U.S. CHEMICAL SAFETY AND HAZARD INVESTIGATION BOARD

INVESTIGATION REPORT

FINAL

WEST FERTILIZER COMPANY FIRE AND EXPLOSION

(15 Fatalities, More Than 260 Injured)

WEST FERTILIZER COMPANY

WEST, TX

APRIL 17, 2013

KEY ISSUES:

- REGULATORY OVERSIGHT
- HAZARD AWARENESS
- EMERGENCY PLANNING AND RESPONSE
- FERTILIZER GRADE AMMONIUM NITRATE STORAGE PRACTICES
- LAND USE PLANNING AND ZONING

REPORT 2013-02-I-TX

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Dedication

This report is dedicated to the 12 emergency responders and 3 members of the public who lost their lives as a result of the explosion at the West Fertilizer Company on April 17, 2013.

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Acronyms and Abbreviations

°C	degrees Celsius
°F	degrees Fahrenheit
AC	air conditioning
AFG	Assistance to Firefighters Grant
AHJ	Authority Having Jurisdiction
AN	ammonium nitrate
ANFO	ammonium nitrate/fuel oil
ANSI	American National Standards Institute
API	American Petroleum Institute
ARA	Agricultural Retailers Association
AS	ammonium sulfate
ATF	Bureau of Alcohol, Tobacco, Firearms and Explosives
CDC	Centers for Disease Control and Prevention
CDP	Center for Domestic Preparedness
CDT	central daylight time
CEPP	Chemical Emergency Preparedness Program
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFATS	Chemical Facility Anti-Terrorism Standards
CFR	Code of Federal Regulations
CMU	concrete masonry unit
COI	chemical of interest
CSAT	Chemical Security Assessment Tool
CSB	U.S. Chemical Safety and Hazard Investigation Board
CTG	Continuing Training Grant
DHS	U.S. Department of Homeland Security
DOL	U.S. Department of Labor
DOT	U.S. Department of Transportation
DWC	Division of Workers' Compensation
EDT	eastern daylight time
EHS	extremely hazardous substance
EMPG	Emergency Management Performance Grant
EMS	emergency medical services
EMT	emergency medical technician

EO	Executive Order
EPA	U.S. Environmental Protection Agency
EPCRA	Emergency Planning and Community Right-to-Know Act
ERDC	Engineer Research and Development Center
ERG	Emergency Response Guidebook
ERP	Emergency Response Plan
EU	European Union
FAST	firefighter assist and search team
FEMA	Federal Emergency Management Agency
FFFIPP	Fire Fighter Fatality Investigation and Prevention Program
FGAN	fertilizer grade ammonium nitrate
FP&S	Fire Prevention and Safety
FR	Federal Register
FRS	Facility Registry Service
g/cm^3	grams per cubic centimeter
GAO	U.S. Government Accountability Office
GPD	Grant Programs Directorate
HAZMAT	hazardous material
HAZWOPER	Hazardous Waste Operations and Emergency Response
HCS	Hazard Communication Standard
HUD	U.S. Department of Housing and Urban Development
HSE	UK Health and Safety Executive
HSNTP	Homeland Security National Training Program
HVAC	heating, ventilation, and air conditioning
IAFC	International Association of Fire Chiefs
IAFF	International Association of Fire Fighters
IAP	Incident Action Plan
IBC	International Building Code
IC	incident commander
ICC	International Code Council
ICS	Incident Command System
ICT	Insurance Council of Texas
IFC	International Fire Code
IME	Institute of Makers of Explosives
ISO	Insurance Services Office

IST	inherently safer technology
K-Mag	potassium magnesium
LEPC	Local Emergency Planning Committee
LNG	liquefied natural gas
MOU	memorandum of understanding
MSDS	Material Safety Data Sheet
NAICS	North American Industry Classification System
NEIC	National Earthquake Information Center
NERRTC	National Emergency Response and Rescue Training Center
NEW	net explosive weight
NFA	National Fire Academy
NFPA	National Fire Protection Association
NIMS	National Incident Management System
NIOSH	National Institute for Occupational Safety and Health
NOX	nitrogen oxide
NPD	National Preparedness Directorate
NTED	National Training and Education Division
NVFC	National Volunteer Fire Council
NYC	New York City
OSHA	Occupational Safety and Health Administration
OTSC	Office of the Texas State Chemist
PHMSA	Pipeline and Hazardous Materials Safety Administration
PPC	Public Protection Classification
PPE	personal protective equipment
PRV	pressure relief valve
PSI	pounds per square inch
PSM	Process Safety Management (standard)
PVC	polyvinyl chloride
Q&A	question and answer
RCRA	Resource Conservation and Recovery Act
RDPC	Rural Domestic Preparedness Consortium
RFI	request for information
RMP	Risk Management Plan
SAA	State Administrative Agency
SAFER	Staffing for Adequate Fire and Emergency Response

SARA	Superfund Amendments and Reauthorization Act
SBA	Small Business Administration
SDS	Safety Data Sheet
SERC	State Emergency Response Commission
SFFMA	State Firefighters' and Fire Marshals' Association
SFMO	State Fire Marshal's Office
SIC	Standard Industrial Classification
SOP	standard operating procedure
SPCC	spill prevention, control, and countermeasures
TAC	Texas Administrative Code
TCEQ	Texas Commission on Environmental Quality
TCFP	Texas Commission on Fire Protection
TDI	Texas Department of Insurance
TEEX	Texas A&M Engineering Extension Service
TFI	The Fertilizer Institute
TGAN	technical grade ammonium nitrate
TIESB	Texas Industrial Emergency Services Board
TNT	Trinitrotoluene
TR	technical report
TRANSCAER	Transportation Community Awareness and Emergency Response
TRI	Toxics Release Inventory
TX	Texas
U.K.	United Kingdom
USFA	U.S. Fire Administration
USGS	U.S. Geological Survey
VFD	volunteer fire department
WFC	West Fertilizer Company
WFD	West Fire Department
WIS	West Intermediate School
WISD	West Independent School District
WMS	West Middle School
WVFD	West Volunteer Fire Department

1.0 Executive Summary

1.1 Overview

On April 17, 2013, a fire and explosion occurred at the West Fertilizer Company (WFC), a fertilizer blending, retail, and distribution facility in West, Texas. The violent detonation fatally injured 12 emergency responders and three members of the public. Local hospitals treated more than 260 injured victims, many of whom required hospital admission. The blast completely destroyed the WFC facility and caused widespread damage to more than 150 offsite buildings. The WFC explosion is one of the most destructive incidents ever investigated by the U.S. Chemical Safety and Hazard Investigation Board (CSB) as measured by the loss of life among emergency responders and civilians; the many injuries sustained by people both inside and outside the facility fenceline; and the extensive damage to residences, schools, and other structures. Following the explosion, WFC filed for bankruptcy.

The explosion happened at about 7:51 pm central daylight time (CDT), approximately 20 minutes after the first signs of a fire were reported to the local 911 emergency response dispatch center. Several local volunteer fire departments responded to the facility, which had a stockpile of between 40 and 60 tons (80,000 to 120,000 pounds) fertilizer grade ammonium nitrate (FGAN), not counting additional FGAN not yet offloaded from a railcar.

More than half of the structures damaged during the explosion were demolished to make way for reconstruction. The demolished buildings include an intermediate school (552 feet southwest of the facility), a high school (1,263 feet southeast), a two-story apartment complex with 22 units (450 feet west) where two members of the public were fatally injured, and a 145-bed nursing home (500 feet west) where many of the seriously injured civilians resided. A middle school (2,000 feet southwest) also sustained serious but reparable damage. Section 3 describes the incident and its consequences in detail.

The CSB investigated the factors that contributed to the detonation of FGAN. Section 4 describes the properties of FGAN and posits three scenarios that could lead to its detonation under the conditions present during the WFC fire. CSB concluded that the construction of the bins and other building materials as well as the lack of an automatic sprinkler system plausibly contributed to the detonation. Section 6 describes inherently safer approaches to FGAN use and storage that reduce the risk of an FGAN detonation.

The total insurance-related losses from the explosion are estimated to be around $230 million and federal disaster assistance is estimated to exceed $16 million. WFC was only insured for $1 million, which fell far short of the incident's damage. Section 5 presents CSB's analysis of the policies and regulations that led to this as well as to the failure of the insurer to identify the risks posed by FGAN. A few years prior to the incident, WFC was dropped by one insurer for failing to address safety concerns identified in loss control surveys. The company that insured WFC at the time of the incident did not appear to have conducted its own safety inspections of the facility.

CSB's analysis of the emergency response, found in Section 7, concludes that the West Volunteer Fire Department did not conduct pre-incident planning or response training at WFC, was likely unaware of the potential for FGAN detonation, did not take recommended incident response actions at the fire scene, and did not have appropriate training in hazardous materials response.

CSB found several shortcomings in federal and state regulations and standards that could reduce the risk of another incident of this type. These include the Occupational Safety and Health Administration's Explosives and Blasting Agents and Process Safety Management standards, the Environmental Protection Agency's Risk Management Program and Emergency Planning and Community Right-to-Know Act, and training provided or certified by the Texas Commission on Fire Protection and the State Firefighters' and Fire Marshals' Association of Texas. CSB's complete analysis is presented in Section 8.

The location of the WFC relative to the surrounding community exacerbated the offsite consequences, leading CSB to assess whether other FGAN storage facilities could pose significant offsite risks. CSB's analysis shows that the risk to the public from a catastrophic incident exists at least within the state of Texas, if not more broadly. For example, 19 other Texas facilities storing more than 10,000 pounds of FGAN are located within 0.5 miles of a school, hospital, or nursing home, raising concerns that an incident with offsite consequences of this magnitude could happen again. Section 9 explores the connection between land use planning and offsite consequences.

1.2 Federal and State Response

In response to this incident, President Barack Obama issued Executive Order (EO) 13650, "Improving Chemical Facility Safety and Security" to coordinate federal actions to reduce the risks of another incident of this type.[1] Details and updates on the status of the EO are included in Section 8.1.

Early investigation activities focused on law enforcement efforts to determine if there was a criminal element to the incident. Responding governmental agencies included the U.S. Bureau of Alcohol, Tobacco, Firearms and Explosives (ATF) National Response Team, Texas State Fire Marshal's Office (SFMO), U.S. Occupational Safety and Health Administration (OSHA), Texas Commission on Environmental Equality, U.S. Federal Emergency Management Agency (FEMA), and U.S. Environmental Protection Agency (EPA). In addition, multiple state and local law enforcement and emergency response organizations responded to the scene.

1.2.1 Joint SFMO/ATF Investigation

Immediately following the incident, ATF deployed to West at the invitation of SFMO and assumed control of the WFC site to conduct a joint investigation of the immediate cause and origin of the fire and explosion and determine whether the initiating fire was intentionally set. The two agencies retained

[1] Executive Order 13650. "Improving Chemical Facility Safety and Security," August 1, 2013. *See*: https://www.whitehouse.gov/the-press-office/2013/08/01/executive-order-improving-chemical-facility-safety-and-security (accessed on December 8, 2015).

control of the scene for about four weeks, interviewing witnesses, excavating the WFC site, and reconstructing the electrical system. To date, law enforcement has not made a final determination of the cause of the fire and ensuing explosion. Three possible scenarios remain under consideration: (1) faulty electrical wiring, (2) short circuit in an electrical golf cart, and (3) intentional act of arson.[2]

1.2.2 CSB Response

CSB investigators from both the Washington, DC, and Denver, Colorado, offices deployed on April 18, 2013, supported by a contingent of contractors that included blast modeling, structural, urban search and rescue, and fire and explosion experts. The joint ATF-SFMO control of the site as a crime scene limited CSB site access and delayed CSB investigator execution of evidence-gathering protocols, chemical testing, and witness interviews. Despite the limited access in the initial stages, driven by the criminal investigation, CSB continued with its investigation.

The investigation of the WFC incident analyzed several root causes and considered multiple contributing causes. Investigative teams partnered with urban search and rescue experts and fire and explosion consultants to survey damage to residences, schools, the nursing home, and other structures. The teams also conducted interviews with eyewitnesses, WFC managers, and hourly workers and gathered physical evidence for further laboratory testing and analysis.

Key Findings

The CSB's analysis includes findings on the technical causes of the fire and explosion; regulatory changes that could have resulted in safety enhancements to the facility; the failure of the insurer to conduct safety inspections or provide an adequate level of coverage; shortcomings in emergency response, including pre-incident planning or response training of the volunteer fire fighters; and deficiencies in land use planning that permitted the City of West to encroach upon the WFC over the years. Section 10 presents the CSB's key findings on the WFC incident.

Recommendations

As a result of the investigation of the WFC fire and explosion, CSB developed recommendations and directed them to the following recipients:

- Environmental Protection Agency (EPA).
- Occupational Safety and Health Administration (OSHA), U.S. Department of Labor.
- Federal Emergency Management Agency (FEMA), U.S. Department of Homeland Security.
- International Codes Council.
- Texas Department of Insurance.
- Texas Commission on Fire Protection.
- State Firefighters' and Fire Marshals' Association of Texas.
- Texas A&M Engineering Extension Services (TEEX).

[2] *See*: http://www.tdi.texas.gov/news/2013/news201320.html (accessed on December 22, 2015).

- El Dorado Chemical Company (EDC).
- West Volunteer Fire Department (WVFD).

Section 11 contains the complete set of recommendations.

2.0 Background

2.1 West Fertilizer Company

The West Fertilizer Company (WFC) was located in the city of West, Texas. The city is approximately 80 miles south of Dallas, Texas, and has a population of about 2,800.[3] The WFC stored and distributed fertilizers, chemicals, grains, and various other farming supplies. At the time of the incident, stockpiles of about 40 to 60 tons of FGAN were estimated to be onsite, and about 30 tons detonated. Table 1 shows the WFC inventory at the time of the explosion and fire.

Table 1. WFC Fertilizer Inventory in April 2013

Fertilizer Name	Amount (in tons)
FGAN (fertilizer building)	40 to 60
FGAN (railcar)	100
Anhydrous ammonia	17
Potash[4]	45
Diammonium phosphate[5]	70
Diammonium phosphate and potash	25
Ammonium sulfate[6]	60 to 70
Zinc sulfate[7]	17.5

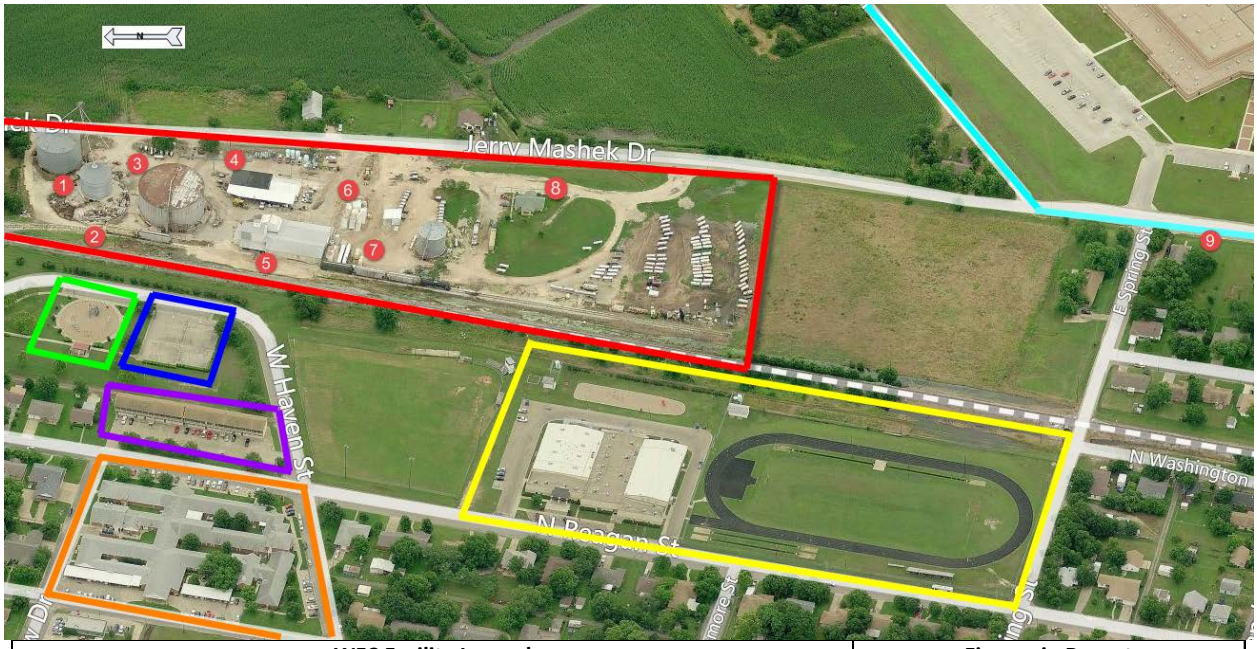
The fertilizer building was constructed in 1961, and business operations started in 1962. Photographs from 1972 show the closest residence about 265 feet from the WFC property. In addition, a baseball field

[3] The 2010 U.S. Census data indicate that the population of West, Texas, is 2,807. *See*: http://www.census.gov/2010census/popmap/ (accessed on December 8, 2015).
[4] Potash is an agricultural fertilizer and is a source of soluble potassium (K).
[5] Diammonium phosphate (DAP), $(NH_4)_2HPO_4$, is one of a series of water-soluble ammonium phosphate salts that can be produced when ammonia reacts with phosphoric acid.
[6] Ammonium sulfate, $(NH_4)_2SO_4$, is an inorganic salt with a number of commercial uses. The most common use is as a soil fertilizer.
[7] Zinc sulfate, $ZnSO_4$, is an inorganic compound and is a colorless solid that is a common source of soluble zinc ions.

was 58 feet from the property. In 1972, the town nursing home and the nearest group of homes were constructed about 500 feet away.[8]

Over the years, growth in the city of West led to the development of land closer to the WFC property line, including a park (less than 150 feet), an apartment complex, the nearest aggregation of homes (about 370 feet), West Intermediate School (a little more than 200 feet), and West High School (about 500 feet). Sections 3.4.2 through 3.4.7 provide additional details on the property damage resulting from the explosion.[9] Figure 1 shows the WFC facility before the fire and explosion in relation to the nearby community, including details on the site and the location of various structures.

[8] This information was determined using Image 272-37A provided by McLennan County and distances calculated using Google Earth (accessed on June 6, 2013).
[9] Calculated using Google Earth (accessed on June 6, 2013).



WFC Facility Legend		Figures in Report
1	Grain Silos	2
2	Location of Overturned FGAN Railcar (post-explosion)	15
3	Corn Silo	-
4	Office/Chemical Storage	-
5	Fertilizer Building	3-5, 7
6	Liquid Fertilizer Tanks	16
7	Anhydrous Ammonia Pressure Vessels	6, 17, 21
8	Scale House	-
9	Nearest Fire Hydrant	-

City of West Legend		Figures in Report	Approximate Distance from Seat of Blast to Fenceline (Feet)
	West Fertilizer Company	2-8, 12	0
	West High School	30	1157
	West Intermediate School	23-29	552
	Basketball Court	20	249
	Playground	19	366
	West Terrace Apartment Complex	36	454
	West Rest Haven Nursing Home	33-35	629

Figure 1. 2013 Overview of WFC Facility (Source: Bing Maps)

2.1.1 Facility Operations Description

The West, Texas, site consisted of two companies owned by the same family. Adair Grain, Inc., bought and sold grain while the WFC sold fertilizer, farming chemicals (pesticides and herbicides), and basic farm equipment (such as barbed wire, baling twine, and fencing). The WFC also rented farming equipment (fertilizer spreading equipment, tillage equipment) and spread fertilizer on farmland when needed, and its daily activities were largely based on season and weather.

Adair Grain bought grain (milo[10] and corn) from farmers and stored it in four onsite silos (shown in Figure 1 and Figure 2). Adair Grain received grain from farmers' trucks and deposited it into pits (Figure 3). An auger then transferred the grain from these pits, depositing it into the grain bin.

Figure 2. Grain Silos (Source: WFC Insurer)

[10] Milo, also called grain sorghum, is a major feed grain for cattle.

Figure 3. West View of Fertilizer Building (Source: Bing Maps)

The WFC operated two buildings and a number of tanks (shown in Figures 1 and 3). One building served as a chemical warehouse, shop area, and office space. Most chemicals purchased by farmers were stored in that building. Such chemicals included Roundup®, Sevin®, and additives to make pesticides adhere to plants (such as Weedmaster® and Grazonnext®) and were stored in containers ranging in size from 2 to 300 gallons.

The WFC also owned the fertilizer building, constructed in the 1960s, where dry fertilizer was stored (Figure 4). Fertilizers stored in that building included diammonium phosphate, ammonium sulfate, potash (potassium chloride), potassium magnesium sulfate (K-Mag), and FGAN. A seed room was located at the north end of this building (Figure 5).

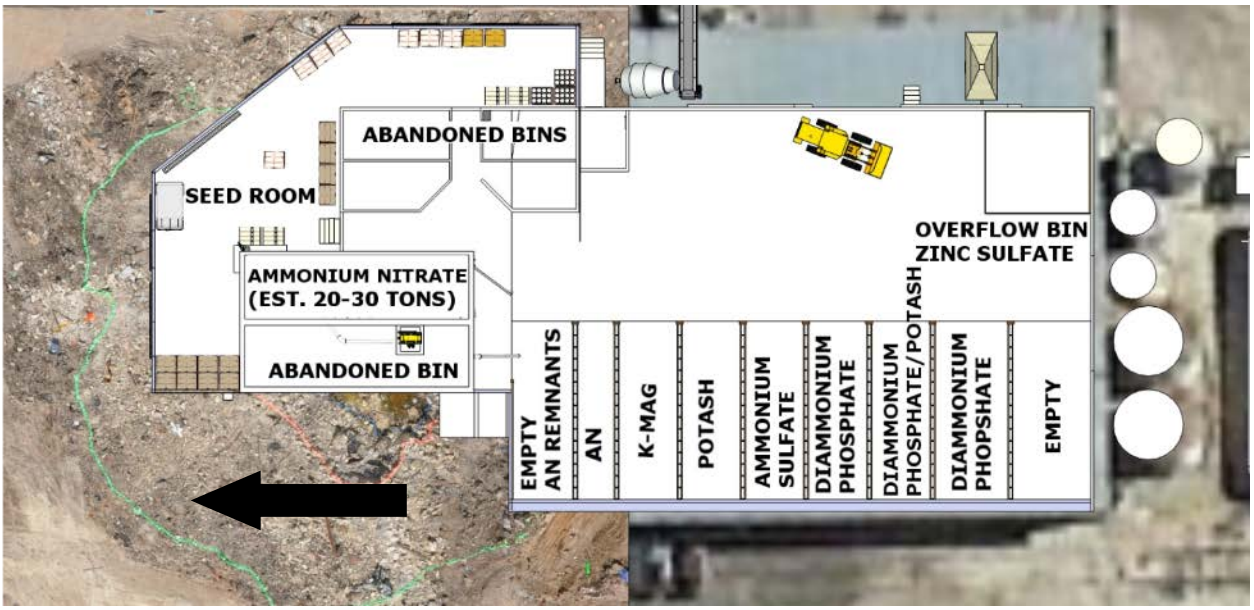


Figure 4. Fertilizer Building Overview (Source: Atlas Engineering)

Figure 5. Southwest View from Northeast Corner of Fertilizer Building (Source: WFC Insurer)

The WFC facility had two 12,000-gallon anhydrous ammonia[11] (NH_3) storage vessels, located to the south of the fertilizer building, for distribution and sale of the product to farmers (Figure 6). The

[11] Anhydrous ammonia is a colorless and extremely water-soluble gas at room temperature, with a strong irritating odor. Ammonia gas is lighter than air, but under certain conditions, ammonia vapor can settle close to the ground during a leak, forming a white cloud. Ammonia can be compressed into a liquid under pressure, and within a concentration in air range of 15 to 28 percent, it is flammable. This is known as the lower explosive limit (LEL) and upper explosive limit (UEL), respectively. Ammonia exposure at lower concentrations can irritate the skin, eyes, and respiratory system, and at high concentrations, exposure can result in pulmonary edema and death.

anhydrous ammonia was primarily trucked into the facility, but delivery by rail was also possible. Although anhydrous ammonia is used in the manufacture of AN, the WFC stored it onsite solely for sale to consumers as liquid fertilizer. Adjacent to the anhydrous ammonia tanks, liquid fertilizer was stored outside in several vertical tanks. This type of fertilizer included liquid nitrogen or liquid phosphate and could be blended to meet specific farmer needs. One outside tank was normally full of water to mix with chemicals or liquid fertilizer.

No products were manufactured onsite; the WFC was essentially a distribution center for suppliers such as Mosaic, BASF, Agri-Phos, El Dorado Chemical Company (EDC), and CF Industries. EDC and CF Industries are the only manufacturers of FGAN in the United States. The WFC mixed and sold bulk fertilizer components or unaltered products such as pure FGAN and ammonium sulfate. Farmers came to the WFC and bought fertilizer that was weighed in a hopper, blended in a mixer, and distributed by conveyor belt (the mixer and conveyor belt can be seen in Figure 7). The WFC also delivered and applied fertilizer or chemicals to a farmer's fields if needed.

Figure 6. Anhydrous Ammonia Storage (Source: WFC Insurer)

Figure 7. West View from East of Fertilizer Building (Source: WFC Insurer)

2.1.2 Facility Layout and Materials of Construction

The fertilizer building (Figure 4) was a wood-framed structure with a concrete floor, at an elevation about 3 feet above grade. The building was constructed piecemeal over the years, starting with the original construction in 1961. The seed room was fabricated in the early 1980s, with a roof constructed of wooden rafters topped with plywood and covered with asphalt shingles. The only trench or drain in the building was in the cattle trough, which was used to collect fertilizer slurry when it became moist. A series of ladders were positioned adjacent to the elevator.

FGAN was stored in two plywood bins along the west wall of the building and in one primary FGAN bin at the north end of building. The primary FGAN bin was normally no more than half full while the fertilizer bins on the west wall could be filled to the top of the containment. In the northeast corner of the building, an abandoned bin had been used to store fertilizer in the past but was unused at the time of the incident.

The primary FGAN bin was constructed differently than the bins on the west wall. The bins on the west wall were composed of three walls rising to a height of about 10 feet and an open front. The primary bin was constructed by attaching plywood sheets to the inside of the exterior beams of the structure. The interior walls were also constructed of 6-inch beams with plywood attached. The main bin was estimated to be 8 feet wide, 20 feet long, and 30 feet high. A large hinged door covered the south end of the bin, with a 3-foot opening at the bottom. Holes were cut in the bin to provide air circulation, and a set of holes on the west wall allowed the bin to overflow into a smaller adjacent bin.

The door to the bin was normally closed when the bin was filled, and it could be opened to provide access

Figure 8. Plywood Bin Wall, Post-Explosion (Source: CSB)

after the inventory was reduced so that the fertilizer was not resting against the door. The bin was just wide enough (8 to 10 feet) to allow a front-end loader to drive in to access and gather the remaining FGAN. Like the west bins, the primary FGAN bin had plywood sheets (including some particle boards) and a wooden frame for support (shown post-explosion in Figure 8). The primary bin also had metal rods connected at opposite sides of the bin, providing internal stiffening support.

About 2 years before the WFC explosion, the northeast corner of the north wall of the primary FGAN bin failed, and employees erected steel and concrete reinforcement around the bottom of the northeast corner to provide support and hold up the bin. As a result, the WFC never completely filled the primary bin to avoid another failure.

A seed room,[12] fabricated in 1980 and located at the north end of the fertilizer building served as the warehouse for seeds sold to consumers. Asphalt shingles covered the roof of the seed room of the fertilizer building. The seed room also stored more than 700 bags of zinc sulfate on the day of the fire and explosion. The zinc sulfate and seeds were stored in bags on pallets, with about 40 to 50 bags per pallet, stacked to a height of about 3 to 4 feet on each pallet. The seed room also contained two pallets of lawn and garden fertilizer (bagged at the WFC), twine, bailing wire, and fencing materials. At the west end of the seed room, 8 to 10 pallets of out-of-season seeds were segregated in an area cooled by an air

[12] The seed room was used for storage of seed, bagged fertilizer, equipment, and vehicles, including a riding lawnmower, a golf cart, and a fork lift. It was constructed as an addition to the main fertilizer building in the early 1980s.

conditioner. The east end of the seed room stored twine and netting. At the time of the incident, the room held a relatively low inventory of seeds (approximately 30 percent of the room's capacity, or 3,000 bags of out-of-season seeds).

2.1.3 Unloading of Fertilizer

Historically, suppliers delivered bulk fertilizer product by truck or rail, but immediately before the incident, most shipments arrived by truck. All bulk fertilizer was transferred into the bins (located as shown in Figure 4), using the same conveyor belt system described in the previous section. Delivered fertilizer was first deposited into a loading pit. An uncovered 20-inch-wide rubber conveyor belt then transported the product into the fertilizer building. The belt was cupped to hold the fertilizer, which was transferred from this conveyor belt to a bucket elevator (pictured post-explosion in Figure 9).

Figure 9. Elevator System Recovered from Blast Debris (Source: CSB)

The elevator lifted the fertilizer to the cupola (the highest structure) and deposited it into polyvinyl chloride (PVC) pipes, which in turn conveyed the fertilizer to either the main FGAN bin or a horizontal conveyor belt for distribution to the bins along the west wall. A valve was used to gravity-feed material to either the large FGAN bin by way of PVC piping (approximately 20 feet long by 1 foot in diameter) or through an approximately 40-foot downpipe toward the horizontal conveyor belt in the main portion of the building. A piece of PVC piping could be added to the downpipe to direct product from the horizontal conveyor belt and to direct FGAN to the two FGAN overload bins on the west wall. The horizontal conveyor belt transported product to the bins in the southern portions of the building. A 6- to 8-foot "kicker" conveyor belt transferred the fertilizer from the horizontal conveyor belt to its final destination in any of the west wall bins. Electric motors powered the conveyor belts. Every fertilizer product used the same conveyor system process for filling the respective bins.

Workers used a front-end loader to move the fertilizer within the fertilizer building. For a blended fertilizer product, the operator would place a load of each product in a predetermined quantity into the weigh hopper. After all of the ingredients were weighed, the product was sent via a conveyor belt to a mixer, which had the appearance of a stationary concrete mixer. The mixed product was deposited on a conveyor belt and loaded into a truck or spreader. A yellow auger next to the conveyor mixed seed with fertilizer. Zinc sulfate could also be added to fertilizer.

2.1.4 Housekeeping

Because unloading operations in the fertilizer building created a dusty environment, the first task of the day in the fertilizer building was cleaning the floor after work during the previous day and evening. To address these conditions during operating hours, the WFC used fans to control the dust during unloading, and on some occasions, workers added a vegetable oil coating to the ammonium phosphate to reduce the dust.[13] An employee reported to CSB that some products were dustier than others and that floor sweeping compound was also applied to the fertilizer building floor on very wet days. When mixing fertilizer, operators usually added phosphate to the hopper and mixer first to eliminate any moisture.

The employees reported that because FGAN tends to absorb moisture and dissolve, the WFC used air conditioning to cool and remove moisture from the primary FGAN bin. After the FGAN bin was emptied, it was swept to remove moisture. On damp or humid days, operators minimized handling FGAN unless necessary because it would “melt” and become lost product.

When the fertilizer became damp and began to “sweat” onto the floor, it was swept into a trench (cattle trough) on the east side of the fertilizer building. The liquid captured as slurry in the trough was then pumped into a liquid fertilizer tank for disposal. Employees reported that the plywood walls between the bins “stayed pretty clean” and did not require any housekeeping.

After a shipment of one type of fertilizer was unloaded, no cleaning process was used to clear the conveyor belt before the next load was transferred. During the unloading process, the fertilizer occasionally spilled because the conveyor belts got off track or ripped. In such cases, operators attempted to separate the products as best they could, but intermixing and cross-contamination nonetheless would occur. The fertilizer in the west bins was occasionally changed out, and if the product became damp and moist, it might have been emptied out with a “drier” product such as K-Mag placed into that bin. The K-Mag would dry out the bin, and afterward, the bin could revert to storage space for another product. Occasionally, the bin walls developed holes or cracks, and when that occurred, either new wood walls were put in place to replace the old ones or caulk was used to fill the holes.

[13] Ammonium phosphate was the only product at the WFC with an oil coating.

3.0 Incident Description

On April 17, 2013, at approximately 7:29 pm, citizens reported signs of smoke and fire at the West Fertilizer Company (WFC) facility to the local 911 dispatch center. Within 20 minutes, a massive explosion occurred, killing 15 people and sending a blast wave through the town that damaged or destroyed many buildings and homes. The fire was witnessed from several vantage points by different individuals associated with the West Police Department, Dallas Fire-Rescue Department, and volunteer fire departments (VFDs) from West, Abbott, Bruceville-Eddy, Mertens, and Navarro Mills. These accounts assisted CSB in determining how the events of the day transpired.

3.1 West Police Department

One of the first responders to the incident was a West Police Department officer who was on routine patrol that evening. The officer reported that he smelled smoke as he was driving through the city park[14] but was not able to identify the exact location of the smoke until he encountered a concerned citizen who advised him that smoke was venting from the highest portion of the WFC building. The officer advised the dispatch center of the smoke and requested that the West Volunteer Fire Department (WVFD) be dispatched to the WFC facility. Once the officer arrived on scene, he witnessed flames that were visible through the wall, extending upward from the lower level to the upper level of the northeast corner of the two-story fertilizer storage building. Then he called dispatchers again and asked them to inform the WVFD that the smoke had escalated to a structure fire.

The WVFD contacted the officer via radio and requested that he establish traffic control to prevent citizens from driving over the fire hoses once the fire engines arrived and laid down fire hoses. The officer agreed but notified the WVFD that he needed to evacuate the city park first. As the officer proceeded to the city park, the responding West firefighters drove past him, heading toward the facility. Once the officer reached the city park, he used his public address system to order an evacuation of the park. After the park was evacuated, he left the area to establish traffic control on the north end of the fertilizer facility. There was no traffic control at the south end toward West High School (WHS), so the officer asked a nearby resident to assist by using his truck to block that intersection. At this time, the officer contacted the police chief and another officer who had called to determine whether he needed assistance. The officer asked the police chief to establish traffic control by the West Intermediate School (WIS) and requested that the other officer relieve the resident who was helping near the high school.

Numerous citizens began parking their cars at WHS to watch the fire. The WVFD truck left the WFC facility and headed toward the police officer. The manager of the WFC arrived on scene to assist the WVFD. Via radio traffic, the officer learned that the entire fertilizer storage building was engulfed in flames, and shortly thereafter he saw and felt the explosion. The officer was briefly disoriented and then unsuccessfully attempted via radio and cell phone to notify the dispatch center of the explosion. An

[14] The city park consisted of the basketball court and the playground.

injured member of the public and an injured firefighter approached the officer, who assisted them. The possibility of further explosions or toxic releases was a concern because of the anhydrous ammonia pressure vessels on the south side of the WFC property. On the basis of this information, the officer decided to evacuate homes within a 1-mile radius. Because the officer's patrol car would not start, he proceeded on foot along Jerry Mashek Drive and Main Street to alert people to evacuate (refer to Figure 1 for a map of the area). By the time the officer made his way to Reagan Street, he had become aware that other emergency responders had initiated the evacuation of the northern portion of the city.

3.2 West Volunteer Fire Department (WVFD)

Emergency dispatchers paged the WVFD, and firefighters responded to the scene with two fire engines, two initial attack apparatus or brush trucks,[15] and a water tender truck[16] at various times. Dispatchers also paged mutual aid personnel from neighboring counties, including Abbott, which responded. Many of the firefighters also responded by using their personally owned vehicles (POVs). According to eyewitness accounts, the fire intensified very quickly and was described as a rolling fire that moved from the northeast end of the fertilizer building (in the seed storage area north of the office) toward the southern end of the building.

Five firefighters arrived on scene in two fire engines at different times. The first fire engine arrived on scene and staged east of the burning structure while one of the brush trucks staged to the north of the first fire engine. Four other firefighters directed water (using two 1.5-inch hoses) from the first fire engine's internal tank onto the fire through the northeast doorway of the bagged fertilizer room, where fire was present. Once the second fire engine arrived on scene, the two firefighters from that fire engine began laying 1,000 feet of 4-inch hose line from the fire hydrant near the high school (1,600 feet away) toward the fertilizer facility. After laying all of the hose lines from the second fire engine, they discovered that the hose was approximately 700 feet short of the length needed to effectively fight the fire. After assessing the situation, one firefighter arranged to take the first fire engine, which had a better pump with greater pressure capabilities and additional hose that would allow him to continue to reverse-lay the lines.[17] However, rather than resuming where the first fire engine ran out of hose, the firefighter went back to the fire hydrant near the high school to connect the first engine to the hydrant without laying the additional length of hose needed to supplement the hose that had already been laid from the second

[15] Initial attack fire apparatus as defined in NFPA 1901 is fire apparatus with a permanently mounted fire pump of at least 250 gallons per minute (gpm) capacity, water tank, and hose body whose primary purpose is to initiate a fire suppression attack on structural, vehicular, or vegetation fires and to support associated fire department operations. Normally, most initial attack fire apparatus are constructed on commercial-style chassis. *NFPA 190:1 Standard for Automotive Fire Apparatus*, 2016 Edition. Quincy, MA: NFPA, 2016.

[16] A water tender is the National Incident Management Systems (NIMS) approved term for a wheeled vehicle carrying water for fire suppression.

[17] In firefighting, reverse lay refers to the nozzle end of the hose being laid from the fire to a water source. This method is used when the pumper must first go to the fire location to size it up before laying supply line, and it is the most expedient way to lay hose if the apparatus must stay close to the water source.

engine. He saw flames (40 to 50 feet high) coming out of the cupola atop the fertilizer storage building and out of the door on the northeast corner of the building. Before the firefighter could make his way back to the end of the hose run, the explosion occurred. Before the explosion, the WVFD assistant chief arrived at the WFC facility, spoke with the police officer on scene, and advised him to begin evacuating nearby homes. He also made a radio request to the dispatch center, asking for a ladder truck to set up at the West Terrace Apartments in case a fire started there, but a ladder truck was not available. The WVFD chief and assistant fire chief were assessing the situation just before the explosion and were considering a total evacuation, even though neither believed that the FGAN would explode.[18]

On the basis of interviews that CSB conducted after the incident, the WVFD came to understand that it did not have enough water to effectively fight the fire.[19] Accordingly, the WVFD was considering the appropriate course of action—possibly standing down, letting the structure burn, and focusing on evacuation.

3.3 Abbott, Bruceville-Eddy, Mertens, and Navarro Mills Volunteer Fire Departments

On the evening of the incident, a group of volunteer firefighters from neighboring city fire departments (including Bruceville-Eddy, Mertens, and Navarro Mills), who were taking an Emergency Medical Technician (EMT)–Basic class at the West Emergency Medical Services (EMS) building, responded to the fire. The West EMS facility is located a few blocks west of the WFC facility.[20] When these volunteer firefighters heard the sirens activated in the city, they immediately made their way to the site. In addition, an ambulance responded with two EMTs and a volunteer firefighter. According to interviews that CSB conducted with emergency responders, radio and cell phone capabilities at the scene were limited after the explosion. Following the explosion, officials established two different staging areas. The first staging area, at the high school football field about 0.25 miles from the blast site, was used as a triage area for injured residents. Injured personnel and residents were relocated from the football field to the second staging area, at the community center about 1 mile away.[21] After the explosion at approximately 8:15 pm, additional volunteer firefighters from the neighboring cities of Abbott, Bruceville-Eddy, Mertens, and Navarro Mills responded to the WFC facility. Figure 10 shows the WFC explosion as it unfolded.

[18] Section 7 of this report provides further details on how the evacuation occurred.
[19] Employees and emergency responders should ***not*** fight AN fires past the incipient stage. Further details on responding to AN fires is available in Section 7.5 and Section 7.6 of this report.
[20] State Fire Marshal's Office. "Firefighter Fatality Investigation," Investigation FFF FY 13-06 (West, TX).
[21] Clements, Bruce. Texas Department of State Health Services, "The Texas Public Health Response to the West Fertilizer Plant Explosion," October 8, 2013.

Figure 10. Video Stills of WFC Fire and Explosion (Source: Member of the Public)

3.4 **Consequences**

3.4.1 Fatalities and Injuries

The violent explosion at the WFC facility fatally injured 12 emergency responders and 3 members of the public. All of the fatalities except one resulted from fractures, blunt force trauma, or blast force injuries sustained at the time of the explosion. Two fatally injured members of the public lived at a nearby apartment complex while the third resided at the nursing home and died from injuries brought on by the trauma of the explosion shortly after the incident. According to the Waco-McLennan County Public Health District's report, [22] the incident resulted in more than 260 injured victims, including emergency responders and members of the public.[23] Hill County (Hill Regional Hospital and Lake Whitney Medical Center) and McLennan County (Hillcrest Baptist Medical Center and Providence Health Center) hospitals received 81 percent of patient visits, with 104 injury visits at Hillcrest Baptist Medical Center, 82 visits at Providence Health Center, 41 injury visits to Hill Regional Hospital, and 1 injury visit at Lake Whitney Medical Center.[24] The injuries ranged from relatively minor wounds (such as contusions, abrasions, and lacerations) to more serious injuries (such as fractures, closed head injuries, traumatic brain injuries, and skin burns). The majority of patients were treated and released after their initial visit to a hospital, medical center, or mobile medical unit. Figure 11 categorizes all injury types sustained by the 252 patients injured directly by the explosion; many patients received multiple types of injuries. The Waco-McLennan County Public Health report also identified the location where 76 percent of the reported 252

[22] Waco-McLennan County Public Health District. "A Public Health Report on Injuries Related to the West (Texas) Fertilizer Plant Explosion," June 24, 2014.

[23] The number of injured victims includes patients who were treated after the explosion and sustained injuries during clean-up or by debris in the neighborhood.

[24] Waco-McLennan County Public Health District. "A Public Health Report on Injuries Related to the West (Texas) Fertilizer Plant Explosion," June 24, 2014: 7.

injuries occurred, outside or inside of a structure. More than half of the injured patients reported being inside a structure (55 percent), and the rest said they were outside (13 percent) or inside of a vehicle (8 percent). The locations cited by the injured also reflected the most common types of injuries. Patients who were inside a structure were twice as likely to suffer abrasions, contusions, and lacerations. People who were outside or inside of a vehicle were eight times more likely to have hearing loss or tinnitus, tympanic membrane rupture, or inhalation injuries. The majority of the injured were within 1,500 feet of the blast, although some were more than 2,000 feet from the explosion; people who were hospitalized were closer to the center of the blast than those who were not admitted. Notably, eye injuries—and traumatic brain injuries and concussions—were equally distributed among the injured, regardless of location.[25] Detailed information regarding the cause of nonfatal injuries was not collected and analyzed. Possible causes of injuries include being struck by primary fragment projectiles, by secondary fragments from remote structures and vehicles, or directly by the blast wave.

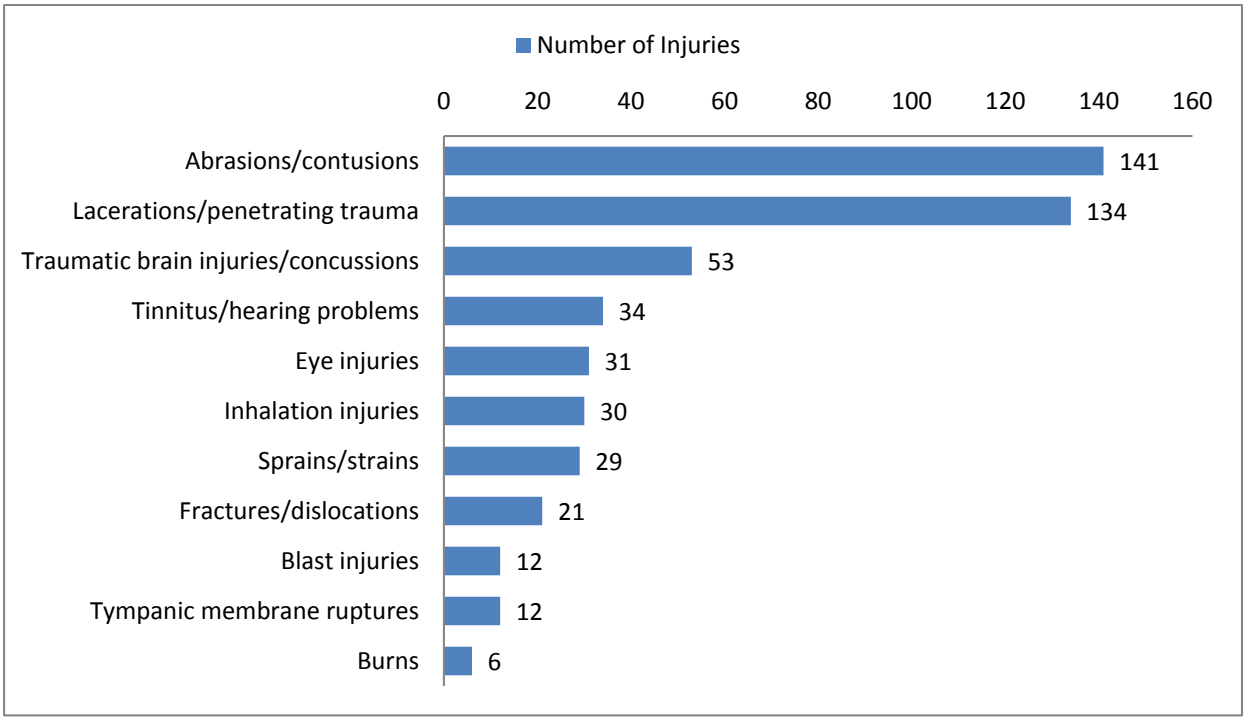


Figure 11. Number of Nonfatal Injuries, by Injury Type (Source: Waco-McLennan County Public Health District)[26]

During the investigation, CSB noted two potential scenarios that could have led to more severe consequences. First, if the fire had started during the middle of a normal school day instead of the

[25] Waco-McLennan County Public Health District. "A Public Health Report on Injuries Related to the West (Texas) Fertilizer Plant Explosion," June 24, 2014.
[26] Waco-McLennan County Public Health District. "Public Health Report: Injuries Related to the West (Texas) Fertilizer Plant Explosion," April 2013 (issued on June 24, 2014).

evening and if all other conditions remained unchanged (specifically, if onsite WFC employees were unable to extinguish the fire), students would have been present at the intermediate and high schools. Had the schools evacuated, students likely would have assembled in areas such as the gymnasium and multipurpose rooms within the schools (and in other pre-designated areas outside of the schools) before the evacuation to conduct a head count. Given the short time that elapsed before the explosion, many students and staff members might have been injured in the 20 minutes from the first discovery of a fire until the explosion. Second, a railcar loaded with more than 100 tons of FGAN toppled during the explosion but did not detonate. If the contents of the railcar had detonated, the damage, injuries, and fatalities would have been significantly worse. These scenarios are important to consider because throughout the United States, there are many facilities that, like WFC, are located near public structures such as schools.[27]

3.4.2 Property Damage

The West incident caused considerable property damage, including the complete destruction of the WFC facility (Figure 12). An initial estimate by the Texas Department of Insurance set total property damage resulting from the explosion and fire at $100 million. CSB hired a consulting firm[28] to perform an assessment of the structural and property damage caused by the fire and explosion. The assessment involved a thorough examination of damage to the WFC facility and to the community structures and facilities.[29] As of the publication of this report, neither the owners of the WFC nor the city of West has decided whether the WFC facility would be rebuilt. Currently, the local farmers are using fertilizer from another fertilizer facility in Leroy, Texas, seven miles east of the city of West.

[27] Section 5.4 provides further details on the location of schools in relation to FGAN facilities throughout Texas.
[28] ABSG Consulting Inc. *See*: http://www.absconsulting.com/ (accessed on June 26, 2015).
[29] Sites examined included the West Intermediate School (WIS), West High School (WHS), West Middle School (WMS), West Rest Haven nursing home, and the park.

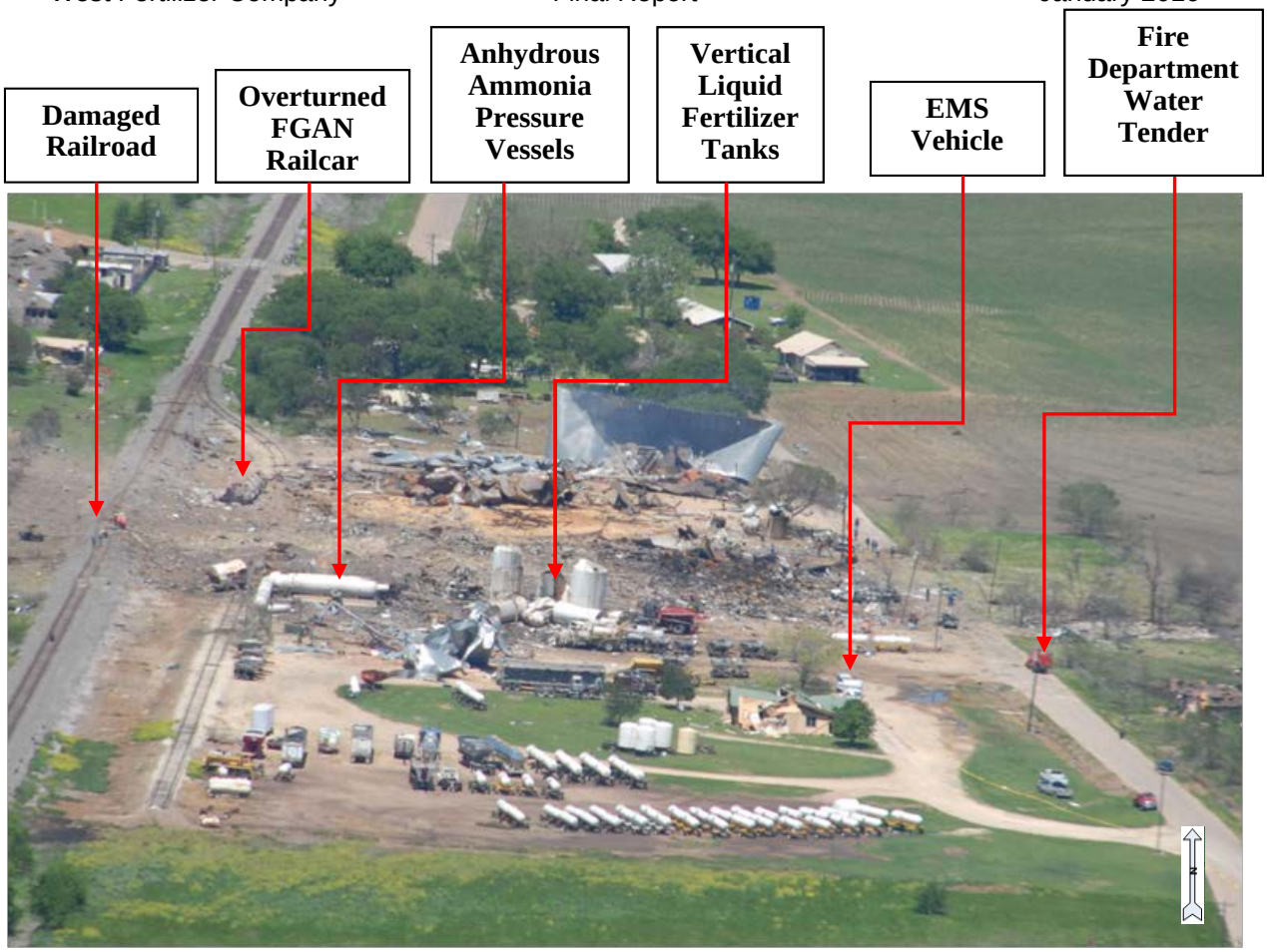


Figure 12. Overview of Damage to WFC Facility (Source: Texas Civil Air Patrol)

The explosion, overpressure, and debris completely destroyed a WVFD brush truck, water tender, and fire engine (Figure 13). The water tender was located southeast of the crater and likely moved about 6 inches south as a result of the blast overpressure. The explosion propelled the door from the water tender to the east. A large farm truck south of the fertilizer storage building and toward the scale house moved about 6 inches south of its original location because of the blast wave (Figure 14). All of the POVs belonging to responding volunteer firefighters who parked onsite were damaged or destroyed in the explosion. In addition, the explosion overturned and destroyed the railroad car loaded with FGAN, approximately 190 feet to the north of the crater (Figure 15).

Figure 13. Damaged WVFD Water Tender (Source: ABS Consulting)

Figure 14. Farm Truck South of Crater, Near the Scale House (Source: ABS Consulting)

Figure 15. Railcar Loaded with FGAN, Destroyed and Overturned by Explosion (Source: CSB)

The explosion completely demolished the scale house; the roof and all four walls failed. The explosion flattened the chemical storage and office building east of the fertilizer storage building—all that remained was a stack of metal debris where the building once stood. The explosion also destroyed the corn silo north of the fertilizer storage building. In addition, the blast heavily damaged the above-ground vertical liquid fertilizer storage tanks. As shown in Figure 16, the liquid level during the explosion in the tank to the left is clearly visible by the crease at the top of the tank where the deformation begins. The tank on the right in Figure 16 clearly shows a large debris impact that folded and crushed the tank.

Figure 16. Liquid Fertilizer Tank Damage (Source: CSB)

The two 12,000-gallon anhydrous ammonia pressure vessels were approximately 30 percent full of ammonia at the time of the explosion. As shown in Figure 17, the anhydrous ammonia pressure vessels were south of the crater. The pressure relief valves (PRVs) on the northern anhydrous ammonia pressure vessel still had their weather caps on and consequently did not relieve the pressure. The weather caps were missing on the PRVs in the middle of the southern anhydrous ammonia pressure vessel.[30] Two additional liquid fertilizer storage tanks sat parallel to the railroad track southwest of the anhydrous ammonia pressure vessels. The blast of the explosion also damaged the tracks on the railroad between the WFC property and the park. The blast was sufficiently powerful to shift the tracks more than 2 feet to one side, creating a prominent curve in the tracks (Figure 18).

Figure 17. Anhydrous Ammonia Pressure Vessels (Source: CSB)

[30] The condition of the anhydrous ammonia pressure vessels is discussed in further detail in Section 3.4.2.1 of this report.

Figure 18. Damaged Railroad Tracks Adjacent to WFC Facility (Source: CSB)

The explosion damaged a playground and basketball court in a park located a few hundred feet west of the WFC facility (Figure 19). The blast destroyed equipment on the playground, including damaging the basketball goal posts on the basketball court (Figure 20). In addition, the trees in the vicinity of the park showed evidence of scorching,[31] likely from the fireball when the explosion occurred. The trees were directly downwind of the anhydrous ammonia pressure vessels and were not within the smoke plume from the fire. Pre-explosion video of the fire shows the smoke traveling with the wind but crossing the playground equipment to the north of the basketball courts.

Figure 19. Damaged Playground Equipment (Source: ABS Consulting)

[31] The ABS damage assessment did not include making a determination about whether the trees were scorched by the fire or by another source.

Figure 20. Damaged Basketball Goal Post at Park (Source: ABS Consulting)

3.4.2.1 WFC Anhydrous Ammonia Vessels

The two 12,000-gallon anhydrous ammonia vessels were located at the south end of the storage building, about 150 feet from the site where the initial fire and smoke were observed. Each vessel was more than 46 feet long, with two affixed PRVs set to vent the tanks to the atmosphere if the pressure inside the tanks exceeded predetermined set points, estimated by one employee as between 250 and 300 pounds per square inch (psi). Both sets of PRVs were fitted with orange plastic caps intended to protect the devices from rain and dirt. The vessels shared a common pipeline that allowed switching between the tanks on occasion, but under normal operation, the connecting pipe was kept in a closed position.

CSB observed the intact PRVs on top of the vessels (Figure 21) on May 28, 2013, although the polyvinyl chloride (PVC) protective caps were no longer in place on the PRVs of the southernmost tank. The absence of detectable residue of this protective material on the PRV suggested that it was exposed to fire to the degree that it melted. The caps were not found during any post-incident salvage or recovery activities. During salvage operations, a crane with lift bucket reportedly struck the PRV for the northernmost tank, knocking it to the ground where it was found.

Figure 21. Anhydrous Ammonia Tank PRV, Post-Incident (Source: CSB)

From interviews with employees who were knowledgeable about the frequency of deliveries and volumes in the tanks, CSB learned that the site received as many as four deliveries of anhydrous ammonia per day under normal operating conditions with good weather and that each vessel was at 30 percent capacity, or about 7,200 gallons, at the time of the fire and explosion. After the incident, technicians removed all remaining contents in both vessels.

When hazardous materials technicians in fully encapsulated personal protection equipment initially entered the area of the anhydrous ammonia vessels after the site was secured, they observed a leaking valve at the east end of the tanks. In light of a buildup of ice around the valve, it is thought that the material leaking was liquid anhydrous ammonia. Notably, anhydrous ammonia stored under pressure contains latent heat. As the liquid is released, it cools rapidly and interacts with moisture in the atmosphere and can freeze on the pipe and adjacent vessel. However, the vessels did not catastrophically fail on the night of the incident. The CSB considers this to be a near-miss of potentially significant consequence.

3.4.3 West Independent School District

The WFC built its facility in 1962, before much of the surrounding community developed. In 1923, the West Independent School District (WISD) (Figure 22) built the West Middle School (WMS), which at the time served as the high school for the city of West. The WMS campus added a building in 1957 that served as supplementary classrooms and library space. The WISD also built West Elementary School (WES) in the early 1960s. WIS was built around 1985, and WHS was constructed in 2000, after the WFC facility was built. Four schools were in close proximity to the facility, including WIS (552 feet southwest

of the facility), WHS (1,263 feet southeast of the facility), WMS (2,000 feet southwest of the facility), and WES (4,867 feet southwest of the facility).[32]

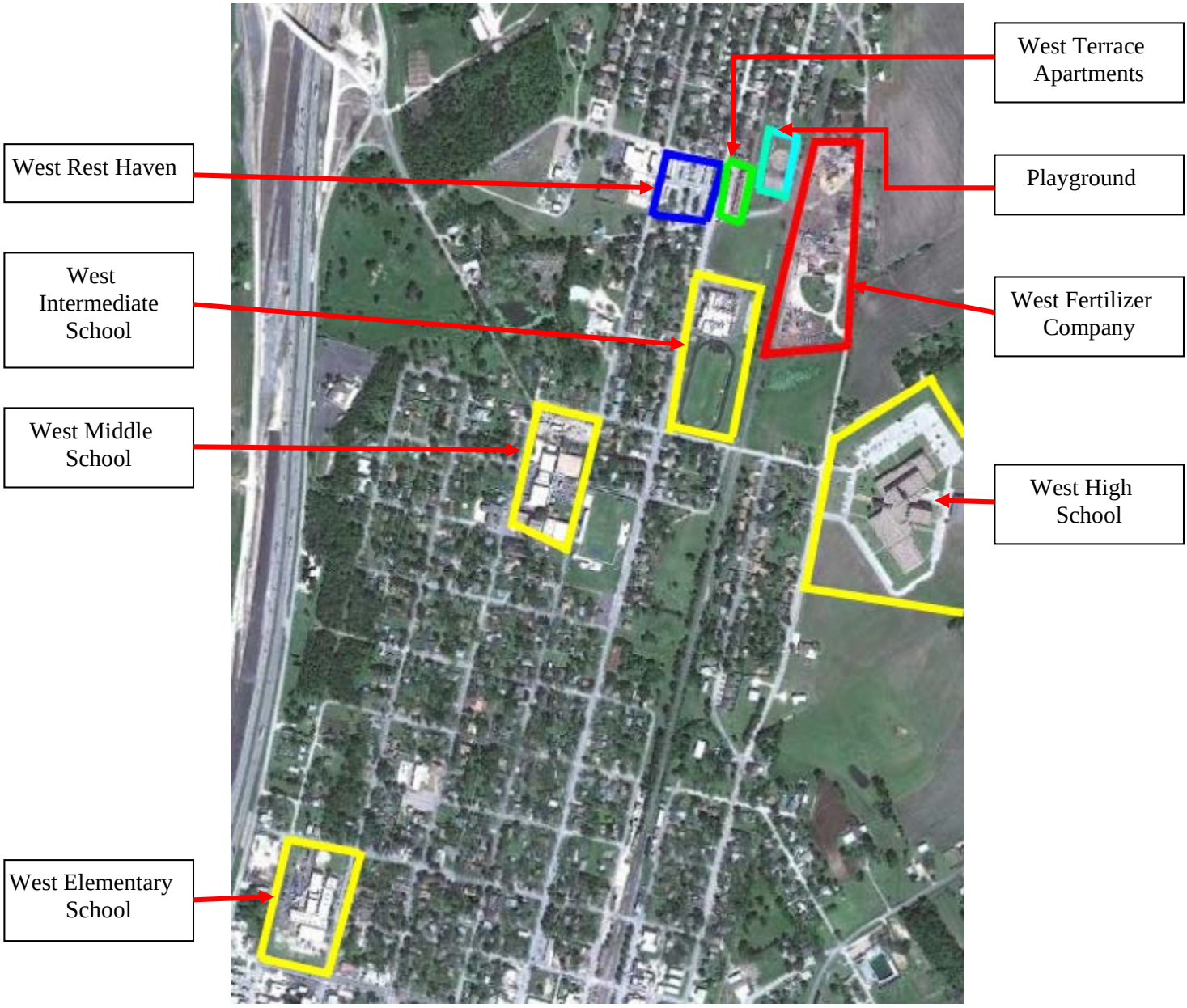


Figure 22. Proximity of WFC Facility to Schools and Other Public Structures (Source: Google Earth)

[32] The growth of the community around the WFC facility is discussed in further detail in Section 9 of this report.

The overpressure from the explosion's blast wave caused most of the damage, although some fires started post-explosion, including those at WIS and many nearby homes. At the time of the incident, school was not in session, which limited the number of fatalities and injuries to members of the public (including students, teachers, and other staff members). However, if the explosion had occurred during normal school hours, the number of injuries and fatalities from the blast wave could have been much higher. Table 2 indicates the projected number of students and staff members who would have been affected and could potentially have been injured or killed by the blast if school had been in session. If all enrolled students had been in school that day, approximately 1,486 students would have been present and vulnerable. Of this total, 665 students would have been at WIS and WHS, which suffered the most severe damage. If the explosion had occurred during school hours and all staff members had been present that day, approximately 191 staff members would have been vulnerable. Of this total, 86 staff members would have been at WIS and WHS. Because of the breadth of damage at the schools, the WISD decided to demolish WIS, WHS, and all WMS facilities except for the gymnasium and the 1923 building. The WISD also demolished select portions of the 1967 annex and the entire cafeteria at WMS. Appendix A includes a discussion of the details of WISD plans to restore and rebuild the school system. For a more complete understanding of the magnitude of the injuries and fatalities that the WFC incident could have caused, this report considers in greater detail the extent of damage at the schools.

Table 2. Estimated Number of Students and Staff During School Hours

School	Grades	Estimated Number of Students Enrolled	Estimated Number of Staff Members
West Intermediate School	4-5	246	22
West Middle School	6	320	40
West High School	7-12	419	64
West Elementary School	K-3	501	45
Total Occupants		**1,486**	**171**

3.4.3.1 Damage Assessment of the West Intermediate School

The original WIS was a pre-engineered metal building consisting of lightweight steel frames, cold-formed girts,[33] and purlins[34] supporting lightweight metal decks. The gymnasium and cafeteria were also pre-engineered metal buildings. The remainder of the school was constructed of precast concrete tilt-up load-bearing walls that supported open webbed steel joists and a metal roof deck with a built-up roof. Figure 23 shows the building room layout in the school evacuation plan and highlights in yellow some classrooms with extensive damage. A considerable amount of debris accumulated in the hallway outside of rooms 11 and 12 (Figure 24). An interior doorframe blocked the hallway; the acoustic ceiling had collapsed; and numerous obstacles would have made exiting the building difficult for students and staff. In addition, the original metal school building just south of this location was involved in a fire after the explosion at the WFC facility, so students and staff members also would have been exposed to smoke and heat. The acoustic ceiling, light fixtures, and other debris were thrown onto all of the desks in the interior of classroom 12 (Figure 25). Moreover, the window on the north facade failed violently, and a large shard of glass (approximately 3 inches long) was embedded in the assignment poster on the south wall of the classroom (Figure 26).

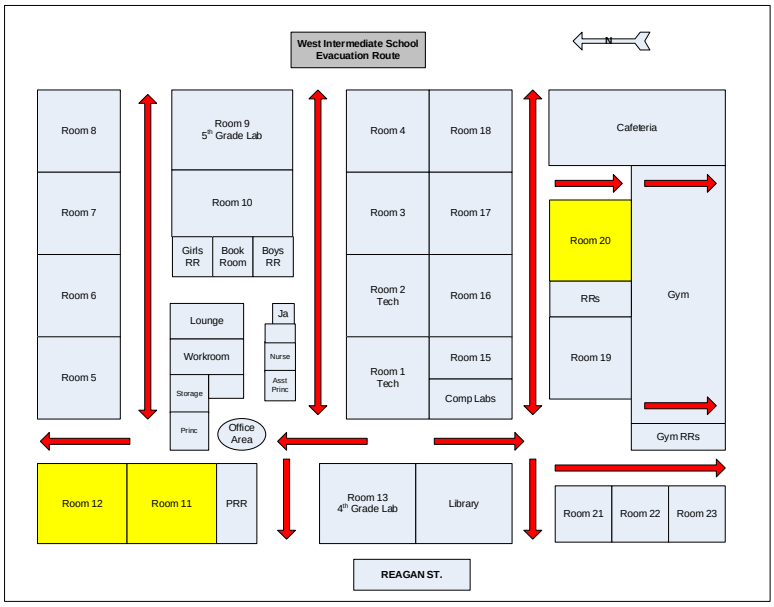


Figure 23. WIS Room Layout in Evacuation Plan (Source: CSB)

[33] A horizontal structural member that spans columns or posts in framed construction and is used to support cladding. *Dictionary of Construction, Surveying and Civil Engineering* (2012).

[34] A horizontal roof member that runs parallel to the ridge and spans the roof trusses and is used to support the roof covering. *Dictionary of Construction, Surveying and Civil Engineering* (2012).

Figure 24. WIS North Hallway, Looking Toward Northeast Exit Door (Source: ABS Consulting)

Figure 25. Glazing Hazard in WIS Room 12 (Source: ABS Consulting)

Figure 26. Embedded Glass in Assignment Poster in WIS Room 12
(Source: ABS Consulting)

The pre-engineered portion of the school in the northeast corner was heavily damaged by blast overpressure and was also fully engulfed in flames. At the time of the physical survey, blast damage to this portion of the building could not be evaluated because of the magnitude of the fire and associated heat; however, Figure 27 does provide a view looking east down the hallway of this part of the school after the fire.

Figure 27. Interior of Burned Northeast Section of WIS
(Source: ABS Consulting)

The WFC explosion heavily damaged the WIS gymnasium (Figure 28). There was evidence that some of the built-up roof over the gymnasium burned; however, the level of heat damage to the roof was minor compared to the damage from blast overpressure. The north half of the gymnasium roof failed. Within the gymnasium, the blast heavily damaged the pre-engineered frames, which were unstable as a result. The roof purlins were moderately deformed, with the exception of the failure that occurred on the north half of the frame spans. Furthermore, the windows from the south facade of the gymnasium failed, and the overpressure propelled them over the south bleachers and onto the gym floor. The explosion also heavily damaged the roof in the cafeteria to the south of the gymnasium.

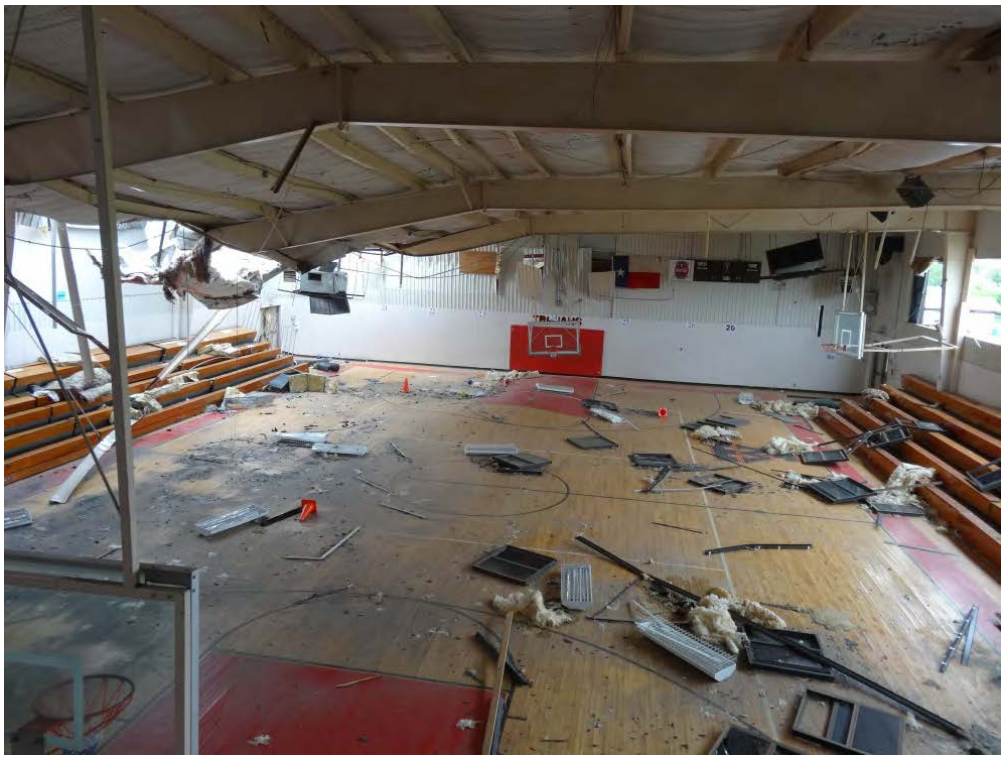


Figure 28. WIS Gymnasium (Source: ABS Consulting)

The interior of classroom 20 also sustained significant damage (Figure 29). The acoustic ceiling, light fixtures, and insulation were blown down onto the floor by a combination of the roof motion and the air blast entering through the heating, ventilation, and air conditioning (HVAC) duct after the explosion displaced the rooftop air conditioner. After the incident, the entire contents of the ceiling plenum were found on top of the desks. If the explosion had occurred during school hours, any students or staff members in the room would have been covered in this debris and would have had to climb over (or through) it to reach the exit. In addition, there was evidence that overpressure entered the room through the HVAC opening and was of sufficient magnitude to cause the door latch to fail. The damage to WIS decreased as the distance from the explosion source increased from the northeast to the southwest. WIS also housed the technical department where all of the school servers were kept. The servers and the data stored on them were lost in the explosion and fire.

Figure 29. WIS Classroom 20 (Source: ABS Consulting)

3.4.3.2 Damage Assessment of West High School

WHS was constructed of concrete masonry unit walls supporting open webbed steel joists and a metal deck with built-up roofing and gravel ballast.[35] The building room layout (on the basis of the school evacuation plan) shows that the school was organized into two wings (Figure 31). The north wing contained the activities area, including the two gymnasiums, two weight rooms, boy's athletics locker room, girl's athletics locker room, and band hall. The south wing included the classrooms as well as a large lecture hall. Between the two wings were the entry hall, administrative offices, common areas, kitchen, and (to the rear) auditorium. A pre-engineered maintenance building sat directly behind the school to the east.

[35] Small gravel placed on a built-up roof to protect the roof from ultraviolet light, heat, and weather and to protect the roof membrane from degradation.

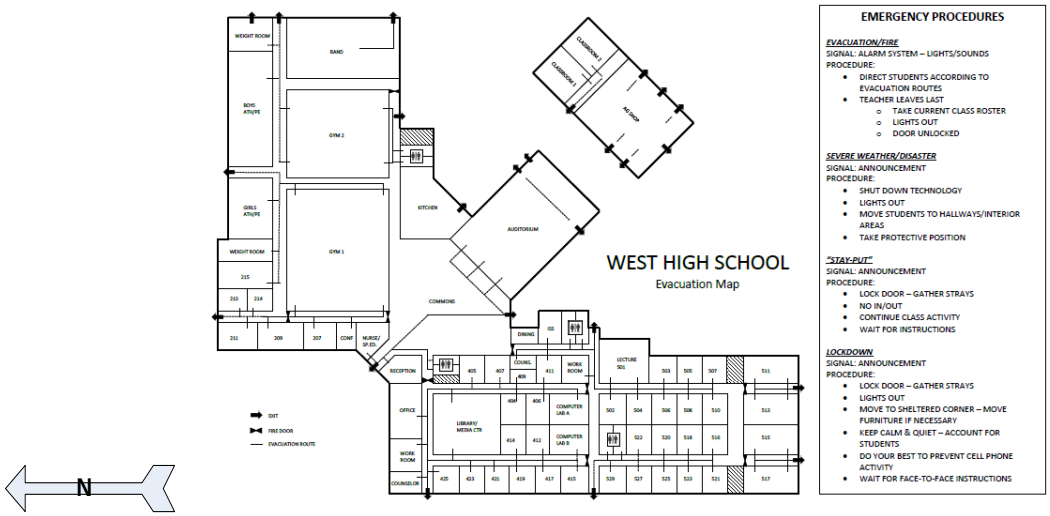


Figure 30. WHS Evacuation Map (Source: WISD)

The WHS auditorium was a steel frame structure with masonry infill walls. After the WFC explosion, some of the masonry veneer on the exterior was loose near the northeast corner. Inside the auditorium, large areas of the hanging ceiling were unstable, and the supporting structure was compromised, especially one area of the ceiling (between the seating and the stage), which was near collapse because of the failed hanger connections. Viewed from underneath, evidence of damage to the ceiling was observable at light fixtures, and evidence of cracking and separation was visible near the walls. However, the severity of the damage and compromise to the ceiling hangers became fully evident when they were inspected from the catwalks above the auditorium.

3.4.3.3 Damage Assessment of West Middle School

WMS was the school third farthest from the WFC site, and although it sustained less damage than WIS and WHS, it was nonetheless severely damaged in the explosion. WMS resided at the site of the original WHS, constructed in 1923. The athletic field east of WMS was the site employed for triage and evacuation of the wounded after the explosion (Figure 31).

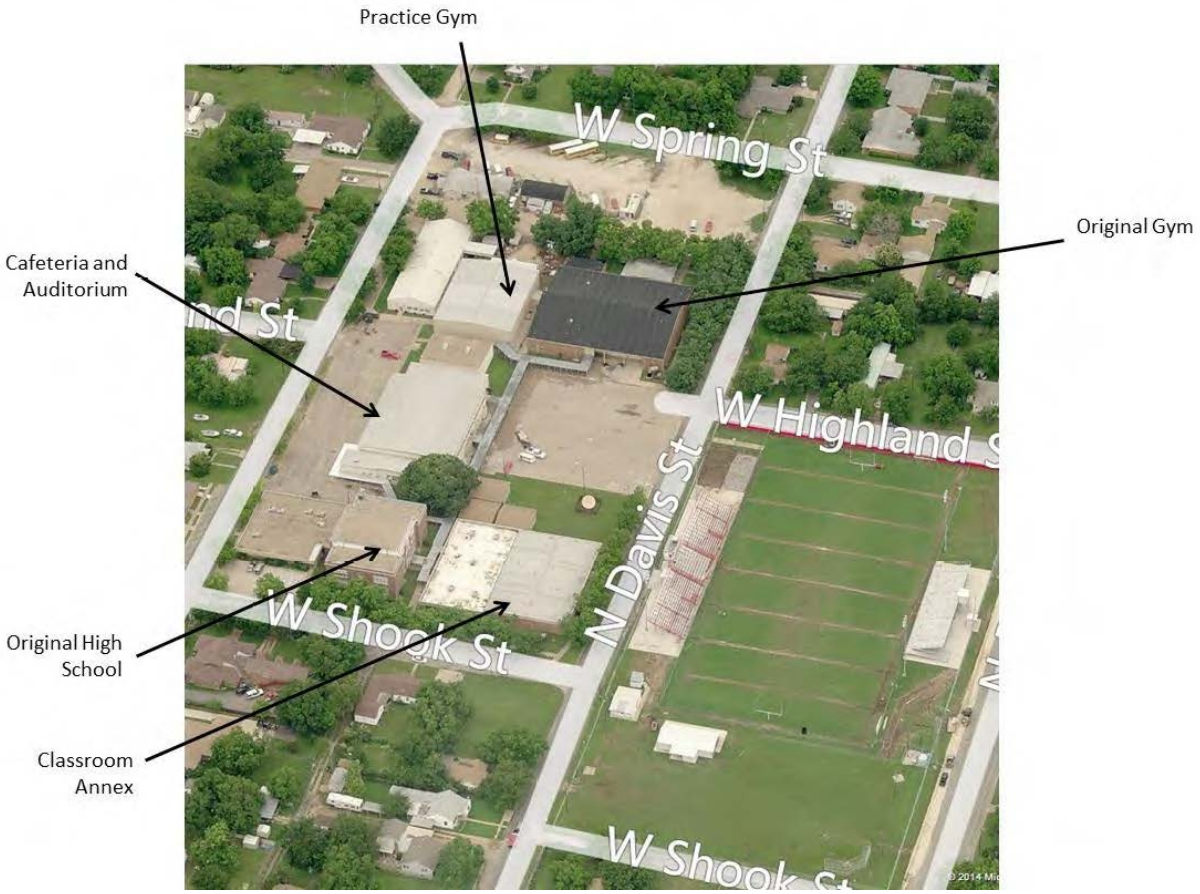


Figure 31. WMS Layout (Source: Bing Maps)

The practice gymnasium was a lightweight pre-engineered metal building with a brick facade. The pre-engineered frames buckled after the explosion, resulting in a small permanent deformation of the roof purlins. In addition, the overpressure damaged the roof purlins and frames. An external assessment of the cafeteria and auditorium indicated damage to the ceiling components. Many of the windows on the west facade were unbroken. The original high school classroom building at WMS was constructed in 1923. The windows facing north toward the WFC facility were broken, but only some of the remaining windows had failed. The building originally was not air conditioned and had a high tin ceiling, but at a later date, a new drop ceiling was installed to accommodate central air conditioning. After the explosion, the new drop ceiling failed, but the original tin ceiling was still in place, and some of the windows were broken. Window hazards thus were low to moderate, and the damage to the exterior appeared to be superficial. The classroom annex building roof structures were open web steel joists supporting a built-up roof on metal deck. The roof structure showed no observable damage; however, the suspended ceiling failed because of the motion of the roof (Figure 32).

