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THESIS

**DO YOU KNOW WHAT'S IN YOUR COMMUNITY?
A STRATEGIC RISK MANAGEMENT APPROACH TO
BETTER PREPARE FOR CHEMICAL EMERGENCIES**

by

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March 2016

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A STRATEGIC RISK MANAGEMENT APPROACH TO BETTER PREPARE
FOR CHEMICAL EMERGENCIES**

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ABSTRACT

Communities throughout the United States are susceptible to hazardous materials releases, with varying impact. Unfortunately, some of those incidents have caused catastrophic casualties, irreversible environmental damage, revenue loss, and nonconventional impacts such as community and industry social implications—many of which could have been prevented. This thesis creates a framework to help communities better prepare for chemical emergencies. The research examined two case studies, revealing three major disconnects and several challenges that emergency management professionals face to pursue a delicate balance of natural resources, population growth, limited resources, security, and the need for commercial goods—made possible by the necessary use and manufacturing of chemicals. This framework enables communities throughout the United States to better prepare for chemical disasters. It offers first responders, emergency management professionals, the private sector, and community members a collaborative path toward making their communities more resilient to chemical disasters in order to diminish preventable hazards and lessen inevitable impacts.

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LIST OF ACRONYMS AND ABBREVIATIONS

ALOHA	Areal Locations of Hazardous Atmospheres
BPCS	basic process control system
CAA	Clean Air Act
CAER	Community Awareness Emergency Response
CalARP	California Accidental Release Prevention
CERS	California Environmental Reporting System
CERT	community emergency response team
CIKR	critical infrastructures and key resources
CSB	United States Chemical Safety Board
CUPA	Certified Unified Program Agency
DHS	Department of Homeland Security
EO	executive order
EPA	Environmental Protection Agency
EPCRA	Emergency Planning and Community Right-to-Know Act
ERNS	Emergency Response Notification System
FEMA	Federal Emergency Management Agency
GDP	gross domestic product
HAZOP	hazard and operability
HSPD	Homeland Security Presidential Directive
IPL	independent protection layer
LEPC	Local Emergency Planning Committee
LOPA	Layers of Protection Analysis
MARPLOT	mapping applications for response, planning, and local operational tasks
NIPP	National Infrastructure Protection Plan
NOAA	National Oceanic and Atmospheric Administration
NRC	National Response Center
OCA	offsite consequence analysis
OSHA	Occupational Safety and Health Administration
PHA	process hazard analysis

PSM	Process Safety Management Standard
RMP	Risk Management Program
RMP Submit	Risk Management Plan Submit
SERC	State Emergency Response Commission
TCEQ	Texas Commission on Environmental Quality
WMD	weapon of mass destruction

EXECUTIVE SUMMARY

Risk, in the context of homeland security, combines likelihood and consequences associated with a hazard. Though it might not be possible to reduce every hazard, once one is identified, appropriate safeguards can be implemented and the risk from the hazard *can* be reduced. Once a hazard is identified, decisions must be made concerning tolerable and acceptable risk. This requires high-quality hazard evaluations. An incorrect perception of risk at any point could lead to either inefficient use of limited resources or unknowingly accepted risks that may exceed the true tolerance of a community.

Most communities are vulnerable to hazardous materials emergencies, whether through unintentional or deliberate acts. Some emergencies are small and infrequent, but too many have catastrophic and deadly outcomes. Because communities lack awareness about their vulnerabilities, prevention and preparedness are often left inadequately addressed. The methodology presented in this thesis evaluates two case studies from recent hazardous materials incidents to connect and identify key root causes that led to these events and their consequences. The research then evaluates current regulatory frameworks and established reporting requirements to determine how they can help improve the safety of communities with high-risk chemical facilities in their jurisdictions.

The methodology reveals three common failures and their underlying root causes that led to the catastrophic disaster. Communities must assess their risks related to chemical releases whether they are related to a facility or transportation. Risk assessments can identify those risks and vulnerabilities to help better plan and prepare for those emergencies. Regulatory risk management must be effective and the research identified significant gaps in the current regulatory framework. Lastly, communities must communicate and have open transparency at all levels. First responders, emergency management professionals, industry, regulatory agencies at all levels, and the public need to effectively work together to safeguard communities against incidents like those presented in this thesis that could have been otherwise preventable. Ultimately, this thesis recommends that communities use a framework built upon risk assessment to evaluate chemical hazards. The study suggests ways to enhance data collection and sharing to

improve prevention, response, and mitigation. Through effective coordination, cooperation, collaboration, and communication, communities can prevent risks and lessen inevitable impacts.

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I. INTRODUCTION

“Risk” is no longer “chance or probability of loss,” but “the effect of uncertainty on objectives.”

—International Organization for Standardization

In 1984, a catastrophic hazardous materials incident occurred in Bhopal, India, at the Union Carbide pesticide manufacturing facility, forever changing the history of chemical safety at industrial facilities around the world. The Union Carbide facility mistakenly released methyl-isocyanate, a highly toxic industrial chemical, killing thousands and causing permanent, disabling injuries to hundreds of thousands more sleeping through the night, coupled with extensive property and environmental damage.¹ The Bhopal incident is considered one of the worst industrial catastrophes of its kind, and prompted legislative proposals designed to reduce the risk of chemical accidents.

Tens of thousands of high-risk chemical facilities are scattered across the United States and are located within close proximity to communities with sensitive receptors such as homes, schools, hospitals, and other critical infrastructures. The Bhopal incident prompted many in the United States to question our own chemical facilities’ safety practices and their potential hazard to our communities and resources, as well as the global economy.

A. THE IMPORTANCE OF CHEMICALS ON A GLOBAL LEVEL

The manufacturing and use of hazardous materials is a vital element to the U.S. economy and is a key component to the critical infrastructure sector. A quick snapshot from the American Chemical Council reveals the chemical sector contributes over 800,000 jobs to the American economy.² Additionally, “chemical manufacturing is one of America’s top exporting industries, with \$191 billion in exports in 2014,” which

¹ Jackson B. Browning, *Union Carbide: Disaster at Bhopal* (Houston, TX: Union Carbide, 1993).

² “Jobs and Wages,” American Chemical Council, accessed June 6, 2015, <http://www.americanchemistry.com/jobs-and-wages>.

accounts for nearly 14% of all U.S. exports.³ Growth in the U.S. gross domestic product (GDP) at the end of 2013 signaled the chemical industry's returning importance to the world economy.⁴ Despite the global economy's recent slowdown, the hazardous materials business is vital to many products that are used in our everyday lives, from basic life necessities to simple conveniences. The American Chemistry Council's Economics & Statistics division projects that the U.S. chemical industry's revenue will reach \$1 trillion in sales by the year 2019.⁵

Supporting U.S. GDP growth, hazardous materials form a vital link in job creation and in the return of a strong domestic manufacturing sector.⁶ For example, for every "one chemical industry job, 6.3 other jobs are generated in other sectors of the economy, including construction, transportation, and agriculture."⁷ This amounts to nearly six million hazardous materials-dependent jobs.⁸ Not only does the chemical industry support employment in the United States, it also strengthens its export base, making it doubly attractive for sabotage. Key critical operations and infrastructures rely on the chemical industry to function, but the economic benefits must not outweigh the safety and risk that these facilities impose on communities and the environment. Industry must have safeguards in place to prevent harm. The role of the emergency management professional is to coordinate and implement that plan, in concert with local emergency responders, to minimize the consequences of any potential chemical release.

Smaller hazardous materials incidents occur all too frequently, but catastrophic incidents such as Bhopal are unusual. Even so, the potential for disaster is ever present due to the increasing demand for consumer products that require hazardous chemicals in some stage of manufacturing. The National Response Center (NRC) maintains a database

³ American Chemistry Council, *Year-End 2013 Chemical Industry Situation and Outlook: American Chemistry Is Back in the Game* (Washington, DC: American Chemistry Council, December 2013).

⁴ Ibid.

⁵ American Chemistry Council, *Year-End 2014 Chemical Industry Situation and Outlook: American Chemistry Builds Momentum* (Washington, DC: American Chemistry Council, December 2014).

⁶ Ibid.

⁷ American Chemistry Council, *Year-End 2013*.

⁸ Ibid.

for reporting all spills and accidents related to hazardous materials, as well as coordinating large-scale incident response. Response is managed through national communications centers, staffed and operated by United States Coast Guard officers and maritime scientists.⁹ The database that captures the information is called the Emergency Response Notification System (ERNS). Although the database is extensive, only chemical releases over the federal reporting threshold are required, by law, to be reported to the system. Some states have their own reportable thresholds that are lower than the federal reporting thresholds. Once recorded in the system, reports to the NRC are then assigned to a regional coordinator for follow-up and/or response activation. The Right-to-Know Network, an organization operated by the Center for Effective Government, provides a number of environmental databases collected from various sources, including the ERNS.¹⁰ In 2014 alone, a total of 21,632 incidents were reported to the NRC as collected by the ERNS. Of that, a staggering number of deaths—835—were reported, along with 1,321 injuries, amounting to \$50,012,848 in property damage.¹¹ Appendix A provides a summary of the types of hazardous materials incidents related to facilities, transportation, and others for 2014.

Few people know that hazardous materials are used in the manufacture of many everyday products, including, but not limited to, plastics, fuel for our vehicles, soaps, cosmetics, agricultural products, solar panel production, components used in wind farms, and pharmaceuticals. From processes used to make water safe to drink, to the electricity we consume continuously, hazardous materials are used and manufactured into our daily necessities, which makes them too vital to eliminate. Chemicals are stored in every community at industrial businesses, chemical manufacturing plants, grocery stores, schools, transportation yards, farms, refineries, gas stations, swimming pools, water treatment facilities, and the like. Large quantities of hazardous materials pass through communities through different modes of transportation, including trucks, trains, ships,

⁹ “Welcome to the National Response Center,” National Response Center, accessed October 25, 2015, <http://www.nrc.uscg.mil/>.

¹⁰ “The Right-to-Know Network,” accessed October 25, 2015, <http://www.rtknet.org/>.

¹¹ “ERNS Database Advanced Search,” The Right-to-Know Network, accessed October 25, 2015, <http://www.rtknet.org/db/erns/search>.

and pipelines. That is without mentioning the un-predictable forces of Mother Nature, including the destructive forces of earthquakes, floods, tsunamis, and fires. Human error, mechanical failure, and acts of terrorism and sabotage add to the many contending factors of risk management, safety, and security at high-risk chemical facilities.

In the last several years, an alarming number of significant hazardous materials incidents have raised concerns related to the regulatory oversight and operations of these high-risk chemical facilities.¹² Although facilities that manufacture and store hazardous materials present a danger, it is a risk that most accept, almost unknowingly. But it is a risk that must be, and can be, managed responsibly.

B. DEFINING THE PROBLEM

Disruptions to a chemical process at a high-risk chemical facility result in a multitude of risks. These disruptions may be a result of natural disasters, mechanical failures, human errors, or sabotage, and consequences may include significant social and economic disruptions not only for the business, but also at the local, state, and regional levels.

Emergency management, as defined by the Federal Emergency Management Agency (FEMA), consists of the “organized analysis, planning, decision making, and assignment of available resources to mitigate (lessen the effect of or prevent), prepare for, respond to, and recover from the effects of all hazards. The goal of emergency management is to save lives, prevent injuries, and protect property and the environment if an emergency occurs.”¹³ Emergency management encompasses the coordination of all emergency functions and services including fire, law enforcement, medical, and health within—and perhaps beyond—a community.

¹² “CSX Corp Train Derailment in Mount Carbon, West Virginia: Crude by Rail Train Derailment Resulted in a Huge Fireball, Destroyed Home, Forced Evacuations and Closed Downstream Public Water Supply, *Globe and Mail*, February 16, 2015,” <http://www.theglobeandmail.com/>; Manny Fernandez, “Lax Oversight Cited as Factor in Deadly Blast at Texas Plant,” *New York Times*, April 22, 2014, <http://www.nytimes.com/>; “47 Dead in Lac-Megantic Crude by Rail Train Derailment, *Globe and Mail*, July 6, 2013, <http://www.theglobeandmail.com/>; “Chevron Refinery Fire,” CSB, accessed October 15, 2015, <http://www.csb.gov/chevron-refinery-fire/>; “Tesoro Refinery Fatal Explosion and Fire,” CSB, accessed October 15, 2015, <http://www.csb.gov/tesoro-refinery-fatal-explosion-and-fire/>.

¹³ FEMA, *Introduction to Emergency Management Course* (Washington, DC: FEMA, 1995), 1–6.

A community consists of individuals who reside in specific locations and share a common geographic locality.¹⁴ Within that common location, communities more specifically comprise networks of people that include stakeholders, foundations, government and non-government organizations involved in community development, housing and economic development, and community, organizational, and business development.¹⁵ The role and impact of an emergency management professional, who bridges communication between industry and regulated agencies, is crucial to a community. Many communities have community emergency response team (CERT) programs that share interests in educating and assisting in disasters and preparedness.¹⁶ An active and involved CERT plays an integral element in the community. The regulatory agencies within a community involve the local offices of emergency services; building, planning, and land use; and environmental health departments, which ensure compliance with codes, mandates, laws, and regulations.¹⁷ Industries bring economic support, jobs, consumer benefits, and tax revenue to the community. Without commercial businesses, a community falls behind in economic growth and development. Every individual and organization within the community plays a vital role in ensuring the health

¹⁴ *Mirriam-Webster*, s.v. “Community,” accessed October 24, 2015, <http://www.merriam-webster.com/dictionary/community>.

¹⁵ Dictionary.com, s.v. “Community,” accessed December 16, 2015, <http://dictionary.reference.com/browse/community>.

¹⁶ “Community Emergency Response Teams,” FEMA, last modified January 5, 2016, <http://www.fema.gov/community-emergency-response-teams>.

¹⁷ “Environmental Health departments have the capability to protect the public from environmental hazards and manages the health effects of an environmental health emergency on the public. Their capability minimizes human exposures to environmental public health hazards (e.g., contaminated food, air, water, solid wastes/debris, hazardous materials, wastes, vegetation, sediments and vectors). Their capability provides the expertise to run fate and transport models; design, implement, and interpret the results of environmental field surveys and laboratory sample analyses; develop protective guidance where none exists; and use available data and judgment to recommend appropriate actions for protecting the public and environment. Environmental Health identifies environmental hazards in the affected area through rapid needs assessments and comprehensive environmental health and risk assessments. It works closely with the health community and environmental agencies to link exposures with predicted diseases outcomes, provides input in the development of Crisis and Emergency Risk Communication messages, provides guidance on personal protective measures, and advises on environmental health guidelines.” Department of Homeland Security, *Target Capabilities List: A Companion to the National Preparedness Guidelines* (Washington, DC: Department of Homeland Security, September 2007), 309, <http://www.fema.gov/pdf/government/training/tcl.pdf>.

and success of that community. A community that has developed a cohesive partnership among all stakeholders has increased resiliency.

Events such as catastrophic hazardous materials releases within a community can result in physical damage to properties, infrastructure, and facilities, but can also affect business through indirect economic losses. Social impacts to a community can extend from distrust and anger toward the responsible business, governing agencies, and the industry in general. These social impacts can cause significant overall problems within a community; the physical aspects of loss and emotional damage as a result of fatalities, injuries, and illnesses can also cause social consequences. A well-prepared community must have the capacity to understand, manage, prevent, and be resilient to impacts of hazardous release. Though larger metropolitan cities often have the resources and evacuation strategies for large-scale chemical disasters, smaller communities with fewer resources and capabilities often rely on the state or nearby mutual aid for assistance.

The need to prepare and pre-plan for chemical emergencies starts with understanding risks. Smaller communities are often unaware of regulatory requirements and mandates for storing chemicals.¹⁸ Homeland security professionals, emergency management professionals, regulatory agencies, and industries must work together as a community to collaboratively identify the chemical sector's vulnerabilities and the impacts and challenges they present. Hazardous materials incident investigations routinely find that communities are not working together. A disconnect exists between emergency management, regulatory agencies, and commercial industries when it comes to working effectively together as a community to recognize, plan, and prepare for chemical disasters.

Though it is foolish to imagine that chemical emergencies can be one hundred percent preventable, they still occur too frequently throughout our communities. Certain measures, however, can be taken to lower the risks and impacts from a catastrophic chemical disaster. Since communities of all sizes house hazardous chemicals, they must all be able to adequately assess and identify the likelihood of risks and potential impacts,

¹⁸ "West Texas Fertilizer Plant Explosion and Fire," CSB, accessed October 15, 2015, <http://www.csb.gov/west-fertilizer-explosion-and-fire/>.

and evaluate potential hazards' severities. Unfortunately, many communities have not prepared nor planned for such impacts. Preparedness and mitigation plans must be in place for response and recovery. According to Chair of the Jefferson County Local Emergency Planning Committee Timothy Gablehouse, communities unaware of their risks are not capable of responding to a chemical disaster.¹⁹ In March, 1999, Gablehouse was responding to a chemical plant disaster that killed four employees in Allentown, Pennsylvania, when he stated:

The tragic accident in Allentown, Pennsylvania is an example of the numerous chemical accidents that occur every year in this country...the United States Chemical Safety and Hazard Investigations Board (now CSB) indicates that some 256 people are killed per year in chemical accidents. They observe that these accidents have impacts well beyond those killed as "Workers, companies, the public, emergency response organizations, and all levels of government pay the figurative and literal price." It is precisely this sense of community impact that is important to the understanding of why chemical risk and accident scenario information in the hands of the public and response agencies is so critical....

Better planning and response begins with better information. Facilities depend upon public response agencies to protect them or at least to support internal response efforts. Accordingly, information about chemicals and risks must be in the hands of these agencies if they are to be effective and protect the lives of their personnel. Equally important, however, is the idea that the general public has a role in the prevention and planning for accidents. This role is found in community decisions such as planning and zoning, funding the equipment a fire department should purchase, and the steps members of the public should take in the event of an accident...

It is notoriously difficult to predict the impact of changed procedures and information in 20/20 hindsight. Nonetheless, there are several things of which I am certain:

1. No community can be prepared to respond to a chemical accident unless it fully understands the chemicals present in that community, the risk of accidents these chemicals present and the accident impact scenarios they may face.

¹⁹ *Joint Hearing before the Subcommittees on Health and Environment and Oversight and Investigations of the Committee on Commerce House of Representatives*. Internet Posting of Chemical "Worst Case" Scenarios: A Roadmap for Terrorists. February 10, 1999, Serial No. 106-3. 107-109.

2. No community can take accident prevention and mitigation steps such as zoning to keep dangerous facilities away from vulnerable areas such as schools and hospitals unless they have this same information.
3. No facility can prevent accidents unless it understands how accidents can happen and the risks they face from the chemicals in their facility.
4. No facility can properly plan to respond to a chemical accident without understanding the accident scenarios they face.
5. No facility is an island—their accidents do have an impact beyond the fence line. Chemical accidents kill and injure people that live in these communities. Chemical accidents can devastate local economies. Chemical accidents can damage or destroy critical community services.
6. The prevention and mitigation of chemical accidents is a community-wide problem. Without adequate information on chemical risk and accident scenarios the community cannot participate.²⁰

Prevention is key, but when a hazardous materials incident occurs that negatively impacts a community, society pushes back, affecting the entire community. The incident also affects the responsible industry in ways for which they may not have been prepared both from public and political outrage, which results in social animosity and negative public perception. Understanding and managing risk effectively can help everyone be prepared.

C. RESEARCH QUESTION AND SIGNIFICANCE

Effective risk management and communication for a wide range of risks requires a concerted approach to the management of emergency preparedness. Although federal, state, regional, and local area hazardous materials response plans offer a framework for how to *respond* to an incident, they do not address how to *prevent and evaluate* the risks of chemical disasters.²¹ An effective and resilient community must have in place

²⁰ *Joint Hearing before the Subcommittees on Health and Environment and Oversight and Investigations.*

²¹ *Public Health and Welfare* (U.S.C. Title 42), Ch. 116, Sec. 11003.

partnerships with local governments, organizations, citizens, and industries to enhance hazardous materials preparedness and lessen their impacts. Without these partnerships, communities will continue to be vulnerable to the next potential hazardous materials disasters. Further, communities must identify and address failures in communication, regulatory inconsistencies, and the ability to recognize hazards and risks from chemical facilities. A community that understands these issues and their risks can then develop and implement a framework at the community level that incorporates hazard mitigation, preparedness, and response recovery for chemical disasters. In support of this community preparedness goal, this thesis asks:

How can emergency management, regulatory agencies, and industries work together as a community to better prepare for chemical emergencies?

