monitors in the Houston region reported at least one of the four highest eight-hour ozone concentrations of 2017 in the days following Hurricane Harvey's landfall, on September 1st through 3rd. Three ozone monitors—at Houston Bayland Park, Clinton, and Park Place—reported the highest ozone levels of 2017 on September 1 and 3, at levels as high as 115 parts per billion (ppb) far exceeding the National Ambient Air Quality Standard of 70 ppb.[39] Five ozone monitors reported the second highest ozone levels of 2017 on September 1 and 2 at Clinton, Park Place, Tom Bass, Moody Tower, and the University of Houston Coastal Center. Three ozone monitors reported the third and fourth highest ozone levels of 2017 at Houston Deer Park, Lang, Katy Park; and Clinton, Hayden Road, and Moody Tower, respectively.[40]

Air Pollution Reporting Discrepancies in the Months After the Hurricane

This report relies on a dataset of industry self-reported "unauthorized" (meaning, not permitted) air pollution emission incidents maintained by the Texas Commission on Environmental Quality. The data in the agency's Sate of Texas Environmental Electronic Reporting System (STEERS) database do not typically include any "authorized" emissions—those that are covered by a permit and do not exceed permit limits. The numbers in the STEERS system may change over time as companies finalize initial reports

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or report new events. Some plants file initial reports out of caution, and may at times overestimate their initial emissions; but final reports are due within two weeks of the event, and must contain accurate data. Some plants disavow their initial reports if they determine the emissions were below reportable thresholds or that the pollution was actually authorized by a permit.

The Environmental Defense Fund collected data from the STEERS system for all excess air emissions during and after Hurricane Harvey, between August 23, 2017, and October 25, 2017. Researchers collected data at two points in time: in October of 2017 and June of 2018. The two reports were then compared to quantify changes in reporting over the nine month period. The anlaysis showed significant differences in the reporting of the amounts of pollution released. In the October 2017 reports of emissions during industrial startup, shutdown, and malfunction events, approximately 3 million pounds of pollution were reported. A review of the final reports covering the same emissions, in June 2018, showed approximately two million pounds of pollution were reported—an overall reduction of one million pounds (33 percent).[41] In total, 18 companies revised their numbers downwards by a combined 1.7 million pounds pollution. Overall, the total statewide amount of reported startup and shutdown emissions decreased by slightly less than this, however, because the drop was offset somewhat by the addition of three new events totaling 520,000 pounds of pollution, and increased reporting by two facilities of approximately 40,000 pounds. Moreover, 29 reports from 23 facilities said that they anticipate that they will retract previous data, which would further reduce the reported levels of contaminants by 32,000 pounds.

Examples of Changed Reports: Some of the specific changes in pollution reporting are the following. Six facilities reported decreased amounts of pollution released from *shutdowns* during August. In Corpus Christi, Flint Hills' East Refinery significantly reduced its emissions from 53,750 pounds to just 226 pounds, providing the explanation of a flexible state-issued permit for planned startup, shutdown, and maintenance activities. Another Corpus Christi refinery, Flint Hills' West, reduced its reported emissions from 108,250 pounds to 167 pounds of emissions, relying on blanket permit authorizations allowing for planned startup and shutdown. Farther up the Texas coast, Chevron Phillips Chemical Port Arthur facility completely removed data on excess emissions from air shutdowns saying that the pollution was authorized under its permit. The three remaining facilities—Chevron Phillips Sweeny Old Ocean Facilities, Pasadena Refining System, and Flint Hills Resources Port Arthur Facility—did not cite any reasons for major decreases in reported levels of emissions.

Seven facilities decreased their reported pollution from air *startups* during August, 2017. The Enterprise Mont Belvieu Complex decreased its initial reported releases by 19,209 pounds, stating that the event "did not result in emissions of a Reportable Quantity (RQ) within 24 hours." Flint Hills Resources East Refinery reduced its emissions report by 98,713 lbs, referencing its flexible state permit for planned startup and shutdown emissions. Enterprise East reduced its reported releases by 10,348 pounds, saying that it did not have any

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reportable quantity of exceedances. No other companies in this group gave reasons for decreasing their reported amount of emissions.