Figure 32. Classroom Annex Interior Hallway and Ceiling Damage at WMS
(Source: ABS Consulting)

3.4.3.4 Damage Assessment of West Elementary School

WES was the campus farthest from the WFC site and sustained very minimal damage. WES received minor renovations, such as removing and replacing damaged ceilings, replacing damaged windows, and performing general interior clean-up.[36]

3.4.4 West Rest Haven Nursing Home

The explosion also destroyed the West Rest Haven nursing home, located west and within 600 feet of the WFC facility, at the corner of North Reagan Street and West Haven Street (Figure 33). Since 1967, the nursing home had provided residents with routine care and also treated patients with Alzheimer's disease, diabetes, and hypertension, among many medical conditions. Approximately 20 of the 155 staff members and 130 patients[37] were in the nursing home during the explosion. All were evacuated with the assistance of the nursing home staff and neighborhood volunteers, yet 72 patients sustained injuries. The level of severity of the injuries varied from cuts caused by broken glass and building materials to broken bones. An 87-year-old man succumbed to a stress-related heart attack; however, his death was not a direct result of the explosion.

Before the explosion, the nursing home's medical director came to the Reagan Street entrance and directed the charge nurse to begin evacuating residents to the other side of the facility in response to the ongoing fire at the WFC facility. As the charge nurse began the evacuation process, the explosion occurred. During the post-blast evacuation, staff members and volunteers removed many bedridden

[36] *See*: http://www.restorewestisd.com/plans.html (accessed on December 22, 2015).
[37] The nursing home had a capacity of 145 individual licenses.

residents from the building through the windows instead of the hallways out of concern that the structure would collapse. The residents were moved from the back of the nursing home to the front during the fire, evacuated after the explosion to a helicopter pad and football field, and eventually moved to the community center. The 72 injured residents were transported to Providence Health Center and Hillcrest Baptist Medical Center to receive treatment. After the residents were treated and released, they were relocated to various nursing homes in the neighboring cities of Waco, Midway, Hewitt, Clifton, and Hillsboro. Uninjured residents were also relocated to these nursing homes.

Within 2 months of the incident, 14 of the West Rest Haven nursing home residents died, a figure cited as unusually high by the facility's administrator,[38] and since the incident, approximately 50 patients have died. According to information the nursing home provided to CSB in May 2015, almost all of the 80 living patients who formerly resided at West Rest Haven tentatively planned to return to the nursing home once the new construction was complete.

Figure 33. Damage to Reagan Street Entry of West Rest Haven (Source: ABS Consulting)

[38] *See*: http://www.dallasnews.com/news/west-explosion/human-toll/20130617-some-say-west-blast-rushed-nursing-home-patients-deaths.ece (accessed on December 22, 2015).

3.4.4.1 West Rest Haven Nursing Home Disaster and Evacuation Plan

West Rest Haven followed a disaster and evacuation plan that include policies and procedures[39] to meet all potential types of emergency and nonemergency situations, including fires, disasters, explosions, toxic fumes, train derailments, broken gas mains, auto and truck collisions, and fire drills. The plan included detailed evacuation procedures in the event of a fire as well as shelter-in-place procedures for events such as severe weather. Depending on the location of the fire, patients could be evacuated to another portion of the building rather than being completely removed from the premises. The disaster and evacuation plan also contained transportation and sheltering agreements if needed during an emergency evacuation of the facility. The plan also provided guidance to the facility's operators on responses to a derailed train or ruptured tank cars containing potentially hazardous liquids and on steps to shelter in place if the facility were exposed to hazardous gas or vapors.[40] West Rest Haven scheduled monthly fire drills to meet the requirement to conduct fire drills during each of the three work shifts. In addition, the nursing home held a mock disaster drill approximately 3 months before the explosion, employing a scenario that assumed a toxic gas release from the WFC facility.

3.4.4.2 Damage Assessment of West Rest Haven Nursing Home

The West Rest Haven nursing home was irreparably damaged (Figure 33), leading the city to completely demolish the structure 3 months after the incident.[41] The nursing home was constructed of load-bearing wood stud walls (with brick veneer) and wood trusses that spanned the wings from exterior wall to exterior wall (east to west). The nursing home's emergency exit plan (Figure 34) shows the floor plan and room layout. The explosion most heavily damaged the eastern-most corridor of the building. As a result of the explosion, the roof trusses collapsed, and the east wall failed. The eastern rooms were heavily damaged and subjected to flying wall debris and window fragments in addition to failing drywall, insulation, and light fixtures from the ceiling. Investigators observed high glazing hazards, including glass shards that penetrated the wall opposite the windows. The ceilings, insulation, and interior contents of rooms were lying on beds and blocking doorways, posing hazards to any occupants of these rooms. In addition, the air blast would have infiltrated the rooms through the failed windows. Pieces of broken glass littered the inside of the nursing home, with the exception of hallway corridors that were shielded from windows by interior partitions. The great rooms, lobby, and patient rooms were also subjected to significant hazards from broken shards of glass.

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[39] The disaster and evacuation plan also includes policy and procedures for severe weather, bomb threats, water shortages, electrical power outages, loss of comfort heating, heat and humidity, and floods.

[40] West Rest Haven Inc. "Disaster and Evacuation Plan."

[41] *See*: http://video.dallasnews.com/Damaged-West-nursing-home-razed-3-months-after-blast-24951515?freewheel=90850&sitesection=dallasnews_nws_non_non&VID=24951515#.Uv58DMKYbIU (accessed on January 4, 2016).

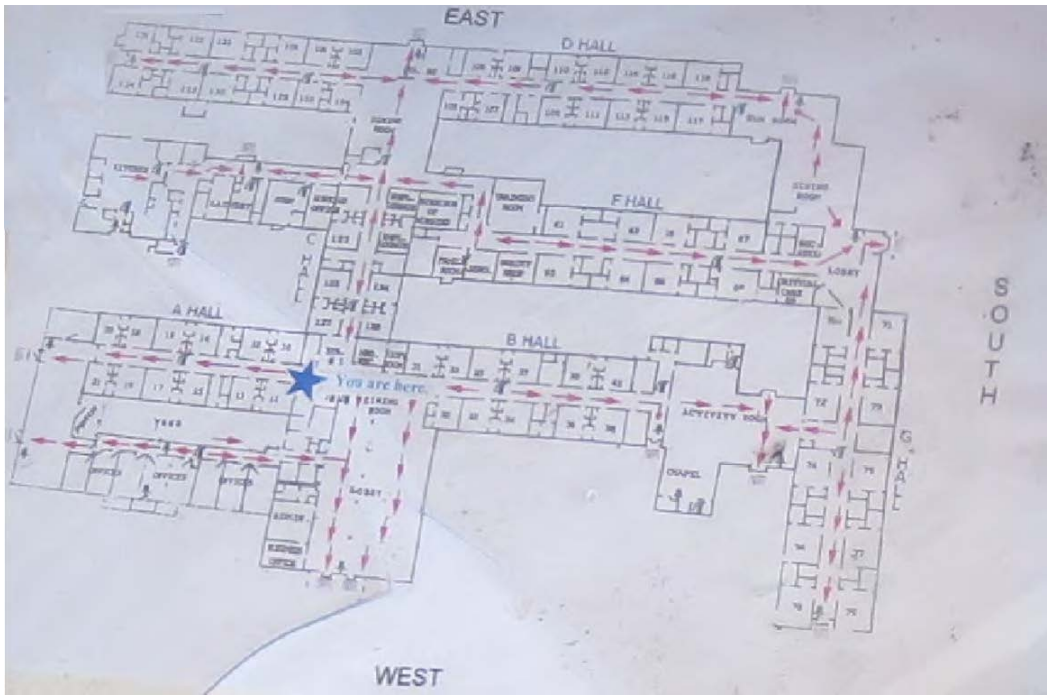

Figure 34. Emergency Exit Floor Plan for the West Rest Haven (Source: CSB)

The blast also inflicted significant damage to the western portion of the nursing home, and the great rooms, such as the lobby, were hit particularly hard because of the large spans of the overhead trusses that failed and collapsed onto the furniture. In addition, hallways in this area presented many hazards, including hanging light fixtures, failed ceiling joists, and collapsed drywall and insulation on the floors. Moreover, the debris field of the nursing home contained secondary fragments from massive pieces of the WFC facility's concrete foundation and also significant masses of earth. Observations indicated that a large piece of the WFC foundation, measuring 16 inches wide by 16 inches tall and 36 inches long (Figure 35, right) impacted room 79, traveling through the roof and the exterior wall (Figure 35, left). This debris fragment was calculated at a weight of approximately 800 pounds and had sufficient momentum after the impact to exit the nursing home, strike the ground, and then travel an additional 60 feet before coming to rest just to the west of North Davis Street.

Figure 35. Crater and Debris (left) from Fragment (right) of WFC Facility Foundation that Impacted West Rest Haven (Source: ABS Consulting)

On April 4, 2014, the city of West broke ground at 503 Meadow Drive, a block away from the original site, on the new 120-bed West Rest Haven nursing home (with 75,000 square feet), which opened in summer 2015.[42] The estimated construction cost is $11 million. West Rest Haven did not receive any grants or federal money to rebuild the facility.

3.4.5 West Terrace Apartment Complex

The West Terrace Apartment Complex, a 22-unit apartment complex built in 1979 and owned by J&B Realty Ltd., was 450 feet due west of the epicenter of the explosion. Two members of the public were fatally injured at the apartment complex. One of the victims was most likely standing on the east side of the complex and watching the fire shortly before the explosion occurred. The second victim was most likely inside her lower-level one-bedroom apartment. The apartment building had four vacant units that were being used for storage. At the time of the explosion, a member of the cleaning staff was just finishing servicing one of the recently vacant units; she was injured in the blast while exiting the apartment building and walking down the stairs to her car. This worker's mother accompanied her on the job that day and was in the just-serviced unit, waiting for her daughter to return with the car, when the explosion occurred; however, the worker's mother was not injured. Four residents of the apartment

[42] *See*: http://dfw.cbslocal.com/2014/04/04/groundbreaking-symbolizes-hope-in-west-one-year-later/ (accessed on April 4, 2014).

complex were treated at Hillcrest Baptist Medical Hospital, and two residents were treated at Providence Health Center for injuries sustained. The explosion completely destroyed West Terrace. The roof and walls of the building completely failed (Figure 36).

Figure 36. West Terrace Apartment Complex East Façade (Source: CSB)

3.4.6 Private Residences

According to the Texas Department of State Health Services, the fire and explosion affected many of the homes within a 2-mile radius of the WFC facility. West had a total of 700 homes, and 350 of those were impacted— with 142with homes damaged beyond repair,[43] 51 homes suffering major damage, 27 homes incurring minor damage, and 130 homes otherwise affected.[44] CSB consultants examined damage to 190 single-family residential buildings within a radius of 3,500 feet of the explosion crater[45] and documented broken windows, facade damage, and nonstructural and structural component (e.g., wall and roof system) failures (Figure 37). The damage assessments were performed in the majority of the cases by inspecting the perimeter of the property. Access to home interiors was limited because owners either were not present or were unwilling to grant access.

[43] Not all homes that were damaged beyond repair have been rebuilt.

[44] Clements, Bruce. Texas Department of State Health Services, "The Texas Public Health Response to the West Fertilizer Plant Explosion," October 8, 2013. *See*: http://www.astho.org/Preparedness/DPHP-Materials-2013/WestTexasExplosion/ (accessed on January 18, 2016).

[45] CSB contractors assessed damage that was measured to 3,500 feet from the WFC site, but damage occurred beyond that distance.

Figure 37. Example of Damage to Single-Family Residential Structure (Source: ABS Consulting)

According to the city of West, 259 building permits were issued as of October 2014. Of those, 79 were for building new homes, 117 for remodeling homes, and 63 for making miscellaneous repairs (such as fence, shed, and carport restoration).

3.4.7 Infrastructure Damage to the City of West

The explosion at the WFC facility damaged the West city infrastructure; it ruptured water lines, deformed sewer manholes, damaged water storage tanks, further rendered wells unusable, cracked walls of a pump house, and caused the loss of water supply to the community. Access to water was restored gradually as the affected infrastructure was repaired. As a result of the explosion, FEMA assisted the city in repairing some of the damaged infrastructure listed in Table 3, such as water facilities and water lines.

Table 3. Infrastructure Repaired with FEMA Funding

Affected Infrastructure	Cost to Repair Damage
Well 4, Ground Storage Tank	$365,000

Well 4, Pump Station Door and Window	$2,000
Davis Street Water Line	$74,000
Walnut Street Sewer Manhole	$9,200
Total	$450,200

The West water system is fed by a 12-inch supply line from the city of Waco at a pump station 11 miles south of West. The pump station supplies 700 gallons per minute, with a storage capacity of 167,000 gallons. Water pressure for homes is usually 48 to 50 psi; however, on the morning after the incident, water pressure was measured at less than 20 psi because of damaged water lines. In response to the abnormal water pressure, the city issued a boil water order. West used two water wells to supply water to the community. The first well had a capacity of 250,000 gallons; however, it had been out of service for about 7 years at the time of the explosion. The second well also had a capacity of 250,000 gallons and was removed from service in January 2013 for rehabilitation.[46] This well also was damaged as a result of the explosion but has since been repaired and was back online as of September 1, 2014. The city also has an above-ground water tower with a storage capacity of 150,000 gallons; the tower was nearly drained by the post-explosion fire department response.[47] According to CSB interviews conducted with the Abbott Fire Department, West had a history of improperly working water hydrants and consistently low water pressure. Abbott firefighters had previously responded to fires in West and were unable to get hydrants to work adequately. The city had installed the above-ground water tower before the WFC incident to address the issue of low pressure.

According to the Mayor of West, "The city generates its revenue in three ways—water and sewer rates, property tax, and sales tax." During the first 2 months after the explosion, West experienced a loss of income (65 percent of water and sewer revenue and 30 percent of property tax values).[48] As of June 2013, the city of West indicated that the fire and explosion at WFC had cost the city $17 million in actual damages; however, the total cost-to-date may be greater as additional demolition, renovation, and construction projects continue throughout the city. On April 15, 2014, the State of Texas provided additional disaster grant assistance[49] to the city of West in the amount of $4,853,500 to fund the disaster recovery work on the water plants, water tank rehabilitation, wastewater outfall interceptor, and disaster zone infrastructure repairs.[50] The first infrastructure project (costing $400,000) was completed in August 2014 and involved installation of a new well and upgrading of a storage tank located by the new nursing home.

[46] State Fire Marshal's Office. "Firefighter Fatality Investigation," Investigation FFF FY 13-06 (West, TX).
[47] *Ibid*.
[48] *See*: http://www.cityofwest.com/wp-content/uploads/2012/12/June-2013.pdf (accessed on December 22, 2015).
[49] The State of Texas provided an initial $3.2 million disaster grant in August 2013.
[50] The State of Texas. Office of the Governor, "Letter to the City of West," April 15, 2014.

4.0 Incident Analysis

4.1 Fertilizer Grade Ammonium Nitrate (FGAN)

4.1.1 The Fertilizer Industry

The Fertilizer Institute defines fertilizer as a "collection of elements needed for plants to grow well."[51] The application of fertilizer to soil provides nutrients for plants to enhance fertility and the production of crops. The primary nutrients for plant nutrition are nitrogen (N), phosphorous (P), and potassium (K). Nitrogen is considered the most important of the three nutrients because it is critical to the formation of protein, which composes the tissue of most living things. Although nitrogen exists in the composition of air, it does not exist in a form that plants can readily absorb. Accordingly, farmers apply fertilizers containing nitrogen compounds to their soils to enhance crop production.

Nitrogen is most readily available for plants in its inorganic forms, such as ammonium (NH_4^+) or nitrate (NO_3^-) ions. It is applied to crops in different forms such as dry granules, liquid, or injection into the soil as a gas. The largest source of nitrogen by volume in commercial fertilizer is anhydrous ammonia, which is applied directly to crops.[52] Other important nitrogen fertilizers include aqueous ammonia (NH3), ammonium sulfate ($(NH_4)_2SO_4$)), ammonium thiosulfate ($H_8N_2O_3S_2$), calcium nitrate ($Ca(NO_3)_2$), sodium nitrate ($NaNO_3$) and FGAN. FGAN, the substance in the fertilizer involved in the West Fertilizer Company (WFC) explosion, is primarily used on pastureland, hay, and fruit and vegetable crops. FGAN is most commonly used in the Southeast and Midwest in the United States, and the largest AN consumers are Missouri (20 percent), Tennessee (14 percent), Alabama (10 percent), and Texas (8 percent).[53]

4.1.2 AN Properties

AN (NH_4NO_3) is a salt compound produced by neutralizing nitric acid (HNO_3) with anhydrous ammonia (NH_3). The AN manufacturing process involves several steps, including solution formation and concentration; solids formation, finishing, screening, and coating; and product bagging, bulk shipping, or both. AN is marketed in different forms depending on its use, but it is primarily manufactured for use in fertilizers or as a precursor in the manufacture of explosives. Liquid FGAN can be sold as a fertilizer or may be concentrated to form a dry solid product. This solid product may be used for fertilizer or fertilizer blends or may be incorporated as part of an explosive. Pure solid AN is a white or grey odorless material that is marketed in several different forms, such as prills, grains, granules, or crystals. Prills are the most commonly produced form and take the shape of spherical pellets. High-density prills are used for FGAN;

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[51] The Fertilizer Institute. *Fertilizer 101, Nourish, Replenish, Grow*. Washington, DC: The Fertilizer Institute, 2010: 13.

[52] *See*: https://www.tfi.org/safety-and-security-tools/get-know-fertilizer-retailer/infographics/ammonium-nitrate-infographic (accessed on November 18, 2015).

[53] *Ibid.*

low-density porous prills are generally considered technical grade ammonium nitrate (TGAN) or explosive grade ammonium nitrate, both of which are used in the manufacturing of explosives. Chemically, however, these prills are identical; the difference is that small quantities of coatings and stabilizers are added to FGAN to prevent caking and degradation.

4.1.3 AN Hazards

Under normal conditions, pure solid AN is a stable material; it usually is not sensitive to mild shock or other typical sources of detonation (such as sparks or friction). However, AN exhibits three main hazards in fire situations:

1. Uncontrollable fire.
2. Decomposition with the formation of toxic gases.
3. Explosion.[54]

These hazards arise in part because AN is an oxidizer. This classification is demonstrated both by the U.S. Department of Transportation (DOT), which categorizes AN as a Class 5.1 oxidizer,[55] and by OSHA, which describes it as an oxidizer in its Explosives and Blasting Agents standard, 29 CFR 1910.109.[56] Significantly, AN is classified as an "explosive" when the prills are produced with more than 0.2 percent carbonaceous material. Carbonaceous material is a substance rich in carbon, such as a hydrocarbon. OSHA defines "oxidizer" as a chemical that "initiates or promotes combustion in other materials, thereby causing fire either of itself or through the release of oxygen or other gases."[57] As an oxidizer, AN can increase the flammability or explosibility (or both) of other combustible substances when it decomposes after exposure to heat. As AN decomposes when in contact with heat or fire, the reactions can release gases such as nitric acid (HNO_3), ammonia (NH_3), nitrogen oxides (NO, NO_2), nitrous oxide (N_2O), nitrogen, oxygen, and water vapor, depending on the heat and pressure. Some by-products can be toxic when emitted.

During fires, AN presents serious risks of explosion beyond those attributed to its oxidizing properties and ability to decompose and emit toxic gases. When AN is contaminated with organic carbon-containing materials or certain inorganic chemicals, its behavior can become dangerously unpredictable,

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[54] Resources Safety, Division of Mines and Petroleum. *Safe Practice: Safe Storage of Solid Ammonium Nitrate*. East Perth, Western Australia: Government of Western Australia, 2013. *See*: http://www.dmp.wa.gov.au/documents/Code_of_Practice/DGS_COP_StorageSolidAmmoniumNitrate.pdf (accessed on August 4, 2015).

[55] U.S. DOT. "Hazardous Material Table," 49 CFR 172.101. *See*: http://www.phmsa.dot.gov/portal/site/PHMSA/menuitem.6f23687cf7b00b0f22e4c6962d9c8789/?vgnextoid=d84ddf479bd7d110VgnVCM1000009ed07898RCRD&vgnextchannel=4f347fd9b896b110VgnVCM1000009ed07898RCRD (accessed on August 4, 2015).

[56] *See*: https://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=9755 (accessed on January 13, 2016).

[57] OSHA. *See*: https://www.osha.gov/dsg/hazcom/ghoshacomparison.html (accessed on August 4, 2015).

especially when the AN is confined and in the presence of fire or high heat.[58] Thus, when AN is combined with contaminants, its explosive sensitivity increases sharply, and the result can lead to detonation.[59] Examples of contaminants include organic chemicals, acids, and flammable and combustible materials.[60]

4.1.3.1 Decomposition of AN

AN has a melting point between 311°F and 337°F (155°C and 169°C). It begins to rapidly decompose at a significant rate soon thereafter.[61] When it is exposed to high heat and pressure, AN experiences endothermic (heat-absorbing) and exothermic (heat-producing) reactions simultaneously, causing the compound to split into its constituent molecules and also transforming it from solid state to molten, or liquefied, state. When AN decomposes or breaks down under thermal conditions, at least seven unique reactions can occur at varying temperatures, with different heat outputs and rates of reaction.[62] Some reactions can produce toxic and detonable by-products. All of the reaction pathways begin with the AN splitting into gaseous ammonia (NH_3) and nitric acid (HNO_3), although that step is usually not explicit.

In the following main exothermic reaction (Eq. 1), which can occur in conditions up to 482°F (250°C), AN yields nitrous oxide and water:

$$NH_4NO_3\,(s) \rightarrow N_2O\,(g) + 2\,H_2O\,(g) \quad \text{(Eq. 1)}$$

Above 482°F (250°C), a reversible endothermic reaction (Eq. 2) takes place at a significant rate, splitting the AN to form ammonia and nitric acid:

$$NH_4NO_3\,(s) \leftrightarrow NH_3\,(g) + HNO_3\,(g) \quad \text{(Eq. 2)}$$

This endothermic reaction is accompanied by a number of exothermic reactions between gaseous ammonia (NH_3) and nitric acid (HNO_3) that vary by degree, depending on reaction conditions. As previously described, AN is in a liquid or molten state, which is aerated with off-gases such as nitrogen oxides (NO, NO_2), water vapor, and nitrous oxide (N_2O). This bubbly liquid is much more sensitive to detonation than solid prills or unaerated liquid. Depending on the rate of these endothermic and

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[58] Greiner, Maurice. "Ammonium Nitrate: Hazards and Handling." *Fertilizer Progress* January/February (1983): 26–38.

[59] Sun, J. et al. "Catalytic effects of inorganic acids on decomposition of ammonium nitrate." *Journal of Hazardous Materials* B127 (2005): 204–210.

[60] The OSHA Explosives and Blasting Agents Standard, 29 CFR 1910.109)(i)(5)(i)(a), lists examples of combustible materials or other contaminating substances, including animal fats, baled cotton, baled rags, baled scrap paper, bleaching powder, burlap or cotton bags, caustic soda, coal, coke, charcoal, cork, camphor, excelsior, fibers of any kind, fish oils, fish meal, foam rubber, hay, lubricating oil, linseed oil, or other oxidizable or drying oils, naphthalene, oakum, oiled clothing, oiled paper, oiled textiles, paint, straw, sawdust, wood shavings, or vegetable oil.

[61] CF Industries. "FGAN." Material Safety Data Sheet Number 004. *See*: http://www.cfindustries.com/pdf/Amtrate_AN_Fertilizer_SDS_NA_FINAL.pdf (accessed on August 4, 2015).

[62] U.S. Department of the Army. *Department of the Army Technical Manual, Ammunition, General*, TM 9-1300-214. Washington, DC: U.S. Department of Defense, September 1984.

exothermic reactions, detonation can occur. Conditions other than heat and pressure, such as pH levels and the presence of impurities, can also influence the rate of reaction.[63]

The decomposition of AN can be controlled to the extent that the main exothermic reaction (Eq. 1) can be used to produce hospital-grade nitrous oxide.[64] However, if the rate of reaction is uncontrolled (which happens, for example, when FGAN is exposed to fire), other reactions can occur as AN decomposes and melts. As the temperature rises over 482°F (250°C), liquid AN becomes less dense and contains many small bubbles of gaseous decomposition products and their reactants, primarily water vapor and nitrous oxide. At 500°F (260°C), liquid AN becomes much more sensitive to shock because these bubbles act as "hot spots" that focus the shock or magnify the energy input. Many tests have shown the direct correlation between temperature and sensitivity in molten AN.[65] In other words, molten AN becomes more sensitive as the temperature under which it is kept rises.

Although the exact sequence of chemical reactions is variable, the primary end products of the detonation process are consistently water, nitrogen (N_2), and oxygen (O_2). As reactions involving nitric acid (HNO_3) and ammonia (NH_3) (Eq. 2) produce these end products, heat is released, which adds energy to a detonation. The nitrous oxide (N_2O) production process (Eq. 1) combines all of the internal fuel (hydrogen) with the oxygen from nitric acid to form water, so no additional oxidation can take place in the pure AN during the detonation reaction. The difference between the uncontrolled detonation reaction and the nitrous oxide reactions is the rate of the reaction and the formation of the triple bond in N_2 and the double bond in O_2, which are exothermic and therefore add to the energy yield during detonation. The following formula (Eq. 3) describes this overall decomposition reaction from the intermediate reactions where AN yields nitrogen, oxygen, and water:

$$NH_4NO_3\,(s) \rightarrow N_2\,(g) + \tfrac{1}{2}\,O_2\,(g) + 2H_2O\,(g) \quad \text{(Eq. 3)}$$

When mixed with AN, many combustible contaminants—including organic materials, fuels, and finely divided materials (e.g., flour, seed or grain dusts, asphalt or fuel oil, or very small metal flakes)—will provide additional fuel that can combine exothermically with the oxygen produced during detonation. Thus, for explosive uses, AN is nearly always combined with a fuel source. This approach increases the energy of the intended explosion and also reduces the toxicity of the end products by reducing nitrogen

[63] Lees, F.P., and M.L. Ang (eds.). *Safety Cases Within Control of Industrial Major Accident Hazards (CIMAH) Regulations*, Chapter 9. Butterworth-Heinemann, 1984; January 1, 1989: 160.

[64] Asia Industrial Gases Association. *Safe Practices for the Production of Nitrous Oxide from Ammonium Nitrate*, AIGA 080/13. Singapore: Asia Industrial Gases Association, 2013. *See*: http://www.asiaiga.org/docs/AIGA%20080_13%20Safe%20practices%20for%20the%20production%20of%20nitrous%20oxide%20from%20ammonium%20nitrate.pdf (accessed on November 19, 2015).

[65] Van Dolah, R.W. et al. *Explosion Hazards of Ammonium Nitrate Under Fire Exposure*. Washington, DC: U.S. Department of the Interior, Bureau of Mines, 1966. *See*: http://www.osmre.gov/resources/blasting/docs/USBM/RI6773ExplosionHazardsAmmoniumNitrateUnderFireExposure.pdf (accessed on December 22, 2015).

oxide (NO_x) production. Nitrogen oxides are produced, for example, by the following reaction (Eq. 4), which shows AN yielding nitrogen, water vapor, and nitrogen oxides:

$$4NH_4NO_3\,(s) \rightarrow 2NO_2\,(g) + 8H_2O\,(g) + 3N_2\,(g) \quad \text{(Eq. 4)}$$

An example of fueling AN to produce a blasting agent is the addition of fuel oil at around 6 percent by weight to produce ammonium nitrate/fuel oil (ANFO). ANFO may be used for mining and other purposes. Moreover, the military uses a mixture of fuel-rich trinitrotoluene (TNT), AN, and sometimes aluminum to produce a more effective explosive than TNT alone.[66]

4.1.4 Previous Incidents Involving FGAN

AN-related explosions have occurred ever since large-scale AN production began in the late 19th century.[67] One of the earlier notable explosions involving FGAN took place in Oppau, Germany, in 1921, when workers fired explosives into a caked mixture of fertilizer to loosen 4,500 tons of ammonium sulfate (AS) and FGAN. The explosion killed 500 to 600 people, injured an additional 2,000 more, and caused as much as $1.7 million (US) in property damage, destroying 80 percent of the city.[68] Today, that property damage would equate to more than $22 million.[69]

Since then, a number of other FGAN incidents have occurred that involved a major fire, explosion, or both. This report highlights the following four incidents involving FGAN because they provide important information about the behavior of FGAN when exposed to fire:

- Cherokee incident (1973). A fire in the storage building of FGAN producer Cherokee Nitrogen resulted in an FGAN detonation in Pryor Creek, OK. Of the 14,000 tons of FGAN in storage, only a few tons were involved. The detonation was believed to have been underneath a front-end loader parked in an area with FGAN on the floor and might have been initiated by one of the loader's components exploding. It was theorized that contamination of the FGAN with flammable fluids in the loader occurred before the detonation. The detonation occurred 25 minutes after the fire was discovered but did not propagate into the main pile.[70]
- Cory's Warehouse incident (1982). A fire in a warehouse storing wooden furniture, charcoal, and more than 3,000 tons of bagged FGAN and mixtures based on FGAN produced some deflagration of the FGAN but no detonation.[71] Several small explosions occurred but were thought to be due

[66] *Ibid*.
[67] Barbrauskas, Vytenis. "Explosions of Ammonium Nitrate Fertilizer in Storage or Transportation Are Preventable Accidents." *Journal of Hazardous Materials* 304, 5 (2016): 134–149.
[68] *See*: http://www.aria.developpement-durable.gouv.fr/wp-content/files_mf/FD_14373_oppau_1921_ang.pdf (accessed on December 19, 2015).
[69] The CPI Inflation calculator. *See*: http://data.bls.gov/cgi-bin/cpicalc.pl?cost1=1%2C700%2C000&year1=1921&year2=2014 (accessed on December 30, 2014).
[70] Freeman, R. "Cherokee Ammonia Plant Explosion." *Chemical Engineering Progress* 71, 11 (1975).
[71] A deflagration occurs when a combustion wave propagates at a velocity less than the speed of sound. A detonation is a combustion wave that propagates at a velocity greater than the speed of sound. Detonations create high-pressure shock waves that can cause damage at large distances from the source.

to reactions between sodium nitrate and charcoal. More than 1,000 people were evacuated, and controlling the fire took 6 hours.

- EDC incident (2009). A fertilizer distribution facility in Bryan, Texas, caught fire and completely burned. Firefighters withdrew and evacuated the area. Unlike the West fire, the Bryan AN-related fire produced light-colored smoke as burning progressed, indicating that the fire was ventilated. No explosion occurred, and after the fire, much of the FGAN was still there. Some of the FGAN melted, spread away from the pile, and then re-solidified in a dark mass. The FGAN remaining in the pile had a black crust on it, but beneath that crust, the prills appeared to be unaffected.[72]
- East Texas Ag Supply incident (2014). A fertilizer warehouse in Athens, Texas, caught fire and burned. The warehouse was near the center of town, and the first responders evacuated the area as rapidly as possible. No explosion occurred. The walls of the structure were masonry, but the bins and roof structure were wood.[73]

A more comprehensive list of FGAN incidents involving fires and explosions is provided in Appendix B.

4.1.5 Historical Knowledge of AN Fire and Explosion Hazards

Over the years, the explosibility and fire hazards of AN have been the subject of a number of research papers. Some of those papers were first published through the U.S. Department of Agriculture (USDA),[74] U.S. Bureau of Mines,[75] and other sources abroad. In 1945, a USDA-archived publication discussed in detail the properties of pure AN, based on worldwide research conducted up to that date.[76] The paper notes the following:

- Under favorable conditions of pressure, rapid heating, and retention of heat, AN may be exploded partially from heat alone near 300°F.
- AN can detonate if subjected to a very strong initial impulse.
- Six factors influence the sensitivity of AN toward an explosion: temperature, strength of initial impulse, density, packing, particle size, and moisture content of the material.

Later, the Bureau of Mines (U.S. Department of the Interior) published reports on its investigation of the detonation of AN.[77] Some of the key findings of a 1966 Bureau of Mines report indicated the following:

- No transition to detonation of AN occurred in numerous burning experiments.

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[72] CSB conducted an assessment of the Bryan, Texas, incident.
[73] CSB collected information after the Athens, Texas, incident.
[74] Davis, R.O.E. "Explosibility and Fire Hazard of Ammonium Nitrate Fertilizer," no. 719. Washington, DC: U.S. Department of Agriculture, 1945.
[75] Van Dolah, R.W. et al. "Explosion Hazards of Ammonium Nitrate under Fire Exposure," R. I. 6773. Pittsburgh: Bureau of Mines, 1966.
[76] *See*: https://ia601703.us.archive.org/1/items/explosibilityfir719davi/explosibilityfir719davi.pdf (accessed on January 6, 2016).
[77] In 1961, the Manufacturing Chemists' Association asked the Bureau of Mines to investigate the potential explosion hazards of AN under the conditions of fire exposure that could occur in storage and transportation incidents.

- The critical diameter (minimum diameter to sustain detonation) of AN was quite small when just below the melting point.
- Initiation of prills by oxygen-acetylene gas detonation was shown to be unlikely.
- Detonations were achieved with fuel added in vessels with restricted vents.
- The initiation of detonation in AN from fire exposure in normal storage is quite improbable.
- The chance of modern AN detonating as the result of fire has been considered to be small or even nonexistent.
- The initial shock need not have an amplitude adequate for immediate initiation of detonation.
- Failure to detonate at a small scale should not be interpreted as meaning that the material is incapable of detonation.
- An acetylene-oxygen mixture in a 3-inch tube failed to detonate hot pulverized AN prills. No attempt was made to initiate detonation in foaming liquid AN by using a gas mixture.
- Large fire tests with bagged AN showed that heat penetrated less than 2 inches into the prills and that a crust formed, preventing liquid from penetrating the prills.[78]

The Bureau of Mines conducted a large-scale study (also in 1966) to determine distances for safe storage of AN. Cardboard tubes 1 meter in diameter were used as the donors and acceptors (the donor is detonated conventionally, and the acceptor, which is placed at a test-determined distance from the donor, either detonates or fails in each test). ANFO was the donor, and the acceptors were ANFO and straight AN. The tests were well documented and were of sufficient scale to produce reliable results. One of the findings was that sheet metal covering the donor increased the distance where sympathetic detonation (a follow-on detonation induced by the explosive effects of an initiating explosion) occurred. In a case with ANFO as the acceptor, a sympathetic detonation was produced over a 50-foot gap. With straight AN, the maximum gap was 19 feet. Without the metal, the gap was 12 feet for AN. The Bureau of Mines also conducted tests at smaller diameters, but no detonation was initiated in AN.

One significant finding was that "strong evidence exists that the apparent insensitiveness of AN results largely from a manifestation of critical diameter effects," highlighting the importance of scale. When evaluating test results, small-scale tests are not reliable indicators of large-scale behavior.

In December 1997, EPA published an alert, "Explosion Hazard from Ammonium Nitrate," with the following recommendations:[79]

- Avoid heating AN in a confined space (e.g., consider that processes involving AN should be designed to avoid this possibility).
- Avoid localized heating of AN, which potentially leads to development of high-temperature areas.
- Ensure that AN is not exposed to strong shock waves from explosives.

[78] Van Dolah, R.W. et al. "Explosion Hazards of Ammonium Nitrate under Fire Exposure," R. I. 6773. Pittsburgh: Bureau of Mines, 1966.

[79] *See*: http://nepis.epa.gov/Exe/ZyPDF.cgi/P100BH59.PDF?Dockey=P100BH59.PDF (accessed on November 19, 2015).

- Avoid contamination of AN with combustible materials or organic substances, such as oils and waxes.
- Avoid contamination of AN with inorganic materials that can contribute to its sensitivity to explosion, including chlorides and some metals, such as chromium, copper, cobalt, and nickel.
- Maintain the pH of AN solutions within the safe operating range of the process, in particular avoiding low pH (acidic) conditions.

This alert was later expanded in August 2013 as a joint EPA, OSHA, and ATF advisory, "Chemical Advisory: Safe Storage, Handling, and Management of Ammonium Nitrate." A June 2015 revision refers explicitly to AN prills.[80]

4.2 Factors Contributing to the Massive Fire and Explosion at the WFC

Because of the unpredictable behavior of FGAN in fire situations, the scenario that contributed to the detonation at the WFC might never be precisely determined; however, several detonation scenarios are plausible. CSB identified two factors or conditions that likely contributed to the intensity of the fire and detonation: (1) the contamination of FGAN with materials that served as fuel and (2) the nature of the heat buildup and ventilation of the FGAN storage space. These factors and scenarios for how the FGAN behaved on the night of the incident are based on the physical evidence that remained, blast analysis commissioned by CSB, U.S. Army Corps of Engineers crater analysis of the WFC explosion, eyewitness accounts, and previous research on FGAN incidents and testing.

4.2.1 Contamination of the FGAN Pile

In fire situations, the behavior of FGAN is unpredictable, in part because of the number of endothermic and exothermic decomposition reactions that take place with increasing temperature. FGAN decomposition reactions beyond the first step have yet to be uniquely defined, and subsequent decomposition reactions of FGAN can only be assumed.[81] When contaminants are added to AN, the decomposition reactions become increasingly more complex.[82] Possible sources of contamination in an FGAN storage area can include ignitable liquids, finely divided metals or organic materials, chloride salts, carbons, acids, fibers, and sulfides. These contaminants can increase the explosive sensitivity of FGAN.

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[80] EPA, OSHA, and ATF. "Chemical Advisory: Safe Storage, Handling and Management of Solid Ammonium Nitrate Prills." *See*: http://www2.epa.gov/sites/production/files/2015-06/documents/an_advisory_6-5-15.pdf (accessed on December 7, 2015).

[81] Cagnina, Stefania; Rotureau, Patricia; and Carlo Adamo. "Study of Incompatibility of Ammonium Nitrate and its Mechanism of Decomposition by Theoretical Approach." *Chemical Engineering Transactions* 31 (2013). *See*: http://www.aidic.it/lp2013/webpapers/141cagnina.pdf (accessed on December 7, 2015).

[82] *Ibid*.

The molten FGAN at the WFC likely came in contact with contaminants that were stored in the fertilizer warehouse or were produced during the fire that preceded the explosion. Seed materials, zinc, and other organic products, including the wood-constructed bins, were present near the FGAN storage area or could have come in contact with molten FGAN. During the fire, soot from the smoke and also collapsing wood and roofing material might have mixed with the FGAN pile.

The presence of possible contamination in the FGAN pile can be evidenced by changes in the smoke observed in the WFC fire before the explosion. The earliest sign of the WFC fire was white smoke streaming from vents in the elevator cupola on top of the fertilizer warehouse that stored the FGAN. Light-colored smoke is evidence of a well-ventilated fire, which would be typical of the early phase of a structure fire before it depletes the oxygen in the room. The initial smoke observed at the WFC was from the incipient fire, now believed to have started in the seed room. Shortly after authorities were notified, the smoke darkened and became opaque, indicating large quantities of soot[83] or hydrocarbons burning (Figure 38). Such soot can be the result of a ventilation-limited fire or a soot-producing fuel such as plastic or asphalt, which produces large amounts of soot even in well-ventilated fires.[84] The fact that smoke was observed coming from the same room that held the FGAN bin suggests that the bin was burning at that time. It is likely that soot or molten asphalt began accumulating on the AN shortly after the fire spread to the roof and the FGAN bin. The soot provided a source of fuel as it contaminated the surface of the pile. Soot also greatly increases the absorption of radiant heat from a fire.[85]

Figure 38. Initial Light Smoke (left) Followed by Dark Plume (right)
(Source: Member of the Public)

[83] Soot is finely divided carbon deposited from flames during the incomplete combustion of organic substances.
[84] Fire Development and Behavior Indicators. *See*: http://cfbt-us.com/pdfs/FBIandFireDevelopment.pdf (accessed on November 19, 2015).
[85] Glassman, Irvin and Yetter, Richard. *Combustion*. Burlington, MA: Academic Press, 2009: 458.

4.2.2 Heating and Ventilation

As the fire progressed, the available oxygen in the building was depleted as it was consumed in the fire. Although the fertilizer warehouse structure had some ventilation louvers in the cupola at the top, ventilation at ground level was limited to only a few louvered vents and the normal infiltration that exists around doors. The limited ventilation increased the quantity of soot in the smoke and the potential contamination of the FGAN pile. The path of the fire from the seed room to the main structure is unknown, but an opening, perhaps resulting from an interior wall or the roof burning, seems to have allowed hot smoke and later flame to flow from the seed room into the main structure and out the cupola. Initially, no flames were visible at the cupola, but as the fire progressed, videos and photographs taken before the explosion show the fuel-rich smoke generated by the burning material inside the structure. Subsequently, asphalt roof shingles ignited and began burning vigorously.

With limited ventilation inside the structure, a hot layer of smoke likely would have developed in the upper portion of the room containing the FGAN bin. Because cooler air settles below warmer air, the air temperatures would have remained relatively cooler inside the bin. The ground-hugging nature of the evolving smoke plume, as evidenced in Figure 39, is a characteristic of partially cooled smoke, perhaps cooling as it passed through the elevator structure before it exited the cupola. Because the elevator likely was filled with opaque black smoke, radiant heat from the fire on the FGAN pile would be reduced because the opaque black smoke shielded the pile from the heat.

Figure 39. Dark and Heavy Smoke, Rich in Soot
(Source: Member of the Public)

At some point around 5 to 6 minutes before the detonation, the character of the fire changed, according to eyewitness accounts and photographic evidence (Figure 40). This change was most likely caused by increased ventilation through an opening low in the building, possibly when the fire burned through the seed room doors or the roof. The fire also might have been enhanced by oxidizing gases from the heated FGAN pile.

Figure 40. Photographs from 7:42 pm (left) and 7:45 pm (right), Showing Transition to Lighter Smoke and Larger Flame, Before Detonation at Approximately 7:51 pm (Source: Member of the Public)

The additional ventilation caused a marked decrease in dark smoke and probably was accompanied by a major increase in heat radiation inside the fertilizer building because of increased oxygen availability to the burning wood and other fuels. With the dark smoke inside of the structure reduced, radiant heat would reach the surface of the FGAN in the bin, and the increased airflow through the building would greatly increase the radiant heat flux by raising the temperature of the burning wood. The surface of the FGAN, covered with soot or molten asphalt, would absorb the heat flux and cause a very rapid heating of the surface of the FGAN pile. The very hot and contaminated surface of the pile was then sensitive to detonation.

If the building had been well ventilated, the ventilation-limited phase of the fire would not have been as prolonged, reducing the amount of soot and creosote on the pile. In this scenario, the increased intensity of the fire would heat the FGAN pile. The lighter color smoke would allow more heat to be reflected, and the liquid FGAN might have run off as it developed. CSB collected data on similar incidents at the facilities in Bryan, Texas, and Athens, Texas. These incidents demonstrate that an FGAN pile can experience a major structure fire without detonating. The plumes of smoke at the Bryan facility (Figure 41) and Athens facility indicated cleaner-burning fires with less soot production. One source of the difference in the fire plumes might be the level of ventilation inside of the structure, as described to CSB investigators by the Athens fire chief. Some materials, such as asphalt and polyvinyl chloride (PVC), will

produce dark plumes even when burning in the open air, but if that smoke production is outside of the structure, no contamination of the FGAN will occur.

Figure 41. Plume of Smoke from AN Fire in Bryan, Texas
(Source: College Station Fire Department)

4.3 Detonation Scenarios

CSB found that contamination (likely from the storage of nearby combustibles or the combustible materials used to construct the FGAN bins and building) and the lack of ventilation were contributing factors that ultimately led to the detonation. However, the exact behavior of the FGAN—specifically how the contaminants, decomposition by-products, ventilation issues, or a combination of those conditions led to the explosion—may never be known.

Previous studies indicated that a detonation of modern FGAN prills under normal standard storage conditions when exposed to fire (unconfined storage without the potential for pressure buildup) was highly unlikely based on a number of factors. Therefore, the three scenarios in this section are considered plausible, but large-scale testing is needed to estimate their relative likelihood. One of the three scenarios (or a combination) is considered plausible as an explanation of event sequences:

- Scenario 1: Detonation from the top of the FGAN pile.
- Scenario 2: Detonation in heated FGAN along exterior wall exposed to fire.
- Scenario 3: Detonation in elevator pit that spread to main FGAN bin.

4.3.1 Scenario 1: Detonation from the Top of the FGAN Pile

Based on the location of the pile and the properties of the bin along with the circumstances of other fire-induced incidents, one possible scenario is that a period of contamination with soot and other organics (possibly including molten asphalt and plastic dripping from the burning composite shingle roof and PVC drop pipe from the elevator mechanism) was followed by about 5 to 6 minutes of intense radiant heating from the flames above and adjacent to the main FGAN bin. During this time, a layer of very hot, contaminated, and sensitive liquid FGAN could have built up on the pile. The foaming FGAN likely produced oxidizing gases, and those mixed with flammable smoke to produce a detonable gas cloud over the FGAN pile in the main bin and possibly in an adjoining bin linked to the main bin through a series of holes cut in the partition between the bins. The cloud consisted of powerful oxidizers that would be expected when FGAN undergoes thermal decomposition—such as NO_2, O_2, and HNO_3 as wells as fuel-rich smoke and pyrolysis[86] products off-gassing from the molten FGAN. The gas cloud then might have ignited from above, undergoing a gas-phase deflagration-to-detonation transition (DDT) in the confinement of the bin. This transition could have been enhanced by the passage of the burning front through the openings between the main and secondary bins, which possibly contained a few hundred pounds of FGAN, in a process known as hot gas injection.[87] Given the powerful oxidizers and mixture of fuels possible in this environment, a direct gas-phase DDT in the partial containment of the main bin by itself might be another possible initiator. This gas detonation then initiated an explosive train on the surface of the pile (Figure 42), moving through the contaminated and sensitive low-density foam, into the mixture of high-density foam and prills beneath, and then into the ambient prills composing the bulk of the pile.

[86] Pyrolysis is the chemical decomposition of a substance by heat.

[87] Byers, Kenneth J. "Pressure Piling and Other Issues Affecting Flameproof Enclosures." Redbank, Australia: Testing and Certification Centre, SIMTARS, 1996.

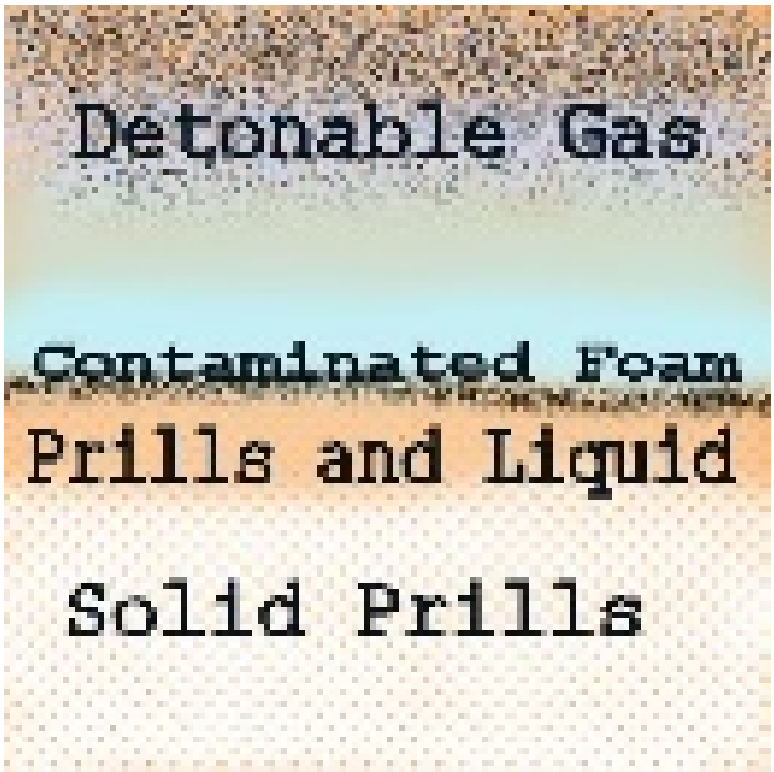

Figure 42. Potential Explosive Train Layers on AN Pile Before Detonation (Source: CSB)

In tests using 1-meter (diameter) cardboard tubes, ambient temperature FGAN has been detonated by a 10-centimeter layer of ANFO at the end of the tube, initiated by a flat shock wave.[88] If a large portion of the surface of the AN pile was detonated by a gas explosion and if the sensitized layer detonated, then the minimum diameter for unconfined FGAN prills (around 1 meter) would be exceeded, and the detonation could potentially proceed through the pile in a complete detonation. In many historical accidents, only part of the AN detonates because of the inability of the detonation wave to spread from a small detonation source into the main pile.[89] This type of incomplete or partial detonation does not seem to have occurred at the WFC; the crater and blast damage indicate a complete detonation of the main pile, however it is unknown how much of the FGAN burned prior to the explosion.

Falling material from a roof collapse has been proposed as a possible initiator in previous accidents, but subsequent testing of falling objects and high-speed projectiles entering solid and molten FGAN did not support this scenario. Although tests have shown that high-velocity impacts (such as those from high-

[88] Winning, C.H. "Detonation Characteristics of Prilled Ammonium Nitrate." *Fire Technology* 1, 1 (1965): 23.
[89] Freeman, R. "Cherokee Nitrogen Co., Pryor OK." *Chemical Engineering Progress* 71, 11 (1975).

caliber bullets) can detonate molten FGAN, the low velocities of falling objects do not appear to provide the energy density needed to detonate even sensitized FGAN.[90]

Fragments from a fire-induced explosion—such as the materials that might be produced in a hot steel roller with FGAN trapped inside—are another potential initiation source at the top of the pile but likely would not create the large flat shock wave required to fully detonate FGAN. No known vehicles or pressure tanks were close enough to the bin to produce high-speed fragments or a strong shock wave on the top of the FGAN pile. A golf cart was in the seed room, and fire extinguishers and an air conditioner could have failed from overpressure due to overheating, but they were separated from the FGAN bin by the substantial walls of the bin and are unlikely to have produced high-speed fragments. As other researchers have noted, the common element linking recent fire-induced FGAN detonations is some level of confinement.[91] At the WFC building in West, the confinement was the wooden bin, whereas in the transportation accidents in Mexico and Romania cited in the reference, the confinement was the semitrailer. The confinement provided by a wooden bin or a trailer would not allow sufficient pressure to build up to support a solid-phase DDT[92] but could allow the gases escaping the heated FGAN to accumulate over the pile. Additional field testing of this possibility would be useful.

4.3.2 Scenario 2: Detonation in Heated FGAN Along Exterior Wall Exposed to Fire

Another possible scenario is that the detonation at the WFC facility was initiated along one of the exterior walls of the bin. The north and east sides of the bin were exposed to the fire and could have been heated through the walls. No evidence indicates that the bin failed during the fire, although that cannot be ruled out, so the side of the FGAN pile likely would have no direct contact with flame, but some heat could have penetrated through the wall of the bin—more heat if the exterior wall adjacent to the seed room was penetrated and fire entered the space between the exterior sheathing and the plywood bin lining. Figure 43 shows some of the features of the fire on the north side of the structure a few minutes before detonation. The structure above the bin had lost its siding and was burning with good air flow. Flames were appearing through the siding outside the bin, indicating that the wooden exterior sheathing and roofing were beginning to burn. The seed room was just a burning frame, and most of its roof had burned and collapsed.

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[90] Van Dolah, R.W. et al. *Explosion Hazards of Ammonium Nitrate Under Fire Exposure*. Washington, DC: U.S. Department of the Interior, Bureau of Mines, 1966. *See*: http://www.osmre.gov/resources/blasting/docs/USBM/RI6773ExplosionHazardsAmmoniumNitrateUnderFireExposure.pdf (accessed on November 19, 2015).

[91] Nygaard, E.C. "Large Scale Testing of Ammonium Nitrate." *4th EFEE World Conference of Explosives and Blasting* 4(1), 2007.

[92] Van Dolah, R.W. et al. *Explosion Hazards of Ammonium Nitrate Under Fire Exposure*. Washington, DC: U.S. Department of the Interior, Bureau of Mines, 1966. *See*: http://www.osmre.gov/resources/blasting/docs/USBM/RI6773ExplosionHazardsAmmoniumNitrateunderFireExposure.pdf.pdf (accessed on December 22, 2015).

Figure 43. North Side of Structure Approximately 3 Minutes Before Detonation, with Dark Foreground Objects Associated with the Bin Complex North of Fertilizer Building (Source: Member of the Public)

Even with some heating of the pile through the bin wall, it is difficult to envision a potential detonation source; FGAN does not normally detonate when heated except under severe confinement.[93] Contamination also would be less likely in the FGAN exposed to heat along the exterior seed room wall, but some liquid AN, contaminated by soot and roofing components, on the pile surface might have penetrated along the heated wall of the bin if the temperature was high enough or the wall was partially breached. A small amount of wood from the bin also might be nitrated by nitric acid off-gassing from the heated FGAN to form nitrocellulose, but such a reaction has not been observed in testing, and no research papers supporting such a scenario were found. The WFC facility had a concrete floor that would have prevented heating of the pile from the bottom. Bin failure, preceded by leakage of the FGAN or FGAN liquid onto burning material such as seed or plastic cannot be ruled out. Because the bin floor was well above the floor of the seed room, the falling material would have some momentum and could produce

[93] Arthur D. Little, Inc. *Study of Ammonium Nitrate Materials*. Springfield, VA: National Technical Information Service, 1952: 1–49. *See*: http://www.dtic.mil/dtic/tr/fulltext/u2/786334.pdf (accessed on November 19, 2015).

significant pressure under ideal conditions. Whether this situation could lead to a detonation is an open question.

4.3.3 Scenario 3: Detonation in Elevator Pit That Spread to Main FGAN Bin

Another possible detonation scenario focuses on the elevator pit near the FGAN bin. A fiberglass lid covered the pit, and the floor sloped away from the pit to prevent runoff from entering it, but the fire might have melted the cover, and FGAN remnants could have been in the pit. The typical elevator mechanism would not provide any areas for strong confinement leading to high pressures, nor does it seem plausible that a small detonation in the pit could have initiated the main FGAN pile. If the detonation began in the pit, then the most feasible mechanism would be a collapse of the west wall of the bin, spilling FGAN into a mixture of burning rubber from the melted elevator belt and residual FGAN in the bottom of the pit. The mass of the falling FGAN, combined with the strong confinement of the concrete pit walls, might have provided the conditions for a solid phase DDT beginning in the bottom of pit and spreading into the main pile. The likelihood of sufficient FGAN near the door, where the pit was located, seems quite low. Liquid FGAN, if it somehow leaked into the pit, would have been under confinement conditions similar to those for liquid in the bin, with no obvious areas where pressure could build. The elevator itself is a belt with cups protected by a sheet metal box open at the top and bottom. The belt that brought the material in from the unloading pit outside provides no obvious containment other than the rollers, which are often hollow metal. Unlike the rollers above the bin, these rollers would have been shielded from the heat of the main fire but could have been heated by a fire (if it existed) in the pit.

Molten and contaminated FGAN on the floor, initiated by an explosion from a burning loader, was suspected in the 1973 Cherokee FGAN storage explosion, but no known source of an initiating detonation existed at the WFC, and the detonation at Cherokee did not propagate into the main pile. The circumstances of the two accidents were too different to draw any firm conclusions about the role of molten AN in the detonations.

Other fires involving FGAN (such as the fires in Bryan, Texas, and Athens, Texas) did not result in detonation, even though the fires totally consumed the structures housing the FGAN bins and the roofs collapsed. This evidence demonstrates the unpredictable behavior of FGAN exposed to fire. Possible differences between the fire incidents and the WFC are ventilation of the fire, which determines the degree of contamination from smoke products; level of confinement in the bin; and degree of direct heating on the FGAN pile.

4.4 **Forensic Testing of West Fertilizer Company Samples**

On the day before the explosion, the WFC sold 8,000 pounds of an FGAN/AS blend of fertilizer to a farmer in Abbot, Texas. The farmer told CSB investigators that the fertilizer he received, which he estimated was about 75 percent FGAN and 25 percent AS, was dustier than usual during spreading. After

the incident, the Office of the Texas State Chemist (OTSC) retained a portion of the fertilizer and provided a sample to CSB for further testing.

The OTSC is part of the Texas A&M University System and administers the requirements of the Texas Feed and Fertilizer Control Service. The OTSC regulates the sale of fertilizer and also conducts laboratory testing of FGAN to ensure that it meets quality guidelines for fertilizer. The OTSC conducted testing of the samples and shared the results with CSB. The OTSC spectral analysis found no activated carbon or any evidence of contamination of the FGAN sample. According to the report, the testing concluded that the sample was a mixture of FGAN and AS. The OTSC ran a nitrogen analysis in the state's combustion laboratory; this is a routine test run by the OTSC to check the concentration of nitrogen in fertilizers. The OTSC determined that the amount of nitrogen contained in the FGAN/AS sample mixture had nitrogen percentages that ranged from 34.33 to 34.61 percent.[94]

The laboratory also conducted tests to determine the particle size distribution of the prills in the farmer's FGAN/AS sample. Results verified that the FGAN/AS samples had high concentrations of fines (smaller broken-down prills). Approximately half (50 to 55 percent) of the farmer's sample consisted of particles smaller than 200 micrometers (0.2 millimeters). Operating under the assumption that the farmer's sample was a blend of FGAN and AS prills, the laboratory obtained a control sample of FGAN and AS mixed in 70:30 portions, respectively. The control sample contained 10 percent particles smaller than 200 micrometers. Although the farmer's sample included a larger than usual number of fines, the particle sizes in this sample are not necessarily representative of the FGAN in the main bin at the WFC because of the addition of AS to the farmer's mixture. Mechanical action such as blending might have taken place when creating the FGAN/AS mixture, reducing the particle size, and further breakage might have occurred during transit.

CSB investigators collected samples of the fertilizer remaining at the WFC facility and the OTSC and in March 2015 commissioned a forensics laboratory to characterize the composition of eight samples by semi-quantitative analysis. Samples 1 through 5 were categorized as solidified and pulverized fertilizer collected from various bins (Figure 44); sample 6 was collected from the FGAN railcar on the WFC property that was the least disturbed by the explosion and firefighting efforts (Figure 45); and samples 7 and 8 were collected from the FGAN mixture purchased by the farmer on the day before the incident (Figure 46). According to shipment records, the railcar contained pure FGAN manufactured by CF Industries. The railcar arrived at the WFC site in early April 2013. At the time of the incident, the WFC had not yet unloaded the railcar. The WFC also received truckloads of EDC pure FGAN product in early April 2013. CSB is unable to conclude whether the CF Industries or EDC product, or a mixture of both, was present in the FGAN main bin at the WFC facility at the time of the explosion.

[94] The percent of nitrogen (34 percent minimum) is typical for a high-density FGAN prill.

Figure 44. Solidified Fertilizer Collected from WFC Property (Approximate Location Unknown) (Source: Forensic Laboratory)

Figure 45. FGAN Prills Collected from a Railcar on WFC Property (Source: Forensic Laboratory)

Figure 46. Farmer's Sample of FGAN and AS Blend (Source: Forensic Laboratory)

The laboratory used infrared spectroscopy and electron microscopy methods to determine the elemental compositions of each sample. Results of this testing confirmed the presence or absence of AN and other salts in some of the samples. Four of the eight samples (1, 2, 3, and 5) contained no FGAN (Table 4). The sample collected from the railcar (no. 6) was determined to contain wholly AN with 36 percent[95] nitrogen and had a prill density of 1.59 grams per cubic centimeter (g/cm^3).[96] The railcar sample consisted of prilled particles with a polyolefin coating, which is commonly applied to reduce caking.[97] Magnesium nitrate or magnesium oxide is also occasionally used as an additive to FGAN prills during the manufacturing process.[98] The purpose of the additive is to act as a desiccant (absorbs moisture) and also to protect against the breakdown of prills at higher temperatures.[99] CSB concluded that the chemical composition of the FGAN obtained from the rail car (no. 6) was typical of FGAN prills commonly used for fertilizer and for creation of fertilizer blends.

Table 4. Forensic Testing Results of Fertilizer Samples Collected from the WFC and the OTSC

No.	Sample Location (if known)	Sample Description	Detected Compounds	FGAN Detected
1	Unknown	White and pink encrusted and prilled layers	AS, magnesium phosphate (with iron), potassium sulfate	No
2	Ammonium phosphate/potassium chloride bin	White prilled particles, pink fragmented particles, and grey encrusted particles	AS, ammonium phosphate, and possibly potassium chloride	No
3	Space between FGAN and potassium chloride bins	Dark pink fragments	Ammonium phosphate, sulfate, alkali salts of fluoride, trace iron	No
4	Backside of diammonium phosphate bin	White powder with red streaks	AN, AS, chlorides, ammonium phosphate, and trace amounts of potassium chloride	Yes

[95] FGAN prills typically contain about 34 percent nitrogen. The 36 percent nitrogen result in the sample is likely attributed to the percent error in the analytical method used. The laboratory conducted a linear regression analysis to determine the percentage error in the determination of elemental sulfur in the FGAN/AS samples compared to a control sample, and it estimated the error to be within +/- 0.3 percent of the sample. The laboratory concluded that the percentage error estimates would be similar for oxygen and nitrogen in the samples that underwent electron dispersive spectroscopy (EDS) methods.

[96] FGAN is a higher-density prill in the range of 1.72 g/cm^3.

[97] According to the FGAN Safety Data Sheet (SDS) from CF Industries, the FGAN prills contain a 0 to 0.2 percent proprietary polyolefin conditioning agent.

[98] Ammonium nitrate particulate fertilizer and method for producing the same. *See*: http://www.google.com/patents/US5720794 (accessed on November 25, 2015).

[99] U.N. Industrial Development Organization. *Fertilizer Manual*, 3rd Edition. The Netherlands: Kluwer Academic Publishers, 1998: 227.

5	Backside of ammonium sulfate bin	Sample containing gravel and pebbles (separated before analysis)	AS, sulfates, and chlorides	No
6	Railcar	White prilled particles	Prilled AN coated with polyolefin	Yes
7	Farmer AS/FGAN mixture	White prilled particles (partially agglomerated from wetting)	AN, AS, sulfate, extractable polyolefin	Yes
8	Farmer AS/FGAN mixture	White prilled particles	AN, AS, sulfate, extractable polyolefin	Yes

The FGAN/AS mixture purchased by the farmer on the day before the incident was the only available sample representative of materials stored in the fertilizer building before the incident. In addition to the testing conducted by the OTSC to determine the percentage of nitrogen and quantity of fine in these samples, CSB commissioned additional laboratory testing of the prills contained in the FGAN/AS mixture (samples 7 and 8 in Table 4) in October 2015. Because the FGAN sample from the railcar on the WFC property remained relatively undisturbed during the fire and explosion, the laboratory also selected a prill from that sample (no. 6 in Table 4) for comparison.

An image from a macroscopic examination of an individual prill from sample items 6, 7, and 8 is shown in Figure 47. Item 6, which was collected from the railcar, had a smooth and uniform coating-like texture, whereas evidence items 7 and 8, which were sampled from the farmer's mixture, had an uneven surface made up of an agglomeration of amorphous (formless) and semicrystalline particles.

Figure 47. Physical Comparison of Samples (20x) (Source: Forensic Laboratory)

Under a microscope, the polyolefin coating was visually apparent on the surface of the item 6 prill. Through infrared spectral analysis, the laboratory was able to chemically identify the external prill coating as a polyolefin. However, the external polyolefin coating on the surface of sample items 7 and 8 could not be identified through the same analysis. To determine whether a coating had been present, the laboratory quantitatively extracted residues from the prills in a solvent that could be analyzed through infrared spectra analysis. Although direct surface scans of items 7 and 8 did not reveal the presence of the coating, solvent extracts indicated the presence of a polyolefin. This coating could have been applied to the prills at some point in time but was no longer acting as a prill coating on the observed sample items 7 and 8.

4.5 Blast and Impact Analysis

CSB commissioned a consultant firm to survey the property damage to the WFC and the surrounding community. On the basis of information obtained from the survey, the consultants characterized the force of the blast and estimated the energy produced during the explosion. Using indicators from the observed damage to residences and community structures, the consultants applied a guideline[100] from the U.S. Army Corps of Engineers and created a three-dimensional model to predict the blast overpressure and determine the explosive weight that was best explained by the physical damage observed in West, Texas.

The computational models and calculations expressed the AN explosive energy estimation normalized against the explosive power of TNT,[101] a high-explosive compound commonly used to quantify blast loads. A TNT equivalence calculation provides an approximation of explosive energy in pounds of TNT. Several TNT equivalent equations are used in industry that employ actual and estimated explosion parameters such as heat capacity, weight of explosive charge, and explosion percent efficiency. Many of the parameters are specific to the material involved. TNT equivalent values are a rough approximation of explosive effects, and the variability of TNT equivalence (20 to 40 percent) might be a result of the ways that it is calculated based on pressure, impulse, crater size, or other damage measures.[102]

The blast modeling consultants estimated the range of potential explosive yields from the WFC explosion to be equivalent to a range of 20,000 to 40,000 pounds of TNT, based on the blast damage indicators recorded and analyzed from 20 lightweight metal buildings, the deformed basketball goalposts, and the condition of the apartment complex and nursing home.

To further refine a specific explosive weight most consistent with all of the observed damage, the consultants used another modeling tool that incorporates a number of different blast prediction methodologies, including the development of a computational fluid dynamic simulation to characterize

[100] U.S. Army Corps of Engineers. "Estimating Damage to Structures from Terrorist Bombs Field Operations Guide," ETL 1110-3-495. Washington, DC: U.S. Army Corps of Engineers, 1999.
[101] One ton of TNT has an explosive energy of 4.184 gigajoules.
[102] National Assessment Group. "Ammonium Nitrate Detonability Review and Assessment, Final Report." Prepared for the Technical Support Working Groups, For Official Use Only. Kirtland AFB, NM: September 2, 2011: 7.

the shock wave as it wrapped around structures and other obstacles during the explosion. The CSB-commissioned blast experts determined that the explosive energy of the WFC explosion that is most consistent with the observed damage is 25,000 pounds (12.5 tons) of TNT. With an estimated 30 tons of FGAN in the main WFC bin at the time of the blast, the 12.5-ton TNT equivalent is based on a 42 percent efficiency of the material that contributed to the explosive energy. Because the quantity of FGAN consumed in the fire before the explosion was not determined, the exact quantity of FGAN that contributed to the explosion remains unknown.

The ATF National Response Team also requested that the U.S. Army Engineer Research and Development Center (ERDC) conduct an assessment of the WFC explosion damage and then estimate the equivalent explosive yield of the blast. The ERDC team arrived in West on April 29, 2013. As part of the site study, the ERDC team conducted a detailed survey of the crater left by the explosion (Figure 48), using survey and three-dimensional scanning equipment to verify critical dimensions. The shape of the crater was asymmetric, with an apparent diameter of 75 feet (lip-to-lip diameter of 89 feet) and a depth of nearly 8 feet (lip-to-bottom depth of 9 feet) (Figure 49).[103]

[103] The ERDC crater dimensions are based on an average of three different measurement methods (standard survey, photogrammetry, and LIDAR scan), which may account for variations on reported crater dimensions.

Figure 48. Ground-Level View of WFC Explosion Crater (Source: CSB)

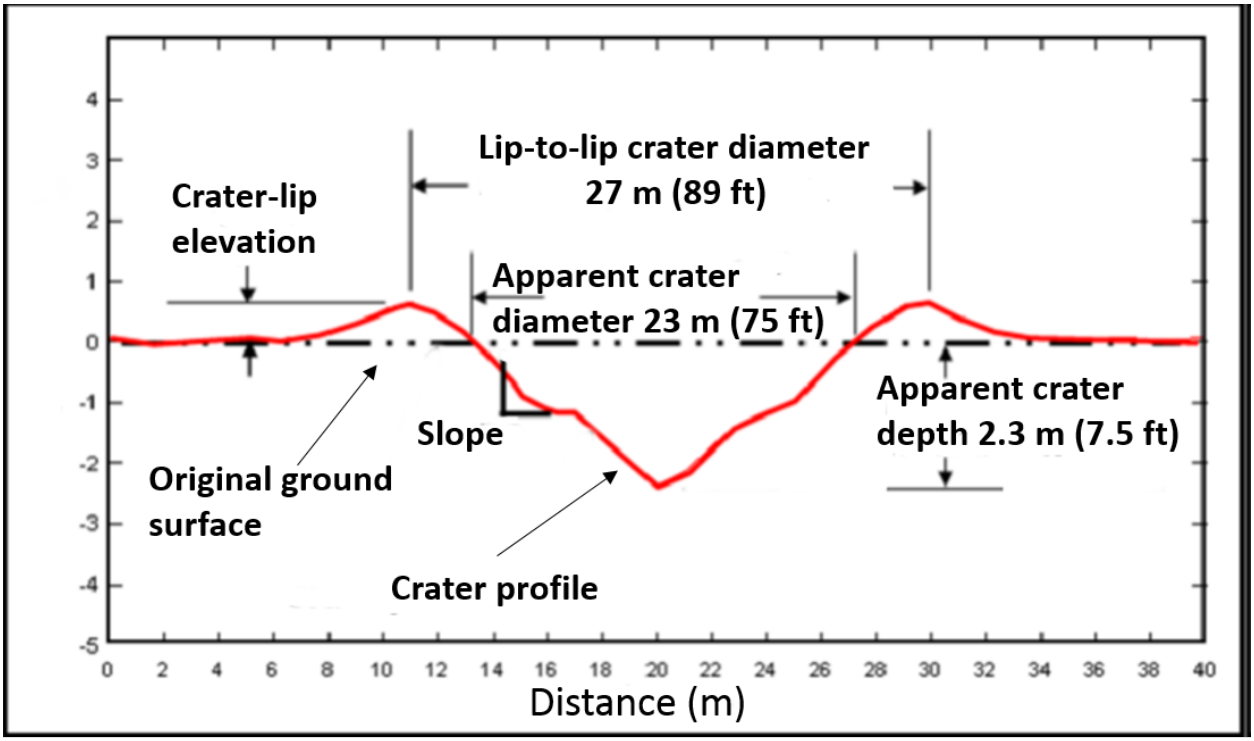

Figure 49. WFC Explosion Crater Profile Measurements (Source: Army Corps of Engineers, dimensions added by CSB)

The ERDC team compared the field crater measurements with experimental data for blast craters and other sources to produce an estimate of the net explosive weight of the FGAN. The experimental data also took into consideration the near-surface geology (soil type and underlying rocks) surrounding the explosion, which has an effect on the crater depth and size. The ERDC team compared the crater dimensions and soil types from the WFC explosion with similar experimental data to estimate the explosive weight of FGAN. The final report on this analysis concluded that this method entails a degree of uncertainty because none of the experimental data included the type of soil with limestone found in Texas.[104] In addition, the experimental charge was C-4, which might have a different explosive or cratering efficiency than FGAN. The ERDC team made assumptions to account for the lack of available data and, on the basis of the crater analysis, estimated the WFC explosion to be within the range of 10,000 to 21,500 pounds of TNT.

The center of the crater was almost directly under the WFC facility's main FGAN bin, which was likely the source of fuel for the explosion. This main bin contained an estimated 20 to 30 tons of FGAN at the time of the incident; however, the blast analyses from consultants hired by CSB and from the Army Corps

[104] The soil at the WFC consists of limestone with varying amounts of chalk and clay. This soil type is consistent with what **would** be expected in West, Texas.

of Engineers indicate that the quantity of FGAN that contributed to the explosion could have been smaller, based on the observed damage. To demonstrate the location of the crater in reference to the fertilizer storage building and the main FGAN bin, CSB commissioned a structural engineering firm to create a three-dimensional rendering of the fertilizer facility over the crater location (Figure 50).[105] Figure 51 shows an elevation view of the fertilizer building, with the underlying crater.

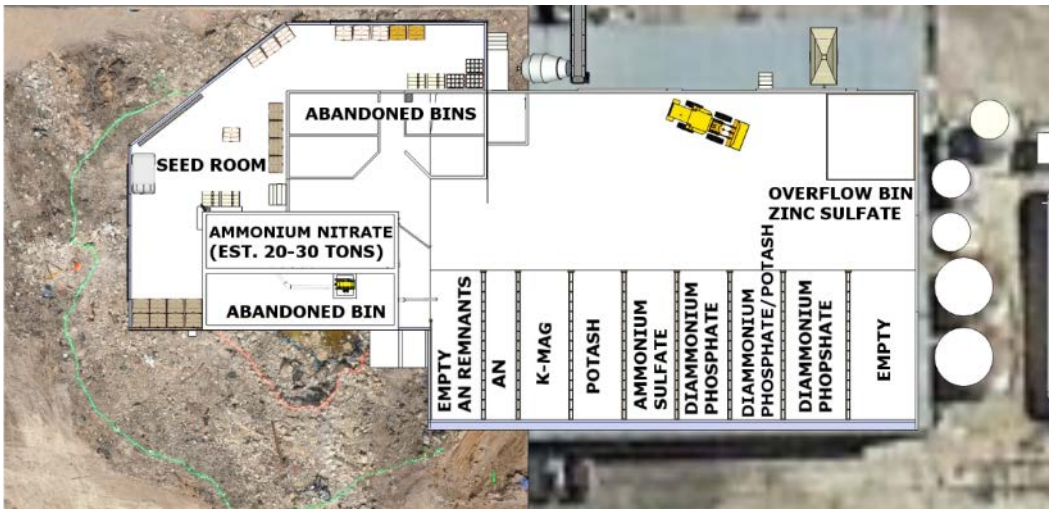

Figure 50. Overhead View of WFC Bins, with Crater Underlay (Source: Atlas Engineering)

Figure 51. Elevation View of Fertilizer Building, with Crater Depth (Source: Atlas Engineering)

105

and building location are estimated to be within +/- 2 feet, based on global positioning information.

4.5.1 Seismic Data

According to the United States Geological Survey (USGS), the WFC explosion registered as an earthquake of magnitude 2.1 on the Richter scale. The Lake Whitney seismic station in Meridian, Texas, about 25 miles west-northwest of the WFC site, recorded seismic signals from the April 17, 2013, explosion. ATF concluded that there were two separate explosions, "one smaller and one larger," based on eyewitness accounts and seismic evidence.[106] After conversations with USGS seismologists, CSB later learned that a system error occurred, and only one event was recorded at the Lake Whitney station. According to USGS, seismic signals resulting from the WFC explosion were recorded on nine seismic stations within a range of 25 to 360 miles. Using the onset time of the seismic energy at these stations and the known location of the explosion, the USGS National Earthquake Information Center estimated that the time of the explosion was 7:50:38 pm local time. According to USGS, the seismic data recording shows both energy that propagated through the earth as well as later-arriving energy that propagated through the air (Figure 52). USGS concluded that the event was a single large explosion, but it could not rule out the possibility of multiple closely timed explosions.