A community's ability to understand risk management and employ effective mechanisms to mitigate, communicate, and manage potential hazards can greatly decrease the occurrences and impacts of hazardous materials releases. This process must be managed by and have the participation of the entire community. The key to any risk management objective is for the community to be able to identify risks and effectively communicate those risks to the public and stakeholders, who can then prepare as necessary.²²

The purpose of this thesis is to provide a framework and model that can be used by communities—and especially by emergency management professionals—to effectively assess and identify vulnerabilities related to chemical hazards from high-risk chemical facilities. The goal is to use common failures from case studies to determine how to effectively approach and mitigate the root causes of those failures. For the framework to effectively coordinate preparedness and response, the community must have cohesive communication, effective regulations, and an understanding of existing risks. Emergency management professionals, from both industry and regulatory areas,

²² Steven Maher, *Practical Guide to Risk Management Communications* (Mission Viejo, CA: Risk Management Professionals, 1999), 3–1.

generally agree that an effective risk communication plan must address general objectives. Some of these objectives include:

- A system that notifies the community of a hazard
- A plan for shelter-in-place and evacuation
- Cooperation from the community to respond quickly at the request of first responders
- Communication with the community about risk-related issues
- Community understanding and preparedness as it relates to emergency preparation activities

These elements help reduce impact in the event of a hazardous materials emergency.²³

The importance of high-risk chemical facilities and their processes has prompted safety regulations such as the risk management plans.²⁴ Providing regulatory risk management to the community is critical, but there are inconsistent regulations and tools needed to effectively enforce those rules. In an attempt to resolve this problem, this thesis evaluates solutions and amendments to existing regulatory frameworks for risk assessment. The research focuses on how to strengthen and update regulations to ensure that facilities are held to a higher and safer operating standard.

Communities as a whole must become more transparent. Existing state and local frameworks must communicate effectively about chemical inventories and their hazards to enhance the safety of the community and first responders. To respond effectively to these challenges, an emergency management preparedness plan must include the development of an emergency preparedness program. Time after time, incident investigations related to chemical disasters indicate that the devastating effects could have, in fact, been prevented. If these disasters are preventable, then why do they still occur?

²³ Maher, *Practical Guide*, 1–2

²⁴ *Chemical Safety Information, Site Security and Fuels Regulatory Relief Act*, Pub. L. No. 106–40 (1999).

This thesis critically evaluates the current failures to get to the root of their causes, using them as lessons learned to create a more resilient community against chemical disasters. This information can then be used to help local governments and communities create a better framework for identifying vulnerabilities and risks, and guidelines for how to effectively lower risks by working together. The objective of this work is to provide guidance to emergency management professionals, regulatory agencies, and industry about how to work together to adequately assess, prepare, coordinate, and allocate resources in the event of chemical disaster within a community.

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II. LITERATURE REVIEW

Literature relating to chemical facility preparedness and risk analysis studies commonly comes from governmental agencies, industry, and technical trade associations. Industry and trade associations, however, focus on best and accepted practices, as well as guidelines on safety measures. Since 9/11, the Department of Homeland Security (DHS) has been evaluating the nation's vulnerabilities and risks related to the safety and security of chemical facilities, generating heightened alert and concern around the ease of access to these facilities and the handling of hazardous materials. The impact from sabotage or an intentional chemical release caused by terrorist activities would cause significant loss, as well as fear. A thorough review of the literature that identifies the importance of protecting our critical chemical infrastructure revealed serious gaps and questioned our emergency management professionals' ability to identify the vulnerabilities by ensuring risk reduction associated with chemical facilities.

Though catastrophic hazardous materials releases are not common, our communities are, nonetheless, in close proximity to facilities that house hazardous chemicals. As such, the emergency response community may well have to deal with hazardous materials releases, regardless of whether they arise from a terrorist attack, accidental release, or natural disaster. Furthermore, the fact that hazardous release *is not common* may create a complacency that cripples both preparedness and response. Since the chemical sector plays such a vital role in our economy, security, and lifestyle, it will always be in close proximity to population centers. It is not only an important element within our nation's infrastructure, but an attractive potential target to cause harm and economic instability. Since terrorist activities directed at critical infrastructures handling hazardous materials have not yet been the cause of a catastrophic incident, this thesis focuses on non-deliberate threats arising from natural disasters, human error, and mechanical failures. Whatever the cause, the consequences of hazardous materials release are potentially catastrophic, and the safeguards developed to prevent, respond to, and recover from such releases will have far-reaching benefits.

A. CURRENTLY ESTABLISHED IMPLEMENTATIONS

Shortly after the Union Carbide incident in Bhopal, India, the United States Congress created the Emergency Planning and Community Right-to-Know Act (EPCRA).²⁵ EPCRA established various monitoring and reporting systems to improve safety protocols, including establishing the Toxic Release Inventory. According to the Environmental Protection Agency (EPA), this inventory requires chemical production facilities to report storage of certain hazardous materials in quantities equal to or greater than 25,000 pounds; any facility handling more than 10,000 pounds of listed chemical must also report their inventory.²⁶ Under EPCRA, states are required to create State Emergency Response Commissions (SERCs) and communities are to form Local Emergency Planning Committees (LEPCs). Programs like these are established to help local emergency responders and stakeholders prepare for chemical emergencies. EPCRA requires facilities that store hazardous materials to provide necessary emergency response information, including chemical inventory and contacts to the LEPCs and the local fire departments on an annual basis.²⁷ Although EPCRA's objective is to focus on community emergency planning, it does not contain provisions to prevent chemical accidents or releases. The LEPCs are required to develop and implement regional plans for hazardous materials emergency response for the community. It is also the mission of the LEPC to ensure that the community is aware of the chemical risks and is prepared to act should a chemical release occur.

In 1990, a few years after the creation of EPCRA, amendments were made to the Clean Air Act (CAA) to include a Risk Management Program (RMP) under Section 112(r), which was to be implemented by the EPA's Office of Emergency Management.²⁸ The CAA required the EPA to regulate and conduct inspections at facilities in order to lower the risk of a release that would impact the environment and the public.²⁹

²⁵ *Superfund Amendments and Reauthorization Act of 1986*, Pub. L. No. 99-499, Title III.

²⁶ "Local Emergency Planning Committees," EPA, accessed June 4, 2015, <http://www.epa.gov/epcra/local-emergency-planning-committees>.

²⁷ "Local Emergency Planning Committees," EPA.

²⁸ Environmental Protection Agency, 40 CFR § 68, Sec. 112(r)(7).

²⁹ *Clean Air Act Amendments of 1990*, Title III, Sec. 304, 301 (1990).

Additionally, the CAA required federal regulatory programs to focus on prevention programs to reduce chemical accidents and ensure the safety of the employees, communities, and environment. As implemented, the RMP was to identify a process for placing regulated substances, at or above a specific threshold quantity, into “risk categories based on: potential for offsite consequences associated with a worst case scenario calculation; accident history; and compliance with the prevention requirements under Occupational Safety and Health Administration’s (OSHA) Process Safety Management Standard (PSM).”³⁰ The PSM program calls for the institution to develop and implement chemical prevention and emergency response programs to protect workers at facilities that utilize and store hazardous materials.³¹ PSM is essentially a comprehensive, ongoing management system tasked with preventing major chemical releases and mitigating their consequences throughout the process life cycle. The emphasis on management systems, with an approach that integrates technologies, procedures, and management practices, serves to achieve safe operations while creating an effective safety culture.

In addition, the CAA required the EPA to designate and list a minimum threshold of toxic and/or flammable substances with identified toxic end points—distances determined by predictive modeling of a chemical release scenario.³² Plume or air dispersion models are used to identify hazard zones based upon exposure to a toxic vapor cloud from a given hazardous material that would lead to severe health effects or death.³³ Facilities that meet the thresholds quantities are regulated under the RMP rule. A plume model indicating the toxic end point is required to be conducted by the facility to determine the relative offsite consequence of impact to the community. Further amendments to the CAA were established to help prevent chemical accidents. Both the PSM standards and the RMP programs mirror the CAA and EPCRA objectives, but the

³⁰ Occupational Safety and Health Administration Process Safety Management Standard, 29 CFR § 1910.

³¹ 29 CFR § 1910.

³² 40 CFR § 68, appendix A.

³³ Environmental Health Center, *Evaluating Chemical Hazards in the Community: Using an RMP’s Offsite Consequence Analysis* (EPA 550-B-99-015) (Washington, DC: EPA, May 1999), 6.

PSM program is focused exclusively on accident prevention and emergency response requirements at the facility.

The RMP program's focus is to regulate facilities' prevention and response processes as a whole to lessen consequences to the public and environment. One major component of the RMP program is to identify risks through a hazard assessment. A hazard assessment is a tool in which risks and vulnerabilities are analyzed and defined. An analysis of the offsite consequences associated with worst-case and alternative release scenarios is conducted with a facility's flammable and/or toxic substances.³⁴ Through that assessment, safety measures are created, and a prevention and safety management program is put in place to implement those measures. In addition, certain chemical facilities must submit a five-year accident history report. The prevention program is essentially a multi-layered comprehensive management system for process safety. This study particularly relies on the chemical processes, including potential incident failures described, in the hazard analysis.

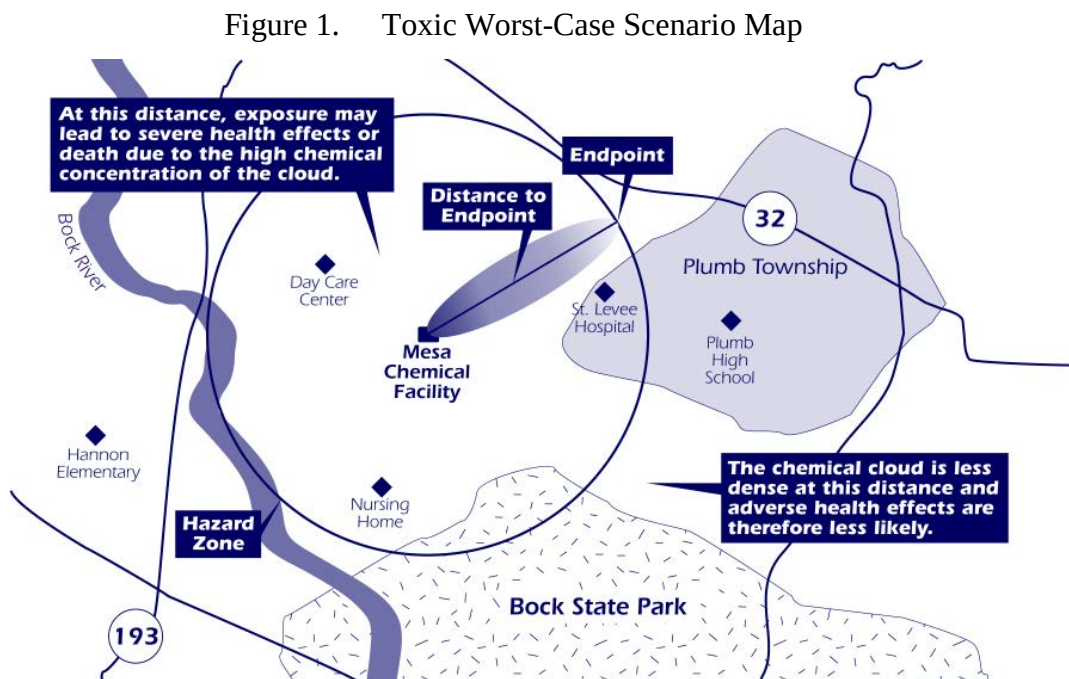
High-risk chemical facilities are required by OSHA and EPA to have similar risk management functions, such as detailed written operating procedures, employee training, ongoing mechanical integrity of process equipment, incident investigation, emergency planning, analysis and control of process hazards, compliance audits, and the identification of safety systems.³⁵ But these measures are not without gaps and inconsistencies. A significant difference between the two risk management programs is that the RMP program (EPA) assesses the risk posed on the community should a release occur, while the PSM program (OSHA) focuses on risk posed to the employees within the facility's fence line from a release. This is analyzed by conducting an offsite consequence analysis (OCA).³⁶ An OCA is an analytical plume model estimate utilizing worst-case or alternative-case release scenarios of the toxic or flammable material in a calculated release to indicate the potential impact the release would have on the public

³⁴ 40 CFR § 68, 112(r)(7).

³⁵ Spellman, Frank. *A Guide to Compliance for Process Safety Management/Risk Management Planning (PSM/RMP)*. Technomic Publishing AG, Pennsylvania, 1997. (156)

³⁶ Chemical Emergency Preparedness and Prevention Office (CEPP), *Risk Management Program Guidance for Offsite Consequence Analysis* (EPA 550-B-99-009) (Washington, DC: EPA, March 2009).

and environmental receptors outside the facility's parameters.³⁷ The EPA defines the worst-case scenario as "the release of the largest quantity of a regulated substance from a single vessel or process line failure that results in the greatest distance to an endpoint."³⁸ Plume modeling incorporates information gathered regarding the chemical properties and conditions to estimate a scenario distance to endpoint. Because it is hard to predict weather conditions, the predictive plume is outlined as a circle, with the center being the facility and location of chemical release, while the radius is the distance to the end point of the potential impact and hazard zone. An OCA plume model will identify individual facility's impact on the community. The vulnerabilities related to population and public receptors within the hazard zone.³⁹ Figure 1 provides an example of a toxic worst-case scenario map given a toxic release.



Chemical facility with a calculated scenario with distance to end point for both worst- and alternative-case scenarios. The hazard zone is depicted in a circle due to unknown wind conditions. Source: CEPP, *Risk Management Program Guidance for Offsite Consequence Analysis* (EPA 550-B-99-009) (Washington, DC: EPA, March 2009), 5.

³⁷ CEPP, *Risk Management Program Guidance*.

³⁸ Ibid.

³⁹ Ibid.

A “public receptor” includes “offsite residences, institutions [such as] schools, hospitals, industrial, commercial and office buildings, parks, or recreational areas inhabited or occupied at any time,” but not those “where members of the public could be exposed to radiant heat or overpressure as a result of an accidental release.”⁴⁰

By character, the worst-case OCA scenario shows a hypothetical maximum impact and is most often considered unlikely under most conditions.⁴¹ The objective of the worst-case OCA is to create awareness about potential hazards and is a way to identify risk-reduction strategies through effective emergency response, preparedness, risk communication, and accident prevention. Subsequently, the alternative-case scenario generally is considered to be more realistic or likely to occur. Surprisingly, however, there is no guideline or standardized approach for developing alternative scenarios. As a consequence, the results of this analysis vary widely and cause confusion among its administrators. By identifying receptors, the emergency management professional can prepare response plans and be able to effectively allocate resources. This, in essence, helps establish communication regarding preparedness with members of the community, industry, first responders, and government. The OCA scenarios, if applied consistently, provide valuable information for risk assessments and preparedness planning.

The RMP worst-case scenario is the standard in which EPA identifies certain criteria. Most often used is the RMP*Comp web-based program, developed by the National Oceanic and Atmospheric Administration (NOAA) and the EPA to help facilities calculate and assess their offsite consequence analysis.⁴² The worst-case scenario is based on the catastrophic release of the single largest vessel storing the toxic or flammable material. Dispersion of the material is dependent on several factors and parameters provided to the plume modeling program, including the surrounding terrain of the region, temperature of the material stored, and mitigation measures such as buildings or containment areas. The calculated hazard radius of the plume dispersion is determined

⁴⁰ 40 CFR 68 Sec. 3.

⁴¹ A theory coined by Nassim Nicholas Taleb to explain hard-to-predict and rare events that are beyond the realm of normal expectations in history, science, finance, and technology. Nassim Nicholas Taleb, *The Black Swan: The Impact of the Highly Improbable* (London: Penguin, 2007).

⁴² “RMP*Comp,” EPA, accessed May 10, 2015, <http://www2.epa.gov/rmp/rmpcomp>.

by the material's toxicity, vapor density, potential heat, and blast radius of an explosion from the vessel that causes irreversible or life-threatening injuries—or death—to those impacted should the chemical be entirely released from its largest stored vessel.⁴³ The RMP*Comp does not take into consideration wind direction, temperature, or time of the release. Therefore, the radius provided as the distance to toxic end point is merely an estimated circumference around the facility instead of a cone- or wedge-shaped plume should wind and area temperature be factored into the calculations.

Additional plume modeling software is available, such as CAMEO.⁴⁴ CAMEO is a software suite, also developed by NOAA and the EPA, normally used by hazardous materials emergency responders. CAMEO is also used by industry to submit chemical reporting for EPCRA. The system allows for a management of chemical inventory by facilities. Within the CAMEO software suite are Areal Locations of Hazardous Atmospheres (ALOHA) and Mapping Applications for Response, Planning, and Local Operational Tasks (MARPLOT), which help users identify potential impacts from chemical hazards. These are additional tools that the emergency management professional should utilize to create a map and framework. For the sake of creating a simple framework for this thesis, however, RMP*Comp alone is used because it does not require a predetermined dataset.

In all, by evaluating the RMP hazard assessment and risk analysis of an OCA, an emergency management professional can recognize that, though catastrophic chemical accidents may be infrequent, they can have a significant impact on the public perception of chemical facilities, and pose risks to the environment and the community's health and safety. More importantly, information provided by an OCA can identify critical vulnerabilities and risks within a community should a chemical facility have an offsite release.

The RMP covers “77 toxic and 63 flammable substances” that pose the greatest risk, including: “death, injury or serious adverse effects to human health or the

⁴³ CEPP, *Risk Management Program Guidance*.

⁴⁴ “What is the CAMEO Software Suite?” EPA, accessed June 14, 2015, <http://www2.epa.gov/cameo/what-cameo-software-suite>.

environment.”⁴⁵ The RMP program places and categorizes facilities into three programs: Program 1, 2, or 3. RMP program levels are determined by the regulatory agencies and the risk management program itself with the assessment of offsite receptor, accidental history, and the applicability of either the RMP or PSM program. Processes with an OCA that unlikely affect any offsite public receptors under a worst-case scenario are placed in Program 1. Program 1 has a minimal set of requirements as opposed to the higher levels of regulation. Program 2 imposes additional requirements on hazard assessments, worst-case and alternative-case scenarios, written operating procedures, employee training with safety and operating procedures, maintaining mechanical integrity of all equipment, investigations of all accidental releases, and internal compliance audits every three years. Program 2 facilities have limited offsite receptors in the event of a worse-case scenario. Program 3 facilities, the most regulated and demanding of all program levels due to the magnitude of potential harm. The facility is required to do everything defined within Program 2, and more. Additional requirements include identifying process safety information and parameters, conducting a process hazard analysis, writing extensive operating procedures to manage the replacement of a process or equipment (otherwise known as management of change), conducting pre-startup safety reviews on any modified stationary sources that required a change in the process safety information, and employees participating during all aspects of the RMP, hot work permit program, and contractor program.

Within each program, each facility must prepare an accidental release history from the previous five years.⁴⁶ Facilities, as required by RMP, must conduct an OCA scenario to determine their worst-case and alternative accidental release scenarios. OCA identifies locations at risk and potential impact upon a release of hazardous materials. All Program 1, 2, and 3 facilities are also required to submit a summary report every five years to the EPA called the Risk Management Plan Submit (RMP Submit), which includes an executive summary and the facility’s emergency response plan. Process Hazard Analysis (PHA) allows a facility to determine and document the priority order for

⁴⁵ 40 CFR 68, Subpart F, Sec. 68.130.

⁴⁶ 40 CFR 68, Sec. 42.

conducting a hazard assessment on the apparent risk associated with the process.⁴⁷ Allowed methodologies of PHAs include: What-If Analysis,⁴⁸ Checklist, What-If/Checklist,⁴⁹ Hazard and Operability (HAZOP) study,⁵⁰ Failure Mode and Effect Analysis,⁵¹ Fault Tree Analysis,⁵² or an appropriate or equivalent methodology.⁵³ The PHA must address:

- The hazard of the process
- The identification of any previous incidents that had 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. Acceptable detection methods might include process monitoring and control instrumentation with alarms, and detection hardware such as hydrocarbon sensors
- Consequences of failure of engineering and administrative controls
- Facility siting
- Human factors
- A qualitative evaluation of a range of the possible safety and health effects on employees in the workplace if there is a failure of controls.⁵⁴

⁴⁷ “Process Safety Management,” OSHA, accessed January 11, 2016, <https://www.osha.gov/Publications/osh3132.html>.

⁴⁸ A scenario-based hazard evaluation procedure using a brainstorming approach, in which typically a team that includes one or more persons familiar with the subject process asks questions or voices concerns about what could go wrong, what consequences could ensue, and if the existing safeguards are adequate. “Safety & Health Management Systems eTool,” OSHA, accessed January 14, 2015, https://www.osha.gov/SLTC/etools/safetyhealth/mod4_tools_methodologies.html.

⁴⁹ Ibid. A What-If Analysis that uses some form of checklist or other listing of broad categories of concern to structure the what-if questioning.

⁵⁰ Ibid. A scenario-based hazard evaluation procedure in which a team uses a series of guide words to identify possible deviations from the intended design or operation of a process, then examines the potential consequences of the deviations and the adequacy of existing safeguards.

⁵¹ Ibid. A systematic, tabular method for evaluating and documenting the effects of known types of component failures.

⁵² Ibid. A logic model that graphically portrays the combinations of failures that can lead to a specific main failure or incident of interest.

⁵³ Robert B. Reich and Joseph A. Dear, *Process Safety Management Guidelines for Compliance* (OSHA 3133) (Washington, DC: OSHA, 1994).

⁵⁴ Reich and Dear, *Process Safety Management Guidelines*.