What Texas' Permitting System Allows: The state's program for authorizing emissions related to maintenance, startup, and shutdown activities is limited to planned activities. Planned activities are included in air permits and subject to emission limits, because (1) emissions from planned activities can be anticipated and controlled and (2) emissions from predicatable activities should be modeled at the permitting stage to ensure that they will not result in unacceptable air quality impacts. Unplanned activites, breakdowns, and mishaps are not authorized and the effective regulatory limit for emissions resulting from these events is zero. Startups, shutdowns, and maintenance activities undertaken in response to a natural disaster are not planned and emissions from such events are unauthorized. Reports from companies claiming that Harvey-related pollution releases are authorized suggests that the state is drafting over-broad permits and that companies are mischaracterizing Harvey-related releases as planned to hide the unauthorized emissions. The TCEQ should scrutinize reports claiming that Harvey-related emissions are authorize and bring enforcement proceedings in each case where a source has improperly claimed that unplanned emissions are authorized. The TCEQ should also take care in the future to draft unambiguous permit terms that cannot be read to authorize emissions resulting from unplanned maintenance, startup, and shutdown activities.

The flooding during Hurricane Harvey turned major interstates into rivers and overwhelming many sewage plants and industrial facilities.

The alterations of the originally-reported emissions estimates also raise questions about whether Gov. Abbott's waiver of pollution reporting requirements encouraged companies to downgrade or eliminate their pollution reporting after the fact. Such activity undermines public trust in our regulatory sytems and may mask real health risks posed by air pollution releases during storms.

Underreporting of Wastewater Released During Hurricane Harvey

As Hurricane Harvey lingered over the upper Texas coast, water inundated the landscape. The storm led to some 25 million gallons of sanitary sewer overflows and 125 million gallons of industrial discharges, according to state records.[42] In the days after the storm, officials and experts worked to discern the mix of pollutants dispersed throughout the floodwaters, which included bacteria, viruses, and other possibly toxic chemicals from the refinery and chemical plant overflows. At least 13 Superfund sites also reported flooding, many of them in low-income neighborhoods.[43] [44]

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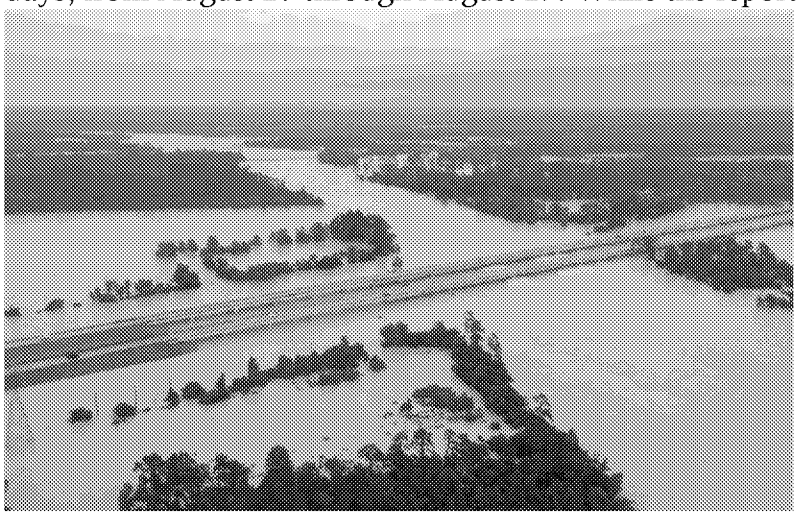
According to state reports, 45 industrial discharges during Hurricane Harvey resulted in the release of 125,173,271 gallons of wastewater from industrial sources, including petrochemical plants, refineries, and terminal facilities that produce and store large quantities of many different hazardous chemicals. However, this figure significantly underrepresents the actual amount of wastewater released during Hurricane Harvey. Many companies reporting discharges to the the state declined to estimate the amount of wastewater discharged and instead listed the amount discharged as zero gallons – even though it was clear that much more than that escaped.

For example, 131 of the 646 sanitary sewer reports contained in a table provided by the Texas Commission on Environmental Quality in response to an Environmental Integrity Project public records request indicated a "0 gallon" discharge (despite the fact that they admitted to releasing wastewater). Thirty-two of the 45 industrial wastewater reports contained in the table indicated a "0 gallon" discharge.