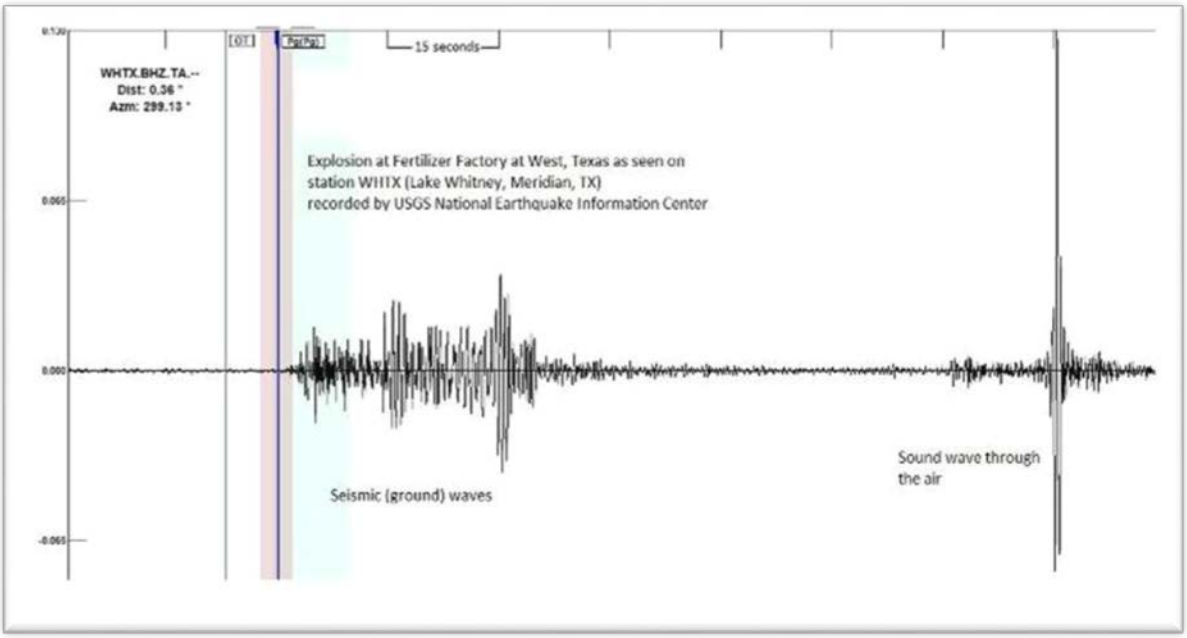

Figure 52. Data Recorded at Lake Whitney Station, WHTX, and Seismograph by the USGS National Earthquake Information Center (Source: USGS)

[106] ATF. "ATF Press Conference Video," May 16, 2013, minute 12:45. *See*: http://www.youtube.com/watch?v=OpLjSvcRqzU (accessed on November 19, 2015).

5.0 Commercial Property and Liability Insurance

The West Fertilizer Company (WFC) had commercial property insurance to cover losses (such as building damage, damage to product, or loss of income due to property damage) from certain loss events, such as fires. The company also held a commercial liability insurance policy to protect itself against claims for bodily injury while onsite or while operating company automobiles. CSB examined available documentation of the WFC's insurance coverage and inspections from 2007 until the April 2013 explosion. The WFC was insured by two different insurance companies, Triangle Insurance Company, Inc. (Triangle) and the United States Fire Insurance Company (U.S. Fire). Triangle issued policies that included coverage for property damage, business interruption, bodily injury, and automobile accidents from 2007 to the end of 2009. In late 2009, Triangle decided not to renew the insurance policy because of the WFC's lack of compliance with loss control recommendations. The WFC insurance policy expired on December 31, 2009. Thereafter, the WFC obtained similar coverage from U.S. Fire in January 2010 and renewed it in 2011, 2012, and 2013. The U.S. Fire insurance policy was in effect at the time of the 2013 explosion.

5.1 Triangle Insurance Coverage and Audits (2006–2010)

Triangle conducted an initial onsite survey of the WFC facility in 2006 and provided insurance coverage from 2007 until 2010. The WFC had a $1 million commercial general liability policy and $2 million in coverage to cover onsite property and business losses. In 2009, Triangle gave notice to the WFC that it was not renewing the policy because of the WFC's lack of compliance with loss control recommendations issued by Triangle following several onsite audits. Triangle conducted annual loss control surveys at the WFC facility from 2006 through 2009, and it issued a number of recommendations for suggested improvements to WFC operations. The Triangle loss control surveys included an evaluation of WFC automobiles and drivers, storage and application of dry and liquid fertilizers, grain and feed milling, and anhydrous ammonia.

CSB investigators requested and reviewed insurance documentation from Triangle, including risk profiles, insurance audit reports, and communications from Triangle to the WFC. In 2006, Triangle performed an initial survey of the WFC facility before issuing coverage. Triangle loss control specialists made four recommendations to the WFC for safety improvements, including replacing missing guards on augers and conveyors and addressing visual damage to one of the grain bins. Triangle's overall risk assessment categorized the facility as average, with housekeeping, maintenance, and grounds in average to fair condition. During the anhydrous ammonia survey, Triangle noted the close proximity of the WFC facility to schools, residences, and businesses and also documented concerns about the ammonia risk management plan (RMP) being out of date (discussed in Section 8.4.2.4). Triangle assigned a representative to work with the WFC to update and improve the RMP submission.

In 2007, Triangle conducted another loss control survey and submitted 10 recommendations to the WFC; 4 of the 10 recommendations were restated from the 2006 survey because they remained unresolved. The loss control specialist identified several safety and compliance issues, including:

- A corroded 440-volt wire ran from the pole on the north side of the plant through the bulk fertilizer facility to the anhydrous ammonia tank area on the south side of the facility.
- An aluminum ground wire showed noticeable signs of corrosion from the fertilizer. The loss control specialist noted that the wire could lose its ability to ground, potentially causing shock and fire hazards (Figure 53).
- Several temporary lighting sockets needed to be wired in permanently to reduce the potential for electrical shocks and fire hazards.

About 2 months later, the WFC responded to some of the Triangle recommendations and reported that 3 of the 10 recommendations were resolved, including replacing guards and repairing an electrical cord on an auger. The remaining seven recommendations, including the exposed 440-volt wire, remained outstanding. The Triangle loss control specialist's overall opinion of risk, documented from this survey, was fair; housekeeping received a fair rating; and maintenance received a fair to poor rating.

Figure 53. Exposed 440-Volt Electrical Wiring Identified in 2007 Survey
(Source: Triangle Insurance Company)

In September 2008, a loss control specialist from Triangle conducted another renewal survey and made 14 recommendations, including several outstanding recommendations from the previous year. During this survey, Triangle identified additional damaged electrical wires at the facility in need of repair (Figure 54). The WFC submitted a completed recommendation form to Triangle later that month, stating that seven recommendations were addressed or in the process of being settled.

Figure 54. Damaged Electrical Cord Identified in 2008 Insurance Survey
(Source: Triangle Insurance Company)

In August 2009, Triangle identified six additional recommendations during the annual loss control survey. One recommendation was restated and designated as "critical" for a lack of safety chains on towing equipment. The Triangle consultant also noted that the WFC "seems to be resistant" to implementing a training program to address the frequency of vehicle and mobile equipment accidents. Triangle documented a large quantity of temporary exposed wiring in the WFC facility that needed to be run in conduits. When evaluating WFC safety programs in 2009, Triangle noted that the company had no positive safety culture and that "written programs are incomplete and outdated, there is no structured safety program." In addition, Triangle found no accident investigation program and no evidence that the WFC held regular safety meetings for employees. The following excerpt from the 2009 survey indicates Triangle concerns:

> They need a SCMP (Safety and Compliance Management Programs) person to help them with safety issues, permits, etc. To my knowledge they have not had a safety meeting since we started insuring them in 2006…I have a concern with the wiring at both grain operation & the dry fertilizer plant. Only about 10% is run in conduit. The rest consist of a heavy flexible 4-wire cable, the type you would normally use to put outside on poles but it is not protected from cuts & abrasion.[107]

In September 2009, the loss control specialist stated in an internal Triangle email that "because of losses and non-compliance of recommendations, Triangle should non-renew Adair Grain, Inc./West Fertilizer Co. in West, Texas."[108] In September 2009, Triangle sent notification to the WFC that all policies would not be renewed for the following year. In 2010, the WFC retained U.S. Fire for insurance coverage.

[107] Triangle Insurance Company Documentation, Loss Control Survey at Adair Grain/WFC. August 2009.
[108] Triangle Representative. "Adair Grain," email message to manager, Underwriting Services Triangle, September 14, 2009.

5.1.1 Triangle Loss Control Surveys That Did Not Include FGAN Hazards

CSB reviewed the WFC loss control survey documentation and the Triangle "Loss Control Best Practice Manual" for insurance inspectors and found no focus on FGAN fire and explosion hazards between 2006 and 2009. In the 2006 survey and subsequent surveys, Triangle documented the presence of ammonium nitrate (AN) onsite for security concerns and answered, "Yes" to the question, "Does the account meet state regulations for the storage and transportation of product?" Although no state-specific regulations for AN storage existed at the time, the survey did not include federal regulations, such as the OSHA Explosives and Blasting Agents standard (29 CFR 1910.109, discussed in Section 8.2), or industry consensus standards, such as National Fire Protection Association (NFPA) 400, *Hazardous Materials Code* (addressed in Section 8.6.1). Triangle guidance included a description of combustible and noncombustible bulk fertilizer storage buildings for informational purposes, but Triangle did not provide guidelines or requirements for specific storage practices, such as separation from potential contaminants, materials of construction, or mechanism for fire and explosion prevention. Other survey focus areas, such as grain milling and anhydrous ammonia, included a more detailed review of federal requirements, such as the OSHA Grain Handling Facilities Standard (29 CFR 1910.272) for the prevention of grain dust explosions and the EPA Risk Management Program rule for anhydrous ammonia storage. In November 2013, Triangle updated the best practice manual to include compliance with federal regulations in addition to state regulations for fertilizer storage and transportation.

5.2 U.S. Fire Insurance Coverage and Audits (2010–2013)

U.S. Fire started providing insurance to the WFC in 2010 and renewed coverage for 2011, 2012, and 2013. The WFC was insured by U.S. Fire at the time of the April 2013 incident. The WFC general liability policy had a maximum limit of $1 million, and the commercial property insurance policy had a limit of about $4.45 million, which included all buildings and equipment on the WFC property. In 2013, the WFC held U.S. Fire coverage for commercial property, general liability, inland marine,[109] and commercial automobile.

According to the insurance policy documentation for the WFC, U.S. Fire offered policyholders a loss control service that included onsite surveys of the facility to provide:

- Safety information and educational material to minimize loss costs.
- Initial survey and evaluation.
- Specific suggestions for improving loss control practices.
- Consultation and training to help management understand hazards associated with operations.
- Follow-up surveys.

[109] Commercial inland marine insurance covers property in transit or property that is movable or portable and is not at a fixed location.

CSB requested additional information from U.S. Fire related to the WFC insurance policy, including claims, audits and inspections, and training requirements for U.S. Fire loss consultants. CSB also requested documentation of U.S. Fire's onsite inspections at the WFC facility over the time period it was insured. To date, U.S. Fire has not provided CSB with the requested documentation. Outside counsel for U.S. Fire indicated to a CSB investigator that the $1 million policy amount did not necessitate much onsite activity, such as audits or inspections, during the time that the WFC was insured. [110]

5.3 Insurance Claims and Other Aid after the Explosion

The Texas Department of Insurance (TDI) regulates the business of insurance in Texas and provides resources for people and businesses to obtain insurance in the state. In response to the WFC explosion, TDI assisted in securing the scene and mobilizing a disaster response program to assist consumers with filing insurance claims related to the incident. The Texas State Fire Marshal's Office (SFMO) and the Division of Workers' Compensation are units within TDI. The total insurance-related losses due to the explosion are estimated to be in the range of $230 million.[111] Many of the residents in the area did not have home or rental insurance. Those individuals relied on aid from FEMA, Salvation Army, and American Red Cross operations. FEMA received a total of 1,108 applications for assistance as a result of the fire and explosion at the WFC facility.[112] Nearly 6 months after the incident, FEMA[113] reported providing federal disaster assistance exceeding $16 million to eligible survivors. This sum included more than $9 million in federal disaster loans from the U.S. Small Business Administration (SBA), nearly $840,000 in individual assistance grants from FEMA, and more than $6.2 million in FEMA Public Assistance funding.[114] Low-interest disaster assistance loans from the SBA[115] were also available to homeowners, renters, businesses of all sizes, and private nonprofit organizations whose property was damaged or destroyed by the incident. On the basis of data provided by FEMA, 580 applications were submitted for individuals or families that had homeowners, homeowners with small business loans, and mobile home insurance. FEMA verified losses totaled about $9,052,308. The real property FEMA verified losses amounted to about $8,145,750. The personal property FEMA verified losses totaled roughly $906,557. Although all losses related to the fire and explosion totaled nearly $250 million, the

[110] Outside Counsel for U.S. Fire, conversation with CSB Investigator, January 20, 2015.
[111] Texas House of Representatives, 84th Texas Legislative Session. Testimony on House Bill 2470. *See*: http://www.house.state.tx.us/video-audio/committee-broadcasts/ (accessed on January 6, 2016).
[112] Official data provided by FEMA.
[113] FEMA—under the authority of Section 408 of the Robert T. Stafford Disaster Relief and Emergency Assistance Act, 42 U.S.C. § 5174, and Title 44 of the Code of Federal Regulations (CFR)—may provide financial assistance and, if necessary, direct services to eligible individuals and households that, as a direct result of a major disaster, have necessary expenses and serious needs and are unable to meet such expenses or needs through other means.
[114] *See*: http://www.fema.gov/news-release/2013/10/07/federal-disaster-assistance-tops-16-million-west-texas (accessed on January 6, 2016).
[115] The SBA serves as the Federal government's primary source of money for the long-term rebuilding of disaster-damaged private property. These disaster loans cover uninsured and uncompensated losses and do not duplicate benefits of other agencies or organizations.

WFC carried a policy from U.S. Fire at the time of the incident with a limit of only $1 million for bodily injury and offsite property damage.

5.4 FGAN Facilities in Texas and the Potential for Offsite Consequences

Under the Texas Commercial Fertilizer Rule (described in Section 8.7.1), facilities that sell or offer to sell FGAN or FGAN-containing materials must obtain annual registrations from the Office of the Texas State Chemist (OTSC) to do business. The OTSC collects information on each facility storing more than 10,000 pounds (5 tons) of AN in Texas. According to the OTSC list of facilities as of September 2014, 80 facilities statewide stored AN in quantities exceeding 10,000 pounds. Of those 80 facilities, 43 stored FGAN, and 37 stored technical grade ammonium nitrate (TGAN). In October 2015, the OTSC reported 40 FGAN facilities in Texas.[116] Of those 40 facilities, only nine (23 percent) are located in jurisdictions with an adopted fire code.

CSB found that West, Texas, is not the only town in the state with FGAN storage in close proximity to residential areas, schools, and hospitals. In fact, some of these occupancies are directly adjacent to, or across the street from, FGAN storage. Because the WFC operated in close proximity to schools, residences, and a nursing home, CSB plotted the 40 FGAN storage facilities in Google Earth™ to determine whether FGAN storage facilities are also in close proximity to residential areas, schools, or other large population clusters.

CSB found that 19 (48 percent) of the facilities storing more than 10,000 pounds of FGAN are located within 0.5 miles of a school, hospital, nursing home, or a combination of those occupancies. Of the 40 FGAN facilities, 33 (83 percent) of the FGAN storage facilities are located within 0.25 miles of a residence or apartment building.[117] The WFC facility was about 550 feet (0.16 miles) from the closest school, which sustained catastrophic damage as a result of the explosion, which could have resulted in additional loss of life had the school been in session at the time of the incident. CSB identified one other school in Texas that is 529 feet (0.12 miles) from an FGAN storage facility, even closer than the school destroyed in West, Texas (Figure 55). Of the 40 FGAN storage facilities, 16 (40 percent) are within 0.5 miles of an elementary school, secondary school, or high school (Figure 56).

[116] CSB noted that two new FGAN facilities registered with the OTSC between September 2014 and October 2015 and that five facilities were listed in September 2014 that did not register to sell FGAN in October 2015.

[117] The closest structures with obvious characteristics of a private residence were selected for this measurement using Google Earth and Google Street View.

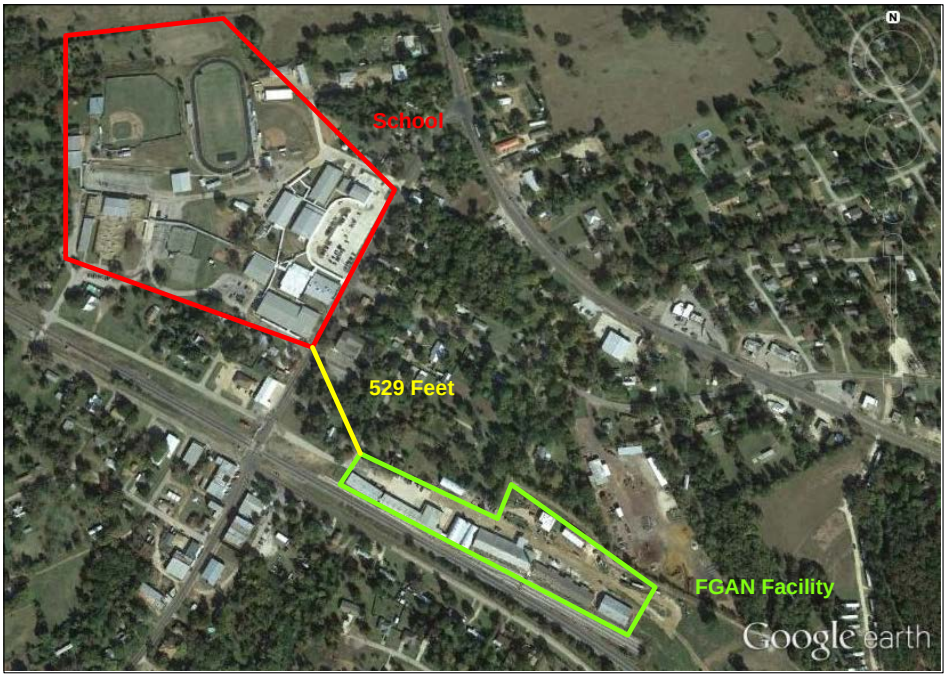

Figure 55. Overhead View of a School Approximately 529 Feet from an FGAN Storage Facility (Source: Google Earth)

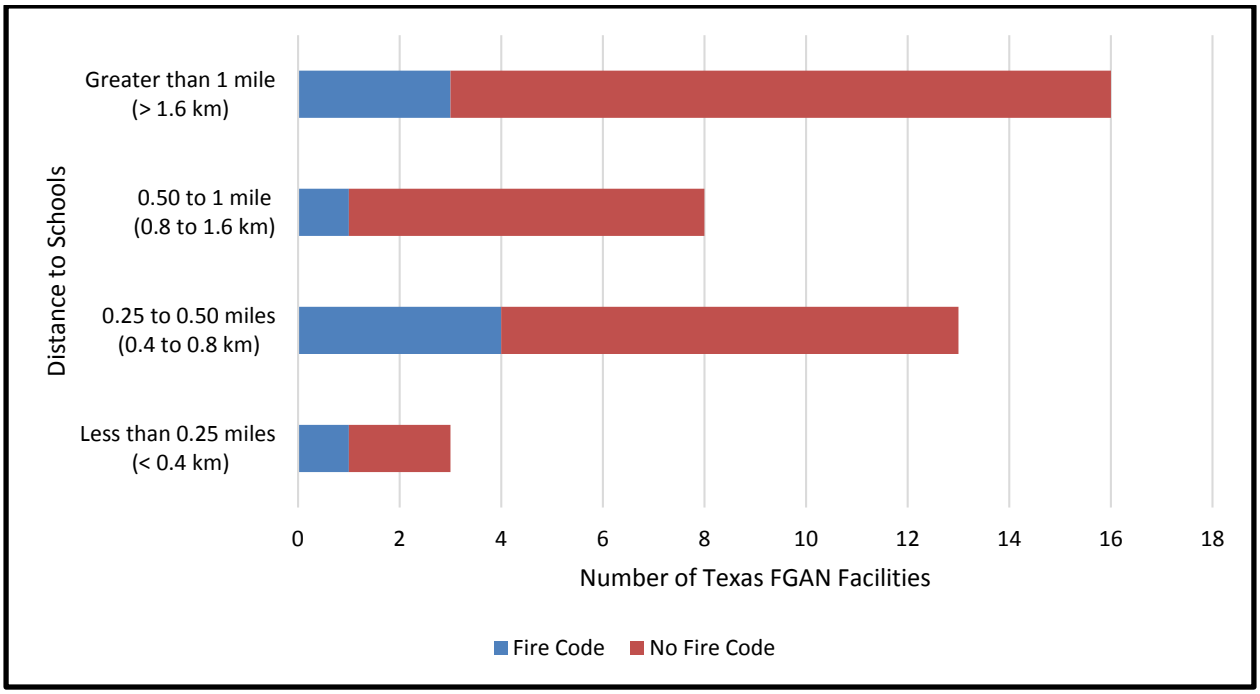

Figure 56. Breakdown of FGAN Storage Facilities (10,000 pounds or more) Within 1 Mile of a Texas School (Source: CSB)

The West Rest Haven nursing home was located about 600 feet from the WFC facility and sustained irreparable damage as a result of the blast. CSB measured distances between Texas FGAN storage facilities and nearby hospitals and nursing homes and found that 38 percent of the facilities are within 1 mile of a nursing home or hospital. In one case, a fertilizer facility is adjacent to a 50-bed hospital and a residence, also a few blocks from a school (Figure 57).

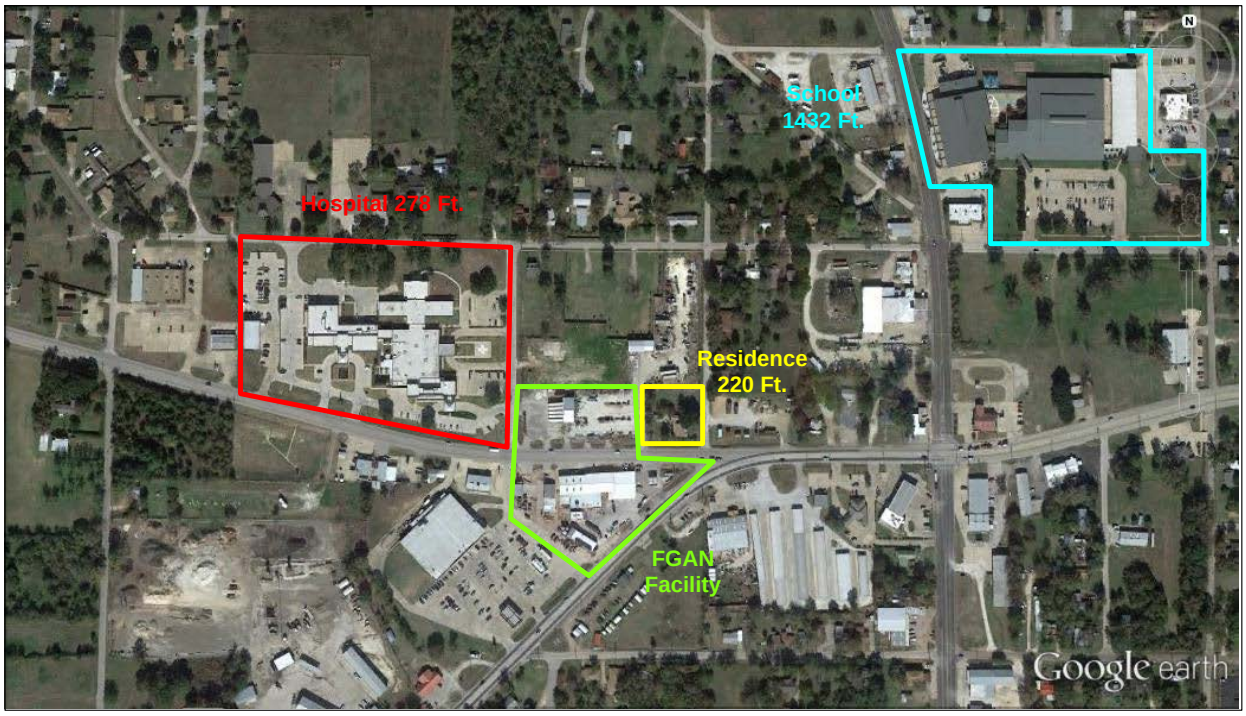

Figure 57. Overhead View of a Texas FGAN Storage Facility near a Hospital, Residence, and School (Source: Google Earth)

Findings from the analysis of the proximity of FGAN storage facilities to various community structures show that the risk to the public from a catastrophic incident exists throughout the state of Texas. Injury data published by the Waco-McLennan County Health Department supported the conclusion that people within 1,500 feet (or 0.28 miles) from the blast epicenter were the majority of those injured in the WFC fire and explosion, particularly those who were inside a structure at the time of the blast.[118]

5.5 Limits of Insurance Coverage in Texas

Property and liability insurance companies can complement government oversight of industry by identifying hazards and reducing losses through the insurance process. In some ways, insurance can

[118] Waco-McLennan County Public Health District. "Public Health Report: Injuries Related to the West (Texas) Fertilizer Plant Explosion," April 2013 (issued on June 24, 2014).

augment government standards and safety monitoring.[119] The insurance industry provides coverage for losses at established premiums but also has an incentive to reduce and manage risks. Insurers perform functions of risk reduction and risk management by using tools such as auditing and inspecting their clients, managing loss prevention efforts, analyzing loss histories, identifying causes of accidents, and teaching clients how to avoid premium increases (or how to secure premium reductions).[120] Insurance reinforces existing government regulations by expecting that policyholders comply with existing requirements. This approach can be effective at reducing risk and preventing incidents because annual insurance audits can be more frequent than state or federal enforcement inspections, such as those by SFMO or OSHA. Texas law does not require facilities that store FGAN to obtain commercial general liability or property insurance; however, the WFC voluntarily obtained insurance. The WFC's $1 million general liability policy with U.S. Fire did not include excess or umbrella coverage for the consequences of serious incidents, such as bodily injury and property damage. If the WFC is found responsible for this incident in civil cases, its insurance would not be sufficient to pay the full amount of insurance claims for the catastrophic consequences caused by the blast.

Texas law requires some businesses to have liability insurance for operations that potentially pose a lower level of public risk than the WFC incident (Table 5). Air conditioning and refrigeration contractors, mold assessors, and plumbers are some of the businesses or services subject to commercial general liability requirements in Texas. For amusement ride owners and operators, Texas set the minimum requirements for insurance at $1.5 million per occurrence and requires proof of insurance to operate an amusement ride. For an amusement park ride to operate in the state, the ride must be inspected at least annually by the insurer.[121] The ride also must meet the standards for coverage and have an adequate amount of insurance coverage.[122] Operators of amusement park rides annually must file copies of the inspection certificate and insurance policy with the TDI Commissioner. The Texas amusement ride regulation also requires operators of coin-operated rides and bounce houses to obtain liability insurance. However, FGAN storage facilities such as the WFC facility can operate next to schools, residential areas, and hospitals with little or no general liability insurance. Adequate levels of coverage would likely prompt rigorous onsite loss control audits by insurers.

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[119] Ben-Shahar, Omri, and Kyle D. Logue. "Outsourcing Regulation: How Insurance Reduces Moral Hazard," *Michigan Law Review* 111:2 (2012); University of Michigan Law and Economics Research Paper No. 12-004; University of Chicago Institute for Law and Economics Olin Research Paper No. 593. *See*: http://ssrn.com/abstract=2038105 (accessed on January 6, 2016).

[120] *Ibid.*

[121] Texas Occupations Code, § 2151.101, "Regulations of Amusement Rides: Requirements for Operation." *See*: http://www.statutes.legis.state.tx.us/Docs/OC/htm/OC.2151.htm (accessed on August 4, 2015).

[122] *Ibid.*

Table 5. Minimum Insurance Requirements in Texas[123]

Business/Operation	Minimum Amount
Amusement ride operators	$1.5 million
Elevator/escalator contractors	$1.5 million[124]
Mold assessors and remediators	$1 million[125]
Electricians	$600,000[126]
Residential appliance installers	$600,000[127]
Plumbers	$300,000[128]
Tow truck operators	$300,000[129]
Structural pest control providers	$300,000[130]
Used automotive parts recyclers	$250,000[131]
Air conditioning service providers	$200,000[132]

Previous incidents in Athens, Bryan, and West have demonstrated the risk imposed by FGAN facilities on Texas communities and the public. In the absence of a state fire code, there is limited state oversight to ensure that facilities are addressing conditions that could potentially lead to an incident similar to the WFC fire and explosion.

[123] *See*: http://www.dallasnews.com/news/west-explosion/headlines/20130508-texas-makes-bounce-house-operators-carry-liability-coverage-but-not-plants-like-west-fertilizer.ece (accessed on January 6, 2016).
[124] *See*: https://www.tdlr.texas.gov/elevator/Elevapp.pdf (accessed on January 6, 2016).
[125] Texas Administrative Code Licensing Requirements. *See*: http://txrules.elaws.us/rule/title25_chapter295_sec.295.309 (accessed on January 6, 2016).
[126] *See*: http://www.tdlr.texas.gov/electricians/forms/ElectricianCOI.pdf (accessed on January 6, 2016).
[127] *See*: http://www.tdlr.texas.gov/electricians/forms/ELC012 Residential Appliance Installation Contractor License Application.pdf (accessed on January 6, 2016).
[128] *See*: http://www.tsbpe.state.tx.us/common/CertificateofInsuranceForm-fillablefeb2012.pdf (accessed on January 6, 2016).
[129] Administrative Rules of the Texas Department of Licensing and Regulation, § 86.400, "Insurance Requirements—Tow Truck Permits." 33 TexReg 2940. New section adopted, effective April 15, 2008.
[130] Texas Occupations Code, § 1951.312, "Liability Insurance." *See*: http://www.statutes.legis.state.tx.us/Docs/OC/htm/OC.1951.htm (accessed on January 6, 2016).
[131] *See*: https://www.tdlr.texas.gov/parts/aprrules.htm#8740 (accessed on January 6, 2016).
[132] Proof of insurance is required only with an initial application for licensure, a change in license assignment (new company), or a request by the Department of Insurance.

Triangle conducted annual inspections at the WFC facility and identified conditions that could result in potential losses, such as fires and worker injuries. Although Triangle did not focus specifically on hazards related to FGAN storage, it offered recommendations to the WFC to correct conditions, such as electrical hazards, that could result in a fire. CSB did not receive any documentation that U.S. Fire continued performing similar audits and inspections at the WFC facility after Triangle's nonrenewal.

It is not common for states to have prescriptive requirements for insuring specific industries. However, TDI does impose liability insurance and inspection requirements for amusement park rides and establishes minimum liability insurance coverage for certain operations and services, as listed in Table 5. CSB identified other FGAN storage facilities located in close proximity to community structures; however, the level of insurance carried by these facilities remains unknown. In response to the WFC incident, TDI conducted a voluntary survey of 95 Texas fertilizer facilities in June 2013 and requested the names of the companies that insure those facilities against general liability, property, and workers' compensation losses. TDI received 12 responses to the 95 inquiries. Although the number of responses does not suggest that the remaining fertilizer facilities are uninsured, there is no way to determine whether these facilities have insurance policies that incorporate audits and inspections to focus on safe FGAN storage and handling conditions.

On March 5, 2015, House Bill 2470 proposed amendments to the Texas Commercial Fertilizer Rules to require proof of liability insurance coverage for annual registration, similar to the requirements for amusement park rides. The bill proposed to amend the Texas Agriculture Code to require public liability insurance to produce, store, transfer, blend, or sell FGAN or FGAN-containing materials upon applying for a permit under the Texas Commercial Fertilizer Rules.[133] However, this bill did not pass the state legislature.

Without insurance and inspection requirements for FGAN facilities, operators can sell bulk quantities of fertilizer with little or no insurance coverage. The process of obtaining insurance could encourage both agricultural insurers and insured parties to assess current risks and to increase the awareness and rigor of insurance audits to ensure that companies are safely storing FGAN in accordance with guidance released as part of Executive Order 13650 (addressed in Section 8.1), OSHA standards, and industry consensus standards such as NFPA 400. Minimum coverage requirements will spur more realistic risk analysis by insurers that write coverage for FGAN bulk storage retail facilities. By providing agricultural businesses the guidance to identify and address FGAN hazards when underwriting and conducting annual loss control inspections, insurers can play a role in ensuring that FGAN facilities mitigate hazardous conditions.

[133] The required liability insurance policy proposed by HB 2470 afforded bodily injury and property damage protection in an amount determined by TDI to compensate a person who incurred damages as a result of FGAN operations. The bill also directed TDI to coordinate with the Texas State Fire Marshal, Department of Health Services, Office of the Texas State Chemist, and other agencies to study the risk exposure for FGAN activities to determine the appropriate requirements for a liability insurance policy.

5.6 Insurance Services Office Rating

The Insurance Services Office (ISO)[134] is an independent commercial enterprise and insurance industry advisory company that provides information, evaluation, and underwriting on safety and risk management related to community fire protection and building code effectiveness, serving insurance companies and other fire safety organizations. ISO adopts a public protection classification (PPC) system to develop fire insurance premiums for residential and commercial properties.[135]

ISO obtains information on municipal fire protection efforts in communities throughout the United States. Those data are then analyzed and evaluated for communities, using a standardized method and criteria known as the Fire Suppression Rating Schedule (FSRS). The FSRS assigns a PPC rating (from 1 to 10) to fire departments in each community. Class 1 represents exemplary public protection, and Class 10 indicates that the area's fire suppression program does not meet ISO minimum criteria. ISO develops a split classification; for example, 5/9. The first class (Class 5 in the example) applies to properties within 5 road miles of a fire station and within 1,000 feet of a fire hydrant. The second class (Class 9 in the example) applies to properties within 5 road miles of a fire station but farther than 1,000 feet from a hydrant. ISO generally assigns Class 10 to properties farther than 5 road miles from a fire station.

To determine a community's PPC, ISO conducts a field survey, with ISO staff members visiting the community to observe and evaluate features of the fire protection systems. Using the FSRS, ISO objectively evaluates three major areas: fire department,[136] water supply,[137] and fire alarm and communication systems.[138] When ISO allocates a high class rating to a fire department, ISO works with the affected fire department and the city to make improvements to the fire department, water system, and/or fire and alarm communication systems. Once these improvements are completed, the city then requests a new ISO reclassification. ISO reevaluates the city and then notifies the fire department of the new PPC rating. If a lower rating is received, the city notifies all homeowners and business owners to inform their insurance carriers to adjust their policies based on the new classification.

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[134] *See*: http://www.isomitigation.com/index.php/about-iso (accessed on January 7, 2016).

[135] Insurance companies often rely on information from ISO about a community's fire protection services to evaluate claims and damages.

[136] A review of the fire department accounts for 50 percent of the total classification. ISO focuses on a fire department's first-alarm response and initial attack to minimize potential loss. Here, ISO reviews items such as engine companies, ladder or service companies, distribution of fire stations and fire companies, equipment carried on apparatus, pumping capacity, reserve apparatus, department personnel, and training.

[137] A review of the water supply system accounts for 40 percent of the total classification. ISO reviews the water supply that a community uses to determine the adequacy for fire suppression purposes. It also considers hydrant size, type, and installation as well as the inspection frequency and condition of fire hydrants.

[138] An ISO review of the fire alarm system accounts for 10 percent of the total classification. The review focuses on the community's facilities and support for handling and dispatching fire alarms.

5.6.1 Impact of the City of West Class 5 ISO Rating on the West Fertilizer Company

According to the West Fire Department, ISO rated the city of West at Class 5 before April 17, 2013. The pre-incident ISO classification and PPC rating of the West Volunteer Fire Department (WVFD) placed the city of West among the top 25 percent of all Texas communities (Figure 58). The average classification rating for communities and fire departments in Texas is Class 7.

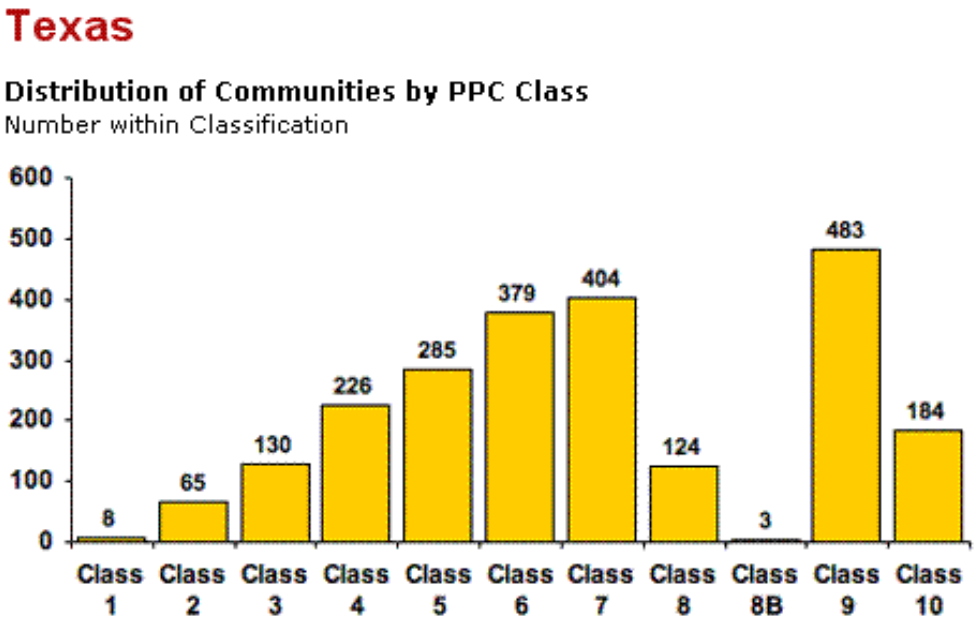

Figure 58. Distribution of ISO Class Ratings for Cities and Communities in Texas (Source: ISO)[139]

On the national scale, the average PPC for cities, fire departments, and communities in the United States is Class 7 (the same as the average for Texas). The current ISO rating of the WVFD places the city of West among the top 30 percent of all communities nationwide (Figure 59).

[139] *See*: http://www.isomitigation.com/index.php/ppc-program/how-the-ppc-program-works/facts-and-figures (accessed on December 20, 2015).

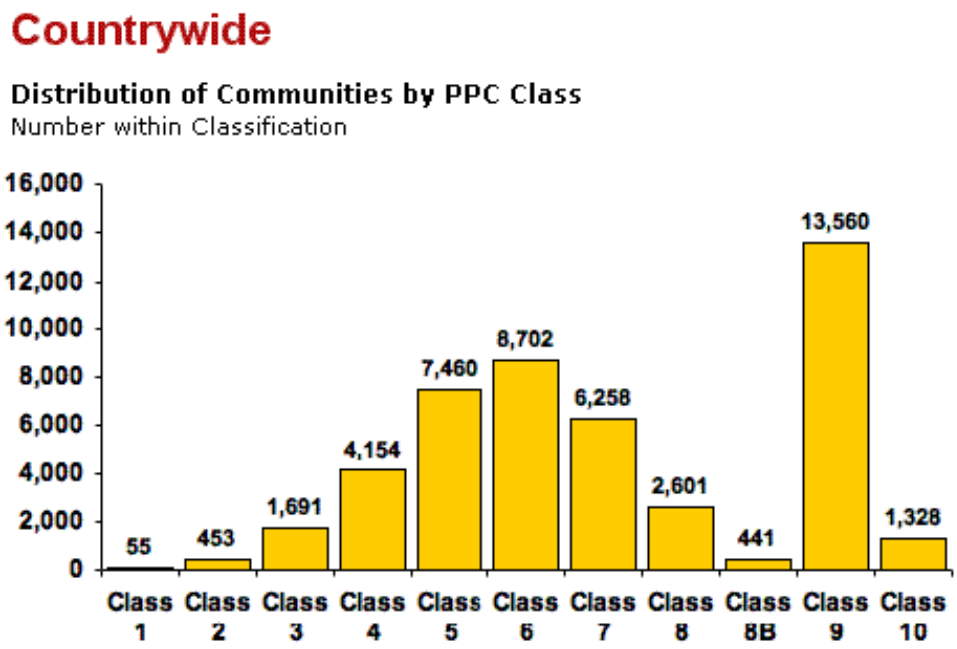

Figure 59. Distribution of ISO Class Ratings for All U.S. Cities and Communities (Source: ISO)[140]

Firefighters who responded to the WFC fire reported difficulty in extending their 4-inch fire hoses to the nearest fire hydrant, which was located at West High School, more than 1,500 feet from the burning fertilizer plant. A surviving firefighter testified that the emergency responders had to use one of their fire trucks as a connector line to reach the nearest fire hydrant at the high school. After dropping all of the hose lines on the engine, they discovered that they were about 700 feet short of the length needed to effectively fight the fire. Some of the volunteer firefighters then arranged to take the engine with hose and continue to string lines. One of the firefighters subsequently returned to the hydrant near the high school to attempt to establish a connection from the hose line to the fire hydrant. The explosion occurred just as the firefighter arrived at the fire hydrant, and he survived the explosion, although with severe injuries.

The WFC plant was not incorporated into the West city limits,[141] so an ISO assessment of the city of West did not capture the fertilizer plant as a high-risk facility. An ISO evaluation of the WFC plant would have increased the city's ISO rating and would have compelled the insured residents[142] and industrial facilities to carry higher homeowners and industrial hazard insurance premiums.[143] The WFC

[140] *Ibid.*
[141] Section 9 discusses land use planning and zoning.
[142] If the WFC plant had been included in the ISO rating, the city of West would have had a higher classification score, with an increased insurance premium for homeowners in West because of the proximity of the fertilizer plant to residential neighborhoods.
[143] The rating directly impacts the premiums that insurance companies charge for commercial and industrial facilities as well as homeowner's coverage. A lower ISO rating means a lower price for insurance coverage.

had insurance coverage of $1 million, without any prior evaluation from ISO. If ISO had evaluated the fertilizer plant, insurance underwriters would have charged a higher premium for the WFC plant based on the level of risks and hazards associated with the chemicals and operations at the WFC facility. Also, the ISO rating system would have revealed the distance from the nearest fire hydrant to the fertilizer plant, which would have increased the PPC rating. To obtain lower ISO PPC ratings, the city of West would have had to make adjustments by installing and regularly maintaining fire hydrants with ISO-minimum water flow rates closer to the fertilizer plant to enable ease of reach during emergencies.[144]

6.0 Inherently Safer Technology

FGAN has certain risk characteristics that can make it inherently dangerous under some conditions. Ammonium nitrate (AN) by itself is a powerful oxidizer; when mixed with fuel oil, it can be used as an industrial explosive when exposed to fire or shock. Traditional safety practices to control FGAN fire and explosion hazards through procedures, hazard awareness, and emergency response are important. However, applying the concept of inherently safer technology (IST) or inherently safer design (ISD) can substantially reduce risk.

IST and ISD are recognized approaches for decreasing risk by permanently reducing or eliminating the hazards associated with materials and operations used in an industrial process.[145] Trevor Kletz, an acknowledged expert on IST and chemical process safety, defined IST as the avoidance of hazards rather than the control of hazards by adding protective equipment.[146] Inherently safer processes can be achieved by strategies such as:

- Substituting dangerous chemicals or processes with safer alternatives.
- Simplifying processes.
- Minimizing the quantity of a chemical on hand or in a process.
- Moderating the operating conditions of a process.

Before the widespread adoption of IST, plant designs in the chemical industry tended to address reduction of risk by relying on layers of protective equipment, procedures, and alarms.[147] IST is preferable to adding layers of protection because, while this approach might reduce the likelihood or impact of an event, the inherent hazards remain.[148] The concept of IST can be derived from a list of strategies for

[144] To qualify for rating credit, fire hydrants must be capable of delivering a minimum of 500 gpm for 30 minutes.
[145] Center for Chemical Process Safety. *Inherently Safer Chemical Processes—A Life Cycle Approach*, Second Edition. New York: John Wiley & Sons, 2009.
[146] Kletz, Trevor A., and Paul Amyotte. *Process Plants: A Handbook for Inherently Safer Design*. Boca Raton, FL: CRC Press, 2009.
[147] Kletz, Trevor, and Paul Amyotte. *Process Plants: A Handbook for Inherently Safer Design*, Second Edition. Boca Raton, FL: Taylor & Francis, 2010.
[148] *Ibid*.

reducing risk (Figure 60). IST is most effective when implemented during the earliest stages of the process design, but it can be applied at all stages of a life cycle (design, operation, shutdown, and demolition).[149]

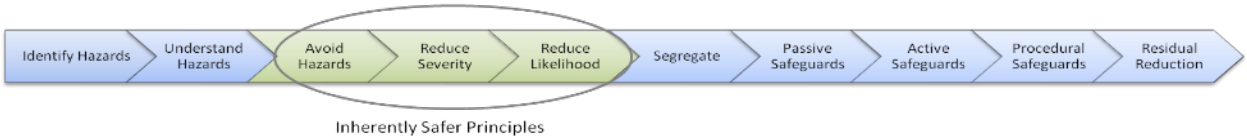

Figure 60. Risk Control Hierarchy (Source: CCPS)[150]

Table 6 lists some IST approaches that can be applied to FGAN.

Table 6. Inherently Safer Approaches for Handling FGAN[151]

Inherently Safer Strategy	**Description**	**Examples**
Substitution	Replacing a hazardous material with a safer option	Use a fertilizer with less explosive potential than FGAN
Minimization	Reducing the quantity of a hazardous material used in a chemical process	Store FGAN in purpose-built buildings holding smaller quantities of materials, well separated from one another and from potential sources of contamination
Moderation	Using a hazardous material under the least hazardous conditions	Store FGAN in bins constructed of materials impervious to the effects of AN and in areas where electric service is not required
Limitation of effects (a form of moderation)	Changing designs or reaction conditions rather than adding protective equipment	Construct FGAN storage bins to minimize the consequence of a possible explosion
Simplification	Eliminating process complexity to provide fewer opportunities for error and equipment failure	Limit the types of FGAN blends sold to minimize the need for staff to handle FGAN.

[149] National Research Council. *The Use and Storage of Methyl Isocyanate (MIC) at Bayer CropScience*. Washington, DC: The National Academies Press, 2012.
[150] Center for Chemical Process Safety. *Inherently Safer Chemical Processes—A Life Cycle Approach*, Second Edition. New York: John Wiley & Sons, 2009: 3, 27.
[151] *Ibid*.

Once all hazards associated with a chemical process are identified and understood, IST can be applied in the design phase or to existing processes. According to Kletz, the concepts of IST are not sharply defined and can merge into each other, depending on how they are applied.[152] Although not always feasible or cost-effective, substitution is often the most desired approach for reducing hazards because it involves replacing a hazardous material with a safer alternative. Minimization to reduce the quantity of a hazardous chemical stored or used within a process can often have a dramatic effect on risk, albeit usually only locally. The concept of moderation usually involves processing or storing chemicals under conditions that are less likely to add to or exacerbate risk—such as lower temperatures and pressures, removal of potential catalysts and sources of ignition, or use of materials of construction that minimize heat exposure near FGAN. In addition, the concept of simplification involves modifying procedures to reduce the likelihood of operator error and designing processes that require little or no operator actions to render the process safe in the event of a loss of control. The implementation of one or more of the inherently safer options, if feasible, can eliminate or minimize hazards instead of controlling them.

IST might not eliminate all risks associated with a process, and some apparently inherently safer options might introduce new hazards that are of greater concern than those eliminated. For example, a reduced quantity of a hazardous chemical at a plant can lead to greater risk in transportation systems or at the originating plant. Elimination of large FGAN inventories at facilities similar to the West Fertilizer Company (WFC) is impractical because farmers rely on large quantities of fertilizer for their crops. Lower inventories could potentially introduce new hazards from the larger number of FGAN shipments needed to supply storage facilities. Accordingly, before implementation, IST options must be thoroughly analyzed and assessed, considering all risks and not only the interests of an individual facility.

In terms of reducing the fire and explosion hazards associated with storage and handling of FGAN, two inherently safe measures are described in the rest of this section: (1) modify or substitute for the formulation of FGAN, making it less susceptible to fire or explosion, and (2) modify the conditions in which FGAN is stored to eliminate the possibility of a large fire and explosion.

6.1 Alternative Formulations of FGAN

An alternative formulation of FGAN could reduce the potential for a detonation under fire conditions. However, more testing is necessary to ensure that these formulations are safer in bulk quantities, agriculturally compatible, and environmentally acceptable. In response to the 1947 FGAN explosion in Texas City, Texas, and to subsequent AN-based bombings across the United States,[153] researchers have

[152] *Ibid*.

[153] Past AN-based bombings in the United States include the 1970 University of Wisconsin bombing, the 1990 Internal Revenue Service building bombing and other attempted bombings in California, the 1995 Murrah Federal Building bombing in Oklahoma City, and the 1996 attempted bombing of the FBI fingerprint database complex in Clarksburg, West Virginia.

explored several options for inerting or desensitizing FGAN to lower the detonation sensitivity of the material. One method introduced in 1968 claimed to render FGAN inert with the addition of 5 to 10 percent monoammonium phosphate and diammonium phosphate.[154] However, in 1995, a test showed that the mixture was detonable with a larger charge diameter than the initially presented charge.[155]

In 1997, the International Fertilizer Development Center conducted a study for ATF to study the feasibility, practicability, and impact of making nitrate-based fertilizer chemicals inert. The study concluded that it is not feasible to inert AN without adversely affecting its effectiveness and efficiency as a fertilizer.[156] In 1998, the National Research Council (NRC) released a report that addressed existing studies for inerting AN. The NRC examination concluded that FGAN with altered prill porosity, dilutants, or chemical additives could still be detonable[157] and that no current technology would reduce the risk without seriously affecting the utility of AN as a fertilizer.[158] The NRC recommends further examinations of the impacts of alternate formulations on agricultural suitability, costs to the end-user and environmental impacts of additives or inertants.[159] Large quantities of inert materials mixed with AN might not be practical because of the cost and the reduction in fertilizer effectiveness. Adding a percentage of another chemical to AN can make it safer, but farmers might need to buy and transport more fertilizer to deliver the same quantity of nitrogen to their crops.[160] CSB has reviewed documentation and publications that describe a few of those alternatives to AN based on the addition of inert chemicals (Table 7).

Table 7. Examples of AN Fertilizer Alternatives

Name	Method	Claims

[154] Porter, S.J. "Method of desensitizing fertilizer grade FGAN and the product contained," U.S. Patent 3,366,468, 1968.
[155] National Research Council. *Containing the Threat from Illegal Bombings: An Integrated National Strategy for Marking, Tagging, Rendering Inert, and Licensing Explosives and Their Precursors*. Washington, DC: National Research Council, 1998: 106. *See*: http://www.nap.edu/openbook.php?record_id=5966&page=106 (accessed on June 26, 2014).
[156] *See*: https://www.atf.gov/file/57516/download (accessed on January 20, 2016).
[157] National Research Council. *Containing the Threat from Illegal Bombings: An Integrated National Strategy for Marking, Tagging, Rendering Inert, and Licensing Explosives and Their Precursors*. Washington, DC: National Research Council, 1998: 106. *See*: http://www.nap.edu/openbook.php?record_id=5966&page=106 (accessed on June 26, 2014).
[158] *Ibid*.
[159] *Ibid.*
[160] Thompson, Steve. *Dallas News*. Quoting Bob Best, Pentagon scientist: "There are safer alternatives to FGAN fertilizer. But a safer form?" *See*: http://watchdogblog.dallasnews.com/2013/10/there-are-safer-alternatives-to-ammonium-nitrate-fertilizer-but-a-safer-form.html/ (accessed on June 26, 2014).

Sulf-N® 26[161] (ASN 26)	FGAN fused with ammonium sulfate[162]	The addition of ammonium sulfate dampens the role of FGAN combustion.[163]
Ferti-Safe[164]	Fly-ash-coated and gypsum-coated fertilizer	Detonation potential can be reduced or eliminated.
Calcium ammonium nitrate (CAN)	Mixture of FGAN and limestone (calcium carbonate) or dolomite (calcium magnesium carbonate)	Some tests revealed less oxidizing capability than FGAN. CAN is less prone to thermal decomposition than FGAN.

Honeywell has developed a fertilizer called Sulf-N 26 (later marketed by J.R. Simplot Company as ASN 26), claimed to be inherently safer than FGAN. Sulf-N 26 is made of nitrogen and sulfur[165] by fusing FGAN with ammonium sulfate (AS), a fire retardant. For the patent, tests were conducted according to United Nations Recommendations on the Transport of Dangerous Goods.[166] The test method is designed to measure the potential for a solid substance to increase the burning rate or burning intensity of a combustible substance when the two are thoroughly mixed. The mixture of FGAN fused with AS did not burn in the test, and the mixture was not classified as an oxidizer. Sulf-N 26 contains significantly less nitrogen than FGAN (26 percent compared to 34 percent).[167] This nitrogen level can be an issue for some farmers as the effective absorption rate of nitrogen is vitally important to plants. Sulf-N 26 also contains higher quantities of sulfur, which farmers can need for certain types of crops and soils but not for others. Further examination is necessary to fully assess the use of Sulf-N 26 as an inherently safer alternative to FGAN. Notably, a 50/50 mixture of AS and FGAN was involved in the 1921 Oppau, Germany, explosion.

Researchers from the University of Kentucky developed a technology called Ferti-Safe to desensitize FGAN by coating it with an ash-like coal combustion by-product.[168] They developed the technology with the intention of preventing the malicious use of FGAN for explosive devices. The Ferti-Safe formulation

[161] Sulf-N 26 was not commercially available at the time of the WFC incident.
[162] Honeywell. "Honeywell Sulf-N 26." *See*: http://sulfn26.com/ (accessed on June 26, 2014).
[163] *Ibid*.
[164] Ferti-Safe was not commercially available at the time of the WFC incident.
[165] Honeywell. "Honeywell Sulf-N 26." *See*: http://sulfn26.com/ (accessed on June 26, 2014).
[166] United Nations. Recommendations on the Transport of Dangerous Goods, Manual of Tests and Criteria, ST/SG/AC.10/11/Rev2, Section 34, Classification Procedures, Test Methods and Criteria Relating To Oxidizing Substances of Division 5.1, Test O.1: Test for Oxidizing Solids, 1995.
[167] Bomgardener, Melody M. "Safer Fertilizer," *Chemical and Engineering News*, December 6 (2011). *See*: http://cen.acs.org/articles/89/web/2011/12/Safer-Fertilizer.html (accessed on May-June 2015).
[168] Taulbee, D. et al. *Reducing the Explosion Potential of Ammonium Nitrate Fertilizer*, Final Report to the National Institute of Hometown Security, Lexington, KY (2012).

involves coating FGAN with gypsum (calcium sulfate) and fly ash.[169] Both coating options are claimed to be effective in stopping an explosion of a blend of ammonium nitrate/fuel oil (ANFO).[170]

Calcium ammonium nitrate (CAN) contains 26 percent nitrogen and about 25 percent inert calcium carbonate. Formulations of CAN have been used in Europe and other countries since the 1920s, but it is not manufactured in the United States. European safety data sheets state that CAN is not capable of self-sustaining progressive thermal decomposition.[171]

The scope of most existing studies on alternative forms of FGAN is focused on reducing or eliminating the security threats associated with using FGAN to construct improvised explosive devices with the addition of fuel oil, but such studies do not focus on FGAN used in agricultural operations. Although some of the available information on these options suggests that they might be inherently safer, only limited testing has been performed to characterize the behavior of the alternatives in fire situations similar to that at the WFC.

FGAN is vital to the nourishment of crops across the country, and alternative formulations must also be capable of meeting agricultural fertilizer needs. Because of the lack of scientific literature to show that alternative formulations of bulk FGAN can resist detonation in fires, CSB concludes that FGAN detonations can currently best be avoided through better compliance with storage practices and the application of inherently safe building design and storage.

6.2 Inherently Safe Building Design and Storage

In the United States, FGAN storage practices at facilities similar to the WFC have not significantly changed over time. Before the fires in Bryan, Athens, and West, these Texas FGAN facilities had similar construction, with combustible materials and construction and limited fire safety features. CSB visited another EDC facility in Itasca, Texas, in 2013 and also noted combustible construction for the storage facility and bins. Findings from the WFC incident demonstrate that inherently safer concepts can be applied to storage practices to significantly reduce the risk of a fire or explosion. Modifying existing facilities or constructing new storage facilities with inherently safe options—such as facility set-back distances and the use of noncombustible construction materials—can reduce such risks.

Because FGAN behavior is unpredictable in fire conditions, the most immediately effective strategy for reducing risk in existing and future FGAN storage facilities is to use inherently safer building design options to avoid creating the hazardous conditions that can contribute to a large uncontrollable FGAN fire and detonation. CSB concluded that the storage of combustible materials near FGAN storage piles and the use of combustible bins likely facilitated the spread of the FGAN-related fire to other bins and nearby

[169] Fly ash is a fine particle residue of coal combustion.

[170] Taulbee, D. et al. *Reducing the Explosion Potential of Ammonium Nitrate Fertilizer*, Final Report to the National Institute of Hometown Security, Lexington, KY (2012).

[171] *See*: http://www.eurochem.ru/wp-content/uploads/2012/08/SDB_27_KASweiss_0124_EU.pdf (accessed on January 7, 2016).

combustibles. The combustibles also likely acted as a fuel during the fire; the soot, creosote, and other contaminants from the burning wood materials mixed with the surface of the FGAN, potentially increasing its energy and sensitivity to detonation.

By eliminating wood and other combustibles as construction materials for FGAN bins and storage facilities and also for the storage of nearby combustible materials, the possibility of contaminating FGAN during a fire or smoldering event is greatly reduced. However, organic materials (such as packing materials or seeds) that are commonly present with the storage of bulk fertilizer will increase the likelihood of an explosion and will make the FGAN explosion more energetic. Certain inorganic contaminants, including chlorides and some metals (such as aluminum powder, chromium, copper alloys, cobalt, and nickel), can also sensitize FGAN, increasing the likelihood of detonation.[172] Current OSHA requirements in the Explosives and Blasting Agents standard in 29 CFR 1910.109(i) do not prohibit the use of wooden FGAN storage bins; instead, OSHA requires bins that are protected against FGAN impregnation (as noted in Section 8.2). The installation and use of concrete or metal[173] storage bins would reduce the potential for a fire to spread throughout the facility and to other piles of FGAN or nearby combustible materials.

It is also inherently safer to store FGAN in places where sources of ignition are not present. For example, a storage building without electric service eliminates the one of the possible sources of ignition and is thus inherently safer.

In July 2009, an FGAN-related fire at the EDC fertilizer storage facility in Bryan, Texas, burned the facility to the ground, but the FGAN did not explode. The fire forced an evacuation of more than 80,000 residents in the Bryan area and students at the Texas A&M College Station campus. EDC rebuilt the facility, originally a wooden structure, with concrete bins surrounded by a concrete dome (Figure 61). EDC's insurance company required the use of concrete construction materials instead of wood to minimize the fire risk.

[172] EPA. "EPA Chemical Advisory: Safe Storage, Handling, and Management of Solid Ammonium Nitrate Prills." *See*: http://www2.epa.gov/sites/production/files/2015-06/documents/an_advisory_6-5-15.pdf (accessed on November 30, 2015).

[173] Galvanized iron, copper or copper alloys, lead, and zinc are not recommended metals for AN storage.

Figure 61. Reconstructed EDC Facility in Bryan, Texas (Source: CSB)

Use of concrete bins or external metal hoppers instead of wooden structures is considered an inherently safer option for FGAN storage. According to Kletz, the IST concept of moderation entails storing or transporting a hazardous material in a less hazardous manner.[174] In this case, eliminating the presence of the combustibles removes an obvious and principal source of fuel and heat that contribute to detonation. Replacing bins with structures made of concrete instead of combustible materials also limits the quantity of FGAN available to support combustion by confining it to the bin and preventing the acceleration of a fire. It is well recognized that wood is not a preferred material of construction for buildings or bins storing FGAN, and untreated wooden bins should never be used to store FGAN because of the oxidizing properties of FGAN that will increase the burning temperature and rate of burn of the structure itself, facilitating the spread of a fire. Concrete or compatible metals should be used to avoid contamination during fires. The Health and Safety Executive in the United Kingdom states that FGAN storage "should be constructed of a material that does not burn, preferably concrete."[175]

In March 2014, CSB responded to OSHA's request for information (RFI) (at 78 *Federal Register* 73756) on future possible revisions to OSHA safety standards, including the Explosives and Blasting Agents standard in 29 CFR 1910.109(i) and the Process Safety Management standard in 29 CFR 1910.119. In response to the RFI, CSB urged OSHA to consider revising existing standards to provide more explicit requirements for the storage and handling of FGAN, including prohibiting wooden or combustible FGAN storage bins.[176] In May 2015, the NFPA issued a new edition of NFPA 400-2016, *Hazardous Materials Code* (Chapter 11, "Ammonium Nitrate"), which prohibits combustible construction materials for new FGAN storage facilities and establishes requirements for automated fire detection, fire suppression, alarm activation, and evacuation plans for existing facilities with combustible construction. CSB recommends that OSHA revise its standards to include requirements similar to those in NFPA 400-2016 for FGAN storage facilities to reduce the likelihood of a detonation when FGAN is exposed to fire.

7.0 Emergency Response

The FGAN explosion at the West Fertilizer Company (WFC) facility killed 15 people and caused more than 260 injuries. Of the 15 fatalities, 12 were first responders (firefighters and emergency services) personnel who responded to the fire—eight volunteer firefighters, with five from the West Volunteer Fire Department (WVFD), two from the City of Abbott Fire Department, and one from the Mertens and

[174] Kletz, Trevor, and Paul Amyotte. "Attenuation." *Process Plants: A Handbook for Inherently Safer Design*, Second Edition. Boca Raton, FL: CRC Press, 2010: 103.

[175] Health and Safety Executive (HSE). *Storing and Handling Ammonium Nitrate*. United Kingdom: Health and Safety Executive, 2004. *See*: http://www.hse.gov.uk/pubns/indg230.pdf (accessed on January 6, 2016).

[176] CSB. "CSB Comments on the OSHA Proposed Rule: Process Safety Management and Prevention of Major Chemical Accidents." *See*: http://www.regulations.gov/#!documentDetail;D=OSHA-2013-0020-0074 (accessed on November 30, 2015).

Navarro Mills Fire Department; an off-duty career firefighter (captain) from the City of Dallas Fire Department; an emergency medical technician (EMT) from West; and two good Samaritans who supported the emergency response at the fertilizer plant.[177] One of the deceased volunteer firefighters who responded to the fire was also an employee of the WFC.

CSB developed this section of our report to provide information to fire departments across the country by evaluating the key factors that contributed to the firefighter fatalities and to share lessons learned so that similar events can be avoided in the future. Accordingly, to determine what went wrong, CSB used emergency response documents, interviews, and video footage to analyze in detail the actions that were taken before and during the approximately 20 minutes that elapsed from the first call for assistance until the explosion occurred.

This analysis is not focused only on volunteer firefighters; it demonstrates the need for effective pre-incident planning and firefighter training. Firefighters are expected to make risk assessments and decisions under time pressure with limited visibility during an actual response to a fire, which is almost impossible without adequate training.

Although this analysis indicates that the emergency responders involved in this incident accepted an extremely high level of risk that resulted in multiple deaths, CSB recognizes that they were attempting to develop a plan of action for a fire scenario that none of them had prior practical experience with.

7.1 Firefighter Response

The chain of events—from the time the volunteer firefighters and other emergency responders arrived at WFC until the time of the explosion—can never be precisely known. On the basis of interviews with surviving firefighters and the evaluation of the incident scene, CSB was able to assess the emergency response process on April 17, 2013. On the evening of the incident, the emergency responders who were initially dispatched to the fire arrived at the scene at different times. CSB obtained a street surveillance camera video recording and also camera footage from the inside of a neighboring hardware store in West.[178] The surveillance recording indicated that four emergency response vehicles were en route between 7:37 pm and 7:51 pm, when the explosion occurred, as shown in the timeline of events in Figure 62.

[177] One of these Good Samaritans was familiar with the equipment used by the WVFD and volunteered to assist the second, who was in the area tending to cattle and offered his help to the firefighters. These two deceased Good Samaritans were made honorary volunteer firefighters at the memorial for the fallen West, Texas, firefighters and other emergency responders held in Waco, Texas, on April 25, 2013.

[178] The convenience store and street surveillance camera are located about a mile from the WFC facility at the intersection between East Pine Street and North Roberts Street.

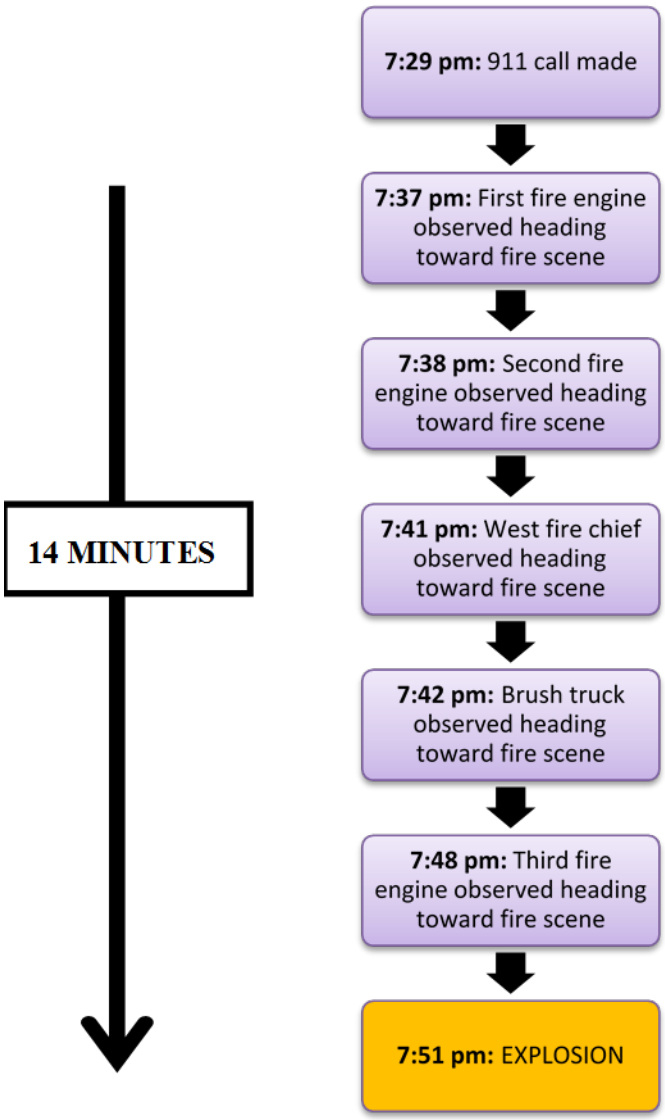

Figure 62. Timeline of Events for Emergency Response to WFC Facility (Source: CSB)

Emergency responders were notified and dispatched to the scene at about 7:29 pm on April 17. The firefighters arrived on scene over a span of about 14 minutes, as recorded on surveillance footage of emergency vehicles en route to the WFC site that night.[179] In the video footage, the WVFD fire chief can be observed driving the water tender toward the incident scene at about 7:41 pm. Firefighters were dispatched to the scene of the emergency without anyone's knowledge of how long the fire had been

[179] Because the WVFD is a volunteer-based service, it should be noted that the volunteer firefighters were not at the station at the time of the incident. Several firefighters were at home, attending to other personal activities or participating in an EMT training class.

burning or smoldering before being noticed.[180] Upon arrival, they concentrated their efforts initially on the incident scene, preparing to suppress flames that were visible at the northeast portion of the storage structure. Without a robust incident pre-planning process in place, without adequate hazardous materials awareness training, and with no previous FGAN-related fire emergency training or drills, the firefighters had no expectation of a possible FGAN explosion. The firefighters were advised by the career fire captain that they did not have the resources to combat the growing fire and should concentrate on cooling the liquid anhydrous ammonia tanks located near the burning building to prevent the tank from rupturing or venting. However, they had not established that stream of water when the explosion occurred because they had to shut off the attack lines while the pumpers were repositioned.[181]

7.2 Key Contributing Factors to Emergency Responders' Fatality

CSB identified the following seven key factors that contributed to the fatalities of firefighters and other emergency responders in West:

1. Lack of incident command system.
2. Lack of established incident management system.
3. Lack of hazardous materials (HAZMAT) and dangerous goods training.
4. Lack of knowledge and understanding of the detonation hazards of FGAN.
5. Lack of situational awareness and risk assessment knowledge on the scene of an FGAN-related fire.
6. Lack of pre-incident planning at the WFC facility.
7. Limited and conflicting technical guidance on AN.

7.2.1 Lack of Incident Command System

CSB found that none of the responding emergency response personnel trained and certified in the National Incident Management System (NIMS) process formally assumed the position of Incident Commander (IC) who would have been responsible for conducting and coordinating an incident command system (ICS). Senior emergency response personnel at the WVFD arrived at the scene of the WFC incident at different times and did not delegate an IC to be in charge of the incident. Also, there was no record that arriving firefighters conducted an initial incident size-up or risk assessment to determine initial actions (offensive or defensive) that would be most suitable in responding to the incident based on the situation and available resources without putting emergency personnel at risk.

Despite multiple responders having ICS training, none of them reportedly established command or took control of the fire ground. On the basis of a review of radio communications and interviews with surviving firefighters, CSB found no clear messaging or discussion among the responding firefighters on who should assume the role of the designated IC. Without a delegated IC officially taking control of the

[180] CSB was unable to determine how long the fire had been burning before the firefighters were notified.
[181] NIOSH Fire Fighter Fatality Investigation and Prevention Program. *See*: http://www.cdc.gov/niosh/fire/ (accessed on December 28, 2015).

fire ground operations, no ICS was established. Consequently, no senior emergency response personnel or IC was responsible for coordinating the various response activities carried out by individual firefighters on the scene. The West fire chief arrived on scene at about 7:41 pm and did not critically assess the conditions on the ground before the explosion 10 minutes later, at about 7:51 pm. The fire chief and assistant chief provided support and advisory functions but did not actively engage in fire ground function or take control of the fire ground; no record indicated that the West fire chief took command of the incident upon his arrival.[182] Without direction to the contrary, the firefighters immediately took offensive action against the flames coming from the doors on north end of the east side of the structure. CSB interviews with surviving firefighters indicated that before the arrival of the fire chief, the other senior firefighters who had reached the incident scene about six minutes earlier had not delegated senior personnel with the training and expertise needed to formally assume responsibility as the IC. The firefighters had not reached a conclusion about how to establish a best approach and how to respond to the fire when the explosion occurred. Despite being trained for the ICS and NIMS process, none of the certified firefighters had prior practical experience in establishing incident command or coordinating and maintaining control of any previous emergency that merited the same approach as an FGAN-related fire scene.

7.2.2 Lack of Established Incident Management System

CSB found that the emergency response personnel who responded to the WFC incident did not take time to set up, implement, and coordinate an effective incident management system plan that would have ensured evacuation of the nearby residents. Because no formal IC was in charge of the incident, none of the firefighters took responsibility for formally establishing and coordinating an effective incident management system.

Witness testimonies revealed that emergency alert systems for the public were not activated before the explosion, although McLennan County had such systems in place.[183] Many of the injuries might have been avoided or might have been less severe if an immediate evacuation had occurred. When the fire was first detected by a police officer, he ordered people in the parks near the facility to evacuate, and he blocked off roads. In addition, employees from the nursing home took the initiative as part of their company emergency response policy to move occupants to the back of the building for fear of smoke or an ammonia release. However, without a formal evacuation order to the entire affected community, many of the residents were left unaware of the risk and chose to watch the fire from inside their homes or vehicles or from the street, placing them within range of the high-pressure blast wave and in the line of flight of debris. In a study conducted after the WFC incident of FGAN-related fires worldwide since

[182] NIMS requires that the ICS should be established by the first arriving NIMS qualified personnel. Best practices indicate that the fire chief does not need to be on the scene of a fire before the ICS can be established.
[183] See Section 8.5 of this report.

1970, the majority of detonations occurred within 60 minutes of the initial fire report.[184] Because this elapsed time to detonation might be shorter than the response times for emergency operations and potential firefighting, a 'let-it-burn' approach with a precautionary evacuation of the surrounding neighborhood is appropriate.[185]

An incident management system is intended to provide a standard approach to management of emergency incidents. The U.S. Department of Homeland Security (DHS) established NIMS in 2004.[186] NFPA 1561 (2014 Edition) indicates, "[T]he incident management system shall provide structure and coordination to the management of emergency incident operations to provide for the safety and health of emergency services organization responders and other persons involved in those activities."[187] DHS developed the NIMS program to standardize the incident management process by facilitating coordination of an emergency among all responders (including all levels of government and public, private, and nongovernmental organizations) so that they work together seamlessly and manage incidents involving threats and hazards (regardless of cause, size, location, or complexity) to reduce loss of life, property damage, and harm to the environment. To achieve this objective, FEMA, an organization within DHS, developed a NIMS training program.[188] All federal emergency responders, including firefighters, are required to receive NIMS training.[189] Presidential Policy Directive 5, which established the NIMS training program, applies to all federal agencies, and non-federal entities, although not required to participate, are encouraged to do so.[190]

NFPA 1500 (*Standard on Fire Department Occupational Safety and Health Program*, 2013 Edition[191]) and NFPA 1561 (*Standard on Emergency Services Incident Management System and Command Safety*, 2014 Edition[192]) emphasize the need to use effective incident management systems at all emergency

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[184] Marlair, G., et al. Comments about the paper entitled "Lessons to be Learned from an analysis of ammonium nitrate disasters in the last 100 years," by Pittman et al., *Journal of Hazardous Materials* 280 (2014).
[185] *Ibid.*
[186] *See*: https://www.fema.gov/national-incident-management-system (accessed on December 28, 2015).
[187] NFPA. *NFPA 1561: Standard on Emergency Services Incident Management System and Command Safety*, 2014 Edition. Quincy, MA: NFPA, 2014.
[188] The NIMS training program specifies National Integration Center and stakeholder responsibilities and activities for developing, maintaining, and sustaining NIMS training. The NIMS training program outlines responsibilities and activities that are consistent with the National Training Program, as mandated by the Post-Katrina Emergency Management Reform Act of 2006. This program integrates with FEMA training offered through the Emergency Management Institute (EMI) and USFA. *See*: http://www.fema.gov/pdf/emergency/nims/nims_training_program.pdf (accessed on December 28, 2015).
[189] *See*: https://www.fema.gov/national-incident-management-system/training (accessed on December 28, 2015).
[190] To compel non-Federal entities seeking grants, FEMA does require its grant recipients to verify that they are "NIMS-compliant." However, there is no requirement for fire services not receiving federal grants to participate in NIMS. *See*: https://www.fema.gov/pdf/emergency/nims/nims_training_program.pdf (accessed on December 28, 2015).
[191] NFPA. *NFPA 1500: Fire Department Occupational Safety and Health Program*, 2013 Edition. Quincy, MA: NFPA, 2013.
[192] NFPA. *NFPA 1561: Standard on Emergency Services Incident Management System and Command Safety*, 2014 Edition. Quincy, MA: NFPA, 2014.

scenes. In most cases, this process is known as the ICS, with the primary objective of managing the incident. NFPA 1561 defines an incident management system as "a system that defines the roles and responsibilities to be assumed by responders and the standard operating procedures to be used in the management and direction of emergency incidents and other functions."

CSB concluded that despite multiple personnel in the WVFD being trained and certified to initiate and manage the NIMS process, none of the certified firefighters who responded to incident was designated to assume or assumed the role of IC to initiate and coordinate the ICS and incident management plan as stipulated in the NIMS process. If the West firefighters had executed a planned, tested, and practiced ICS and incident management plan, the number of injuries and casualties sustained by both responders and neighboring residents could have been reduced.

7.2.3 Firefighter Training

Firefighters must cope with extraordinary situations and circumstances that threaten their personal safety. To improve execution and reduce the threat of injury or loss of life, it is vital for both volunteer and career firefighters to receive thorough training and information supporting effective decision making. CSB's investigation of the WFC incident revealed that no standardized training requirement applies to volunteer firefighters across the nation.[193]

The NFPA has found that, in general, career firefighters have more funding from their local municipalities and thus are often better trained and better equipped compared to volunteer or hybrid fire departments across the country.[194] In some communities, volunteer firefighters receive training in formal or informal settings; however, this training hinges on the state and regulatory authority, and the level and type of this basic and specialty training are not standardized. Some VFDs provide training programs equal to those of paid departments, but most volunteer firefighters either pay out of pocket or raise funds to pay for any additional specialty training. Such specialty training can address wildland firefighting, technical rescue, swift water rescue, HAZMAT response, vehicle extrication, and firefighter assist and search teams.

CSB found that since there is no federal agency regulating municipal fire departments, some volunteer firefighters in less populated areas or rural communities rarely receive any major type of course training, and most of their initial training is usually on-the-job experience.[195] In addition, some volunteer

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[193] Career firefighters have a standardized basic minimum training requirement.