The purpose of the PHA is to hold the facility responsible for adequately identifying and assessing the hazard. The facility must then address the findings and recommendations to ensure resolutions in a timely manner.⁵⁵ A thorough PHA should be the foundation for a chemical facility to strategically analyze the equipment, safety systems, and operating procedures for handling regulated substances in their various processes. It is also a way to potentially analyze accident scenarios. In essence, the PHA has the ability to identify the failures that could occur and the analysis of the likelihood of the release occurring. In totality, the findings from the PHA should then focus on ensuring redundancy of safety systems, plans, and mitigation measures in place will function properly and effectively to eliminate or lessen the impact from an accidental release.

To put this all in perspective, an EPA study identified 123 high-risk chemical facilities in the United States with worst-case scenarios that would put one million individuals at risk from exposure to a toxic or flammable vapor cloud should an accidental release occur.⁵⁶ The study additionally identifies 600 other high-risk chemical facilities with worst-case scenarios that threaten populations between 100,000 and one million. This total does not include the 2,300 other high-risk chemical facilities that have a worst-case scenario affecting a population or receptor of 10,000 to 100,000 should a toxic or flammable vapor cloud be catastrophically released.⁵⁷ According to the EPA, there are 12,743 national facilities currently regulated under RMP. In EPA Region IX alone, there are 1,780 RMP facilities.⁵⁸

The number of high-risk U.S. chemical facilities is statistically alarming when considering governing regulatory agencies are unable to conduct routine inspections due

⁵⁵ EPA, "Process Hazard Analysis," *Chemical Emergency Prevention & Planning Newsletter*, July–August 2008, http://www3.epa.gov/region10/pdf/rmp/cepp_newsletter_0708.pdf.

⁵⁶ John Stephenson, *Voluntary Initiatives are Under Way at Chemical Facilities, but the Extent of Security Preparedness is Unknown* (GAO-03-439) (Washington, DC: General Accounting Office, March 2003), 4.

⁵⁷ Stephenson, *Voluntary Initiatives*, 4.

⁵⁸ FedEPA Region IX includes Arizona, Hawaii, Nevada, California, and Pacific Islands. "Pacific Southwest, Region 9," EPA, accessed June 11, 2015, <http://www.epa.gov/region9/enforcement/>.

to limited resources and often proper training.⁵⁹ Because of this, some states have developed additional and more restrictive reporting thresholds on top of the federal RMP program. During the writing of this thesis, legislative proposals to amend the PSM and RMP programs may potentially create regulations and policy to improve chemical safety and security throughout at these high-risk facilities.

The function of many of our critical infrastructures and key resources depend upon the chemical sector. A catastrophic attack on a key chemical facility would cause devastating and cascading reaction effects on other sectors. So, not only would a catastrophic release affect a community and the environment, it may potentially cause a compounding effect on the global economy.

More recently, Presidential Executive Order 13650 (EO 13650) mandates the establishment of the Chemical Facility Safety and Security Working Group, combining DHS, the EPA, Department of Agriculture, Department of Justice, Department of Transportation, and Department of Labor to improve operational coordination with state, local, and chemical industries.⁶⁰ EO 13650 was initiated due to the West, Texas ammonium nitrate explosion on April 17, 2013. The order focuses on several areas of effort to enhance federal coordination; information collection and sharing; regulation modernization; guidance, policy, and standards; and best practices. The working group, led by the EPA, has been developing operational and coordinating plans to further enable all stakeholders (including state regulators, emergency responders, industry, and communities) “to work together to improve chemical facility safety and preparedness.”⁶¹

Key concepts for review and establishment include engagement with regulatory agencies in the local emergency planning process. EO 13650’s scope is to improve the training of first responders to include technical assistance with prevention and preparedness at the SERC and LEPC levels. Electronic reporting and data management between agencies are also to be improved. Improving public access to information about

⁵⁹ EPA Office of Inspector General, *Report: Improvements Needed in EPA Training and Oversight for Risk Management Program Inspections* (Report No. 13-P-0178) (Washington, DC: EPA, March 2013).

⁶⁰ Exec. Order No. 13650, *Improving Chemical Facility Safety and Security* (2013).

⁶¹ Exec. Order No. 13650.

chemical facilities while simultaneously protecting security and sensitive information is also required by EO 13650. With EO 13650, the collaborative efforts may facilitate the working relationships that are needed to ensure the safety of our first responders and communities from chemical disasters.

The United States Chemical Safety Board (CSB) was created by Congress as part of the 1990 CAA amendments to investigate chemical-related industrial accidents. As a separate and non-governed agency, Congress gave the CSB the authority to fully investigate and identify the causes of accidents without any direct oversight from other agencies or the executive branch. Its focus is to merely understand the circumstances that led to, and to determine the cause of, the chemical accident. It is simple to identify unanticipated chemical reactions or hazards, mechanical or process equipment failures, or lack of training, but it is harder to truly get to the bottom of those reasons of failure. The CSB identifies the root causes of deficiencies within the safety management systems that may have resulted in the disaster. Common root causes of failures may include human error, inefficient safety culture within the organization or facility, or a gap in regulatory oversight.⁶² In addition, the CSB also makes recommendations to OSHA and EPA to review the effectiveness of regulations and their enforcement.⁶³ A number of regulatory safety gaps have been identified by the CSB to OSHA and EPA in the RMP and PSM programs. Effective safety management systems are essential, as are key concepts that require high-risk chemical facilities to operate and function at a higher level of stewardship in safety. These concepts protect facilities' vested interest in their employees, investors, products, profits, communities, first responders, and the environment.⁶⁴

⁶² "Mission," CSB, accessed October 3, 2015, <http://www.csb.gov/about-the-csb/mission>.

⁶³ CSB Homepage, accessed October 3, 2015, <http://www.csb.gov>.

⁶⁴ The case studies in this thesis are and have been investigated by the CSB. These case studies have also resulted, and will yet result, in a number of regulatory changes to improve the safety of facilities that handle hazardous materials. An analytical review of those results will assist the community as a whole to utilize those findings to better prepare for a chemical disaster.

B. THE TERRORIST FACTOR

A study conducted by the Lawrence Livermore National Laboratory asserts that motivational and social factors affect terrorist organizations' predisposition to attack chemical facilities.⁶⁵ The study investigated three predominant questions:

- Why do terrorists choose to attack chemical-related infrastructures over other targets?
- What specific factors influence their target selection decisions concerning chemical facilities?
- Which, if any, types of groups are most inclined to attack chemical infrastructure targets?⁶⁶

In this particular literature, the assessment defined critical chemical infrastructure and its significance regarding both the economy and public safety. The study also delves into other terrorism-related threat assessments and industry-specific literature, presenting a well-rounded approach for identifying high-risk chemical facilities that are targets of interest for acts of terrorism. Government reports, chemical industry analysis, studies conducted by environmental organizations, and other sources were used to establish the threat of terrorist attacks on chemical facilities. Most of the research was conducted after 9/11 and mainly focused on possible effects of a successful terrorist attack against a chemical facility or the existing security vulnerabilities of chemical facilities. Because no previous studies had examined terrorist motivations for attacking chemical facilities, the Lawrence Livermore study provided valuable insight into how critical chemical infrastructures might best be understood in the context of counterterrorism. It also indicated a wide range of motivations that may or may not cause terrorists to attack critical chemical infrastructures. In general, the study highlights that terrorists target chemical infrastructures to accomplish operational objectives that fall into one or more discrete categories, such as mass casualties, physical destruction, environmental contamination, economic downfall or disruption, disruption of strategic industrial

⁶⁵ G. Ackerman et al., *Assessing Terrorist Motivations for Attacking Critical Chemical Infrastructure* (UCRL-TR-227068) (Livermore, CA: Lawrence Livermore National Laboratory, January 2004).

⁶⁶ Ackerman et al., *Assessing Terrorist Motivations*.

functions, or acquisition of chemicals for weapons. This is done to directly and indirectly influence or establish their social identity within a terrorist network.⁶⁷

By recognizing that certain chemical facilities can be catastrophically damaged, terrorists seeking weapons of mass destruction (WMDs) could sidestep many of the technical and resource hurdles associated with building such weapons by simply attacking a high-risk chemical facility. Chemical facilities are present in populated areas and near other key critical infrastructures and major routes of transportation. This provides additional potential targets for terrorists to leverage into cascading failures. Livermore's study, in particular, also identifies that the majority of the country's critical chemical infrastructures remain inadequately secured. Despite the recognition that chemical facilities can be attacked with catastrophic consequences, little has been done to enhance physical security around most chemical facilities. As a consequence, chemical facilities remain vulnerable targets.

The Lawrence Livermore study reviewed incidents chronologically from 1933 to 2004. Within that time frame, low incidents of terrorist attacks against chemical infrastructures occurred. The majority of cases identified suggested that the primary motivation behind the attacks was opposition to ruling governments. This suggests that external terrorist threats against the chemical sector may not be as likely as they seem. Yet, in the world of terrorism, tactics and mindsets are always evolving. The overriding conclusion of these case studies is that terrorists are capable of attacks on chemical infrastructures. If such a mindset exists within a terrorist organization, significant damage could truly harm and impact first responders, communities, and the environment.⁶⁸ Potential catastrophic damage of the chemical sector could manifest as a coordinated attack on a number of facilities, leading to cascading effects on other industries or

⁶⁷ Social identity theory offers an understanding of terrorist organizations' motivational objectives, whether related to in-group or out-group cohesion, or external factors; it is an effective methodology to analytically understand terrorist groups and their actions. David Brannan, Kristin Darken, and Anders Strindberg, *A Practitioner's Way forward: Terrorism Analysis* (Salinas, CA: Agile Research and Technology, 2014), 153.

⁶⁸ Ackerman et al., *Assessing Terrorist Motivations*.

infrastructures, accompanied by mass casualties and widespread economic instability.⁶⁹ Because an incident of such scale would require a coordinated effort by groups of individuals with specific scientific or technical knowledge, however, an attack on a chemical facility by a terrorist organization is less likely to occur than a failure from a non-deliberate act causing a chemical disaster. A community's safety is best guaranteed with an all-hazards approach. The Livermore study concludes that the community must understand its hazards and the importance of identifying vulnerabilities for community preparedness.

C. THEORIES OF RISK ASSESSMENT

Homeland Security Presidential Directive 7 (HSPD-7) directs the Secretary of Homeland Security to coordinate the nation's effort in identifying, prioritizing, and protecting critical infrastructure and key resources.⁷⁰ Presidential Policy Directive 21, *Critical Infrastructure Security and Resilience*, replaced HSPD-7 in 2013.⁷¹ The 16 critical infrastructure sectors assess vulnerabilities by utilizing risk strategies to protect and mitigate terrorist attacks against those identified critical infrastructures. As stipulated by HSPD-7, the National Infrastructure Protection Plan (NIPP) was created.⁷² The NIPP ultimately provides a strategy of actionable objectives to reduce the vulnerabilities of those sectors. The 2013 NIPP identified its main goals as to:

- Evaluate and analyze critical infrastructure threats, vulnerabilities, and consequences to information risk management
- Address multiple threats through sustainable efforts to reduce risk; account for costs and benefits of security investments
- Enhance critical infrastructure resilience; minimize the adverse consequences of incidents, as well as conduct effective responses

⁶⁹ Margaret E. Kosal, *Chemical Terrorism: U.S. Policies to Reduce the Chemical Terror Threat*. (Atlanta: Georgia Institute of Technology, September 2008).

⁷⁰ Department of Homeland Security, *Critical Infrastructure Identification, Prioritization, and Protection* (HSPD-7) (Washington, DC: Department of Homeland Security, 2003).

⁷¹ "Critical Infrastructure Sectors," Department of Homeland Security, accessed July 15, 2015, <http://www.dhs.gov/critical-infrastructure-sectors>.

⁷² Department of Homeland Security, *NIPP 2013: Partnering for Critical Infrastructure Security and Resilience* (Washington, DC: Department of Homeland Security, 2013).

- Share actionable and relevant information across the critical infrastructure community to build awareness and enable risk-informed decision making⁷³

According to the Interagency Security Committee, “Risk is a function of threat, vulnerability, and consequences. The objective of risk management is to create a level of protection that mitigates vulnerabilities to threats and the potential consequence, thereby reducing risk to an acceptable level.”⁷⁴ There are many models and methodologies that assess threats, vulnerabilities, and risks, all of which can be integrated to determine risk. Roper’s *Risk Management for Security Professionals*, for example, provides clear guidance for the methodology and assessments.⁷⁵ One way Roper suggests risk can be calculated through critical assessments that identify assets and characterize those assets’ vulnerability to specific threats.⁷⁶ From that, risk reduction and prioritization of risk reduction activities can be identified and implemented. All of this is, of course, predicated upon a reproducible process for risk measurement.

Roper’s methodology identifies assets within the community, activities and operations, information, businesses, and equipment.⁷⁷ He asserts that not every asset is as important as another; all assessments must be analyzed according to the asset’s criticality. In order to assess resources, assets judged to be most critical are provided prioritization. Should the loss of a particular asset threaten the survival or prosperity of those who depend on it, the higher it falls on the criticality spectrum. Consequences can be separated and identified with end results related to factors that are economic, financial, environmental, health and safety related, technological, operational, or timeliness related.⁷⁸ For example, a facility has identified that their decrepit process control center

⁷³ Department of Homeland Security, *NIPP 2013*.

⁷⁴ Interagency Security Committee, *The Risk Management Process for Federal Facilities: An Interagency Security Committee Standard* (Washington, DC: Department of Homeland Security, 2013).

⁷⁵ Carl A. Roper, *Risk Management for Security Professionals* (Oxford: Butterworth-Heinemann, 1999).

⁷⁶ Roper, *Risk Management*.

⁷⁷ *Ibid.*

⁷⁸ John Moteff, *Risk Management and Critical Infrastructure Protection: Assessing, Integrating, and Managing Threats, Vulnerabilities, and Consequences* (CRS Report No. RL32561) (Washington, DC: Congressional Research Service, 2005).

could potentially fail, causing a catastrophic system failure with a chemical release. Knowing that the replacement of this equipment would cause significant downtime, resulting in a disruption to production and a loss in revenue—coupled with the capital costs associated with replacing the failing component—the facility chooses to spend its money elsewhere for the time being until the components reaches failure point. The consequences resulted from an asset’s failure to reduce associated risks for a number of reasons, one being its priority was on competitive advantage and financial costs rather than safety. While the immediate impact of the incident may be significant, the social ramification and resources required to replace those lost assets may be invaluable.

To identify, characterize, and assess threat, Roper first defines threat as “any indication, circumstance or event with the potential to cause loss or damage to an asset.”⁷⁹ He further explains that, in order to fully assess threat, one should consider the evaluation of insider, terrorist, military, or environmental threats. The intent, motivational factors, capabilities, methods, and trends all change depending on the course of objectives.

Risk also implies uncertain consequences. HSPD-7 provides guidance to help facilities identify, prioritize, and coordinate the protection of key assets that have the potential to cause epidemic outbreaks with mass casualties, similar to the effects of WMDs.⁸⁰ Much greater criticality should be given to loss of life consequences by those incidents.

⁷⁹ Roper, *Risk Management*, 43.

⁸⁰ The *Chemical Sector-Specific Plan: An Annex to the National Infrastructure Protection Plan* offers a unifying structure to achieve the NIPP’s goal. Department of Homeland Security, *Chemical Sector-Specific Plan: An Annex to the National Infrastructure Protection Plan* (Washington, DC: Department of Homeland Security, 2010).

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III. RESEARCH DESIGN

Currently, there is a disconnect between emergency management professionals, governing regulatory agencies, and industry that hinders their ability to work effectively together to recognize, plan, and prepare for chemical disasters. Though emergency response plans for hazardous materials emergencies do exist in communities, they have not addressed several common failures that are root causes of chemical disasters. Addressing these root causes would greatly enhance prevention. Furthermore, communities lack a common framework for understanding how to communicate, regulate, and recognize risks effectively. In essence, though emergency response plans do exist, without a framework to implement them communities have not assessed nor prepared for hazardous materials disasters. The objective of this study is to understand the root causes of those failures and, using those causes as lessons learned, to create a framework that a community can use to collaboratively prevent and better prepare for chemical disasters. The proposed framework provides solutions on how to effectively work together to analyze risks and identify high-risk chemical facilities' vulnerabilities, as well as how regulations and communication can help stakeholders prepare for chemical disasters. This framework can then be used to develop and implement a plan that would better assist in coordination and resource allocation in the event of a hazardous materials incident.

A. MODE OF ANALYSIS

This thesis is organized into chapters and sections that help the reader understand the elements used to create the suggested framework. Two case studies were evaluated, each involving a chemical disaster within a community. Each case study discusses the failures, synthesizes the root cause of the failures, and identifies three main disconnects related to emergency management, the regulatory framework, and industry. The mode of analysis is the evaluation of these failures, which helps determine the likelihood and severity of the risks and the resulting consequences.

Chapter IV introduces the suggested framework by providing background information related to hazard assessments and the necessary framework for analyzing the case studies. Chapters V and VI present the case studies, beginning with a brief overview of the incident, followed by a detailed evaluation of the incident that identifies the root cause of its failures. Each case study is analyzed by comparing the actions or safeguards taken against those ignored, and how that impacted the community. These case studies synthesize, in detail, the root cause of the failures as well as the resulting casualties, property damage, business interruption, and environmental damage.

After the case studies are analyzed, Chapter VII offers solutions that communities can use to address the root causes found in those case studies. The elements of this new framework allow communities to learn from their mistakes and improve their overall safety culture. The ability to recognize effective safeguards and to develop a safety culture is another key piece of the puzzle; “Safety culture is a considered a subcomponent of corporate culture, which alludes to individual, job and organizational features that affect and influence safety.”⁸¹ Effective leadership must develop, communicate, and implement the safety culture change process. This process must be proactive and must involve all levels of management and individuals.

B. SELECTION

The two case studies were selected from several large-scale hazardous materials chemical industrial accidents that resulted in injuries, death, economic disruption, and environmental damage. All the accidents analyzed have identical failures and root causes that could have been prevented. In addition, each case study displays catastrophic failures from non-deliberate acts such as a mechanical failure, failure of the safety culture, and regulatory inconsistencies. The impacts of those failures could have been greatly diminished if protective measures that were identified had actually been implemented. This is a result of a failure to recognize the urgency or significance of failure in a particular element of the process.

⁸¹ Dominic Cooper, “Safety Culture: A Model for Understanding & Quantifying a Difficult Concept,” *Professional Safety*, June 2002: 30–36.

The case study analyses allow for the identification of key concepts and root causes of the chemical disasters. It is important to understand the existing regulatory framework in which these incidents occurred. Many states rely solely on the federal government's existing regulatory framework. The two case studies presented exist in states that have two very different, yet similar, regulatory frameworks: California and Texas. Both states have different regulatory environment and presence, yet the same root causes of failure can still be identified. The concept and the intent of the California program is distinguished from other state and federal regulatory authorities. Data include a facility's chemical inventory, emergency response procedures, site maps, and identification of hazards associated with their processes as well as their risk assessment. Dissemination of the data is also important to understand if the program and the information provided are intended to safeguard communities and first responders. Even in California's more restrictive regulatory framework, there are missed core failures within safety compliance and safety culture.

With the careful selection of case studies and understanding of risks and regulatory frameworks, the analysis and evaluation of the information can be combined to create a model that identifies vulnerabilities and risks associated with high-hazard materials facilities, and that helps determine the likelihood of failures and the resulting impacts. By understanding and identifying the impacts, a community can better prepare for and prevent chemical emergencies.

C. DATA SOURCES

Data sources come from the open literature, inventory reports, process hazard analysis reports, incident investigations, and inspection records of the case studies. The two case studies considered in this thesis were:

- The West Fertilizer Company explosion in West, Texas
- The Chevron Refinery fire in Richmond, California

Data sources for the West Fertilizer Company explosion include investigations conducted by the CSB, inspection reports from regulatory agencies, open literature, and incident and analytical findings. The analysis focuses on the safety culture at this facility.

The focus of this data collection was the failures to recognize a hazard's severity, as well as the need for community preparedness and understanding of risks associated with chemical facilities. This case study emphasizes the regulatory differences and first responder knowledge about these types of hazardous materials facilities. The importance of this case study is to acknowledge the various existing regulatory frameworks for the value and significance of data sharing and regulatory oversight, and the need for community preparedness. By grouping the data by the risk analyses and identified failures, this study identifies the root causes of the failure to recognize risk.

Analysis of the Chevron Refinery accident includes investigations conducted by the CSB, inspection reports from regulatory agencies, an open literature review, and incident and analytical findings, including the failure to recognize the hazard and actionable prioritization of consequences and impacts. Impacts of failed mechanical systems and inappropriate identification of failed communication within a community resulted in a catastrophic release of a hazardous material into a community, resulting in injuries, casualties, damage to the environment, business interruption, economic burden, and change to regulatory oversight.

D. LIMITATIONS

This study does not complete a summative evaluation and does not make generalizations about risk analysis and its effectiveness; it merely identifies common failures and their root causes in order to help communities learn from those failures and adequately prepare for a chemical disaster. Ultimately, this study aims to increase the community's ability—as a whole—to recognize risks and to prevent, protect from, and prepare for those risks. The case studies and their risk assessments should be evaluated in terms of consequences and impact, and action prioritization should be based on the likelihood and severity of a chemical disaster. The process hazards analysis and protective measures should be evaluated based on if the identified risk is actionable and effective. Evaluating each case study's chemical disaster according to its PHA may reflect missed or wrongly categorized risk associated with a risk matrix.