Many "zero" discharge incidents actually appear to have actually involved large volumes of pollution. For example, Dow's Deer Park chemical plant east of Houston reported a water pollution release lasting for two days, from August 27 through August 29. While the report indicates that the plant discharged zero gallons, the description of the incident in a state report makes it clear that a significant amount of waste was released: "Greater than normal storm water flow into the aeration basins at East and West WW (wastewater) Treatment Plants. 103,592,933 pounds of non-hazardous biosolids from WWTP (West Waste Water Treatment Plant) and 17,445,312 pounds overflowed from EWTP (East Waste Water Treatment Plant)."[45] It is not clear how many gallons of wastewater were mixed with those millions of pounds of overflowing solids, but it is highly likely to have been much more than zero.



Contaminated waters flooded the entire region during Hurricane Harvey, including Superfund sites and industrial plants.

Another "0 gallon" event was reported at Chevron Phillips' Pasadena Plastics Complex, lasting from August 26 through August 30. According to the event description provided by Chevron Phillips: "Due to Hurricane Harvey and the resulting flooding, the Chevron Phillips Pasadena Plastics Complex process WW (wastewater) ponds were inundated by storm surge and floodwaters. Based on accounts from plant emergency response personnel on-site during the storm, the floodwaters covered all the process WW ponds, which normally flow in series to outfall 001. As a result, an undetermined quantity of pond

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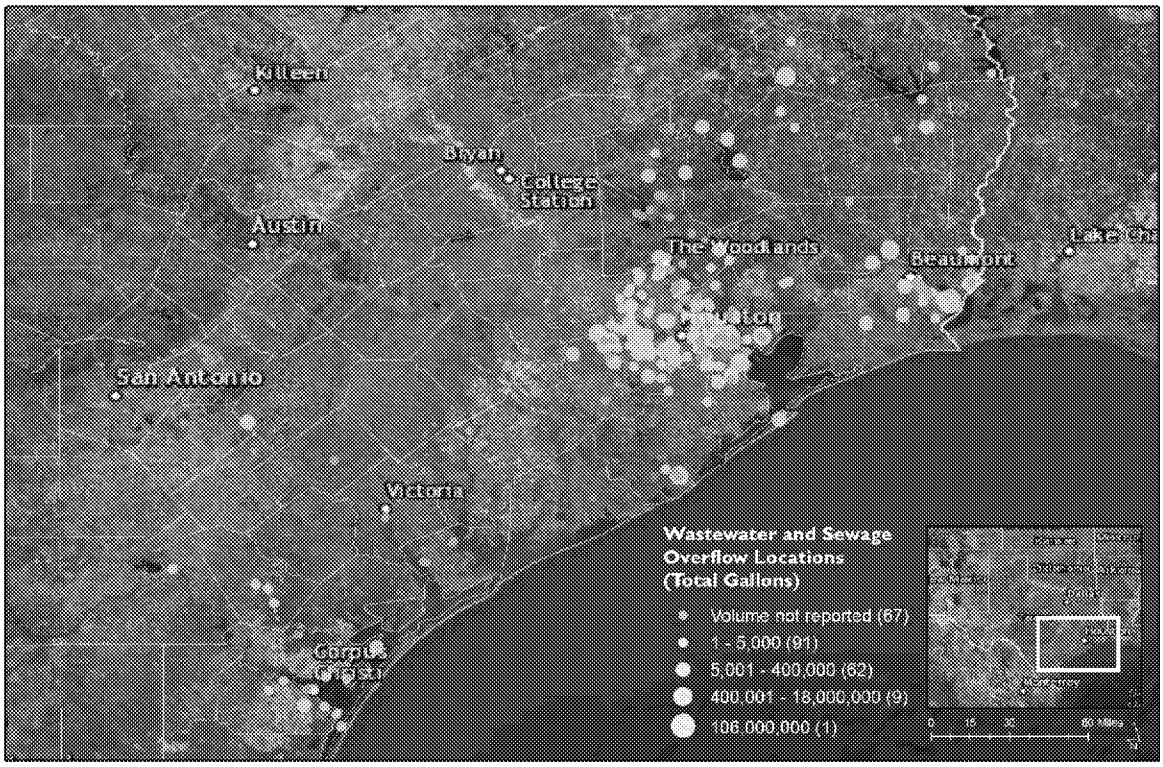
contents was likely combined with the floodwaters and discharged as sheet flow to the Houston Ship Channel."