[194] In its report *A Third Needs Assessment of the U.S. Fire Service*, the NFPA found that compared to their big city counterparts, fire departments in smaller communities were more likely to report that many firefighters had not had formal training in various activities and did not have sufficient PPE. *See*: http://www.nfpa.org/~/media/files/research/nfpa-reports/fire-service-statistics/2011needsassessment.pdf?la=en (accessed on December 28, 2015).

[195] Many volunteer firefighters near special or large manufacturing and storage facilities do receive training from the facility staff. This observation is particularly true when the volunteers include employees of the facility.

firefighters receive EMT[196] and fire academy training.[197] After completing the EMT and fire academy training, most firefighters are required to earn state certification. To maintain additional professional competency, some volunteer firefighters become state certified, but they must meet the same levels of requirements as those that apply to career firefighters.

For example, in Texas, the general requirements for volunteer fire protection personnel certification programs are the same as those for paid personnel. Certification for paid fire protection personnel in Texas is mandatory, but for volunteer fire protection personnel, participation in a certification program is voluntary and not enforced.[198] Texas does not require volunteer firefighters to receive a minimum level of training on how to respond to fires involving hazardous materials. In some cases, volunteer firefighters receive first-level certification, which gives an overview of fire suppression and rescue techniques, including HAZMAT and jaws-of-life training.

NFPA 1001 *(Standard for Fire Fighter Professional Qualifications*, 2013 Edition[199]*)* provides recommended basic and minimum training requirements that all firefighters are expected to complete to respond to fire emergency calls. Once the basic training requirement has been met, the subsequent level of training differs between paid career and volunteer firefighters. In Texas, paid career firefighters are required to complete about 500 hours of training certification over four levels—introduction, basic, immediate, and advanced—through an academy-type program. Training and certification for volunteer firefighters are provided through the State Firefighters' and Fire Marshals' Association of Texas (SFFMA).[200] The SFFMA sets up standards for training and certification, but local jurisdictions are left to decide how many firefighters should be sent for particular training and the level of certification needed to protect their respective localities. For example, VFDs in rural areas and sparsely populated communities might require their firefighters to be certified only at the introductory level because few

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[196] Some firefighters are mandated to receive certification as an EMT. The general EMT-Basic training requires about 100 hours of classroom or field instruction, usually involving some hours of practice in a hospital or ambulance. At the end of the training, EMT-Basic students must take and pass an examination. Firefighters seeking additional training may enroll in the EMT-Intermediate class or the Advanced EMT class, which includes an additional 1,000 hours of education in advanced medical emergency response and care. *See*: http://work.chron.com/certifications-need-become-firefighter-17338.html (accessed on December 28, 2015).

[197] The fire academy training program prepares firefighters for state firefighter certification. The fire academy program involves the completion of classes in the fire science program. Other courses administered in the fire academy program for entry-level firefighters address building codes, emergency medical procedures, and prevention techniques. In addition, the programs train students to fight fires with standard equipment, such as fire extinguishers, ladders, axes, and chainsaws. *See*: http://work.chron.com/certifications-need-become-firefighter-17338.html (accessed on December 28, 2015).

[198] *See*: http://www.tcfp.texas.gov/certification/certification_overview.asp (accessed on December 28, 2015).

[199] NFPA. *NFPA 1001: Standard for Fire Fighter Professional Qualifications*, 2013 Edition. Quincy, MA: NFPA, 2013.

[200] According to its website, the SFFMA was established in 1876 to support fire and emergency service providers in Texas and beyond. The SFFMA offers support to more than 1,200 fire departments, 22,000 individual members, 80 industrial fire brigades, and EMS and international departments. *See*: http://www.sffma.org/web/SFFMA/About_Us/SFFMA/About.aspx?hkey=84e079d0-75c2-47df-b9e9-7ae03d5685dd (accessed on December 28, 2015).

buildings are in the area. In contrast, other towns or communities (such as West) that are near a chemical plant might require their firefighters to receive HAZMAT training and certification.

7.2.4 Firefighter FGAN Knowledge and Lack of HAZMAT Training

CSB determined that lack of knowledge and understanding of FGAN detonation hazards at the WFC facility contributed to the emergency responder fatalities. Interviews with surviving firefighters indicated that they did not have sufficient time and information to properly assess the WFC facility and evaluate the behavior of the FGAN-related fire. Because the firefighters did not have adequate knowledge of the FGAN hazard, they focused their emergency response efforts on the anhydrous ammonia tanks. The lack of adequate HAZMAT training and the lack of FGAN firefighting guidance contributed to the deaths of the emergency responders.

A joint NFPA-USFA survey revealed that an estimated 36 percent of U.S. fire departments involved in HAZMAT responses have not provided formal training in those duties to all involved personnel.[201] CSB reviewed the training and experience of the firefighters who were fatality injured in the WFC incident and found that all of the responding firefighters had minimum training and certifications for responding to fire emergencies, especially training through FEMA courses.[202] In addition, very few of the volunteer firefighters involved in this explosion, including surviving officers, had received HAZMAT training. Only two of the deceased volunteer firefighters had taken the HAZMAT awareness course, which is the introductory basic level for HAZMAT training and includes recognition and use of the *Emergency Response Guidebook* (ERG) as well as notification protocols.[203] Table 8 shows the age, rank, function at the scene, and training and experience levels of the victims.

Table 8. Training and Experience Information of the Fatally Injured Firefighters[204]

Victim	Rank	Age	Years of Experience	Training	Function on Scene
1	Firefighter	48	15 years with WVFD	Landing zone safety, propane emergency response, fire and emergency management services emergency response, HAZMAT awareness, ladder practices, hose handling, live burns, basic self-contained breathing apparatus (SCBA), Introduction to Incident	Dispatched to incident site by WVFD

[201] NFPA, USFA. "Four Years Later: A Second Needs Assessment of the U.S. Fire Service." *See*: www.usfa.fema.gov/downloads/pdf/publications/fa-303-508.pdf (accessed on December 28, 2015).
[202] *See*: https://training.fema.gov/is/crslist.aspx?all=true (accessed on December 28, 2015).
[203] NIOSH. "9 Volunteer Fire Fighters and 1 Off-Duty Career Fire Captain Killed by an Ammonium Nitrate Explosion at a Fertilizer Plant Fire–Texas." *NIOSH Report on Death in the Line of Duty.* Report Number F2013-11. *See*: http://www.cdc.gov/niosh/fire/pdfs/face201311.pdf (accessed on December 28, 2015).
[204] *Ibid*.

Victim	Rank	Age	Years of Experience	Training	Function on Scene
				Command System (ICS-100),[205] ICS for Single Resources and Initial Action Incidents (ICS-200),[206] National Incident Management System (NIMS): An Introduction (IS-700),[207] National Response Framework: An Introduction (IS-800b)[208]	
2	Career Fire Captain (off duty)	52	31 years with career fire department	31 years as a career firefighter from Dallas (Training status unknown)	Responded voluntarily to assist WVFD
3	Firefighter	26	2 years at mutual aid VFD	ICS-100, ICS-200, IS-700a, NIMS Multiagency Coordination System (MACS) Course (IS-701a),[209] NIMS Public Information Systems (IS-702a),[210] NIMS Resource Management (IS-703a)[211]	Dispatched for mutual aid
4	Firefighter	37	17 years at mutual aid VFDs[212]	Emergency vehicle operations, basic auto extrication, compressed air foam systems,[213] basic firefighting, ICS-100, ICS-200, IS-700a, IS-800.b, HAZMAT I & II,[214] Various training classes offered by TEEX and other departments since 1996.[215]	Responded in privately owned vehicle (POV); dispatched for mutual aid
5	Volunteer Captain	29	10 years at mutual aid VFD	Training status unknown	Attending EMT class nearby. Dispatched for mutual aid; responded in POV

[205] *See*: https://training.fema.gov/is/courseoverview.aspx?code=IS-100.b (accessed on December 28, 2015).
[206] *See*: https://training.fema.gov/is/courseoverview.aspx?code=IS-200.b (accessed on December 28, 2015).
[207] *See*: https://training.fema.gov/is/courseoverview.aspx?code=IS-700.a (accessed on December 28, 2015).
[208] *See*: https://training.fema.gov/is/courseoverview.aspx?code=IS-800.b (accessed on December 28, 2015).
[209] *See*: https://training.fema.gov/is/courseoverview.aspx?code=IS-701.a (accessed on December 28, 2015).
[210] *See*: https://training.fema.gov/is/courseoverview.aspx?code=IS-702.a (accessed on December 28, 2015).
[211] *See*: https://training.fema.gov/is/courseoverview.aspx?code=IS-703.a (accessed on December 28, 2015).
[212] Training information provided to the CSB by victim's family.
[213] *Ibid.*
[214] *Ibid.*
[215] *Ibid.*

Victim	Rank	Age	Years of Experience	Training	Function on Scene
6	EMT, Firefighter	33	1 year at mutual aid VFD	Training status unknown	Attending EMT class nearby. Rode in city ambulance
7	On E-1 Firefighter	41	2 years with WVFD	Basic auto extrication, emergency driving, landing zone safety, ICS-100, IS-700a	Responded on Engine 1
8	Firefighter	50	13 years with city VFD	Fire and EMS emergency vehicle response, landing zone safety, ground cover (basic and intermediate), EMS emergency vehicle response, vehicle extrication, propane ER, fire and EMS ER, Intro to IC, HAZMAT awareness, fire emergency vehicle response, ladder practices, hose handling, live burns, basic SCBA, ICS-100, ICS-700a, IS-800b	Drove the brush truck
9	Volunteer Captain	50	18 years with WVFD	Basic firefighting, propane emergency response, ICS-100, IS-700a	Responded in POV
10	Firefighter	29	3 years with WVFD	Firefighting phase 1, emergency driving, basic auto extrication, landing zone safety, SCBA and smokehouse training, ICS-100, ICS-200b, Intermediate ICS for Expanding Incidents (ICS-300),[216] Advanced ICS (ICS-400),[217] IS-700a, IS-701a, IS-702a, IS-703a, NIMS Communication and Information Management (IS-704), NIMS Intrastate Mutual Aid: An Introduction (IS-706),[218] IS-800b	Drove in Engine 1

Texas provides voluntary certification for HAZMAT technicians and HAZMAT ICs through the Texas Commission on Fire Protection (TCFP).[219] The TCFP was established under Texas Government Code, Chapter 419, to develop and enforce recognized professional standards for individuals and the fire service.[220] In addition, the TCFP provides education and assistance to the fire service and enforces

[216] Intermediate ICS for Expanding Incidents (ICS-300) provides training and resources for personnel who require advanced knowledge and application of the ICS. This course expands on information covered in the ICS-100 and ICS-200 courses. *See*: http://training.fema.gov/emiweb/is/icsresource/trainingmaterials.htm (accessed on December 28, 2015).

[217] The Advanced ICS (ICS-400) course provides training and resources for personnel who require advanced application of ICS. This course expands on information covered in ICS-100 through ICS-300. *See*: http://training.fema.gov/emiweb/is/icsresource/trainingmaterials.htm (accessed on December 28, 2015).

[218] *See*: https://training.fema.gov/is/courseoverview.aspx?code=IS-706 (accessed on December 28, 2015).

[219] *See*: http://www.tcfp.texas.gov/certification/certification_requirements.asp (accessed on December 28, 2015).

[220] *See*: http://www.statutes.legis.state.tx.us/Docs/GV/htm/GV.419.htm (accessed on December 28, 2015).

statewide fire service standards. The TCFP is responsible for certification, training approval, and testing and compliance.[221]

CSB evaluated the curriculum manual used for HAZMAT certification for firefighters in Texas and found that FGAN explosion hazards were not covered at all. In fact, the manual mentioned FGAN twice under United Nations (UN)/DOT hazard classes and divisions of hazardous materials and weapons of mass destruction (WMD)—as a Class 1, Division 1.5 insensitive explosive[222] and as a Class 5, Division 5.1 oxidizing substance[223]—in the 349-page document.[224]

Nationally, CSB found that the curriculum used for HAZMAT training does not fully address the hazards and severity of FGAN-related fires and explosions. A review of the U.S. Fire Administration (USFA) National Fire Academy HAZMAT field course outlines confirmed that they place little emphasis on emergency response to storage sites containing dangerous reactive chemicals and oxidizers such as FGAN. Conversely, HAZMAT shipping and transportation are covered in detail in the courses. A review of one firefighter training reference manual, *Fundamentals of Firefighter Skills*, compiled by the International Association of Fire Chiefs (IAFC) and the NFPA, indicated that very little guidance is provided to firefighters regarding responses to HAZMAT incidents involving reactive chemicals. Chapter 29 ("Hazardous Materials: Recognizing and Identifying the Hazards") of the second edition of the *Fundamentals of Firefighter Skills* reference manual includes in-depth information on various HAZMAT transportation methods and containers but does not consider storage and warehousing for these materials. FGAN is not mentioned in the entire chapter.[225]

CSB concludes that the current training resources at the local, state, and federal levels do not provide sufficient information for firefighters to understand the hazards of FGAN. It is therefore essential for firefighter and emergency response training institutions to collaborate with fire departments to develop and implement a realistic process for ensuring that hazard response knowledge, once attained, does not become unused and obsolete.[226]

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[221] TCFP. *See*: http://www.tcfp.texas.gov/about/mission_and_goals.asp (accessed on December 28, 2015).

[222] AN is mentioned as FGAN fertilizer and fuel oil mixtures (ANFO), an example of a very insensitive explosive with a mass explosion hazard (blasting agent) under Division 1.5 (Explosives). Chapter 6, "Hazardous Materials Awareness." *United Nations/Department of Transportation (UN/DOT) Hazard Class and Division of Hazardous Materials and Weapons of Mass Destruction (WMD), Class 1*. Section 601: 3. *See*: http://www.tcfp.texas.gov/manuals/curriculum_manual/chapter_6.pdf (accessed on December 28, 2015).

[223] AN is mentioned as an example of a Division 5.1 oxidizing substance under U.N./DOT Hazard Class 5. Chapter 6, "Hazardous Materials Awareness," Section 601: 4. *See*: http://www.tcfp.texas.gov/manuals/curriculum_manual/chapter_6.pdf (accessed on December 28, 2015).

[224] TCFP. Chapter Six, "Hazardous Materials." *Certification Curriculum Manual*, effective on June 1, 2010. Based on NFPA 472 (2008 Edition). *See*: http://www.tcfp.texas.gov/manuals/curriculum_manual/chapter_6.pdf (accessed on December 28, 2015).

[225] NFPA, IAFC. *Fundamentals of Fire Fighter Skills*, 2nd Edition. Burlington, MA: Jones & Bartlett Publishers, 2008.

[226] Hazard response knowledge must be retained, and an effective retraining process must be put in place to prevent the loss of its organizational value.

7.2.5 Lack of Situational Awareness and Risk Assessment Knowledge

Although many firefighter training courses provide overviews of initial fire scene size-up, assessment, incident planning, and execution, CSB found that none of the firefighter HAZMAT field training courses provide sufficient information on firefighter situational awareness and risk assessment that could help them make informed decisions while at the fire scene.[227,228] The firefighters who initially responded to WFC did not have the tools to effectively perform the situational awareness and risk assessment that would have enabled them to make an informed decision to not fight the fire. Situational awareness in firefighting involves the capability to "read" the scene of a fire or emergency, including changes in the behavior of a fire. Effective situational awareness supports prompt decision making to either evacuate the scene of a fire or continue fighting the fire by taking a defensive or offensive stance. Chapter 4 of NFPA 472 (*Standard for Competence of Responders to Hazardous Materials/Weapons of Mass Destruction Incidents*, 2013 Edition) provides guidance on situational awareness competencies for responder-level personnel.[229]

In fires involving HAZMAT, it is not always possible for firefighters to obtain needed information before acting, but they might be able to characterize a HAZMAT incident based on initial information acquired from the emergency call center and dispatcher; emergency response manuals and guides; knowledge base on the response area; and visual, auditory, and olfactory (odorous) clues. In some cases, the fire department's standard operating procedures (SOPs) and the level of training of the emergency response crew might be insufficient to respond at the incident scene to changing events and scenarios that were not planned for or anticipated—hence, the need for effective training on situational awareness and risk assessment.

Clearly written SOPs would afford fire department trainees the opportunity to read and understand the operational procedures of their fire department. The NIOSH Alert, "Preventing Injuries and Deaths of Fire Fighters," emphasizes the need for departments to establish and adhere to the firefighting policies and procedures stipulated in the SOPs.[230] NFPA 1500 (*Fire Department Occupational Safety and Health Program*, 2013 Edition[231]) emphasizes the need for development of a risk management plan, including risk identification of actual and potential hazards. In addition, it states that "fire departments shall prepare and maintain policies and standard operating procedures that document the organizational structure, membership, roles and responsibilities, expected functions, and training requirements." NFPA 1500 also

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[227] NFPA, IAFC. *Fundamentals of Fire Fighter Skills*, 2nd Edition. Burlington, MA: Jones & Bartlett Publishers, 2008.

[228] Texas Commission on Fire Protection. Chapter Six, "Hazardous Materials." *Certification Curriculum Manual*, effective on June 1, 2010. Based on NFPA 472 (2008 Edition). *See*: http://www.tcfp.texas.gov/manuals/curriculum_manual/chapter_6.pdf (accessed on December 28, 2015).

[229] NFPA. *NFPA 472: Standard for Competence of Responders to Hazardous Materials/Weapons of Mass Destruction Incidents*, 2013 Edition. Quincy, MA: NFPA, 2013.

[230] *See*: http://www.cdc.gov/niosh/docs/2005-132/pdfs/2005-132.pdf (accessed on December 28, 2015).

[231] NFPA. *NFPA 1500: Fire Department Occupational Safety and Health Program*, 2013 Edition. Quincy, MA: NFPA, 2013.

provides guidance on the procedures to initiate and manage operations at the scene of an emergency incident. Moreover, NFPA 1561 (*Standard on Emergency Services Incident Management System and Command Safety*, 2014 Edition) states that "SOPs shall include the requirements for implementation of the incident management system and shall describe the options available for application according to the needs of each particular situation."[232]

Firefighting environments are inherently unpredictable, volatile, and fraught with risk.[233] It is therefore important for decisions to be made in a context of changing priorities, uncertain information, and limited resources. Firefighters must be able to rapidly size up[234] any situation and create scenarios (or what-ifs) to make quick and informed decisions and predict the nature and behavior of a fire. NFPA 472 (*Standard for Competence of Responders to Hazardous Materials/Weapons of Mass Destruction Incidents*, 2013 Edition) offers guidance on competencies for ICs. Scene size-up is essential in any emergency situation, especially for HAZMAT incidents.[235] This approach includes a thorough overall assessment of the scene and the identification of all possible hazards to ensure the safety of the emergency response crew. CSB concluded that training references and guides on emergency response do not address how to effectively respond to AN-related fires.

7.2.6 Lack of Pre-Incident Planning at Facility

The fire department did not have a formal pre-incident planning program for FGAN at WFC. Firefighters responding to the incident were aware of the risks associated with anhydrous ammonia leaking from the tanks and that it could form a toxic flammable cloud that could leave the facility, drift into nearby homes, and potentially explode. Although some responding firefighters knew that FGAN was onsite, they did not anticipate a possible FGAN explosion. Some of the West fire department officials reported that they were aware of the chemicals routinely stored at the WFC, but there was never any formal training to prepare for a fire or chemical emergency. Effective site-specific pre-incident planning for emergency responders is essential to guide initial and subsequent actions while responders are at an emergency. Onsite pre-incident planning might have identified the possible FGAN explosion hazard. CSB did not find evidence of regularly scheduled training exercises to ensure that the WVFD conducted incident pre-planning and facility tours to address fire safety and chemicals onsite.

A pre-incident plan must provide clear information on the magnitude of hazards in a chemical plant or business. A competent incident commander (IC) or designated authority must be capable of executing the pre-incident plan, including analyzing the incident, planning the response, implementing the planned

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[232] NFPA. *NFPA 1561: Standard on Emergency Services Incident Management System and Command Safety*, 2014 Edition. Quincy, MA: NFPA, 2014.
[233] Flin, R. *Sitting in the Hot Seat: Leaders and Teams for Critical Incident Management*. Chichester: Wiley, 1996.
[234] Incident size-up uses ongoing processes of information gathering and analysis that will help the firefighters make quick and informed decisions concerning how better to respond to the incident.
[235] NFPA. *NFPA 472: Standard for Competence of Responders to Hazardous Materials/Weapons of Mass Destruction Incidents*, 2013 Edition. Quincy, MA: NFPA, 2013.

response, evaluating progress, retreating from the incident, and terminating the response. The NFPA [236] provides guidance on developing an effective incident response plan methodology for emergency responders.[237] NFPA 472 (*Standard for Competence of Responders to Hazardous Materials/Weapons of Mass Destruction Incidents*, 2013 Edition[238]) provides guidance on the competencies required for hazardous materials responders (including the IC) involved in pre-incident planning and execution of the plan.

The pre-incident plan also must be effectively communicated to other external emergency units in the surrounding areas for times when these agencies are called on for mutual aid. In addition, a pre-incident plan must be systemic and must include a realistic exit and evacuation strategy, especially when a decision is made to not take offensive action at a hazardous materials incident.

Pre-incident planning must include all of the HAZMAT onsite. Plans must be put in place to address how to effectively respond to an emergency. NFPA 1620 (*Standard for Pre-Incident Planning*, 2015 Edition) states that the pre-incident plan "shall identify and document any special hazards recognized by the authority having jurisdiction that present extraordinary life safety challenges, operations challenges, or other challenges to emergency responders."[239] NFPA 1620 further states that the "pre-incident plan should be the foundation for decision making during an emergency situation and provides important data that will assist the IC in developing appropriate strategies and tactics for managing the incident." This standard also states that the "primary purpose of a pre-incident plan is to help responding personnel effectively manage emergencies with available resources." Pre-incident planning involves evaluating the protection systems, building construction, building contents, and operating procedures that can affect emergency operations.

NFPA 1620 outlines the steps involved in developing, maintaining, and using a pre-incident plan by isolating the incident into pre-incident, incident, and post-incident phases. In the pre-incident phase, for example, the guidance covers factors such as physical elements and site or occupant considerations, protection systems, water supplies, hydrant locations, and special hazard considerations. Building characteristics—including type of construction, materials used, occupancy, fuel load, roof and floor design, and unusual or distinguishing characteristics—should be recorded, shared with other departments that provide mutual aid, and entered into the dispatcher's computer if possible so that the information is readily available if an incident is reported at the noted address.

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[236] The NFPA, a nonprofit standards organization, has been developing standards since 1896 that directly affect fire services at the department level. The NFPA produces more than 300 consensus codes and standards intended to minimize the possibility and effects of fire and other risks. The codes are voluntary standards that industry can adopt and that regulatory agencies can enforce once the codes are signed into law. Standards are an attempt by an industry or profession to self-regulate by establishing minimal operating, performance, or safety criteria. *See*: http://www.nfpa.org/about-nfpa (accessed on December 28, 2015).

[237] CSB referred to the most current edition of the NFPA codes and standards throughout this report.

[238] NFPA. *NFPA 472: Standard for Competence of Responders to Hazardous Materials/Weapons of Mass Destruction Incidents*, 2013 Edition. Quincy, MA: NFPA, 2013.

[239] NFPA. *NFPA 1620: Standard for Pre-Incident Planning*, 2015 Edition. Quincy, MA: NFPA, 2015.

An adequate pre-incident plan must include, at a minimum, specific tested and practiced procedures for responding to an emergency at a given facility; a list of potential HAZMAT such as FGAN, including the quantity of each chemical that may be onsite; details on HAZMAT handling and storage; chemical locations at a particular site; the likely behavior of chemicals in a fire, flood, or other emergency; worst case scenario regarding how these chemicals might behave or interact in an emergency; the Safety Data Sheet (SDS)[240] for each of the HAZMAT; and specific recommendations on how to respond to a fire when these chemicals are involved.

Before the incident, the WVFD did not conduct a pre-inspection for an FGAN-related fire emergency. In most cases, a site-specific pre-incident plan would be developed in partnership with each chemical plant or chemical business in the response jurisdiction. Although WFC reported the quantity and location of each of its hazardous chemicals, including FGAN, to the WVFD, no mechanism ensured that pre-incident drills or inspections were conducted. Although the firefighters in West conducted some onsite anhydrous ammonia drills, none of the drills or training focused on the potential of an FGAN-related fire emergency.

A fire pre-plan would enable firefighters to determine various situations where conditions could dramatically change in a burning structure. This information would enable them to consider the hazards associated with each site. Also, the pre-incident plan could provide this advanced information, which might have aided the WVFD in developing a response strategy or might have facilitated a decision to stand down and allow the structure to burn to the ground if no lives were endangered by doing so. Whether a volunteer fire department (VFD) has pre-incident plans in place often depends on the individual fire department. Currently, no federal agency regulates municipal fire departments in the United States. Although the U.S. Congress funded the National Institute for Occupational Safety and Health (NIOSH) in 1998 to establish the Fire Fighter Fatality Investigation and Prevention Program, NIOSH only investigates on-the-job firefighter fatalities and makes recommendations for improvements to the profession. NIOSH lacks authority to enforce regulations or mandate firefighter training requirements.[241]

7.3 Limited and Conflicting Technical Guidance on FGAN

Firefighters might not have at their fingertips all of the hazard information regarding the chemicals that can be found in their communities. Regardless of the instant availability of information on the hazards of a specific chemical, firefighters are required to respond immediately upon dispatch and are expected to

[240] An SDS is a document developed by the manufacturer of a hazardous chemical product that communicates the hazards of the product. It is required under OSHA's Hazard Communication Standard. Under this standard, all chemical manufacturers, distributors, or importers must provide to downstream users an SDS for each hazardous chemical. Previously, SDSs were known as Material Safety Data Sheets (MSDS); however, in 2012, the name underwent a change when OSHA decided to modify the Hazard Communication Standard to adopt the U.N. Globally Harmonized System.

[241] NIOSH Fire Fighter Fatality Investigation and Prevention Program. *See*: http://www.cdc.gov/niosh/fire/ (accessed on December 28, 2015).

make prompt decisions. To make effective decisions in fire emergencies, some fire prevention and emergency response stakeholders have developed technical manuals and guidebooks. These guidebooks help emergency responders and firefighters to better understand chemical hazards. References include the Emergency Response Guidebook (ERG), SDSs, and NFPA standards.[242] Although firefighting manuals support the prevention of injuries and fatalities, CSB found conflicting information and inconsistencies in various emergency response guidelines.

7.3.1 Emergency Response Guidebook

The ERG is a readily available and widely used guidebook among the emergency response community. Formerly known as the DOT ERG, this document is now jointly produced by DOT, Transport Canada, and the Secretariat of Communications and Transportation (Mexico). The current ERG is designed as a resource for first responders to consult during the initial phase of a dangerous goods or HAZMAT transportation incident. Emergency response personnel (such as firefighters, EMTs, and police officers) in the United States, Canada, Mexico, and other countries use the ERG when responding to transportation emergencies involving HAZMAT. In most cases, firefighters who complete HAZMAT courses, the most basic of which is Awareness Level training, are expected to be familiar with the ERG. Figure 63 shows the 2012 edition of the ERG.

[242] Annex E of NFPA 400 (2013 Edition) also provides AN firefighting guidance. NFPA. *NFPA 400: Hazardous Materials Code*, 2013 Edition. Quincy, MA: NFPA, 2013.

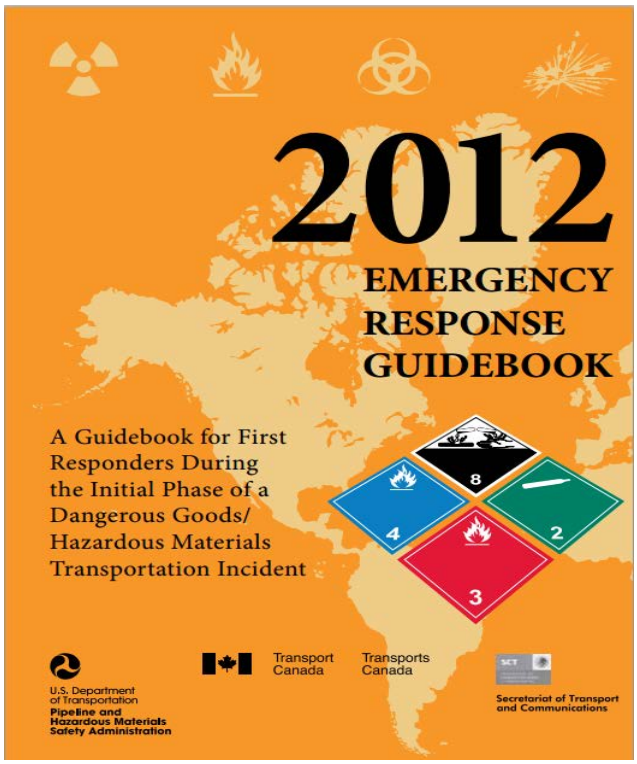

Figure 63. Cover Page of 2012 Edition of ERG (Source: DOT PHMSA)[243]

Most firefighting apparatuses have a copy of the ERG.[244] After the WFC incident, NIOSH investigators found copies of the 2012 ERG in the glove boxes of some of the damaged fire equipment and apparatuses.[245] However, CSB does not have any evidence that indicates whether the West firefighters consulted the ERG on the night of the explosion. The ERG is especially useful in situations when the relevant SDS is not readily available to firefighters.

The ERG gives direction (based on DOT Hazard Classification Criteria) on response to HAZMAT and dangerous goods emergencies during transportation. It does not provide any specific guidance on the

[243] DOT Pipeline and Hazardous Materials Safety Administration (PHMSA). *See*: http://phmsa.dot.gov/pv_obj_cache/pv_obj_id_7410989F4294AE44A2EBF6A80ADB640BCA8E4200/filename/ERG2012.pdf (accessed on December 28, 2015).

[244] DOT. *The Emergency Response Guidebook: A Guidebook for First Responders During the Initial Phase of a Dangerous Goods/Hazardous Materials Transportation Incident (ERG)*, 2012 Edition. *See*: http://phmsa.dot.gov/staticfiles//PHMSA/DownloadableFiles/Files/Hazmat/ERG2012.pdf (accessed on December 28, 2015).

[245] NIOSH. "9 Volunteer Fire Fighters and 1 Off-Duty Career Fire Captain Killed by an Ammonium Nitrate Explosion at a Fertilizer Plant Fire–Texas." *NIOSH Report on Death in the Line of Duty*. Report Number F2013-11. *See*: http://www.cdc.gov/niosh/fire/pdfs/face201311.pdf (accessed on December 28, 2015).

handling of ammonium fertilizer.[246] In fact, the ERG includes the following commentary under the heading of its 2012 Edition:

> This guidebook will assist responders in making initial decisions upon arriving at the scene of a dangerous goods incident. It should not be considered as a substitute for emergency response training, knowledge or sound judgment. ERG2012 does not address all possible circumstances that may be associated with a dangerous goods incident. It is primarily designed for use at a dangerous goods incident occurring on a highway or railroad. Be mindful that there may be limited value in its application at fixed facility locations.[247]

The current edition of the ERG lists 15 variations of FGAN. Next to each FGAN variant is a guide number that leads to information on the potential hazard and the appropriate emergency response, but the suggested measures are broad and subject to varying interpretations.

On October 1, 2014, CSB provided comments on a DOT request for information (RFI), "Hazardous Materials: Revision of Emergency Response Guidebook" (FR Doc. 2014-20683), which was published on August 29, 2014.[248] CSB commented as follows:

> The ERG is intended for incidents involving the transport of hazardous materials and is limited to the size of the transportation containers involved.[249] However, the CSB has found in several investigations[250] that the ERG manual was used by emergency responders for incidents involving chemical fires, explosions and releases of hazardous materials at fixed facilities. Incidents at fixed facilities may involve larger quantities of hazardous materials as well as additional hazards involving process conditions or other hazardous chemicals stored nearby, resulting in higher risk to emergency responders. The directions regarding response to a chemical release or fire incident intended for transportation may be different when applied to an incident at a fixed chemical or manufacturing facility. For this reason, the CSB suggests that the DOT consider additional language to clarify ERG's use limitations at fixed facilities.

CSB also urged DOT to highlight in bold text on the front cover page of the next edition of the ERG: "Only Intended for Use When Responding to Transportation Incidents." Realizing that emergency

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[246] The ERG provides some information and guidance on handling Division 5.1 oxidizers.

[247] DOT. *The Emergency Response Guidebook: A Guidebook for First Responders During the Initial Phase of a Dangerous Goods/Hazardous Materials Transportation Incident (ERG)*, 2012 Edition: 356. *See*: http://phmsa.dot.gov/staticfiles//PHMSA/DownloadableFiles/Files/Hazmat/ERG2012.pdf (accessed on December 28, 2015).

[248] *See*: http://www.csb.gov/csb-recommends-safety-improvements-to-us-department-of-transportation-emergency-response-guidebook-widely-used-by-firefighters/ (accessed on December 28, 2015).

[249] *See*: http://www.csb.gov/assets/1/7/DOT_ERG__RFI10_1_14.pdf (accessed on December 28, 2015).

[250] Technics, Inc., 2003. *See*: http://www.csb.gov/technic-inc-ventilation-system-explosion/ (accessed on December 28, 2015);
DuPont Belle, 2010. *See*: http://www.csb.gov/dupont-corporation-toxic-chemical-releases/ (accessed on December 28, 2015);
Millard Refrigerated Services, 2010. *See*: http://www.csb.gov/millard-refrigerated-services-ammonia-release/ (accessed on December 28, 2015);
AL Solutions, 2010. *See*: http://www.csb.gov/al-solutions-fatal-dust-explosion/ (accessed on December 28, 2015).

responders will continue to reference the ERG for incidents involving HAZMAT releases at fixed facilities, CSB suggested that DOT consider adding guidance such as the information that first responders should obtain and reference when responding to an incident at a fixed facility, such as the company SDSs and submitted Tier II information.[251] CSB advised that such guidance also should be in the front section of the ERG (for example, on pages 1 and 2). In addition, CSB suggested that DOT move the user's guide from page 356 to page 1 or 2 of the next ERG edition to provide users with earlier guidance.

CSB also urged DOT to take the following actions:

- Review and revise the ERG to remove generic and vague information in the emergency response section of Guide 140 and other ERG sections.
- Include a statement that urges emergency responders to reference other sources in addition to the ERG to obtain more detailed instructions when responding to emergency incidents at fixed facilities. First responders should obtain and refer to the company SDSs or submitted Tier II information when responding to an incident at a fixed facility. This information should also be in the introduction of the ERG (for example, on pages 1 and 2).
- Revise the ERG to address the unpredictable behavior of fires involving FGAN and the potential for detonation within a very short time frame. DOT should consider recommending a more conservative response to fires involving FGAN by emphasizing firefighter and resident evacuation when the threat is to human lives rather than property.
- Revise Guide 140 to include a separate discussion of the properties and behaviors unique to FGAN (such as the potential for detonation within a very short time frame) that might differ from those of other oxidizers covered by Guide 140.

On its website, DOT provided a preview of updates for the 2016 Edition of the ERG.[252] The link to the ERG updates provided by DOT showed that the review working group on the ERG had made the following changes:

- Replaced written instructions on page 1 with a flow chart to show how to use the new ERG (2016).
- Expanded the Table of Placards and updated the title to Table of Markings, Labels, and Placards and Initial Response Guide to Use on Scene.
- Expanded the Railcar Identification Chart and the Road Trailer Identification Chart to two pages each.
- Updated Table 1 and Table 3 based on new toxic inhalation hazard (TIH)[253] data and reactivity research.

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[251] Additional information on Tier II information is noted in Section 8.5 of this report.

[252] DOT. "Preview of Updates for the ERG 2016." *See*: http://www.phmsa.dot.gov/pv_obj_cache/pv_obj_id_CDF7F93A3E0C2F808D9EA09C262749DAEF400200/filename/ERG2016_Preview.pdf (accessed on December 28, 2015).

[253] TIH is the abbreviation for toxic inhalation hazard. Under the Hazardous Materials Regulations (HMR), 49 CFR Parts 171–180, TIH materials are gases or liquids that are known (or presumed on the basis of tests) to be so toxic to humans as to pose a hazard to health in the event of a release during transportation. *See*:

- Updated pipeline emergency response information.
- Added information about Globally Harmonized System of Classification and Labeling of Chemicals (GHS) markings.
- Added all new dangerous goods and HAZMAT listed in the U.N. Recommendations on the Transport of Dangerous Goods, 19th Revised Edition.
- Added information on emergency response assistance plans applicable in Canada.

Also, DOT provided a snapshot of the cover page of the 2016 edition of the ERG (Figure 64) on its website.

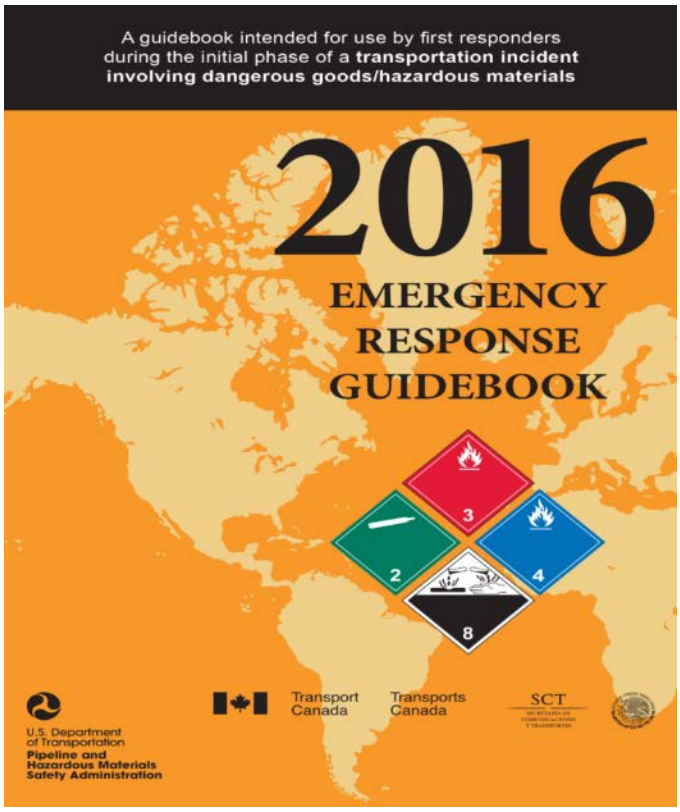

Figure 64. Cover Page of 2016 Edition of ERG (Source: DOT PHMSA)[254]

CSB noticed (from the preview of the 2016 edition of the ERG), that DOT and other authors of the ERG moved the warning statement, "A Guidebook for First Responders During the Initial Phase of a Dangerous Goods/Hazardous Materials Transportation Incident" from the left side of the cover page of the 2012 edition to the top of the cover page, as recommended by CSB. However, DOT and other authors

https://www.federalregister.gov/articles/2004/08/16/04-18705/hazardous-materials-enhancing-rail-transportation-security-for-toxic-inhalation-hazard-materials (accessed on January 20, 2016).

[254] *See*: http://www.phmsa.dot.gov/staticfiles/PHMSA/ImageCollections/Images/ERG2016_Cover.png (accessed on December 28, 2015).

of the ERG did not include the statement "Only Intended for Use When Responding to Transportation Incidents" in bold on the front cover page of the 2016 edition of the ERG, as suggested by CSB in its response to the DOT RFI for the ERG revision.[255] Instead, DOT and other ERG authors modified the statement "A Guidebook for First Responders During the Initial Phase of a Dangerous Goods/Hazardous Materials Transportation Incident" to "A guidebook intended for use by first responders during the initial phase of a **transportation incident involving dangerous goods/hazardous materials**."[256] Note that "transportation incident involving dangerous goods/hazardous materials" is in bold on the cover page of the 2016 edition of the ERG.

7.3.2 Safety Data Sheets

CSB did not find any record that the WVFD consulted the SDS for FGAN and other chemicals present at the WFC facility during the incident. After the incident, CSB reviewed the SDS (that was current at the time of the WFC incident) provided by CF Industries and EDC, the manufacturers of the FGAN used at the WFC. The CF Industries SDS for FGAN (SDS Number 004) provided guidance on FGAN hazards in the December 11, 2012, revision of the SDS.[257] Under the Hazards Identification, Emergency Overview heading (item three, page 1), CF Industries described FGAN:

> Strong oxidizer. Contact with combustible material will increase fire hazard. May undergo detonation if heated under confinement causing pressure buildup or if subjected to strong shocks. Solid AN when sensitized or during decomposition may become unstable and/or explosive. When AN is heated to decomposition it may produce vapor which contains nitrogen oxides (NO_X). AN is an oxidizer and as such may increase the flammability and/or explosiveness of other substances. Use water to control fires involving AN, if water is compatible with burning material. AN itself is non-flammable. AN can cause irritation to eyes and skin and may be an inhalation discomfort in confined locations.[258]

Under the Firefighting Measures heading (item five, page 3), CF Industries noted:

> Flood burning ammonium nitrate fertilizer with large volumes of low pressure water. Do not use salt water, carbon dioxide, dry chemicals or foam extinguishers. Never attempt to smother fire, such as by sealing off, closing a compartment or building doors when fire occurs. Do not add steam. Ammonium nitrate fertilizer does not have the property of spontaneous combustion. Fire fighters should wear approved self-contained breathing apparatus to protect themselves from the

[255] *See*: http://www.csb.gov/csb-recommends-safety-improvements-to-us-department-of-transportation-emergency-response-guidebook-widely-used-by-firefighters/ (accessed on December 28, 2015).

[256] *See*: http://www.phmsa.dot.gov/staticfiles/PHMSA/ImageCollections/Images/ERG2016_Cover.png (accessed on December 28, 2015).

[257] CF Industries has since removed its December 11, 2012, SDS for FGAN from its website. CF industries replaced the December 11, 2012, SDS for FGAN with a revised and updated SDS for FGAN (April 23, 2013). *See*: http://www.cfindustries.com/pdf/Ammonium-Nitrate-Amtrate-MSDS.pdf (accessed on January 20, 2016). On May 15, 2015, CF Industries published its current SDS for Amtrate FGAN fertilizer, which supersedes every other SDS. *See:* http://www.cfindustries.com/pdf/Amtrate_AN_Fertilizer_SDS_NA_FINAL.pdf (accessed on December 28, 2015).

[258] CF Industries LLC. "Safety Data Sheet, FGAN." SDS Number 004, revised December 11, 2012.

> toxic fumes of decomposing ammonium nitrate, and protective clothing to guard against molten nitrate splashes should also be worn.[259]

This SDS for FGAN referred to NFPA 400 (*Hazardous Materials Code*, 2013 Edition) under its section on handling and storage but not in its section on firefighting measures. Although Chapter 11 of NFPA 400 provided some recommendations for safe storage, handling, and use of AN, it did not include any specific guidelines on FGAN firefighting measures. Annex E of NFPA 400 outlined some general procedures and suggestions on firefighting for FGAN incidents. Section E.2.1 of Annex E of the 2013 edition of NFPA 400 states:

> [S]hould a fire break out in an area where FGAN is stored, it is important that the mass be kept cool and the burning be promptly extinguished. Apply large volumes of water as quickly as possible. If fires reach massive and uncontrollable proportions, fire-fighting personnel should evacuate the area and withdraw to a safe location.[260]

Also, Section E.2.2 of NFPA 400 suggested the provision of as much ventilation as possible to the fire area.[261] Although the FGAN SDS provided by CF Industries contained some useful insights and guidance on how to respond to FGAN-related fires, it did not clearly define "a distance" from which a fire could be "flooded" (one of the special firefighting procedures) and did not specify what "volumes of low pressure water" would be needed.

CSB compared the firefighting measures in the CF Industries and EDC SDS with those in the SDS provided by a similar large technical grade AN (TGAN) manufacturer (Orica)[262] and with those in the current edition of the DOT ERG (Table 9).

Table 9. Comparison of Various AN-Related Firefighting Measures in April 2013

EDC SDS (FGAN)	**CF Industries SDS (FGAN)**	**Orica AN SDS (TGAN)**	**DOT ERG (2012 Edition)**
If confined when an ignition occurs, an explosion may occur.	FGAN may undergo detonation if heated under confinement.	FGAN may explode under confinement and high temperature.	FGAN may explode from heat or contamination.
Flood with water.	Flood fire area from a distance.	Fires should be fought from a protected location.	Flood large fire with water from a distance.

[259] *Ibid*.
[260] NFPA. *NFPA 400: Hazardous Materials Code*, 2013 Edition. Quincy, MA: NFPA, 2013.
[261] *Ibid*.
[262] According to its website, Orica is the largest provider of commercial explosives and blasting systems to the mining and infrastructure markets, a global leader in the provision of ground support in mining and tunneling, and a leading supplier of sodium cyanide for gold extraction. *See*: http://www.orica.com/About-Us#.VlXviHarSUk (accessed on December 28, 2015).

Firefighters should wear proper protective equipment and self-contained breathing apparatus.	For massive fires, use unmanned fire nozzles; if this is impossible, withdraw from area, and let burn.	A major fire may involve a risk of explosion.	For massive fire, use unmanned hose holders or monitor nozzles; if this is impossible, withdraw from area and let fire burn.

These examples of guidance for fighting fires involving FGAN illustrate hazards that were broadly defined and were not clearly communicated to emergency responders. The use of vague and broad terminologies in some of the guidelines compared in Table 9 indicates that the behavior of FGAN under heat and confinement is not clearly understood because no standardized methods are used to communicate the hazards of FGAN and possible firefighting procedures to emergency responders. Also, terms such as "massive," "major," "large," "protected location," and "distance" were not clearly defined in the guidelines. The CF Industries SDS and the ERG suggested "flooding" a fire involving FGAN from a distance, and the Orica SDS suggested fighting such fires from a "protected location." The EDC SDS instructed firefighting personnel to flood with water but did not address the need to extinguish fires from a distance or to evacuate under massive fire situations. In these guidelines, the safe distance or protected location is not clearly defined. Hence, a firefighter must make a judgment to determine which location or area is protected, which distance is safe enough to fight a fire involving FGAN, how much water is needed for flooding, and which fire is massive or major**.** Unfortunately, firefighters are often forced to make these decisions without adequate training, information, preparation, and pre-planning. The WFC incident highlighted the need for greater awareness of FGAN hazards. In response to the 2013 explosion, EDC updated its SDS to include more information about the explosive hazards of AN and information for firefighters. The revised EDC SDS now advises firefighters to fight AN fires remotely because of the risk of explosion. If an AN-containing structure is fully engulfed in flames, firefighters are instructed not to fight the fire and to evacuate the surrounding area to at least a one-half-mile radius.[263]

7.4 Lessons Not Learned and Lessons Learned

7.4.1 Pre-West-Incident FGAN-Related Fires and Explosions: Lessons Not Learned

CSB found that lessons learned from previous firefighter fatalities and emergency responses to FGAN-related incidents were not effectively disseminated to firefighters and emergency responders in other communities where FGAN is stored or used. Had those lessons been applied to the very similar situation

[263] *See*: www.eldoradochemical.com/MSDS_Sheets/EDC/EDC_Products/EDCC_AN_Prill_SDS_Information_Bulletin_Nov_2014.pdf (accessed on December 28, 2015).

in West, the firefighters and emergency responders might have better understood the risks associated with FGAN-related fires.

Although the firefighters in West knew of the hazards associated with the tanks of anhydrous ammonia as a result of previous releases, they were not alert to the explosion hazard from the FGAN inside the warehouse. Although FGAN itself does not burn, the conditions under which AN might detonate when exposed to fire are unpredictable and not clearly understood, and current guidance does not offer consistent advice on how to attempt to guarantee firefighter safety. The deaths of the volunteer firefighters and emergency responders in West was not the first time that firefighters have been killed when responding to FGAN-related explosion incidents.

On April 16, 1947, a ship containing 7,000 tons of wax-coated FGAN[264] exploded in the port of Texas City, Texas, killing 581 people, including all 26 Texas City firefighters who responded to the incident.[265]

The November 29, 1988, Kansas City, Missouri, ammonium nitrate/fuel oil (ANFO) incident, although not directly related to an FGAN fire, is worth mentioning because of its severity, the important lessons learned from the incident, and its implication for emergency response. Six firefighters from the Kansas City, Missouri, fire department were killed in an explosion while they were extinguishing a fire at a construction site.[266] About 40 minutes later, a second explosion occurred, followed by several minor explosions. Investigators later learned that after the first explosion, the battalion chief immediately pulled back and prevented other firefighters from entering the area. A command post was set up at a safe distance, which ultimately prevented more firefighter casualties. The initial fire involved a trailer/magazine containing blasting mixtures of FGAN, fuel oil, and aluminum pellets. One end of the trailer contained approximately 3,500 pounds of ANFO mixture while the remainder of the load was approximately 17,000 pounds of ANFO mixed with 5 percent aluminum pellets. In addition, a second explosion rocked another trailer/magazine loaded with approximately 1,000 30-pound sacks of ANFO mixture with 5 percent aluminum pellets.[267]

Both explosions in Kansas City created large craters where the two trailers had been parked, similar to the impact of the explosion in West. The first trailer explosion produced a swimming-pool-like crater that

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[264] Although the Texas City incident involved a form of wax-coated FGAN that is no longer manufactured for fertilizer purposes and a form of strong confinement (the locked hull of a ship), the lessons of confinement were developed and incorporated into industry guidance after the Texas City incident.

[265] *See*: https://www.txdps.state.tx.us/dem/temo/archives/2013/Vol60No4/Articles/article2.htm (accessed on December 28, 2015).

[266] The Texas City incident is discussed in this section to indicate that firefighters have lost their lives in the past because of a lack of pre-incident planning, inadequate training and information, and erroneous knowledge of the hazards with which they were dealing. The same observation applied to Kansas City, even though it was an ANFO incident; firefighters were not equipped with the right information and had inadequate knowledge of the hazards of the explosive material (ANFO) that they dealt with that evening, and they lost their lives as a result.

[267] USFA. "Six Firefighter Fatalities in Construction Site Explosion; Kansas City, Missouri." Technical Report Series," USFA-TR-024, November 1988. *See*: http://www.usfa.fema.gov/downloads/pdf/publications/tr024.pdf (accessed on January 20, 2016).

was 80 feet in diameter with a depth of 8 feet, connected to a smaller crater that was 20 feet in diameter and 6 feet deep. The second trailer explosion gouged a crater approximately 100 feet in diameter and 8 feet deep, similar in dimensions to the crater resulting from the explosion in West, Texas. The Kansas City incident investigation determined that the firefighters were not told specifically about the contents of the trailer/magazine, although the dispatcher did caution them about explosives on the site. The firefighters did not report any indication of the presence of warning placards on the trailers because there was no requirement by firefighters to report the presence or absence of warning placards over the radio upon their arrival at a scene of a fire. Also, it was not clear whether the firefighters realized that the trailers housed an explosive magazine.[268]

No record of communication among the dispatch official, fire chief, and firefighters indicated that the firefighters knew the contents of the magazine, and the firefighters did not seem alarmed when they arrived at the site. In addition, the fire department was not aware of the presence of the trailers/magazines or their contents before the incident because of a lack of jurisdictional authority. The Kansas City Fire Prevention and Protection Code did not require the city engineer to notify the fire department that blasting permits had been issued, although this provision was changed immediately after the incident. The Kansas City Fire Department had no authority or responsibility to inspect the construction site because it was a state enclave.[269]

Shortly after the Kansas City explosions, the USFA produced a technical report (USFA-TR-024/November 1988)[270] with findings of its investigation and lessons learned. Although the fertilizer-related incidents in Texas City and West did not involve explosives per se, the Kansas City incident further illustrated that the lack of knowledge about the stored HAZMAT and the lack of pre-incident planning by firefighters before their response led to the fatalities. Most of the recommendations based on lessons learned emphasized the need to be properly prepared through pre-incident planning and through the provision of clear information to firefighters and emergency responders dealing with fires involving HAZMAT.

CSB observed that within the last 6 years, three notable FGAN-related incidents in Texas involved emergency responders. Subsequently, CSB reviewed the emergency response activities associated with the FGAN-related fires that occurred in 2009 at the EDC facility in Bryan, Texas, and in 2014 at the East Texas Ag Supply facility in Athens, Texas.

On Thursday, July 30, 2009, at about 11:40 am CDT, a fire broke out at the EDC facility in Bryan. The EDC facility stores FGAN and blends it with other materials to create fertilizer. The fire at the EDC fertilizer plant led to the evacuation of more than 80,000 residents in the Bryan and College Station area.

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[268] An explosive magazine is an enclosed storage structure for holding explosives.
[269] A state enclave is any portion of a state that is completely surrounded by the territory of another state.
[270] USFA. "Six Firefighter Fatalities in Construction Site Explosion; Kansas City, Missouri." Technical Report Series," USFA-TR-024, November 1988. *See*: http://www.usfa.fema.gov/downloads/pdf/publications/tr024.pdf (accessed on January 20, 2016).

Although the storage structure burned to the ground, unlike the incident at the WFC facility, no explosion, loss of life, or major injuries were recorded.

At Bryan, the firefighters were informed that a welder had accidentally heated an FGAN bin and that the chemical was smoldering. The firefighters decided not to fight the fire, evacuated the area, and let the facility burn to the ground, without any explosion. Their knowledge of FGAN and the risks associated with a probable explosion most likely led the Bryan firefighters to decide to evacuate. Figure 65 shows the post-incident aerial view of the EDC facility wooden fertilizer warehouse.

Figure 65. Post-Incident Aerial View of EDC Facility Wooden Fertilizer Warehouse (Source: Bryan-College Station Eagle)

After the incident, the Bryan Fire Department—in conjunction with the emergency management divisions for Brazos County, the city of Bryan, the city of College Station, and Texas A&M University—performed an emergency review and analysis and released an after-action report and improvement plan. These documents were shared with fire departments and emergency response agencies that were involved in the incident response and investigation, including local and regional emergency response agencies—mostly

in the Brazos Valley area, where Brazos County, the cities of Bryan and College State, and Texas A&M University are located—and other state agencies that responded to the incident.[271]

The 2009 EDC fire after-action report for Brazos Valley highlighted the need for emergency response departments to reflect on protection, response, and recovery activities that occurred during the EDC incident, despite the fact that the community-wide response to the incident resulted in no loss of life or serious injuries. In addition, the after-action report identified potential strengths to be maintained and built on, noted potential areas for further improvement, and suggested recommendations for corrective and preventive actions based on the incident. The after-action report indicated:

> The Texas Division of Emergency Management provides the National Emergency Response and Rescue Training Center (NERRTC) funding to develop regional plans that will enable local emergency management to rapidly respond to disasters using the region's resources before requesting assistance from State and Federal partners. Within that scope, NERRTC also develops after-action reports on behalf of local, regional and state governments that have been affected by major disasters. As in the case of the EDC fire, lessons learned help recognize needs for plans, policies and procedures revisions to enhance the effectiveness of response (personnel, teams and/or equipment).[272]

Unfortunately, CSB did not find any record that the WVFD requested or received a copy of the Brazos Valley after-action report and improvement plan. In addition, no record suggested that lessons learned from the EDC incident were discussed or shared with firefighters at West.[273] Although circumstances in West might have differed from those in Bryan, if lessons learned had been effectively relayed among the firefighters at West, the volunteer firefighters who responded to the WFC incident possibly could have drawn on the experience of Bryan firefighters to inform response strategies, both in the pre-planning stages and in the response to the incident on the night of April 17, 2013.

7.4.2 Post-West Incident FGAN-Related Fire: Lessons Learned

On May 29, 2014, at around 5:45 pm, a fire involving FGAN occurred at the East Texas Ag Supply facility in downtown Athens, Texas. Emergency dispatchers and the Athens Police Department promptly notified firefighters from the Athens Fire Department (AFD).[274] Emergency response units from the AFD arrived on the scene of the fire at 5:50 pm and found fire and smoke coming from the northwest end of the 3,500-square-foot East Texas Ag Supply facility. This facility was built with masonry bricks and combustible wooden structures, similar to construction at the WFC facility.[275] The AFD chief arrived

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[271] EDC. "2009 El Dorado Chemical Fire After-Action Report for Brazos Valley," August 11, 2009.
[272] *Ibid*.
[273] CSB found that several surviving West firefighters interviewed after the WFC incident did not have adequate information about the EDC incident at Bryan (approximately 100 miles south of West, Texas).
[274] The AFD was organized as a volunteer department in 1911. Currently, the AFD is a fully paid fire department with two stations and 27 firefighters. *See*: http://athenstexas.us/fire.cfm (accessed on December 28, 2015).
[275] Shortly after the April 17, 2013, incident at the WFC facility in West, Texas, an investigative reporter from the Dallas news station (WFAA) entered the Athens facility with a camera crew and revealed that East Texas Ag Supply

about 2 minutes after the first responding units were dispatched to the site of the incident, and he found that the fire had self-ventilated at the northwest end. On the basis of his observation of the enormous scope of the fire and the possibility of detonation of FGAN in the engulfed building, the fire chief promptly decided to let the East Texas Ag Supply facility burn to the ground instead of attempting to fight the fire.[276] He ordered his firefighters to retreat from the scene and began an extensive evacuation of the downtown Athens, Texas, area. The Athens Police Department coordinated the evacuation of the nearby residential areas, setting up an initial three-block evacuation perimeter, which was later expanded to five blocks.[277] Fortunately, no injuries were associated with this incident. On June 2, 2014, the State Fire Marshal's Office (SFMO) completed its investigation of the East Texas Ag Supply facility incident and released its findings, ruling and classifying the source of the fire as undetermined.[278]

The East Texas Ag Supply facility was a privately owned business with annual revenues estimated between $10 million to $20 million and a work force of approximately nine employees. The East Texas Ag Supply facility was an FGAN and potash fertilizer storage facility, and it was registered under Standard Industrial Classification Code 5191 (Farm Supplies) and North American Industry Classification System (NAICS) Code 424910 (Farm Supplies Merchant Wholesalers).[279] On the day of this incident, the East Texas Ag Supply facility received approximately 70 tons of FGAN (total) and 100,000 pounds of potash, which were stored inside the building when the fire occurred.

CSB gathered information concerning the East Texas Ag Supply incident from the emergency responders and the facility and also conducted an interview with the AFD fire chief. According to the incident statement provided to CSB, the Athens, Texas, fire chief stated:

> We allowed the fire to mitigate itself, with research showing that some such facilities had burned out with no explosions. We had learned a lot from West and had already removed other products that could cause contamination and had made the owner remove his diesel tractor from within the building and to keep it off site when not in use. We feel this was a major deterrent from having a detonation.[280]

Figure 66 and Figure 67 show photographs of the East Texas Ag Supply facility during the fire incident.

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was receiving and storing the same substance thought to have been involved in the explosion in West. *See*: http://www.wfaa.com/story/news/local/investigates/2014/08/18/14029198/ (accessed on December 28, 2015).

[276] According to the Athens, Texas, fire chief, the initial plan of action was to engage the fire at the incipient stage, but by the time he arrived on scene, the chief knew that the fire was well past the incipient stage and that the quantity of water needed to squelch the fire at that stage was beyond the capabilities of the equipment on hand. He gave the order for his men to cease firefighting based on his early observations and to begin evacuation activities.

[277] The City of Athens police chief was in charge of the evacuation and the control of traffic. The police chief set the initial evacuation perimeter at three blocks from the facility based on the immediate resources available to the police chief at that time; the perimeter subsequently was expanded to five blocks. Police and fire personnel conducted the evacuation notification by using their public address systems and going door to door.

[278] *See*: http://www.tdi.texas.gov/news/2014/news201443.html (accessed on December 28, 2015).

[279] After the WFC incident in West, the city of Athens, Texas, received a lot of attention because of the presence of a fertilizer storage facility downtown that was similar to and older than the WFC facility. Wooden bins were used for storage of AN at the East Texas Ag Supply facility.

[280] The fire incident statement was provided to CSB via email on October 3, 2014, by the Athens, Texas, fire chief.

Figure 66. Dark Grey Smoke[281] Originating from East Texas Ag Supply Facility in Downtown Athens, Texas (Source: Athens Fire Department)

[281] However, this smoke was not as black as the smoke from the WFC fire (see Section 4 of this report).

Figure 67. Dark Smoke Combined with Flames at East Texas Ag Supply Facility in Athens, Texas[282] (Source: Athens Fire Department)

In an interview, the fire chief reported that the AFD conducted extensive pre-planning, visited the East Texas Ag Supply fertilizer storage facility on multiple occasions, and instructed the owner of the facility to repair anything that seemed to be hazardous or noncompliant with the International Fire Code, which the city of Athens adopted in 2009. SFMO officials had also visited the facility previously on at least two occasions and compelled the owner of the East Texas Ag Supply facility to fix old broken machinery that was onsite.[283] In addition to these visits from SFMO, AFD officials often toured the facility to randomly inspect loading and unloading operations and to take note of other fire safety issues, including the location and spacing of exits within the facility. Pre-incident assessment of the facility indicated that the fertilizer storage bins were old and constructed of double layer plywood, each about 10 feet from the ceiling of the 35- to 40-foot-tall building, with three of the bins used to store FGAN. Similar to the WFC facility in West, the East Texas Ag Supply facility had no sprinkler systems, and the building was

[282] At the East Texas Ag Supply facility incident in Athens, Texas, the flame appeared to be the normal yellow color of many wood and other combustibles burning in normal air. Unlike the WFC incident, there was no detonation of FGAN; hence, no evidence of brighter (higher-temperature) white flame was observed before the detonation at West (see Section 4 of this report).

[283] In addition to the actions taken by the city of Athens before the East Texas Ag Supply fire on May 29, 2014, the SFMO—as part of its endeavors to share the lessons learned from the West, Texas, AN explosion—went to all 66 counties with businesses that had 10,000 pounds or more of AN. The statewide tour started on December 12, 2013, and was completed on December 17, 2014. Local first responders, LEPC members, local officials, business staff, and citizens were invited to the public meetings organized by the SFMO. On April 3, 2014, the SFMO visited Athens, Texas (Henderson County) to enlighten the public on the hazards of FGAN. *See*: http://www.tdi.texas.gov/fire/fman.html (accessed on December 28, 2015).

constructed with masonry brick walls on three sides, covered with an asphalt shingle roof. Figure 68 shows the East Texas Ag Supply facility, including its masonry brick walls completely burned to the ground.

Figure 68. East Texas Ag Supply Facility's Masonry Brick Walls, Engulfed by Fire and Smoke (Source: Athens Fire Department)

The Athens community has two community alert systems, CodeRED and FIRST Alert. The CodeRED community alert system was developed to notify residents of any emergency. The FIRST Alert system is directed from the Henderson County 911 dispatch center.[284] The protocol for use of the CodeRED system indicates that during any emergency situation or a fire incident, the fire chief or a designee (usually the police chief) would give the order for the CodeRED notification. Once a CodeRED order is given, the designee or authorized emergency staff member is expected to make a recorded speech, which is then broadcast over the Internet and to all landline telephones in the city. The process also notifies mobile phone subscribers. The CodeRED system was not deployed during the East Texas Ag Supply incident to notify Athens residents.[285] However, the CodeRED alert system was used the following day (May 30, 2014) to notify the community about the post-incident status of the East Texas Ag Supply facility and the conditions surrounding that facility.

The Athens, Texas, fire chief compared the city's situation to that in West and stated that the AFD conducted additional research and identified how best to respond to any emergency situation that could

[284] Athens, Texas, is located in Henderson County, about 70 miles southeast of Dallas, Texas.

[285] On the day of the incident, there was no clear communication on the designation of the appropriate party to make the outgoing emergency notification message. The fire chief maintained that because he was occupied with command firefighting operations, the task of making the announcement should have been transferred to the Athens Police Department (police chief); unfortunately, this was not the case. Moving forward with the post-incident critique, the fire chief indicated that standardizing the designation of who makes the announcement would be better defined for future community notifications.

arise because of the East Texas Ag Supply facility. In West, the WFC plant was primarily a fertilizer facility, with anhydrous ammonia tanks, carts, loaders, insecticides, and other potential contaminants for FGAN. On the basis of the aftermath of the WFC explosion in West, Henderson County reviewed its existing local emergency planning committee (LEPC) process. About a year before the Athens fire incident, the natural disaster planning LEPC was expanded, with the fire chief as its chair, to address emergencies arising from human activities or industrial facilities.

Although the cause of the Athens fire incident has not been determined, the city of Athens initiated reforms aimed at protecting the city from another incident in the future. On May 29, 2015, a year after the fire at the East Texas Ag Supply facility, the city passed an ordinance that banned the bulk storage of FGAN in Athens. The ordinance included a mandatory reporting process for facilities with limited quantities of hazardous chemicals such as FGAN so that they would report the quantities of the hazardous chemicals in their facilities, thereby enabling VFDs to conduct inspections at such facilities.[286] CSB investigators conducted a teleconference with the city of Athens fire chief on June 24, 2015. The fire chief stated that the East Texas Ag Supply facility had been torn down and will not be rebuilt within the Athens city limits. In addition, Athens is now considering efforts aimed at monitoring other hazardous chemicals (similar to FGAN) that are currently stored by facilities within the city limits.[287]

7.5 Other Post-Incident Investigation Reports Related to Firefighting

After the fire and explosion at the WFC facility, several other agencies conducted investigations of the incident. EPA and OSHA conducted their investigations for violations of environmental and workplace safety and health laws, while the Texas SFMO and NIOSH conducted their investigations on the firefighters and the emergency response at the WFC facility. The ATF investigation of the WFC incident is ongoing.

7.5.1 Texas State Fire Marshal's Office (SFMO)

The SFMO [288] served as the lead Texas investigatory agency for the WFC incident, working in collaboration with ATF.[289] On May 15, 2014, the SFMO released its line-of-duty deaths investigation of the West, Texas, incident, "Firefighter Fatality Investigation" (Investigation FFF FY 13-06).[290]

The SFMO report described the incident and issued recommendations focused on the emergency response to the WFC incident, including the conditions that led to the fire and explosion. The report indicated that the firefighters at West were not prepared for what they faced on the night of April 17, 2013. Also, the

[286] Section 8.7.3 of this report discusses the Athens City ordinance in detail.
[287] Section 8.7 of this report addresses state and local regulatory developments (post-West, Texas, and Athens, Texas, incidents).
[288] *See*: http://www.tdi.texas.gov/fire/documents/fmohistory.pdf (accessed on December 28, 2015).
[289] Section 1.2.1 of this report addresses the ATF investigation.
[290] *See*: http://www.tdi.texas.gov/reports/fire/documents/fmloddwest.pdf (accessed on December 28, 2015).

SFMO highlighted that the emergency responders were victims of a "systemic deficiency in the training and preparation" of the WVFD, attempting to put out a fire that was beyond its incipient stage[291] and could no longer be extinguished. The report also included findings related to training and operational best practices for firefighters. On page 47, the SFMO report identified training deficiency as a key finding:

> The State of Texas has not adopted minimum training standards for volunteer fire departments; however, all fire department members must be properly trained and qualified to perform their assigned duties. Members who are authorized to work in high-level assignments (rank) must be trained and evaluated in performing those duties. All members must be periodically re-evaluated to ensure that they are capable of performing their assigned duties safely and effectively.[292]

The SFMO firefighter fatality report on the WFC incident further proposed several recommendations based on training of firefighters, including establishment of "realistic training and educational requirements for all positions and ranks and a promotional process that ensures that ranking members demonstrate a progressive knowledge, skill, and ability to perform their assigned duties and responsibilities according to their position in the organization." The SFMO report concludes by recommending that "fire departments should develop standard operating guidelines and appropriate training involving those critical findings specific to incident command, strategy and tactics, and firefighter safety."[293]

The SFMO report findings and recommendations are similar to those of CSB in this report with regard to the emergency response in West. Section 7.2 of this report describes in detail pre-incident planning, fire scene risk assessment, and development of a clearly defined incident command structure for emergency situations.[294]

7.5.2 NIOSH Findings and Recommendations

In 1998, the U.S. Congress funded NIOSH to establish the Fire Fighter Fatality Investigation and Prevention Program, which investigates on-the-job fatalities of firefighters and provides improvement recommendations to the profession.[295] On November 12, 2014, NIOSH released its report on the emergency responder fatalities caused by the WFC explosion.[296] The report, "9 Volunteer Fire Fighters and 1 Off-Duty Career Fire Captain Killed by an FGAN Explosion at a Fertilizer Plant Fire–Texas," identified contributing factors to the firefighter fatalities, specifically failure to recognize hazards associated with FGAN, limited pre-incident planning of the commercial facility, quick spread of the fire

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[291] The term "incipient" has been widely used in the firefighting community and in various fire codes, including NFPA codes. However, CSB believes that it could be easily misinterpreted and imposes on firefighters a responsibility to make a subjective determination regarding the seriousness of a fire.
[292] *See*: http://www.tdi.texas.gov/reports/fire/documents/fmloddwest.pdf (accessed on December 28, 2015).
[293] *Ibid*.
[294] Section 7.1 of this report considers the firefighter response and Section 7.2 discussed details of factors contributing to the firefighter and other emergency responder fatalities in West, Texas.
[295] *See*: www.cdc.gov/niosh/fire (accessed on December 28, 2015).
[296] *See*: http://www.cdc.gov/niosh/fire/pdfs/face201311.pdf (accessed on December 28, 2015).

to uncontrollable size, unexpected detonation of approximately 40 to 60 tons of solid FGAN, emergency responders working within the blast radius at the time of the explosion, and large non-sprinklered wood construction in the commercial structure.[297]

In addition, NIOSH issued recommendations to prevent a similar incident from recurring. Recommendations included pre-incident planning inspections of facilities within the jurisdiction of a fire department; development of a written risk management plan; fire department use of risk management principles at all structure fires, especially for incidents involving high-risk hazards; development, implementation, and enforcement of a written incident management system to be applied during all emergency incident operations; standards for firefighters to wear a full array of turnout clothing and personal protective equipment (PPE) appropriate for the assigned tasks; and firefighter training that meets or exceeds NFPA 1001 (*Standard for Fire Fighter Professional Qualifications*).

CSB concluded that most of the key contributing factors and recommendations cited by NIOSH in its WFC incident investigation report are similar to those of CSB.[298]

7.6 Summary of Incident Emergency Response

CSB found no evidence of pre-incident planning addressing the likelihood of a fire involving FGAN at the WFC facility. As a result, the firefighters who responded to the WFC fire did not take the time to critically assess the situation on the ground before the explosion occurred. Senior emergency response personnel from the WVFD arrived at the scene of the incident at different times, and firefighters who were ICS trained and certified in the NIMS process did not assume the role of IC to establish, implement, and coordinate an incident command structure and incident management system for the fire emergency. The firefighters did not fully understand the hazards of FGAN detonation and consequently shifted their firefighting tactics to strategies to ensure that the anhydrous ammonia tanks onsite did not rupture. Also, the emergency response personnel at West did not take the time to implement an incident management system plan, which would have facilitated the prompt and proper evacuation of the nearby residents.

The volunteers who responded to the WFC facility fire did not have sufficient HAZMAT training to make an informed decision on how best to respond to the fire at the fertilizer facility. Furthermore, lessons learned from previous firefighter fatalities and emergency responses to FGAN-related incidents were not effectively disseminated to firefighters and emergency responders in other communities, such as West, where FGAN is stored or used.

A review of firefighter training courses, information in emergency response guides, manufacturers' manuals, and other information available to emergency responders concerning AN-related fires at incident sites confirms that such materials place little emphasis on how to effectively respond to fire

[297] NIOSH. "9 Volunteer Fire Fighters and 1 Off-Duty Career Fire Captain Killed by an Ammonium Nitrate Explosion at a Fertilizer Plant Fire–Texas." *NIOSH Report on Death in the Line of Duty.* Report Number F2013-11. *See*: http://www.cdc.gov/niosh/fire/pdfs/face201311.pdf (accessed on December 28, 2015).

[298] *Ibid*.

incidents involving the handling and storage of FGAN and might altogether be insufficient to enable firefighters to recognize the potential magnitude of an FGAN explosion. The commonly used emergency response guides and manuals contain inconsistent information regarding the best response to FGAN-related fires. In a fire situation, an FGAN explosion could occur at any time, and without knowing how long an AN-related fire has been burning, firefighters might not be aware of how much time they have to make informed emergency response decisions before an explosion occurs. That is why in the DECIDE model widely used by HAZMAT responders, after it is determined that HAZMAT is present, the next step is to estimate likely harm, without intervention.[299] Above all, the conditions under which FGAN might detonate when exposed to a fire are unpredictable and not clearly understood, and current guidance does not offer best practices to protect firefighters from FGAN fire and detonation hazards.

7.7 Firefighter Training Grants and Programs

7.7.1 Need for Training

CSB found that currently no federal requirements compel municipal fire departments to develop site-specific pre-incident plans with businesses and chemical plants that process and store HAZMAT such as FGAN. To implement any reform in nationwide inspection of businesses and facilities storing hazardous chemicals, determining the number of fire departments and firefighters in the United States (especially in rural communities such as West, Texas) is important. In addition, it is important to understand how prepared fire departments and firefighters should respond to fires involving FGAN. Part of being prepared is being properly trained on the hazards surrounding a community.

7.7.1.1 U.S. Firefighter Statistics

CSB conducted a review of firefighter statistics across the country at the time of the WFC fire and explosion. The review indicated that the majority of the nation's firefighters are volunteers and that 85 percent of fire departments are composed of volunteer firefighters. In addition, the NFPA estimated the number of firefighters in the United States in 2013 at more than a million, including 345,600 career firefighters (31 percent of the total) and 786,150 volunteer firefighters (69 percent of the total).[300] Approximately 95 percent of all volunteer firefighters serve in local fire departments that protect fewer than 25,000 people.[301] More than half of these volunteer firefighters support small rural departments that protect fewer than 2,500 residents, such as the WVFD in West, Texas.[302] At the end of 2012, an estimated 30,100 fire departments operated in the United States. Of these, 2,610 (9 percent of all departments) were composed of only career firefighters; 1,995 (7 percent) relied on mostly career

[299] Ludwig Benner. "D.E.C.I.D.E in Hazardous Materials Emergencies." *See*: http://www.henrycoema.org/EMA/HazMat_Training_Materials_files/DECIDE.pdf (accessed on January 8, 2016).
[300] *See*: http://www.nfpa.org/research/reports-and-statistics/the-fire-service (accessed on December 28, 2015).
[301] *Ibid*.
[302] *Ibid*.

firefighters; 5,445 (18 percent) were supported by a mostly volunteer firefighting force; and 20,050 (67 percent) depended entirely on volunteer firefighters.[303] Despite the fact that the majority of the nation's firefighters are volunteers and that 85 percent of fire departments are composed of volunteers, no federal requirements mandate that VFDs work with businesses and chemical plants that process and store HAZMAT (such as FGAN) to develop site-specific pre-incident plans.

7.7.1.2 U.S. On-Duty Firefighter Fatalities

Over the last few decades, the fire service industry has made notable advancements, including building code improvements, incorporation of sprinkler systems in commercial and industrial buildings, and development of improved personal protective gear and technologically advanced apparatus. In addition, several laws and programs have been implemented to improve firefighter health and safety in the United States.[304,305,306] Despite these laws and improvements, many firefighters are injured or killed while on duty each year. The USFA has recorded the number of firefighter fatalities and conducted an annual analysis since 1977, noting almost 4,500 on-duty firefighter fatalities in the United States in the last 35 years.[307] By the end of 2013, 101 firefighter fatalities were reported for the year nationally, including those in West, Texas; four Houston Fire Department firefighters who died while responding to a hotel fire on May 31, 2013; and 19 firefighters from the Prescott Fire Department who lost their lives while responding to a wildland fire in Arizona on June 30, 2013. The NFPA also publishes its own annual study detailing on-duty firefighter fatalities in the United States.[308] The annual number of fatalities for volunteer firefighters is substantially higher than the annual number of fatalities for career firefighters (Figure 69).

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[303] NFPA, Fire Analysis and Research Division. "US Fire Department Profile 2012." *See*: http://www.kolb.net/FireReports/2013/US_DeptProfile2012.pdf (accessed on December 28, 2015).
[304] Fabio, A. et al. "Incident-level risk factors for firefighter injuries at structural fires." *Journal of Occupational and Environmental Medicine*, 44(11) (2002): 1059–63.
[305] NFPA. *NFPA 1500: Standard on Fire Department Occupational Safety and Health Program*. Quincy, MA: NFPA, 2013.
[306] Moore-Merrell, L. et al. *Contributing Factors to Firefighter Line-of-Duty Injury In Metropolitan Fire Departments in the United States*. Emmitsburg, MD: USFA, 2008.
[307] *USFA. See*: http://www.usfa.fema.gov (accessed on December 28, 2015).
[308] NFPA. "U.S. Fire Service." *See*: http://www.nfpa.org/research/fire-statistics/the-us-fire-service (accessed on December 28, 2015).