The case studies in this thesis do not represent all hazards, but are restricted to mechanical/process equipment and organizational, regulatory, and human failures. As a side note, catastrophic failures of a high-risk chemical facility arising from a natural disaster have far more catastrophic consequences than detailed in this thesis. However, if hazards are evaluated correctly, natural disasters most certainly can be considered within the present framework, since they would have similar requirements for protective measures, stakeholder collaboration, and community preparedness to lessen the risk. Therefore, plant vulnerabilities and their identified risks arising from hazard assessments that include mechanical failures, personnel failures, and natural disasters would have far-reaching effects that would also protect communities from acts of terrorism and sabotage. This study shows that an all-hazards approach to risk analysis provides a high-risk chemical facility the ability to allocate its protective investments in a manner that would also encompass terrorism.

As mentioned previously, the regulatory framework in each case study's state must be taken into consideration. California's framework should be carefully assessed. California is a large state that encompasses various demographics and diverse communities that represent much of the United States; it has communities that are urban, suburban, and rural with integrated industrial, agricultural, and manufacturing facilities. The regulatory framework in California (described later in this thesis) may not work for every state. Many rural communities do not have the ability or resources necessary to conduct studies and must rely on either the state or federal government to conduct them. In many communities throughout the United States, the collection and dissemination of data from chemical facilities is vastly different. Comparing options when seeking the right regulatory framework is important since a key element for successful consequence management includes information sharing so communities can preplan for a chemical disaster.

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IV. A FRAMEWORK TO ANALYZE THE CASE STUDIES

To help gain an understanding of the framework, several key terms must first be defined:

Incident: “An unexpected and usually unpleasant thing that happens.”⁸²

In this thesis, **incident** is an event or series of events that result in an adverse impact or exposure to an employee, contractor, property, community, or the environment.

Near miss: “An accident that is just barely avoided.”⁸³

In this thesis, a **near miss** is an unplanned event that had the potential for injury or damage to property, environment, social and economic reputation, or financial performance.

Hazard: “A source of danger.”⁸⁴

In this thesis, a **hazard** refers to the presence of a dangerous material or condition—such as a large inventory of a toxic gas—where loss of control could lead to casualties, property damage, interruption losses, and/or environmental damage.

Risk Analysis: “A procedure in the identification of risks by analyzing them to understand the potential failures, and to assess how to eliminate or reduce those risks.”⁸⁵

In this thesis, a **risk analysis** is an estimate of frequency and severity of undesired events.

⁸² *Mirriam-Webster*, s.v. “Incident,” accessed January 14, 2016, <http://www.merriam-webster.com/dictionary/incident>.

⁸³ *Mirriam-Webster*, s.v. “Near miss,” accessed January 14, 2016, <http://www.merriam-webster.com/dictionary/near%20miss>.

⁸⁴ *Mirriam-Webster*, s.v. “Hazard,” accessed January 14, 2016, <http://www.merriam-webster.com/dictionary/hazard>.

⁸⁵ International Organization for Standardization, *ISO/IEC Guide 27001:2009: Information Technology—Security Techniques—Information Security Management Systems—Requirements* (Geneva, Switzerland: ISO, 2013).

Safeguard: “Something that provides protection against possible loss, damage, etc.”⁸⁶

In this thesis, a **safeguard** is a physical device, a process, system, or action that would interrupt the sequence of initiating event or that would mitigate or lessen an impact from a loss event.⁸⁷

A. THE REVIEW PROCESS

Using risk analysis, an emergency management professional can measure and quantify risk. A significant vulnerability with little or no safeguards in place exhibits high likelihood of a release or failure, resulting in significant risk. Conversely, having a low vulnerability and substantial safeguard will likely reduce the risk of a release or a failure. It is important to remember, however, that if the impact is substantially low and the risk inconsequential or acceptable, safeguards may not be necessary.

Hazard identification starts by surveying the nature of materials and the use conditions. All hazardous materials have their own hazard properties based on the chemical composition and physical, chemical, and toxicological properties, such as flammability, reactivity, corrosivity, vapor pressure, boiling point, and toxicity. Other use conditions considered should be the temperature and pressure of the material, ambient temperatures, and the proximity to other chemicals. A hazard assessment can help identify the risks and vulnerabilities associated with a process and its equipment.⁸⁸

B. ANATOMY OF AN INCIDENT

An incident event (see Table 1) can transform the threat posed by a process hazard into an occurrence. The first event in an incident is known as the initiating cause or initiating event. An initiating event can be identified or predicted during a PHA as an anticipated system process failure mode or system perturbation. Any operation outside of normal is considered a deviation with potential incident outcomes if system control

⁸⁶ *Mirriam-Webster*, s.v. “Safeguard,” accessed January 14, 2016, <http://www.merriam-webster.com/dictionary/safeguard>.

⁸⁷ Center for Chemical Process Safety (CCPS), *Guidelines for Hazard Evaluation Procedures*, 3rd ed. (New York: Wiley-Interscience, 2008), xxvi.

⁸⁸ CCPS, *Guidelines for Hazard Evaluation Procedures*, xxiv.

safeguards are not put into place. The severity of consequences of the loss event is considered the impact. The impact can be a measure of the loss and harm from the event, such as the number of injuries and/or fatalities, environmental and/or property damage, material loss, production and recovery costs, or a combination of these factors.⁸⁹

Table 1. Potential Hazard Events at Chemical Facilities

Process Hazards	Initiating Causes	Incident Outcomes
• Hazards of the chemical ○ Toxicity, flammability, reactivity, corrosivity • Physical conditions of the storage of the materials ○ Pressure, temperature	• Containment failures ○ Pipes, vessels • Equipment malfunctions ○ Pumps, valves, compressors, sensors, control failures • Loss of necessary utilities • Human error • External events ○ Earthquakes, vandalism, sabotage, other incidents	• Loss events ○ Release, fire, explosion • Exposure to ○ Community, workers, environment • Loss of production, monetary revenue

Adapted from EPA. “Clean Air Act 112(r) Risk Management Program (RMP),” *Chemical Emergency Prevention & Planning Newsletter*, July–August 2008, http://www3.epa.gov/region10/pdf/rmp/cepp_newsletter_0708.pdf.

⁸⁹ CCPS, *Guidelines for Hazard Evaluation Procedures*, xxiv.

C. SAFEGUARDS

Safeguards are engineered systems or administrative controls that prevent a failure within a chemical process.⁹⁰ Safeguards can protect against system deviations that can progress to a loss event, but can also mitigate the immediate loss event. Safeguards fall into three basic classifications:

- Safety systems in place within a process that assist with process failure
- Detection and monitoring devices that provide early warning following the release of a hazardous or flammable material
- Written operating procedures that mitigate the human factor to prevent the release of hazardous or flammable material

Different safeguards can have different functions, depending on whether they are preventative or mitigative safeguards. A preventative safeguard or an active layer of control serves to achieve a safe state of operation when the process has gone awry; it is able to disrupt an initiating cause factor and prevent the loss event(s) from following. Preventative safeguards do not affect the likelihood of initiating causes, but do affect the probability of a loss event given an initiating cause. Therefore, the preventative safeguard affects the overall scenario frequency. An example of a preventative safeguard may include an automatic safety system, such as pressure valve relieving overpressure from a pressurized vessel. Another example would be a safety alarm, which prompts the equipment operator to manually shut down the process before a system failure can occur. Preventive safeguards also affect the overall scenario frequency to avoid a loss event or a more severe loss event from occurring. In order to avoid a loss event from a mechanical equipment failure, for example, a control or design safeguard would automatically shut down the system when it detects an inconsistency to prevent failure. Preventative safeguards can also include existing mechanical integrity, preventative maintenance, inspection, testing, operator training, backup systems, and automatic/manual process controls. A mitigative safeguard or a passive safety control, on the other hand, is designed to reduce the severity of consequences of a loss event. Mitigative safeguards directly affect safety, business, community, and environmental impacts resulting from a

⁹⁰ Ibid.

fire, explosion, toxic release, or other irreversible physical events.⁹¹ Examples of these safeguards may include secondary containment, flammable/release detection sensors, blast-resistant supports, isolation valves, deluge systems, and emergency response and emergency management planning. The objective of a mitigative safeguard is to detect and respond to emergency situations in such a way as to reduce the impacts of loss events.

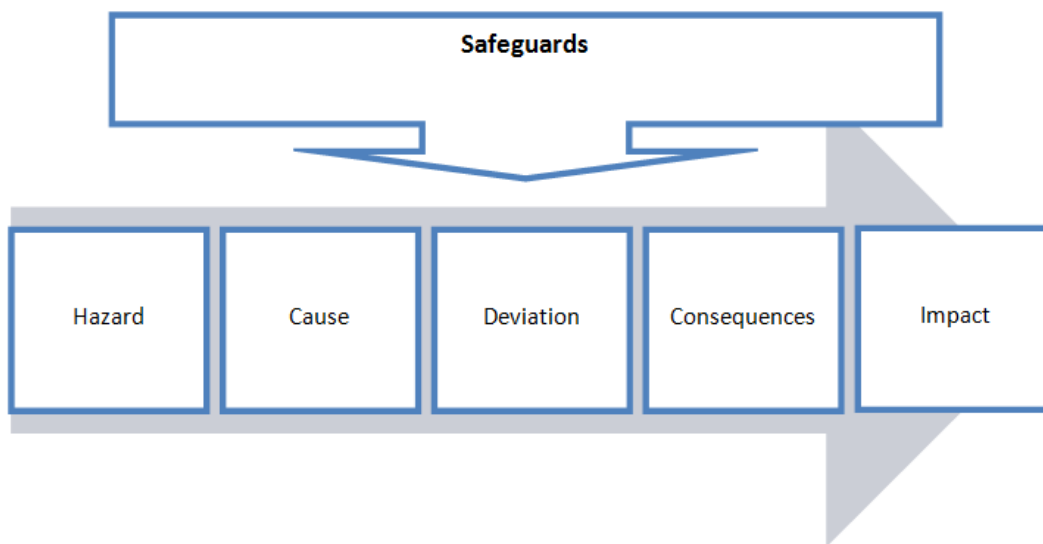
In addition to mitigative and preventative safeguards, inherently safe approaches and methods of reducing risks include:

- Eliminating by removing the hazard
- Substituting by replacing or lowering concentrations of a lesser hazardous material
- Minimizing the quantity of chemical stored, used, or generated
- Modifying operations to inherently safer designs
- Isolating or moving the hazard further away from a sensitive receptor

Recognizing key mitigative and/or preventative safeguards is essential for an emergency management professional during a facility's safety review. Identifying safeguards can directly prevent a catastrophic release from occurring or can lessen the impact should a release of a hazardous material occur. As shown in Figure 2, safeguards should be put in place at all levels of the process to lessen the impact.

⁹¹ CCPS, *Guidelines for Hazard Evaluation Procedures*, 28.

Figure 2. Role of Safeguards in the Event Process

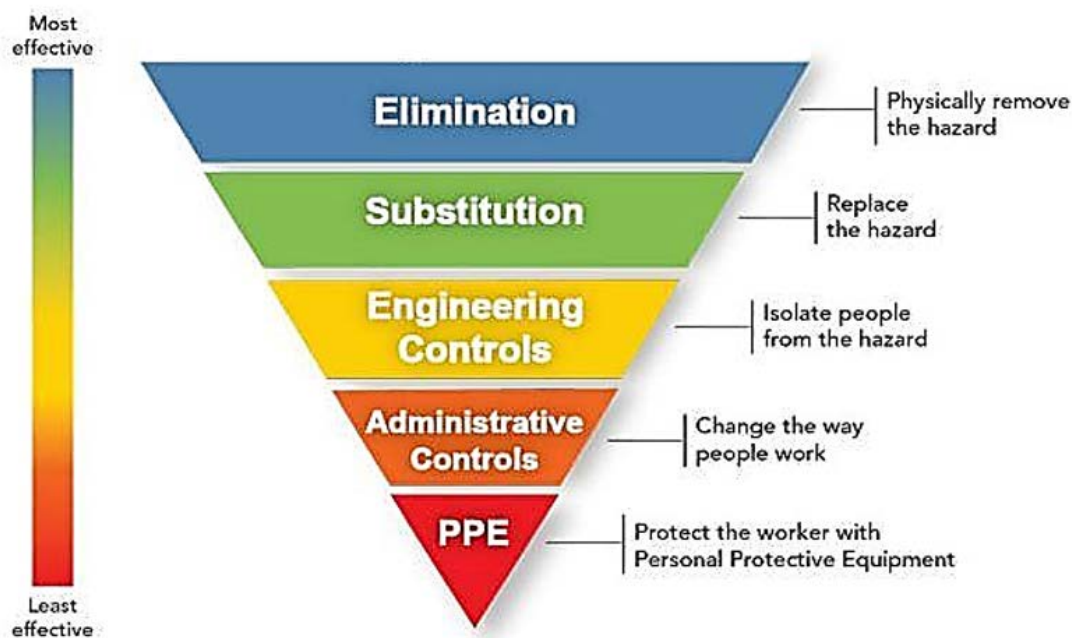


The safeguards can be used to reduce each of the contributions to the failure chain, reducing the overall impact. Adapted from Center for Chemical Process Safety, *Guidelines for Hazard Evaluation Procedures*, 3rd ed. (New York: Wiley-Interscience, 2008), 218, Figure 7.4.

Inherently safer designs integrated into a chemical process ultimately reduce the risk of a catastrophic and cascading failure by reducing the consequence should an impact or hazard occur.⁹² The more advanced the system is according to the hierarchy of controls (seen in Figure 3), the more effective the risk reduction.

⁹² CCPS, *Inherently Safer Chemical Processes—A Life Cycle Approach*, 2nd ed. (Hoboken, NJ: Wiley, 2009), section 2.1.

Figure 3. Hierarchy of Controls



The control methods at the top of the chart are often viewed as being more effective and protective than those at the bottom. Source: "Hierarchy of Controls," CDC, last modified April 21, 2015, <http://www.cdc.gov/niosh/topics/hierarchy>.

Inherently safer principles rely on risk reduction through: 1) avoiding hazards, 2) reducing severity, and 3) reducing likelihood. Currently, there are no regulatory requirements for chemical facilities to analyze or evaluate their process design equipment to use inherently safer technologies. The reduction of process hazards using hierarchical controls—with safe designs at the top of the hierarchy—should always be evaluated. Ultimately, an inherently safer system will reduce the risk of injury and exposure to both the employees and community.

The process of investigating an incident allows an emergency management professional to understand and evaluate trends to identify root causes that may have contributed to the incident. Incident investigations are often triggered by one or multiple occurrences, such as injury/fatality, fire, loss of production or profit, regulatory requirement after a release or injury, or mainstream media or social media. One of the hardest aspects of evaluating root causes is analyzing for trends and systemic issues. By

determining and sharing lessons learned, many of these incident investigations can be applied across fields to prevent similar accidents.

D. KEY HAZARD EVALUATION OBJECTIVES: THREAT ASSESSMENT

Controls needed to mitigate hazards can only be established if the hazards have been identified and evaluated. The following list provides examples of key hazard evaluations that an emergency management professional or a risk analysis professional should be evaluating:

- Identify chemical reactions that could cause runaway reactions, fires, explosions, or toxic gas releases
- Identify process safety data
- Identify possibilities of alternate inherently safer chemicals, process, or units
- Incorporate an inherently safer design of process
- Compare hazards of from nearby sites
- Seek other historical incidents and lessons learned on similar facilities within the industry
- Identify facility siting
- Identify and understand the ways hazardous materials may be released into the environment through the process
- Identify potential hazardous operator interfaces
- Determine who may be impacted or affected
- Strive for source and waste reduction
- Identify detailed engineering of flammable/toxic mixtures forming inside process equipment
- Develop a report and notification process for spills
- Develop a process for mitigating a release
- Develop emergency response procedures
- Identify process control malfunctions that can cause runaway reactions

- Evaluate preventative and mitigative safeguards for effectiveness
- Identify safety-critical equipment for routine maintenance testing, inspection, and frequency of replacement
- Identify issues during start-up and operating procedures
- Verify previously identified deficiencies and intolerable risks have been corrected
- Identify hazards associated with vessels, piping, cleaning procedures, safety, shutdowns, emergency operations, and standard (routine) operations
- Identify employee hazards associated with operating procedures
- Identify hazards associated with new, existing, or out-of-service process equipment
- Track historical data concerning natural disasters such as tornados, hurricanes, floods, fires, or earthquakes
- Identify target attractiveness to social, political, or environmental threats

These factors and many more create a roadmap to assist emergency management and the community. When identifying the infrastructure, a detailed review should be conducted to prepare for, prevent, and mitigate the effects of a chemical incident. In identifying the hazard evaluation objectives, the results should pinpoint if vulnerabilities have been identified and if there are layers of protection or safeguards in place to lower those vulnerabilities and, ultimately, to reduce risk.

After process hazards have been identified, it is essential to review the worst-case scenario consequences for the identified hazard. This achieves several objectives. For each of the hazards of concern, the consequences show the radius/distance and the estimated impact in terms of number of persons or receptors potentially affected. The assessment will calculate a distance to end point for a worst-case scenario and will then determine the impacts on surrounding populations, buildings, and equipment. The method of hazard assessment within the EPA's RMP Rule is one of the chosen sources to determine the worst-case scenario distance for toxic releases, fires, and vapor cloud

explosions involving high-risk chemicals. The RMP*Comp modeling is used in this study.

E. UNDERSTANDING RISK

Determining the need for action comes with two issues:

- Risk estimation—the likelihood and severity
- Risk assessment—action needed qualifier

The need for action, including a process or procedure change, is based on the level of risk for each scenario. Risk is commonly defined as the product of consequences (hazard) and frequency (likelihood) with the effectiveness of safeguards.⁹³

$$\text{RISK} = f \left\{ \frac{\text{Frequency}}{\text{Effectiveness of Safeguards}} \times \text{Severity of Consequence} \right\}$$

Risk is estimated by orders of magnitude, as are the frequencies, using a ranking scheme.⁹⁴ The higher the rank number, the higher the severity of the consequence; the higher the frequency or likelihood of the event to occur, the higher the category it is given. These are placed into a risk matrix (see Table 2) and used to assist the risk manager.⁹⁵ A risk analysis matrix provides one measure of acceptable risk and understanding of frequency of failures and the magnitude of consequences. Though these risk matrices are highly granular, they can be used effectively when identifying hazards related to chemical facilities.

⁹³ CCPS, *Inherently Safer Chemical Processes*, Section 2.1.

⁹⁴ CCPS, *Guidelines for Chemical Process*.

⁹⁵ J. S. Arendt and D. K. Lorenzo, *Evaluating Process Safety in the Chemical Industry: A Manager's Guide to Quantitative Risk Assessment* (Hoboken, NJ: Wiley, 2000).

Table 2. Risk Matrix = Severity of Consequence x Frequency/Likelihood

Severity	Catastrophic Hazard Category 5	5	10	15	20	25
	Significant Hazard Category 4	4	8	12	16	20
	Moderate Hazard Category 3	3	6	9	12	15
	Low Hazard Category 2	2	4	6	8	10
	Negligible Hazard Category 1	1	2	3	4	5
		Improbable Likelihood Category 1	Remote Likelihood Category 2	Occasional Likelihood Category 3	Probable Likelihood Category 4	Frequent Likelihood Category 5

Frequency/Likelihood

Very High	Risk is unacceptable. Immediate corrective action or measures must be taken to reduce the risks and mitigate the hazards. Maximum resources should be made to protect from this level of risk.
High	Risk is unacceptable and undesirable. Measures to reduce risk and mitigation of hazard should be implemented as soon as possible. Moderate resources should be utilized to protect from this level of risk.
Medium	Risk may be acceptable over a short period of time but needs controls. Plans to reduce risk and mitigate the hazard should be corrected within a year. Minimal resources should be spent to protect risks at this level.
Low	Risks are acceptable. Measures to further reduce risk or mitigate hazards should be implemented in conjunction with other security and mitigation upgrades.

Adapted from "IP Protection Risk Factor Decision Matrix," Cipher, accessed January 14, 2016, <http://www.cipher-sys.com/wp-content/uploads/2014/09/IP-Protection-Risk-Factor-Decision-Matrix.png>.

Hazard analysis identifies hazards and the effects of the reasonable worst-case scenario impacts associated with that hazard. Risks associated with the facility's process must first be identified and assessed in order to determine if the safeguards implemented are sufficient or if additional layers of protection are required.