MAP OF REPORTED WASTEWATER RELEASES DURING STORM



Lack of Information on Contaminants

Neither the wastewater reports summary provided in response to the Environmental Integrity Project's public records request or the materials on the TCEQ's Harvey Response webpage provide any description of the kinds and quantity of contaminants released in Harvey-related wastewater discharges. The wastewater summaries likely omit information about contaminants contained in these discharges because companies did not provide this information in their reports to the state. While the reports indicate that limited onsite wastewater sampling and private well sampling was conducted in response to some serious overflow events, such sampling as floodwaters subside does not provide reliable information about the kinds and amount of contaminants that were swept offsite during the storm. The state has not made offsite sampling information available on its Hurricane Harvey website.

Texas should develop a better system for quickly assessing dangerous chemicals discharged from industrial sources during flooding and communicating potential risks to the public.

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Improving Sewage Treatment Plants

For weeks after Hurricane Harvey hit, sewage treatment plants in the Houston area remained in disrepair.[46] Thousands of people across the region—already struggling to recover from the storm's many impacts—were instructed to limit toilet flushing, bathing, and even using their washing machines to reduce impacts on the sewage system. According to Michelle Hummel, a civil engineer and researcher at the University of California, Berkeley, many wastewater plants today use technology developed decades ago, including big open tanks prone to flooding. Hummel, the lead researcher on a recent study about how sea level rise may impact wastewater treatment, said these plants need to start better planning for future flooding threats, especially in coastal areas like Houston.[47] This could involve building more resilient barriers and levees, moving inland to higher ground, or transitioning to smaller plants that are engineered to handle flooding. Combining treatment facilities with artificial wetlands could also help, as wetlands act as natural filters. If flooding breached a wastewater dam, wetlands would also provide additional buffers and storage between the facility and surrounding communities.

Largest Reported Industrial Overflows During Harvey

Rank	Regulated Entity	County	Amount (gallons)	Start Date	End Date	Permittee Name
1	BASF Total Olefins Complex	Jefferson	106,000,000	08/28/2017	08/28/2017	BASF Total Petrochemicals
2	FKP Site	Harris	18,000,000	08/25/2017	08/30/2017	WLSK-Pasadena, LLC
3	Bayport Facility	Harris	404,000	08/28/2017	08/29/2017	Gulf Coast Waste Disposal Authority
4	Diboll Complex	Angelina	350,000	08/28/2017	08/28/2017	Georgia-Pacific Wood Products LLC
5	Diboll Complex	Angelina	350,000	08/28/2017	08/29/2017	Georgia-Pacific Wood Products LLC;
6	INEOS Calabrian WWTP	Jefferson	35,000	08/29/2017	08/30/2017	INEOS Calabrian Corporation
7	Penn City Terminal	Harris	21,000	08/27/2017	09/08/2017	Kinder Morgan Petcoke LP
8	Wyman Gordon Forgings Cypress Plant	Harris	10,000	08/26/2017	08/26/2017	Wyman-Gordon Forgings Inc
9	Akzo Nobel Battleground Plant	Harris	2,410	08/27/2017	08/30/2017	Akzo Nobel Chemicals LLC
10	Citgo Corpus Christi Refinery	Nueces	700	08/25/2017	08/25/2017	Citgo Refining And Chemicals

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Largest Reported Municipal Sewage Overflows During Harvey

Rank	Regulated Entity	County	Amount (gallons)	Start Date	End Date	Permittee Name
1	City of Katy WWTP	Fort Bend	9,500,000	08/28/2017	08/30/2017	City of Katy
2	San Jacinto Battleground	Harris	1,272,300	08/28/2017	08/31/2017	Texas Parks & Wildlife
3	Dow Chemical	Brazoria	887,900	08/28/2017	08/29/2017	Dow Chemical
4	Turkey Creek WWTP	Harris	387,000	09/08/2017	09/09/2017	City of Houston
5	NB Davidson South WWTP	Walker	386,400	08/27/2017	08/29/2017	City of Huntsville
6	East District WWTP	Harris	294,600	09/01/2017	09/02/2017	City of Baytown
7	Rockport WWTP	Aransas	275,000	08/26/2017	12/31/3000	City of Rockport
8	Oxy Vinyl's Deer Park PVC Plant	Harris	200,000	08/17/2017	08/22/2017	Oxy Vinyl, LP
9	Galveston WWTP	Galveston	135,000	09/12/2017	09/12/2107	City of Galveston
10	Lumberton Mud WWTP 2	Hardin	100,000	08/28/2017	08/30/2017	Lumberton Municipal Utilities District

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Conclusion

When a natural disaster like Hurricane Harvey devastates an entire region, it forces communities to come together to weather the storm, and to look to each other for answers about why the damage was so extensive and how it can be avoided in the future. Texans worked together like never before to achieve heroic rescue and recovery efforts during Harvey. Now, as the state's coastal residents turn towards the specter of the next storm, there are clear ways that state authorities and industries can improve their responses in the future.