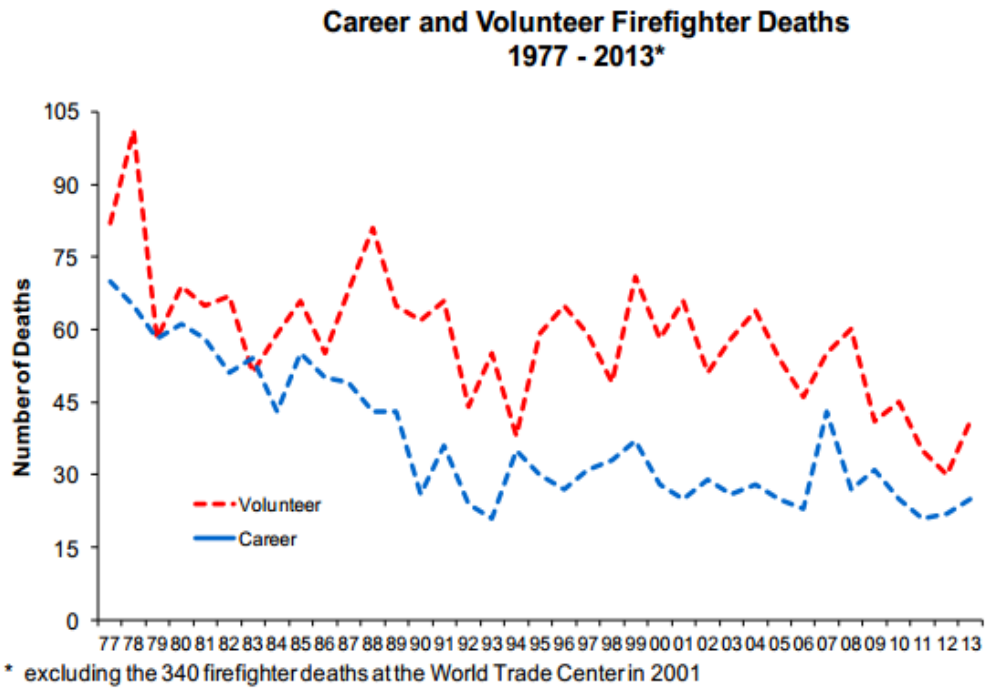

Figure 69. Comparison of Volunteer and Career Firefighter Deaths (1977–2013) (Source: NFPA)[309]

This discrepancy could be due to a number of factors, such as the larger population of volunteer firefighters (more than 67 percent of all firefighters nationwide) or the lack of standardized training requirements for volunteers. Of the 82 firefighter fatalities in 2012, 39 were volunteer firefighters (47.6 percent of the total), and 32 were career firefighters (39 percent of the total); in addition, four part-time wildland firefighters, three contract wildland firefighters, two paid on-call firefighters, one part-time (paid) firefighter, and one industrial firefighter lost their lives (1.2 percent of the total). CSB believes that adequate training is essential to reduce on-the-job firefighter fatalities, especially among volunteer firefighters who are not required to complete the same level of training as career firefighters.

7.8.1.3 U.S. Volunteer Firefighter Statistics

A VFD is a fire department composed of volunteers, usually residents or nearby citizens, who perform fire suppression and other related emergency services for a local jurisdiction or community. The U.S. Department of Labor (DOL) classifies volunteer firefighters as firefighters who receive either no compensation or nominal fees (up to 20 percent of the compensation that a full-time firefighter would receive in the same capacity).[310] DOL allows volunteer firefighters to receive benefits such as worker's compensation, health insurance, life insurance, disability insurance, pension plans, length-of-service

[309] *See*: http://nysfma.org/diyFiles/FirefighterFatalitiesinttheUS2013.pdf (accessed on December 28, 2015).
[310] Dodge, G., and M. Mullarkey. *Managing Volunteer Firefighters for FLSA Compliance: A Guide for Fire Chiefs and Community Leaders*. Fairfax, VA: International Association of Fire Chiefs, 2006.

awards, and property tax relief. DOL also states that volunteer firefighters may be paid nominal fees on a per-call or per-shift basis or on the basis of various service requirements, but they may not be compensated based on productivity (such as receiving an hourly wage).

Career firefighters are fully compensated for their services. Some volunteer firefighters might serve in a hybrid fire department that relies on both full-time and volunteer firefighters. In this approach, career firefighters can regularly staff a station for rapid response with needed apparatuses, and the volunteers can provide supplementary staffing and staff apparatuses before, during, and after an incident or while full-time career personnel are out of service for training. Moreover, volunteer firefighters can sometimes compose a group of part-time or on-call firefighters who have other occupations when not engaged in occasional firefighting.

The West volunteer firefighters held other (full-time) jobs and were not financially compensated for their time. Some VFDs compensate their firefighters as employees during the time that they are responding to or attending to an emergency scene and possibly during training. An on-call firefighter can also volunteer time for other nonemergency duties, such as training, fundraising, and equipment maintenance. In addition to fundraising, fire departments and emergency response services often seek alternative sources to support and fund their daily operations and long-term plans. Federal and state funding is available through grants from DHS and FEMA to assist emergency responders and fire departments in addressing EMS and firefighter-related needs such as training and equipment procurement and maintenance. National programs that support the need for emergency preparedness, including firefighter training, are discussed in the next section of this report.

7.7.2 National Firefighter Training Funds and Programs

7.7.2.1 U.S. Department of Homeland Security (DHS)

DHS was formed after the terrorist attacks of September 11, 2001, as part of a national effort to safeguard the United States against terrorism. The mission of DHS includes preventing terrorism and enhancing security, managing U.S. borders, administering immigration laws, securing cyberspace, and ensuring disaster resilience. DHS also provides the coordinated comprehensive federal response in the event of a terrorist attack, natural disaster, or other large-scale emergency while working with federal, state, local, and private sector partners to ensure a swift and effective recovery effort. DHS builds a ready and resilient nation through efforts to accomplish the following:

- Bolstering information sharing and collaboration.
- Providing grants, plans, and training to homeland security and law enforcement partners.
- Facilitating rebuilding and recovery.[311]

Although the scope of DHS is expansive, it contains many components, including FEMA, where much of the federal funding flows to various FEMA programs that assist in elements of national resiliency, such as

[311] *See*: http://www.dhs.gov/building-resilient-nation (accessed on December 28, 2015).

rebuilding and recovering after a disaster (such as the West, Texas, incident) or encouraging emergency response preparedness training.

Federal Emergency Management Agency (FEMA)

FEMA was created in 1979 in an effort to coordinate the federal government's role in preparing for, preventing, mitigating the effects of, responding to, and recovering from all domestic disasters, whether natural or man-made, including acts of terror.[312] On March 1, 2003, FEMA became part of DHS, and FEMA's Office of National Preparedness was given responsibility for helping to ensure that the nation's first responders were trained and equipped to deal with WMD along with other types of disasters. FEMA supports preparedness by developing policies; ensuring that adequate plans are in place and are validated; defining the necessary capabilities required to address threats; providing resources and technical assistance to state, local, tribal, and territorial partners; and integrating and synchronizing preparedness efforts throughout the nation.

DHS and FEMA achieve their mission of ensuring disaster resiliency partly by providing funding and support to various federal programs that are tasked with preparing the nation to respond to various hazards, such as community exposure to chemicals and hazardous materials. Fire departments use the programs to assist in developing a well-organized, equipped, and trained function for the communities they serve. CSB reviewed the nationwide funding mechanisms available to career and VFDs through DHS and FEMA. Volunteer firefighters similar to those who responded at West have access to these firefighting resource funds if they can demonstrate that they have a need for it. CSB examined whether federal and state funds could be allocated to fire departments to assist them in obtaining the training that firefighters need to address fires and explosions involving HAZMAT such as FGAN.

Grants

It is important to understand the process for allocating grants to emergency responders such as fire departments. First, this section discusses the application process for a DHS FEMA grant. Second, the FEMA Grant Programs Directorate (GPD), the program that administers these grants once they receive proposals from applicants for funding is discussed. Third, the DHS FEMA preparedness (non-disaster) grants are described. Fourth, the Assistance to Firefighter Grants (AFG) Program is discussed in detail and in relation to funding in Texas. Specifically, the AFG, Staffing for Adequate Fire and Emergency Response (SAFER) grants, and the Fire Prevention and Safety (FP&S) grants are examined.

DHS FEMA Grants Application Process

Often federal grant funding flows to the local level through the states. However, some states provide direct funding for emergency medical services (EMS), especially in rural areas. On the other hand, some states have no funding for local programs. Most SFMOs and EMS bureaus offer technical assistance to

[312] *See*: http://www.fema.gov/about-agency (accessed on December 28, 2015).

local agencies and subsidized training programs to first responders.[313] A large portion of the federal grant budget is passed to the states through formula or block[314] grants. The states then decide how to use the grant money. However, some direct federal grant programs are for fire departments and EMS agencies such as the AFG.[315] Direct grants are given specifically to the applying agency, but pass-through grants[316] require the state to apply to the federal government and then distribute grant money to agencies that request it. Project grants are the most common form of federal grant. Depending on the program requirements, EMS organizations gain access to the funds through a competitive bidding process. Application for a project grant does not guarantee an award, and the amount received by grantees is not predetermined by a formula.[317] Although most DHS components possess some programs that support grants,[318] FEMA has the majority of programs and funding.[319]

FEMA Grant Programs Directorate (GPD)

The purpose of FEMA GPD is to strategically and effectively administer and manage FEMA grants to ensure critical and measurable results for customers and stakeholders. The mission is to manage federal assistance to measurably improve capability and reduce the risks that the nation faces in times of man-made and natural disasters. The focus of GPD is to provide customer service to all grantees as well as internal and external partners; establish and promote consistent outreach and communication with state, local, and tribal stakeholders; ensure transparency in the grant process; and enhance the nation's level of preparedness and the public's capability to prevent, protect, mitigate against, respond to, and recover from all hazards. GPD also holds program management responsibility for the suite of preparedness grants that included, and continue to include, the following goals and objectives:

- Review, negotiate, award, and manage the FEMA preparedness grant portfolio.
- Provide subject matter expertise in response to regional office and stakeholder inquiries.
- Develop grant guidance.
- Formulate risk methodology to support grant allocations.
- Analyze investments.
- Manage budget execution and formulation.

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[313] FEMA and USFA. "Funding Alternatives for Emergency Medical and Fire Services." FA-331, April 2012.
[314] A block grant does not involve competition. The federal government distributes funds to the states based on an established formula.
[315] The AFG Program is discussed in further detail in the *Assistance to Firefighters Grant Program* Section of this report.
[316] Funds issued by a federal agency to a state agency or institution that are then transferred to other state agencies, units of local government, or other eligible groups, per the award eligibility terms.
[317] FEMA and USFA. "Funding Alternatives for Emergency Medical and Fire Services." FA-331, April 2012.
[318] DHS supports a wide variety of financial assistance, including post-disaster relief and resilience, preparedness, boating safety, cybersecurity, research, university centers of excellence, and assistance to firefighters.
[319] *See*: http://www.dhs.gov/dhs-financial-assistance (accessed on December 28, 2015).

- Provide the driving force for grant management initiatives through the strategic delivery of policy, training, systems, and data analysis.[320]

The GPD carries out its mission through three divisions, including the GPD Front Office, Grant Operations Division, and Preparedness Grant Division.[321] The FEMA grants that pertain to firefighter training and emergency response are discussed in the *Preparedness (Non-Disaster) Grants* and *Assistance to Firefighters Grant Program* Sections of this report.

Preparedness (Non-Disaster) Grants

FEMA provides state and local governments with preparedness program funding in the form of Non-Disaster Grants to enhance the capacity of state and local emergency responders to prevent, respond to, and recover from a WMD terrorism incident involving chemical, biological, radiological, nuclear, and explosive (CBRNE) devices and cyber attacks.[322] The Emergency Management Performance Grant (EMPG) Program is a preparedness grant that provides more than $350 million to assist local, tribal, territorial, and state governments in enhancing and sustaining all-hazards emergency management capabilities.[323] Either the State Administrative Agency (SAA) or the state's Emergency Management Agency (EMA) is eligible to apply directly to FEMA for EMPG Program funds on behalf of state and local EMAs.[324] The fiscal year (FY 2015) EMPG Program will focus on planning, operations, equipment acquisitions, training, exercises, construction, and renovation to enhance and sustain the all-hazards core capabilities of state, local, tribal, and territorial governments.[325] The period of performance for the EMPG Program is 24 months. In FY 2015, the EMPG Program allocated $20,163,325 to the state of Texas.[326]

Assistance to Firefighters Grant Program

Within FEMA, the AFG Program consists of three types of grants[327] that support improvements in training, staffing, and safety within fire departments. These grants include the AFG, FP&S grants, and SAFER grants:

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[320] *See*: https://www.fema.gov/grant-programs-directorate (accessed on October, 23, 2015).
[321] The Preparedness Grant Division includes the Preparedness (Non-Disaster) Grants.
[322] *See*: https://www.fema.gov/preparedness-non-disaster-grants (accessed on October, 22, 2015).
[323] *See*: http://www.dhs.gov/news/2015/07/28/dhs-announces-grant-allocations-fiscal-year-fy-2015-preparedness-grants (accessed on October 22, 2015).
[324] *See*: http://www.fema.gov/media-library-data/1427284579730-8faafd19a62444a974429c3e12d803fa/FY2015EMPG_FAQ.pdf (accessed on December 28, 2015).
[325] *See*: http://www.fema.gov/media-library-data/1438020444107-4db58a4f1c24b3bd0962b8327652df5b/FY_2015_EMPG_Fact_Sheet_Allocations.pdf (accessed on October 22, 2015).
[326] *See*: http://www.fema.gov/media-library-data/1438020444107-4db58a4f1c24b3bd0962b8327652df5b/FY_2015_EMPG_Fact_Sheet_Allocations.pdf (accessed on November 25, 2015)
[327] The AFG Program also includes Assistance to Firefighters Fire Station Construction Grants.

- **AFG**. The primary goal of the AFG Program is to meet the firefighting and emergency response needs of fire departments and nonaffiliated EMS organizations. Since 2001, the AFG Program has helped firefighters and other first responders to obtain critically needed equipment, protective gear, emergency vehicles, training, and other resources needed to protect the public and emergency personnel from fire and related hazards.[328] AFGs are awarded to fire departments, state fire training academies, and EMS organizations.
- **SAFER Grants**. The SAFER Grants were created to provide funding directly to fire departments and volunteer firefighter interest organizations to help them increase the number of trained frontline firefighters available in their communities. The goal of SAFER is to enhance the local fire departments' capabilities to comply with staffing, response, and operational standards established by the NFPA (NFPA 1710, NFPA 1720, or both).[329]
- **FP&S Grants**. The FP&S Grants are part of the AFG Program and support projects that enhance the safety of the public and firefighters from fire and related hazards.[330] The primary goal is to reduce injury and prevent death among high-risk populations. In 2005, Congress reauthorized funding for FP&S Grants and expanded the eligible uses of funds to include firefighter safety research and development.[331]

In FY 2014, the AFG provided more than $300 million in grant money nationwide; of this $300 million, Texas received approximately $6.5 million. The AFG Program issued 2,243 individual grants nationwide, and of those, only 90 grants were to fire departments for the purpose of training firefighters.[332] Moreover, in FY 2014, the AFG Program awarded grant money to 40 firefighting and EMS organizations in Texas to provide aid for much needed resources (Figure 70). Of those 40 Texas organizations, 20 career fire departments, but only 14 VFDs, were awarded funding through the AFG Program. The remaining six organizations include emergency service organizations and one state fire training academy. Notably, an interesting finding is that of the grants awarded in Texas, only one award was specific to training personnel while the majority of the awards were used to fund equipment, PPE, facility modifications, vehicle acquisitions, and wellness and fitness programs.

[328] *See*: http://www.fema.gov/welcome-assistance-firefighters-grant-program (accessed on December 28, 2015).
[329] *See*: http://www.fema.gov/staffing-adequate-fire-emergency-response-grants (accessed on December 28, 2015).
[330] *See*: http://www.fema.gov/welcome-assistance-firefighters-grant-program (accessed on December 28, 2015).
[331] *See*: http://www.fema.gov/fire-prevention-safety-grants (accessed on December 28, 2015).
[332] *See*: http://www.fema.gov/assistance-firefighters-grants-award-year-2014 (accessed on October 21, 2015).

FEMA

Assistance to Firefighters Grant Program (AFG)
FY 2014 Award Recipients
Last Updated: 9/25/2015 - www.fema.gov/firegrants/

Organization	City	State	Program	Award Amount	Activity Breakdown	Award Date
Martindale Volunteer Fire Dept. Co.	Martindale	TX	Operations and Safety	$46,196.00	Personal Protective Equipment ($48,005)	4/24/2015
Northwest Rural Emergency Medical Services Association, Inc.	Tomball	TX	Operations and Safety	$160,572.00	EMS Equipment ($168,600)	4/24/2015
Sulphur Springs Fire Rescue	Sulphur Springs	TX	Operations and Safety	$57,143.00	Modify Facilities ($60,000)	4/24/2015
Devine Volunteer Fire and Rescue Department	Devine	TX	Operations and Safety	$23,982.00	Equipment ($24,056)	5/8/2015
Farmers Branch Fire Department	Farmers Branch	TX	Operations and Safety	$223,773.00	Personal Protective Equipment ($246,150)	5/22/2015
Frankston Volunteer Fire Department	Frankston	TX	Operations and Safety	$80,000.00	Equipment ($45,900) || Personal Protective Equipment ($38,100)	5/22/2015
City of Paris Fire Department	Paris	TX	Operations and Safety	$11,632.00	Equipment ($12,795)	5/29/2015
Commerce Fire Department	Commerce	TX	Operations and Safety	$153,048.00	Personal Protective Equipment ($160,075)	5/29/2015
Texas Engineering Extension Service (TEEX)	College Station	TX	State Fire Training Academy	$265,243.00	Equipment ($265,600)	6/19/2015
Hitchcock Volunteer Fire Department	Hitchcock	TX	Operations and Safety	$160,667.00	Personal Protective Equipment ($167,500)	7/3/2015
Leander Fire Department	Leander	TX	Operations and Safety	$22,719.00	Wellness and Fitness Programs ($6,540)	7/10/2015
San Marcos Fire Department	San Marcos	TX	Regional Request	$707,546.00	Equipment ($778,300)	7/10/2015
Troup Volunteer Fire Dept	Troup	TX	Vehicle Acquisition	$238,096.00	Vehicle Acquisition ($250,000)	7/10/2015
Bonham Fire Department	Bonham	TX	Vehicle Acquisition	$663,713.00	Vehicle Acquisition ($696,898)	7/24/2015
Glenn Heights Fire Department	Glenn Heights	TX	Operations and Safety	$78,858.00	Personal Protective Equipment ($82,800)	7/24/2015
Houston Fire Department	Houston	TX	Operations and Safety	$915,120.00	Training ($1,008,732)	7/24/2015
Itasca Fire Department	Itasca	TX	Vehicle Acquisition	$103,621.00	Vehicle Acquisition ($108,802)	7/24/2015
Burnet County Emergency Services District No. 9	Spicewood	TX	Operations and Safety	$72,000.00	Personal Protective Equipment ($75,600)	7/31/2015
Apple Springs Volunteer Fire Dept	Apple Springs	TX	Operations and Safety	$53,143.00	Personal Protective Equipment ($55,800)	8/14/2015
Mic-County Volunteer Fire Department	Lockhart	TX	Regional Request	$399,637.00	Equipment ($423,600)	8/14/2015
Orange County Emergency Services District #1	Vidor	TX	Operations and Safety	$173,993.00	Personal Protective Equipment ($191,392)	8/14/2015
Anna Fire Department	Anna	TX	Operations and Safety	$28,572.00	Modify Facilities ($30,000)	8/21/2015
Cash Fire Department Assoc. Inc.	Greenville	TX	Operations and Safety	$71,760.00	Equipment ($74,355)	8/21/2015
City of Palestine Fire Department	Palestine	TX	Operations and Safety	$170,667.00	Personal Protective Equipment ($179,200)	8/21/2015
City of Terrell Fire Department	Terrell	TX	Operations and Safety	$246,215.00	Modify Facilities ($65,700) || Personal Protective Equipment ($139,500) || Wellness and Fitness Programs ($53,325)	8/21/2015
eastex freeway volunteer fire department	humble	TX	Operations and Safety	$73,119.00	Equipment ($80,430)	8/21/2015
Elm Mott Volunteer Fire and Rescue	Elm Mott	TX	Operations and Safety	$31,429.00	Equipment ($33,000)	8/21/2015
Kilgore Fire Department	Kilgore	TX	Operations and Safety	$158,364.00	Personal Protective Equipment ($174,200)	8/21/2015
Comanche Volunteer Fire Department	Comanche	TX	Operations and Safety	$116,071.00	Personal Protective Equipment ($121,374)	8/28/2015
Sanger Volunteer Fire Department	Sanger	TX	Operations and Safety	$36,364.00	Equipment ($40,000)	8/28/2015
Tarkington Volunteer Fire Department	Cleveland	TX	Operations and Safety	$62,858.00	Personal Protective Equipment ($66,000)	8/28/2015
Kingsville Fire Department	Kingsville	TX	Vehicle Acquisition	$362,728.00	Vehicle Acquisition ($399,000)	9/4/2015
Muenster Volunteer Fire Department	Muenster	TX	Operations and Safety	$78,572.00	Personal Protective Equipment ($82,500)	9/4/2015
Richland Hills Fire Rescue	Richland Hills	TX	Operations and Safety	$41,214.00	Equipment ($43,274)	9/4/2015
Stafford, City of	Stafford	TX	Operations and Safety	$152,728.00	Personal Protective Equipment ($168,000)	9/4/2015
Quitman Fire & Rescue	Quitman	TX	Operations and Safety	$111,429.00	Personal Protective Equipment ($117,000)	9/11/2015
CITY OF WEBSTER	WEBSTER	TX	Operations and Safety	$23,620.00	Equipment ($24,800)	9/18/2015
Garland Fire Department	Garland	TX	Operations and Safety	$18,730.00	Equipment ($20,400)	9/18/2015
Van Alstyne Fire Department	Van Alstyne	TX	Operations and Safety	$33,387.00	Modify Facilities ($23,500) || Equipment ($10,056)	9/18/2015
Centerville Volunteer Fire Dept., Inc	Centerville	TX	Operations and Safety	$97,381.00	Personal Protective Equipment ($102,250)	9/25/2015
TOTAL				**$6,525,910.00**		

Figure 70. Assistance to Firefighter Grant Program Recipients in Texas (Source: FEMA)

In FY 2014, the awarded SAFER Grants totaled approximately $11.7 million to five fire departments in Texas to increase the number of trained firefighters; of these five departments, only one was a VFD (Figure 71). Similarly, the awarded FP&S Grants totaled approximately $1.5 million to two organizations in Texas, neither of which were fire departments, to support projects that enhance the safety of the public and firefighters from fire and related hazards (Figure 72).

FEMA

Adequate Fire and Emergency Response (SAFER)
FY 2014 Award Recipients
Last Updated: 9/25/2015 - www.fema.gov/firegrants/

Organization	City	State	Program	Award Amount	Award Date
Houston Fire Department	Houston	TX	Hiring	$4,797,650.00	7/10/2015
Fresno Volunteer Fire Department	Fresno	TX	Hiring	$225,792.00	7/17/2015
College Station Fire Department	College Station	TX	Hiring	$758,982.00	8/21/2015
City of Killeen/Fire Department	Killeen	TX	Hiring	$4,443,404.00	9/11/2015
Little Elm Fire Department	Little Elm	TX	Hiring	$1,489,518.00	9/11/2015
TOTAL				$11,715,346.00	

Figure 71. SAFER Grant Award Recipients in Texas (Source: FEMA)

FEMA

Prevention & Safety Grants Awards (FP&S)
FY 2014 Award Recipients
Last Updated: 9/25/2015 - www.fema.gov/firegrants/

Organization	City	State	Program	Award Amount	Award Date
City of Dallas	Dallas	TX	Fire Prevention	$94,412.00	8/28/2015
Scott & White Memorial Hospital	Temple	TX	Fire Prevention	$1,394,953.00	9/11/2015
TOTAL				$1,489,365.00	

Figure 72. FP&S Grant Recipients in Texas (Source: FEMA)

On the basis of the analysis of the FEMA FY 2014 funding allocation to fire departments throughout the nation, it can be concluded that much of the grant monies went toward non training-related support. Given the constraints that many VFDs experience regarding funds to support training, fire departments should express a greater interest in also applying for federal grants for training purposes and not solely for supporting other firefighting-related needs such as equipment. For this reason, FEMA should develop a grant that specifically supports firefighter training needs and cannot be used toward funding other resource needs such as equipment or PPE.

DHS FEMA Programs

A general understanding of the intricate landscape of federal grant programs also enables a better understanding of many of the DHS and FEMA programs specific to training. This section describes the various components and programs that promote preparedness at a national level. First, the FEMA National Preparedness Directorate (NPD) serves as a mechanism for fostering programs and resources. Second, training programs reside within the National Training and Education Division (NTED). Third, the Homeland Security National Training Program (HSNTP) is positioned to create accessible training and specifically addresses national preparedness gaps. Fourth and fifth, the Center for Domestic Preparedness (CDP) and the Rural Domestic Preparedness Consortium (RDPC) are NTED training

partners. Sixth, the USFA role as a leader in firefighter training is reviewed. Each is discussed in detail in the rest of this section.

National Preparedness Directorate (NPD)

The NPD is an organizational component of FEMA that provides the doctrine, programs, and resources to prepare the nation to prevent, protect, mitigate, respond to, and recover from disasters while minimizing the loss of lives, infrastructure, and property.[333] A variety of courses in all-hazards emergency planning and response constitutes a key aspect of building a culture of preparedness and involves training at many levels, including:

- State, local, tribal, and territorial elected officials.
- Emergency managers.
- First responders.
- Appropriate whole community members, such as volunteer organizations, Community Emergency Response Teams, Citizen Corps, and bystanders.
- Other emergency responders.

Through the NPD, FEMA has established and delivered effective training and professional education programs and developed a national certification system for overall emergency management competency and expertise. This work is accomplished by the National Emergency Training Center (NETC), CDP, and other training partners.[334]

National Training and Education Division (NTED)

NTED serves the nation's first responder community, offering more than 150 courses to help build critical skills that responders need to function effectively in mass consequence events. NTED primarily serves state, local, and tribal entities in 10 professional disciplines, but has expanded to serve the private sector and citizens as well. Instruction is offered at the awareness, performance, and management and planning levels. Emergency responders attend NTED courses to learn how to apply the basic skills of their profession in the context of preparing, preventing, deterring, responding to, and recovering from acts of terrorism and catastrophic events. Training partners or providers that develop and deliver NTED approved training courses include:

- CDP.
- Counterterrorism Operations Support.
- Louisiana State University.
- New Mexico Institute of Mining and Technology.

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[333] *See*: http://www.fema.gov/national-preparedness-directorate (accessed on December 28, 2015).
[334] *See*: http://www.dhs.gov/topic/plan-and-prepare-disasters (accessed on December 28, 2015).

- Texas Engineering Extension Service.[335]
- Transportation Technology Center, Inc.
- University of Hawaii, National Disaster Preparedness Training Center.

Other training partners, such as the following, have developed or are developing training courses for NTED:

- BCFS Health and Human Services.
- Frederick Community College.
- International Association of Fire Fighters.[336]
- Naval Postgraduate School.
- RDPC.[337]

NTED training partners deliver training at no cost to the individual or to the individual's jurisdiction or agency. In some circumstances, with approval from the SAA state/territory training point of contact, Homeland Security Grant Program (HSGP) funds [338] may be used for overtime and backfill costs for those individuals attending NTED courses.

Training providers have a limited supply of training for each state. Occasionally, a state exhausts the available free training. In these cases, NTED has an Excess Delivery Acquisition Program that allows NTED training partners to charge for course delivery when more sessions of a requested class are needed than the grant funds can accommodate. Select training partners potentially could support training firefighters on the hazards associated with FGAN fires, as discussed in further detail.

NTED courses include multiple delivery methods, specifically instructor-led (direct), train-the-trainers (indirect), customized (conferences and seminars), and web-based deliveries. Instructor-led courses are offered in residence (i.e., at a training facility) or through mobile programs that deliver courses to state and local jurisdictions that request the training. While the GPD, Grant Operations Division manages, administers, and conducts application budget review, creates the award package, approves, amends and closes out awards, the NPD NTED holds programmatic responsibility for the HSNTP Continuing Training Grants (CTG) Program and also maintains the program management function and responsibilities throughout the life cycle of the awarded grant.[339]

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[335] TEEX currently has an 8-hour course delivered in any participating jurisdiction that focuses on training responders to meet the requirements established in NFPA 472, Chapter 4, "Competencies for Awareness Level Personnel," and the OSHA 29 CFR 1910.120 (q)(6)(i) (a–f) First Responder Awareness Level competencies. This course takes an all-hazards approach to HAZMAT incidents. It provides participants with the knowledge to recognize the HAZMAT, protect themselves, notify others, and secure the scene. As part of a DHS FEMA funded HSNTP Cooperative Agreement, this course is available at no direct cost to state, county, and local government agencies.

[336] Section 7.7.3.1 of this report provides additional information about the IAFF.

[337] RDPC is discussed in further details in the *Rural Domestic Preparedness Consortium* Section of this report.

[338] HSGP funds can be used to reimburse the state agency or local jurisdiction for delivery of, and attendance to, the course.

[339] DHS, HSNTP, CTG Program. "Notice of Funding Opportunity." DHS-15-NPD-005-000-01.

Homeland Security National Training Program, Continuing Training Grants

The FY 2015 HSNTP CTG program[340] provides funding via cooperative agreements[341] to training partners to develop and deliver training to prepare whole communities to prevent, protect against, mitigate, respond to, and recover from acts of terrorism and from natural, man-made, and technological hazards. An objective of the program is to create accessible training solutions to address specific national preparedness gaps across the country.

For FY 2015, the total HSNTP funds available under the CTG Program is $11.521 million, to be used for training in the following focus areas:

- Cybersecurity.
- HAZMAT.
- Countering violent extremism.
- Rural training.

The FY 2015 HSNTP CTG Program is an open and competitive funding opportunity, available to entities with existing programs or demonstrable expertise relevant to the focus areas in the funding opportunity announcement—including state, local, tribal, and territorial entities; nonprofit national associations and organizations; nonprofit higher education institutions; and nonprofits such as community and faith-based organizations.

HAZMAT and rural training are two focus areas of interest to this investigation because fire departments with HAZMAT or FGAN facilities in their jurisdiction (or those in rural[342] locations) can apply for this grant since they fall under these focus areas. Within the HAZMAT focus area, departments are required to identify current and emerging national gaps in HAZMAT incident planning, response, and recovery as well as the training solutions to address these gaps. The FY 2015 HSNTP CTG Program prescribed the following standards related to HAZMAT training: NFPA standards, including NFPA 472 (*Standard for Competence of Responders to Hazardous Materials /Weapons of Mass Destruction Incidents*), NFPA 473 (*Standard for Competencies for EMS Personnel Responding to Hazardous Materials/Weapons of Mass Destruction Incidents*), and 29 CFR 1910.120 (Hazardous Waste Operations and Emergency Response). In addition, Executive Order 13650, "Improving Chemical Facility Safety and Security," and published reports from the Chemical Facility Safety and Security Working Group have been incorporated. The proposed training should address the following issues:

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[340] As appropriated by the Department of Homeland Security Appropriations Act, 2015 (Pub. L. 114-4) and authorized by the Implementing Recommendations of the 9/11 Commission Act of 2007 (Pub. L. 110-53) (hereafter the 9/11 Act), and the Homeland Security Act of 2002 (6 U.S.C. § 101 et seq.).

[341] A legal instrument of financial assistance between a federal awarding agency or pass-through entity and a non-federal entity that is consistent with 31 U.S.C. 6302–6305.

[342] The U.S. Census Bureau defines rural areas as all areas not meeting the following definition of a metropolitan area: Metropolitan statistical area (MSA) must include at least one city with 50,000 or more inhabitants or an urbanized area with at least 50,000 inhabitants and a total MSA population of at least 100,000.

- Planning, response and mitigation strategies, defensible critical decision making to save lives and property, and actions for fixed-facility spills and releases.
- Increasing knowledge, skills, and abilities to achieve core capabilities of interdiction and disruption, on-scene security and protection, and operational communications and coordination to enhance a jurisdiction's capability to mitigate and respond to HAZMAT incidents.
- Responder health and safety to prepare for, respond to, and recover from HAZMAT incidents by including on-scene health risk assessments and hazard risk analysis, incident safety and health plans, air monitoring plans, PPE selection and use, and safe work practices.

Many VFDs similar to the WVFD are situated in rural environments where the funding to support training is limited. The required training objectives for the rural training focus area include HAZMAT, mass fatality planning and response, crisis management for school-based incidents, development of emergency operations plans, railcar safety, agroterrorism and food and animal safety, and media engagement strategies for first responders.[343]

Center for Domestic Preparedness

CDP opened in June 1998 as a training center for the nation's emergency responders. The CDP mission is to train emergency response providers from state, local, and tribal governments as well as the Federal government, foreign governments, and private entities, as available. CDP training is also available for international, federal, and private sector responders who may participate if space is available on a fee-for-service basis. The scope of training includes preparedness, protection, and response. CDP provides onsite and mobile training at the performance, management, and planning levels while also facilitating the delivery of training by DHS training partners. DHS fully funds CDP training for state, local, and tribal responders. CDP has three distinct facilities that support training, specifically the Chemical, Ordnance, Biological, and Radiological Training Facility (COBRATF), Advanced Responder Training Complex (ARTC), and Noble Training Facility. The CDP COBRATF offers the only program in the nation featuring civilian training exercises in a toxic chemical agent environment, including biological materials. The advanced hands-on training enables responders to effectively respond to real-world incidents involving chemical, biological, explosive, or radiological materials or other HAZMAT. The ARTC provides responders with a realistic training environment to exercise the skills acquired during training. The CDP Noble Training Facility is the nation's only hospital dedicated solely to preparing the health care, public health, and environmental health communities for mass casualty events related to terrorism or natural disasters.

CDP's federal training partners include agencies such as:

- Emergency Management Institute (EMI).
- National Fire Academy (NFA).
- Federal Law Enforcement Training Centers.

[343] DHS HSNTP CTP Program. "Notice of Funding Opportunity (NOFO)," DHS-15-NPD-005-000-01.

- Center for Disease Control and Prevention.
- Veterans Administration.
- DHS Office for Bombing Prevention.
- Radiological Emergency Preparedness Program.
- Department of Agriculture.
- DHS Domestic Nuclear Detection Office.
- Health and Human Services Division of Strategic National Stockpile.

Rural Domestic Preparedness Consortium (RDPC)

Rural emergency responders face unique challenges compared to their urban counterparts, such as limited access to funding for fundamental training. These challenges in providing consistent and high-quality training for first responders were recognized by Congress and DHS, which then established RDPC. Led by the Center for Rural Development, RDPC is a DHS-funded program providing training and resources to rural first responders. RDPC develops and delivers relevant all-hazards training specific to rural environments, and courses are offered both in person and online at no cost. To ensure that training directly reflects the needs of rural emergency responders, RDPC convenes a national rural preparedness summit and completes a biannual national survey of rural stakeholders. Data gathered from these activities are used to determine the type of training needs, level of need, and best delivery methods.[344]

U.S. Fire Administration (USFA)

The USFA is currently an entity within FEMA. The USFA was established by the Federal Fire Prevention and Control Act of 1974.[345] The mission of the USFA is to provide leadership, coordination, and support for the nation's fire prevention and control, fire training and education, and EMS activities and to prepare first responders and health care leaders to react to all-hazard and terrorism emergencies. One of USFA's key objectives is to reduce the nation's loss of life from fire while also reducing property loss and nonfatal injury due to fire.[346]

The USFA develops and delivers fire prevention and safety education programs in partnership with other federal agencies, the fire and emergency response community, media, and safety interest groups.[347] The USFA collaborates with public and private groups to promote and improve fire prevention and life safety through research, testing, and evaluation. The USFA manages many of the federal programs related to firefighting, including the National Fire Incident Reporting System, a dataset and collection of statistical

[344] *See*: https://www.ruraltraining.org/about/overview/ (accessed on October 21, 2015).
[345] The U.S. Congress passed P.L. 93-498, the Federal Fire Prevention and Control Act, in 1974, which led to establishment of the USFA and the NFA. *See*: http://legcounsel.house.gov/Comps/FIREPREV.PDF (accessed on December 28, 2015).
[346] *See*: https://www.fas.org/sgp/crs/homesec/RS20071.pdf (accessed on December 28, 2015).
[347] *See*: http://www.usfa.fema.gov/about/index.html (accessed on December 28, 2015).

information relating to fire incidents, public fire education campaign materials, and information on grants and funding.

The USFA oversees the NFA at the NETC in Emmitsburg, Maryland. The NFA works to enhance the capability of fire and emergency services and allied professionals to deal more effectively with fire-related emergencies. The NFA offers free training courses and programs on campus, online, and throughout the nation.[348]

The USFA offers federal funding and grants directly to local career fire departments and VFDs and unaffiliated EMS organizations to help address a variety of equipment, training, and other firefighter and EMS-related needs. The grants are provided through the Fire Act Grants under the FEMA AFG Program, FP&S Grants, and SAFER Grants, which provide grants for hiring, recruiting, and retaining firefighters.[349] [350] Firefighters often dedicate personal time for training, public education, fundraising, and other nonemergency department-related activities. In addition, they are often members of their local or national firefighter associations.

7.8.2 Texas Firefighting Training Organizations and Programs

CSB reviewed the availability of national firefighter training grants and programs. The review revealed that career and volunteer firefighters and fire departments have access to many federally funded training grants and programs throughout the nation. Moreover, CSB reviewed state-level funding and programs available to Texas firefighters and fire departments in an effort to determine how access to HAZMAT and FGAN-specific training can be increased while also improving training standards for FGAN. Select state resources—such as the Texas Commission on Fire Protection (TCFP), Texas Rural Volunteer Fire Department Assistance Program, SFFMA, and Texas A&M Engineering & Extension Services (TEEX) are discussed further. As a result, CSB issues recommendations to some of these state resources, which are identified in Section 11.

7.7.2.2 Texas Commission on Fire Protection (TCFP)

The TCFP, a state government agency, is one of many state and local agencies that compose the Texas fire protection community. The commission's statutory authority and role within this community is to serve Texas fire departments as follows:

- Provide training guidelines and assistance to the fire service.
- Establish and enforce statewide fire service standards.[351]

[348] *See*: http://www.usfa.fema.gov/training/nfa/ (accessed on December 28, 2015).
[349] *See*: https://www.fema.gov/welcome-assistance-firefighters-grant-program (accessed on December 28, 2015).
[350] The AFG, FP&S Grants, and SAFER Grants are discussed in the *Assistance to Firefighters Grant Program* Section of this report.
[351] *See*: http://www.tcfp.texas.gov/about/compact.asp (accessed on November 13, 2015).

An important TCFP characteristic is its service to regulated organizations, including paid fire departments and those volunteer departments that choose to be voluntarily regulated. The policymaking body of the TCFP is a 13-member board appointed by the governor and confirmed by the Texas Senate. The commissioners adopt policies in accordance with Chapter 419 of the Texas Government Code. Upon adoption by the TCFP, these policies become state administrative laws collected under Part 13 of Title 37 of the Texas Administrative Code (TAC). The TCFP may propose or adopt changes to the TAC. The firefighter advisory committee[352] is responsible for reviewing and commenting on the administrative rules that govern the state's fire service and also assists the TCFP in matters relating to fire protection personnel, volunteer firefighters, fire departments, and VFDs.[353] The advisory committee may submit new curricula (or changes to curricula) for study and review before approval by the TCFP. The commission often creates ad hoc advisory committees to assist in creating and updating curricula, validating test questions, and addressing other related matters. Members of the Texas fire service serve voluntarily on these committees.[354]

The goal of the TCFP compliance program is to ensure the safety of the state's fire protection personnel by inspecting fire departments and other regulated entities to confirm that they are in compliance with state laws and rules. The compliance inspectors also inspect training records to ensure that fire protection personnel are in compliance with the appropriate certification rules for their disciplines. The commission's compliance officers travel to every regulated entity at least once every 2 years to inspect fire protection personnel certifications, training records, breathing air test records, protective clothing, and self-contained breathing apparatus. If a fire department is found to be in violation of a state law or TCFP rule, the Compliance Section compels the department to correct the violation immediately or works with it to develop a plan that will lead to compliance.[355]

The TCFP certification program certifies approximately 32,000 fire protection personnel in Texas. State law requires paid fire protection personnel to be certified by this commission; volunteers and individuals not affiliated with a paid or volunteer department can voluntarily choose to be certified by TCFP. The commission certifies fire protection personnel to multiple levels (basic, intermediate, advanced, and master) in several different disciplines.[356] In addition, TCFP certifies training facilities. When fire departments have unmet training needs, TCFP may take a number of actions:

- Authorize reimbursement for a local government agency for training program expenses.
- Provide staff or educational materials on request to training programs or fire departments.

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[352] The firefighter advisory committee is created by the TCFP enabling statute, Chapter 419 of the Government Code. The TCFP appoints members. *See*: http://www.statutes.legis.state.tx.us/Docs/GV/htm/GV.419.htm#419.023 (accessed on December 28, 2015).
[353] *See*: http://www.tcfp.texas.gov/directory/commission_and_committees.asp (accessed on November 3, 2015).
[354] *See*: http://www.tcfp.texas.gov/directory/commission_and_committees.asp (accessed on November 13, 2015).
[355] *See*: http://www.tcfp.texas.gov/about/compact.asp (accessed on October 27, 2015).
[356] Including structure fire protection, aircraft rescue fire protection, marine fire protection, fire inspector, fire and arson investigation, HAZMAT technician, pumper driver and operator, fire instructor, fire officer, and head of department.

- Establish minimum curriculum requirements for courses in schools operated by state or local governments.
- Provide training assistance to fire departments through the following methods:
  - Purchase and provide training aids to fire departments, temporarily or permanently.
  - Finance training seminars for fire departments.
  - Pay instructor fees to teach specialized courses for fire departments that employ fully paid fire protection personnel.[357]

Although these four elements are cited in the TCFP statute (Section 419.028), the commission is no longer funded for the type of assistance provided by authorizing reimbursements or delivering training. The TCFP funding program that offers this type of training assistance to fire departments was transferred to the Texas A&M Forest Service in 2009.[358] TCFP's Certification Curriculum Manual supplies the curriculum for the training of structural fire suppression personnel, aircraft rescue fire protection personnel, and marine fire protection personnel as well as fire inspectors, fire investigators, HAZMAT technicians, pumper drivers and operators, fire instructors, fire officers, and wildland firefighters. [359] The Certification Curriculum Manual's Hazardous Materials Awareness chapter was updated in June 2015. This chapter of the manual includes course material on Class 5 oxidizing substances and organic peroxides; this class includes AN.[360] The curriculum sets the minimum standards for materials covered in the course; however, instructors decide whether to go into further detail within specific topic areas such as AN.

The TCFP may consult and cooperate with a local governmental agency, other governmental agency, university, college, junior college, or other relevant institutions concerning the development of training schools and associated programs of courses of instruction for fire protection personnel, including the preparation or implementation of continuing education or training programs.[361] The TCFP has entered into a memorandum of understanding (MOU) with TEEX[362] to coordinate each organization's training responsibilities. In addition, the TCFP has an MOU with the Texas A&M Forest Service to coordinate the provision of training assistance and other assistance to firefighting entities. The Texas A&M Forest Service consists of many programs directed to VFDs to enhance the ability of firefighters to protect themselves and the public from fire-related hazards. One such program within the Texas A&M Forest Service that supports volunteer firefighter training is discussed in more detail in the next section.

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[357] *See*: http://www.statutes.legis.state.tx.us/Docs/GV/htm/GV.419.htm (accessed on October 28, 2015), Section 419.028 through Section 419.031.
[358] The Rural VFD Assistance Program in the Texas A&M Forest Service is discussed further in Section 7.7.4 of this report.
[359] *See*: http://www.tcfp.texas.gov/manuals/curriculum_manual.asp (accessed on October 28, 2015).
[360] *See*: http://www.tcfp.texas.gov/manuals/curriculum_manual/chapter_6.pdf (accessed on October 28, 2015).
[361] Section 419.030.
[362] Section 7.7.2.5 discusses TEEX in further detail.

7.7.2.3 Texas Rural Volunteer Fire Department Assistance Program (HB 2604)

In a January 2015 interim report by the Texas Committee on Homeland Security and Public Safety, Chairman Joe Pickett (D-El Paso) submitted recommendations to, and drafted legislation for consideration by, the House of Representatives, 84th Texas Legislature.[363] The committee's report indicates that of the 40 fire departments that represent the authority with jurisdiction for the 43 FGAN facilities across the state, 27 are VFDs; 7 are a combination of paid and volunteer firefighters; and 6 consist only of paid firefighters. A recommendation that stemmed from this finding encouraged the legislature to approve a rider in the Appropriations Bill for Texas A&M Forest Service that addresses funding in the Rural Volunteer Fire Department (Rural VFD) Assistance Program. The purpose of this funding is to provide training for VFDs across the state that are in a jurisdiction with an FGAN facility.[364]

The 77th Texas Legislature passed House Bill 2604 in 2001, establishing the Rural VFD Assistance Program.[365] The primary goal of the VFD Assistance Programs is to enhance the emergency response capabilities of volunteer and combination fire departments with 20 or fewer paid members.[366] The Texas Rural VFD Assistance Program provides funding to rural VFDs for the acquisition of firefighting vehicles, fire and rescue equipment, protective clothing, dry hydrants, computer systems, and firefighter training. This cost-share program is funded by the Texas State Legislature. Beginning on September 1, 2015, the annual grant budget for the program increased to $24.3 million from the previous annual budget of $12.8 million. Cost share assistance for training tuition has increased after changes to the Rural VFD Assistance Program that also took effect on September 1, 2015. The new reimbursement rate is 100 percent of the actual cost of tuition, not to exceed $125 per day up to a maximum of $625 per trainee per school. The annual maximum for training tuition grant assistance per fire department is $12,500.[367] The Texas A&M Forest Service conducted a funding meeting for FY 2015 on March 11, 2015, to determine how grants would be awarded. During this meeting, approximately $1.4 million in grants was awarded to Texas VFDs. Two VFDs in McLennan County, Texas, were approved for funding, and one is the WVFD, approved for $8,000 for a training library (Table 10).[368] All VFDs that apply for state grants,

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[363] *See*: http://www.house.state.tx.us/_media/pdf/committees/reports/83interim/House-Committee-on-Homeland-Security-and-Public-Safety-interim-report.pdf (accessed on October 28, 2015).

[364] *See*: http://www.house.state.tx.us/_media/pdf/committees/reports/83interim/House-Committee-on-Homeland-Security-and-Public-Safety-interim-report.pdf (accessed on October 28, 2015): 22–24.

[365] *See*: http://texasforestservice.tamu.edu/uploadedFiles/FRP/New_-_Local_Capacity_Building/TFS_Assistance_Programs/Historical_Funding_Summaries/2604/HB%202604%20Funding%20Meeting%20Approvals%2003_11_15.pdf (accessed on November 13, 2015).

[366] *See*: http://texasforestservice.tamu.edu/content/article.aspx?id=19857 (accessed on October 28, 2015).

[367] *See*: http://texasforestservice.tamu.edu/uploadedFiles/TFSMain/Preparing_for_Wildfires/Fire_Department_Programs/Local_Volunteer_Fire_Department_Programs/Rural_VFD_Assistance_Program/Special%20Announcement%20--%20Program%20Changes%20FY16(1).pdf (accessed on October 27, 2015)

[368] *See*: http://texasforestservice.tamu.edu/uploadedFiles/FRP/New_-_Local_Capacity_Building/TFS_Assistance_Programs/Historical_Funding_Summaries/2604/HB%202604%20Funding%20Meeting%20Approvals%2003_11_15.pdf (accessed on November 16, 2015).

including matching federal funds, must certify that they have adopted NIMS. Before the WFC incident in December 2012, the WVFD had requested funds through the Rural VFD Assistance Program for a large brush truck, but the request was not approved. The WVFD requested this funding every year thereafter, although it did not meet the NIMS certification requirement.[369]

Table 10. Funds Allocated to WVFD through the Rural VFD Assistance Program

Date Approved	**Equipment/Training Category**	**Approved Amount**
January 2003	Truck Chassis Large	$40,000
May 2004	C/S Structural Gear	$6,000
September 2008	Wildland Gear	$5,700
March 2015	Training Library	$8,000

The SFFMA of Texas was instrumental in the creation of House Bill 2604, which annually distributes grant funding through the Texas Forest Service to fire departments in need. Similar to the TCFP, the SFFMA assists many volunteer firefighters and fire departments in obtaining training.

7.7.2.4 State Firefighters' and Fire Marshals' Association of Texas (SFFMA)

Organized in 1876, the SFFMA is Texas's oldest and largest fire association serving the fire and emergency service responders of Texas. The SFFMA has the support of more than 1,200 fire departments, 22,000 individual members, 80 industrial fire brigades, and EMS and international departments. The association is active in legislative efforts that affect the fire service in Texas.[370] The SFFMA is a fee-based membership organization that offers individual and fire department memberships,[371] and has partnered with the National Volunteer Fire Council (NVFC)[372] to provide joint benefits to their members.

The SFFMA consists of a volunteer firefighter certification program that encourages VFDs to initiate the program in an effort to upgrade training standards. A VFD must be a member of the SFFMA to participate in the certification programs. Through the program, the fire department's selected

[369] *See*: http://tfsweb.tamu.edu/HistoricalFunding/ (accessed on November 17, 2015).
[370] *See*: http://www.sffma.org/web/SFFMA/About_Us/SFFMA/About.aspx?hkey=84e079d0-75c2-47df-b9e9-7ae03d5685dd (accessed on October 29, 2015).
[371] The fire department membership dues are based on the Federal Census population of the cities and towns that they serve.
[372] NVFC is discussed in further detail in Section 7.7.3 of this report.

certification coordinator is required to attend a free certification workshop at least once every 2 years. The certification workshop is a requirement to maintain the departments' participation status. The certification coordinator validates that all training and certifications meet state criteria; it is the coordinator's responsibility to document the training and ensure that a qualified instructor has conducted the training. To verify that a department holds continual training and correctly maintains its records, the coordinator must submit an annual training summary or progress report.[373] The SFFMA Certification Board sets the criteria for the training curriculum; however, it does not develop topic-specific training modules for firefighters and departments. The SFFMA relies on firefighter training schools, approved training providers, or certified training instructors to administer the training. The SFFMA Program allows individual departments and their members to decide how far they will go in the process. The process levels include NFPA 1403, Introductory; NFPA 1001, Firefighter I; NFPA 1001, Firefighter II; and Master certifications.[374] Currently, the SFFMA does not have an exclusive program that certifies firefighters on HAZMAT or AN; however, part of the certification for the Firefighter I program includes a section on HAZMAT.[375] As part of the minimum standards for firefighter certification, the section designates that trainees recognize the hazard classes and divisions of HAZMAT and WMD[376] and identify common examples of materials and primary hazards in each hazard class or division, such as Class 5 oxidizers.[377]

The SFFMA Texas Industrial Emergency Services Board (TIESB) provides guidance for the Texas Industrial Fire Protection Program. The TIESB works with the Texas Chemical Council and the National Petroleum Refiners Association in reviewing differences among various industries in training needs for all emergencies and loss prevention programs. The TIESB has many objectives, including promoting the development of fire training and loss prevention programs for industrial firefighters or members of the SFFMA and also recommending for each member industry-minimum criteria for maintaining effective fire training, loss prevention, and educational programs.[378] Currently, the TIESB has a certification program for industrial HAZMAT teams and emergency response personnel[379] that establishes minimum criteria for certification but also provides flexibility so that each facility can structure its training programs to address individual needs. The TIESB has formally adopted NIMS, designating it as the incident management system for all members seeking certification of their training programs.[380]

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[373] *See*: http://www.sffma.org/web/SFFMAPages/Certification/2015/Navigating_Cert_2015_Apr.pdf (accessed on November 2, 2015).
[374] *See*: http://www.sffma.org/WEB/SFFMAPages/Certification/Resources/Certification_FAQ.pdf?WebsiteKey=65a2a6d5-cf92-4d26-8251-b69cdeecaa68&hkey=1509bff9-ad5b-411d-904d-9de79e384a6d (accessed on October 30, 2015).
[375] Of the 22 sections in the program, Section 18 covers HAZMAT.
[376] NFPA 472, Section 4.2.1: 2, 3.
[377] *See*: http://www.sffma.org/web/SFFMAPages/Certification/2015/Full_Program_2015_02.pdf (accessed on October 29, 2015): 61.
[378] *See*: http://www.sffma.org/web/SFFMA/Divisions/Industrial/SFFMA/TIESB.aspx?hkey=60a9d6ce-7f4f-4d91-b642-d41585bf3597 (accessed on October 30, 2015).
[379] Training program certification is for HAZMAT Technician, Specialist, and Incident Command levels.
[380] *See*: http://www.sffma.org/web/SFFMAPages/TIESB/Policy_Docs/TIESB010.pdf (accessed on October 30, 2015).

Within Texas, multiple organizations support firefighter standards for training curricula and certification. These organizations work with training partners such as TEEX in the development of course curricula and the implementation of training programs that suit the diverse needs of fire departments.

7.7.2.5 Texas A&M Engineering Extension Services (TEEX)

In 1929, the State Firemen's and Fire Marshals' Association of Texas (SFFMA) selected Texas A&M College as the site for a permanent firefighter training school. In 1931, the Texas Legislature authorized the creation of a Firemen's training school by passing House Bill No. 921. This bill authorized Texas A&M to create, conduct and maintain a Firemen's training school.

A member of The Texas A&M University System, the Texas A&M Engineering Extension Service (TEEX) has more than 80 years of experience in providing professional services with expertise in national and industrial security, emergency preparedness and response, public infrastructure, occupational safety, economic development, and technology assessment and validation. TEEX employees nearly 1,000 experts in various fields and is able to develop training solutions for emergency responders across the state and nationwide. Funding for Texas agencies and fire departments is available from several sources to support TEEX tuition, fees, and other related expenses.

TEEX encourages fire departments to take advantage of federal funding programs such as those in DHS FEMA as well as no-cost training in Texas through the fire extension services, NFA, area schools, and other assistance programs and associations.[381] TEEX tailors need-specific services and training at a number of its facilities and also at customer-specified locations worldwide. TEEX has the ability to offer a full-range of services and delivery methods, including:

- Course design and development.
- Online course delivery.
- Hosting services for eLearning courses.
- Classroom-based instruction.
- Hands-on skills-based instruction.
- National certification testing.
- Technical assistance and technology validation.
- Bilingual training and translation services.

TEEX collaborates with resources within The Texas A&M University System to provide a unique blend of research and technical expertise. The TEEX Emergency Services Training Institute's (ESTI) main training facility is the Brayton Firemen's Training Field. Adjacent to this facility is Disaster City®, which is comprised of 296 acres in College Station, Texas, making it the world's largest, most comprehensive campus for first responders. Each year thousands of students participate in ESTI's hands-on training in firefighting, emergency medical services, hazardous materials, rescue, Incident Command, and

[381] *See*: https://teex.org/Pages/about-us/funding-grants.aspx (accessed on November 6, 2015).

specialized programs. ESTI offers over 200 different courses in more than 130 specialty areas to students from across Texas, the United States and around the world.[382]

In FY15 TEEX/ESTI provided training for some 96,364 students in 3,670 separate classes which accounted for 1.625 million man contact hours. During the course of FY15 training, all 254 Texas Counties were served including 92% of all Texas Communities. TEEX/ESTI also trained students from 81 foreign countries during FY15. TEEX receives General Revenue from the State of Texas to provide outreach or extension training to the States Emergency Responders. In FY15, more than 20,000 responders of the State trained through this program at no cost to them or their department.

Through its accreditation with the National Professional Qualification System (NPQS), or ProBoard, TEEX/ESTI is authorized to offer certification training in compliance with National Fire Protection Association (NFPA) standards.[383]ESTI is currently accredited to provide certifications in 46 individual disciplines. TEEX/ESTI currently leads the nation in the number of ProBoard certifications issued on an annual basis. The certification levels TEEX/ESTI offers include:

- NFPA 1001 Fire fighter I & II.
- NFPA 1002 Driver/Operator Pumper, Aerial, ARFF, Mobile Water Supply.
- NFPA 1003 Airport Firefighter.
- NFPA 1006 Rescue Technician - Rope Rescue I, II; Trench Rescue I, II; Confined Space Rescue I, II; Wilderness Rescue I, II; Vehicle & Machinery I, II; Structural Collapse I, II.
- NFPA 1021 Fire Office I – IV.
- NFPA 1031 Fire Inspector I & II, Plans Examiner I.
- NFPA 1041 Fire Instructor I & II.
- NFPA 1061 Public Safety Telecommunicator I & II.
- NFPA 1081 Fire Brigade - Incipient, Advanced Exterior, Interior Structural, Leader.
- NFPA 472 Hazardous Materials - Awareness; Operations Core; Operations Mission Specific: PPE, Product Control, Air Monitoring & Sampling, Response to Illicit Laboratory Incidents; Technician; Technician w/ Tank Car Specialty; Technician w/ Cargo Tank Specialty; Technician w/ Intermodal Tank Specialty; Technician with Flammable Liquids Bulk Storage Specialty; Incident Commander.

ESTI supports FEMA's HSNTP with the delivery of over twenty different courses across the nation with topics that range from tactical level, Wide Area Search and WMD Defensive Operations to simulation-driven incident management courses to executive-level workshops and seminars. In addition, ESTI provides technical assistance, exercise planning expertise and event review and After-Action Report support to organizations across the nation. Throughout the year, TEEX hosts full-scale operational readiness exercises (OREs) that test a team's entire response capabilities.

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[382] *See*: https://teex.org/Pages/about-us/disaster-city.aspx (accessed on December 31, 2015).
[383] *See*: https://teex.org/Pages/Program.aspx?catID=613&courseTitle=Pro%20Board (NPQS) (accessed on December 31, 2015).

TEEX/ESTI provides many DHS FEMA funded training programs that can be delivered online, face to face, or in a combination format. One such training program funded by DHS FEMA involves HAZMAT response; this training is geared toward emergency responders and focuses on the special challenges of dealing with WMDs or a terrorist incident, including knowledge of CBRNE events and responses to incidents involving CBRNE materials. The Standardized Awareness Training course focuses on training responders to meet competency requirements established in NFPA 472, Chapter 4, and in OSHA 29 CFR 1910.120. The course takes an all-hazards approach to HAZMAT incidents and gives participants the knowledge needed to recognize the hazardous material, protect themselves, notify others, and secure the scene. Another training program funded by DHS FEMA addresses incident management and response. These courses facilitate the implementation of the all-hazards multidisciplinary team-based approach outlined in the DHS National Response Framework, which is designed to respond to large-scale or expanding incidents, including those involving HAZMAT.[384] In addition to the in-person training, ESTI offers a variety of web-based training, such as awareness-level courses and those within the innovative Online Recruit Academy. These interactive courses provide emergency responders with a convenient way to complete knowledge-based training at their own pace.

There is an increasing need to provide training to responders who have the potential and will be expected to respond to Industrial Facilities/Industrial Emergencies in their area. There are multitudes of newly-introduced specialized hazards across the United States that First Responder communities have the potential to respond to. The increased potential for incidents to occur in these areas further highlights the need for all response and emergency management personnel be trained on how to properly preplan for, respond to, and mitigate these specialized incidents. Components of this training should address the preplanning, command, safety, operational, logistical, and local resource coordination and public information areas and should focus on assisting local responders in addressing key priorities and a safe outcome for their personnel.

These hazards include emergencies that result from drilling and fracking operations, flammable liquid bulk storage facilities, transportation emergencies (pipelines, rail[385], trucking, maritime, and air), and warehousing or storage of hazardous chemicals and materials such as FGAN. In light of these potential exposures to the response community, TEEX has developed a course entitled, "Industrial Emergencies for Municipal Based Responders" (IEMBR). This is a two-phased course with the awareness-level information contained in Phase I and the hands-on (firefighting and Hazardous Materials Response) contained in Phase II. TEEX is currently reaching out across the State of Texas and providing Phase I IEMBR training to first responders. Due to the complexity of the Phase II response scenarios and the

[384] *See*: https://teex.org/Pages/Program.aspx?catID=469&courseTitle=Response-Hazardous%20Materials%20and%20Search%20and%20Rescue (accessed on November 6, 2015).

[385] TEEX has also developed and is currently delivering a 24-hour Crude by Rail course. TEEX worked in corporation with rail service providers, owning companies and the response community to develop this course. It provides a detailed look at rail car construction, hazards associated with rail car emergencies, response plans, resource management and responder safety.

need for realistic training props, all Phase II training is conducted at the TEEX/ESTI Brayton Firemen's Training Field. Phase II of the IEMBR course is more costly than Phase I due to the flammable liquid fuels, LPG and firefighting foams that are used as part of the training.[386] There is a critical need to establish a funding mechanism for First Responders to attend IEMBR Phase II training.

7.7.3 National Membership Firefighter Associations

Although several bodies represent the interests of firefighters and emergency responders, the three most prominent labor unions and associations for firefighters in the United States are the International Association of Fire Fighters (IAFF), NVFC, and IAFC. Combined, these three associations have more than a million members across the United States.[387] An important aspect of the mission of each association entails providing training information and resources to members.

7.7.3.1 International Association of Fire Fighters (IAFF)

The IAFF[388] is a labor union that represents career firefighters in the United States and Canada. Established in 1918, the IAFF currently represents a membership of more than 300,000 professional firefighters in more than 3,200 fire departments. The IAFF acts to ensure that adequate resources and tools, including the development and implementation of new training and equipment, are provided to career firefighters and paramedics in all member fire departments.

7.7.3.2 National Volunteer Fire Council (NVFC)

The NVFC is a nonprofit association that represents the interests of fire and emergency services at the national level by providing advocacy, information, resources, and programs to support volunteer first responders. The NVFC serves as the voice of the volunteer firefighter in the national arena and supplies tools, resources, programs, and advocacy for first responders nationwide. The NVFC also conducts national advocacy for first responders, including promoting legislation that benefits the fire and emergency medical services. The NVFC offers information, education, and training for volunteer fire and EMS organizations throughout their respective states.[389]

7.7.3.3 International Association of Fire Chiefs (IAFC)

The IAFC represents the leadership of firefighters and emergency responders worldwide.[390] With a network of more than 10,000 fire chiefs and emergency personnel, IAFC members include experts in firefighting, EMS, terrorism responses, HAZMAT spills, natural disasters, search and rescue operations, and public safety policy. The IAFC was established in 1873 to provide a forum for fire and emergency

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[386] *See*: https://teex.org/Documents/2014-04-firetalk.pdf (accessed December 31, 2015).
[387] *See*: http://www.nfpa.org/research/reports-and-statistics/the-fire-service (accessed on December 28, 2015).
[388] *See*: http://client.prod.iaff.org/#page=AboutUs (accessed on December 28, 2015).
[389] NVFC. *See*: http://www.nvfc.org/ (accessed on December 28, 2015).
[390] IAFC. *See*: http://www.iafc.org/About/?navItemNumber=537 (accessed on December 28, 2015).

service leaders to exchange ideas, develop professionally, and identify the latest products and services available to first responders, including career and VFD chiefs.[391]

8.0 Regulatory Analysis

Multiple federal, state, and local agencies regulate FGAN storage and handling, depending on statutory requirements, which can address worker safety, environmental protection, public safety, national security, and transportation. Requirements for reporting bulk quantities of FGAN also vary. CSB reviewed FGAN safety-related requirements in the United States and found differences in how FGAN facilities are identified and regulated. This section includes a discussion of the requirements for FGAN safety and security as well as voluntary efforts by industry, including:

- President Obama's Executive Order (EO) 13650 (Section 8.1).
- OSHA Explosives and Blasting Agents standard (Section 8.2).
- DHS Chemical Facility Anti-Terrorism Standards (CFATS) (Section 8.3).
- OSHA Process Safety Management (PSM) standard (Section 8.4.1).
- EPA Risk Management Program rule (Section 8.4.2).
- EPA Emergency Planning and Community Right-to-Know Act (EPCRA) regulations (Section 8.5).
- National fire protection standards and Texas fire codes (Section 8.6).
- Post incident state and local regulatory developments (Section 8.7).
- Voluntary industry initiatives (Section 8.8).

Each of these sections includes background and analysis. The sections provide supporting information for the CSB recommendations in Section 11, which includes recommendations to regulatory agencies to revise existing standards so that they include FGAN-specific requirements.

8.1 President Obama's Executive Order 13650

In the aftermath of the West Fertilizer Company (WFC) incident, President Barack Obama issued EO 13650, "Improving Chemical Facility Safety and Security," on August 1, 2013.[392] The EO states that "…measures can be taken by executive departments and agencies with the regulatory authority to further improve chemical facility safety and security in coordination with owners and operators."[393] The EO established the Chemical Facility Safety and Security Working Group, which is co-chaired by the

[391] According to its website, the mission of the IAFC is to provide leadership to current and future career, volunteer, fire rescue, and EMS chiefs; chief fire officers; and company officers and managers of emergency service organizations throughout the international community, using vision, information, education, services, and representation to enhance their professionalism and capabilities. *See:* http://www.iafc.org/About/index.cfm?navItemNumber=537 (accessed on December 28, 2015).
[392] Executive Order 13650. "Improving Chemical Facility Safety and Security." August 1, 2013.
[393] *Ibid*.

Secretary of Homeland Security, the EPA Administrator, and the Secretary of Labor.[394] Working with multiple governmental agencies, the EO Working Group was tasked with improving operational coordination with state, local, and tribal partners; enhancing federal coordination regarding chemical facility safety and security; improving information collection and sharing; modernizing key policies, regulations, and standards; and identifying best practices.[395]

One of the group's first deliverables, issued in August 2013, was the document, "Chemical Advisory: Safe Storage, Handling, and Management of FGAN."[396] The advisory summarized best practices for AN storage, lessons learned from past AN incidents, hazard information, hazard reduction options, emergency planning activities, emergency response operations, and information resources.[397] In June 2015, the advisory was reissued as "Chemical Advisory: Safe Storage, Handling, and Management of Solid Ammonium Nitrate Prills."[398] This advisory includes a more detailed and reorganized regulatory information section.[399] It has been distributed by government agencies such as EPA and OSHA and by the two U.S. manufacturers of FGAN, CF Industries and EDC.

In addition, in June 2014, the EO Working Group published "Actions to Improve Chemical Facility Safety and Security—A Shared Commitment: Report for the President."[400] That report summarized the EO Working Group's progress, focusing on actions to date, findings and lessons learned, challenges, and high-priority next steps.[401] The report includes an aggressive action plan that details specifically how the EO Working Group has begun to, or will, tackle each of its aforementioned tasks.[402]

8.2 OSHA Explosives and Blasting Agents Standard

The 1971 OSHA Explosives and Blasting Agents standard (29 CFR 1910.109) regulates, in part, the storage, use, and transportation of explosives and blasting agents and specifies safety requirements for various grades of AN. The standard was based on two national consensus standards—NFPA[403] 495 (*Code for the Manufacture, Transportation, Storage, and Use of Explosives and Blasting Agents*, 1970

[394] *Ibid*.
[395] *Ibid*.
[396] *See*: http://www.ctif.org/sites/default/files/news/files/fed_an_advisory-083013.pdf (accessed on December 28, 2015).
[397] *Ibid*.
[398] *See*: http://www.epa.gov/sites/production/files/2015-06/documents/an_advisory_6-5-15.pdf (accessed on December 28, 2015).
[399] *Ibid*.
[400] *See*: https://www.osha.gov/chemicalexecutiveorder/final_chemical_eo_status_report.pdf (accessed on December 28, 2015).
[401] *Ibid*.
[402] *See*: https://www.osha.gov/chemicalexecutiveorder/ (accessed on December 28, 2015).
[403] NFPA codes, standards, and guides are voluntary consensus products that are not enforceable unless adopted into law.

Edition), and NFPA 490 (*Code for the Storage of Ammonium Nitrate*, 1970 Edition).[404] The first nine sections of OSHA's Explosives and Blasting Agents standard, (a) through (h), cover the storage and transportation of explosives and blasting agents. The last two sections, (j) and (k), address small arms ammunition and the manufacture of explosives and pyrotechnics.

AN is covered in the middle of the standard, under section (g) when it is used as a blasting agent[405] and under section (i) when it is stored in the form of crystals, flakes, grains, or prills, including fertilizer grade, dynamite grade, nitrous oxide grade, technical grade, and other mixtures containing 60 percent or more AN by weight.[406] Included in 29 CFR 1910.109(i) are requirements for storage, building construction, ventilation, and fire protection associated with bulk and bagged AN. These requirements cover facilities that store more than 1,000 pounds of AN.[407] At the time of the incident, the WFC facility stored FGAN well in excess of 1,000 pounds.

The standard includes various requirements for the bulk storage of AN.[408] For example, the standard mandates that warehouses have "adequate ventilation or be capable of adequate ventilation in case of fire."[409] Also, storage bins must "be clean and free of materials which may contaminate AN."[410] Bins storing bulk quantities of AN may not be constructed with galvanized iron, copper, lead, or zinc "unless suitably protected," and wooden bins "protected against impregnation by AN" are permitted.[411] The partitions dividing AN storage from other products that would contaminate the AN must be of "tight construction."[412] To avoid potentially dangerous contamination, AN must be in a separate building or must be separated by "approved type firewalls of not less than 1 hour fire-resistance rating from storage of organic chemicals, acids, or other corrosive materials, materials that may require blasting during processing or handling, compressed flammable gases, flammable and combustible materials or other contaminating substances."[413]

While CSB found no evidence to suggest that any detonation of AN in the United States has occurred at a facility compliant with OSHA's 1910.109(i) standard, CSB does find that these requirements do not offer sufficient safeguards concerning the bulk storage of FGAN. This conclusion is evidenced best by the

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[404] *See*: https://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=FEDERAL_REGISTER&p_id=19509 (accessed on December 28, 2015). The NFPA 490 standard went through several updates. The most recent edition was issued in 2002. In 2010, NFPA incorporated NFPA 490 into a more recently developed standard, NFPA 400 (*Hazardous Materials Code*) (discussed in detail in Section 8.6.1). OSHA, however, has not updated its Explosives and Blasting Agents standard to incorporate the provisions of NFPA 400 because OSHA's legal authority to adopt consensus standards expired in the mid-1970s.

[405] Because it was not pertinent to this investigation, 29 CFR 1910.109(g) is not discussed.

[406] 29 CFR 1910.109(i)(1)(i)(a).

[407] 29 CFR 1910.109(i)(2)(i).

[408] Because bulk storage of FGAN was primarily at issue at the WFC facility, bagged storage is discussed only briefly for the sake of comparison.

[409] 29 CFR 1910.109(i)(4)(i)(a).

[410] 29 CFR 1910.109(i)(4)(ii)(a).

[411] *Ibid*.

[412] *Ibid*.

[413] 29 CFR 1910.109(i)(5)(i)(a).

WFC incident, in which the use of wooden bins (albeit not untreated wooden bins) to store FGAN was allowed under the 1910.109(i) standard. The CSB found that such construction likely facilitated the fire's spread between storage bins.[414] Moreover, the CSB found that even if the wooden bins had been treated (e.g., with coated or clad materials), the incident may have still occurred. This is because, as discussed previously, although coated or clad materials may protect wood against AN impregnation, they are not fire resistant and will still burn. Accordingly, CSB issued public comments on March 31, 2014 when OSHA released a Request for Information (RFI) to CSB and other stakeholders on its Explosives and Blasting Agents standard.[415]

The comments made by CSB pertained in part to the weakness of the provisions in 29 CFR 1910.109(i), particularly with respect to the bulk storage of FGAN.[416] Specifically, CSB expressed concern that, because of certain gaps in 1910.109(i), users are left to decide appropriate safety measures without proper instruction.[417] For example, 1910.109(i) permits the use of wooden bins "protected against impregnation of AN" without defining the word "impregnation."[418] Furthermore, even if the word had been defined, CSB noted that the use of wooden bins is not recommended in other countries, such as the United Kingdom (U.K.), which recommend the use of concrete for bulk AN storage.[419] Moreover, CSB noted in its RFI comments that 1910.109(i) does not provide sufficient fire protection measures with respect to the storage of bulk quantities of FGAN because it requires sprinklers only for bagged AN in amounts exceeding 2,500 tons.[420] CSB concluded that the requirement for sprinklers (or other fire suppression methods) as well as fire detection equipment likely would have helped minimize the severity of the impact of the WFC fire and explosion on the facility and on the surrounding community.[421]

In addition, CSB commented that the title of the standard, "Explosives and Blasting Agents," should be revised so that it is clear that FGAN not used as a blasting agent or explosive is also covered under the standard.[422] As currently titled, the name of the standard might mislead readers to believe that the standard applies only to the explosives industry. Accordingly, CSB recommended that the title be revised to clearly indicate that the standard also applies to the fertilizer industry. Similarly, CSB noted that no scope describing the purpose and application of the standard is listed at the beginning of the standard.[423] Rather, the scope of 29 CFR 1910.109(i) that applies to FGAN appears in the middle of the standard.

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[414] It should be noted, however, that 29 CFR 1910.109(i) did prohibit the configuration and contents of the seed room adjacent to the AN bin.

[415] On December 9, 2013, OSHA issued an RFI on 17 issues regarding revision to the agency's regulatory standards. CSB commented on 15 of the 17 issues in a public comment dated March 31, 2014. The CSB comments are posted on the OSHA website; *see*: http://www.csb.gov/assets/1/16/CSB_RFIcomments.pdf (accessed on December 28, 2015).

[416] *See*: http://www.csb.gov/assets/1/16/CSB_RFIcomments.pdf (accessed on December 28, 2015).

[417] *Ibid*.

[418] *Ibid*.

[419] *Ibid*.

[420] *Ibid*. *See*: 29 CFR 1910.109(i)(7)(i).

[421] *See*: http://www.csb.gov/assets/1/16/CSB_RFIcomments.pdf (accessed on December 28, 2015).

[422] *Ibid*.

[423] *Ibid*.

CSB recommended changing this organization so that the scope is specified early in the document and is easy to locate. CSB concluded that the implementation of such recommendations regarding the standard's title and scope would likely make the standard easier to understand.

In addition to providing comments in response to the OSHA RFI, CSB reviewed guidance documents on FGAN from government and industry sources, finding that the only pre-WFC incident reference to the OSHA standard was in an EPA Chemical Safety Alert, "Explosion Hazard from AN," from December 1997.[424] In a letter to EPA, The Fertilizer Institute (TFI), a major trade association composed of fertilizer industry representatives, contended that the reference was inaccurate and that EPA therefore should remove it from its alert.[425] Specifically, TFI said that the standard "was not applicable to facilities handling AN, unless the facility also handles an explosive or blasting agent."[426] This assertion, however, is incorrect; no part of the standard supports such a reading. As previously mentioned, 29 CFR 1910.109(i) clearly states that it applies to ". . . the storage of AN in the form of . . . prills including fertilizer grade . . ."[427] Nonetheless, CSB finds that additional and well publicized guidance is needed to explain the applicability and provisions of the standard.

Fertilizer industry representatives reported to the Government Accountability Office (GAO) that it was not well known that 1910.109(i) applies to FGAN.[428] While conducting interviews with WFC management and employees, CSB found that WFC personnel knew little about the pertinent section. During these interviews, CSB learned that OSHA conducted its last inspection of the WFC plant[429] in 1985, when the facility was cited for various violations concerning anhydrous ammonia, respiratory protection, and recordkeeping. CSB found no evidence that OSHA cited the WFC for violating any requirement of 1910.109(i) before the April 2013 fire and explosion. It is unknown whether OSHA inspected the facility against this section of the standard.

CSB found that, in addition to WFC personnel, others who would reasonably be expected to know about 29 CFR 1910.109(i) might not have had such knowledge. After the current owners acquired the facility in 2004, third-party safety consultants who visited the facility never referenced 1910.109(i) in their final inspection reports. In fact, in reviewing documentation provided by the WFC, CSB identified only one mention of 1910.109(i)—in a Safety Data Sheet (SDS) provided by one of the WFC's FGAN suppliers, CF Industries, which the WFC received in 2012. The GAO confirmed this observation, noting in its May

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[424] *See*: http://nepis.epa.gov/Exe/ZyPDF.cgi/P100BH59.PDF?Dockey=P100BH59.PDF (accessed on December 28, 2015).

[425] The Fertilizer Institute. "Fertilizer Grade Ammonium Nitrate: Properties and Recommended Methods for Packaging, Handling, Transportation, Storage and Use."

[426] Leason, Chris S., counsel to TFI. Letter to Tawai-David Chung, EPA OSWER, CEPPO, June 27, 1997. At the request of CSB, EPA conducted a search to find its final signed response to TFI's letter. Because of the age of the document, it would only exist in paper form; however, EPA no longer has paper files from that time frame. Thus, EPA's response to this letter is unknown.

[427] 29 CFR 1910.109(i)(1)(i)(a).