Hazard categories for the severity of the consequence identified commonly in industry standards are as follows:

- Hazard Category 1: Negligible
- Hazard Category 2: Low
- Hazard Category 3: Moderate
- Hazard Category 4: Significant
- Hazard Category 5: Catastrophic

The frequency or the likelihood of the initiating event commonly identified in industry standards can be identified as:

- Likelihood Category 1: Improbable
- Likelihood Category 2: Remote
- Likelihood Category 3: Occasional
- Likelihood Category 4: Probable
- Likelihood Category 5: Frequent

By reducing or eliminating the risk and underlying hazard, the inherent safety of the process can be increased. Further, by eliminating or reducing the likelihood of the cause, prevention has been implemented. By relocating sources, adding new mitigation systems, including inherently safer designs to the process, and improving effectiveness of existing mitigation safeguards, the severity of consequences, through mitigation, has also reduced the scenario risk. By adding layers of protection and improving existing safeguards' the availability and reliability, risk reduction can be achieved.

F. METHODS OF RISK ANALYSIS

1. Process Hazard Analysis (PHA)

PHAs are required to be conducted by high-risk chemical facilities that fall under the regulatory oversight of OSHA's PSM program and EPA's RMP program.⁹⁶ The governing Code of Federal Regulation explains that this PHA

shall be appropriate to the complexity of the process and shall identify, evaluate, and control the hazards involved in the process. Employers shall determine and document the priority order for conducting process hazard analyses based on a rationale which includes such considerations as extent of the process hazards, number of potentially affected employees, age of the process, and operating history of the process.⁹⁷

The initial PHA must address:

- Equipment in the process
- Hazards of the process
- Identification of previous incidents
- Engineering and administrative controls
- Consequences of failures
- Facility siting
- Human factors
- Qualitative evaluation of safety and health effects
- Consequences of deviation
- Steps required to correct or avoid deviation⁹⁸

A thorough PHA study can not only avert risks and identify opportunities to prioritize safeguards through risk-ranking techniques, but can also save the organization money. This is where emergency management professional need to closely evaluate and

⁹⁶ 29 CFR § 1910.

⁹⁷ Ibid.

⁹⁸ Ibid.

review if a facility's PHA has adequately identified their risks and has implemented necessary risk reduction safeguards.

The hazard analysis should be evaluated against procedural-based operations such as process startups, loading/unloading of hazardous materials, modification of operating states, and computer programmable logic controllers. The concept of a PHA is to identify problems, not to solve them. Solutions are then developed outside of the PHA. The following sections present PHA methodologies discussed in this thesis: HAZOP and What-If Analysis. There are other PHA methodologies (such as the Fault Tree Analysis, Failure Modes and Effects Analysis, Event Tree Analysis, Cause-Consequence Analysis and Bow Tie Analysis) but for discussion purposes, the HAZOP and What-If Analysis relate better to the case studies conducted in this thesis.

2. Hazard Operability (HAZOP)

The HAZOP study seeks to identify and evaluate safety hazards at a high-risk chemical facility and is the most commonly used method for PHA study. It is also designed to identify operability issues that could threaten the safety of the operations, employees, and community. The objective of the HAZOP study is to analyze deviations from the design or operational intent that could lead to unintended consequences, such as a release or catastrophic failure (problems that occur at specific points during the process are referred to as nodes).⁹⁹ Existing safeguards protecting the process are also evaluated for potential causes and consequences associated with any process/procedure deviations. When there is a determination that an inadequate safeguards exist for a credible deviation, recommendations and actions are suggested to reduce the risk. The HAZOP concept is designed to see how well the system operates under design specifications and conditions. Problems arise when deviations from design conditions occur. This is seen by utilizing guided words that stimulate the brainstorming by team leaders, and subject-matter experts apply the parameters such as flow, temperature, time, volume, and voltage to the process. To achieve an effective study, it is essential to consider the process deviations as well as abnormal situations within the design scope and abnormal

⁹⁹ CCPS, *Guidelines for Hazard Evaluation Procedures*, 115.

operations. A HAZOP study is beneficial because it is a more rigorous and creative approach to identifying potential problems.

HAZOP studies utilize guide words to standardize results. These words are shown in Figure 4.

Figure 4. HAZOP Guide Words

Guide Word		Process Parameter
None		Flow
More of or Less of		Presser
Part of		Temperature
As well as		Composition
Reverse		Phase
Other than		Level
		Relief
		Instrumentation
		Viscosity
		Reaction
		Addition
		Separation
		Time
		pH
		Speed
		Level

Adapted from Geoff Wells, *Hazard Identification and Risk Assessment* (Rugby, U.K.: Institution of Chemical Engineers, 1996), 93–95.

Using a guide word with a parameter creates a study node that deviates from the original process condition, which then causes an equipment failure or human error. Subsequently, a consequence without safeguards, such as a fire, explosion, or a toxic release, impacts the production, employees, and the community. Once the cause of

deviation from the study nodes is identified, safeguards—whether engineered or administratively designed—are created as an action.

In the HAZOP study, the deviation must be realistic and sufficient enough to credibly occur. Three basic deviations often include human error, equipment failure, and external events. For example, a human error can be an operator mistakenly turning the wrong valve, creating a hazard that results in a release of hazardous material from a process.¹⁰⁰ Equipment failure often includes a mechanical operating failure resulting in the release of a hazardous material, causing an impact loss. External events, such as an earthquake, flood, power failure, or fire are events that affect the operation of the unit resulting in the release of hazardous materials.¹⁰¹ External events can also be events attributed to sabotage.¹⁰² Table 3 presents a shortened list of guide words used in a risk assessment within the operating parameters and paired with deviations outside the normal process parameters.¹⁰³

Table 3. Guide Words for Deviation

Guide Word	Parameter	Deviation
No	Flow	No flow
More	Pressure	High pressure
Less	Temperature	Low temperature
As well as	Addition	Extra steps performed, extra chemicals added

The principle of a HAZOP study aims to identify and compare the normal design and operations from the deviated nodes. The HAZOP starts with the study node and proceeds to each process, reviewing the design and intention. A guide word is selected along with a parameter and meaningful deviation. A list of causes, consequences, and

¹⁰⁰ CCPS, *Guidelines for Hazard Evaluation Procedures*, xxiv.

¹⁰¹ Ibid., xxiii.

¹⁰² Ibid.

¹⁰³ Reich and Dear, *Process Safety Management Guidelines*.

safeguards are identified. An evaluation need is completed based on the risk identified in the risk matrix. The study nodes identified as “very high” would then have immediate recommendations for action, and so on with the rest of the risk categories based on the risk matrix. Other considerations required by OSHA and EPA include consequence studies to include the qualitative range of potential impacts.¹⁰⁴ Causes, consequences, and safeguards that involve human error are to be included. In addition, causes and safeguards that are influenced by plant siting should be described and included as a study node. The study is complete when every component of the hazard based on the process and instrumentation diagram, as well as the block flow diagram of the entire covered process, has been studied against all the guide words and nodes.

The HAZOP is also able to help determine a risk ranking should multiple hazards be discovered. Evaluating safeguards helps the study determine what combination of cause and consequences present a credible process hazard based on the risk reduction of severity. It is essential for the emergency management professional to review the mitigative and preventative safeguards, warnings/alarms that warn of deviations, relief systems, and ventilation systems to ensure, again, if practical safeguards have reduced risks and have been adequately addressed.

3. What-If Analysis

The What-If Analysis is another PHA technique with a specific approach to identifying hazards, initiating events, or a sequence of events that could produce unwanted consequences. Possible abnormal operations, causes, consequences, and existing safeguards are reviewed and evaluated using the guided questions that start with, “what if?” The purpose of a What-If Analysis study is to conduct a thorough, systematic examination of the process by formulating questions that suggest an initiating event and a failure.¹⁰⁵ An example of a “what-if” question would be: What if the raw material is added in the wrong concentration? A hypothetical process response would be: If the concentration of the raw material were not added correctly as procedures indicate, the

¹⁰⁴ 29 CFR § 1910, Sec. 119, Appendix C.

¹⁰⁵ “Safety & Health Management Systems eTool,” OSHA.

reaction cannot be controlled and a rapid exothermic reaction would result. The recommendation would be to establish a raw material written policy and procedure. Training would be recommended to ensure employees understand the adverse consequence should the wrong concentration of material be added.

4. Layers of Protection

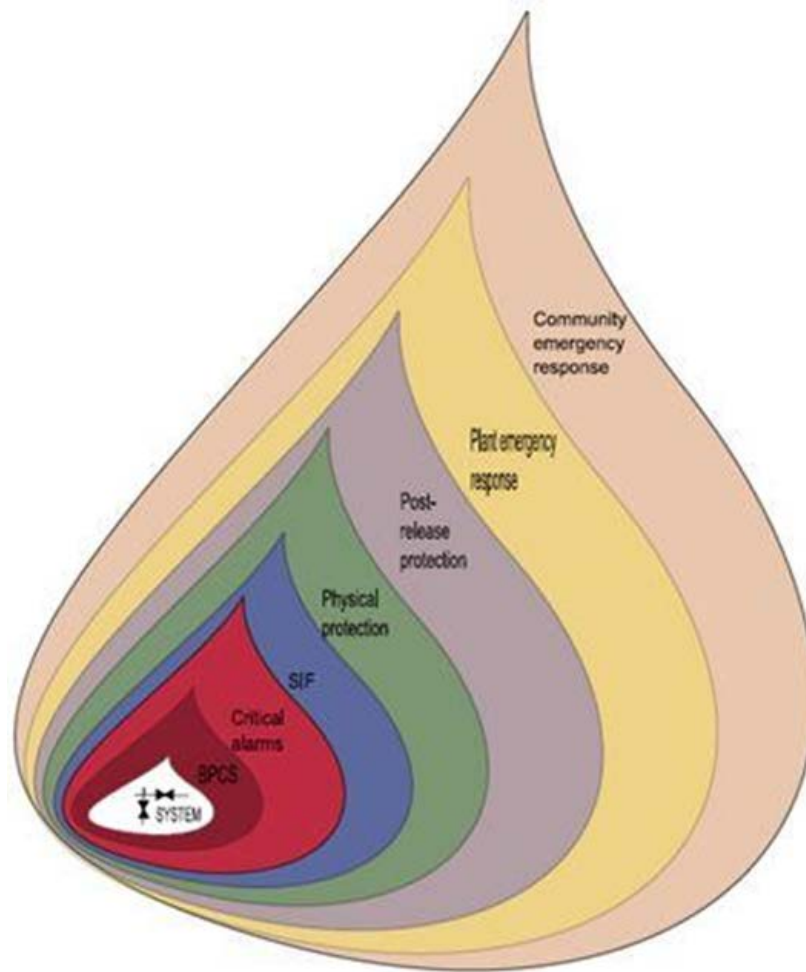
Layer of Protection Analysis (LOPA) is a semi-quantitative risk analysis tool that is used to assist with any PHA to determine the risk of individual hazard scenarios by order of magnitude.¹⁰⁶ Initiating cause, frequency, severity of consequence, and the likelihood of a failure can all be utilized as independent protection layers (IPLs).¹⁰⁷ An individual review regarding the effectiveness of the safeguards must be analyzed to show that the mechanism can operate independently and be considered an inherently safer design. IPLs are often depicted as layers of an onion.¹⁰⁸ The core of the onion, as depicted in Figure 5, consists of the basic integrity design and process. Basic process control systems (BPCS) used during normal conditions allow for process levels to be relayed back to the operator. Under abnormal conditions, the BPCS signals from the process to alert the operator that out-of-normal conditions have been identified, which may then trigger mechanical or automated action. Critical alarms and operator intervention is engineered into the process design so that, in the event of a critical situation under abnormal conditions, actions completed by the design or operator must be addressed. Safety instrument functions (otherwise known as a safety instrument system) as the implemented IPL. As a separate layer of protection, an example of the physical protection would be a pressure relief valve. Release protection would be a physical protection, such as a containment wall or blast wall. The outer layers of the onion correspond to the prevention and risk communication that is needed on top of physical and mechanical protection from a release.

¹⁰⁶ CCPS, *Layer of Protection Analysis: Simplified Risk Assessment* (Hoboken, NJ: Wiley, 2010).

¹⁰⁷ CCPS, *Layer of Protection Analysis*.

¹⁰⁸ Arther M. Dowell III and Tom R. William, "Layers of Protection Analysis: Generating Scenarios Automatically from HAZOP Data," *Process Safety Progress* 24, no. 1 (March 2005): 38–44.

Figure 5. LOPA Onion



Source: Health Safety Environment and Quality Engineering Knowledge Book, accessed October 2, 2015, <http://tetrasafe.com/what-is-layers-of-protection-analysis-lop-a-simplified-process-risk-assesment/>.

Each layer of the LOPA onion operates independently from one another in terms of operation. Sufficiently designed IPLs are engineered so that the failure of one IPL does not negatively affect the potential or cascading effect causing or resulting in the failure of another IPL.¹⁰⁹ Each IPL is designed to prevent the hazardous event. An IPL can also be used as a resource to mitigate the consequences of the event. Further, IPLs are designed to perform their safety functions in all conditions, including deviations. As part of a

¹⁰⁹ Dowell and William, "Layers of Protection Analysis."

hazard assessment, safeguards that meet specific criteria are identified as IPLs. The purpose of a LOPA study is to help answer several questions, such as:

- How safe is safe enough?
- How many layers of protection are needed?
- How much risk reduction should each layer be able to provide?

By analyzing selected scenarios in detail, specifically from a HAZOP study, effective application of LOPA can help determine if the risk analyzed has been reduced to an acceptable risk range. LOPAs can further identify existing operations and practices thought to have sufficient safeguards, but upon evaluation, the safeguards are found to insufficiently reduce risk.

A LOPA provides quantified risk assessment and is based on the concept of protective layers. In order to prevent the occurrence of an undesired consequence, a layer of safeguard must be implemented. If the IPL provides the end to the event or hazard, then no additional layers of protection are needed. However, there is no such thing as perfect protection, so several IPLs are needed to reduce the risk to a tolerable level. Each IPL, ideally, should reduce the frequency of the event. A LOPA study is not to be used in place of a formal PHA. It should merely be additional assistance to ensure the safeguards put in place are adequate as identified in the hazard assessment. Currently, LOPA is not required as an assessment by OSHA or the EPA, but should be an integral part of a chemical facility's thorough risk assessment.

V. CASE STUDY: WEST FERTILIZER PLANT

On April 17, 2013, a massive fire and explosion at the West Fertilizer Company plant rocked the little town of West, Texas, killing 15 people and wounding 226.¹¹⁰ West has a population of nearly 3,000 and is located in the north-central part of the state, approximately 70 miles south of Dallas-Fort Worth and 120 miles north of Austin.¹¹¹ During the incident, “the intense explosion in the wooden warehouse detonated nearly 30 tons of ammonium nitrate, destroyed three nearby schools, a nursing home, and thirty-seven city blocks.”¹¹² The image in Figure 6 shows the impact blast. This case study highlights three major failures that led to the catastrophic incident: regulation failures, lack of a safety culture, and the community’s failure to understand risk.

Figure 6. Impact Blast of the West Fertilizer Company Plant



Image courtesy of Tony Gutierrez, accessed September 18, 2015, www.dispatch.com/content/graphics/2013/04/texas-explosion/texas-419-01-620.jpg.

¹¹⁰ Elliott C. McLaughlin, “West, Texas, Fertilizer Plant Blast that Killed 15 ‘Preventable,’ Safety Board Says,” CNN, April 22, 2014, <http://www.cnn.com/2014/04/22/us/west-texas-fertilizer-plant-explosion-investigation>.

¹¹¹ Wikipedia, s.v. “West, Texas,” last modified November 20, 2015, https://en.wikipedia.org/wiki/West,_Texas.

¹¹² “Preliminary Findings of the U.S. Chemical Safety Board from its Investigation of the West Fertilizer Explosion and Fire,” CSB, June 27, 2013, <http://www.csb.gov/documents/?SID=102>.

Amid ongoing investigation, CSB Chairman Rafael Moure-Eraso stated in a news conference that the accident should never have occurred, citing the company's failure to prevent the explosion and subsequent deaths. Moure-Eraso further holds the federal, state, and local regulatory agencies accountable for not identifying the serious hazard that led to this incident.¹¹³ The facility was storing nearly 60 tons of ammonium nitrate fertilizer, 30 tons of which were stored in combustible wooden bins *inside* a wooden building.¹¹⁴ Large pressurized vessels of anhydrous ammonia were stored along the outside of that same building. Ammonium nitrate, a common agricultural fertilizer in prill form, is an oxidizer that, under confinement and high temperatures, will react violently if not managed and stored properly.¹¹⁵ While the hazardous material will not burn by itself, ammonium nitrate supports and accelerates the combustion of other materials. This oxidizing hazardous material is also noted to be shock sensitive when mixed with organic materials, which adds to the hazard and challenge of fighting an ammonium nitrate fire as seen historically in other incidents as described later.

A. THE INCIDENT

At approximately 7:29 p.m. on the night of April 17, 2013, firefighters responded to a report of a fire at the West Fertilizer Company plant. At approximately 7:53 p.m., the 911 dispatch center received a report of an explosion; the caller indicated there were many victims. Shortly after the explosion, reports indicated people were trapped inside the nearby West Rest Haven nursing home. More than 100 residents of the nursing home had to be evacuated.¹¹⁶ Approximately one mile from the West Fertilizer plant, at a local convenience store, the explosion could be seen, as depicted in Figure 7.

¹¹³ "Final Statements from CSB's April 22 News Conference in Dallas, TX," CSB, April 22, 2014, <http://www.csb.gov/documents/?SID=102>.

¹¹⁴ "Preliminary Findings," CSB.

¹¹⁵ "Ammonium Nitrate," CDC, last modified July 1, 2014, <http://www.cdc.gov/niosh/ipcsneng/neng0216.html>.

¹¹⁶ Holly K. Hacker, "Timeline: Fire at West Fertilizer Plant," *Dallas Morning News*, April 19, 2013, <http://www.dallasnews.com/news/databases/20130419-timeline-fire-at-west-fertilizer-plant.ece>.

Figure 7. Czech Stop in West, Texas, on April 17, 2013



Source: Holly K. Hacker, "Timeline: Fire at West Fertilizer Plant," *Dallas Morning News*, April 19, 2013, <http://www.dallasnews.com/news/databases/20130419-timeline-fire-at-west-fertilizer-plant.ece>.

Among the fifteen casualties, twelve were firefighters from five different departments responding that night, including volunteers from the West Fire Department, Abbott Fire Department, Merkel Fire Department, Dallas Fire Department, and Bruceville-Eddy Fire Department.¹¹⁷ Nearby schools were closed for a week following the accident due to toxic ammonia fumes.

B. FAILURE TO REGULATE

The West Fertilizer Company started their business in 1962.¹¹⁸ The first and only OSHA inspection prior to the incident was in 1985, during which the plant was issued a

¹¹⁷ Natalie DiBlasio, "A Look at Those Killed in West, Texas, Explosion," *USA Today*, April 25, 2013, <http://www.usatoday.com/story/news/nation/2013/04/25/hero-firefighters-west-texas/2112525>.

¹¹⁸ Ginger Allen, "I-Team: What Went Wrong at West Fertilizer Plant," CBS, April 18, 2013, <http://dfw.cbslocal.com/2013/04/18/i-team-what-went-wrong-at-west-fertilizer-plant>.

\$30 citation for improper storage of anhydrous ammonia.¹¹⁹ At that time, OSHA also cited four serious violations for respiratory protection, but did not levy any additional penalties. Of the seven agencies that regulated and permitted the facility, the Texas Commission on Environmental Quality (TCEQ), state equivalent to the EPA, investigated the facility two weeks after an ammonia smell complaint in 2006.¹²⁰ TCEQ cited the facility for not obtaining a permit for the storage of approximately 100,000 pounds of anhydrous ammonia.¹²¹ Also in 2006, the EPA fined the facility \$2,300 for not submitting the required RMP plan in 2004 for the storage of anhydrous ammonia in quantities over the threshold.¹²² There was no mention or citation from either the EPA or TCEQ for the company's failure to conduct a hazard analysis. Furthermore, there was no mention of any inspection of the facility's process safety program. If such an inspection had been conducted, many glaring shortcomings would have been uncovered, including the facility's poor management and understanding of hazards and their emergency response plan, and lack of coordination with the local fire department and the LEPC. In June of 2012, the U.S. Department of Transportation's Pipeline and Hazardous Materials Safety Administration fined the facility for \$5,350 for violating, yet again, guidelines for storage of anhydrous ammonia.¹²³

After the explosion, it was discovered that DHS did not know that the West Fertilizer plant stored hazardous materials above the reportable threshold quantities required by regulation. The company failed to report their quantities under the Chemical Facility Anti-Terrorism Standards program, which requires chemical facilities to report

¹¹⁹ "Inspection Detail: West Chemical & Fertilizer Co.," OSHA, accessed June 23, 2015, https://www.osha.gov/pls/imis/establishment.inspection_detail?id=1911015.

¹²⁰ OSHA, EPA, DHS, U.S. Pipeline and Hazardous Materials Safety Administration, Texas Department of State Health Services, Texas Commission on Environmental Quality, and the Texas Feed and Fertilizer Control Service; Theodor Meyer, "What Went Wrong in West, Texas—And Where Were the Regulators?," ProPublica, April 25, 2013, <http://www.propublica.org/article/what-went-wrong-in-west-texas-and-where-were-the-regulators>.