Rescue efforts during Harvey helped countless people in need of assistance. A similar spirit of coopration is needed as the region plans for the next hurricane.

Both the state of Texas and the petrochemical industry need to better protect workers and neighboring communities from the risks associated with locating massive industrial complexes in low-lying, densely populated coastal areas. This means making a greater effort to monitor air quality during and immediately after storms, and to inform the public of any hazardous leaks or spills. Environmental, health and safety rules should remain in force at all times, even during emergencies. Better planning for hurricanes and major storms will also require state leadership to coordinate the systematic, staggered, shutting down of refineries and petrochemical plants well in advance of disastrous flooding. Well-planned pre-emptive shutdowns can avoid unnecessary releases of dangerous amounts of pollution – and help protect the health of nearby communities.

The question is not if another Harvey-like storm will hit the region, but when. State lawmakers, regulators, and industry leaders need to realize that time is of the essence in enacting commonsense policies and protocols to safeguard the public.

Key Recommendations:

- As the state agency for environmental emergencies, the TCEQ has the authority and the know-how to coordinate multiple industrial plant shutdowns and subsequent startups, so as to limit the cumulative impacts to surrounding communities. Ahead of future storms, the state agency should coordinate staggered, pre-emptive shutdowns of industrial plants for safety reasons. Officials should discourage last-minute shutdowns, which increase the risk of accidents and the exposure of nearby communities to dangerous concentrations of pollution.

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- Texas needs to be better prepared to monitor air and water pollution during and immediately after natural disasters. While there may be good reason to shutter some expensive equipment to protect it from damage, the state also has an obligation to protect public health. During future storms, some air monitors could be kept online. In addition, Texas should deploy inexpensive passive monitors, such as those that can be easily attached to refinery or petrochemical plant fencelines and near storage tanks to monitor for toxics such as benzene. And the state should invest in mobile air monitoring units that can seek out and detect air pollution hotspots during emergencies and natural disasters.

- With more intense storms and greater unpredictability forecast along the Texas coast due to climate change, it is imperative that oil and gas infrastructure, refineries, petrochemical plants and other industries that store dangerous chemicals better prepare themselves for power outages, floods, and other storm impacts. This includes more robust backup electric generation systems, and making tanks more resilient to heavy rains, especially in flood-prone areas like the Texas coast. Floating roof and fixed roof tanks should be upgraded to not only better withstand precipitation, but also to capture emissions during normal operations. Along with improved tank design, more vigilant inspection and maintenance is necessary.

- Federal and state environmental regulators have an obligation to ensure that the high-risk industries meet the most stringent technological requirements for pollution controls. That will require strict compliance with federal and state air permitting rules, instead of the weak standards that are written into so many Texas permits.

- Many wastewater treatment plants in Texas and elsewhere are using technology that was developed decades ago, including large open tanks vulnerable to flooding. When they upgrade in the future, the mangers of these plants should consider incorporating precautionary steps, including building more protective walls or integrating artificial wetlands into their treatment systems.

- TCEQ should ensure that industry pollution reporting to the State of Texas Environmental Electronic Reporting System (STEERS) database is accurate. The state should require the reporting of facility locations using latitude and longitude coordinates and use of Chemical Abstracts Service (CAS) registry numbers for chemicals.

- The state should not suspend reporting requirements during natural disasters, and the TCEQ should scrutinize claims that emissions resulting from natural disasters are the result of planned acitivities authorized by a permit. Both transparent reporting and consistent monitoring are necessary to understand the public health impacts of air pollution releases, incuding during storms.

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- Industry and municipalities should work together to create detailed emergency response plans that include improved risk communication and notification of communities about emissions that pose a risk to public health. Millions of pounds of toxic pollutants were released during Hurricane Harvey and many communities were caught unaware due to a lack of access to reports, especially on ambient air quality monitoring, but also on sewage releases and water quality.

Hurricane Harvey's price tag was monumental: at least $125 billion, not counting the incalculable personal tolls. Preparing for the next storm will require costs and an investment of political will. But better planning could also save lives, homes, and the future of industries all along the Gulf Coast, and so be well worth the effort.

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ED_004042_00009109-00033