[428] GAO. "Chemical Safety: Actions Needed to Improve Federal Oversight of Facilities with Ammonium Nitrate." Washington, DC: GAO, May 2014.

[429] Certain structures of the WFC plant had not yet been built at the time of the 1985 OSHA inspection.

2014 report that it reviewed four SDSs from producers of solid FGAN fertilizer and only one mentioned the pertinent section of the OSHA standard.[430] CSB notes as a concern the fact that the fertilizer industry, as recently as 2014, reported that personnel exhibited little recognition of the applicability of 1910.109(i) to FGAN.[431]

With respect to enforcement, CSB found very little history of OSHA using 29 CFR 1910.109(i) to cite fertilizer facilities. Table 11 shows OSHA's record of 1910.109(i) citations and also the citation that OSHA issued against the WFC by Standard Industrial Classification (SIC)[432] code.

Table 11. OSHA 29 CFR 1910.109(i) Citation History

No.	Facility	Inspection Year	Standard Industrial Classification
1.	Coshocton Farm Bureau (Coshocton, OH)	1974	5083: Farm and Garden Machinery
2.	Smith-Douglass Chemical Div. Bo. (Clayton, DE)	1975	5191: Farm Supplies
3.	Jr. Simplot Co. (Bartley, NE)	1975	2875: Fertilizers, Mixing Only
4.	Farmers Union Cooperative Oil (Flandreau, SD)	1975	5541: Gasoline Service Stations
5.	Old Fox Chemical Co, Inc. (East Providence, RI)	1976	2875: Fertilizers, Mixing Only
6.	Drake Chemical Inc. (Lock Haven, PA)	1976	2865: Cyclic Crudes and Intermediates
7.	IMC Chemical Group Inc. Trojan (New Tripoli, PA)	1976	2892: Explosives
8.	Atlas Powder Co. Kinepak (Alvarado, TX)	1977	2892: Explosives
9.	Jacklin-Plant Food Center (Post Falls, ID)	1977	5191: Farm Supplies
10.	Genstar Chemical Inc. (Presque Isle, ME)	1978	2873: Nitrogenous Fertilizers
11.	Nipak Energy Corp. (Krum, TX)	1979	2892: Explosives
12.	Iuka Coop Exchange (Iuka, KS)	1979	5153: Grain and Field Beans
13.	Beaver Explosives Inc. (New Castle, PA)	1980	2892: Explosives
14.	Independent Explosives Co. of Pennsylvania (Pittston Township, PA)	1987	2892: Explosives

[430] GAO. "Chemical Safety: Actions Needed to Improve Federal Oversight of Facilities with Ammonium Nitrate." Washington, DC: GAO, May 2014.
[431] *Ibid.*
[432] SIC is a system for classifying industries according to industry-specific four-digit codes.

15.	Thermex Energy Corp. (Parrish, AL)	1990	2892: Explosives
16.	Kesco, Inc. (Kittanning, PA)	1994	2892: Explosives
17.	Howard Fertilizer Company, Inc. (Orlando, FL)	1997	2875: Fertilizers, Mixing Only
18.	Hall Explosives Inc. (Good Springs-Tremont, PA)	1998	1629: Heavy Construction, Nec.
19.	American East Explosives (Mount Carmel, PA)	1999	2892: Explosives
20.	West Fertilizer Co. (West, TX)	2013	5191: Farm Supplies

As shown in Table 11, 19 inspections resulted in citations, excluding the citation against the WFC. The SIC code for 10 of these citations are clearly nonfarm, addressing mostly explosives; the nine remaining citations are related to farm supplies. It is important to note, however, that these data reflect citations only, not inspections. That is, although the facilities in Table 11 were inspected against, and cited for violations of, 1910.109(i), they do not represent all inspections conducted by OSHA against that section of the standard. It is impossible to determine whether OSHA inspected any other facilities for compliance, but did not cite them. CSB found no evidence of citations from 1999 to 2013.

The OSHA 29 CFR 1910.109(i) citation history in Table 11 is also similar to that of more recent OSHA enforcement data from 2005 to 2013. These data show that no other facility with the same North American Industry Classification System (NAICS)[433] code as the WFC (NAICS Code 424910) received a citation for violating 1910.109(i). The GAO May 2014 report similarly concluded that OSHA rarely issued citations for violations of the standard's requirements for FGAN storage at fertilizer facilities.[434] GAO found that "a citation for a violation of [OSHA's] AN storage regulations was issued as a result of an inspection of a fertilizer facility only once before the explosion in West, Texas."[435]

After the WFC explosion, OSHA issued 24 citations to the WFC on October 9, 2013, including nine citations for serious violations of 29 CFR 1910.109(i).[436] These violations included lack of adequate ventilation, absence of fire-resistive construction, and improper storage and bin pile heights.[437] The agency also cited the WFC for not ensuring that the wooden bins it used to store FGAN were treated to prevent FGAN impregnation.[438] OSHA and the WFC ultimately settled, with the WFC agreeing to pay

[433] NAICS is the standard used by Federal statistical agencies in classifying business establishments for the purpose of collecting, analyzing, and publishing statistical data related to the U.S. business economy.
[434] GAO. "Chemical Safety: Actions Needed to Improve Federal Oversight of Facilities with Ammonium Nitrate." Washington, DC: GAO, May 2014.
[435] *Ibid*.
[436] OSHA. "Citation and Notification of Penalty to Adair Grain," October 9, 2013.
[437] *Ibid*.
[438] *Ibid*.

penalties without admitting guilt about violating the standards under which it was cited, including 1910.109(i).

There is evidence that the WFC owners made efforts to comply with regulations when notified of noncompliance. When the WFC owners acquired the facility in 2004, state and federal regulators found them to be noncompliant with environmental, product quality, and transportation regulations—issues that the owners promptly corrected. For example, Federal EPA inspectors cited the WFC for not refiling its Risk Management Plan (RMP) registration in 2004.[439] This citation prompted the WFC to hire an insurance company to develop a comprehensive RMP for the safe storage of its anhydrous ammonia.[440] Also, Texas Commission on Environmental Quality (TCEQ) inspectors issued a citation to the facility in 2006 for not having an air permit for anhydrous ammonia.[441] The WFC subsequently developed maintenance and inspection programs to prevent anhydrous ammonia releases. As a result of these inspections and citations, the WFC took appropriate corrective actions. The importance of regulatory awareness and notification, therefore, cannot be overemphasized.

8.2.1 OSHA Issuance of Guidance on Explosives and Blasting Agents Standard

In December 2014, the OSHA Directorate of Enforcement Programs issued investigatory and citation guidance to OSHA enforcement personnel on elements of 29 CFR 1910.109. The nine-page guidance document provides additional clarification of the scope of 1910.109(i) and its application to facilities that store FGAN. This document includes specific compliance guidance for the majority of standard provisions and describes conditions that would be considered in or out of compliance. This guidance further clarifies the application of the standard to facilities storing FGAN and provides a list of NAICS industry codes for facilities most likely to manufacture, use, store, handle, or possess FGAN. The list of NAICS codes includes facilities such as the WFC plant and states that particular attention to AN hazards is needed when inspecting these facilities. The guidance also clarifies the standard's definition of "adequate ventilation" and includes the types of ventilation likely to be unacceptable under the regulations as well as a ventilation rate calculation to assess compliance.

Furthermore, the guidance document provides additional clarification on the subject of wood protection against FGAN impregnation. As discussed previously, 1910.109(i) does not specifically define compliant approaches for the treatment of wood to protect against FGAN impregnation. The standard prohibits untreated wood bin construction for FGAN storage. Although OSHA does not recommend the use of treated wood bins, wood with impermeable coating and claddings (such as two-part epoxy coatings, steel sheet cladding, or sodium silicate) are considered acceptable means for protecting wood against FGAN impregnation. OSHA provides additional guidance for varying types of wood construction that might be encountered during field inspections, including citable conditions such as improperly treated wood and

[439] EPA. "Enforcement Case Report to West Chemical & Fertilizer Company," August 14, 2006.
[440] Triangle Insurance Company. Anhydrous Ammonia Supplement for WFC, 2006.
[441] TCEQ. "TCEQ Enforcement Referral to West Chemical & Fertilizer," June 21, 2006.

treated wood that has not been maintained to protect the coating integrity. The guidance also addresses pile heights for clumping and caking conditions and fire prevention.

The 2014 guidance document for 1910.109(i) addressed some of the issues with vague wording that CSB raised in the RFI comments. Some of the requirements listed under the standard, however, do not provide sufficient safeguards to a facility owner storing bulk quantities of FGAN. In the case of the WFC incident, the wood-constructed bins were made of combustible materials and likely facilitated the spread of a fire between storage bins. According to OSHA, AN impregnation of porous combustible materials, such as wood, can accelerate combustion in the event of a structural fire and increase the explosion risk.[442] OSHA permits the use of wood bins and wood construction only if the wood is protected against impregnation. Although coated or clad materials can protect against AN impregnation, they are not fire resistant and will still burn, contributing to the generation of heat during a fire. CSB determined that the wood-constructed bins likely contaminated the AN, ultimately leading to the detonation by increasing AN energy and sensitivity (discussed in Section 4.2.1). Completely eliminating wood and other combustibles as materials for constructing FGAN bins and storage facilities greatly reduces the possibility of contaminating FGAN during a fire or smoldering event.

Although OSHA enforcement guidance and other efforts have provided greater clarity on how 1910.109(i) applies to FGAN facilities, OSHA still needs to revise and update the standard to incorporate the most recent provisions in NFPA 400 (2016 Edition) that address the safe storage of FGAN.

OSHA cannot enforce some of the regulations in the current 1910.109(i) because they contain requirements reserved for the authority having jurisdiction, such as the municipal or state code official for occupancy permits. Moreover, OSHA cannot cite the following requirements in the standard:

- 29 CFR 1910.109(i)(2)(ii): Approval of large quantity storage shall be subject to due consideration of the fire and explosion hazards, including exposure to toxic vapors from burning or decomposing ammonium nitrate.
- 29 CFR 1910.109(i)(2)(iii)(e): The continued use of an existing storage building or structure not in strict conformity with this paragraph may be approved in cases where such continued use will not constitute a hazard to life.

Because the current version of 1910.109(i) has limited enforcement in some areas—and because NFPA 400 (2016 Edition) (discussed in Section 8.6.1.1) includes updated provisions, some in response to the WFC incident, for increasing the safety of AN storage facilities—OSHA should update 1910.109(i) to include requirements similar to the provisions in NFPA 400 (2016 Edition). It also should revise the rules that currently are enforceable only by municipal or state officials.

[442] OSHA enforcement directive on 1910.109(i).

8.2.2 Need for an Emphasis Program

Unfortunately, only after the WFC incident was more attention focused on the hazards of FGAN and the role of applicable regulations. Since the explosion and issuance of the EO, OSHA has worked to increase awareness of FGAN and the scope of 29 CFR 1910.109(i) through the joint agency advisory on safe storage of FGAN, the letter to the fertilizer industry, and the guidance document for compliance officers to assist in enforcing the 1910.109 standard for FGAN facilities. However, enforcement guidance does not provide the resources needed by OSHA to increase the frequency of inspections, although such guidance may help ensure that 1910.109(i) is applied appropriately when OSHA compliance officers happen to inspect facilities that fall under the rule.

A more realistic and immediate approach to confirm that FGAN facilities are complying with the standard would be for OSHA to launch a regional emphasis program (e.g., in Regions IV, VI, and VII[443]) where these types of facilities are more common. A regional emphasis program would include a certain number of annual inspections per year, which would facilitate bringing FGAN facility operators into compliance with both regulatory and industry standards and would reduce the potential for a future event similar to the WFC incident.

Imposing stricter requirements on AN storage and handling could take several years before enactment into federal regulations. OSHA has initiated several national, regional, and local emphasis programs targeted at specific industries or located in specific geographical areas to help prevent hazards. Such emphasis programs have successfully focused inspection and enforcement efforts on specific industries.

A 1910.109(i) emphasis program can include NFPA 400 (2016 Edition) as a guidance document for compliance officers to support recognition of hazardous conditions or issuance of violations when found. It would also prompt improvement of safe FGAN storage and handling practices through increased awareness and would allow OSHA to collect information and data that could support future revisions to current regulations on FGAN.

8.3 **Chemical Facility Anti-Terrorism Standards (CFATS)**

DHS promulgated the CFATS in 2007 to address security issues at high-risk chemical facilities, including those that store certain quantities of FGAN. The rule establishes risk-based performance standards for chemical facility security and requires facilities to prepare vulnerability assessments and security plans to protect the public from a breach of security or an intentional release.

Under CFATS, DHS collects information from facilities that possess designated quantities of chemicals of interest (COIs).[444] In creating the COI list, DHS referenced other established lists that regulate

[443] These regions include the following states: Alabama, Florida, Georgia, North Carolina, South Carolina, Tennessee, Mississippi, Kentucky, Nebraska, Kansas, Missouri, Iowa, Texas, Oklahoma, Arkansas, Louisiana, and New Mexico.

[444] CFATS § 27.210(a)(1)(i).

chemicals—including the list of chemicals covered under the EPA Risk Management Program, the Chemical Weapons Convention, and DOT—and a list of chemicals with known inhalation hazards. The COI list includes 322 chemicals and also screening threshold quantities for each chemical as it relates to each of the three defined security hazards (release, theft, and sabotage).

Chemical facilities that meet the COI criteria listed in Appendix A of the CFATS rule must complete and electronically submit a Chemical Security Assessment Tool (CSAT) Top-Screen form to DHS. Using the information collected from facility Top-Screen information, DHS assigns a preliminary risk-based tier—from the highest (tier 1) to the lowest "high-risk" level (tier 4) and the "not high-risk" level (tiered out)—based on a basic assessment of the potential consequences in association with the chemical holdings at each facility.[445] Once a preliminary tier is assigned, each facility in tiers 1 through 4 must submit a CSAT Security Vulnerability Assessment to DHS, and DHS uses that assessment to make a final determination of the facility's assessed level of risk. If DHS retains the facility in one of the four high-risk tiers, the facility must submit a site security plan. DHS reviews the plan, conducts an onsite inspection of the facility, and approves the plan if it is deemed adequate relative to the risks inherent in the facility, its chemical holdings, and potential consequences of a security breach.

Since publication of the CFATS rule, DHS has received more than 50,000 Top-Screen forms submitted by chemical facilities. As of September 2015, DHS covers 3,182 high-risk facilities nationwide, and 2,607 of those sites have undergone onsite authorization inspections.

8.3.1 AN Screening Thresholds

FGAN is listed in CFATS Appendix A as a DHS COI. A facility reports to DHS based on possession of AN under three conditions:

1. If a facility possesses 5,000 pounds or more of FGAN with more than 0.2 percent combustible substances, including any organic substance calculated as carbon, to the exclusion of any other added substance in bulk storage, the facility must report. Facilities meeting this threshold must also submit information to DHS on quantity and on method of storage or packaging.
2. If a facility possesses 400 pounds or more of FGAN with more than 0.2 percent combustible substances, including any organic substance calculated as carbon, to the exclusion of any other added substance in transportation packaging, the facility must report.
3. If a facility possesses 2,000 pounds or more of solid FGAN with a nitrogen concentration of 23 percent or higher in transportation packaging, the facility must report.

CSB requested and reviewed CFATS data from all facilities in the United States that submitted information to DHS for storage of FGAN as of March 2014. According to the DHS data, 1,351 facilities in the United States store AN in quantities that exceed the screening thresholds. The majority of those

[445] When determining whether a facility is high risk, DHS primarily focuses on the potential consequences associated with a successful terrorist attack on the facility (including the use of stolen or diverted materials in a separate attack offsite). A threat factor also is incorporated into the risk assessment for facilities with release hazards.

facilities store FGAN for agricultural uses (Figure 73). Based on the NAICS codes submitted with Top-Screen information, 46 percent of the facilities that report to DHS stock FGAN for agricultural purposes such as farm merchandising and wholesale or crop preparation. An additional 6 percent store FGAN for fertilizer mixing.

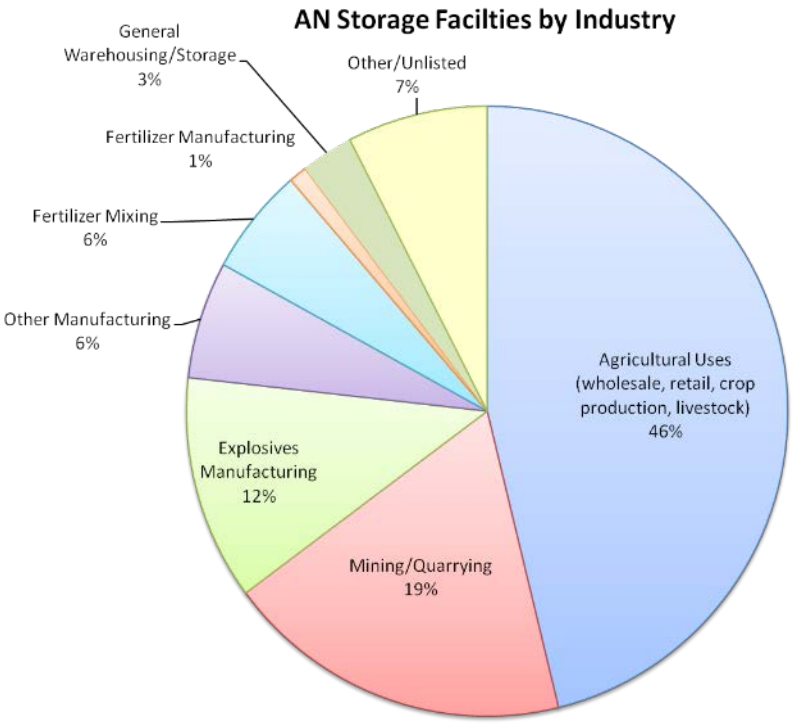

Figure 73. Percentage of AN Storage Facilities by Industry (Source: DHS)

In 2008, DHS filed a reporting extension to agricultural facilities meeting screening thresholds of FGAN for farmers and agricultural end users of FGAN, such as the preparation and application of crops, feed, land, or livestock.[446] However, this extension does not apply to chemical distribution facilities or to commercial chemical application services, such as the WFC. At the time of the April 2013 explosion, the WFC possessed an estimated maximum of 120,000 pounds of FGAN, about 60 times the screening threshold of 2,000 pounds, but did not submit Top-Screen information to DHS as required under the CFATS. Consequently, DHS was unaware that the WFC possessed FGAN until the 2013 explosion. After the incident, the WFC retroactively submitted a Top Screen to DHS upon notification that it was not compliant with the rule, and DHS did not issue a citation to the WFC for originally failing to submit the form. If the WFC had complied with the CFATS, a CFATS inspection or assistance visit might have noted the storage conditions at the WFC facility and prompted change. In addition, DHS engagement

[446] 73 *Federal Register* 1640.

with facility management might have prompted greater engagement by local law enforcement, which in turn might have supported greater involvement by other community emergency services.

8.4 Safety Management Programs

Following a number of major chemical accidents in the United States and abroad in the 1970s and 1980s, Congress amended the Clean Air Act (CAA) in 1990 to require both OSHA and EPA to publish new regulations to help prevent similar accidents. Through Section 304 of the CAA Amendments, Congress directed the Secretary of Labor, in coordination with the EPA Administrator, to promulgate, pursuant to the Occupational Safety and Health Act of 1970, a chemical process safety standard to prevent accidental releases of chemicals that could pose a threat to employees.[447] Also, through CAA Amendments Section 112(r), Congress required EPA to publish regulations and guidance for chemical accident prevention at facilities using substances that posed the greatest risk of harm from accidental releases.[448] The following sections focus on the intertwined regulations that OSHA and EPA developed – the OSHA Process Safety Management of Highly Hazardous Chemicals standard and the EPA Risk Management Program rule.

8.4.1 OSHA Process Safety Management Standard

OSHA's Process Safety Management of Highly Hazardous Chemicals standard (29 CFR 1910.119) (known as the PSM standard) became effective in May 1992.[449] The standard contains requirements for preventing or minimizing the consequences of catastrophic releases of toxic, reactive, flammable, or explosive chemicals.[450] It includes the following 14 elements:

1. Employee participation.
2. Process safety information.
3. Process hazard analysis.
4. Operating procedures.
5. Training.
6. Contractors.
7. Pre-startup safety review.
8. Mechanical integrity.
9. Hot work permits.
10. Management of change.
11. Incident investigation.
12. Emergency planning and response.
13. Compliance audits.

[447] *See*: https://www.osha.gov/Publications/osha3132.html (accessed December 28, 2013).
[448] *See*: http://www.epa.gov/sites/production/files/2013-10/documents/caa112_rmp_factsheet.pdf (accessed December 28, 2015).
[449] OSHA. "Process Safety Management." OSHA 3132, 2000.
[450] 29 CFR 1910.119.

14. Trade secrets.[451]

The PSM standard states that it applies, in part, to "a process which involves a chemical at or above the specified threshold quantities listed in Appendix A [List of Highly Hazardous Chemicals, Toxics and Reactives] to this section."[452] Notably, FGAN is not on this list.

In deciding which chemicals to regulate under the PSM standard, OSHA reviewed potential "highly reactive and explosive substances," as required by Section 304(b) of the CAA Amendments.[453] OSHA considered information drawn from multiple sources, including EPA, DOT, World Bank, NFPA, the Health and Safety Commission of the U.K., and the states of Delaware and New Jersey.[454] With respect to reactives, OSHA chose to include only those chemicals with the two highest (i.e., most dangerous) reactivity ratings under NFPA 490 because of the significant risk that they posed to workers.[455] These chemicals had reactivity ratings of 3 or 4.[456] FGAN, however, was left off the PSM list, despite having a reactivity rating of 3.[457] Although the agency did consider adding FGAN to the PSM list in the late 1990s, this effort failed due to "resource constraints and other priorities."[458] Thus, FGAN has yet to be regulated under the PSM standard.

Anhydrous ammonia, on the other hand, is on the List of Highly Hazardous Chemicals, Toxics and Reactives, with a threshold quantity of 10,000 pounds. CSB found that, at the time of the incident, the WFC was storing the equivalent of 34,000 pounds of anhydrous ammonia, more than three times the threshold quantity that triggers PSM coverage. CSB also discovered that the WFC had previously stored 54,000 pounds of anhydrous ammonia in 2006 and 2011. Given these facts, the WFC should have complied with the PSM standard because the company stored anhydrous ammonia, at least in 2006, 2011, and 2013, in quantities that exceeded its threshold quantity. However, CSB learned that the PSM standard did not apply to the WFC at the time of the incident because the facility qualified under OSHA's interpretation of the standard's retail facilities exemption.

At the time of the incident, a facility qualified under the retail facilities exemption if the following conditions were met: (1) the facility contained a highly hazardous chemical in a quantity that met or exceeded the threshold quantity for the chemical; (2) the facility used a process[459] covered by the PSM

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[451] *Ibid*.
[452] 29 CFR 1910.119(a)(1)(i).
[453] CONSAD OSHA Report, 1988.
[454] 55 *Federal Register* 29150.
[455] CONSAD OSHA Report, 1988.
[456] *Ibid*.
[457] Federal OSHA in discussion with CSB, May 14, 2015.
[458] *See*: https://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=FEDERAL_REGISTER&p_id=16946 (accessed December 28, 2015).
[459] The PSM standard defines "process" as any activity involving a highly hazardous chemical, including any use, storage, manufacturing, handling, or onsite movement of such chemicals (or any combination of these activities). It also states that, for purposes of this definition, any group of vessels that are interconnected—and separate vessels

standard; and (3) more than 50 percent of the facility's income was derived from direct end users.[460] The WFC facility met all three conditions for its storage of anhydrous ammonia. It stored anhydrous ammonia, a highly hazardous chemical, in quantities that exceeded its threshold quantity. Also, the facility used a process because it stored the anhydrous ammonia, and storage meets the PSM standard definition of a "process." Because the WFC primarily sold its products, including anhydrous ammonia, to farmers (i.e., direct end users), the company met the third condition as well. Thus, the WFC qualified under the PSM standard's retail facilities exemption and was not required to comply with the standard.

If the PSM standard had applied to the WFC for its storage of anhydrous ammonia however, the WFC would have been required to conduct a process hazard analysis (PHA). A PHA must address the following:

- Hazards of the process.
- Identification of any previous incident that had a potential for catastrophic consequences in the workplace.
- Engineering and administrative controls applicable to the hazards and their interrelationships, such as appropriate application of detection methodologies to provide early warning of releases, with acceptable detection methods that might include process monitoring and control instrumentation with alarms and also detection hardware such as hydrocarbon sensors.
- Consequences of a failure of engineering and administrative controls.
- Facility siting.
- Human factors.
- Qualitative evaluation of a range of the possible safety and health effects on employees in the workplace if a failure of controls occurs.[461]

The WFC would have had to address facility siting as part of its PHA. Facility siting refers to the location of the covered process and its proximity to various other components within the facility's property.[462] It does not refer to the site of the facility in relation to the surrounding community.[463] A facility siting analysis at the WFC likely would have identified the close proximity of the facility's FGAN storage warehouse and its anhydrous ammonia storage tanks, thus triggering implementation of necessary safeguards to mitigate the possibility of potentially catastrophic successive incidents involving the two hazardous chemicals. This observation was a critical element of CSB's investigation because evidence indicated that the FGAN explosion damaged the facility's anhydrous ammonia tanks. If more force had been applied to the tanks, their contents could have been released into the neighboring community and

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that are located so that a highly hazardous chemical could be involved in a potential release— must be considered a single process.

[460] OSHA interpretation letter. *See*: https://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=INTERPRETATIONS&p_id=23885 (accessed December 28, 2015).

[461] *See*: https://www.osha.gov/Publications/osha3132.html (accessed on December 28, 2015).

[462] *See*: https://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=DIRECTIVES&p_id=1558 (accessed on December 28, 2015).

[463] *Ibid*.

caused even more fatalities and injuries. However, the WFC was not required to conduct facility siting because it qualified for the PSM standard's retail facilities exemption.

CSB communicated its concern about the retail facilities exemption in its March 31, 2014, comments to OSHA's December 9, 2013 RFI.[464] CSB asked OSHA to consider whether the retail facilities exemption should be revised in order to cover facilities such as WFC, which stored bulk quantities of chemicals covered by the PSM standard.[465]

8.4.1.1 Revised Interpretation of the PSM Retail Facilities Exemption

On July 22, 2015, OSHA issued a memorandum, "Process Safety Management of Highly Hazardous Chemicals and Application of the Retail Exemption" (Retail Exemption Memorandum).[466] OSHA noted in the memorandum that the PSM exemption for retail facilities does not define the term "retail facility."[467] However, the agency also said that the preamble to the PSM standard does explain that chemicals in retail facilities are generally sold in "small volume packages, containers, and allotments."[468] OSHA pointed out that the preamble gives an example of a gasoline station as a type of facility that would fit within the definition of a retail facility and thus qualify for the exemption.[469] OSHA also mentioned in the Retail Exemption Memorandum that other federal agencies define the term similarly.[470] In particular, it states that the U.S. Department of Commerce, which develops NAICS codes, characterizes retail trade as follows (emphasis added):

> The Retail Trade sector comprises establishments engaged in retailing merchandise, generally without transformation, and rendering services incidental to the sale of merchandise. The retailing process is the final step in the distribution of merchandise; retailers are, therefore, organized to sell merchandise in ***small quantities*** to the general public. [471]

However, this is not how OSHA had always interpreted its PSM retail exemption.

After promulgation of the PSM standard, OSHA issued a series of letters of interpretation[472] and a PSM compliance directive[473] that interpreted the retail exemption more broadly than originally intended.[474] Under these interpretations, a facility was considered exempt from the PSM standard if it derived "more

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[464] *See*: http://www.csb.gov/assets/1/16/CSB_RFIcomments.pdf (accessed on December 28, 2015).
[465] *Ibid*.
[466] OSHA. "Process Safety Management of Highly Hazardous Chemicals and Application of the Retail Exemption (29 CFR 1910.119(a)(2)(i))." OSHA Memorandum, July 22, 2015.
[467] *Ibid*.
[468] 57 *Federal Register* 6356, 6369.
[469] *Ibid*.
[470] OSHA. "Process Safety Management of Highly Hazardous Chemicals and Application of the Retail Exemption (29 CFR 1910.119(a)(2)(i))." OSHA Memorandum, July 22, 2015.
[471] U.S. Department of Commerce. *NAICS Manual*, Sector 44–45: Retail Trade.
[472] OSHA letters of interpretation explain OSHA requirements, which are set by statute, standards, and regulations.
[473] OSHA. Compliance Directive (CPL) 02-03-045.
[474] OSHA. "Process Safety Management of Highly Hazardous Chemicals and Application of the Retail Exemption (29 CFR 1910.119(a)(2)(i))." OSHA Memorandum, July 22, 2015.

than 50 percent of its income from direct sales of highly hazardous chemicals to the end user" (the 50 percent test).[475] This rationale is how the WFC claimed the retail exemption for its storage of anhydrous ammonia. If FGAN had been covered under the PSM standard before the WFC incident, the retail exemption, as it had been interpreted, would have precluded PSM coverage at the WFC and similar facilities. In addition, this 50 percent test allowed employers that sold or distributed large bulk quantities of highly hazardous chemicals directly to end users to claim the exemption, even if the end users were themselves commercial establishments.[476] This reasoning led to confusion about the definition of the term "end user." In its Retail Exemption Memorandum, OSHA said that it did not intend either of these outcomes.

OSHA's Retail Exemption Memorandum rescinded all previous documents, letters of interpretation, and memoranda related to the retail exemption and the 50 percent test.[477] OSHA states that its interpretation of the exemption is now more consistent with the standard's original intent.[478] In reference to the NAICS Manual, OSHA states that:

> Only facilities, or the portions of facilities, engaged in retail trade as defined by the current and any future updates to sectors 44 and 45 of the NAICS Manual may be afforded the retail exemption at 29 CFR 1910.119(a)(2)(i).[479]

Facilities that fall within Sectors 44–45: Retail Trade, consist of a number of subsectors. These facilities are now (or are still) considered retail facilities eligible for the retail exemption. Notably, NAICS codes typically used for FGAN bulk storage and sales do not fit into one of these classifications. As such, facilities that store or sell bulk FGAN do not qualify for the retail exemption. If OSHA's new interpretation were in effect before the incident, the WFC could not have claimed the retail exemption for its storage of anhydrous ammonia. Furthermore, it could not have claimed the exemption for its storage of FGAN had FGAN been included on the PSM list pre-incident.

If this new interpretation had been in effect before the incident, the WFC might have recognized that its storage of anhydrous ammonia was covered by the PSM standard. Although compliance efforts would have focused on this potential hazard, the WFC might have learned about FGAN-related hazards as well. As previously discussed, if the WFC had conducted a facility siting analysis, it could have identified the close proximity of its FGAN storage warehouse to its anhydrous ammonia pressure tanks. This may have

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[475] *Ibid*.
[476] *Ibid*.
[477] *Ibid*.
[478] *Ibid*. According to a December 23, 2015, OSHA memorandum, through September 30, 2016, OSHA will not cite employers for violations of the PSM standard at facilities that it would not have cited applying the interpretation of the term "retail" that was in place prior to July 22, 2015.
[479] OSHA. "Process Safety Management of Highly Hazardous Chemicals and Application of the Retail Exemption (29 CFR 1910.119(a)(2)(i))." OSHA Memorandum, July 22, 2015. Facilities that fall under Sectors 44–45: Retail Trade consist of a number of subsectors, including Motor Vehicle and Parts Dealers (NAICS 441), Building Material and Garden Equipment and Supplies Dealers (NAICS 444), Gasoline Stations (NAICS 447), and General Merchandise Store (NAICS 452).

led the WFC to explore the potential for FGAN to catch fire and detonate under certain conditions. It also may have caused the WFC to implement safeguards to prevent hazards associated with the two different chemicals.

OSHA's revised interpretation of the retail exemption would mean that facilities such as the WFC would be covered for their use of anhydrous ammonia. According to the fertilizer industry, more than 3,800 U.S. retail facilities previously exempted by the older interpretation of the retail exemption would be covered under the requirements of the PSM standard because of anhydrous ammonia storage.[480] WFC use of FGAN could also be regulated directly in the future, but only if FGAN were added to PSM's List of Highly Hazardous Chemicals, Toxics and Reactives. CSB recommends that OSHA consider including FGAN for coverage under the PSM standard.[481] CSB supports OSHA's revised interpretation of the retail exemption to guarantee that potential changes to the PSM standard will apply to facilities like the WFC that store anhydrous ammonia as well as FGAN, which would provide the basis for the CSB's proposed recommendation to add FGAN to the PSM list.

8.4.1.2 Guidance on Recognized and Generally Accepted Good Engineering Practices Under the PSM Standard

OSHA also recently addressed its reference to the common industry term, "recognized and generally accepted good engineering practices" (RAGAGEP), under its PSM standard. This term is often used in performance-based standards like PSM. Generally, standards can be either prescriptive or performance based. As its name suggests, a prescriptive standard sets rigid compliance specifications. A performance-based standard, on the other hand, simply delineates the expected performance outcome or end result, without specifying how the outcome or result is to be achieved. In other words, a prescriptive standard describes *how* something is to be achieved, but a performance-based standard only specifies *what* is to be accomplished. For example, OSHA's Explosives and Blasting Agents standard (Section 8.2) is a prescriptive standard that contains FGAN-specific provisions. That part of the standard is prescriptive because its provisions set out *how* to handle FGAN; the provisions are inflexible.

In contrast, OSHA's PSM standard is performance-based. It employs a broad approach to materials and applications and enables incorporation of current industry practices. As a performance-based standard, it allows employers to select the RAGAGEP that they choose to apply to their facilities.[482] These chosen RAGAGEP are the ones that employers must follow at their facilities so that they are deemed compliant. Although the PSM standard does not define RAGAGEP, OSHA's Petroleum Refinery PSM National

[480] TFI/ARA Hearing Statement: "Examining the Use of Agency Regulatory Guidance." *See*: http://www.mo-ag.com/uploaded/Senate%20HSGAC%20RFAM%20Hearing%209-23-15.pdf (accessed December 1, 2015).
[481] OSHA has initiated a Small Business Regulatory Enforcement Fairness Act panel on its PSM standard, after issuing an RFI in November 2013 seeking public comment on ways to improve the standard. ATF/OSHA/EPA. "Actions to Improve Chemical Facility Safety and Security." ATF/OSHA/EPA Fact Sheet, June 2015.
[482] OSHA. "RAGAGEP in Process Safety Management Enforcement." OSHA Memorandum, June 8, 2015.

Emphasis Program references the definition established in the Center for Chemical Process Safety's *Guidelines for Mechanical Integrity Systems*:

> Recognized and Generally Accepted Good Engineering Practices (RAGAGEP) are engineering, operation, or maintenance activities based on established codes, standards, published technical reports or recommended practices or a similar document. RAGAGEP detail generally approved ways to perform specific engineering, inspection or mechanical integrity activities, such as fabricating a vessel, inspecting a storage tank, or servicing a relief valve.[483]

This is the definition OSHA references in addressing its use of the term under the PSM standard.

Following the WFC incident, OSHA provided guidance on its use of the term RAGAGEP under its PSM standard in a June 8, 2015, memorandum, "RAGAGEP in Process Safety Management Enforcement" (PSM RAGAGEP Memorandum). As noted by OSHA in its PSM RAGAGEP Memorandum, the PSM standard directly references or implies the use of RAGAGEP in three provisions:

1. 29 CFR 1910.119(d)(3)(ii): Employers must document that all equipment in PSM-covered processes complies with RAGAGEP.
2. 29 CFR 1910.119(j)(4)(ii): Inspections and tests are performed on process equipment subject to the standard's mechanical integrity requirements in accordance with RAGAGEP.
3. 29 CFR 1910.119(j)(4)(iii): Inspection and test frequency follows manufacturer's recommendations and good engineering practice, and more frequently if indicated by operating experience.[484]

Accordingly, RAGAGEP under the PSM standard apply to process equipment design, installation, operation, and maintenance; inspection and test practices; and inspection and test frequencies.[485]

The PSM RAGAGEP Memorandum notes the following primary sources of RAGAGEP: (1) published and widely adopted codes, (2) published consensus documents, and (3) published nonconsensus documents.[486] Published and widely adopted codes are those consensus standards that have been widely adopted by federal, state, or municipal jurisdictions.[487] Published consensus documents are identified as those published by certain organizations which must follow the American National Standards Institute (ANSI) "Essential Requirements: Due process requirements for American National Standards" (ANSI Essential Requirements).[488] Published nonconsensus documents include publications that do not conform to the ANSI Essential Requirements and peer-reviewed technical articles.[489] It is important to note that

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[483] OSHA. Compliance Directive (CPL) 03-00-010.
[484] OSHA. "RAGAGEP in Process Safety Management Enforcement." OSHA Memorandum, June 8, 2015.
[485] *Ibid*.
[486] *Ibid*.
[487] *Ibid*. Examples of published and widely adopted codes include NFPA 101 (*Life Safety Code*) and NFPA 70 (*National Electric Code*).
[488] *Ibid*. Examples of published consensus documents include the ASME B31.3, "Process Piping Code," and the International Institute of Ammonia Refrigeration (IIAR) ANSI/IIAR 2-2008, "Equipment, Design, and Installation of Closed-Circuit Ammonia Mechanical Refrigerating Systems."
[489] *Ibid*. Examples of published nonconsensus documents include the Chlorine Institute "pamphlets" focusing on chlorine and sodium hypochlorite safety and the Design Institute for Emergency Relief Systems guideline book addressing technology for reactive and multiphase relief systems design.

while OSHA generally accepts published and widely adopted codes and published consensus documents as RAGAGEP, published nonconsensus documents are not necessarily generally accepted. However, OSHA may choose to accept them if they are applicable and appropriate.[490]

The PSM RAGAGEP Memorandum also explains the difference between "shall" and "should" language. In particular, OSHA notes that positive and negative uses of "shall," "must," or similar language in published RAGAGEP reflect the developer's view that the practice is a mandatory minimum to control a hazard.[491] Thus, if an employer deviates from such RAGAGEP, OSHA will presume a violation.[492] Where "should" language applies in RAGAGEP, OSHA presumes that employer compliance with the recommended approach is acceptable.[493] If an employer chooses to deviate from the recommended approach, however, OSHA will evaluate whether the employer has determined and documented that its alternative approach is at least as protective as the recommended approach or whether the recommended approach does not apply to the employer's operation.[494] OSHA presumes a violation if employers act in a way that RAGAGEP deem they "should not."[495]

These enforcement considerations emphasize that RAGAGEP are more than optional recommendations. Many RAGAGEP are mandatory standards based on scientific data and previous incidents and it is crucial that employers comply with them. If FGAN is added to the PSM list, the use of RAGAGEP will allow facilities to select and comply with FGAN-specific standards, such as NFPA 400, that have been recently updated to address and help prevent the conditions that led to the WFC explosion.

8.4.2 EPA Risk Management Program Rule

The EPA Risk Management Program rule (40 CFR Part 68, Subparts A through H) is intended to prevent and minimize the consequences of accidental releases of toxic or flammable substances.[496] Enacted in 1996, the regulation required facilities to be compliant by 1999.[497] In general, covered facilities are those with a substance on one of the Risk Management Program rule's two lists, one for toxic substances and one for flammable substances, in a quantity that meets or exceeds the threshold quantity for the substance.[498] These facilities must perform a hazard assessment, consisting of worst case and alternative release scenarios as well as a five-year accident history; implement an accident prevention program (which is required for most facilities); establish an emergency response program; and develop an RMP

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[490] *Ibid*.
[491] *Ibid*.
[492] *Ibid*.
[493] *Ibid*.
[494] *Ibid*.
[495] *Ibid*.
[496] EPA. "Accidental Release Prevention Requirements: Risk Management Program Under the Clean Air Act." RFI, July 31, 2014.
[497] *See*: http://nepis.epa.gov/Exe/ZyPDF.cgi/100038BD.PDF?Dockey=100038BD.PDF (accessed on December 28, 2015).
[498] *See*: http://www.epa.gov/rmp/risk-management-plan-rmp-rule-overview (accessed on December 28, 2015).

and submit it to EPA.[499] Facility management must revise and resubmit its RMP to EPA at least every five years.[500]

EPA has developed three program levels for process classification to ensure that individual processes are subject to requirements that appropriately match their size and risks they pose.[501] Program Level 1 applies to processes with lower risks that would not significantly affect the public in a worst case release scenario and that have had no accidents with specific offsite consequences in the last five years.[502] These facilities have limited and/or minimal accident prevention requirements.[503] Program Levels 2 and 3 cover higher-risk facilities that must meet more stringent accident prevention requirements.[504] A Program Level 3 facility is not eligible for classification under Program Level 1 and is either (1) subject to OSHA's PSM standard or (2) classified in one of 10 specified NAICS codes.[505] Program Level 3 requires implementation of an accident prevention program that is virtually equivalent to the one required under the PSM standard.[506] Program Level 2 applies to facilities that are not eligible for classification in Program Level 1 or Program Level 3.[507] Program Level 2 requires implementation of a streamlined accident prevention program.[508]

The WFC was a Program Level 2 facility under the Risk Management Program rule for its storage of anhydrous ammonia, a regulated substance, which the WFC kept in amounts that exceeded the substance's threshold quantity. Program Level 2 facilities must conduct hazard reviews.[509] For this requirement to be satisfied, facilities must conduct a review and identify the following:

- Hazards associated with the Program 2 process and regulated substances.
- Opportunities for equipment malfunction or human error that could cause a release.
- Safeguards that will control the hazards or prevent the malfunction or error.
- Steps to detect or monitor releases.[510]

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[499] *Ibid*.
[500] *Ibid*.
[501] *See*: http://www.epa.gov/sites/production/files/2013-10/documents/caa112_rmp_factsheet.pdf (accessed on December 28, 2015).
[502] *Ibid*.
[503] *Ibid.*
[504] *Ibid*.
[505] *Ibid*. These 10 manufacturing NAICS codes are (1) 32211 pulp mills; (2) 32411 petroleum refineries; (3) 32511 petrochemical manufacturing; (4) 325181 alkalis and chlorine manufacturing; (5) 325188 all other basic inorganic chemical manufacturing; (6) 325192 cyclic crude and intermediate manufacturing; (7) all other basic organic chemical manufacturing; (8) plastics material and resin manufacturing; (9) nitrogenous fertilizer manufacturing; and (10) pesticide and other agricultural chemical manufacturing. *See*: http://www2.epa.gov/sites/production/files/2013-11/documents/cd-chap-02.pdf (accessed on December 28, 2015).
[506] *See*: http://www.epa.gov/sites/production/files/2013-10/documents/caa112_rmp_factsheet.pdf (accessed on December 28, 2015).
[507] *Ibid.*
[508] *Ibid*.
[509] *See*: http://www.epa.gov/sites/production/files/2013-11/documents/chap-06-final.pdf (accessed on December 28, 2015).
[510] *Ibid*.

CSB discovered that the WFC implemented a prevention program that included a hazard review. In its most recent RMP from 2011, the WFC identified major hazards, which included toxic releases, equipment failure, and earthquakes, but did not include fire or explosion.[511] The facility also indicated that it did not use mitigation systems, such as sprinklers, for its storage of anhydrous ammonia.[512] Clearly, this hazard review did not provide the type of protection needed to address the fire and explosion that occurred on the day of the WFC incident. Because FGAN is not a regulated substance, the WFC was not required to conduct such a hazard review for its storage of FGAN. Accordingly, CSB recommends that FGAN be added to the Risk Management Program list.[513]

CSB contends that EPA should consider adding FGAN to the list of regulated substances, taking into account the more recent recognition of the unpredictable explosive hazards of FGAN, better awareness of the location of FGAN facilities across the United States, greater knowledge of the quantity of FGAN normally stored at these facilities, and continuance of FGAN-related incidents since the issuance of the final Risk Management Program list. As demonstrated in Appendix B, FGAN-related incidents continue to occur, domestically and abroad. Despite tremendous property damage and economic cost, the most devastating result of these incidents is the immeasurable loss of human life. CSB found that a likely cause of such loss of life is the alarming number of FGAN facilities located in communities—next to schools, hospitals, residences, and businesses (discussed in Section 9). Another cause, as determined by CSB, is the tendency of these facilities to store FGAN in large quantities. Coupling these factors with the more recent recognition that FGAN is susceptible to unstable detonation under certain conditions, CSB recommends that FGAN be listed under the Risk Management Program rule. Moreover, CSB reviewed original listing criteria and found that inclusion of FGAN on the Risk Management Program list is warranted.

8.4.2.1 Risk Management Program Rule Listing Criteria Background

Under CAA Section 112(r)(4), the factors to be considered in listing substances for Risk Management Program rule coverage are (1) the severity of acute adverse health effects associated with accidental releases of the substance, (2) the likelihood of accidental releases of the substance, and (3) the potential magnitude of human exposure to accidental releases of the substance.[514] When EPA first promulgated its Risk Management Program list of chemicals and threshold quantities in 1994, it reviewed 11 different lists, including three EPA lists.[515] The criteria used for development of these lists were reviewed to determine whether the criteria were related to the factors mandated by Congress for list development

[511] WFC 2011 RMP submission to EPA.
[512] *Ibid*.
[513] EPA has issued a RFI and worked on a Notice of Proposed Rulemaking for its Risk Management Program rule. ATF/OSHA/EPA. "Actions to Improve Chemical Facility Safety and Security." ATF/OSHA/EPA Fact Sheet, June 2015.
[514] 58 *Federal Register* 5102 (January 19, 1993).
[515] *Ibid*.

under CAA Section 112(r).[516] Acute toxicity was generally considered in developing these lists of chemicals, but some also used flammability and explosivity as criteria for regulating chemicals.[517]

As part of its review of the first factor to be considered for listing substances under the Risk Management Program rule, EPA reviewed chemicals that could cause severe acute adverse health effects. EPA found that the severity of acute adverse health effects can be related to the inherent hazards (i.e., hazardous material properties that cannot be changed) of the substances of interest, such as the toxicity of a substance resulting in lethal effects.[518] EPA noted that acute adverse health effects also could result from other inherent hazards, such as the flammability or high reactivity of the substance.[519] Importantly, it stated that the phenomena associated with these hazards could be, for example, radiant heat from a chemical fire or blast waves from an explosion of a chemical.[520]

In reviewing the second Risk Management Program listing criteria factor, EPA stated that the likelihood of an accidental release of a chemical can be related to typical usage and handling scenarios, such as equipment commonly used in typical facility operations.[521] EPA stated that ubiquitous substances, because of greater handling and use, might have a greater potential for an accidental release.[522] The agency observed that a history of a large number of accidents in the past, for example, might be an indicator of an existing hazard related to a particular substance and its potential to be involved in accidental releases in the future.[523] Notably, EPA stated that chemicals that are found in large volumes at many locations and chemicals that are particularly prevalent (e.g., commodity chemicals, like chlorine and ammonia) might be more likely to be involved in accidental releases than small-volume, less commonly used chemicals.[524]

With respect to the last factor to be considered for Risk Management Program listing, EPA found the magnitude of human exposure associated with accidental releases to be related to the severity of the health effects (hazards) and the likelihood of a release (the chance that a release will have an effect on the population of environment beyond the facility fenceline).[525] The agency noted that this definition was somewhat different from the traditional risk assessment definition of human exposure, which relates magnitude of exposure to the population and sensitive environments that might be affected by a release from a specific site.[526] It recognized that factors that might affect the magnitude of human exposure could be site specific or accident specific and could vary widely by location and incident.[527] Significantly, EPA

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[516] *Ibid*.
[517] *Ibid*.
[518] *Ibid*.
[519] *Ibid*.
[520] *Ibid*.
[521] *Ibid*.
[522] *Ibid*.
[523] *Ibid*.
[524] *Ibid*.
[525] *Ibid*.
[526] *Ibid*.
[527] *Ibid*.

also contended that proximity to population centers, for example, might play a role in the magnitude of accidental releases.[528]

8.4.2.2 Risk Management Program Rule Listing Criteria and Coverage for FGAN

CSB reviewed the original listing criteria to determine their application to FGAN and found support for inclusion of FGAN on the Risk Management Program list. First, CSB found a high severity of acute adverse health effects related to accidental releases of FGAN because one of the phenomena associated with the hazards of FGAN as a reactive and as an explosive is blast waves from an FGAN explosion. Acute adverse health effects from blast waves can include not only major injuries (such as fractures and injuries to the head, ears, and eyes), but also death. All of these were reported after the WFC incident. As stated previously, EPA specifically deemed blast waves to be considered in assessing the severity of acute adverse health effects related to accidental releases of the substance.

CSB concluded that FGAN meets the second criteria for listing under the Risk Management Program rule because the likelihood of accidental releases of FGAN is high. Before assessing the merits of this listing factor, CSB sought to define such accidental releases and ultimately found that they can be described as emissions of blast waves and thermal energy from FGAN explosions. An accidental release is defined by the CAA Amendments of 1990 as "an unanticipated emission of a regulated substance or other extremely hazardous substance into the ambient air from a stationary source."[529] In general, this definition has been interpreted to apply only to gases and liquids, not to solids such as FGAN.[530] However, in its original Risk Management Program rule listing notice, EPA determined the proposed threshold quantity for high explosives[531] based on the quantity that could produce potentially lethal blast waves from an explosion at a distance of 100 meters.[532] This determination is significant because it supports the conclusion that EPA envisioned blast waves as qualifying as unanticipated emissions when it considered explosives for addition to the Risk Management Program list.

CSB also conducted its own research on explosions and emissions. An explosion involves a sudden release of large amounts of energy. This energy release can be dissipated as blast waves, propulsion of

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[528] *Ibid*.
[529] 40 CFR 68.3
[530] ARA. "Re: Accidental Release Prevention Requirements: Risk Management Programs under the Clean Air Act, Section 112(r)(7); Request for Information; Docket # EPA-HQ-OEM-2014-0328; FRL-9911-61-OSWER." October 29, 2014.
[531] High explosives represent the category of explosives that might most easily detonate. 59 *Federal Register* 4487 (January 31, 1994). They are likely to cause severe impacts in detonation scenarios. These explosives were subsequently deleted from coverage in 1998 due to settlement of litigation with the Institute for Manufacturers of Explosives. 63 *Federal Register* 640 (January 6, 1998). It is important to note, however, that this was not due to any potential misinterpretation of the term "accidental release" (as discussed in the *Explosive Substances* Section).
[532] 58 *Federal Register* 5102 (January 19, 1993).

debris, or the emission of thermal and ionizing radiation.[533] Furthermore, the term "emissions" is not strictly limited to the release of toxic or flammable liquids and vapors. It can refer to the generation of hot gases and overpressures that result from explosions. This interpretation aligns with EPA's reasoning that explosives can produce accidental releases, as demonstrated by EPA's original inclusion of high explosives on the Risk Management Program list and by its associated determination of the appropriate threshold quantity for such explosives. CSB supports EPA's original reasoning that blast waves are emissions for purposes of listing substances under the Risk Management Program rule. In particular, CSB supports that this reasoning should apply to FGAN.

CSB concluded that there is a reasonable likelihood of an accidental release of FGAN because FGAN is a ubiquitous commodity chemical that is stored in large volumes at many locations. CSB found that this was true not only at the WFC facility (where the WFC stored 80,000 to 120,000 pounds of FGAN), but also at domestic fertilizer facilities throughout the South and the Midwest where Alabama, Missouri, Tennessee and Texas make up more than 50 percent of FGAN consumption in the United States.[534] FGAN also has been involved in a large number of accidents in the past (described in Appendix B). It has been at the center of major disasters such as the Oppau, Germany, incident in 1921 and the Texas City, Texas, incident in 1947; each caused more than 500 fatalities. EPA considered these exact factors (i.e., ubiquity, commodity, volume, and past accident history) to be indicative of whether an accidental release of a substance is likely.

Finally, CSB determined the magnitude of human exposure associated with accidental FGAN releases is significant because FGAN storage is commonly located close to many population centers. This was clearly the case in West, Texas, where a playground, four public school buildings, a nursing home, and an apartment complex all surrounded the WFC facility. It is also the case throughout Texas, where many fertilizer facilities are in communities and downtown neighborhoods (noted in Section 5.4). Because of the WFC investigation and other CSB investigations that identified offsite consequences from chemical releases, land use planning and siting of chemical facilities remain important issues for CSB. As discussed previously, EPA considered the proximity of facilities to population centers as a significant determinant of potential impact. The WFC incident demonstrates the validity of this conclusion. After finding that all three listing criteria were satisfied, CSB concludes that FGAN warrants listing under the Risk Management Program rule.

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[533] Akhavan, *Chemistry of Explosives* (3rd Edition). London: Royal Society of Chemistry, 2011. *See*: http://app.knovel.com/hotlink/toc/id:kpCEE0001C/chemistry-explosives/chemistry-explosives (accessed on November 14, 2015).

[534] *See*: https://www.tfi.org/sites/default/files/documents/ammoniumnitrateinfographic.pdf (accessed November 17, 2015). Akhavan, *Chemistry of Explosives* (3rd Edition). London: Royal Society of Chemistry, 2011. *See*: http://app.knovel.com/hotlink/toc/id:kpCEE0001C/chemistry-explosives/chemistry-explosives (accessed on November 14, 2015).

[534] *See*: https://www.tfi.org/sites/default/files/documents/ammoniumnitrateinfographic.pdf (accessed November 17, 2015).

8.4.2.3 Additional Support for Risk Management Program Rule Coverage for FGAN

Besides considering the three listing criteria factors mandated under the CAA, EPA identified other substances based on similarities with the mandated substances and selection criteria.[535] EPA considered options that accounted for the inherent hazards of the substances to be listed and for the potential of these hazards to affect the community if an accidental release occurred.[536] In particular, EPA analyzed hazards such as toxicity, flammability, reactivity, explosivity, and radioactivity, stating that all of them can result in acute effects after short-term exposure.[537] EPA identified substances associated with each of these hazards, but also considered the potential impact that the identified substances would have on the community if a release took place.[538] It evaluated each hazard independently, as well as each hazard's potential to pose a threat to the community.[539] Ultimately, a group of toxic substances, a group of flammable substances, and a group of explosive substances were proposed in the January 19, 1993, rule for addition to the 16 mandated substances in the CAA.[540] Because they pertain to FGAN, CSB conducted further research on explosives and on reactive substances.

Explosive Substances

With respect to the group of explosive substances, EPA proposed to focus on physical hazards because of their ability to impact communities beyond the fenceline in the event of an accidental release.[541] EPA viewed commercial high explosives, which have the potential to detonate, as the explosive substances with the greatest potential to affect such communities and therefore proposed commercial high explosives as a category for listing.[542] In determining the threshold methodology, EPA indicated that a blast wave overpressure of 3.0 psi from a detonation could have potentially lethal effects in communities beyond the fenceline.[543] The agency noted that this overpressure level could cause serious structural damage to buildings, lead to serious wounds from flying glass, and potentially cause eardrum rupture.[544] The agency also considered reactive substances that have explosive properties, including oxidizers (e.g., pure AN), for listing.[545] In its final decision however, EPA deferred listing these types of substances for lack of an adequate technical basis upon which to evaluate offsite consequences from unstable and reactive substances.[546] Nonetheless, EPA concluded in its response that "this decision does not preclude the

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[535] 58 *Federal Register* 5102 (January 19, 1993).
[536] *Ibid*.
[537] *Ibid*.
[538] *Ibid*.
[539] *Ibid*.
[540] *Ibid*.
[541] *Ibid*.
[542] *Ibid*.
[543] *Ibid*.
[544] *Ibid*.
[545] *Ibid*.
[546] EPA. "Proposed List of Substances and Thresholds for Accidental Release Prevention: Summary and Response to Comments," January 14, 1994: 146.

Agency from revisiting this issue in the future, in response to a petition to list, or when the list is reviewed and the listing criteria modified."[547]

For several decades, a number of agencies and organizations have regulated materials with explosive potential. ATF regulates the manufacture, processing, use, distribution, and storage of explosive materials; ATF regulations include requirements for licensing, permitting, and recordkeeping and for storage of explosives.[548] DOT regulates the transportation of explosives, and other agencies, such as OSHA, Mine Safety and Health Administration (MSHA), Department of Defense (DOD), and International Maritime Organization, regulate certain aspects of the explosive industry.[549] In its 1993 *Federal Register* notice, however, EPA stated that although explosives are regulated by federal, state, and local governments, these regulations do not uniformly address the issue of using appropriate hazard assessment techniques to identify hazards, designing and maintaining a safe facility, and minimizing the consequences of accidental releases when they do occur.[550] EPA noted that all of these elements were to be addressed in the Risk Management Program regulations, which it described as "intended to help focus on accident prevention."[551] The agency therefore asserted that these substances should be considered for purposes of list development and accidental release prevention regulations, and for some time, high explosives (classified as Class 1, Division 1.1 on DOT's Hazardous Materials Table) were included on the final 1994 Risk Management Program list.[552] However, DOT Division 1.1 explosives were delisted four years later.[553]

After promulgation of the Risk Management Program list, the Institute of Makers of Explosives (IME) petitioned against EPA for judicial review, challenging the listing of high explosives.[554] IME objections included the contention that existing ATF, DOT, MSHA, and OSHA regulations already adequately controlled DOT Division 1.1 explosives.[555] EPA and IME ultimately settled, with EPA agreeing to delist the explosives in exchange for IME's promise to undertake specific measures to enhance local emergency response.[556] CSB found this information important with respect to its investigation because FGAN has explosive properties under certain conditions. Accordingly, CSB conducted research to determine whether FGAN was listed and then delisted along with these DOT Division 1.1 explosives.

CSB found that DOT Division 1.1 explosives include one less common form of AN (classified by the United Nations as UN0222) containing more than 0.2 percent carbonaceous material. However, this form of AN is not commercially used or manufactured. Importantly, CSB discovered that FGAN has never

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[547] *Ibid*.
[548] 58 *Federal Register* 5201 (January 19, 1993).
[549] *Ibid*.
[550] *Ibid*.
[551] *Ibid*.
[552] *Ibid*.
[553] 79 *Federal Register* 44607 (July 31, 2014).
[554] 61 *Federal Register* 16598 (April 15, 1996).
[555] *Ibid*.
[556] *Ibid*. *See also*: 63 *Federal Register* 640 (January 6, 1998).

been explicitly regulated under the Risk Management Program rule because it is not a DOT Division 1.1 explosive. Furthermore, even if FGAN were a DOT Division 1.1 explosive, the DOT Division 1.1 explosives were never specifically identified by name on the Risk Management Program list. Therefore, AN has never explicitly been listed under the Risk Management Program rule. Nonetheless, CSB found it significant that EPA evaluated explosives, and the effects they can have upon communities in detonation scenarios, when determining the substances to include on the Risk Management Program list.[557] Because FGAN can detonate under certain conditions, CSB recommends that FGAN be included for coverage under the Risk Management Program rule. Further support for including FGAN on the Risk Management Program list can be found in EPA's original inquiry into reactive substances and in CSB's past work on reactives.

Reactive Substances

At the time of its 1993 *Federal Register* notice, EPA was attempting to evaluate the hazards of reactive and unstable chemicals and to develop an adequate technical basis for determining the potential effects on the community.[558] For example, EPA investigated computer models that estimate heats of reaction and also the possible use of heats of reaction to compare the effects of an explosion of an unstable substance to the effects of an explosion of TNT.[559] EPA stated that this method would only be appropriate for substances that detonate, an outcome that appeared to be unlikely for many unstable substances.[560] Ultimately, EPA contended that unstable and reactive substances would be considered for listing for accidental release prevention if the evaluation indicated potential community consequences.[561] On the basis of the WFC investigation and on the CSB's "Improving Reactive Hazard Management" study, CSB recommends that FGAN be added to the Risk Management Program list.

In the early 1990s, EPA considered listing reactive substances, such as AN, on the Risk Management Program list.[562] Specifically, EPA assessed whether to include chemicals whose reactive properties could cause impacts on nearby communities in the event of an accident.[563] In December 2002, CSB issued the study, "Improving Reactive Hazard Management," which examined reactive hazard management across the United States.[564] The study found regulatory coverage of reactive hazards to be a key issue.[565] As a result of the study, CSB issued several regulatory recommendations, including the following recommendation to EPA:

> Revise the Accidental Release Prevention Requirements, 40 CFR 68, to explicitly cover catastrophic reactive hazards that have the potential to seriously impact the public, including

[557] 58 *Federal Register* 5102 (January 19, 1993).
[558] *Ibid*.
[559] *Ibid*.
[560] *Ibid*.
[561] *Ibid*.
[562] *Ibid*.
[563] *Ibid*.
[564] CSB. "Hazard Investigation: Improving Reactive Hazard Management." December 2001.
[565] CSB. "Hazard Investigation: Improving Reactive Hazard Management." December 2001, 3.

> those resulting from self-reactive chemicals and combinations of chemicals and process-specific conditions. Take into account the recommendations of this report to OSHA on reactive hazard coverage. Seek congressional authority if necessary to amend the regulation.[566]

Unfortunately, EPA has not initiated rulemaking consistent with CSB's recommendation more than 10 years since its issuance.[567] Therefore, CSB has categorized the status of this recommendation as "Open—Unacceptable Response."[568]

Since issuing its reactive hazard investigation study in 2002, CSB has investigated several industrial accidents involving reactive chemicals.[569] These are summarized in Table 12.

Table 12. CSB Investigations Involving Reactive Chemicals Since 2002

Incident	**Date**	**Location**	**Severity**
First Chemical Corp.: Reactive Chemical Explosion	October 13, 2002	Pascagoula, MS	• 3 injured
MFG Chemical Inc.: Toxic Gas Release	April 12, 2004	Dalton, GA	• 154 hospitalized
Synthron Chemical: Explosion	July 31, 2007	Morganton, NC	• 1 fatality • 12 injured
T2 Laboratories Inc.: Reactive Chemical Explosion	December 19, 2007	Jacksonville, FL	• 4 fatalities • 13 hospitalized
Bayer CropScience: Pesticide Waste Tank Explosion	August 28, 2008	Institute, WV	• 2 fatalities
West Fertilizer Company: Explosion and Fire	April 17, 2013	West, TX	• 15 fatalities • More than 260 injured

It is important to note, however, that Table 12 depicts only those incidents involving reactive chemicals *that CSB investigated* since 2002. That is, these incidents do not represent the universe of reactive chemical accidents, which is much larger.

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[566] CSB. "Hazard Investigation: Improving Reactive Hazard Management." December 2001, 102.
[567] CSB. "Recommendations Status Change Summary." Improving Reactive Hazard Management, 2001-1-H-R3. March 11, 2014.
[568] *See*: http://www.csb.gov/recommendations/?F_RecipientId=8 (accessed on December 17, 2015). OSHA's associated recommendations are also categorized as "Open—Unacceptable Response." *See*: http://www.csb.gov/UserFiles/file/CSB-OSHACorrespondence.pdf (accessed on January 15, 2016).
[569] CSB. "Recommendations Status Change Summary." Improving Reactive Hazard Management, 2001-1-H-R3. March 11, 2014.

8.4.2.3.1.1 General Duty Clause

After the incident, CSB referenced its reactives study in "Preliminary Findings of the CSB from its Investigation of the West Fertilizer Explosion and Fire."[570] With respect to the EPA Risk Management Program rule, CSB specifically stated:

> In developing the RMP regulation, the EPA did not explicitly include explosives or reactive chemicals in the list of covered chemicals. In 2002, the CSB issued a study on reactive hazards, identifying 167 prior reactive incidents (including a 1994 explosion at an AN manufacturer). The Board recommended that . . . EPA expand [its] standard[] to include reactive chemicals and hazards. However, [EPA has not] yet acted upon the recommendation[].[571]

On June 6, 2014, after learning the Open—Unacceptable Response status of its recommendation, EPA raised, in a letter to CSB, its concern that CSB had mischaracterized in its reactives study the scope and history of EPA's use of the CAA Section 112(r)(1), General Duty Clause (GDC).[572] Because the GDC is a provision which CSB believes likely could have been used to cite the WFC facility, but was not, CSB conducted further research into the requirement.

The GDC is a statutory obligation that makes owners and operators of facilities that possess regulated and other extremely hazardous substances responsible for ensuring that their chemicals are managed safely.[573] In CAA Section 112(r)(1), the GDC states:

> The owners and operators of stationary sources producing, processing, handling or storing such substances [i.e., a chemical in 40 CFR Part 68 or any other extremely hazardous substance] have a general duty [in the same manner and to the same extent as the general duty clause in the Occupational Safety and Health Act] to identify hazards which may result from (such) releases using appropriate hazard assessment techniques, to design and maintain a safe facility taking such steps as are necessary to prevent releases, and to minimize the consequences of accidental releases which do occur.[574]

Accordingly, EPA has the authority to apply the GDC to facilities not only after incidents, but also before incidents to prevent them. The GDC is a broad provision with great potential to enhance safety measures at facilities that contain certain hazardous substances.

In addressing the hazards associated with reactive substances and application of the GDC, CSB has stated that "many substances are unlikely to be considered 'extremely hazardous' since they do not present an inherent catastrophic reactive hazard until combined with other chemicals or under process-specific conditions."[575] This circumstance should not preclude, and EPA affirms has not precluded, such

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[570] CSB. "Preliminary Findings of the U.S. Chemical Safety Board from its Investigation of the West Fertilizer Explosion and Fire," June 27, 2013.
[571] *Ibid*.
[572] EPA letter to CSB, June 6, 2014.
[573] *See*: http://www2.epa.gov/sites/production/files/2013-10/documents/gdc-fact.pdf (accessed on December 29, 2015).
[574] 42 U.S.C. § 7412(r)(1).
[575] CSB. "Recommendations Status Change Summary." Improving Reactive Hazard Management, 2001-1-H-R3. March 11, 2014.

substances from enforcement under the GDC. EPA referenced a 1989 Report of the Senate Environment and Public Works Committee, which stated that the presumption should be that a substance is extremely hazardous if it causes significant adverse impacts by acute toxic effect or "by blast, fire, corrosion or other reaction."[576] The report also states that "extremely hazardous substances" would "include other agents which may or may not be listed" that "as the result of short-term exposures associated with [accidental] releases to the air cause death, injury or property damage due to their toxicity, reactivity, flammability, volatility, or corrosivity."[577] According to this report, therefore, EPA could apply the GDC to reactive substances. However, EPA did not use the GDC to cite the WFC after the incident for its unsafe storage of FGAN.

Considering the totality of the EPA regulatory landscape, CSB determined that requirements for facilities to safely store and handle FGAN are insufficient. As discussed, the Risk Management Program rule does not regulate FGAN because FGAN is not on the list of regulated substances. Furthermore, while EPA could use the GDC to impose requirements on facilities to ensure the safe management of FGAN as a reactive substance, EPA does not contend that the GDC is as easy to apply as a regulation. EPA may have been able to apply the GDC against the WFC after the incident, but it did not. Therefore, without more from the GDC, it is the recommendation of CSB that FGAN be included on the Risk Management Program list, especially in light of the fatal incident in West, Texas.

8.4.2.4 Risk Management Program Rule and Coverage of Anhydrous Ammonia

As previously discussed, although the WFC was not covered under the Risk Management Program rule for its storage of FGAN, it was covered under Program Level 2[578] of the rule for its storage of more than 10,000 pounds, the threshold limit, of anhydrous ammonia. The facility submitted its RMP registration in 1999, 2006,[579] and 2011.[580] The WFC's 2006 RMP for anhydrous ammonia included important safety elements to prevent, control, and respond to an anhydrous ammonia release.[581] For example, the insurance company conducted a hazard review to identify major release scenarios and address actions that would prevent or mitigate a release.[582] Another important feature of the RMP was development of an emergency action plan with step-by-step procedures, detailing how employees should respond to an anhydrous ammonia release.[583] Other program elements included operating procedures, maintenance and

[576] EPA letter to CSB, June 6, 2014.
[577] Senate Committee on Environment and Public Works, CAA Amendments of 1989, Senate Report No. 228, 101st Congress, 1st Session 211 (1989).
[578] The WFC fell under Program 2 requirements for its storage of anhydrous ammonia because it did not meet the requirements for Program Level 3 and was not eligible for Program Level 1 coverage.
[579] The WFC did not resubmit its RMP registration as it was supposed to in 2004 because of a change in ownership. EPA cited the company in 2006 for failing to refile its RMP in a timely manner. The WFC refiled it in 2006.
[580] WFC RMP submissions to EPA.
[581] *Ibid*.
[582] *Ibid*.
[583] *Ibid*.

inspection programs, training programs, incident investigations, offsite consequence analyses, and compliance audits.[584]

The Risk Management Program rule also required the WFC to comply with RAGAGEP for anhydrous ammonia, such as ANSI K61.1, "Safety Requirements for the Storage and Handling of Anhydrous Ammonia," and OSHA's Storage and Handling of Anhydrous Ammonia regulation (29 CFR 1910.111).[585] As previously mentioned, the Risk Management Program list does not include FGAN, so the WFC was not required to take related Risk Management Program safety measures for FGAN. Of course, FGAN coverage under the Risk Management Program rule likely would have increased awareness of the explosion hazards of FGAN, leading to better management of the substance through compliance with federal safety regulations and best industry practices. If EPA had included FGAN under the Risk Management Program rule, the WFC would have been required to apply it for its storage of FGAN and perhaps could have reduced the risk of catastrophic accidents like the one that occurred at the WFC.

8.5 Emergency Planning

The CSB investigation of the WFC incident identified the explosive potential of FGAN. CSB further found that no immediate evacuation at the first sign of fire occurred, in part because no in-place emergency plan addressed response specifically to an incident at the WFC warehouse. This situation left emergency responders and the West community unaware of the urgent need to evacuate. For FGAN facilities, there must be a well-exercised local emergency plan that emphasizes immediate notification to emergency responders and the community at the first sign of fire, as well as evacuation protocols. If there was an immediate evacuation once the fire was detected at the WFC, the number of fatalities and injuries likely would have been lower.

Emergency planning is part of emergency management, which includes four different stages: (1) mitigation, (2) planning, (3) response, and (4) recovery. The nation's emergency management system is intended to prepare communities for all types of hazards, including natural disasters, terrorism, and hazardous materials (HAZMAT) incidents. The responsibilities of emergency management personnel are shared among federal agencies that provide assistance through funding and training. For example, DHS primarily focuses its efforts on terrorism and natural hazards and also serves as the umbrella organization for other agencies that supply assistance to state and local authorities. Other federal agencies such as EPA and OSHA have emergency planning regulations for environmental and occupational accidents involving HAZMAT. The next sections discuss these regulations at the federal, state, and city levels and discuss their relevance to the WFC incident.

[584] *Ibid*.
[585] 40 CFR 68.48(b).

8.5.1 Federal Emergency Planning

In response to growing concerns about the safety and health of people and the environment after releases of hazardous substances in the U.S. in the 1970s and 1980s and the disaster in Bhopal, India, Congress passed new laws authorizing EPA and OSHA to regulate these risks. One was the Emergency Planning and Community Right-to-Know Act (EPCRA) of 1986, which was intended to address concerns about local preparedness for chemical emergencies and to ensure public access to information. EPCRA established a framework for states to organize resources to pre-plan for chemical accidents. EPCRA requirements include: (1) emergency planning (SARA Title III, Sections 301–303); and (2) emergency and hazardous chemical inventory reporting (SARA Title III, Sections 311 and 312).[586] Each section of EPCRA covers a subset of chemicals and the statute and EPA regulations specify quantities that trigger reporting requirements (Table 13).[587] Because they are pertinent to the WFC incident, requirements for emergency planning and hazardous chemical inventory reporting are discussed in greater detail.

Table 13. EPCRA Chemicals and Reporting Thresholds

	Section 302	**Sections 311 and 312**
Chemicals Covered	355 extremely hazardous substances (EHSs)	Approximately 500,000 hazardous chemicals
Thresholds	Threshold planning quantity (TPQ): 1 to 10,000 lbs. onsite at any one time	500 lbs. or TPQ, whichever is lower, for EHSs; 75,000 gallons for gasoline; 100,000 gallons for diesel; and 10,000 lbs. for all other hazardous chemicals

EPCRA emergency planning establishes, in part, requirements for sharing information among industry and state, tribal, and local governments. As shown in Table 13, under Section 302, a facility that has an extremely hazardous substance (EHS) at or above its specific threshold planning quantity (TPQ) must report the substance. Reporting of EHSs, as well as other hazardous chemicals under Sections 311 and 312, must be made to the State Emergency Response Commission (SERC), Local Emergency Planning Committee (LEPC), and local fire department.[588]

State governors designated the SERCs which then designated roughly 3,500 local emergency planning districts and LEPCs for each district.[589] At minimum, LEPCs must be composed of elected state and local officials; police, fire, civil defense, public health, transportation, and environmental professionals; representatives of facilities subject to EPCRA emergency planning requirements; community groups; and

[586] Regulations implementing EPCRA are codified at 40 CFR Parts 350–372.
[587] *See*: http://www2.epa.gov/sites/production/files/2013-08/documents/epcra_fact_sheet.pdf (accessed on December 29, 2015).
[588] The local fire department receives only inventory information under Sections 311 and 312.
[589] *See*: http://www2.epa.gov/sites/production/files/2013-08/documents/epcra_fact_sheet.pdf (accessed on December 29, 2015).

the media.[590] SERCs are supposed to supervise and coordinate the activities of LEPCs, establish procedures for receiving and processing public requests for information, and review local emergency response plans.[591] LEPCs are supposed to develop emergency response plans, review the plans annually, and provide information to the public.[592]

EPCRA emergency planning also requires LEPCs to develop and update emergency response plans. LEPCs are supposed to use information reported by facilities to develop these plans, which cover procedures that describe how emergency responders should respond to chemical releases.[593] The plans must (1) identify EHS facilities and transportation routes; (2) describe emergency response procedures, onsite and offsite; (3) designate a community coordinator and facility coordinators to implement the plan; (4) outline emergency notification procedures; (5) explain the means to determine the probable area and population affected by chemical releases; (6) describe local emergency equipment and facilities and the people responsible for them; (7) outline evacuation plans; (8) provide a training program for emergency responders (including schedules); and (9) detail methods and schedules for exercising emergency response plans.[594]

Importantly, EPCRA emergency planning requirements mandate the identification of facilities with EHSs only; identification of facilities without EHSs is not required. Thus, although facilities must *report* EHSs and certain non-EHSs (i.e., other hazardous chemicals under Sections 311 and 312), only facilities with EHSs trigger EPCRA emergency response *plan* requirements.[595] For purposes of the WFC investigation, CSB determined that while anhydrous ammonia is on the EHS list, FGAN is not. CSB found, however, that AN is on the list of hazardous chemicals under Sections 311 and 312 that triggers emergency and hazardous chemical inventory reporting requirements.

EPCRA emergency and hazardous chemical inventory reporting requires reporting of certain quantities of EHSs and hazardous chemicals. As shown in Table 13, under Sections 311 and 312, an EHS must be reported if it is held at the lower of 500 pounds or the substance's TPQ, gasoline must be reported at 75,000 gallons, diesel must be reported at 100,000 gallons, and all other hazardous chemicals must be reported at 10,000 pounds.[596] These reporting requirements are tied to OSHA's Hazard Communication Standard (29 CFR 1910.1200). This standard requires employers to maintain SDSs for all hazardous chemicals in the workplace.[597] SDSs contain crucial information, including chemical and hazard

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[590] *Ibid. See also*: 42 U.S.C. §11001(c).
[591] *Ibid. See also*: 42 U.S.C. §11001(a).
[592] *Ibid. See also*: 42 U.S.C. §11001(c).
[593] *See*: http://www2.epa.gov/sites/production/files/2013-08/documents/epcra_fact_sheet.pdf (accessed on December 29, 2015).
[594] *Ibid. See also*: 42 U.S.C. §11003(c).
[595] It should be noted that EPA has suggested, through guidance to SERCs and LEPCs (including the most recent fact sheet to these entities), that they include Sections 311 and 312 facilities in their planning process.
[596] *See*: http://www.epa.gov/sites/production/files/2013-08/documents/epcra_fact_sheet.pdf (accessed on December 29, 2015).
[597] *Ibid.*

identification; ingredient composition; first aid measures; firefighting measures; accidental release measures; handling and storage precautions; exposure controls and personal protection; physical and chemical properties; stability and reactivity properties; toxicological information; ecological concerns; disposal considerations; transport information; regulatory requirements; and other information.[598] Facilities must maintain SDSs onsite and submit copies of them (or a list of SDS-covered chemicals) to their SERCs, LEPCs, and local fire departments.[599]

Facilities covered by Section 311 must also submit Emergency and Hazardous Chemical Inventory forms to their SERCs, LEPCs, and local fire departments annually.[600] Facilities provide either a Tier I or Tier II inventory form.[601] Tier I inventory form include the following aggregate information for each applicable hazard category:

- An estimate (in ranges) of the maximum amount of hazardous chemicals for each category present at the facility at any time during the preceding calendar year.
- An estimate (in ranges) of the average daily amount of hazardous chemicals in each category.
- The general location of hazardous chemicals in each category.[602]

The Tier II inventory form contains basically the same information as the Tier I, but it must list the specific chemicals. Tier II inventory form provide the following for each chemical:

- The chemical name or the common name as indicated on the SDS.
- An estimate (in ranges) of the maximum amount of the chemical present at any time during the preceding calendar year and the average daily amount.
- A brief description of the manner of storage of the chemical.
- The location of the chemical at the facility.
- An indication of whether the owner elects to withhold location information from disclosure to the public.[603]

Information submitted under Sections 311 and 312 is available to the public from SERCs and LEPCs.[604]

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[598] *See*: https://www.osha.gov/Publications/HazComm_QuickCard_SafetyData.html (accessed on December 29, 2015). OSHA does not enforce the ecological information, disposal considerations, transport information, and regulatory information sections of SDSs because other agencies regulate this information.
[599] *See*: http://www2.epa.gov/sites/production/files/2013-08/documents/epcra_fact_sheet.pdf (accessed on December 29, 2015).
[600] *Ibid*.
[601] *Ibid*.
[602] *Ibid*.
[603] *Ibid*. It is important to note that under Section 312(f), upon request by the fire department with jurisdiction over the facility, owners/operators must provide *fire departments* with location information. They must also allow fire departments to conduct onsite inspections.
[604] *Ibid*.