¹²¹ Bryce Covert, "A Year after the Deadly West, Texas Explosion, No New Regulations," ThinkProgress, April 17, 2014, <http://thinkprogress.org/economy/2014/04/17/3428069/west-texas-explosion-regulations>.

¹²² "Detailed Facility Report," EPA, last modified September 2, 2014, <http://echo.epa.gov/detailed-facility-report>.

¹²³ Manny Fernandez and John Schwartz, "Plant Explosion Tears at the Heart of a Texas Town," *New York Times*, April 18, 2013, www.nytimes.com.

their chemical inventories and chemical processes that exceed a certain threshold.¹²⁴ Reporting requirements are only effective if the correct agencies and organizations are notified. Once those notifications are received and regulated by the appropriate agencies, it is then a shared responsibility within the community to develop preparedness plans based on the hazard assessments.

OSHA and the EPA both play essential roles in protecting communities from chemical disasters. According to these agencies, however, the West Fertilizer facility did not pose a significant risk because it lacked any prior history of an accidental release.¹²⁵ While many of their citations were issued for the storage of anhydrous ammonia, none of them were related to the storage of ammonium nitrate. Given the severity of this accident, however, it is apparent that small facilities like West Fertilizer should still be regulated, and must apply inherently safer designs to their process. Further, they should be required to have an emergency response plan, and they be held accountable for reducing risk to the community, environment, and employees.

Ultimately, the root cause of this accident was the regulatory agencies' failure to understand the nature of the hazard at West Fertilizer, as well as the need to conduct thorough inspections at high-risk chemical facilities, regardless of size. To simply conduct bare minimum inspections and enforce only simple documentation failures is inadequate. Inspections of the site did not include the necessary review of the facility's program elements to ensure the facility's owner/operator and employees understood process safety. Nor did the inspections from any of the regulatory agencies include a review of the process hazard. With no substantial inspections, only citations and monetary fines for failure to submit a document, there was no regulatory oversight of a facility that stored a significant amount of a highly regulated substance. Had a thorough inspection and audit been completed, inherently safer design and safeguards would have been evaluated for compliance, identifying a need for the facility to fully implement process safety management. Regulatory agencies should have facilities that follow the

¹²⁴ "Preliminary Findings," CSB.

¹²⁵ Ibid.

most current and safest handling practices and storage requirements for any regulated material.

Regulations and laws are created to ensure that businesses operate in a safe manner. These documents are also written to protect the employees, community, and environment from chemical hazards. In order for regulations to work, however, enforcement is essential. State and local governments must regulate chemical facilities under federal and state guidelines, and must establish local laws, regulations, or ordinances to protect the community from chemical disasters. Regulations and laws should also be meaningful and coordinated between all regulatory agencies and industry; this allows for less confusion and effective implementation.

Following the incident, the *Dallas Morning News* reported that, according to federal data, twenty-two percent of facilities that store or process hazardous materials in Texas have never been inspected, and ten percent were inspected by contractors and insurance companies.¹²⁶ In total, only thirty-three percent of more than the 1,347 facilities in Texas have filed an emergency plan with the EPA stating they have not had an outside safety inspection.¹²⁷ This creates huge safety and inventory information-sharing gaps, especially at the local emergency level. It is a shared responsibility of a business and the regulators to ensure the protection of the community from disasters.

Local fire departments are also required to conduct inspections at facilities for pre-fire walk plans, but not all inspections are consistent. Large jurisdictions have the ability to train fire personnel and inspectors in hazardous materials and emergency response and planning, while smaller departments, such as the West Fire Department, may not have that expertise. Not only does Texas not have a statewide fire code, it “prohibits smaller rural counties from adopting one....McLennan County had not adopted a fire code, although it had the authority to do so because of its proximity to the more populous Bell County.”¹²⁸ As a result, industry standards, codes, and regulations set by

¹²⁶ Daniel Lathrop, “Many Texas Plants Lack Safety Inspections despite Risks, Data Shows,” *Dallas Morning News*, last modified October 2, 2013, www.dallasnews.com.

¹²⁷ Lathrop “Many Texas Plants.”

¹²⁸ “Preliminary Findings,” CSB.

the National Fire Protection Association or International Code Council for the storage of ammonium nitrate were not practiced by the West Fertilizer.¹²⁹ Facilities that store high-risk chemicals should be required to have fire suppression systems in place.

In addition, there are no existing federal, state, or local restrictions that would require building ammonium nitrate storage facilities at rational stand-off distances from sensitive receptors such as homes, businesses, schools, and hospitals. In many cases, it is up to the local jurisdictions to enforce zoning and planning codes. Had the community been aware of the vulnerabilities and risks associated with the storage of hazardous materials at this facility, sensitive receptors may not have been located in such close proximity to the plant. To prevent a similar incident, federal, state, regional, and local municipalities must work more closely together to appropriately regulate and inspect chemical facilities.

C. FAILURE TO COMMUNICATE

Under EPCRA sections 311 and 312, often referred to as the Tier II report, facilities storing extremely hazardous materials at quantities above the reporting threshold must submit safety data sheets and inventory reports annually to the SERC, LEPC, and the local fire department.¹³⁰ Tier II reports must include basic facility information, employee contact information for emergencies, and, most importantly, information regarding the maximum amount of chemical(s) stored or used at a facility. According to TCEQ records, a Tier II report was submitted by West Fertilizer that reported 110,000 pounds of anhydrous ammonia, 270 tons of ammonium nitrate, and several other regulated extremely hazardous materials (see Appendix B).¹³¹ In 2012, West Fertilizer filed an EPCRA Tier II report with the McLennan County LEPC reporting the storage of up to 270 tons of ammonium nitrate as well as the storage of

¹²⁹ Ibid.

¹³⁰ *Emergency and Hazardous Chemical Inventory Forms*, 42 USC § 11022; 40 CFR § 370.

¹³¹ *Tier Two, Emergency and Hazardous Chemical Inventory, Reporting Period: January 1 to December 31, 2012*: Adair Grain, Inc., DBA West Fertilizer Co., April 18, 2013, <https://assets.documentcloud.org/documents/690112/adair-grain-inc-2012-tier-2-report-tx-dshs.pdf>.

anhydrous ammonia.¹³² However, West Fertilizer failed to provide the local fire departments the same Tier II information. Safety data sheets, chemical inventory, and storage locations were never provided to the most essential parties that would ultimately respond to an emergency at the facility.

Even though a Tier II report was provided to the McLennan County LEPC and the Texas Department of State Health Services, the information was never shared or disseminated to those who could develop and implement an emergency response plan. The information provided to the LEPC and the Health Services should have been provided to the first responders in order for the community to appropriately train and prepare for a chemical disaster. In addition to the provided information, no hazard assessment was completed regarding the facility's close proximity to other sensitive receptors. The LEPC never provided the information to the local planning or building departments that needed to recognize the hazard.

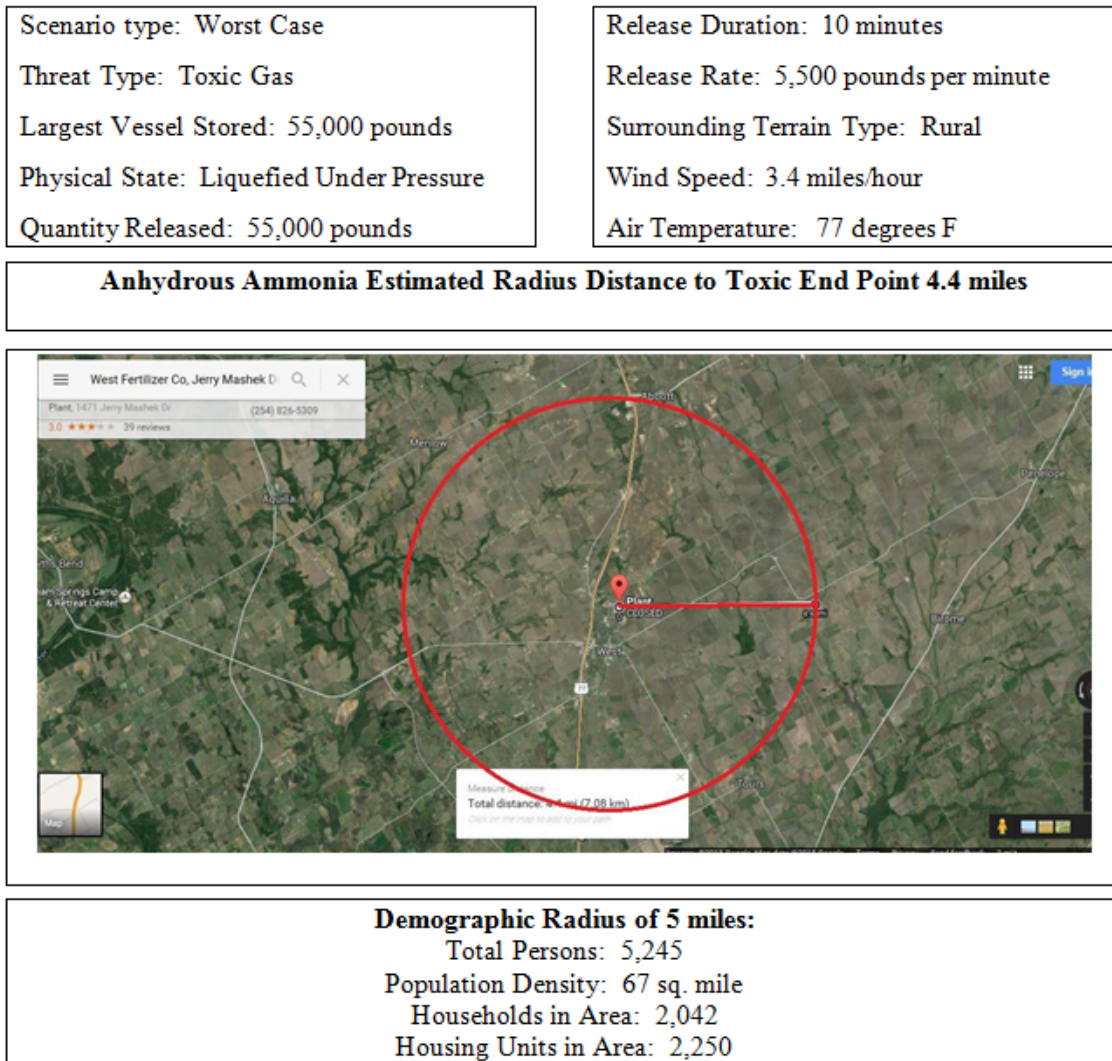
In 2011, West Fertilizer Company resubmitted their RMP data to the EPA, indicating the storage of approximately 110,000 pounds of anhydrous ammonia (see Appendix C).¹³³ A quick calculation and analysis conducted on RMP*Comp indicates that the worst-case release scenario would impact approximately 4.4 miles around the plant if one anhydrous ammonia tank were to release its entire contents. Figure 8 outlines the hazard zone for the offsite consequence analysis. According to the EPA's Environmental and Compliance History Online data system, the population associated with the impact zone is rounded up from 4.4 to a 5-mile radius. Within less than one mile, approximately 671 households, 753 housing units, and a 588 square mile population density would be affected.¹³⁴

¹³² "Preliminary Findings," CSB.

¹³³ "West Fertilizer Risk Management Plan [Redacted]," EPA, April 8, 2013, <https://assets.documentcloud.org/documents/690113/epa-west-fertilizer-risk-management-plan-redacted.txt>.

¹³⁴ "Detailed Facility Report," EPA.

Figure 8. Anhydrous Ammonia Worst-Case Scenario OCA
at West Fertilizer Plant



Calculations were completed in RMP*Comp plume modeling. Adapted from *Tier Two Emergency and Hazardous Chemical Inventory, Reporting Period: January 1 to December 31, 2012, Adair Grain, Inc. DBA West Fertilizer Co.*, April 18, 2013, <https://assets.documentcloud.org/documents/690112/adair-grain-inc-2012-tier-2-report-tx-dshs.pdf>.

Had the information in Figure 8 been provided to the LEPC, the community development and planning personnel would have flagged the nearby nursing home and school as receptors too sensitive to be placed in such close proximity to the plant.

The West Fertilizer plant also failed to communicate its potential hazards to the community and its neighbors. Even after the ammonia complaint in 2006, the plant did

not actively educate the community about the hazards of anhydrous ammonia or ammonium nitrate. The facility also failed to involve the local fire department in adequately recognizing the hazards. Had the community and fire department known about the hazards and risks involved with the storage of ammonia products, communication of those risks and concerns could have prevented lives lost.

In all, several failed lines of communication led to the unfortunate event at the West Fertilizer plant. Whether it was the failure of communication at the regulatory or community levels, all levels of communications failed to protect the safety and lives of those affected. The state and local governments play a fundamental role in the implementation of EPCRA, and the LEPCs within a community have a responsibility and duty to ensure that the lines of effective communication are developed and implemented. Fostering those communication lines is essential to community safety.

D. THE CASCADING FAILURES TO RECOGNIZE HAZARD

Ammonium nitrate has been used historically by terrorists, both domestically and internationally. Timothy McVeigh used 4,000 pounds of ammonium nitrate and diesel fuel to attack the Oklahoma City Federal Building in 1995, killing 168 and injuring hundreds.¹³⁵ The dangers of ammonium nitrate became known as early as 1947, when SS *Grandcamp* and SS *High Flyer*, cargo ships loading ammonium nitrate exploded, at the Port of Texas City, Texas, killing 576 and injuring nearly 3,500.¹³⁶ The explosion caused \$100 million of damage, with nearly \$17 million compensated to 1,394 victims.¹³⁷ That day, the Texas City Fire Department lost all but one firefighter.¹³⁸

¹³⁵ Andrew Seidman, "Homeland Security Plans to Regulate Bomb Fertilizer," August 2, 2011, *Los Angeles Times*, <http://articles.latimes.com/>; "Terror Hits Home: The Oklahoma City Bombing," FBI, accessed July 1, 2015, <https://www.fbi.gov/about-us/history/famous-cases/oklahoma-city-bombing>.

¹³⁶ "Fertilizer Explosion Kills 581 in Texas," History.com, accessed January 14, 2016, <http://www.history.com/this-day-in-history/fertilizer-explosion-kills-581-in-texas>.

¹³⁷ "Fertilizer Explosion," History.com.

¹³⁸ Robert Burke, "The Day Texas City Lost its Fire Department," *Firehouse*, May 1, 2007, <http://www.firehouse.com/article/10505314/the-day-texas-city-lost-its-fire-department>.

In 2009, the El Dorado Chemical Company located in Bryan, Texas—one of the largest ammonium fertilizer plants in Texas—caught fire.¹³⁹ The chemical fire impacted nearly 80,000 residents, 50 of whom required medical attention.¹⁴⁰ The same news report indicated with an estimate of \$1 million damages, the facility rebuilt within the community and encased the storage of ammonium nitrate in a concrete dome. In addition, the facility recognized the hazard and the risk of the materials and endorsed a process safety culture that included training and procedures.¹⁴¹ Lessons learned, including recognition of the hazards associated with ammonium nitrate at El Dorado, could have been adopted by others in the industry. Yet poor safety culture for the handling and storage of ammonium nitrate remains in other communities. Sadly, lessons learned from the incident at El Dorado did not improve the storage and handling of the hazardous chemicals at the West Fertilizer plant.

Industries must be held accountable for the safe handling of materials. Facilities should consider a hierarchy of controls and implement the use of inherently safer designs. By simply storing less of the material, the potential danger decreases. Storing hazardous materials in appropriate storage units and in safe conditions is essential. In addition, the use of safer blends or formulations can also make ammonium nitrate or other chemicals less explosive.

The CSB’s investigative findings for the incident at West Fertilizer Company are still pending. However, their preliminary findings indicate that the West Fertilizer plant failed to supply the local first responders with information regarding the hazardous materials stored onsite. Although most who lived and worked in West, Texas were familiar with the fertilizer plant, neither the first responders nor the community knew the real dangers and risks of anhydrous ammonia or ammonium nitrate. Furthermore, the community did not know how to appropriately handle a chemical emergency at this

¹³⁹ “Evacuation Lifted, Fire at Texas Chemical Plant under Control,” Fox News, July 30, 2009, <http://www.foxnews.com/story/2009/07/30/evacuation-lifted-fire-at-texas-chemical-plant-under-control.html>.

¹⁴⁰ Andrea Salazar, “Bryan Officials Learned from 2009 Fertilizer Fire,” theeagle.com, April 19, 2013, http://www.theeagle.com/news/local/bryan-officials-learned-from-fertilizer-fire/article_3a3b5d89-2989-55b0-a50e-1e6a0abc1712.html.

¹⁴¹ Salazar, “Bryan Officials.”

facility. The company did not provide the LEPC or the West Fire Department with safety data sheets of the hazardous materials, as required by EPCRA. In turn, McLennan County failed to have an emergency response plan in place to handle such an incident. Ultimately, these factors caused the community to be unaware of and unprepared for the potential hazard the facility posed to the residents.

As an emergency management professional, the obligation to understand risk in order to protect and prepare a community is essential. West, Texas was clearly unaware of the risk the facility posed to the community. An emergency management professional should be assisting local planning and zoning departments to ensure that high-risk chemical facilities are safely sited far from schools, residences, and critical infrastructures. This becomes even more essential with the progression of urban sprawl. Figure 9 depicts the close proximity of the sensitive receptors to the fertilizer plant.

Figure 9. Impact of Sensitive Receptors Close to the West Fertilizer Plant Explosion

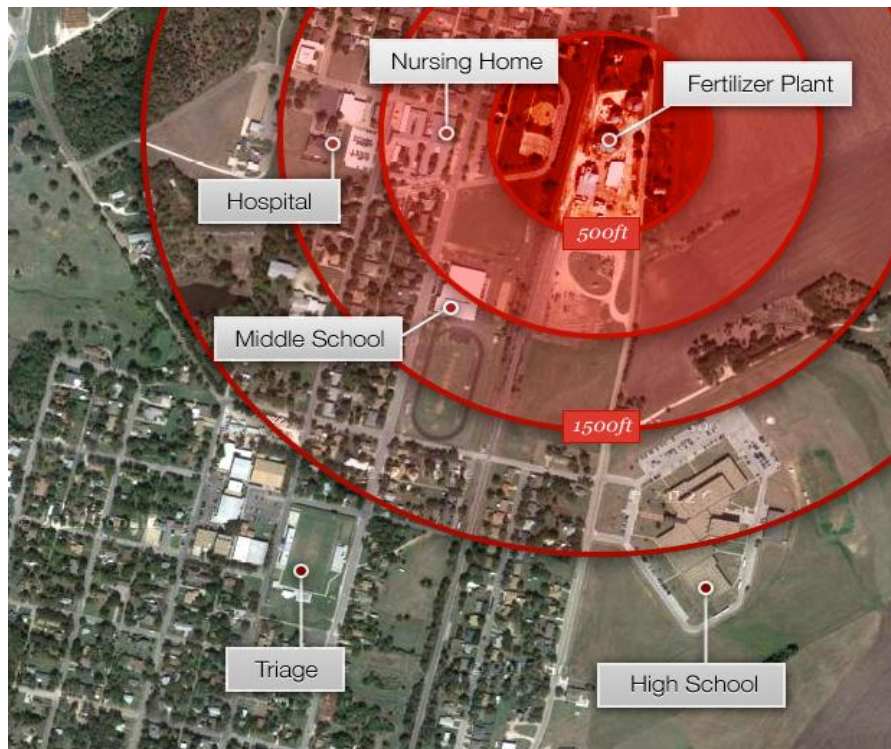


Photo courtesy of CBS News. Source: "Texas Fertilizer Plant," Linkmeister, April 18, 2013, <http://linkmeister.com/wordpress/2013/04/texas-fertilizer-plant>.

In 2002, CSB recommended that both OSHA and the EPA expand their regulated substance standards to reactive and hazardous chemicals such as ammonium nitrate. However, in developing the RMP and PSM, neither agency adopted the explosives or reactive lists as recommended.¹⁴² As a result, ammonium nitrate is not listed as an extremely hazardous chemical.

The West Fertilizer Company reportedly stored 110,000 pounds of anhydrous ammonia. This process unit met the federal threshold and regulatory reporting requirement of over 10,000 pounds under RMP and PSM. Since the West Fertilizer incident, the EPA, OSHA, and Bureau of Alcohol, Tobacco, Firearms, and Explosives have published *Chemical Advisory: Safe Storage, Handling, and Management of Solid Ammonium Nitrate Prills*.¹⁴³ Under the CCA, there is debate about whether or not ammonium nitrate falls under the EPA's general duty clause. The general duty clause 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...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.¹⁴⁴

Ammonium nitrate is not currently listed as a regulated extremely hazardous substance, but the evaluation and proposal of additional requirements may change.

Another root cause attributed to the incident at the West Fertilizer plant can be found in the failure to recognize the hazards and risks from multiple factors. Not recognizing the necessary safeguards and safety culture led to the business's failed responsibility to operate in a safe manner. Because the community failed to recognize those hazards, it lacked the awareness needed to implement and enforce safety laws and

¹⁴² "Preliminary Findings," CSB.

¹⁴³ EPA, OSHA, Bureau of Alcohol, Tobacco, Firearms and Explosives, *Chemical Advisory: Safe Storage, Handling, and Management of Solid Ammonium Nitrate Prills* (EPA 5550-F-15-001) (Washington, DC: EPA, June 2015).

¹⁴⁴ "The General Duty Clause," EPA, accessed July 15, 2015, <http://www.epa.gov/sites/production/files/2013-10/documents/gdc-fact.pdf>.

regulations. The failure to communicate the hazards and risks between regulatory agencies and the community led to the failure to prepare for a chemical disaster.

E. CONSEQUENCES

Lax regulatory oversight was a major contributor to the West Fertilizer Company incident. Sadly, there are many facilities that similarly store ammonium nitrate in large quantities, under the same conditions. As a result, there are many communities living with the same hazards, risks, and vulnerabilities as West, Texas before the incident.

EO 13650, signed in November 2013, has resulted in many regulatory discussions and changes to coordinate chemical industry safety improvements. Recently, EPA Region IX chartered a Standard Operating Guideline for chemical facilities. Ongoing state-specific annual implementation plans are still being developed and implemented.

So far, preliminary findings from the state agencies, including the CSB, have already shed light on the failures related to the federal, state, and local regulations. At the state level, the lack of an adopted fire code allowed the unsafe handling and storage of chemicals that resulted in the incident. The Texas State Fire Marshal's Office and the Bureau of Alcohol, Tobacco, Firearms, and Explosives concluded the cause of the fire as "undetermined."¹⁴⁵ Communities, in all aspects, must work together and learn from the failures to understand the root causes and prevent another tragic disaster like that in West, Texas from happening elsewhere.

¹⁴⁵ "The State Fire Marshal's Office and ATF Conclude Scene Investigation at the West Fertilizer Plant," Texas Department of Insurance, last modified October 8, 2015, <http://www.tdi.texas.gov/news/2013/news201320.html>.

VI. CASE STUDY: CHEVRON RICHMOND REFINERY

A. THE INCIDENT

On August 6, 2012, the Chevron Refinery, located in Richmond, California, experienced a catastrophic event in their processing facility.¹⁴⁶ A process pipe flowing a flammable, high-temperature light oil gas through an eight-inch line ruptured, releasing a flammable vapor cloud into the facility.¹⁴⁷ Two minutes after the vapor cloud formed, at 6:33 p.m., the process fluid ignited. Eighteen employees safely escaped the vapor cloud prior to its ignition, but one Chevron refinery firefighter inside a fire engine was engulfed by a fireball. Luckily, the firefighter was able to make his way to safety.¹⁴⁸ Subsequently, the accident released a large plume of hydrocarbons, particulate, and black acrid smoke to the surrounding neighborhoods, as seen in Figure 10.

Figure 10. Initial Vapor Cloud (White) and Ignited Cloud (Black Smoke)



Source: CSB, *Final Investigation Report: Chevron Richmond Refinery Pipe Rupture and Fire* (Report No. 2012-03-I-CA) (Washington, DC: CSB, January 2015).

¹⁴⁶ CSB, *Final Investigation Report: Chevron Richmond Refinery Pipe Rupture and Fire* (Report No. 2012-03-I-CA) (Washington, DC: CSB, January 2015).

¹⁴⁷ CSB, *Final Investigation Report*.

¹⁴⁸ *Ibid.*

At 6:38 p.m., the accident triggered the Community Warning System Level 3 alert and a shelter-in-place advisory activated by the County of Contra Costa.¹⁴⁹ Contra Costa Health Services Hazardous Materials Incident Response Team, under the unified command of the local fire department, issued the alert to the cities of Richmond, San Pablo, and North Richmond. Nearly five hours later, the fire was fully extinguished and the alert and advisory was rescinded.¹⁵⁰ In the aftermath, approximately 15,000 people from the surrounding areas sought medical treatments at local hospitals, exhibiting respiratory and inhalation symptoms, chest pain, and headaches; “Approximately 20 of those were admitted to local hospitals for treatment.”¹⁵¹

B. FAILURE TO RECOGNIZE THE HAZARD

This case study highlights several technical, organizational, emergency response, safety culture, and regulatory deficiencies that resulted in the catastrophic outcome. In all, gaps and disconnects within the community failed to prevent this chemical incident.

The incident initially started around 3:50 p.m. on August 6. A Chevron operator was performing a routine inspection and noticed a puddle of material below the process piping. The leak was traced to the crude unit column. The operator then determined that the line could not be isolated from the process and concluded that the leak did not constitute a need for a shutdown, though it was a concern.¹⁵² When discussing options, operators and Chevron inspectors noted that the pipe walls had been reported as thinning due to sulfidation corrosion several years prior.¹⁵³ Under the direction of a Chevron project management two months prior to the incident; however, data collected indicated that the line had sufficient wall thickness to last until 2016. Further discussion among the

¹⁴⁹ “Hazardous Materials Incident Notification Policy,” Contra Costa Health Services, last modified February 2010, http://cchealth.org/hazmat/pdf/incident_notification_policy.pdf; “Shelter-in-Place,” Contra Costa Health Services, accessed March 14, 2015, <http://cchealth.org/emergencies/shelter-in-place.php>.

¹⁵⁰ CSB, *Final Investigation Report*.

¹⁵¹ *Ibid.*

¹⁵² CSB, *Final Investigation Report*.

¹⁵³ Sulfidation corrosion (also known as sulfidic corrosion) is a result of naturally occurring sulfur compounds found in crude oil. In absence of hydrogen, corrosion due to sulfur compounds in the crude is thought to occur at temperatures above 500 degrees F. “Sulfidation Corrosion,” Inspectioneering, last modified June 26, 2015, <https://inspectioneering.com/tag/sulfidation>.

Chevron operators resulted in a leak repair contractor being called out to patch-clamp the process piping. In order to properly assess the leak, the Chevron crew removed the insulation surrounding the pipe. Chevron firefighters assembled scaffolding and started removing the soaked hydrocarbon insulation. As the insulation was removed, the leaking material autoignited when exposed to oxygen. Firefighters knocked down the fire on the insulation. Under the direction of the operators, the Chevron fire personnel hit the line with water to remove more insulation from the piping. This unknowingly caused further damage; liquid and vapor hydrocarbons began to form a heavy vapor flammable cloud. This was the moment when the 18 firefighters and operators narrowly escaped, making their way through the heavy vapor cloud just prior to ignition. The firefighter inside the fire engine was sitting approximately sixty-five feet away from the source when he was engulfed in a ball of fire. Dressed in full personnel protective gear, the firefighter ran out of the engine to safety.¹⁵⁴ Figure 11 shows the ruptured pipe as a result of the damage.

Figure 11. Photo of Ruptured Process Line



Source: CSB, *Final Investigation Report: Chevron Richmond Refinery Pipe Rupture and Fire* (Report No. 2012-03-I-CA) (Washington, DC: CSB, January 2015).

¹⁵⁴ *Final Investigation Report*, CSB.

C. UNDERSTANDING CHEVRON'S PROCESS HAZARDS

The Chevron Richmond Refinery's last-submitted RMP, as identified in Contra Costa Health Services inspection, in February 2013, identified the covered processes onsite that handle regulatory substances as above the threshold quantity.¹⁵⁵ Four regulated substances were identified: flammables, ammonia, hydrogen sulfide, and sulfuric acid (containing flammable mixtures). A total of thirty-four process units were listed. The following are regulatory reporting thresholds that place the facility into the RMP and PSM regulations:

- Flammables: 10,000 pounds of materials listed in Table 2 of the California Accidental Release Prevention (CalARP) and federal RMP rules. A total of 30 process units at the refinery exceeded the flammable threshold quantity.
- Ammonia: anhydrous ammonia regulatory threshold is 500 pounds for CalARP and 10,000 pounds for RMP. Aqueous ammonia thresholds are 500 pounds for CalARP and 20,000 pounds federal RMP for concentrations greater than 20% solution in concentration. A total of 11 process units containing anhydrous ammonia met the CalARP threshold, while only 3 process units met the federal threshold.
- Hydrogen sulfide: regulatory threshold is 500 pounds for CalARP and 10,000 pounds for federal RMP. A total of 8 process units met the CalARP threshold while none met the federal RMP threshold.
- Sulfuric acid: the CalARP regulatory threshold for the material is 1,000 pounds and only one process met the threshold.¹⁵⁶

D. OFFSITE CONSEQUENCE ANALYSIS DATA

The plume models presented in this section were created using the RMP*Comp to calculate an estimated offsite consequence analysis (OCA). Inventory information regarding quantities was collected from the California Environmental Reporting System (CERS) for the facility. CERS is a unique database system in which all regulated

¹⁵⁵ Contra Costa Health Services, *Preliminary Determination: Chevron Products Company Richmond Refinery* (Martinez, CA: Contra Costa Health Services, August 2014).

¹⁵⁶ Contra Costa Health Services, *Preliminary Determination*.

hazardous materials facilities¹⁵⁷ in California are required to submit a Hazardous Materials Business Plan, which reports the facility's hazardous materials inventory, emergency response plans, site maps, owner/operator information, and training plans.¹⁵⁸ The reportable quantities as prescribed in California are much lower than those for EPCRA reporting. The CERS submissions are reported to the local administering agency, also known as the Certified Unified Program Agency (CUPA). CUPA is the local regulatory agency designated by California's EPA to regulate, implement and enforce state-mandated environmental and emergency programs within their jurisdiction.¹⁵⁹ The business plan submission provides essential site-specific hazardous materials information to the local first responders. Additionally, the submitted report satisfies both the state and federal Community Right-to-Know Acts. CUPAs are required by the EPA and the state's the EPA to conduct inspections every three years at regulated facilities. However, gaps and limitations related to the system for collaborative response and agency oversights do exist, and are discussed later in this chapter.

Using the largest vessel stored onsite for the regulated toxic or flammable material, Figures 12 and 13 depict the plume modeling calculation and the estimated distance of toxic or flammable endpoints subject to certain assumptions, such as wind speed and air temperature. The chemicals depicted in the models are not the actual chemical released in this particular case study; however, the plume model clearly shows the estimated potential and hazard should those materials be released. It should also be noted that the facility's OCA for each toxic and/or flammable process, and the estimated population effected by the toxic end point for both the worst-case and the alternative-case scenarios are estimated in the RMP Submittal. Taken from the federal EPA's

¹⁵⁷ Regulated facilities include facilities that store and manage hazardous materials/waste that are over the reportable threshold—55 gallons of a liquid, 200 cubic feet of a compressed gas, 500 pounds of a solid, radioactive materials (where an emergency plan is required by Federal Law), and any extremely hazardous substance (at or above the threshold planning quantities). Health and Safety Code Section 22500–22520.

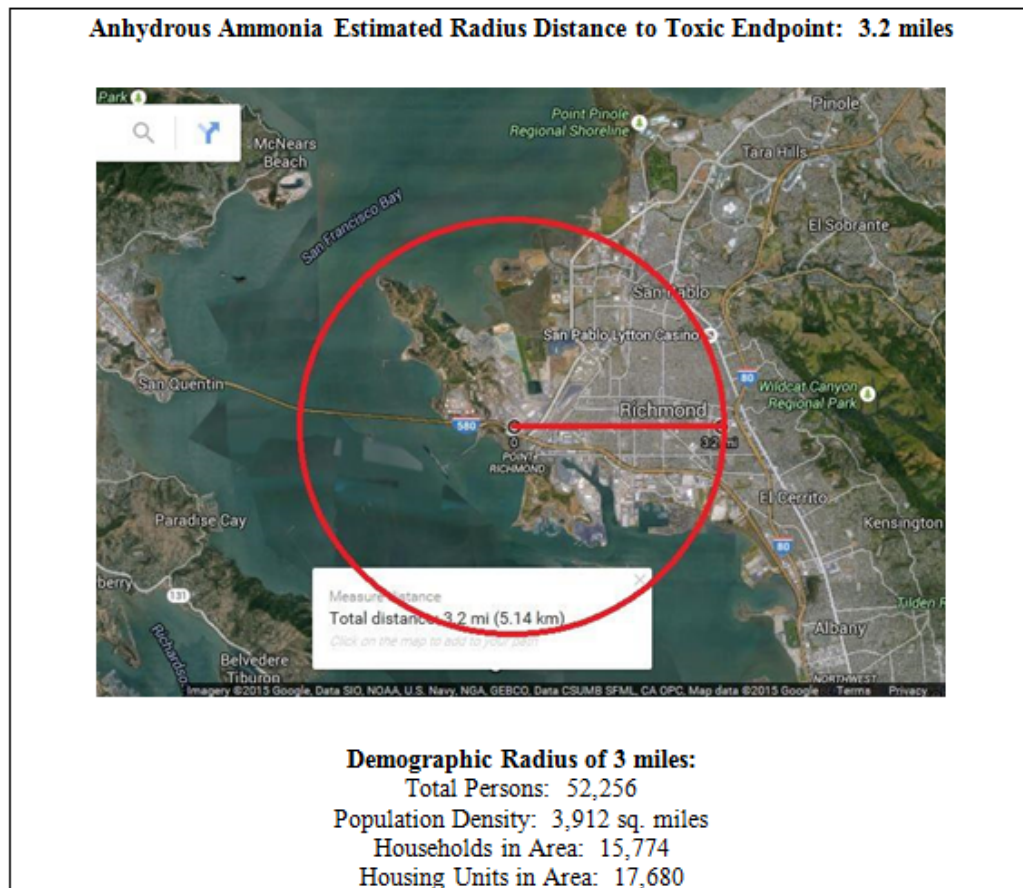
¹⁵⁸ In California, the Hazardous Materials Business Plan is an electronic document with detailed information about a facility that handles or stores hazardous materials/hazardous wastes above the specific threshold quantities, and about each specific hazardous materials onsite. It assists Emergency Responders in identifying hazardous materials and their storage locations in the event of an emergency. "Electronic Reporting," CalEPA, last modified September 1, 2015, <http://www.calepa.ca.gov/CUPA/EReporting/>.

¹⁵⁹ "Electronic Reporting," CalEPA.

Environmental and Compliance History Online data system, the demographic surrounding a three-mile radius based upon the 2010 U.S. Census poll is added to the information in Figures 12 and 13.¹⁶⁰

Figure 12. Anhydrous Ammonia Worst-Case Scenario OCA

Scenario type: Worst Case	Release Duration: 10 minutes
Threat Type: Toxic Gas	Release Rate: 7,500 pounds per minute
Largest Vessel Stored: 75,000 pounds	Surrounding Terrain Type: Urban
Physical State: Liquefied Under Pressure	Wind Speed: 3.4 miles/hour
Quantity Released: 75,000 pounds	Air Temperature: 77 degrees F



Calculations were completed in RMP*Comp plume modeling. Quantities were obtained by the facilities submission in CERS.

¹⁶⁰ "Detailed Facility Report," EPA.

Figure 13. Isobutane Worst-Case Scenario OCA

Scenario type: Worst Case

Threat Type: Flammable Gas

Largest Vessel Stored: 145,000 pounds

Physical State: Liquefied Under Pressure

Quantity Released: 145,000 pounds

Release Type: Vapor Cloud Explosion

Surrounding Terrain Type: Urban

Wind Speed: 3.4 miles/hour

Air Temperature: 77 degrees F

Isobutane Estimated Radius Distance to Flammable End Point 0.4 miles



Demographic Radius of 1 mile:

Total Persons: 1,141

Population Density: 437 sq. mile

Households in Area: 621

Housing Units in Area: 687

Calculations were completed in RMP*Comp plume modeling. Quantities were obtained by the facilities submission in CERS.

It is important to note that the toxic end point extends beyond the flammable end point of a release.

E. FAILURE TO RECOGNIZE HAZARDS AND RISKS

For decades, the refinery industry has known about sulfidation corrosion in aging carbon steel piping. According to CSB findings, nearly “95% of the 144 refineries in the United States, including the Chevron Richmond Refinery, were built before 1985.”¹⁶¹ Piping manufacturers prior to 1985 did not produce carbon steel alloys that met the specifications of sulfidation corrosion rates. Only a certain percentage of refineries have addressed piping replacements for their processes. In this particular case study, Chevron failed to carry out and recognize the necessary inherently-safer-design requirements to replace the piping. In 2002, a limited number of individuals from Chevron Energy Technology Company, a separate organization that provides technical expertise to Chevron, knew and understood sulfidation corrosion and recommended that Chevron fully inspect and replace process piping throughout the plant.¹⁶² Those recommendations, however, were never carried out nor addressed in the PHA. Despite inspections showing evidence of corrosion, no formal system of checks and balances was in place to track the company’s follow-through with the replacement.

Surprisingly, a failure in 2010 occurred at the Chevron Richmond Refinery—an event that should have prompted further investigation and risk evaluation. A process pipe, unrelated to the one that failed in 2012, was found to be leaking high-temperature jet fuel in another portion of the refinery.¹⁶³ Operations “reported the leak to management, however, no action was taken to repair the leak or shut down the unit.”¹⁶⁴ Unit operators expressed concerns over the continuous operations of the unit with the given hazardous process leak. The unit was finally shut down for repair, but only after an additional two days, during which the leak worsened.¹⁶⁵

Further evaluation of the missed hazards indicate, through a series of events, that Chevron lacked management oversight (or action) to effectively deal with replacement

¹⁶¹ CSB, *Final Investigation Report*.

¹⁶² *Ibid.*

¹⁶³ *Ibid.*

¹⁶⁴ *Ibid.*

¹⁶⁵ *Ibid.*

and inspections of the process piping; repairs were denied due to a lack of understanding and communication regarding the importance of sulfidation corrosion, or the importance of implementing a safer design. The root cause makes it clear that facilities must identify mechanical failures and their related vulnerabilities to minimize the potential of process failure. Currently, there is no requirement for facilities to conduct a damage mechanism review on chemical processes. Ultimately, Chevron's failure to recognize process hazards and the apparent lack of a safety culture led to a cascading catastrophic release that could have been prevented.

F. FAILURE TO REGULATE

The challenge of regulation is to create effective and meaningful laws that reduce risks and make facilities and processes safe. California, among many other states, is progressive in health and safety regulations. Inspections and evaluations of process safety were not to blame at the Chevron Richmond Refinery. Instead, gaps in regulations allowed for the conditions that led to the refinery disaster. As mentioned previously, there is no requirement for chemical processes to conduct a damage mechanism review of failures within a chemical process that might be caused by process corrosion, heat, vibration, and chemical interaction. Had Chevron been required to conduct damage mechanism review and to *act* upon those findings, the review would have indicated deficiencies in both industry and inspectors. Chevron had, in previous studies, recognized and identified the sulfidation corrosion on piping, but did not act upon those findings due to production pressures. This is where regulations should have actionable enforcement action. If the review included revealing the consequences should failure occur, as well as including the safeguards in place to control those hazards, the need for action would have been clear. Regulatory agencies would then have been able to enforce facilities to implement corrective actions based upon the findings from the damage mechanism review. This review coincides with the mechanical integrity and PHA. Failure to have effective enforcement tools and recognize the importance of damage mechanism reviews within the PHA is a double-missed opportunity.

Current regulations also do not require businesses to analyze and use inherently safer technologies. Although inherently safer technologies are known in industry as best practice, they are not currently mandated or required by law. The identification of an inherently safer design should, in fact, be placed into operation of a system to reduce process hazards. By analyzing the existing inherently safer technology, this ensures that the failures of others' controls do not cause the failure of the safety design. The inherently safer technology is intended to operate and function separately. Inherently safer designs must be evaluated for their effectiveness as safeguards on a process. Had Chevron been required to utilize inherently safer technologies and had evaluated their safeguards, the piping would have been replaced, preventing the release. A hierarchy of controls with safe designs should be used to reduce process hazards. The use of higher safe controls to be the most effective should be considered in order to eliminate or minimize the hazards associated with the process. Regulations, for the most part, require only the completion of a PHA and a hazard analysis; a mandate to reduce risk or to continuously operate and evaluate for safety improvements does not exist.

Currently, RMP and PSM regulations are vague and left open to interpretation regarding when deficiencies or identified risks should be corrected. The need to implement corrective actions is left to the facility within a "reasonable" timeframe. To be effective, regulations must implement timeframes to correct potential failures if they are related to the safety or recognized failure of a system based on risk. Recognized failures and safety issues cannot stay unaddressed.

The Chevron Richmond Refinery incident is having a huge impact on regulatory changes for refineries in California and the development of the Interagency Refinery Task Force, led by the California EPA, to improve both public and worker safety at oil refineries.¹⁶⁶ Regulations must evolve and provide for an understanding of process safety and the recognition of hazards.

¹⁶⁶ "Interagency Refinery Task Force," CalEPA, last modified December 1, 2015, <http://www.calepa.ca.gov/Refinery>.