8.5.2 State Emergency Planning in the State of Texas

Texas has suffered some of the worst disasters in U.S. history, both in kind and magnitude. One of the first was the devastating hurricane in Galveston in 1900, which almost destroyed the city and killed thousands. In 1937, in New London, a gas leak explosion destroyed a school and killed approximately 300 students and teachers. Ten years later, the FGAN explosion in Texas City inflicted an enormous loss of life and property that remains unknown to this day; it is ranked as one of the worst industrial accidents in U.S. history.[605]

As a result of these disasters, Texas enacted statutes to address all-hazard emergency management.[606] The Texas Disaster Act of 1975 requires local jurisdictions to designate an emergency management coordinator to develop an emergency operations plan composed of a basic plan with 22 annexes.[607] The basic plan and its annexes outline guidance for emergency management activities and assign roles and responsibilities to local agencies.[608] Although the basic plan offers general guidance, the annexes provide more detail.[609] For example, Annex Q, "Hazardous Materials and Oil Spill Response," identifies the HAZMAT incidents that could occur in a specific community and how such an incident would likely affect nearby populations.[610] Once a hazard is identified, appropriate response actions must be planned, including timely notification, identification of evacuation routes, and assignment of roles and responsibilities.[611] Training exercises and drills must also test response effectiveness.[612]

When Congress enacted EPCRA in 1986, its provisions were incorporated into Texas's existing emergency planning framework and into state codes.[613] The SERC is the Emergency Management Council of Texas and includes participation from multiple state agencies.[614] Within that group of agencies, 10 are considered to be SERC members with specific roles in emergency response and planning. For example, the TCEQ is responsible for receiving reports about accidental spills and releases;[615] the Texas Department of State Health Services is designated to receive the Tier I or Tier II Emergency and Hazardous Chemical Inventory forms submitted electronically by facilities;[616] and the Texas Department of Public Safety, Division of Emergency Management, is tasked with overseeing the

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[605] *Texas Emergency Management Executive Guide* (FY 2014 Edition).
[606] *Ibid.*
[607] Texas Administrative Code, Title 37, Part 1, Chapter 7. Texas Government Code, Chapter 418.
[608] *See*: *Texas Emergency Management Executive Guide* (FY 2014 Edition), 4.
[609] *Ibid*.
[610] *See*: McLennan County. Annex Q: Hazardous Materials & Oil Spill Response. Version 2.4, July 2009.
[611] *See*: *Texas Emergency Management Executive Guide* (FY 2014 Edition), 4.
[612] *Ibid*.
[613] Texas Health and Safety Code, Title 6, Subtitle D, "Hazardous Substances," Chapters 505 through 507. Texas Administrative Code, Title 37, Part 1, Chapter 7. Texas Government Code, Chapter 418.
[614] Texas Department of Public Safety. *See*: https://www.txdps.state.tx.us/dem/stateLocalOrganizations.htm#EMC (accessed on December 29, 2015).
[615] *See*: https://www.tceq.texas.gov/response/spills (accessed on December 29, 2015).
[616] This designation has changed since the date of the WFC incident. The Tier II Chemical Reporting Program has moved to the TCEQ. *See*: https://www.dshs.state.tx.us/tiertwo/ (accessed on December 29, 2015).

all-hazard emergency management program and providing guidance and funding for cities, counties, and state agencies so that they can develop their own programs.[617]

8.5.3 City Emergency Planning in the City of West

To fully understand the WFC incident, this section reviews emergency planning and management in West and at the WFC facility. West is located in McLennan County, which is West's local emergency management district and which formed an LEPC in 1992. The McLennan County LEPC meets four times per year.[618] Its members are nominated by the county judge and approved by the SERC.[619] The LEPC membership consists of city, industry, hospital, and emergency response officials.[620] CSB found that the WFC, however, was not listed on the attendance roster for any LEPC meeting for more than 21 years.

As required by both state and federal regulations, the McLennan County LEPC prepared an emergency response plan (ERP) in accordance with guidance from the Texas Department of Public Safety, Division of Emergency Management.[621] As discussed previously, this consisted of a basic plan with 22 annexes. It described in part McLennan County's approach toward emergency planning, response, and notification. McLennan County officials review the plan annually and officially revise or update it every 5 years, as required by Texas law.[622] Prior to the WFC incident, McLennan County last formally reviewed its ERP in 2010.[623]

The McLennan County ERP includes procedures on how to alert the public when natural or human-initiated disasters occur. ERP annexes describe actions to take in various scenarios, such as how to disseminate information quickly,[624] how to warn special facilities (e.g., hospitals and schools) and populations of a hazard,[625] and how to use alert systems to activate immediate evacuation.[626] A vital component of ERPs and ERP annexes is LEPC engagement and communication. Without these, community members might not have the necessary information to respond appropriately to a specific type of incident.

For example, on February 12, 2013, WIS was temporarily evacuated because of a controlled burn at the WFC facility. Before the evacuation, the school principal alerted 911 of the fire, but the 911 dispatcher did not acknowledge a coordinated burn. Students and staff were evacuated for approximately 30 minutes to WMS, using coordinated transportation. The WFC did not notify the WISD or WIS in advance that the

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[617] *See*: https://www.txdps.state.tx.us/internetforms/Forms/TDEM-10.pdf (accessed on December 29, 2015).
[618] McLennan County LEPC Bylaws, Article II, Section 5, "Meetings."
[619] McLennan County LEPC Bylaws, Article II, Section 1, "Membership."
[620] *Ibid*.
[621] State of Texas. *Local Emergency Planning Committee (LEPC): A Primer for Local Planning for Hazardous Materials*, July 2006.
[622] Texas Administrative Code, Title 37, Part 1, Chapter 7, Subchapter B, Rule 7.12.
[623] CSB reviewed the 2010 McLennan County ERP for this investigation report.
[624] McLennan County Basic Plan, Annex I.
[625] McLennan County Basic Plan, Annex E.
[626] *Ibid.*

facility was conducting a controlled burn of pallets and brush. After this incident, the WISD asked the emergency service providers and the WFC to provide advance notice of future burning activities. The WFC could have communicated its plans to the WISD or WIS through LEPC activities.

The McLennan County ERP specifically includes Annex Q, "Hazardous Material and Oil Spill Response," which requires identification of all regulated facilities within the county.[627] Such facilities are those that are regulated by EPCRA. In particular, a regulated facility is:

> A plant site where handling/transfer, processing, and/or storage of chemicals is performed. For the purposes of [Annex Q], regulated facilities (1) produce, use, or store EHSs in quantities which exceed threshold planning quantities or (2) hold one or more hazardous chemicals in a quantity greater than 10,000 pounds at any time.[628]

Because the WFC was regulated by EPCRA, it would follow that Annex Q might list the WFC. However, the WFC was not listed.

EPCRA covered the WFC for at least two reasons. First, the WFC stored anhydrous ammonia in quantities that exceeded the anhydrous ammonia TPQ of 500 pounds. Specifically, CSB found that the WFC reported holding 34,000 pounds of anhydrous ammonia at the time of the incident. Clearly, the WFC had onsite sufficient amounts of an EPCRA Section 302 EHS. This triggered not only reporting requirements, but also emergency response planning requirements.[629] Thus, the WFC should have been listed in Annex Q for its EPCRA-regulated storage of anhydrous ammonia.

Second, the WFC stored FGAN, a hazardous chemical under EPCRA Sections 311 and 312, in quantities that exceeded the AN threshold quantity of 10,000 pounds. In particular, CSB found that the WFC reported 80,000 to 120,000 pounds of FGAN onsite at the time of the incident. As such, the WFC was required to report its quantities of FGAN under EPCRA. CSB obtained WFC Tier II form documents, dated from 2000 to 2012, and found that the WFC annually reported its quantities of anhydrous ammonia to the WVFD, McLennan County LEPC, and Texas Department of State Health Services, but reported its FGAN only in its 2012 Tier II report. Ideally, under the best set of circumstances, the WFC should have been listed in Annex Q for its storage of FGAN. The WFC was not listed in Annex Q, however, due to a misunderstanding of EPCRA's agricultural use exemption.

EPCRA's agricultural use exemption is a statutory exemption to the definition of "hazardous chemical." It reads:

> Hazardous Chemical Defined. For purposes of this section, the term "hazardous chemical" has the meaning given such term by section 1910.1200(c) of title 29 of the Code of Federal

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[627] McLennan County Basic Plan, Annex Q.
[628] *Ibid*.

[629] The WFC was also expected to develop an emergency response plan for its storage of anhydrous ammonia, as required by the Risk Management Program rule. According to EPA, the EPCRA plan and the RMP must be coordinated. *See*: http://www2.epa.gov/sites/production/files/2013-11/documents/chap-08-final.pdf (accessed on December 29, 2015). However, no evidence indicated that the WFC RMP was shared with the LEPC or the WVFD.

> Regulations, except that such term does not include the following: . . . Any substance to the extent it is used in routine agricultural operations or is a fertilizer held for sale by a retailer to the ultimate customer.[630]

It is important to note that this exemption may apply only to Sections 311 and 312 reporting requirements; it does not apply to emergency planning requirements under Section 302. Furthermore, the agricultural use exemption applies directly to the hazardous chemical itself, not the specific individual or entity holding the chemical. That is, the exemption does not relieve an individual or entity of its responsibilities; rather, the individual or entity is exempt from EPCRA reporting requirements if the chemical in question is exempt. Where individuals or entities hold multiple chemicals, each chemical must be assessed individually to determine exemption status.

The agricultural use exemption impacts those who use substances in "routine agricultural operations" and retailers who hold substances as fertilizer for sale to the ultimate customer. With respect to those who use substances in routine agricultural operations, CSB referred to guidance on EPA's website that, in response to a question asking which hazardous chemicals are reportable for farmers under Sections 311 and 312, states:

> Under Section 311(e)(5), any substance when used in routine agricultural operations is exempt from reporting under Section 311 and 312. This exemption is designed to eliminate the reporting of fertilizers, pesticides, and other chemicals when stored, applied, or otherwise used at the farm facility as part of routine agricultural activities. . . . Thus, the storage and use of a pesticide or fertilizer on a farm would be considered the use of a chemical in routine agricultural operations and is, therefore, exempt under Sections 311 and 312.[631]

The belief is that minimal risk is involved when farmers use a substance in routine agricultural operations because farmers promptly apply those substances to their crops. Therefore, the exemption eliminates EPCRA reporting requirements under Sections 311 and 312 for at least certain farmers. However, for retailers who hold a substance as fertilizer for sale to the ultimate customer, CSB found that although EPA has published several hypothetical-based questions and answers on its website, it offers little *general* guidance.

CSB discovered that the McLennan County LEPC reported that the WFC's storage of anhydrous ammonia and FGAN appeared to qualify under EPCRA's agricultural use exemption, a conclusion which the county stated was also confirmed by the SERC. The WFC's anhydrous ammonia and FGAN were erroneously considered exempt from both emergency planning and hazardous chemical inventory reporting requirements because of the phrase "fertilizer held for sale by a retailer[632] to the ultimate customer" and because the main WFC customers who bought fertilizer were nearby farmers (ultimate

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[630] EPCRA, Section 311(e)(5). 40 CFR 370.66.

[631] *See*: https://emergencymanagement.zendesk.com/hc/en-us/articles/211416278-What-hazardous-chemicals-are-reportable-for-farmers-under-311-and-312- (accessed on December 29, 2015). It should be noted, however, that although farmers may be exempt under Section 311(e)(5) from reporting these fertilizers in their Sections 311 and 312 reports, they are still required to notify the SERC (or TERC), LEPC (or TEPC), and local fire department under Section 302 if they have an EHS at or above its TPQ.

[632] There is no definition of "retailer" under EPCRA.

customers / end users). This reason likely explains why the McLennan County LEPC ERP did not include the WFC for its storage of anhydrous ammonia, despite the fact that the exemption does not relieve reporting requirements for EHSs under Section 302.

Because the WFC facility not only sold pure fertilizer but also blended chemicals to make fertilizer (e.g., for custom orders), CSB also examined how the agricultural use exemption applies to blends. EPA states that chemicals "held for the purpose of producing fertilizer" are "starting materials used to make a fertilizer," not the fertilizer itself, so the retailer therefore should report them.[633] EPA recognizes, however, that if those chemicals are not blended but rather sold individually to the end customer, then those chemicals are exempt.[634] EPA confirmed this position in a September 3, 2010, letter to TFI, stating that the "mixing of fertilizers" must be reported and reiterating that "fertilizer held for sale by a retailer to the ultimate customer . . . is one that is merely held for sale, not one that is mixed or formulated."[635]

To bolster its reasoning, EPA further explained:

> Congress' intent was to focus Section 311/312 reporting on manufacturers and wholesalers—those are facilities that typically have large quantities of fertilizer, and that use and manufacture a wide range of chemical compounds. Congress appreciated that such manufacturers and wholesalers presented significant risks that needed to be addressed by emergency response authorities, but that mere retailers did not. Assuming arguendo that Congress' intent is ambiguous, the above interpretation is one that EPA adopts as being the most reasonable interpretation of the statute. Therefore, consistent with the Agency's prior Q&A guidance, the amount of chemicals intended for blending and the new product should be reported under Section 311 and 312 if the reporting thresholds are exceeded.[636]

On this basis, facilities that blend chemicals to make fertilizer such as the WFC should not apply the agricultural use exemption to those chemicals meant for blending. However, there is confusion about both who specifically qualifies for the exemption as well as the issue of blending because, although hypothetical-based Q&As are available, limited general EPA guidance exists. Therefore, EPA should develop a general guidance document pertaining to EPCRA's agricultural use exemption and make a widespread effort to communicate its contents to the fertilizer industry.

Since the incident, the Agricultural Retailers Association (ARA), a nonprofit trade association that represents the interests of agricultural retailers and distributors on legislative and regulatory issues, issued an alert to its members on May 14, 2013, warning agricultural retailers that blend (i.e., use nonchemical reactions to mix) dry fertilizers to report those fertilizers on their annual Tier I or Tier II inventory reports submitted to SERCs, LEPCs, and local fire departments. The alert also warned members that EPA has

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[633] *See*: https://emergencymanagement.zendesk.com/hc/en-us/articles/212089537-Are-hazardous-chemicals-blended-for-fertilizer-exempted-under-agricultural-use-exemption- (accessed on December 29, 2015).
[634] *Ibid*.
[635] Dana S. Tulis, EPA Acting Director Office of Emergency Management. Letter to Chris S. Leason, counsel to TFI, September 3, 2010.
[636] *Ibid*.

cited agricultural retailers for incomplete inventory forms.[637] TFI further noted in a verbal statement on November 15, 2013, at the Washington, DC, "Listening Session Regarding President Obama's Executive Order Improving Chemical Facility Safety and Security":

> As most of you know, there is a fertilizer retail exclusion for reporting under EPCRA. TFI supports removal of this exclusion. We feel everyone should report hazardous chemicals stored on site to the LEPC and SERC and work with local fire departments without exception.[638]

Despite these post-incident efforts, the ARA and TFI cover only some of the thousands of FGAN facilities in the United States. Consequently, EPA should take steps to ensure that fertilizer facilities fully comply with EPCRA and do not mistakenly apply the agricultural use exemption. In fact, EPA already hosted, from May to September 2014, 32 workshops for members of Local Emergency Planning Committees, which were held in Texas, Arkansas, Louisiana, Oklahoma, and New Mexico and attended by 1,340 representatives from local, state, and federal government as well as industry.[639] It also recently released an online training module of key requirements for SERCs and LEPCs and a factsheet, "How to Better Prepare Your Community for a Chemical Emergency: A Guide for State, Tribal, and Local Agencies."[640] While these efforts demonstrate progress, CSB believes the development of more general EPCRA guidance, as well as a guidance document on the agricultural use exemption, could help significantly improve emergency planning at all levels.

8.5.4 Other Emergency Planning Requirements

During the course of its investigation, CSB also found issues in emergency planning related to FGAN training and compliance with OSHA's Hazardous Waste Operations and Emergency Response (HAZWOPER) standard (29 CFR 1910.120). CSB determined that employees at the WFC had limited training on FGAN hazards. The agency learned through interviews that some WFC employees were unaware that the FGAN fertilizer stored onsite could explode. Many said the April 1995 Oklahoma City bombing was the only basis of their knowledge of this. Nonetheless, WFC employees generally understood FGAN security regulations so as to verify that customers buying FGAN were registered and were using it only for agricultural purposes. CSB found that the lack of formal training at the WFC was a central reason why employees were largely unaware of FGAN hazards.

Some WFC employees recalled having discussions about avoiding FGAN contact with heat, fire, and moisture. However, CSB concluded that FGAN safety training was inconsistent and that no formal training addressed FGAN hazards or required discussion of the FGAN SDS. WFC employees also lacked formal training on the facility's ERP for anhydrous ammonia. Employees informally shared information

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[637] Unfortunately, the alert, even if made before the date of the incident, would have had little impact on the WFC because the facility was not a member of the ARA.

[638] *See*: http://www.tfi.org/media-center/news-releases/tfis-verbal-statement-presented-nov-15-washington-dc-listening-session-re (accessed on December 29, 2015).

[639] *See*: https://www.osha.gov/chemicalexecutiveorder/EO13650FS-ImprovingChemicalFacilitySafety.pdf (accessed on December 29, 2015).

[640] *Ibid*.

so that they knew to evacuate as far as possible if such a release occurred. They also knew which emergency numbers to call. However, much of the WFC employee training was hands on and job specific. Thus, a lack of comprehensive emergency planning and response training played a role in how the incident unfolded.

In addition, CSB discovered issues with OSHA's HAZWOPER standard, which too is an integral element of emergency planning. Under the HAZWOPER standard, the WFC was required to develop an ERP for all "hazardous substances." As defined by the standard, hazardous substances include those covered by EPA or DOT.[641] FGAN meets this definition because it is listed in DOT's Hazardous Materials Table.[642] The WFC was therefore required to develop a HAZWOPER ERP, or would be considered exempt if it met another OSHA standard, Emergency Actions Plans (29 CFR 1910.38).[643]

The HAZWOPER ERP should have addressed pre-emergency planning and coordination with outside parties, personnel roles, lines of authority, training and communication, emergency recognition and prevention, safe distances and places of refuge, site security and control, evacuation routes and procedures, decontamination, and emergency medical treatment and first aid.[644] However, no evidence indicated that the WFC developed the HAZWOPER ERP or was considered exempt under the Emergency Action Plans standard for FGAN. Consequently, OSHA cited the WFC after the incident for not providing an FGAN-related HAZWOPER ERP.

8.6 Fire Protection Codes and Standards

Fire protection codes and standards generally refer to the most recently developed practices to protect people and property from fire and natural disasters. When adopted by states or local jurisdictions, codes (including building, electrical, plumbing, mechanical, and other codes) represent mandatory regulations. Standards, on the other hand, provide methods to achieve compliance with codes. Both codes and standards must be adopted through some process, usually state-level fire or building codes. The legislature must enact that adoption before a fire protection (or prevention) code or standard applies. Because fire and building codes may also include references to many standards, such standards are generally not adopted separately but instead are included once the fire or building code is adopted.

Fire codes specify practices that must be followed; that is, codes are mandatory only if adopted. In contrast, fire protection standards typically refer to practices that, despite their mandatory language, are voluntary unless adopted into law (e.g., as a state fire code). The nation's leading fire protection codes and standards are issued by the NFPA and the International Code Council (ICC). Both employ a public consensus process to produce model codes and standards that jurisdictions can adopt into law. The NFPA updated its current code for FGAN, NFPA 400 (*Hazardous Materials Code*) Chapter 11, after the WFC

[641] 29 CFR 1910(a)(3).
[642] 49 CFR 172.101.
[643] 29 CFR 1910.120(q)(1).
[644] 29 CFR 1910.120(q)(2).

incident to address the conditions that likely led to the FGAN detonation. The ICC's International Fire Code (IFC) also addresses storage and handling of oxidizing materials.

Texas does not have a state-wide fire code and as a result, most fire departments in the state have no authority to inspect facilities against, or compel them to follow the safe practices outline in these codes, unless a fire code is adopted at the county or city level. In July 2015, the Texas Department of Insurance did adopt NFPA 1 (*Fire Code*) for inspections by the Texas State Fire Marshal's office on the complaint of any person. However, even if fire protection standards are incorporated into state and local fire codes, catastrophic incidents can occur when such standards are deficient.

CSB reviewed the ICC IFC and NFPA 1 (*Fire Code*). The IFC is in use or adopted in 42 states,[645] and NFPA 1 is adopted statewide in 19 states. CSB also researched fire protection codes on the state, county, and city levels—specifically, in the state of Texas, in McLennan County, and in the city of West. The first part of this section describes the NFPA, with details on the NFPA standard for FGAN. The second part of this section describes the ICC, with details on how it addresses HAZMAT. The third and last part of this section describes fire code regimes on a more local level and analyzes codes in Texas, which can be improved to better protect emergency responders and the public from fire events.

8.6.1 National Fire Protection Association

The NFPA is an international nonprofit organization that develops and publishes industry consensus codes and standards, guides, and recommended practices associated with fire prevention and related hazards. Companies can voluntarily comply with NFPA codes and standards or can be required to follow a standard if it is adopted by reference in local, state, or federal laws (e.g., in a local or state fire code). Many of the NFPA codes and standards are also incorporated in OSHA regulations. The EPA Risk Management Program rule and OSHA PSM standard regulations require owners and operators of covered facilities to ensure that facility processes are designed to comply with RAGAGEP, which can include NFPA codes and standards. However, if these consensus codes and standards are deficient, they can lead to insufficient protections.

8.6.1.1 NFPA Code for FGAN

AN requirements were first covered by NFPA 490 (*Storage of Ammonium Nitrate*), which was adopted in 1965. In 2010, NFPA withdrew NFPA 490 when it was incorporated into NFPA 400 (*Hazardous Materials Code*). NFPA 400 establishes provisions for the storage, use, and handling of a number of hazardous substances, using four broad categories addressing building construction, storage requirements, fire protection systems, and general protections against fire. The 2013 edition had been published and was in effect at the time of the incident.

The code has a specific chapter on AN (Chapter 11, "Ammonium Nitrate Solids and Liquids"). This distinguishes AN from other chapters because other chapters of the code are organized by chemical

[645] The IFC is also adopted in the District of Columbia, NYC, Guam and Puerto Rico.

properties (such as "oxidizers" or "unstable or water reactive materials") that can each apply to several chemicals. The scope of Chapter 11 covers "the storage, use, and handling of solid or liquid AN" in quantities exceeding 1,000 pounds. The chapter does not include FGAN manufacturing operations or the composition of FGAN designated as DOT hazard Class 1 explosives. The NFPA 400 code includes provisions for indoor and outdoor storage, fire protection systems, and general use; annexes offer additional guidance. In addition, the maximum allowable quantity (MAQ) designation is used in building and fire codes when addressing the storage, handling, and use of HAZMAT. The MAQ is integral to the NFPA 400 approach. It includes provisions for classifying materials, determining their MAQs, and adding other protective features if the intention is to use greater quantities of material.

When evaluating the provisions in NFPA 400 (2013 Edition) against the factors that likely contributed to the WFC incident, CSB found code deficiencies concerning scope, building design, storage practices, and fire prevention and firefighting response for facilities that store bulk FGAN. However, it is important to note that the WFC would not have been required to comply with the code at the time of the incident unless the authority having jurisdiction enforced it retroactively. The WFC facility was constructed in 1962, so the requirements of NFPA 400 did not apply. Nonetheless, in response to some of the lessons learned from the WFC incident, CSB and other agencies and organizations participated in meetings with the NFPA Technical Committee on Hazardous Chemicals to provide input on the next revision of NFPA 400 (2016 Edition).

A significant effort of the NFPA Technical Committee focused on addressing the requirements for existing FGAN storage facilities covered under NFPA 400 because the previous editions had primarily covered requirements for new facilities.[646] As discussed, the wood construction of the WFC warehouse and bins that stored FGAN not only assisted in the rapid spread of the fire but also increased the sensitivity of the material that led to the detonation. In addition, the WFC warehouse had no installed fire detection or suppression systems, allowing the fire to spread through the building. If a building fire detection system had been operational, the early stages of the fire possibly could have been extinguished. Furthermore, sprinklers could have extinguished the fire before it could heat the FGAN pile sufficiently to produce a detonation.

Similar to the OSHA Explosives and Blasting Agents standard, NFPA 400 (2013 Edition) allowed wood and combustible construction materials for bulk storage bins for FGAN as long as the bins were "protected against impregnation by FGAN." The code noted in an annex that sodium silicate, epoxy coatings, or polyvinyl chloride (PVC) coatings were acceptable means to achieve this protection. However, the method used to coat the wood to resist FGAN impregnation does not prevent a fire. The presence of combustibles during a fire can create explosive conditions within a building that stores bulk FGAN. NFPA 400 (2016 Edition) now prohibits the use of combustible materials for all construction and bins at new facilities, even when coatings are applied to protect against FGAN impregnation.

[646] Pearce, Nancy. "Safer Storage." NFPA Journal, May 1, 2015.

However, the 2016 revisions to NFPA 400 do not apply the same requirements to prohibit combustible construction at existing facilities. The NFPA was challenged to reasonably specify construction requirements for facilities with combustible construction, which comprise the majority of FGAN storage facilities.[647] To address existing facilities, NFPA 400 (2016 Edition) contains the new Section 11.1.5, "Protection of Existing Buildings." This includes requirements that apply retroactively, where adopted, for existing buildings with combustible content. Facilities are required to install automatic fire sprinkler and detection systems. Activation of the fire detection system must automatically initiate an audible and visual alarm at the facility as well as a public notification or alert system to warn individuals located within one mile of the facility that they need to evacuate.

Another shortcoming of NFPA 400 (2013 Edition) lies in Annex E, "Properties and Uses of Ammonium Nitrate and Fire-Fighting Procedures," which called for large volumes of water to be applied as quickly as possible unless the fire reached "massive and uncontrollable proportions," when responders were advised to evacuate and withdraw to a safe location. CSB found this guidance to be vague because the user had to determine when to categorize a fire as "massive and uncontrollable" and when to make the decision to evacuate rather than attempt to extinguish the fire. Because of FGAN's unpredictable nature, immediate evacuation should be the first action for responders, using a minimum evacuation distance calculated in advance based on the quantity of FGAN stored. The 2013 edition of NFPA 400 did not require pre-planning, but given the events that unfolded during the WFC response, firefighters should also have a pre-incident plan to facilitate quick and effective decision making when responding to an FGAN fire.

NFPA 400 (2016 Edition) now requires new and existing facilities to have emergency action plans that clearly state that "fire potentially affecting FGAN storage beyond the initial (incipient) stage shall not be approached by facility personnel."[648] The emergency plan must also specify whether the FGAN storage facility has a sprinkler system and whether it is constructed of combustible materials. For new facilities, the plan must establish a safe evacuation distance based on an approved[649] analysis of potential offsite consequences. If no analysis has been performed, a distance of one mile should be used. The revised Annex E of NFPA 400 (2016 Edition) offers additional guidance to firefighters, including information on the conditions that cause FGAN explosions. The guidance states that only incipient fires in FGAN storage areas (or in vehicles transporting FGAN) should be attacked by using manual fire extinguishing methods that require a human operator.[650] Firefighters should withdraw to a safe distance and allow the structural fire to burn to completion once it progresses beyond the incipient stage.[651]

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[647] *Ibid*.
[648] NFPA. *NFPA 400: Hazardous Materials Code*, 2016 Edition. Quincy, MA: NFPA, 2016.
[649] Plan approvals are performed by the authority having jurisdiction, such as the fire department or fire marshal.
[650] NFPA. *NFPA 400: Hazardous Materials Code*, Annex E, 2016 Edition. Quincy, MA: NFPA, 2016.
[651] NFPA 400 (2016 Edition) states that "responses to incipient releases of hazardous materials where the material can be absorbed, neutralized, or otherwise controlled at the time of release by employees in the immediate release area, or by maintenance personnel, shall not be considered emergency responses as defined within the scope of this code."

Following the WFC incident, the NFPA-sponsored Fire Protection Research Foundation[652] (the Foundation) conducted a study[653] to determine the adequacy of the separation distances prescribed for hazardous materials in NFPA 400, with a greater focus on FGAN. NFPA 400 specifies separation and clearance distances for newly constructed hazardous chemical storage from other on-site equipment and occupied buildings.

The Foundation's technical committee was made up of industry representatives, and research and engineering organizations that conducted literature reviews of existing methodologies to determine safe separation distances and testing to characterize the effect of AN detonations on personnel and processes near an explosive event. The study included reviews of various sources for risk-based and consequence-based methodologies for determining the safe distances as well as established distance tables. To study the adequacy of the existing separation distances in NFPA 400, the Foundation commissioned explosive testing to characterize the effects of nearby processes and personnel using a 3,000 pound ANFO donor charge to simulate an explosion.

As part of the analysis, blast consultants compared the blast pressures and data recorded at various distances from the donor charge and compared the effects to the recommended distances for Class 3 Oxidizers in detached unsprinklered storage prescribed in NFPA 400 Chapter 15 (*Oxidizer Solids and Liquids*). The study concluded that the process-to-process separation distances for solid AN may be inadequate to provide protection against blast effects, but the process-to-personnel separation distances may be acceptable if personnel are inside buildings located at prescribed distances. However, the study concluded that additional testing and analysis is necessary to validate the absolute safety of personnel based on variations in processes, design, and potential reactants.

The purpose of the project was to provide guidance to the NFPA technical committee for the development of technically-based separation distances for storage. Thus, the Foundation recommends a technical-based approach to establish safe separation distances that takes into account the risks associated with a known material and process, as well as the potential consequences of a catastrophic event involving that material.

8.6.2 International Code Council

Like the NFPA, the ICC is an international nonprofit organization that develops and publishes consensus codes and standards. In addition to publishing the IFC, the ICC also produces the International Building Code (IBC), which is in use or adopted in 50 states. Jurisdictions can adopt the model codes by reference. The ICC views its codes as "companion" documents that work across disciplines (e.g., building construction, fire protection, mechanical systems, plumbing, zoning). Thus, a regulation for HAZMAT storage will affect building code requirements for construction, mechanical code requirements for

[652] The Fire Protection Research Foundation is an affiliate of NFPA and plans, manages, and communicates research on fire safety issues in collaboration with academics, laboratories, and industry.

[653] *See*: http://www.nfpa.org/Assets/files/AboutTheCodes/59A/RFSeparationDistancesNFPACodesAndStandards.pdf (accessed on December 30, 2015).

ventilation, plumbing code requirements for drainage, and fire code requirements for operations and handling. The codes are cross-referenced for ease of use.

The ICC requirements for protecting AN from fire exposure and explosion are based on material properties, quantities stored, and storage and handling conditions. The ICC defines storage as "the keeping, retention or leaving of hazardous materials in closed containers, tanks, cylinders, or similar vessels; or vessels supplying operations through closed connections to the vessel."[654] Therefore, despite common references to the WFC FGAN as "in storage," the IFC would interpret this application as "handling," which it defines as "the deliberate transport by any means to a point of storage or use," or as "use," which it defines as "placing a material into action, including solids, liquids and gases."[655]

The IFC does not have a separate chapter for AN. The IFC refers to NFPA 400 when AN intended for explosive materials is stored, handled, or used. Otherwise, AN is treated as an oxidizing agent, subject to the general requirements for each oxidizer class in IFC Chapter 63 (*Oxidizers, Oxidizing Gases and Oxidizing Cryogenic Fluids*) and Chapter 50 (*Hazardous Materials*).

8.6.3 State Fire Codes

Without a comprehensive federal standard, states must rely on their own regulations to oversee HAZMAT storage. Most states have enacted fire codes or have adopted model fire codes. These codes typically include HAZMAT storage and emergency planning provisions. However, at the time of the incident, Texas had no state fire code, and the state still has no such code as of publication of this report.

The majority of states have adopted model fire codes through referencing them into law.[656] Two recognized model fire codes are the IFC and NFPA 1. Both establish minimum requirements for fire prevention and protection systems. Some states and municipalities have developed their own fire codes, using model codes as a guide. New York City updated its fire code in December 2007, marking its first major revision since 1913.[657] After investigating an industrial waste explosion and fire in 2001 in the Chelsea district of Manhattan, CSB issued a recommendation to the Mayor and City Council to better address HAZMAT.[658] The city developed its own code, borrowing heavily from the IFC (2003 Edition) but requiring some more stringent provisions.

States could potentially apply other IFC chapters for storing bulk FGAN. For example, IFC Chapter 63 (*Oxidizers, Oxidizing Gases and Oxidizing Cryogenic Fluids*) includes provisions for storage and use of oxidizing materials, such as FGAN. This chapter says that indoor storage of oxidizers should be located in a detached building with an automatic sprinkler system and smoke detection systems. Additional

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[654] ICC. Chapter 50, Section 5002.1. *International Fire Code*, 2015 Edition. Washington, DC: ICC, 2015.
[655] *Ibid*.
[656] ICC. "International Code Adoption." *International Fire Code*. Washington, DC: ICC, 2014. *See*: http://www.iccsafe.org/gr/Pages/adoptions.aspx (accessed on November 6, 2014).
[657] Cassono, Salvatore. "A New Fire Code for New York City." *Building Safety Journal* (July–August 2008).
[658] CSB. "Chemical Waste-Mixing Incident: Kaltech Industries Group, Inc." CSB Investigation Report, April 25, 2002.

requirements for storage configuration, separation barriers, and explosion control depend on the class of oxidizer, of which the IFC names four. NFPA 1 includes similar requirements for oxidizers in Chapter 70 (*Oxidizer Solids and Liquids*). This chapter directs users to follow NFPA 400, which also incorporates similar building and fire protection requirements for indoor storage of oxidizers.

The WFC did not voluntarily implement any of the provisions from the oxidizer chapters of the IFC or NFPA 1, nor were they required to do so by the authority having jurisdiction. The WFC did not install an automatic sprinkler or smoke detection system in the fertilizer warehouse, nor did it store its FGAN in a separate building, away from combustibles. The location where the fire originated was adjacent to the FGAN bin, and no fire-rated wall separated the rooms. The WFC was not subject to code provisions because none of the relevant jurisdictions—not the state of Texas, McLennan County, or the city of West—had adopted a fire code.

Texas affords counties and municipalities the discretion to adopt or develop fire codes. However, state law limits which counties can adopt such codes. Only a county with a population of more than 250,000 (and counties adjacent to a county with a population of more than 250,000) may adopt a fire code. Moreover, even if such a county does adopt a fire code, that code applies only to the unincorporated areas of the county. Cities within the county can adopt the county fire code, not adopt a fire code, or develop their own fire codes. Adoption of a city fire code does not affect any unincorporated areas outside the city. Although many major Texas cities have adopted fire codes, the pattern is inconsistent.

As of September 2014, 43 facilities stored FGAN in 36 Texas counties. Only one of those 36 counties has a population of more than 250,000 people,[659] and only six of those counties are adjacent to counties with populations that equal or exceed 250,000. Consequently, 79 percent of the 43 FGAN storage facilities are located in Texas jurisdictions that, under state law, cannot adopt a fire code.

According to the 2010 census, the population of McLennan County was 241,281. Thus, the county fell below the population threshold. However, one of the seven adjacent counties had a population of more than 250,000. Accordingly, McLennan County had the authority to adopt a fire code, but this was not required. It is also important to note that the WFC facility was only partially within city limits. The fertilizer warehouse was located in an unincorporated area of West. If McLennan County had adopted a fire code, it would have applied to the WFC fertilizer warehouse only. Furthermore, if West had decided to adopt its own fire code, it would have applied to the entire WFC facility except for the warehouse.

Although efforts have been made to make a state fire code in Texas mandatory, such endeavors have not been successful. The Texas Legislature debated the issue of adopting a state fire code at least as far back as 1978. Legislative committee reports between 1978 and 1984 from the Texas House of Representatives and the Texas State Senate identified the severe fire problem, and one report contended that the losses from fires exceeded "loss of life and property" from "all natural disasters combined" in the state.[660] After

[659] U.S. Census Bureau. *2010 U.S. Census*. Washington, DC: U.S. Census Bureau, 2011.
[660] Texas House of Representatives Committee on Business and Industry. "Interim Report," October 13, 1978.

hearing multiple testimonies in public hearings across the state, a committee report concluded that Texas was "one of the leading states in property loss and lives lost because of fire."[661] This same committee report also found that such major losses occurred not in the most populated municipalities that had adopted fire and building codes, but in the unincorporated areas where fire codes did not apply.[662] It stated that unincorporated areas were particularly problematic when annexed into a municipality because the city assumed responsibility for fire-prone buildings that were not built to code specifications.[663] Because growth areas in counties are inevitable targets for municipal annexation, if counties are not granted proper regulatory authority, cities inevitably inherit the problems thus created.

The Texas legislative committee reports also identified that without a state fire code, the State Fire Marshal cannot fulfill the duty of minimizing fire risks. One report noted that the State Fire Marshal has no authority to adopt a fire code, despite holding responsibility for the inspection of state-owned and state-leased buildings. Without a code, the State Fire Marshal is unable to set criteria to assess a fire hazard and enforce corrective actions. Moreover, although the local fire marshals hold authority to inspect facilities in their jurisdictions, without a fire code, they cannot enforce safety measures that are not legally required.

The Texas Fire Protection Standard Committee, a special interim legislative committee, studied the fire problem and issued an interim report to the 69th session of the Texas Legislature in December 1984.[664] This committee confirmed many of the findings above.[665] In addition, the committee analyzed NFPA national fire data from 1978 to 1982.[666] These data indicated that the per capita number of fires, deaths, and injuries and the dollar loss resulting from fire were all lower in states with fire codes than in those without them.[667] The data also suggested that education alone to minimize human errors was insufficient to reduce fire loss because fire causation was mostly attributable to improper structural design and equipment malfunction.[668] This committee also received extensive testimony from around the state indicating that the loss of life in the volunteer firefighter service was primarily "because there were no codes."[669]

Over the years, proposed bills in the Texas Legislature for adoption of a fire code failed to gain support. In 1977, the Texas House of Representatives addressed a proposed bill to enforce a "fire prevention code" that would apply only to unincorporated areas and would be enforced by the state and county fire

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[661] Texas Senate Subcommittee on Consumer Affairs. "Final Staff Recommendations," December 1980.
[662] *Ibid*.
[663] *Ibid*.
[664] Texas Fire Protection Standards Committee. "Interim Report to the 69th Texas Legislature." December 1984.
[665] *Ibid*.
[666] *Ibid*.
[667] *Ibid*. It was noted in the report that the fire loss data had limitations because mandatory reporting requirements were not consistent throughout the nation. This limited statistical analysis nonetheless pointed out principal causes of fires.
[668] *Ibid*.
[669] *Ibid*.

marshals.[670] In 1997, 20 years later, another proposed Texas House bill sought adoption of a code that would apply to (1) buildings located in unincorporated areas that have not adopted a fire code, (2) municipalities that did not adopt a fire code, (3) public assembly buildings in municipalities that have not adopted either model code, and (4) state-owned buildings.[671] Neither bill progressed out of committee.

In 1989, the Texas Legislature granted limited authority to counties with a population of 250,000 or more to adopt and enforce a fire code.[672] This authority was later amended in 1997 to address growing populations and include counties adjacent to those with a population of at least 250,000.[673] The failure to mandate a statewide fire code left some counties such as McLennan County without minimum fire protection measures.

The absence of a state-wide fire code and the local population restrictions for code adoption remain an important issue for CSB. However, since the WFC incident, Texas has amended the administrative code to provide the State Fire Marshal with greater authority to enforce some NFPA codes at FGAN storage facilities, as well as to enter, upon complaint, and inspect facilities against the provisions of NFPA 1. Though the adoption did not create a state-wide fire code, it allows for the State Fire Marshal to inspect against a more comprehensive standard than NFPA 101 (*Life Safety Code*) that Texas previously adopted.[674] Additional changes to the Texas State Fire Marshal's authority to inspect FGAN facilities were enacted as part of House Bill 942 (described in Section 8.7.2). In addition, the Texas Agriculture Code was amended to impose additional requirements on FGAN retailers (described in Section 8.7.1).

8.7 Post-Incident State and Local Regulatory Developments

Since the 2013 WFC incident, state and local legislators in Texas have attempted to improve FGAN safety through regulatory change. These efforts represent important first steps in recognizing the potential catastrophic hazards of FGAN under certain conditions. However, they are not entirely adequate. For example, when Texas House Bill (HB) 942 became law, it simply codified existing state hazardous chemical reporting requirements. Also, although the revised Texas Commercial Fertilizer Rules establish requirements for FGAN to be separated by at least 30 feet from combustible and flammable materials,[675] this requirement is much less restrictive than the newly revised NFPA 400

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[670] 65th Texas Legislative Session. House Bill (HB) 325, "An act relating to the promulgation and enforcement of a state fire prevention code for unincorporated areas of the state by the State Board of Insurance."
[671] 75th Texas Legislative Session. HB 2922, "An act relating to a statewide building and fire code."
[672] 71st Texas Legislative Session. HB 2252, "An act relating to the authority of the commissioners courts of certain counties to adopt a fire code for certain buildings in unincorporated areas."
[673] 75th Texas Legislative Session. State Bill (SB) 10, "An act relating to the authority of certain counties to adopt and enforce a fire code."
[674] *See*: https://texreg.sos.state.tx.us/public/readtac$ext.TacPage?sl=R&app=9&p_dir=&p_rloc=&p_tloc=&p_ploc=&pg=1&p_tac=&ti=28&pt=1&ch=34&rl=303 (accessed on December 30, 2015).
[675] Texas Administrative Code, Title 4, Chapter 65, Section 65.6(d)(3). *See*: http://otscweb.tamu.edu/Laws/PDF/CommercialFertilizerRules.pdf (accessed on December 29, 2015).

standard and might not fully eliminate the risk of molten FGAN contamination during a fire. This section includes a discussion of the Texas Commercial Fertilizer Rules, a general analysis of HB 942 as well as a comparison of HB 942 to other legislation pending in committee as of this report's publication date, and a review of an Athens, Texas, ordinance that mandates a ban on the bulk storage of FGAN.

8.7.1 Texas Commercial Fertilizer Rules

The Office of the Texas State Chemist (OTSC) regulates the sale of FGAN and FGAN-containing materials. Enacted by 2007 amendments to the Texas Agricultural Code Section 65.6, the law places limits on FGAN sales. It establishes requirements for registration certificates issued by the Texas Feed and Fertilizer Control Service as a condition of selling (or offering to sell) FGAN.[676] To reduce theft or terrorism, the requirements focus on security measures for FGAN storage and on recordkeeping to identify people who purchase FGAN.

In June 2014, Texas revised the provisions of its Commercial Fertilizer Rules.[677] The revised rules require FGAN facilities to file Top-Screen information under the federal CFATS rule as well as EPCRA Tier II information with the Texas Department of State Health Services as a condition for receiving an annual certificate of registration to sell FGAN. The 2014 revisions also require OTSC to inspect FGAN storage areas. Such inspections are to confirm that combustible and flammable materials, such as potential sources of ignition—fuels, oils, hay, or other organic materials—are separated from FGAN by at least 30 feet. If facilities do not comply with these requirements, OTSC can deny, suspend, or revoke annual certificates to sell (or offer to sell) FGAN.

8.7.2 Texas House Bill 942

The summary of Texas HB 942 says that it is an "act relating to the storage of certain hazardous chemicals; transferring enforcement of certain reporting requirements, including the imposition of criminal, civil, and administrative penalties, from the Department of State Health Services to the Texas Commission on Environmental Quality." It became law on June16, 2015.[678] The law bars facilities from storing FGAN with any nonfertilizer materials, requires that FGAN be stored at least 30 feet away from combustible materials, moves FGAN regulation from the Department of State Health Services to the TCEQ, allows the State Fire Marshal to inspect FGAN facilities, gives fire departments access for pre-fire planning assessments, and requires correction of hazardous conditions within 10 days.[679]

Although this law is an effort by state legislators to better regulate FGAN, it is not entirely adequate. For example, the requirement that FGAN storage be at least 30 feet from combustible materials was already required by the Texas Commercial Fertilizer Rules, as amended in June 2014 (and discussed in Section

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[676] *See*: http://www.tlc.state.tx.us/pubssoe/80soe/80soe.pdf (accessed on December 29, 2015).
[677] *See*: http://otscweb.tamu.edu/Risk/AmNitrate/PDF/AN-Compliance-Guide.pdf (accessed on December 29, 2015).
[678] *Ibid*.
[679] *See*: http://kwbu.org/post/abbott-signs-bill-tackles-ammonium-nitrate-storage (accessed on December 29, 2015).

8.7.1), a year before HB 942 became law. During a May 2015 meeting of the Texas Senate Committee on Natural Resources and Economic Development, Senator Brian Birdwell, who sponsored the bill, affirmed this fact. He said, "To be clear this is not a new regulatory scheme. HB 942 simply codifies existing regulations regarding reporting of hazardous chemicals. These are existing regulations which 100 percent of FGAN storage facilities in this state [must currently comply with]."[680]

A related bill, HB 417, would impose penalties for improper FGAN storage and would create rulemaking authority over FGAN facilities.[681] The bill states, "The commissioner of insurance, after consultation with the state fire marshal, by rule shall adopt fire protection standards for FGAN storage facilities, including standards for the storage of FGAN at those facilities."[682] State Representative Joe Pickett, the author of HB 417, told the Texas House Committee on Environmental Regulation in April 2015 that "the rulemaking authority is a way to make changes without the Legislature being in session," explaining that the Commissioner of Insurance would work with state agencies.[683] This regulatory authority distinguishes HB 417 from HB 942. Although HB 417 does not necessarily establish new regulations, it gives the Commissioner of Insurance an opportunity to do so. As of December 2015, however, this bill remains pending in committee.[684]

8.7.3 Athens City Ordinance

After the May 29, 2014, FGAN-related fire at the East Texas Ag Supply facility in Athens, Texas (discussed in Section 7.4), the city of Athens initiated efforts to prevent similar events. On May 29, 2015, Athens passed an ordinance that banned bulk storage of FGAN and anhydrous ammonia.[685] The ordinance (No. O-24-14) states in simple terms, "Commercial Fertilizer Storage or Manufacturing Facilities used to produce, transfer, store, or offer for sale Bulk FGAN, Bulk FGAN Material and/or Anhydrous Ammonia shall not be allowed in any zoning district in the City." A "commercial fertilizer storage or manufacturing facility" is defined as one that "stores, mixes, or manufactures 10,000 or more pounds of FGAN and/or anhydrous ammonia and/or is required to register with the Texas Feed and Fertilizer Control Service." The ordinance also streamlines chemical reporting and allows volunteer fire departments to inspect facilities.[686] However, this ordinance does not apply retroactively to the facilities that existed when the ordinance was enacted.

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[680] *Ibid*.
[681] *See*: http://www.texastribune.org/2015/04/07/proposed-bill-aims-prevent-another-fertilizer-blas/ (accessed on December 29, 2015).
[682] Texas HB 417, "An act relating to information regarding the storage of certain hazardous chemicals; providing penalties."
[683] *See*: http://www.texastribune.org/2015/04/07/proposed-bill-aims-prevent-another-fertilizer-blas/ (accessed on December 29, 2015).
[684] *See*: http://txlege.texastribune.org/84/bills/HB417/ (accessed on December 29, 2015).
[685] *See*: http://www.kltv.com/story/29192400/one-year-after-fire-city-of-athens-state-make-changes-in-ammonium-nitrate-storage (accessed on December 29, 2015).
[686] *Ibid*.

8.8 Industry Standards

Since the WFC incident, the fertilizer industry has implemented initiatives to prevent such an incident from reoccurring. In February 2014, TFI and the ARA, two primary agricultural trade associations, developed and issued *Safety and Security Guidelines for the Storage and Transportation of Fertilizer Grade Ammonium Nitrate at Fertilizer Retail Facilities* (or Safety and Security Guidelines).[687] This public document explains the OSHA Explosives and Blasting Agents standard, but also provides more specific guidance. In March 2014, TFI and the ARA initiated an FGAN stewardship program. Participation involves a voluntary assessment every three years of facility safety and security, focusing on FGAN and anhydrous ammonia.

8.8.1 The Fertilizer Institute (TFI)

TFI is a major trade association for the fertilizer industry.[688] TFI members include BP Energy Company, Dow AgroSciences, DuPont Sulfur Products, JP Morgan, Mitsubishi International Corporation, Shell Sulphur Solutions, and Union Pacific Railroad.[689] TFI lists security, energy, the environment, and worker health and safety as concerns to its members.[690] It also lists product safety stewardship as one of its key issues.[691] TFI offers tools to enhance the safety and security of products and equipment (discussed in Appendix E) across the supply chain.[692] Post-WFC incident tools include the Compliance Assessment Tool, the Safety and Security Guidelines, and the ResponsibleAg program. Each of these is discussed in the next sections.

8.8.1.1 Compliance Assessment Tool

The Asmark Institute, a private not-for-profit educational organization that is a resource center for the agricultural retail industry, developed the web-based Compliance Assessment Tool.[693] With regulatory compliance consistently cited during the last 18 years as one of the top 10 threats to the long-term viability of agricultural retail facilities, the Compliance Assessment Tool is meant to assist the agricultural retail industry.[694] This tool helps personnel at facilities, terminals, warehouses, and farm equipment dealers in identifying the regulations that apply to their specific sites.[695] The Compliance Assessment Tool evaluates onsite compliance efforts.[696] Through accessing the website, entering facility

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[687] ARA, TFI. "Safety and Security Guidelines for the Storage and Transportation of Fertilizer Grade Ammonium Nitrate at Fertilizer Retail Facilities," February 2014.
[688] *See*: http://www.tfi.org/about (accessed on December 29, 2015).
[689] *See*: http://www.tfi.org/about/membership-list (accessed on December 29, 2015).
[690] *See*: http://www.tfi.org/about (accessed on December 29, 2015).
[691] *See*: https://www.tfi.org/advocacy/stewardship (accessed on December 29, 2015).
[692] *See*: http://www.tfi.org/safety-and-security-tools (accessed on December 29, 2015).
[693] *See*: http://www.tfi.org/compliance-assessment-tool (accessed on December 29, 2015).
[694] *See*: https://www.asmark.org/Compass/ComplianceAssessmentTool/ (accessed on December 29, 2015).
[695] *Ibid*.
[696] *Ibid*.

information, and describing scope of operations, the user can download a specific compliance assessment document and then complete a worksheet.[697] Periodic use of the tool is encouraged to help control risk and to support compliance efforts.[698]

8.8.1.2 Safety and Security Guidelines for the Storage and Transportation of FGAN at Fertilizer Retail Facilities

TFI and the ARA created the Safety and Security Guidelines.[699] TFI's website notes that "the document was created to fill the void in emergency response guidelines specific to FGAN fertilizer at retail fertilizer facilities."[700] The guidelines outline best practices for safe and secure storage and transport of FGAN.[701] They also summarize storage and handling regulations for FGAN facilities as well as recommendations for first responders.[702] Moreover, they provide rules for transporting FGAN via truck, highway, rail, and barge.[703]

8.8.1.3 ResponsibleAg

Created by TFI and the ARA in 2014, ResponsibleAg is a third-party auditing program for fertilizer retailers.[704] Although any business that stores or handles fertilizer product is eligible to participate in the ResponsibleAg Certification Program, the first three years of the program focus on companies that store and handle AN and/or anhydrous ammonia fertilizer.[705] Using federal requirements for the storage and handling of fertilizer products, ResponsibleAg has compiled a checklist of more than 320 questions for auditing each participating facility.[706] The participating facility determines the audit scope; however, all participants must have a "base audit."[707] A participating facility may become ResponsibleAg certified only if it passes the initial audit or if it takes all necessary steps to correct the issues identified during the audit and documented in the facility's corrective action plan.[708]

ResponsibleAg also allows its participating suppliers to access the list of participating facilities that have successfully completed the assessment and earned certification.[709] This is important because it allows suppliers to determine whether prospective buyers have successfully completed the ResponsibleAg assessment, which thereby promoted federal regulatory compliance. This approach enables

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[697] *Ibid*.
[698] *Ibid*.
[699] *See*: http://www.tfi.org/ammonium_nitrate_guidelines (accessed on December 29, 2015).
[700] *Ibid*.
[701] *Ibid*.
[702] *Ibid*.
[703] *Ibid*.
[704] *Ibid*.
[705] *See*: http://www.responsibleag.org/About.cgi (accessed on December 29, 2015).
[706] *Ibid*.
[707] *Ibid*.
[708] These corrective actions must be certified by ResponsibleAg, usually during a verification audit.
[709] *See*: https://www.responsibleag.org/FAQ.cgi#Link02 (accessed on December 29, 2015).

ResponsibleAg members to engage in some elements of product stewardship (as discussed in Section 8.8.3). Notably, CF Industries and EDC, the only AN fertilizer manufacturers in the United States, are listed as ResponsibleAg participants.[710] Appendix F includes additional information on the ResponsibleAg program process.

8.8.2 Agricultural Retailers Association (ARA)

The ARA is also a major trade association for the fertilizer industry.[711] It represents agricultural retailers and distributors across the United States on legislative and regulatory issues.[712] ARA members represent the majority of agribusinesses in the United States.[713] The ARA works with Congress to create legislation, and updates federal agencies and legislators on important issues affecting the industry.[714] The ARA offers programs and services to keep its members informed of important industry issues.[715]

8.8.3 Product Stewardship

As of this report's publication, only two companies in the United States, CF Industries and EDC, manufacture FGAN.[716] Fertilizer manufacturers can promote the safe storage and handling of FGAN by distributors and retailers by implementing product stewardship programs. According to the Center for Chemical Process Safety, product stewardship encourages safety and health in the design, manufacture, marketing, distribution, handling, use, and disposal of chemical products.[717] Responsibility for safely managing the product is shared throughout the supply chain and the product life cycle. Because it is a self-regulated program, product stewardship can only be as effective as industry intends and allows.

CSB determined that components of an effective product stewardship program should generally include the following elements for each product:

- Identifying and communicating all product hazards among manufacturers, distributors, and retailers.
- Providing supplemental technical information on safe handling practices for the product (furnished by manufacturers and/or distributors) to other distributors and/or retailers.
- Establishing accountability for distributors and retailers to promote safe handling of a product throughout the chain of customers.
- Performing monitoring and auditing, such as onsite visits to the locations where the product will be stored or used.

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[710] *See*: https://www.responsibleag.org/ParticipantList.cgi (accessed on December 29, 2015).
[711] *See*: http://www.aradc.org/ARADC/About/About/ (accessed on December 29, 2015).
[712] *See*: http://www.aradc.org/becomeamember/ (accessed on December 29, 2015).
[713] *Ibid*.
[714] *Ibid*.
[715] *See*: http://www.aradc.org/about/about (accessed on December 29, 2015).
[716] The WFC also reported receiving imported AN from foreign manufacturers between 2006 and 2013.
[717] Center for Chemical Process Safety. *Guidelines for Safe Handling of Powders and Bulk Solids*. New York: Center for Chemical Process Safety/AIChE, 2005: 521.

- Developing mechanisms for outreach to communities near the facilities where the products are stored or used.

Information sharing is an important component of product stewardship. When information about product hazards or details about the storage practices of a certain facility are known, people and companies dealing with the product or with the facility have the opportunity to effectively manage the risks associated with that product. The same logic applies to the management of FGAN. The WFC incident highlighted the need for greater awareness of the unpredictable nature of AN and the conditions under which it can detonate. Two industry programs, Responsible Care and ResponsibleAg, both advocate information sharing. Accordingly, the programs have serious product stewardship potential.

As described in Section 8.8.1.3, the joint TFI-ARA ResponsibleAg program currently addresses some aspects of product stewardship. In particular, fertilizer sellers (i.e., manufacturers and/or distributors) may elect to access the list of ResponsibleAg-participating facilities to determine assessment completion and certification of prospective buyers (i.e., distributors and/or retailers). By doing so, the seller verifies that the buyer safely stores fertilizer (or at least has a record of safely storing fertilizer). Similarly, the American Chemistry Council's (ACC) Responsible Care initiative includes information sharing in its product stewardship program. Participation in Responsible Care is a condition of membership for ACC members.[718] The program specifies 11 management practices and focuses on leadership commitment, accountability and management, prioritization of products, product information, risk characterization, management of new information, product safety management, product design and improvement, value chain communication, cooperation and outreach, information sharing, and performance assessment and continual improvement.[719]

Serious participation in product stewardship programs such as ResponsibleAg and Responsible Care can promote the safe handling and storage of domestically manufactured FGAN. This is especially true for FGAN because there are only two companies, CF Industries and EDC, that manufacture FGAN in the United States. As such, domestically manufactured FGAN product can be linked to one of these two companies. CF Industries and EDC are already members of ResponsibleAg. Product stewardship programs such as ResponsibleAg can ensure that FGAN management practices, starting with FGAN manufacturers CF Industries and EDC, are subject to greater scrutiny. However, it is also important to make sure that distributors and retailers handle and store the product safely.

Because responsibility for a chemical product does not always end after it is manufactured, it is important that manufacturing companies know how the product is handled and stored once it leaves the production site. In other words, a manufacturer cannot simply confirm that its direct buyer safely stores and handles the manufacturer's product because that buyer may in turn sell to another buyer that does not store or handle the product safely. The same reasoning applies to communicating product hazards. Of course, requiring the manufacturer to communicate the hazards of its product to its buyer is surely a step in the

[718] *See*: http://responsiblecare.americanchemistry.com/ (accessed on November 30, 2015).
[719] *See*: http://responsiblecare.americanchemistry.com/Responsible-Care-Program-Elements/Product-Safety-Code/Responsible-Care-Product-Safety-Code-PDF.pdf (accessed on November 30, 2015).

right direction, but the buyer must also communicate the same hazards to its buyers, if any. Otherwise, catastrophic incidents can occur. Importantly, therefore, these distribution chains must not break; effective communication must endure from top to bottom.

To ensure continuity of communication throughout the supply chain, industry should voluntarily take an active role. Because government agencies cannot reasonably be expected to routinely inspect every FGAN facility, industry's product stewardship programs must play a significant role in making sure that this top-to-bottom approach is implemented. Product stewardship offers an important opportunity for industry to further manage risk, beyond providing SDSs to retailers. Although CF Industries and EDC use different business models, both have executed initiatives that ascribe to product stewardship elements post-incident.

8.8.4 Efforts to Address FGAN Hazards Post-Incident

Since the WFC incident, both CF Industries and EDC have made additional efforts to make sure that their FGAN product is stored and handled safely as it moves out of their manufacturing facilities. CF Industries has implemented a certification process for its customers (purchasing organizations as well as facilities that receive FGAN deliveries) to confirm that customers communicate both the hazards and safe storage and handling practices of FGAN. As of December 31, 2014, CF Industries requires existing facilities to certify through a signed certification letter that they are in compliance with applicable guidelines and regulations before they can receive FGAN product. All new purchasing organizations and sites must also return the signed certification letter before receiving FGAN from CF Industries. Specifically, the letter requires senior responsible officials at both the purchasing organization and the delivery facility to certify that they are either in compliance with, or legally exempt from, 17 items. These items include, for example, attestations that:

- The purchasing organization provided the FGAN SDS developed by CF Industries to all of its sites.
- The purchasing organization and site provided copies of the CF Industries FGAN SDS to all employees.
- The site complies with OSHA requirements for FGAN storage.
- The site filed EPCRA and SARA Tier II Chemical Inventory Reports with appropriate emergency response organizations.
- The site maintains and follows an emergency response plan and written procedures for the safe handling of AN.

By signing the certification statement, officials at the purchasing organization certify that all relevant personnel at the site are aware of FGAN safety handling requirements and that adequate procedures are in place to comply with all 17 listed items. The certification packet also includes an up-to-date FGAN SDS developed by CF Industries and the TFI-ARA guidance for FGAN. CSB determined that this process could provide a reasonable degree of assurance that FGAN product hazards are being communicated as the product is delivered to new and existing customers and, most important, that those customers comply

with applicable regulations and practices in order to receive product. If CF Industries does not receive a completed and signed certification statement, it will not sell FGAN product.

Although not in the form of a certification statement program, EDC also took steps to enhance the safety of its FGAN product post-incident. EDC updated its SDS for FGAN to include more information regarding firefighter precautions and added a reference to NFPA 400.[720] Moreover, EDC developed a product information bulletin to accompany its SDS to emphasize FGAN hazards and safety measures.[721] To better communicate FGAN hazards in response to the WFC incident, EDC conducted mass mailings to all of its customers. The mailings included the following:

- EDC's revised SDS (September 2013 and November 2014 versions).
- TFI-ARA Safety and Security Guidelines for Ammonium Nitrate.
- OSHA Guidance on Ammonium Nitrate Storage Requirements in 29 CFR 1910.109(i).

In addition, EDC repaired and replaced wooden bins at its own owned-and-operated retail site locations to ensure compliance with OSHA requirements regarding the protection of bins against AN impregnation.

In gathering information regarding these post-incident safety initiatives, CSB found that CF Industries and EDC operate under different business models, despite their status as the only two manufacturers of FGAN in the United States. CF Industries does not directly sell to retailers, but may deliver directly to retailers at the instruction of a direct customer. It delivers FGAN only to independently owned and operated distributors or their retail customers. CF Industries does not own any of the distribution facilities to which it ships product, and it does not sell directly to retailers, although it might deliver directly to retailers at the instruction of a direct customer.

Unlike CF Industries, EDC delivers some FGAN product to its own owned-and-operated distribution sites. In this regard, the business models of CF Industries and EDC differ. EDC produces FGAN in El Dorado, Arkansas, which is shipped by rail or truck to either (1) its own distribution sites, which operate under the name EDC Ag Products Company, LLC (EDC Ag Products),[722] or (2) its larger customers. Approximately 40 percent of the FGAN produced at the EDC Arkansas manufacturing facility is shipped to its 11 EDC Ag Products distributor locations (most in Texas), and approximately 60 percent is sold directly to customers. From the EDC Ag Products distributor locations, FGAN may be sold to other distributors or to retailers or farmers. All of the FGAN sold directly from the EDC manufacturing facility in Arkansas is delivered mainly to dealers, with a small quantity to brokers.

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[720] *See*: http://eldoradochemical.com/MSDS_Sheets/EDC/EDC_Products/EDCC_AN_Prill_SDS_Information_Bulletin_Nov_2014.pdf (accessed December 29, 2015).

[721] *Ibid*.

[722] At the time of the incident, the distribution sites operated under the name El Dorado Chemical. El Dorado Chemical Company and EDC Ag Products Company, LLC are subsidiaries of LSB Industries, a manufacturing and marketing company.

At the time of the WFC incident and as long ago as 2004, EDC sold products to International Chemical Company (Inter-Chem), which acted as a trader or supplier of FGAN, among other fertilizer products. Through its Domestic Plant Foods Group, Inter-Chem is a distributor of phosphate, nitrogen, and potash products in the United States.[723] Essentially, Inter-Chem served as a broker and consignee of finished fertilizer products to the WFC. Although Inter-Chem did not produce or manufacture the fertilizer product that was sold to the WFC, its role as a broker was significant. Importantly, Inter-Chem functioned as another link in the chain of commerce as the FGAN traveled from manufacturer to retailer through the broker. To better understand the chain of hazard communication involved in this investigation, CSB started at the top with the manufacturers and analyzed the pre-incident SDSs and hazard communication practices of both EDC and CF Industries.

Before the WFC incident, EDC provided a copy of its SDS to its customers and to Inter-Chem. The EDC SDS in use at the time of the 2013 WFC incident was last revised in 2011. CSB reviewed the SDS and found that it lacked certain safety information, specifically related to firefighting measures. The 2011 EDC SDS included warnings about the hazards of AN, such as its capability to support combustion and become explosive in the presence of contaminants or when under confinement. Under the firefighting measures section, the SDS instructed firefighters to "flood with water" but did not address the proper way to handle massive and uncontrollable fires, the need to extinguish such fires from a distance, or the possible need for evacuation. In addition, the SDS lacked references to applicable AN safety standards, such as the OSHA Explosives and Blasting Agents standard and NFPA 400 (2010 Edition). On the other hand, the CF Industries pre-incident SDS included a comprehensive list of AN hazards and firefighting measures. Nonetheless, both CF Industries and EDC made changes to enhance the safe handling of their products after the WFC incident.

As previously discussed, both U.S. FGAN manufacturers have improved communications with their customers about FGAN hazards and safe storage practices since the WFC incident. CF Industries implemented a program to certify compliance with applicable standards and guidelines as a condition of sale. In contrast, EDC conducted hazard communication in the form of mass mailings, replaced and repaired its own wooden bins at EDC Ag Products facilities, and continues to audit and inspect its retail sites (which it can readily do because EDC owns and operates these retail divisions) to make sure that about 40 percent of its manufactured FGAN is stored in compliance with applicable standards. These efforts represent a step in the right direction. However, because both EDC and CF Industries sell significant quantities of FGAN through brokers or through independent warehouses or distributors, whose direct customers may be unknown to EDC and CF Industries, it might not be possible in certain situations for the manufacturers to always ensure that their product is handled and stored in accordance with safety guidelines as the product moves downstream. At the very least, however, the certification statement program implemented by CF Industries attempts to ensure compliance with applicable regulations by causing its customers to attest to having knowledge of them.

[723] *See*: http://www.ictulsa.com/domestic_fert.html (accessed on December 29, 2015).

As previously discussed, the CF Industries certification program strives to certify compliance by requiring purchasing organizations to affirm that their customers are in compliance with the CF Industries certification program elements. CSB found no evidence of such a program at EDC. Because EDC also sells product through wholesalers and distributors, a similar certification program, if implemented properly in conjunction with other components of product stewardship, will ensure that EDC product is handled safely throughout by its chain of customers. In concert with CF Industries' efforts, this can effectively promote the safety of all domestically manufactured FGAN.

9.0 Land Use

The West Fertilizer Company (WFC) incident led many observers to ask a seemingly simple question: Why would a community be located so close to a facility storing a potentially dangerous chemical? Although the question might be simple, the answer is not. In fact, the city of West, Texas, was so near the WFC facility primarily because of the following factors:

- The city "came to" the WFC facility over the years.
- There was a lack of zoning regulations.

These factors are interrelated. The growth of the community near the WFC facility made it difficult for the city to later enact zoning regulations to require risk mitigating actions such as a buffer zone between the facility and the community.

This is not to say that West is an anomaly. Many communities in Texas and nationwide are located too close to facilities resembling the WFC plant.[724] This reality highlights the need to explore why communities live with these hazards so that authorities can better mitigate the offsite consequences from incidents such as the fire and explosion at the WFC plant in West.

In this section, CSB seeks to explain the previously mentioned factors, providing insights into the proximity of the WFC facility to the West community. Following that discussion, other CSB investigations involving offsite consequences are highlighted to emphasize the scope of the problem. International land use perspectives also are provided to compare various approaches to the issue. In addition, efforts to address land use planning after the WFC incident are discussed.

9.1 Land Use Planning: An Introduction

Land use planning is a complex and controversial topic. It provides a framework for limiting private land use when necessary for the public benefit. However, economic, social, safety, and environmental interests must be effectively balanced to achieve this benefit. Such competing interests generate highly emotional and contentious debates. Ultimately, however, the decision is political in nature. The community must decide on the best use of land for its development and growth. Urban sprawl,

[724] As of December 6, 2013, Texas had 104 facilities storing 10,000 pounds or more of FGAN.

environmental concerns, and hazardous conditions are just some of the issues that land use planning addresses.

The United States takes a decentralized approach to land use planning; that is, states are largely vested with the authority to regulate and enforce the private use of land. In turn, the states delegate this authority to local governments. This approach generally results in municipalities establishing land use regulations for various areas within their respective jurisdictions. The federal or state government has asserted authority in some areas of land use planning, but the majority of land use planning authority in the United States lies with local governments. The benefits of such an approach stem from the regulatory flexibility to address issues of land use. The judiciary resolves any potential conflicts.

Land use planning cannot be said to solve all developmental issues that a community encounters. Land use regulation does give the community a control mechanism to reduce the consequences of an incident but does not eliminate the need for preventive controls. Rather, the mitigative control of land use planning must be combined with preventive controls employed by a variety of different stakeholders. Land use planning is a critical control to foster community development, but it must be integrated with other complementary approaches.

At its heart, land use planning offers the means for dealing with development and growth. However, many interests must be taken into account when attempting to effectively ensure a safe and satisfying community. Land use planning considerations can offer insights into the issues evident in the WFC incident. The location of the city of West near the WFC facility produced numerous benefits for the community; however, as the WFC fire and explosion revealed, such siting also had deadly consequences.

9.2 The City That "Came to" the WFC Over the Years

The WFC facilities were constructed and began operations in 1962.[725] At the time, the facilities were largely surrounded by open fields, raising little concern about any potential offsite consequences. Furthermore, no zoning regulations existed when the WFC began business.[726] Over the years, however, the city of West began to slowly develop around the WFC property. As the WFC was grandfathered into West ordinances and the city was subsequently zoned residential, little attention was paid to the city's slow but steady encroachment toward the WFC facility.

[725] Crain, Zac. "Love and Loss in a Small Texas Town." *D Magazine* (July 2013). *See*: http://www.dmagazine.com/Home/D_Magazine/2013/July/West_Texas_Love_and_Loss_in_a_Small_Town.aspx?page=1 (accessed on November 25, 2014).

[726] According to the West Code of Ordinances, the earliest zoning regulation was adopted on March 21, 1967. City of West. Chapter 14, Section 14.01.001. *Code of Ordinances*. *See*: http://z2codes.franklinlegal.net/franklin/Z2Browser2.html?showset=westset (accessed on November 25, 2014).

West was officially incorporated as a city in 1892, and with the help of a railroad track and fertile land for farming, it thrived.[727] Before construction of the WFC plant, the area north of the city was largely open fields used for agriculture and ranching. At the time that the WFC began operations, the area maintained the same character except for a residence located approximately 250 feet north of the WFC property line.[728] The location was ideal for such a business—just outside of the city, next to a railroad track, and within a convenient distance for local farmers. West lacked zoning regulations when the WFC completed its construction, and there appeared to be little need for such regulations as the WFC facilities were far removed from the city. Furthermore, the portion of the WFC property where fertilizers and pesticides were stored was outside of the West city limits and thus outside of its jurisdiction.[729]

Within this framework, the city of West began to expand and grow around the WFC facility. As shown in Figure 74, the city began developing further north over the years. This growth continued until the community was adjacent to the WFC property. Parks, subdivisions, nursing homes, schools, and an apartment complex sat within a 600-foot radius of the facilities. Furthermore, as the city continued to build its infrastructure near the WFC facility, the area became an even more attractive target for development. The community hardly noticed the WFC facility. It was only aware of the risk of accidental releases of anhydrous ammonia but viewed such events with little concern. Figure 75 shows the WFC facility before and after the incident.

[727] City of West. "City of West, Our History." *See*: http://www.cityofwest.com/our-history (accessed on November 25, 2014).
[728] Determined by using the December 14, 1964, aerial photograph of West, Texas, and employing Google Earth.
[729] McLennan CAD. "Property Search Results: Property ID 2013357, Adair Grain, Inc. for Year 2013." *See*: https://propaccess.trueautomation.com/Map/View/Map/20/201357/2013 (accessed on December 28, 2015).

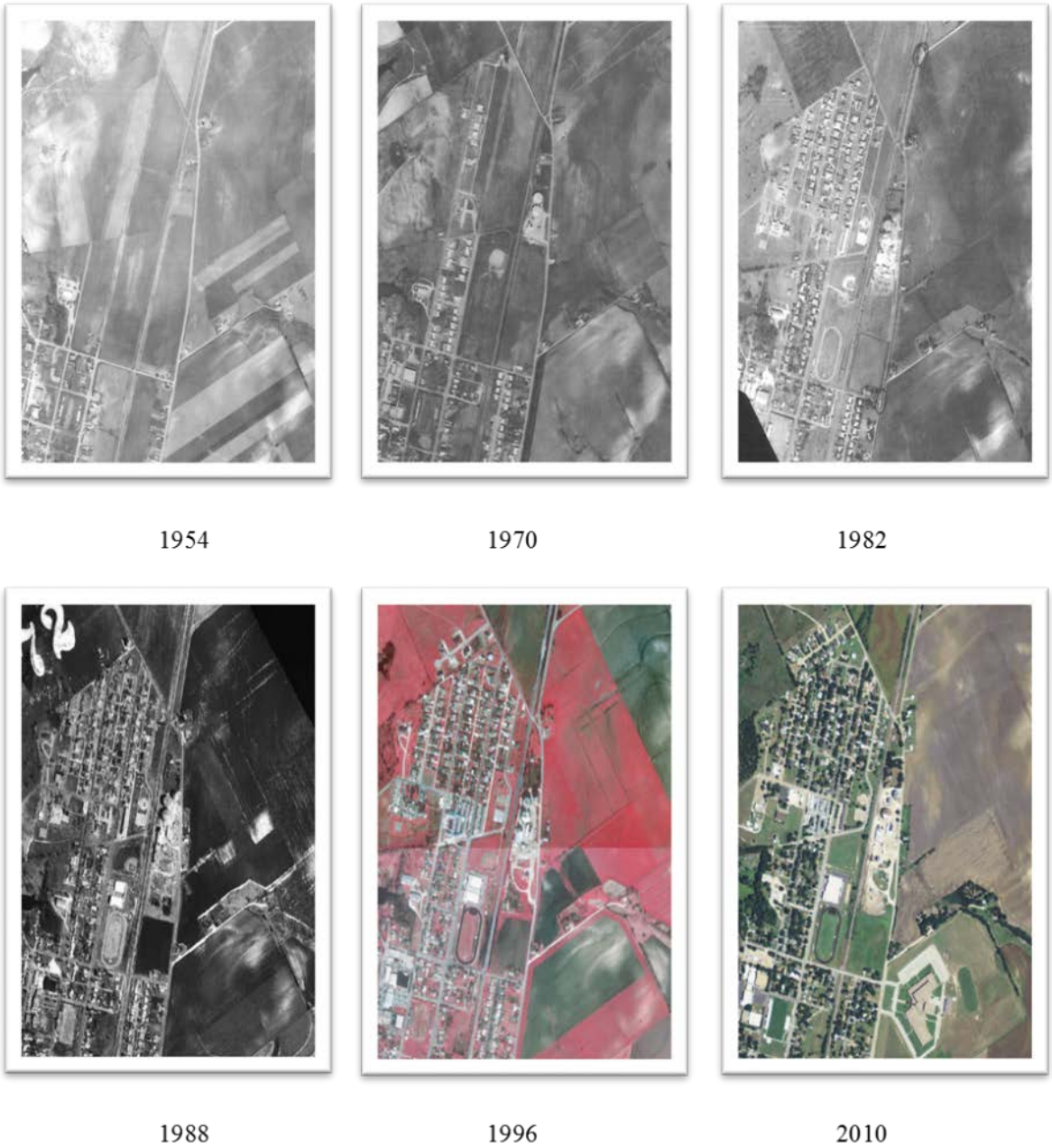

Figure 74. Progressive Development of West (Source: GeoSearch)

Figure 75. Aerial Photographs of the WFC Facility Before (left) and After (right) the Incident (Source: NBC News)

This lack of proper foresight played a significant role in explaining why West came to be located so close to the WFC plant. Unfortunately, as the WFC was grandfathered into the city's Code of Ordinances,[730] the city was not required to address the risks involved in this encroachment. Not that West is a peculiar case; in many instances across the country, similar problems exist.[731]

9.3 Lack of Zoning Regulations

Both the federal government and Texas have failed to issue regulations relating to siting facilities that store and distribute FGAN near communities such as West. If a regulation had addressed issues such as buffer zones, barricades, or other techniques to mitigate consequences, the severity of the casualties and damage experienced in West could have been significantly reduced. Moreover, although regulation cannot solve all problems, it serves as a mechanism to compel all industries to adopt and implement safer operations. Ultimately, the failure to mitigate the consequences of incidents such as the WFC fire and explosion in West exists at all levels of government.

U.S. law largely assigns the authority to regulate private land use to the individual states.[732] In turn, the states generally assign this authority to individual municipalities. It is important to note, however, that

[730] City of West. Chapter 14. *Code of Ordinances*. *See*: http://z2codes.franklinlegal.net/franklin/Z2Browser2.html?showset=westset (accessed on November 25, 2014).

[731] For example, CSB reports on NDK, DPC, Concept Sciences, and the Caribbean Petroleum Refining tank explosion and fire.

[732] Because the Federal government is only vested with the powers delegated to it through the Constitution—such as the power to regulate interstate commerce, coin money, and so forth—it is limited in its capability to regulate issues

the state's authority can be preempted by the federal government in certain instances, and two of the main instances are matters concerning interstate commerce[733] and international treaties.[734] This dual sovereignty can allow for greater flexibility in resolving land use issues that affect the public. Over time, the federal government has assumed an increasing role in the regulation of land use issues, including those relating to storing chemicals such as FGAN. ATF, the U.S. Department of Housing and Urban Development (HUD), the Pipeline and Hazardous Materials Safety Administration (PHMSA), OSHA, and EPA have all promulgated regulations or recommendations relating to the siting of explosives, reactives, oxidizers such as FGAN, and flammable cryogenics such as liquefied natural gas (LNG) near populated areas. Table 14 briefly lists the relevant regulations issued by these agencies.

Table 14. Relevant Siting Regulations

Agency	Regulation	CFR
ATF	Commerce in Explosives	27 CFR Part 555
DOT	Liquefied Natural Gas Facilities: Federal Safety Standards	49 CFR Part 193
HUD	Environmental Criteria and Standards	24 CFR Part 51
OSHA	Occupational Safety and Health Standards	29 CFR Part 1910
EPA	Chemical Accident Prevention Provisions	40 CFR Part 68
	Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities	40 CFR Part 264

ATF holds the authority to require setting off stored explosive materials and low-explosive materials from inhabited buildings, public highways, public railways, and magazines.[735] Although explosive grades of FGAN are currently listed as explosive materials, the FGAN stored at the WFC facility is not categorized as an explosive material or a low-explosive[736] material.[737] Therefore, WFC storage of FGAN was not

related to land use. *See*: 10th Amendment, U.S. Constitution. However, state zoning regulations are subject to Federal preemption in areas where the use of land affects interstate commerce, international treaties, and Federal government spending powers.

[733] U.S. Constitution, Article I, Section 8.

[734] U.S. Constitution, Article VI.

[735] 27 CFR 555.218–219: "Explosive materials" are defined as explosives, blasting agents, water gels, and detonators. 27 CFR 555.11: "Explosives" are defined as any chemical compound, mixture, or device, the primary or common purpose of which is to function by explosion.

[736] Low explosives are defined as "explosive materials which can be caused to deflagrate when confined. *See*: http://www.gpo.gov/fdsys/pkg/FR-2012-09-20/pdf/2012-23241.pdf (accessed on December 29, 2015).

[737] *See*: http://www.gpo.gov/fdsys/pkg/FR-2012-09-20/pdf/2012-23241.pdf (accessed on December 28, 2015). *See also*: 27 CFR 555.220 Note (1), which states: "FGAN, by itself, is not considered to be a [explosive or blasting

subject to ATF set-off distances.[738] However, ATF has the authority to require a minimum separation distance between the FGAN stored at the WFC facility and certain blasting agents.[739]

DOT received Congressional authorization to "prescribe minimum safety standards for deciding on the location of a new liquefied natural gas [LNG] pipeline facility," which it oversees through PHMSA.[740] In turn, PHMSA has promulgated a series of recommendations concerning siting requirements for LNG facilities.[741] The regulations are based on NFPA 59A concerning the production, storage, and handling of LNG.[742] The siting requirements address issues such as thermal radiation protection, flammable vapor-gas dispersion protection, and wind forces. PHMSA applies the regulations to LNG facilities "designed, constructed, replaced, relocated or significantly altered after March 31, 2000," thereby grandfathering LNG facilities that existed before the March 31 date.[743] However, PHMSA has no regulations concerning the siting of AN facilities.

HUD requires projects receiving its assistance to be separated by an acceptable distance from specific stationary hazardous operations that store, handle, or process hazardous substances.[744] Hazardous substances are defined as "petroleum products (petrochemicals)" and other hazardous chemicals identified by HUD that can produce blast overpressure or thermal radiation levels in excess of HUD standards.[745] FGAN is not identified as a hazardous substance for the purposes of this standard.[746] In addition, the city of West would not qualify for HUD assistance as it does not meet HUD eligibility requirements.[747]

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agent]." *See also*: 72 *Federal Register* 18792, 18796, which states: "[A]lthough FGAN is a component of certain explosives such as ANFO, by itself, it is not an explosive. Therefore, it is not regulated by these ATF regulations."

[738] The purpose behind regulating the siting of ANFO was "to protect interstate and foreign commerce against interference and interruption by reducing the hazard to persons and property arising from misuse and unsafe or insecure storage of explosive materials." Section 1101, Public Law 91-452, reprinted in: *U.S. Code Congressional and Administrative News* 1109 (1970).

[739] 27 CFR 555.220.

[740] 49 U.S.C. § 60103 (2014).

[741] 49 CFR 193 Subpart B (2014).

[742] 65 CFR 10950 (2000) and 69 *Federal Register* 11330 (2004).

[743] 49 CFR § 193.2051(2014).

[744] 24 CFR Subpart C; specifically 24 CFR 51.204 and 24 CFR 51.205. *See*: http://portal.hud.gov/hudportal/HUD?src=/program_offices/comm_planning/environment/training/guidebooks/hazfacilities (accessed on December 28, 2015). The intent in creating these regulations was "to encourage improvements in housing standards and conditions." "The National Housing Act." *See*: http://portal.hud.gov/hudportal/documents/huddoc?id=HUD-Guidebook.pdf (accessed on December 28, 2015): 3–4.

[745] 24 CFR 51.201, 203.

[746] 24 CFR Part 51, Appendix I to Subpart C. Anhydrous ammonia is also not listed as a hazardous substance; however, under special circumstances, the Secretary may require the application of a substance not listed in Appendix I to Subpart C. *See*: 24 CFR 51.207 (2014).

[747] *See*: http://portal.hud.gov/hudportal/HUD?src=/program_offices/comm_planning/communitydevelopment/programs/entitlement (accessed on December 28, 2015). Eligible HUD grantees include (1) principal cities of metropolitan statistical areas, (2) other metropolitan cities with populations of at least 50,000, and (3) qualified urban counties with populations of at least 200,000 (excluding the population of entitled cities).

OSHA requires facilities handling highly hazardous chemicals to address facility siting issues; however, the requirement only deals with onsite consequences, not the issue of siting communities near highly hazardous chemical facilities.[748] This requirement is part of the Process Safety Management (PSM) regulation, which seeks to prevent or minimize the consequences of catastrophic releases of "highly hazardous chemicals."[749] However, the PSM regulation does not include FGAN as a highly hazardous chemical.[750] In addition, OSHA has the authority to require separation distances between FGAN and blasting agents,[751] in the same manner as ATF.[752]

The federal agency concerned with offsite consequences, EPA, addresses the siting of hazardous facilities near population centers by issuing various regulations and guidance.[753] For example, EPA regulates facility siting through its Risk Management Program rule, which calls on operators to address "stationary source siting" in its Program Level 3 process hazard analysis.[754] However, EPA offers little to no guidance to operators on how to satisfy the "stationary source siting" requirement.[755] The Risk Management Program rule also requires operators to conduct an offsite consequence analysis to provide government officials and the public with information about the potential consequences of an accidental release.[756] However, as FGAN is not classified as a hazardous regulated substance under the Risk Management Program rule, the WFC was not required to conduct such an analysis for its stored FGAN. In addition, EPA is currently considering the inclusion of "facility and equipment siting factors" in the Risk Management Program rule.[757]

Furthermore, EPA addresses facility siting through regulation and guidance concerning the siting of hazardous waste management facilities near communities and sensitive environments.[758] EPA also has issued guidelines relating to siting schools near potential environmental hazards, which could have proven

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[748] 29 CFR 1910.119(e)(3)(vii).
[749] 29 CFR 1910.119.
[750] 29 CFR 1910.119, Appendix A.
[751] 29 CFR 1910.109, Table H-22.
[752] 27 CFR 555.220.
[753] *See*: http://www.epa.gov/statelocalclimate/local/topics/land.html (accessed on December 28, 2015).
[754] 40 CFR 68.67(c)(5) (2014).
[755] The only real guidance on these terms is found in API RP 752, "Permanent Building Siting"; API RP 753, "Portable Building Siting"; and API RP 756, Tent Siting (to be issued in 2014). However, these guidance documents have been developed without any regulatory guidance. Furthermore, the identified standards have nothing to do with the relationship of the facility to its surrounding community. *See*: http://www.absconsulting.com/webinars/facility-siting.cfm (accessed on December 28, 2015).
[756] 40 CFR 68.150–68.195 (2014). The analysis consists of two elements, a worst case release scenario and alternative release scenarios.
[757] *See*: https://www.osha.gov/chemicalexecutiveorder/final_chemical_eo_status_report.pdf (accessed on December 28, 2015): 36.
[758] *See*: http://www.epa.gov/osw/hazard/tsd/permit/site/sites.htm (accessed on December 28, 2015); 42 U.S.C. § 6924 (2014); 40 CFR 264.18 (2014); 40 CFR 265.18 (2014); 40 CFR 270.14(b)(11) (2014); and 40 CFR 270.32(b)(2) (2014). *See also*: http://homer.ornl.gov/sesa/environment/guidance/rcra/locate.pdf (accessed on December 28, 2015).

helpful to West and similarly situated communities.[759] Moreover, EPA has recommended using information related to the Emergency Planning and Community Right-to-Know Act to inform a community's decisions concerning zoning and land use planning.[760]

Thus, federal regulations and guidance on land use do exist and do give communities valuable information regarding various chemical hazards. However, because FGAN is not defined as an explosive or hazardous material, it is excluded from federal zoning regulations. Unfortunately, this situation allows fertilizer facilities to store FGAN onsite without any federal oversight to confirm that the associated risks of locating communities nearby are mitigated to sufficient levels.

At the state level, Texas does little to oversee land use issues.[761] Instead, Texas grants the most land use oversight authority to its municipalities.[762] Texas has no regulation relating to siting hazardous facilities near communities.[763] Moreover, no state administrative agency oversees hazardous facility siting.[764] At the county level, regulatory authority is limited to zoning specific areas (such as Padre Island, Lake Tawakoni, and Falcon Lake), which results in a failure to approach county zoning from a general perspective.[765] This observation does not indicate that a one-size-fits-all approach to zoning is always desired.[766] In fact, in many instances, land use oversight needs to be tailored to specific political, social, economic, and environmental needs of the community.[767]

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[759] *See*: http://www.epa.gov/schools/siting/basic.html (accessed on December 28, 2015).

[760] *See*: http://www.epa.gov/osweroe1/docs/chem/notice.pdf (accessed on January 6, 2016): 7; *see also*: http://www.nicsinfo.org/docs/LEPCStudyFinalReport.pdf (accessed on December 28, 2015): 7.

[761] *See*: http://stateimpact.npr.org/texas/2013/04/22/after-west-fertilizer-explosion-concerns-over-safety-regulation-and-zoning/ (accessed on December 28, 2015).

[762] Texas Statute, Local Government Code, Title 7, "Regulation of Land Use, Structures, Businesses, and Related Activities." *See*: http://www.statutes.legis.state.tx.us/ (accessed on January 6, 2016). For instance, municipalities must adopt a zoning ordinance in accordance with a comprehensive plan; county zoning ordinances deal with specific areas such as military zones, Padre Island, and Amistad Recreation Area. *See*: http://www.statutes.legis.state.tx.us/Docs/LG/htm/LG.231.htm (accessed on December 28, 2015).

[763] The Texas Administrative Code fails to address such siting issues. The Texas Department of Public Safety, Division of Emergency Management, holds responsibility for preparing the state emergency management plan, which may include "recommendations for zoning, building restrictions, and other land-use controls . . . to eliminate or reduce disasters or their impact . . . ." Texas Government Code, Title 4, Subtitle B, Chapter 418, Section 418.042. However, the state has not issued any such recommendations. *See*: https://www.txdps.state.tx.us/dem/downloadableforms.htm#stateplan (accessed on December 28, 2015).

[764] *See*: http://texreg.sos.state.tx.us/public/readtac$ext.ViewTAC (accessed on December 29, 2015).

[765] *See*: http://www.statutes.legis.state.tx.us/Docs/LG/htm/LG.231.htm (accessed on December 28, 2015). Texas House of Representatives, Committee on County Affairs. "Interim Report to the 80th Texas Legislature," December 2006: 7. *See also*: http://www.lrl.state.tx.us/scanned/interim/79/C832.pdf (accessed on December 8, 2014).

[766] APA discussion on Growing Smart project with Stuart Meck. *See*: http://www.planning.org/growingsmart/background.htm (accessed on January 6, 2016).

[767] *See*: http://www.planning.org/growingsmart/background.htm (accessed on December 28, 2015).

At the local level, Texas municipalities are granted the authority to regulate private land, including the location of hazardous facilities.[768] Among other requirements, the zoning regulations must be designed to ensure public safety from fires and other dangers.[769] However, the municipality is not given the authority to remove the hazardous condition on the property that exists at the time the governing body implements zoning authority and that is used in a public service business.[770] The municipality is allowed to impose zoning regulations relevant to the storage and use of hazardous substances.[771]

In the case of West, Texas, this arrangement led to the city being vested with the most authority in regulating public use. West exercised this authority through its Code of Ordinances.[772] West had zoned all property within the city limits for residential purposes only. However, all real property that had been used for commercial purposes before 1987 could remain commercial in nature. Any future development with commercial intent required a rezoning procedure.[773] This provision is consistent with West's comprehensive plan to zone all property within the city limits as residential property.

In essence, regulatory authority has been delegated to municipalities to oversee the siting of facilities storing and distributing FGAN near cities such as West. Neither the federal government nor the state of Texas takes any part in oversight. In many instances, however, municipalities are unable to adequately address this complex issue through regulatory mechanisms. For instance, facilities such as the WFC plant existed before promulgation of the city's Code of Ordinances, posing an issue of grandfathered facilities. Many different economic, safety, environmental, and agricultural interests must also be balanced. Furthermore, municipalities already face a shortage of resources for other essential governmental functions. However, safety issues can be addressed through reasoned regulation, using a number of methods. For example, a regulation requiring separation distances between public receptors and facilities handling FGAN could help mitigate offsite consequences in cities such as West. At root, however, locating these facilities near communities represents a national concern; therefore, all levels of government should give consideration to developing land use regulations to counter this problem.

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[768] Texas Statute, Local Government Code, Title 7, Subtitle A, Chapter 211, Section 211.003. *See*: http://www.statutes.legis.state.tx.us/Docs/LG/pdf/LG.211.pdf (accessed on December 28, 2015).

[769] Texas Statute, Local Government Code, Title 7, Subtitle A, Chapter 211, Section 211.004. *See*: http://www.statutes.legis.state.tx.us/Docs/LG/pdf/LG.211.pdf (accessed on December 28, 2015).

[770] Texas Statute, Local Government Code, Title 7, Subtitle A, Chapter 211, Section 211.013. *See*: http://www.statutes.legis.state.tx.us/Docs/LG/pdf/LG.211.pdf (accessed on December 28, 2015).

[771] Texas Statute, Local Government Code, Title 7, Subtitle A, Chapter 211, Section 211.017. *See*: http://www.statutes.legis.state.tx.us/Docs/LG/pdf/LG.211.pdf (accessed on December 28, 2015). The term "hazardous substances" is not defined in the chapter.

[772] *See*: http://z2codes.franklinlegal.net/franklin/Z2Browser2.html?showset=westset (accessed on December 28, 2015).

[773] Section 14.01.002. *See*: http://z2codes.franklinlegal.net/franklin/Z2Browser2.html?showset=westset (accessed on December 28, 2015).

9.3.1 Importance of Land Use Planning in Siting Communities Near Facilities Storing FGAN and Other Hazardous Chemicals

The issue of siting hazardous facilities storing FGAN near cities such as West is not an anomaly; it is a nationwide problem. In addition, although not directly associated with FGAN storage facilities, land use issues have been at the forefront of multiple CSB investigations. Furthermore, CSB has identified—multiple times—the risks of locating a hazardous chemical facility near public receptors. Table 15 lists CSB investigations that involved land use issues.

Table 15. Investigations Involving Land Use Issues

Investigation	Public Receptors	Chemical Involved	Offsite Consequences
NDK Crystal, Inc.	Interstate commerce, businesses	Synthetic quartz crystal (silica and NaOH)	1 fatality
DPC (Festus, MO)	Highways, railroads, residences, businesses, farms	Chlorine	63 residents who sought medical treatment
Concept Sciences	Businesses, residences	Hydroxylamine	5 fatalities, 14 injuries, significant damage to buildings and shattered windows at residences
CAI/Arnel	Businesses, residences	Heptane, isopropyl alcohol, n-propyl alcohol	10 injuries, 24 houses and 6 businesses significantly destroyed
DPC (Glendale, AZ)	Residences	Chlorine	14 injuries
Freedom Industries	Residences, businesses, drinking water supply	MCHM, PPH	369 residents who sought medical treatment for exposure
Millard Refrigerated Services	Businesses, environment	Anhydrous ammonia	150 people who sought medical treatment for ammonia exposure
T-2 Laboratories Inc.	Businesses, residences, railroads	Methylcyclopentadienyl manganese tri-carbonyl	28 injuries, significant property damage to nearby businesses
Silver Eagle Refinery	Residences	Hydrocarbons	Damage to residences
Kaltech	Residences, businesses, public streets	Chemical waste	At least 36 injured people, damage to residences and businesses
Chevron Refinery	Residences, businesses, public streets	Hydrocarbons	Approximately 15,000 people who sought medical treatment

Investigation	Public Receptors	Chemical Involved	Offsite Consequences
Caribbean Petroleum	Residences, businesses, public streets	Hydrocarbons	Shutdown of major highways, evacuation of local residents
Bayer CropScience	Residences, college, businesses, interstate commerce, waterways	Methomyl, methyl isobutyl ketone	Property damage, community shelter-in-place activated

In light of this information, the WFC incident in West serves as yet another unnecessary and deadly reminder that little has been done to address the risks of locating communities near facilities handling hazardous chemicals such as FGAN. Furthermore, if the incident had occurred during school hours, many more adults and children could have been injured. This incident represents a microcosm of the potential harms that many communities across the nations could endure.[774]

9.3.2 International Perspectives

Other countries have confronted problems similar to those in West, Texas, and have taken a variety of approaches to address them. The European and Australian strategies merit consideration given their sophistication relative to the current U.S. approach. The discussion in this section explores the approaches taken by the European Union (EU), the United Kingdom (U.K.), and Australia.

9.3.2.1 European Union

Through its Seveso III Directive, the EU requires member countries to take land use planning policies "into account" as part of major accident prevention.[775] The policy behind the requirement is designed to mitigate the consequences of major chemical accidents experienced by public receptors. The EU developed this requirement in the aftermath of major industrial incidents, including the FGAN explosion in Toulouse.[776] In fact, the Seveso III Directive lists AN as a "dangerous substance," classifying the chemical into four different categories, depending on whether it is FGAN, technical grade ammonium

[774] *See*: http://news.yahoo.com/devastated-texas-town-ponders-schools-140711695.html (accessed on December 29, 2015).
Jaeah Lee. "Map: Is There a Risky Chemical Plant Near You?" *Mother Jones* (April 17, 2014). *See*: http://www.motherjones.com/environment/2014/04/west-texas-hazardous-chemical-map (accessed on July 8, 2014).
[775] Seveso III Directive, Article 13, "Land-use planning." *See*: http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32012L0018 (accessed on November, 2, 2015).
[776] G. Vierendeels, et al. "Modeling the major accident prevention legislation change process within Europe." *Safety Science.* 516 (2010).

nitrate (TGAN), off-specification ammonium nitrate (AN), or AN capable of self-sustaining decomposition.[777]

Under the Seveso III requirements, member countries are to ensure that their policies address "appropriate distances" between covered facilities and residential areas. Furthermore, the countries must "set up appropriate consultation procedures" with competent authorities to "facilitate the implementation" of the land use planning policies. The Seveso III Directive applies to new facilities, facilities undergoing modifications, and new developments. Existing facilities must determine whether additional technical measures are required to avoid an increase in risk to the nearby community.[778]

The Seveso III Directive does not prescribe best practice guidance for its technical requirements (such as separation distances), consistent with its respect for each country's political, cultural, technical, and economic differences. However, various entities such as the Institute for Systems and Informatics and Safety provide best practice guidance, which refers to the use of technical approaches and procedural issues.[779] Although such guidance offers helpful insights to member countries, the appropriate response for a specific site is still recognized as a matter of interpretation for each country.

Given the immense differences among the approaches to land use planning of the member countries, it is difficult to compare EU country land use policies. However, the establishment of groups such as the European Commission and the Committee of the Competent Authorities under the Seveso III Directive emphasizes the important role that land use planning issues play in the European community.[780] Although issues still remain relating to each country's practices and methodologies, the emphasis on siting of facilities storing hazardous materials near public receptors highlights the importance that the European community places on land use planning in major accident prevention.

9.3.2.2 United Kingdom

The U.K. vests a hazardous substances authority with the power to administer and enforce land use planning as it relates to storing or using hazardous substances. The hazardous substances authority is generally an entity charged with dealing with land use planning and zoning issues, known as the local

[777] Seveso III Directive, Notes Section, "AN compounds with more that 28% by weight and AN based fertilizers." 2012/18/EU. *See*: http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32012L0018 (accessed on November 2, 2015).

[778] Seveso III Directive, Article 13, "Land-use planning." 2012/18/EU. *See*: http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32012L0018 (accessed on November 2, 2015).

[779] Christou, M.D., and S. Porter. "Guidance on Land Use Planning as Required by Council Directive 96/82/EC (Seveso II)." Institute for Systems Informatics and Safety, 1999. *See*: http://ipsc.jrc.ec.europa.eu/fileadmin/repository/sta/mahb/docs/LandUsePlanning/EUR18695EN_LandUsePlanningGuidance.pdf (accessed on December 28, 2015).

[780] Major Accident Hazards Bureau. "Land Use Planning." *See*: http://ipsc.jrc.ec.europa.eu/index.php/Land-use-planning/694/0/ (accessed on December 28, 2015).

planning authority.[781] Consequently, the U.K. takes an approach similar to that of the United States in decentralizing land use planning to allow a local authority to promulgate and enforce land use requirements.[782] For the WFC incident in West, Texas, the West City Council would be the analogue to the U.K. hazardous substances authority.

The U.K., however, requires land use policies to account for major accidents caused by hazardous substances.[783] This responsibility is executed through a collaborative effort among the hazardous substances authority, U.K. Health and Safety Executive (HSE),[784] U.K. Environment Agency,[785] and other interested stakeholders. Essentially, organizers of a proposed development must seek a hazardous substances consent from the hazardous substances authority to establish a facility that will store or use hazardous substances[786] within its jurisdiction.[787]

When the hazardous substances authority receives an application for consent, it must consult with the HSE and the U.K. Environment Agency for advice on whether consent to the proposed development is warranted. Other interested stakeholders are also consulted or given the opportunity to publicly comment on the proposed development.[788] Using all of the relevant information provided, the hazardous substances authority weighs all competing interests and decides whether to grant a hazardous substances consent to the proposed development.[789]

The U.K. attempts to balance each local community's interest in deciding the risks that it will tolerate, drawing on the expertise and resources of national governmental bodies. Such an approach makes it more likely that all relevant issues and concerns about locating a development that stores or uses hazardous substances near the public will be presented to the hazardous substances authority before a

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[781] *See*: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/16628/hazardoussubstancesguide.pdf (accessed on December 28, 2015).

[782] The U.K. has experienced similar catastrophic incidents that had effects on the population, including the Flixborough (Nypro UK) Explosion in 1974 and the Buncefield incident in 2005. *See*: http://www.hse.gov.uk/comah/sragtech/caseflixboroug74.htm and http://www.buncefieldinvestigation.gov.uk/, respectively (accessed on December 28, 2015).

[783] Seveso Directive II, Article 12, "Land Use Planning." *See*: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CONSLEG:1996L0082:20031231:EN:PDF (accessed on December 28, 2015).

[784] The U.K. HSE is a governmental body responsible for enforcing health and safety at workplaces. *See*: http://www.hse.gov.uk/contact/authority.htm (accessed on December 28, 2015).

[785] The U.K. Environment Agency is a governmental body responsible for protecting and improving the environment and for promoting sustainable development. *See*: http://www.environment-agency.gov.uk/aboutus/default.aspx (accessed on December 28, 2015).

[786] FGAN is included within the definition of a "hazardous substance." *See*: http://www.legislation.gov.uk/uksi/1999/981/schedule/1/made (accessed on December 28, 2015).

[787] *See*: http://www.hse.gov.uk/landuseplanning/what.htm (accessed on December 28, 2015).

[788] Other stakeholders include the local parish council, fire and civil defense authorities, and the governmental agency English Nature.

[789] *See*: http://www.environment-agency.gov.uk/aboutus/default.aspx (accessed on December 28, 2015).

decision is rendered. The U.K. thus believes that major offsite risks can be effectively managed before permitting a hazardous substance to be stored near a population in its vicinity.[790]

9.3.2.3 Western Australia

Australia's land use planning methods regarding hazardous substances vary across jurisdictions.[791] Although each Australian state and territory applies varying regulations regarding land use planning of FGAN storage facilities, the Government of Western Australia employs an insightful and sophisticated approach to the issue. In essence, Western Australia uses a risk-based method that subjects FGAN storage facility siting to government approval.[792]

Western Australia legislatively addresses land use issues concerning FGAN through its Dangerous Goods Safety Act 2004 (the Dangerous Goods Act). This act places a duty on all people involved with dangerous goods to minimize risk associated with those goods.[793] To minimize risk, the Dangerous Goods Act requires that "all reasonably practicable measures" be used. In determining whether a measure is "reasonably practicable," consideration is given to issues such as the severity of the harm, severity of the risk to people, and suitability of the means in question.[794] FGAN is treated as a dangerous good under the Dangerous Goods Safety (Storage and Handling Non-Explosives) Regulations 2007 and the Dangerous Goods Safety (Major Hazard Facilities) Regulations 2007, which both support the Dangerous Goods Act.[795]

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[790] *See*: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/16628/hazardoussubstancesguide.pdf (accessed on December 28, 2015).

[791] See: http://www.chemicalspolicy.org/downloads/chemicals-plastics-regulation.pdf (accessed on December 29, 2015).

[792] Dangerous Goods Safety Act 2004. *See*: http://www.slp.wa.gov.au/legislation/statutes.nsf/main_mrtitle_242_homepage.html (accessed on December 28, 2015). Dangerous Goods Safety (Storage and Handling Non-Explosives) Regulations 2007. *See*: http://www.slp.wa.gov.au/legislation/statutes.nsf/main_mrtitle_12972_homepage.html (accessed on December 28, 2015). Dangerous Goods Safety (Major Hazard Facilities) Regulations 2007. *See*: http://www.slp.wa.gov.au/legislation/statutes.nsf/main_mrtitle_12983_homepage.html (accessed on December 28, 2015). Department of Consumer and Employment Protection Government of Western Australia. *Safe Storage of Solid FGAN: Code of Practice*: iii. *See*: https://miningandblasting.files.wordpress.com/2009/09/safe-storage-of-solid-ammonium-nitrate-code-of-practice.pdf (accessed on December 28, 2015).

[793] Dangerous Goods Safety Act 2004, Part 2. *See*: http://www.slp.wa.gov.au/legislation/statutes.nsf/main_mrtitle_242_homepage.html (accessed on December 28, 2015).

[794] *Ibid*.

[795] Dangerous Goods Safety (Storage and Handling Non-Explosives) Regulations 2007. *See*: http://www.slp.wa.gov.au/legislation/statutes.nsf/main_mrtitle_12972_homepage.html (accessed on December 28, 2015). Dangerous Goods Safety (Major Hazard Facilities) Regulations 2007. *See*: http://www.slp.wa.gov.au/legislation/statutes.nsf/main_mrtitle_12983_homepage.html (accessed on December 28, 2015). Department of Consumer and Employment Protection Government of Western Australia. *Safe Storage of Solid FGAN: Code of Practice*: iii. *See*: https://miningandblasting.files.wordpress.com/2009/09/safe-storage-of-solid-ammonium-nitrate-code-of-practice.pdf (accessed on December 28, 2015).

Land use planning as related to siting facilities storing FGAN near public receptors is implemented by applying separation distances. These distances are subject to acceptance by Resource Safety, a department of the Government of Western Australia.[796] If it is determined that an FGAN facility is not satisfying the separation distance requirement, Resource Safety may limit the quantity of FGAN within the facility or require that other safety conditions be met.[797]

The New South Wales Department developed the required separation distances with the intent of reducing the risk of offsite consequences insofar as reasonably practicable.[798] The distances were not designed to completely eliminate the risks associated with offsite consequences, nor were they intended to replace preventive controls.[799] The separation distances are categorized by a threshold quantity (i.e., whether FGAN is stored in quantities greater than or less than 10 metric tons). For instance, if FGAN exceeding 10 tons is stored at a facility, it must be separated by at least 300 meters (985 feet) from critical infrastructure, 240 meters (790 feet) from residential buildings, and 140 meters (460 feet) from commercial buildings.[800]

Western Australia seeks to address land use planning through a risk-based scheme that requires government permission to site FGAN facilities near public receptors. Depending on the quantity of FGAN stored, each facility must be sited at a minimum distance from such public receptors. Furthermore, if the facility is not sited at the required minimum distance, it might have to limit the maximum quantity of FGAN that it can store. A study of the risk associated with a particular facility might be required to reach agreement between the government and the facility on appropriate separation

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[796] Department of Consumer and Employment Protection Government of Western Australia. *Safe Storage of Solid FGAN: Code of Practice*: 8–10. *See*: https://miningandblasting.files.wordpress.com/2009/09/safe-storage-of-solid-ammonium-nitrate-code-of-practice.pdf (accessed on December 28, 2015).
See also: http://www.dmp.wa.gov.au/6611.aspx (accessed on December 28, 2015).

[797] Department of Consumer and Employment Protection Government of Western Australia. *Safe Storage of Solid FGAN: Code of Practice*: 8–10. *See*: https://miningandblasting.files.wordpress.com/2009/09/safe-storage-of-solid-ammonium-nitrate-code-of-practice.pdf (accessed on December 28, 2015).

[798] Department of Consumer and Employment Protection Government of Western Australia. *Safe Storage of Solid FGAN: Code of Practice*: 8–10. *See*: https://miningandblasting.files.wordpress.com/2009/09/safe-storage-of-solid-ammonium-nitrate-code-of-practice.pdf.
Government of Western Australia. *Code of Practice: Safe Storage of solid FGAN*, 3rd Edition: 6-7. *See*: http://www.dmp.wa.gov.au/Documents/Dangerous-Goods/DGS_COP_StorageSolidAmmoniumNitrate.pdf (accessed on December 29, 2015). *Hazardous Industry Planning Advisory Paper No. 4—Risk criteria for land use safety planning*. HIPAP4. *See*: http://www.planning.nsw.gov.au/Policy-and-Legislation/~/media/0D39F08E7889409BBA1FA88D5FB859FD.ashx (accessed on January 7, 2014).

[799] Department of Consumer and Employment Protection Government of Western Australia. *Safe Storage of Solid Ammonium Nitrate: Code of Practice*: 8–10. *See*: https://miningandblasting.files.wordpress.com/2009/09/safe-storage-of-solid-ammonium-nitrate-code-of-practice.pdf (accessed on January 6, 2016). Government of Western Australia. *Code of Practice: Safe Storage of solid ammonium nitrate*, 3rd Edition: 6–7. *See*: http://www.dmp.wa.gov.au/Documents/Dangerous-Goods/DGS_COP_StorageSolidAmmoniumNitrate.pdf (accessed on December 29, 2015).

[800] Government of Western Australia. *Code of Practice: Safe Storage of solid ammonium nitrate*, 3rd Edition: 6–7. *See*: http://www.dmp.wa.gov.au/Documents/Dangerous-Goods/DGS_COP_StorageSolidAmmoniumNitrate.pdf (accessed on December 29, 2015).

distances. This approach gives Western Australia the capability to balance the risk associated with storing FGAN against the need for land development.

9.4 Efforts to Address Land Use Planning After the West Incident

In the weeks, months, and years following the West incident, few inroads have been made to resolve land use issues. The federal government has developed a working group that is tasked with developing recommendations related to chemical facility safety and security; however, the timeline for delivery has been extended.[801] At the state level, general opposition remains to any type of change in the Texas approach to land use planning.[802] In fact, strong opposition has contested any regulation of FGAN facilities in Texas.[803] The city of West is currently awaiting recommendations from state and federal officials; however, it does plan on siting any new fertilizer facilities away from the community.[804]

The Texas State Fire Marshal's Office (SFMO) has taken a proactive approach by providing all counties with software demonstrations that estimate blast zones from facilities storing FGAN.[805] In addition to assisting first responders, the software gives community leaders the opportunity to assess community impacts relating to the siting of a new FGAN facility. In addition, the SFMO will assist each county in reviewing best practices for dealing with the storage and handling of FGAN.

At the county level, the McLennan County Local Emergency Planning Committee (LEPC) has emphasized the importance of land use issues in agreeing to focus on "upfront planning" when siting community buildings such as schools or hospitals near chemical facilities.[806] The LEPC has agreed to continue to meet quarterly. The city of West has also committed to advising other communities about identifying the potential hazards that they might face in locating chemical facilities near their towns and citizens.[807]

Applied Research Associates, Inc. (Applied Research) has engaged in an effort to understand and validate the separation distances prescribed in NFPA 400. After completing a literature review, Applied Research selected a consequence-based case study and developed a test plan. The firm then carried out the case

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[801] *See*: https://www.osha.gov/chemicalexecutiveorder/index.html (accessed on December 28, 2015).
[802] *See*: http://www.nytimes.com/2013/05/10/us/after-plant-explosion-texas-remains-wary-of-regulation.html?_r=0 (accessed on December 28, 2015).
[803] Henry, Terrence, NPR. "Proposals to Prevent Another Fertilizer Explosion Immediately Meet Resistance," July 2, 2014. *See*: http://stateimpact.npr.org/texas/2014/07/02/proposals-to-prevent-another-fertilizer-explosion-immediately-meet-resistance/ (accessed on December 8, 2014). The Associated Press. "New bill on West blast would delay new rules." *CBS DFW* (August 5, 2014). *See*: http://dfw.cbslocal.com/2014/08/05/new-bill-on-west-blast-would-delay-new-rules/ (accessed on December 29, 2015).
[804] *See*: http://res.dallasnews.com/interactives/2013_December/westretrospective/1215_westretrospective.html (accessed on December 28, 2015).
[805] *See*: http://res.dallasnews.com/interactives/2013_December/westretrospective/1215_assessment.html (accessed on December 28, 2015).
[806] *Ibid.*
[807] *Ibid.*

study test plan to assess the adequacy of the separation distance for safe storage of AN and the safe separation distance for personnel in a process building in the event of an explosion. Applied Research then developed a series of recommendations regarding separation distances in NFPA 400, including possible approaches for improving those distances, to guide NFPA and its affiliated Fire Protection Research Foundation project panel in future research efforts.[808]

The city of West is currently rebuilding. The blast substantially damaged more than 350 homes, completely destroying 150 of them, and caused approximately $100 million in damages.[809] The West High School has been razed, and a new school will be constructed on the same site.[810] The site of the accident will likely become an industrial park.[811]

10.0 Key Findings

Technical Findings

1. The presence of combustible materials used for construction of the facility and the fertilizer grade ammonium nitrate (FGAN) storage bins, in addition to the West Fertilizer Company (WFC) practice of storing combustibles near the FGAN pile, contributed to the progression and intensity of the fire and likely resulted in the detonation.

2. The WFC facility did not have a fire detection system to alert emergency responders or an automatic sprinkler system to extinguish the fire at an earlier stage of the incident.

3. On the basis of interviews with eyewitnesses and supporting photographic evidence, the first observed fire and smoke originated in and above the seed room and progressed throughout the northern half of the WFC facility. The radiant heat from the fire, fueled by the structure, flammable building contents, and the asphalt roof shingles, likely heated the surface of the FGAN pile. Contamination from soot, molten asphalt, and molten polyvinyl chloride (PVC) from an overhead conveyer produced a detonable mixture of combustibles and FGAN oxidizers. Increased ventilation generated a brighter and hotter flame, heating the FGAN-fuel mixture on the surface of the pile.

Regulatory Findings

4. Occupational Safety and Health Administration (OSHA) efforts to oversee facilities that store and handle FGAN fell short at the time of the incident.

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[808] Fire Protection Research Foundation. "Separation Distances in NFPA Codes and Standards, 2014." *See*: http://www.nfpa.org/Assets/files/AboutTheCodes/59A/RFSeparationDistancesNFPACodesAndStandards.pdf (accessed on September 25, 2015).

[809] *See*: http://www.hazmatmag.com/news/in-harms-way/1002482923/ (accessed on January 6, 2016) and http://res.dallasnews.com/interactives/2013_December/westretrospective/1215_whatwelearned.html (accessed on December 28, 2015).

[810] CBS. "DFW, West Getting New Schools After Explosion," October 30, 2014. *See*: http://dfw.cbslocal.com/2014/10/30/west-getting-new-schools-after-explosion/ (accessed on December 6, 2014).

[811] *See*: http://res.dallasnews.com/interactives/2013_December/westretrospective/1215_westretrospective.html (accessed on December 28, 2015).

a. Section (i) of the OSHA Explosives and Blasting Agents standard, 29 CFR 1910.109(i), was not very well known among those in the fertilizer industry, likely due in part to the fact that (1) application of the section was unclear; and (2) the section had rarely been used previously to cite fertilizer facilities.

b. OSHA inadvertently omitted ammonium nitrate (AN) from the List of Highly Hazardous Chemicals, Toxics and Reactives in its Process Safety Management (PSM) standard, 29 CFR 1910.119, even though AN possesses reactive characteristics that would have triggered its inclusion.

5. Because the WFC facility was covered under the U.S. Environmental Protection Agency (EPA) Risk Management Program rule for its anhydrous ammonia tanks (but not for its FGAN), WFC employees and emergency responders demonstrated a greater awareness of the hazards associated with onsite storage of anhydrous ammonia than those associated with FGAN. AN is not on the EPA Risk Management Program list of chemicals, so the WFC was not required to take safety measures for FGAN similar to those for ammonia.

Insurance Findings

6. WFC's previous property and liability insurer, which provided insurance to WFC from 2006 through 2009, did not focus on FGAN hazards in its annual insurance inspections because it was not required to do so. However, the insurer did not renew WFC's commercial property policy in 2010 because WFC-repeatedly failed to comply with the insurer's safety-related recommendations (e.g., to replace corroded electrical wiring), which were identified in loss control surveys. The CSB found little evidence of onsite activity or inspections by WFC's subsequent insurer, U.S. Fire, which insured the facility at the time of the incident.

Emergency Response Findings

7. The West Volunteer Fire Department (WVFD) did not conduct pre-incident planning or response training at the WFC facility to address FGAN-related incidents because was no such regulatory requirement. Thus, the firefighters who responded to the WFC fire did not have sufficient information to make an informed decision on how best to respond to the fire at the fertilizer facility.

8. Federal and state of Texas curriculum manuals used for hazardous materials (HAZMAT) training and certification of firefighters placed little emphasis on emergency response to storage sites containing FGAN. On the other hand, HAZMAT shipping and transportation were covered frequently in the courses. Many federal and state grants support the resource needs of firefighters and fire departments; however, these grants are used more often for resources such as personal protection equipment or firefighting equipment rather than for training.

9. Lessons learned from previous FGAN-related fires and explosions were not shared with volunteer fire departments, including the WVFD. If previous lessons learned had been applied in West, the firefighters and emergency personnel who responded to the incident might have better understood the risks associated with FGAN-related fire.

Emergency Planning Findings

10. Despite WFC documentation of its FGAN in a 2012 Tier II report, the WVFD did not conduct drills and exercises at the WFC facility before the 2013 fire and explosion.

11. The agricultural use exemption under the Emergency Planning and Community Right-to-Know Act (EPCRA) is not clear about which facilities are covered under the exemption. Before the WFC fire and explosion, the state of Texas determined that the WFC was exempt under the EPCRA agricultural use exemption.

Land Use Planning Findings

12. At the time of its construction, the WFC facility was surrounded by open fields, and no zoning regulations existed when it began operations.

13. As the city of West developed over the years, it expanded toward the WFC facility.

14. The proximity of the city of West to the WFC facility magnified the offsite consequence impacts.

15. Other FGAN facilities throughout Texas are located in close proximity to schools, residences, and care facilities. Of the 40 FGAN facilities in Texas as of October 2015, 48 percent are within 0.5 miles of a school, nursing home, or hospital while 83 percent are within 0.25 miles of a residence.

11.0 Recommendations

U.S. Environmental Protection Agency (EPA)

2013-02-I-TX R1

Develop a guidance document on Emergency Planning and Community Right-to-Know Act (EPCRA) requirements that is issued annually to State Emergency Response Commissions (SERCs) and Local Emergency Planning Committees (LEPCs) and ensure that the guidance focuses on the following:

a. Explains which chemicals are exempt and which must be reported.
b. Describes how emergency responders should use Tier I and Tier II inventory reports and Safety Data Sheets, such as in safety training, practice drills, and for emergency planning.
c. Includes comprehensive LEPC planning requirements, with an emphasis on annual training exercises and drills for local emergency response agencies.

2013-02-I-TX R2

Develop a general guidance document on the agricultural exemption under EPCRA Section 311(e)(5) and its associated regulation, 40 CFR 370.13(c)(3), to clarify that fertilizer facilities that store or blend fertilizer are covered under EPCRA. Communicate to the fertilizer industry publication of this guidance document as well as the intention of Section 311(e)(5).

2013-02-I-TX R3

Revise the Risk Management Program rule to include fertilizer grade ammonium nitrate (FGAN) at an appropriate threshold quantity on the List of Regulated Substances.

a. Ensure that the calculation for the offsite consequence analysis considers the unique explosive characteristics of FGAN explosions to determine the endpoint for explosive effects and overpressure levels. Examples of such analyses include that adopted by the 2014 Fire Protection Research Foundation report, "Separation Distances in NFPA Codes and Standards," Great Britain's Health and Safety Executive, and other technical guidance.
b. Develop Risk Management Program rule guidance document(s) for regulated FGAN facilities.

U.S. Occupational Safety and Health Administration (OSHA)

2013-02-I-TX R4

Develop and issue a Regional Emphasis Program for Section (i) of the Explosives and Blasting Agent standard, 29 CFR 1910.109(i), in appropriate regions (such as Regions IV, VI, and VII) where fertilizer grade ammonium nitrate (FGAN) facilities similar to the West Fertilizer Company facility are prevalent. Establish a minimum number of emphasis program inspections per region for each fiscal year. Work with regional offices to communicate information about the emphasis program to potential inspection recipients.

2013-02-I-TX R5

Implement one of the following two regulatory changes, either option (a) or (b) below, to address FGAN hazards:

a. Add FGAN to the OSHA Process Safety Management (PSM) standard List of Highly Hazardous Chemicals, Toxics and Reactives in 29 CFR 1910.119**,** Appendix A, and establish an appropriate threshold quantity. Identify National Fire Protection Association (NFPA) 400 as a source of Recognized and Generally Accepted Good Engineering Practices (RAGAGEP) for PSM-covered FGAN equipment and processes.
b. Revise the OSHA Explosives and Blasting Agents standard, 29 CFR 1910.109, to ensure that the title, scope, or both make(s) clear that the standard applies to facilities that store bulk quantities of FGAN. Revise 1910.109(i), "Storage of Ammonium Nitrate," to include requirements similar to those in NFPA 400, *Hazardous Materials Code* (2016 Edition), Chapter 11. Ensure the following elements are considered:
    i. For new construction, prohibit combustible materials of construction for FGAN facilities and FGAN bins. For existing facilities, establish a phase-in requirement for the replacement of wooden bins with bins made of noncombustible materials of construction within a reasonable time period (e.g., 3 to 5 years from the date standard revisions are enacted), based on feedback from the fertilizer industry.
    ii. Require automatic fire sprinkler systems and fire detection systems for indoor FGAN storage areas.

iii. Define adequate ventilation for FGAN for indoor storage areas.
iv. Require all FGAN storage areas to be isolated from the storage of combustible, flammable, and other contaminating materials.
v. Establish separation distances between FGAN storage areas and other hazardous chemicals, processes, and facility boundaries.

International Code Council (ICC)

2013-02-I-TX R6

In a subsequent edition of the International Fire Code, develop a chapter or a separate section under Chapter 50 ("Hazardous Materials") or Chapter 63 ("Oxidizers, Oxidizing Gases and Oxidizing Cryogenic Fluids") that includes the following requirements for the storage and handling of ammonium nitrate (AN):

a. Require automatic fire detection and suppression systems in existing buildings constructed of combustible materials
b. Provide ventilation requirements in accordance with the International Mechanical Code to prevent the accumulation of off-gases produced during AN decomposition
c. Provide smoke and heat vents to remove heat from AN during fire situations
d. Establish minimum safe separation distances between AN and combustible materials to avoid contamination in the event of fire.
e. Prohibit the use of combustible materials of construction.

Department of Homeland Security, Federal Emergency Management Agency (FEMA)

2013-02-I-TX R7

Through a new or existing program and in conjunction with training partners, create and implement a competitive funding mechanism to provide training to regional, state, and local career and volunteer fire departments on how to respond to fire and explosion incidents at facilities that store fertilizer grade ammonium nitrate (FGAN). Continue to use available funding to ensure training effectiveness.

2013-02-I-TX R8

During the proposal review process for the program, ensure that the FGAN training includes multiple delivery methods to enable a broad reach. Training should allow for instructor-led, web-based, and train-the-trainer courses; initial orientation; and refresher training. Training also should accommodate both resident and mobile capabilities to facilitate flexible delivery.

Objectives of the selected training course should address the following:

a. Previous FGAN fire and explosion incidents, incorporating lessons learned
b. Hazards posed by other materials and chemicals stored near FGAN, including FGAN incompatibility with those materials and chemicals

c. Pre-incident planning for fires involving FGAN
d. On-scene emergency response and decision-making requirements for FGAN fires, including risk assessment, scene size-up, and situational awareness
e. National Incident Management System and Incident Command System.

2013-02-I-TX R9

Assist training partners to develop and provide continual oversight for an FGAN training program. In addition, evaluate the training curriculum to confirm that it adequately meets course objectives as well as the details of recommendation 2013-02-I-TX R8.

2013-02-I-TX R10

Develop an outreach program that notifies regional, state, and local fire departments about available FGAN training opportunities. The program should include the following:

a. Guidance for fire departments on how to identify FGAN hazards within their communities by engaging State Emergency Response Commissions and Local Emergency Planning Committees
b. Details on how to obtain FGAN training by submitting a proposal in response to the funding opportunity
c. Information on training partners and programs that provide FGAN training.

Texas Commission on Fire Protection (TCFP)

2013-02-I-TX R11

Develop minimum standards for course curricula to include hazard awareness of fertilizer grade ammonium nitrate (FGAN) for those fire departments that either have FGAN facilities in their jurisdictions or respond as mutual aid to other jurisdictions with FGAN facilities. In addition, develop a training program specific to FGAN.

Objectives of the program's training course should address the following:

a. Previous FGAN fire and explosion incidents, incorporating lessons learned
b. Hazards posed by other materials and chemicals stored near FGAN, including FGAN incompatibility with those materials and chemicals
c. Pre-incident planning for fires involving FGAN
d. On-scene emergency response and decision-making requirements for FGAN fires, including risk assessment, scene size-up, and situational awareness
e. National Incident Management System and Incident Command System.

2013-02-I-TX R12

Implement outreach to regional, state, and local fire departments that either have FGAN facilities in their jurisdictions or respond as mutual aid to jurisdictions with FGAN facilities, informing them about the new FGAN training certification requirements and opportunities to receive training. Include the following in the outreach:

a. Guidance for fire departments on how to identify FGAN hazards within their communities by engaging State Emergency Response Commissions and Local Emergency Planning Committees
b. Encouragement for fire departments in jurisdictions with FGAN facilities to become certified in FGAN training.

State Firefighters' and Fire Marshals' Association of Texas (SFFMA)

2013-02-I-TX R13

Develop a fertilizer grade ammonium nitrate (FGAN) training certification program for fire departments that either have FGAN facilities in their jurisdictions or respond as mutual aid to other jurisdictions with FGAN facilities. The certification program should include multiple delivery methods to enable a broad reach. The certification program should allow for instructor-led, web-based, and train-the-trainer courses; initial orientation; and refresher training. The training also should accommodate both resident and mobile capabilities to facilitate flexibility in delivery.

The criteria for the certification program should address the following:

a. Previous FGAN fire and explosion incidents, incorporating lessons learned
b. Hazards posed by other materials and chemicals stored near FGAN, including FGAN incompatibility with those materials and chemicals
c. Pre-incident planning for fires involving FGAN
d. On-scene emergency response and decision-making requirements for FGAN fires, including risk assessment, scene size-up, and situational awareness
e. National Incident Management System and Incident Command System.

2013-02-I-TX R14

Develop an outreach component for the training certification program that notifies regional, state, and local fire departments with FGAN facilities in their jurisdictions about the training certification opportunities available for FGAN. Ensure that the following items are included in the development of this program:

a. Guidance for fire departments on how to identify FGAN hazards within their communities by engaging State Emergency Response Commissions and Local Emergency Planning Committees
b. Encouragement for members in jurisdictions with FGAN facilities to become certified in FGAN training
c. Information on training partners and programs that provide FGAN training.

Texas A&M Engineering Extension Services (TEEX)

2013-02-I-TX R15

Develop and administer a hazardous materials training module for career and volunteer fire departments that addresses fertilizer grade ammonium nitrate (FGAN) and other hazardous materials or chemicals that could pose new specialized hazards. Ensure that the training includes multiple delivery methods to enable a broad reach. The training should allow for instructor-led, web-based, and train-the-trainer courses; initial orientation; and refresher training. The training also should accommodate both resident and mobile capabilities to facilitate flexibility in delivery.

Objectives of the training course should address the following:

a. How to respond to industrial fires involving FGAN and other hazardous materials or chemicals that could pose new specialized hazards to responding firefighters
b. Previous FGAN fire and explosion incidents, incorporating lessons learned
c. Hazards posed by other materials and chemicals stored near the FGAN, including FGAN incompatibility with those materials and chemicals
d. Pre-incident planning for fires involving FGAN and other hazardous materials or chemicals that could pose new specialized hazards to responding firefighters
e. On-scene emergency response and decision-making requirements for FGAN fires, including risk assessment, scene size-up, and situational awareness
f. National Incident Management System and Incident Command System.

2013-02-I-TX R16

Develop an outreach program that notifies state, regional, and local fire departments about available FGAN training opportunities. The program should include the following elements:

a. Guidance for fire departments on how to identify FGAN and other recognized hazards associated with other hazardous materials or chemicals within their communities by engaging with State Emergency Response Commissions and Local Emergency Planning Committees
b. Promotion of use of the hazardous materials training module with TEEX training partners.

Texas Department of Insurance (TDI)

2013-02-I-TX R17

For companies that provide insurance to agricultural facilities storing bulk fertilizer grade ammonium nitrate (FGAN) in Texas, including surplus lines insurers and Texas-registered risk retention groups, develop and issue guidance to assist in underwriting risk and conducting annual loss control surveys. Guidance should include the following:

a. Combustible materials of construction for facilities and bins storing FGAN
b. Storage of combustible materials near FGAN piles
c. Adequate ventilation for indoor FGAN storage areas
d. Automatic sprinklers and smoke detection systems for indoor FGAN storage areas
e. Separation distances between FGAN and other hazardous materials onsite

f. Potential for offsite consequences from a fire or explosion, including the proximity of FGAN facilities to nearby residences, schools, hospitals, and other community structures.

Provide references in the guidance document to existing materials from the following sources or to other equivalent guidance:

a. National Fire Protection Association (NFPA), *NFPA 400, Hazardous Materials Code*, 2016 Edition, Chapter 11, "Ammonium Nitrate"
b. FM Global, "Property Loss Prevention Data Sheet 7-89"
c. U.S. Environmental Protection Agency, Occupational Safety and Health Administration, and Bureau of Alcohol, Tobacco, Firearms and Explosives; "Chemical Advisory: Safe Storage, Handling, and Management of Solid Ammonium Nitrate Prills"
d. TDI, "Best Practices for the Storage of Ammonium Nitrate"
e. National Fire Protection Research Foundation, "Separation Distances and NFPA Codes and Standards."

West Volunteer Fire Department (WVFD)

2013-02-I-TX R18

Develop standard operating procedures for pre-incident planning for facilities that store or handle hazardous materials such as fertilizer grade ammonium nitrate (FGAN).

El Dorado Chemical Company (EDC)

2013-02-I-TX R19

For all distributors and bulk retail sites (i.e., customers) that receive fertilizer grade ammonium nitrate (FGAN) manufactured by El Dorado Chemical Company (EDC) for storage, shipment, and sale:

a. Encourage customers to conduct internal monitoring and auditing (in accordance with recent industry standards and guidelines) in locations where FGAN will be stored or used. Communicate that such internal monitoring and auditing may be conducted through established product safety programs, including ResponsibleAg.
b. Develop a process to establish mutual product stewardship expectations for the downstream chain of customers. Communicate expectations to existing customers, and to new customers before their first shipment of FGAN. Include the following components:
    i. For all FGAN sold to distributors, encourage distributors to provide Safety Data Sheets and FGAN safety guidance to their customers and bulk retail sites to which FGAN is sold or shipped
    ii. For all EDC bulk retailers and non-EDC bulk retailers that store and sell FGAN, encourage bulk retailers to address, such as through certification checklists, the following:
        - Written procedures for the safe handling of FGAN, including employee training

- Emergency response plans to be sent to Local Emergency Planning Committees and local fire departments
- Tier II Chemical Inventory Report submissions.

This signature block is placed immediately after the last recommendation.

By the

U.S. Chemical Safety and Hazard Investigation Board

Vanessa Allen Sutherland

Chair

Kristen Kulinowski

Member

Manuel Ehrlich

Member

Richard Engler

Member

Date of Board Approval

12.0 Appendix A: Rebuilding of the West Independent School District

The West Independent School District (WISD) ultimately decided to demolish the West Intermediate School (WIS),[1] West High School (WHS), and approximately half of West Middle School (WMS) based on the level of damage to these buildings. The WISD is rebuilding by constructing a combined middle school and high school consisting of a common entryway, cafeteria, and auditorium but separate offices and gymnasiums for each school. The left side of the structure will accommodate the middle school students (grades 6 through 8), and the right side will serve high school students (grades 9 through 12). Table 16 shows the distribution of grade levels within the old facilities and the new facilities. Groundbreaking took place on October 30, 2014, and construction began shortly thereafter; the WISD expects the school to open in September 2016. The new West Middle School/West High School will be located on the same site as the previous WHS campus. The site will house the WISD baseball field, softball field, eight-lane running track and facilities for field events, two practice fields, four tennis courts, and supporting concession and restroom facilities.[2] Although the city demolished the WIS campus, the existing site paving remained in place so that it could serve as temporary parking for the WISD transportation department. The former WIS site currently houses a donated metal building used for agriculture shop for WHS students[3] but could potentially become the final location of the WISD transportation, maintenance, and receiving facility.

[1] WIS will not be rebuilt.
[2] *See*: http://www.restorewestisd.com/assets/sd_west-hs-ms-final-web.pdf (accessed on December 30, 2015).
[3] The donated metal building is approximately a block and a half from the temporary high school; however, it would take up too much instructional time for students to walk there, so buses take each class to the shop on days when students participate in agriculture class.

Table 16. Distribution of Grade Levels at the Old and New WISD Schools

School	**Old Facilities (Grades)**	**New Facilities (Grades)**
West Intermediate School	4 and 5	Not rebuilt
West Middle School	6 and 7	6 through 8
West High School	7 through 12	9 through 12
West Elementary School	K through 3	K through **5**

During the rebuild, the WISD created a temporary campus for middle and high school students, ultimately locating it on the existing middle school site. Students in grades pre-K through 5 attended school at West Elementary School, which sustained minimal damage in the explosion. Students in grades 6 through 12 were housed in temporary facilities at the existing WMS site.[4] The sixth graders from WMS initially transferred to portable structures behind the elementary school until the end of the school year before moving to the middle school site for the 2013–2014 school year. The students in grades 7 through 12 moved to empty buildings owned by the Connally Independent School District,[5] which is about 9 miles south of West, from April 17, 2013, until the end of the school year. Although the physical location of classes changed, WISD teachers still taught these students, who were still enrolled in the WISD. In August 2013, all of the students in grades 7 through 12 returned to West for classes in modular and portable buildings, and they eventually will transfer to the new school once the rebuild is complete. The temporary middle school and high school site consisted of 17 temporary portable facilities, 10 portable facilities donated by surrounding school districts that were leased by the WISD, and a temporary structure to cover the existing foundation and floor system saved from the original practice gymnasium.[6]

FEMA provided the WISD with a grant totaling nearly $20.8 million to assist in providing secure temporary classrooms and administrative buildings to replace those that were destroyed.[7] The FEMA grant will pay the federal share, or 75 percent, of the eligible costs for the rebuild, and the WISD will

[4] *See*: http://www.restorewestisd.com/plans.html (accessed on December 30, 2015).
[5] Connally Independent School District is a Texas public school district located in central McLennan County, serving the cities of Lacy, Lakeview, and Waco as well as the communities of Elm Mott, Chalk Bluff, and Gholson.
[6] *See*: http://www.restorewestisd.com/plans.html (accessed on December 30, 2015).
[7] *See*: http://www.fema.gov/news-release/2013/08/01/fema-obligates-nearly-28-million-west-texas-independent-school-district (accessed on December 30, 2015). *See*: http://www.wfaa.com/story/local/2015/07/06/14167886/ (accessed on December 30, 2015).

cover the remaining 25 percent of the cost. The remaining cost to rebuild will be funded by the Texas Education Agency, which is providing the WISD with almost $10.3 million in Foundation School Program funds.

At the time of the incident, the WISD was insured for $58 million. The school district received $30 million from the Argonaut Insurance Company, the WISD's insurance carrier at the time of the explosion; however, WISD assessments indicate that the damage to its four schools far exceeded $30 million. Currently, the WISD is in litigation with Argonaut Insurance Company,[8] Trident Insurance Services LLC,[9]and the Texas Association of Public Educators.[10] Based on a district assessment and planning presentation to the WISD Board of Trustees on April 29, 2013, the proposed cost for rebuilding temporary facilities and renovating the facilities damaged by the explosion would amount to $16,562,706.[11] This Phase One cost estimate for temporary facilities and renovations includes the following:

- Existing administrative and office building renovations.
- High school football stadium renovations.
- Existing middle school site (1967 gymnasium repair, 1923 and 1957 building weatherization, maintenance and transportation building replacement).
- Existing elementary school cafeteria additions and building renovations.
- WISD-wide demolition and temporary classrooms.
- Loose equipment moving and temporary storage.
- WISD-wide technology connectivity.
- Contingency funds.

The initial proposed estimated cost for Phase Two rebuilding—including a new high school, new intermediate and middle school, new track and field facility, new maintenance and transportation permanent replacement building and contingency, and program financial audit—was $100,791,719.[12]

13.0 Appendix B: FGAN Incidents Tables

Appendix B provides two tables, both depicting incidents involving FGAN. CSB listed only those incidents that it could confirm. As such, these lists are not meant to be comprehensive. The first table

[8] Argonaut Insurance provides specialty property and casualty insurance and is a subsidiary of Argo Group International Holdings, Ltd.
[9] Trident Insurance Services is a specialty commercial insurance provider for small- to middle-market public sector entities; it served as the administrator and adjustor for the insurance policy sold by Argonaut Insurance Company.
[10] The Texas Association of Public Educators is a nonprofit organization managed by Argonaut Insurance Company to assist in the procurement of insurance and the administration of claims for school districts.
[11] *See*: http://www.restorewestisd.com/assets/west-isd-presentation_final-sm.pdf (accessed on December 30, 2015).
[12] *See*: http://www.restorewestisd.com/assets/west-isd-presentation_final-sm.pdf (accessed on December 30, 2015).

(Table 17) provides only those FGAN incidents that occurred at stationary sites. The second table (Table 18) shows all other FGAN incidents, many of which are transportation-related.

The incidents are listed chronologically. Date, location, and a brief description of each incident are provided. For transportation incidents, the location given is the location where the incident occurred. An indication of whether the incident involved fire and/or explosion is also included. Quantity, or mass, of FGAN involved in each incident is provided as well. This information may or may not reflect the quantity of FGAN that actually caught fire and/or detonated. Where available, a description of casualties and property damage is given. Where information could not be found or determined, entries appear blank.

Of the 32 total confirmed FGAN incidents researched by CSB, 22 occurred at stationary sites. At least 654 fatalities resulted from these stationary-site incidents. Thousands were injured and/or evacuated. Of the 10 FGAN incidents that occurred at non-stationary sites, at least 823 were fatally injured. Again, thousands were injured and/or evacuated.

Table 17. FGAN Incidents at Stationary Sites

Date	Location	Description	Fire	Explosion	Quantity (lbs)	Casualties	Property Damage	References
14-Jan-1916	Gibbstown NJ, USA	Explosion occurred in evaporating pan		x	4K	• One fatality • 12 injured	Plant property heavily damaged	[1]
21-May-1921	Oppau, Germany	Detonation involved FGAN and ammonium sulfate mixture or hidden explosives		x	900K	• 561 fatalities • 2,000 injured	Buildings flattened	[2]
1-Mar-1924	New Brunswick (Nixon), NJ	Explosion occurred at fertilizer building	x	x		• At least 20 fatalities • A dozen missing		[3]
5-Aug-1940	Miramas, France	Explosion of freight car launched explosive shell into burning mixture of FGAN and toluene at storage building	x	x	480K			[4]
26-Aug-1947	Presque Isle, ME	Fire involving fertilizers occurred	x	--				[5]

[1] NFPA. *Quarterly of the NFPA*, Vol. 16, No. 1. July 1922. *See*: https://books.google.com/books?id=-MAdAQAAIAAJ&printsec=frontcover&source=gbs_ge_summary_r&cad=0#v=onepage&q&f=false (accessed on December 30, 2015).
[2] Oxley, J.C. et al. "AN: thermal stability and explosivity modifiers." *Thermochimica Acta* 384 (2002): 23–45.
[3] *See*: http://query.nytimes.com/gst/abstract.html?res=9E05EEDD1E3CE733A25751C0A9659C946595D6CF (accessed on December 31, 2015).
[4] *See*: http://www.societechimiquedefrance.fr/extras/Guiochon%20VO/exinvolontaireVO.htm (accessed on December 31, 2015).
[5] Oxley, J.C. et al. "AN: thermal stability and explosivity modifiers." *Thermochimica Acta* 384 (2002): 23–45.

Date	Location	Description	Fire	Explosion	Quantity (lbs)	Casualties	Property Damage	References
1-Sep-1947	St. Stephens, Canada	Fire occurred in warehouse containing bagged FGAN	x	--	800K			[6]
14-Oct-1949	Independence, KS	Fire occurred in warehouse next to storage building containing FGAN piled in paper bags	x	--	2.8– 5.4 million			[7]
9-Nov-1966	Mt. Vernon, MO	Explosion involving bagged FGAN occurred	x	x	100K			[8]
c. 1967	USA	Screw conveyor shaft for FGAN burst after welding operation	x	x				[9]
c. 1973	Cherokee, OK	Severe storage fire occurred in wooden FGAN storage area	x	x	28 million	None injured		[10]
c. 1978	Rocky Mountain, NC	Fire occurred at storage facility containing FGAN	x	--	1 million		Storage facility destroyed by fire	[11]

[6] *Ibid*.
[7] *Ibid*.
[8] *Ibid*.
[9] ABS Consulting. "West Fertilizer Incident Support Services Final Report." August 28, 2015.
[10] Marlair, G., and M.A. Kordek. "Safety and security issues relating to low capacity storage of AN-based fertilizers." *Journal of Hazardous Materials* 123(1–3) (2005): 13–28.
[11] Oxley, J.C. et al. "AN: thermal stability and explosivity modifiers." *Thermochimica Acta* 384 (2002): 23–45.

Date	Location	Description	Fire	Explosion	Quantity (lbs)	Casualties	Property Damage	References
c. 1979	Moreland, ID	Fire involved wood framework and belting of overhead conveyor system in fertilizer plant while being used to unload railroad car of FGAN	x	--	400K		Fire spread to roof	[12]
c. 1982	United Kingdom	Fire in warehouse where wooden furniture stored near FGAN resulted in deflagration	x	x	6 million	750–1,000 evacuated		[13]
13-Dec-1994	Port Neal, IA	Two explosions occurred at the Terra Industries AN plant		x		• Four fatalities • 18 injured	• Anhydrous ammonia released • Ground water under plant contaminated	[14]
6-Jan-1998	Xingping, Shaanxi, China	Explosions occurred at fertilizer company		x		• 24 fatalities • 56 injured		

[12] Boggs, Thomas L. et al. "Realistic Safe-Separation Distance Determination for Mass Fire Hazards." Naval Air Warfare Center Weapons Division. March 2013.
[13] Nygaard, Erik C. et al. "Safety of Ammonium Nitrate." International Society of Explosives Engineers. Vol. 2, 2006. *See*: https://miningandblasting.files.wordpress.com/2009/09/safety-of-ammonium-nitrate.pdf (accessed on January 4, 2016).
[14] Boggs, Thomas L. et al. "Realistic Safe-Separation Distance Determination for Mass Fire Hazards." Naval Air Warfare Center Weapons Division. March 2013.

Date	Location	Description	Fire	Explosion	Quantity (lbs)	Casualties	Property Damage	References
21-Sep-2001	Toulouse, France	Explosion occurred in warehouse containing FGAN and TGAN		x	400 – 600 K (TGAN+FGAN)	• 29 fatalities • Nearly 2,500 injured, 30 of which severe	Severe damage to plant and surrounding community	[15]
Jan-2003	Cartagena, Murcia, Spain	Fertilizer storage facility held self-sustained detonation fire	x	x				[16]
Oct-2003	Saint-Romain-en-Jarez, France	Fire occurred in end user storage facility containing FGAN in bags	x	x	10K	Three heavily injured		[17]
30-Jul-2009	Bryan, TX	Fertilizer plant caught fire	x			Over 80,000 evacuated		[18]

[15] Nygaard, Erik C. et al. "Safety of Ammonium Nitrate." International Society of Explosives Engineers. Vol. 2, 2006. *See*: https://miningandblasting.files.wordpress.com/2009/09/safety-of-ammonium-nitrate.pdf (accessed on January 4, 2016).
[16] Boggs, Thomas L. et al. "Realistic Safe-Separation Distance Determination for Mass Fire Hazards." Naval Air Warfare Center Weapons Division. March 2013.
[17] Marlair, G., and M.A. Kordek. "Safety and security issues relating to low capacity storage of AN-based fertilizers." *Journal of Hazardous Materials* 123(1–3) (2005): 13–28.
[18] Boggs, Thomas L. et al. "Realistic Safe-Separation Distance Determination for Mass Fire Hazards." Naval Air Warfare Center Weapons Division. March 2013.

Date	Location	Description	Fire	Explosion	Quantity (lbs)	Casualties	Property Damage	References
17-Apr-2013	West, TX	Fire and explosion occurred at fertilizer plant	x	x	80 – 100 K	• 15 fatalities • Over 236 injured	• Facility destroyed • Widespread damage to over 150 offsite buildings, including high school, middle school, intermediate school, apartment complex, and nursing home • Early estimates placed property damage at over $100 million	
29-May-2014	Athens, TX	Fertilizer warehouse containing FGAN caught fire and burned	x					[19]
12-Aug-2015	Tianjin, China	Hazardous materials storage warehouse containing AN* caught fire and exploded	x	x		Over 100 fatalities		[20]

[19] Babrauskas, Vytenis. "Explosions of ammonium nitrate fertilizer in storage or transportation are preventable accidents." *Journal of Hazardous Materials* (2015).
[20] See: http://www.theguardian.com/world/2015/aug/18/tianjin-blasts-warehouse-handled-toxic-chemicals-without-licence-reports (accessed on January 19, 2016)

Table 18. Non-Stationary FGAN Incidents

Date	Location	Description	Fire	Explosion	Quantity (lbs)	Casualties	Property Damage	References
16-Apr-1947	Texas City, TX	Fire occurred in hold of ship and detonated	x	x	4–11 million	• Approximately 500 fatalities • Approximately 3,000 injured • 2,000 left homeless	• Commercial and residential buildings damaged or destroyed • Ships destroyed • Two planes knocked out of sky • Barge lifted out of water • Early property damage total estimated at approximately $40 million	[21]
23-Jan-1953	Red Sea, Israel	Spontaneous ignition of paper bags containing FGAN on ship	x	x	8–16 K		Ship destroyed	[22]
17-Dec-1960	Traskwood, AR	Explosion occurred in cars containing FGAN, petroleum, and paper	x	x	80—100 K			[23]

[21] NFPA. "The Texas City Disaster." The Quarterly. July 1947.
[22] Oxley, J.C. et al. "AN: thermal stability and explosivity modifiers." *Thermochimica Acta* 384 (2002): 23–45.
[23] *Ibid*.

Date	Location	Description	Fire	Explosion	Quantity (lbs)	Casualties	Property Damage	References
1972	Taroon, Australia	Transport of low density bagged AN prills involved in fire and explosion	x	x		Three fatalities		[24]
c. 1997	Brazil	Delayed explosion occurred involving truck loaded with FGAN that caught fire due to nearby petrol tanker	x	x				[25]
c. 2000	FL	Collision occurred between AN truck and gasoline tanker	x	--				[26]
18-Feb-2004	Neyshabur, Khorasan, Iran	Fire and explosion resulted from derailment of train containing bagged FGAN	x	x	840K	300 fatalities		[27]
Feb-2004	Barracas, Spain	Accident occurred during road transport of FGAN	x	x	50K	• Two fatalities • Three injured		[28]

[24] Marlair, G., and M.A. Kordek. "Safety and security issues relating to low capacity storage of AN-based fertilizers." *Journal of Hazardous Materials* 123(1–3) (2005): 13–28.
[25] *Ibid*.
[26] *Ibid*.
[27] Nygaard, Erik C. et al. "Safety of Ammonium Nitrate." International Society of Explosives Engineers. Vol. 2, 2006. *See*: https://miningandblasting.files.wordpress.com/2009/09/safety-of-ammonium-nitrate.pdf (accessed on January 4, 2016).
[28] Marlair, G., and M.A. Kordek. "Safety and security issues relating to low capacity storage of AN-based fertilizers." *Journal of Hazardous Materials* 123(1–3) (2005): 13–28.

Date	Location	Description	Fire	Explosion	Quantity (lbs)	Casualties	Property Damage	References
May-2004	Near Bucharest, Romania	Truck accident occurred during road transport of bagged FGAN	x	x	50K	At least 18 fatalities		[29]
17-Feb-2007	Estaca de Bares, Spain	Self-sustained decomposition fire of nitrogen, phosphorous, potassium (NPK) fertilizer occurred in cargo of ship	x		12.024 million (NPK)			[30]

[29] *Ibid*.
[30] Boggs, Thomas L. et al. "Realistic Safe-Separation Distance Determination for Mass Fire Hazards." Naval Air Warfare Center Weapons Division. March 2013.

14.0 Appendix C: TFI Safety and Security Tools

The Fertilizer Institute (TFI) offers a wide variety of tools designed to support the fertilizer industry. Most of these tools are information based and readily accessible online; some of the tools, however, are also interactive, allowing for personalization and customization. These tools include the following:

- Access to a new online Compliance Assessment Tool.
- General fertilizer retail industry information resources, such as industry fact sheets, fertilizer product fact sheets, and infographics.
- New fertilizer grade ammonium nitrate (FGAN) guidelines, "Safety and Security Guidelines for the Storage and Transportation of Fertilizer Grade Ammonium Nitrate at Retail Facilities."
- An educational brochure, "America's Security Begins with You," designed to alert the agriculture community of the dangers associated with ammonium nitrate (AN) if it ends up in the wrong hands.
- A brochure, "Health Effects of Ammonia," discussing the sources and uses of ammonia as well as how the body processes it.
- Newly updated liquid fertilizer guidelines, "Aboveground Storage Tanks Containing Liquid Fertilizer–Recommended Mechanical Integrity Practices," which provides recommended uniform industry inspection and maintenance procedures for aboveground storage tanks of liquid fertilizer.[1]
- An anhydrous ammonia brochure, "Recommended Practices for Loading/Unloading Anhydrous Ammonia Rail Tank Cars in North America–Reduce and Eliminate Non-Accidental Release," accompanied by an associated DVD.
- Access to a new nonprofit organization, ResponsibleAg, an industry-led stewardship[2] initiative founded to promote the public welfare by helping agribusinesses comply with safety and security rules regarding the handling and storage of fertilizer products.[3]
- Access to a multimedia safety training program, the "Anhydrous Ammonia Training Tour," developed through TFI sponsorship of the Transportation Community Awareness and Emergency Response and focused on the provision of pertinent information regarding the properties of ammonia, steps that should be taken to ensure safe transport of ammonia, appropriate emergency response measures in case of an ammonia release, and hands-on training.[4]
- Access to free web-based anhydrous ammonia safety training, composed of subject-based training modules on (1) properties of ammonia, (2) personal protective equipment, (3) transportation of ammonia to and from the field, (4) safe hook-up of ammonia tanks in the field, and (5) emergency response and first aid procedures.[5]

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[1] *See*: http://www.tfi.org/safety-and-security-tools/recommended-mechanical-integrity-guidelines-aboveground-storage-tanks-liqu (accessed on December 30, 2015).
[2] Merriam-Webster defines a stewardship as "the activity or job of protecting and being responsible for something."
[3] *See*: http://www.responsibleag.org/FAQ.cgi (accessed on December 30, 2015).
[4] *See*: http://www.tfi.org/safety-and-security-tools/transcaer%C2%AE-anhydrous-ammonia-safety-training (accessed on December 30, 2015).
[5] *See*: http://www.tfi.org/safety-and-security-tools/web-based-anhydrous-ammonia-safety-training (accessed on December 30, 2015).

- Access to a web-based compliance tool, myRMP Suite of Guidance Materials, a revised version of the Retail Guidance Document for Agricultural Retailers supported by the U.S. Environmental Protection Agency.[6]
- A new suite of second-generation web-based tools, mySPCC Suite of Guidance Materials Version 2.0, developed exclusively to assist agricultural retailers in implementing their Spill Prevention, Control, and Countermeasures (SPCC) plans, which enables the personalization of such plans to specific facilities and incorporates base information from the SPCC rule with accumulated knowledge gained by industry over the last 20 years.[7]

[6] *See*: http://www.tfi.org/safety-and-security-tools/myrmp (accessed on December 30, 2015).
[7] *See*: https://www.asmark.org/mySPCC/ (accessed on December 30, 2015).

15.0 Appendix D: ResponsibleAg

As part of the ResponsibleAg program, participating facilities undergo an audit once every 3 years, and as many as 17 areas of a facility (e.g., dry fertilizer, liquid fertilizer, anhydrous ammonia, shop, office, and grounds) are assessed.[1] Within 24 hours after completing the audit, the auditor enters findings into a secure portal on the ResponsibleAg website.[2] Once the information is processed, the participating facility receives a corrective action plan if applicable, detailing any issues detected during the audit.[3] This plan not only lists the issues discovered but also provides information on how to correct the issues and a recommended time frame for doing so.[4] At the end of the recommended period of time, the auditor visits the facility again for a verification audit. The participating facility obtains certification only after all outstanding issues are addressed.[5] To ensure a high level of reliability, a statistically valid sample of all participating facilities receives random verification from an independent auditor, approved by ResponsibleAg, every year.[6] An annual accountability report includes the number of registered facilities, credentialed auditors, completed assessments, and random verifications.

[1] *See*: http://www.responsibleag.org/About.cgi (accessed on December 30, 2015).
[2] *Ibid*.
[3] *Ibid*.
[4] *Ibid*.
[5] *Ibid*.
[6] *See*: http://www.tfi.org/node/736 (accessed on January 6, 2016). *See also*: https://www.responsibleag.org/documents/RAHandout.pdf (accessed on December 30, 2015).