G. FAILURE TO COMMUNICATE AND THE CONSEQUENCES

Understandably, though unexpectedly, a large number of residents sought medical evaluation after the incident. Because of the densely populated location, air quality sampling was essential. The Bay Area Air Quality Management District conducted numerous air samples throughout the area both during and after the incident due to the community's concerns. Analytical data results indicated slightly elevated levels of elemental carbon, an indication of combustion. Particulate levels were present, but still below the allowable state and federal air quality standards. Officials indicated that the Chevron incident did not present any health impacts to the residents in the immediate area.¹⁶⁷ Community environmental justice activists, joined by the citizens of Richmond and city council members, filed roughly 10,000 lawsuits against the Chevron Corporation for their lack of a safety culture and negligence.¹⁶⁸ Chevron announced in January of 2013 that \$10 million in settlement claims had been issued to the 24,000 residents who suffered from breathing problems as a result of the fire, including compensation monies for area hospitals and local government agencies.¹⁶⁹ In August of 2013, Chevron Corporation agreed to pay \$2 million in fines and restitution for the incident.¹⁷⁰ Chevron pled no contest to six charges filed by the California Attorney General's Office and the Contra Costa District Attorney. Charges included the failure to "correct deficiencies in equipment and failing to require the use of inherently safer designs to protect employees from potential harm."¹⁷¹ In addition, California OSHA issued the Chevron Richmond Refinery 25 citations, nearing \$1 million.¹⁷² OSHA citation documents that the facility willfully committed eleven serious violations that led to the incident, including the failure to follow recommendations to replace the corroded pipe. Additional citations included

¹⁶⁷ "Air District Lab Completes PM Sample Analysis from Chevron Fire," Bay Area Air Quality Management District, August 23, 2012, <http://www.baaqmd.gov/~media/Files/Communications%20and%20Outreach/Publications/News%20Releases/2012/2012-033-PMDataMediaRelease-82312.ashx?la=en>.

¹⁶⁸ "Chevron Agrees to Pay \$2M for Calif. Refinery Fire," *USA Today*, August 5, 2013, <http://www.usatoday.com>.

¹⁶⁹ "Chevron Agrees to Pay," *USA Today*.

¹⁷⁰ *Ibid.*

¹⁷¹ *Ibid.*

¹⁷² "Notable Citations Issued," State of California Department of Industrial Relations, last modified January 7, 2016, <http://www.dir.ca.gov/dosh/citation.html>.

twelve other serious violations for failure to follow emergency shutdown procedures and, most importantly, failure to implement the required PSM procedure.¹⁷³

Thirteen million dollars later and counting, had appropriate risk assessment, communication and regulatory measures been taken, this incident could have been prevented. Chevron operated outside the margins of safety, placing their employees, the community, and the environment at risk. Chevron failed to instill a safety culture, failed to properly understand their hazards and associated risks, and endangered many by emphasizing production over safety. Chevron failed to ensure the safety and protection of their employees and the community. The failures and actions to communicate internally resulted in the disaster. Chevron must evaluate their use of inherently safer technologies to ensure that the safest and most effective uses of controls are in place to lower or eliminate the risks. Chevron must change their safety culture.

Transparency between the regulated facility, regulators, and members of the community must exist. Communication must exist in order to have preparedness within a community. Since the incident, Chevron has inspected all piping components within the refinery that were susceptible to the sulfidation corrosion. Chevron has also inspected all of the piping associated with the crude unit that was potentially subject to sulfidation corrosion. Multiple sections throughout the plant consisting of the carbon steel piping components have been replaced. In addition, Chevron developed and implemented an enhanced mechanical integrity inspection program to identify the replacement of components. Damage review mechanisms have also been added as safeguards necessary to mitigate risk.¹⁷⁴

¹⁷³ “Notable Citations Issued,” State of California Department of Industrial Relations.

¹⁷⁴ Letter from Nigel Hearne, General Manager of Chevron Richmond Refinery to Senator Loni Hancock dated April 5, 2013, <http://www.ci.richmond.ca.us/DocumentCenter/View/26765>.

VII. PROPOSED SOLUTIONS

After any accident, it is easy to point blame and address the problem(s) or symptoms associated with a particular facility. This, however, does not address the underlying structural causes of the problem. As illustrated by the case studies, several root causes were identified as precursors to chemical disasters. In both cases, it was a combination of a failure to communicate, failure of existing regulations, and failure to implement those regulations. Furthermore, the failure by all parties to recognize and understand the magnitude of the hazards and risks led to a disconnect between emergency management professionals, regulatory agencies, and the local industries. Clearly, the community of these stakeholders, as well as the local population, must work together to recognize, plan, and prepare for the hazards that reside in their communities. By taking key concepts from these case studies, we can provide a framework for communities to effectively use the information available to better plan and allocate resources. There are two key concepts to this proposed framework:

1. Risk communication must embrace a wide spectrum of risks and address risk issues clearly and directly.
2. With safety foremost in mind, the community stakeholders must communicate clearly to prepare, in advance, emergency response and mitigation measures.

A. RECOGNIZING THE HAZARDS AND RISKS

Based on the number of RMP facilities in this nation, it is abundantly clear that there are a large number of potentially hazardous chemical facilities embedded in our communities. The consequences may vary, but there is a reasonable understanding that communities are at risk should a hazardous materials release occur at a facility. By balancing the potential severity and likelihood of the risks posed by these facilities, a community should plan for the worst-case scenario and the impact of an OCA. The failure scenario and potential consequence can be refined after conducting a process hazard analysis. This is crucial and depends on the facility conducting a comprehensive

hazard analysis that recognizes risks and has fully evaluated and implemented the use of inherently safer design to technologies and chemicals.

By taking the tools and programs in place for individual facilities to evaluate their risks, the community as a whole can utilize the same concepts to examine their risks. This view allows the community to have a more holistic, systems perspective. By evaluating the OCA data and identifying the location of critical infrastructures and key resources (CIKR), a community can better assess the severity of a chemical release. The CIKR map should identify all the CIKR within a community, such as fire stations, law enforcement departments (substations), hospitals, schools, water sources, energy infrastructure assets, chemical facilities and their OCAs, communication centers, defense centers, financial institutions, food and agricultural suppliers, government facilities, transportation systems, and other key essential sectors. Only by so doing can the analyst see the ripple effects that could be caused by a chemical release. PPD-21 identifies sixteen critical infrastructure sectors and networks that are considered vital to the nation. Should any of these infrastructures be compromised by a chemical release, it may well cause cascading effects that degrade a community's security, economy, public health, and general safety.¹⁷⁵

The mapping tool would assist local emergency management professionals and emergency services in effectively evaluating protective actions for those key resources and sensitive receptors. This is done by initially mapping out the OCA toxic/flammable distance end point of the regulated high-risk chemical facility and overlaying that plume onto the CIKR assets. By identifying the potential worst-case scenario impacts, emergency management professionals can utilize this tool, in real-time response, to assess what may be potentially impacted.

The evaluation begins by assessing the first responders' strategic locations and logistical movements to the impacted receptor. Responders must be able to respond without also being personally affected. Adequate protective resources must be provided to the first responders for the likely range of potential hazards. This will only be possible

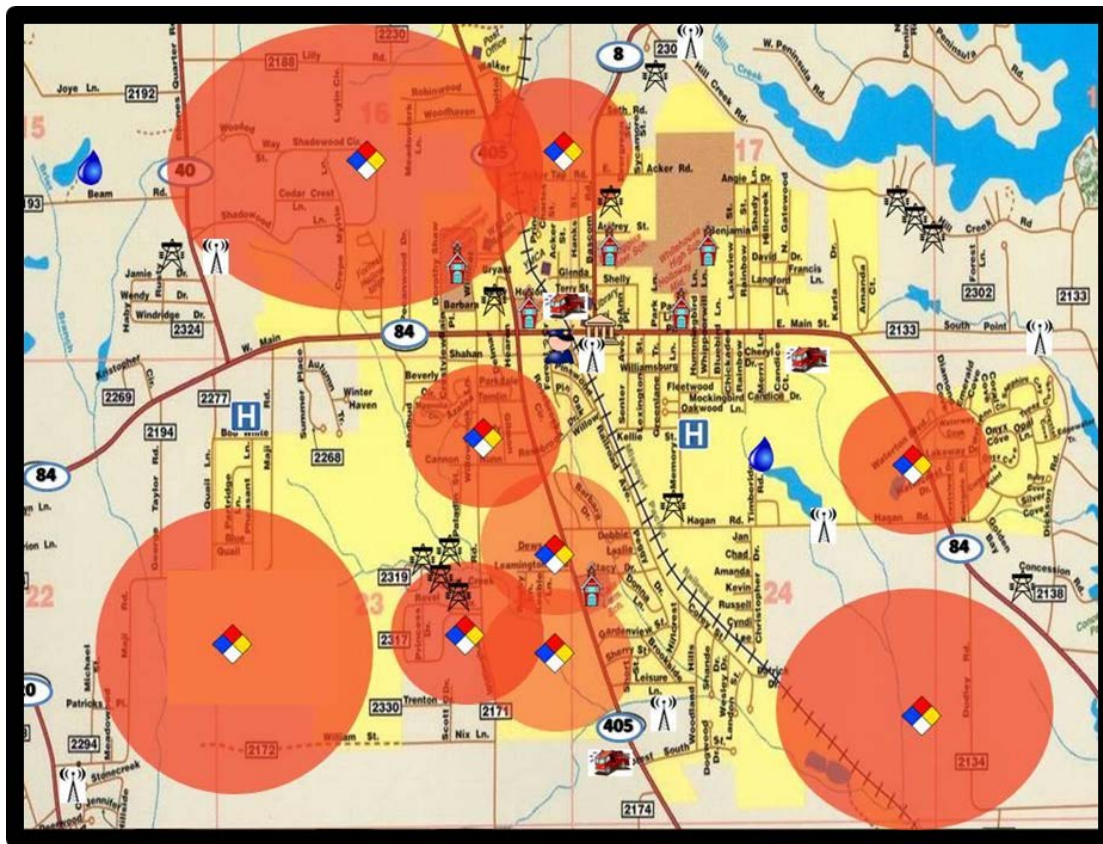
¹⁷⁵ The White House, *Critical Infrastructure Security and Resilience* (PPD-21) (Washington, DC: The White House, February 2013).

if the first responders partner with the facility and train together. They absolutely must understand the hazards and their associated risks in order to protect the community.

By evaluating the facility risk profile in its entirety, the worst-case scenario is identified as the most consequential to the community should mitigations and safeguards fail. Keep in mind that this could potentially result in mass casualties and injuries that overwhelm the first responders. If such a scenario is possible, steps must be taken to either bolster the first responder force or decrease the potential magnitude of a release.

Because most chemical facilities have been operating in communities for some time, it may be economically prohibitive to move a facility away from sensitive receptors or to relocate the receptors. However, if the risk is high and the values of frequency/likelihood remain high despite safeguards, re-location should be considered. Again, the evaluation of tolerable risk comes into consideration. Land use and zoning requirements must keep sensitive receptors far from the toxic end points identified in the offsite consequence analysis. For example, Figure 14 shows a hypothetical city with its CIKR and OCA mapped out. Such a map allows a community to determine safe routes of evacuation, locations to implement sheltering in place, and key protection zones. In all, a community that is aware of its hazards and risks can better prepare and plan for them.

Figure 14. Hypothetical City with High-Risk Chemical Facilities



OCA data and toxic/flammable end points and CIKR are depicted. This figure shows a hypothetical town with high-risk facilities and locations of CIKR. Adapted from mappery at <http://www.mappery.com/Whitehouse-City-Map>.

Any new developments, such as homes, hospitals, nursing homes, daycare centers, and shopping malls, should be placed on the hazard map so they do not fall within the identified plume endpoints. Unfortunately, many chemical facilities already exist in close proximity to our neighborhoods and communities. As such, the proposed mapping should be used to pre-plan emergency response actions. By requiring chemical facilities to utilize inherently safer technologies and designs, the potential end-point zones would not change, but the likely severity of the release, as well as the probability of release, would be smaller and the hazard would be reduced.

Businesses that store high-risk chemicals onsite should reduce their risks to the greatest extent practicable. They must evaluate the effectiveness of their safeguards and consider the liability associated with their hazards. It is also the business' responsibility

to minimize the risks they impose on the community. Safe operations that require inherently safer technologies can be implemented to reduce and minimize impact. Hierarchy of controls should be used in conjunction with safer designs so that the most effective and safest overall process design is used to reduce process hazard. The evaluation of effective safeguards put in place must be proven to show the reduction of risks within the process. If the facility does not fully implement the recommendations that arise from a PHA, they should be held accountable. As a result of the incidents that occurred in Richmond, California and West, Texas, regulatory agencies are modernizing policies and regulations to update key programs to protect and prepare communities, employees, and facilities. It remains to be seen, however, how prescriptive these new regulations will be and if the community risk can be reduced.

B. FIXING REGULATION

Regulatory agencies should conduct more comprehensive reviews and should have a more coordinated regulatory effort to ensure the safety of high-risk chemical processes. Effective regulations that propose changes should achieve the highest possible level of safety for the community. These changes should ultimately provide resources to the community so it can effectively prepare for and respond to chemical emergencies. Regulations should avoid conflicting with one another, and should be based on scientific studies that are corroborated with evidence. With a coordinated effort, meaningful regulation and effective regulatory agencies must strike a delicate balance that assures safety at the highest level while simultaneously allowing businesses to be efficient and profitable.

Rulemaking and amendments must ensure that inherently safer technologies and designs are assessed and utilized. The effectiveness of safeguards must also be evaluated and ensured. Those safeguards at the top of the hierarchy should be utilized in order to reduce process hazards. This will result in the reduction of impact and lower risk. Most importantly, the hazard assessment and associated recommendations should be addressed and resolved within a standard compliance timeframe mandated by the EPA and OSHA.

Facilities should be required to conduct a damage mechanism review within a PHA. By assessing damage as a result of process chemical reactions, including corrosion, pressure, and temperature, industries can more deeply assess and identify plant vulnerabilities. As mentioned earlier, although damage mechanism reviews have been conducted by industries, they have never been required by regulations. It is time for regulations to incorporate damage mechanisms.

The facility's emergency response and contingency plan should also be assessed for adequacy. Mitigation safeguards should be in place to contain downstream impacts should a release occur. Regulations must also ensure that the safety culture and the risks associated with the hazards have been adequately addressed and enforced. Regulations should always mandate that actual risk reduction shall occur at all processes of such degree of hazard. A continuous safety improvement must be always in sight.

Currently, there is no nationwide mandate—consistent in every state—that requires inspections at high-risk chemical facilities. In California, the CUPAs inspect CalARP and RMP facilities and other businesses that store and generate hazardous materials/waste only every three years. Mandates at these high-risk facilities should be more frequent based upon the risk the facility imposes on the community. Furthermore, inspectors must be trained to conduct these technical assessments.

A careful review of the list of regulated substances that fall under EPA and/or OSHA programs should be evaluated for completeness. Including ammonium nitrate in the list should be considered due to its inherent hazard and risk. Community should be required to adopt building codes and fire codes. This is a necessary standard to ensure safety for all within a community. Without standards, and without enforcement of standards, safety does not exist.

Chemical inventory reporting between agencies, first responders, and the community must be carried out in a more transparent and effective manner. Database exchange systems must be in place between agencies so that businesses do not have to the same information in multiple databases. Communication of data must be streamlined to where the information is most needed, and in a format that can be easily identified.

C. WHAT NOW?

First responders and regulatory agencies must have open dialogue with facilities about the dangers of chemicals and potential impacts to the employees, community, and the environment. In turn, first responders, regulatory agencies, and facilities have an obligation to communicate and engage in effective preplanning for a chemical disaster. This can be done at the LEPC level. LEPCs already exist, and contain a framework made up of emergency management professionals, regulatory agents, industry, and citizens. LEPCs can be used to strengthen community planning and preparedness, while addressing risks and vulnerabilities. Plans can be developed and implemented to address those identified risks. The LEPCs' regional plans and local area plan should include:

- Identification of hazard zones as determined by OCA
- Identification of critical infrastructures and key resources
- Facilities and commodities flow studies of routes of hazardous materials within a community
- Emergency response procedures
- Emergency management personnel to coordinate and collaborate
- A facility coordinator to implement the plan
- Emergency notification procedures
- Methods for determining the occurrence of a chemical release
- Determination of the area and population affected by potential releases
- Identification of local emergency resources, such as equipment, facilities, and agencies
- Evacuation plans
- Shelter-in-place procedures
- Training programs for emergency responders
- Methods and schedules for exercising emergency response plans¹⁷⁶

¹⁷⁶ EPA, *How to Better Prepare Your Community for a Chemical Emergency—A Guide for State, Tribal and Local Agencies* (Washington, DC: EPA, November 2014).

By communicating and working together before an incident, clear guidance and incident plans will already have been established and exercised by the community. Communities at risk should understand and be prepared for the conditions under which they should shelter in place, or when and where to evacuate, depending upon the situation. It is also essential to identify evacuation routes and dedicated locations for safe gatherings, as well as methods of communication for reuniting families. Being prepared for a disaster entails understanding the conditions and executing appropriate plans. This can be done by involving local planners, emergency responders, LEPCs, SERCs, and members of the community, industry, and non-profit organizations. Preparedness starts with communications within a community.

It is easy to say that most emergency response personnel are trained and equipped to handle emergencies. But responding to and managing a large-scale chemical emergency is a very different scenario. Information is key. The community and responders must understand the nature of the hazard and respond appropriately. The necessary coordination, training, resources, equipment, and knowledge are essential. Mass causality and decontamination procedures and equipment must be available. Ambulances must be ready to transport critical patients to hospitals while avoiding the potential plume. Emergency medical services must also be prepared to treat and triage in place. Hospitals must be ready to accept a large number of critically wounded patients, and still be able to handle the normal traffic of victims that arrive in personal vehicles without being properly decontaminated. Hospitals must also have sufficient resources to treat patients exposed to hazardous chemicals. This need for surge capacity in response and treatment to accommodate rare, but devastating, accidents is critical to keeping communities safe.

As part of emergency preparedness, it is essential that a community is aware of evacuation routes, orders, notifications, and shelter-in-place procedures. Shelter-in-place is an important concept because there are times when evacuation may not be appropriate to keep a community safe from chemical exposure. Many counties have a warning system in which sirens or alerts are used to communicate the need for a response. In addition, reverse 911 call-down systems can be used to alert residents of a chemical release with

potential impact to the community. An emergency management professional should evaluate what resources and plans are in place or need to be updated, and implement those plans for the community.

There are many communities today that are not prepared and are unaware of how to take actions to protect themselves during a chemical emergency. This is in addition to unrecognized hazards and the risks posed by the facilities within their communities. First responders, industries, community groups, and local governments must establish preparedness for such emergencies for the community. For example, Contra Costa County in California, where the Chevron Richmond Refinery operates, has an active community awareness program called Community Awareness Emergency Response (CAER). CAER is a nonprofit organization where public emergency response agencies, local government officials, and industries come together to share a common goal. According to the CAER website's business plan,

The goal of the Community Awareness and Emergency Response (CAER) Code of Management Practices is to assure emergency preparedness and to foster community right-to-know. It demands a commitment to openness and community dialogue. The code has two major components: first, to assure that member facilities that manufacture, process, use, distribute or store hazardous materials initiate and maintain a community outreach program to openly communicate relevant, useful information responsive to the public's questions and concerns about safety, health, and the environment; and second, to help protect employees and communities by assuring that each facility has an emergency response program to respond rapidly and effectively to emergencies.¹⁷⁷

There are numerous CAER programs all over the United States. Enhancing these programs and/or establishing them in a community allows for working partnerships to prevent, engage, and rebuild after an event.

By dissolving the many disconnects between hazard and understanding, and facility and community, and applying real frameworks to the root cause, communities can work together to better prepare for chemical disasters. Communities have a vested interest in ensuring that effective communication, awareness, and preparedness are in

¹⁷⁷ "Business Plan," Contra Costa County CAER Group, accessed April 3, 2015, <http://www.cococaer.org/PDF/CAERBusinessPlan.pdf>.

place. In order for that to happen, regulatory agencies must work together to amend current gaps in regulation and achieve the highest level of safety for the community and the environment. Whatever regulations are in place, or proposed, must be enforced. In addition, fostering relationships between industry, the community, and regulatory agencies is essential in helping communities better understand their risks. Regionally, LEPCs within each jurisdiction should be providing information to communities and first responders regarding hazards and planning their response to chemical emergencies. The evaluation completed by the community should be carefully reviewed, prioritized, and carried out following several key principle strategies.

(1) Identify the Risk

- Identification of facilities and their chemical related risks within the community
- Identification of routes of transportation of chemicals and their risks associated to the community
- Identification of critical infrastructures and key resources (law enforcement, fire, water, electricity, emergency medical services, hospitals, transportation, civil defense, communications, financial institutions, etc.)
- Identification of sensitive receptors and their locations (schools, hospitals, day care centers, nursing homes, prisons, malls, large public gathering locations, events, elected state and local officials, etc.)
- Identification of environmental sensitive receptors (rivers, parks, reserves, lakes, beach, wildlife, agricultural areas, etc.)
- Identification of risks related to natural disasters related to geological, hydrological, and meteorological (wildfire, flood, hurricane, tornado, earthquakes, tsunamis, volcanoes, etc.)
- Identification of other vulnerabilities such as cyber, health, and terrorism
- Determination of OCA of chemical releases from facilities
- Determination of area(s) and population affected by a chemical release

(2) Plan and Prepare

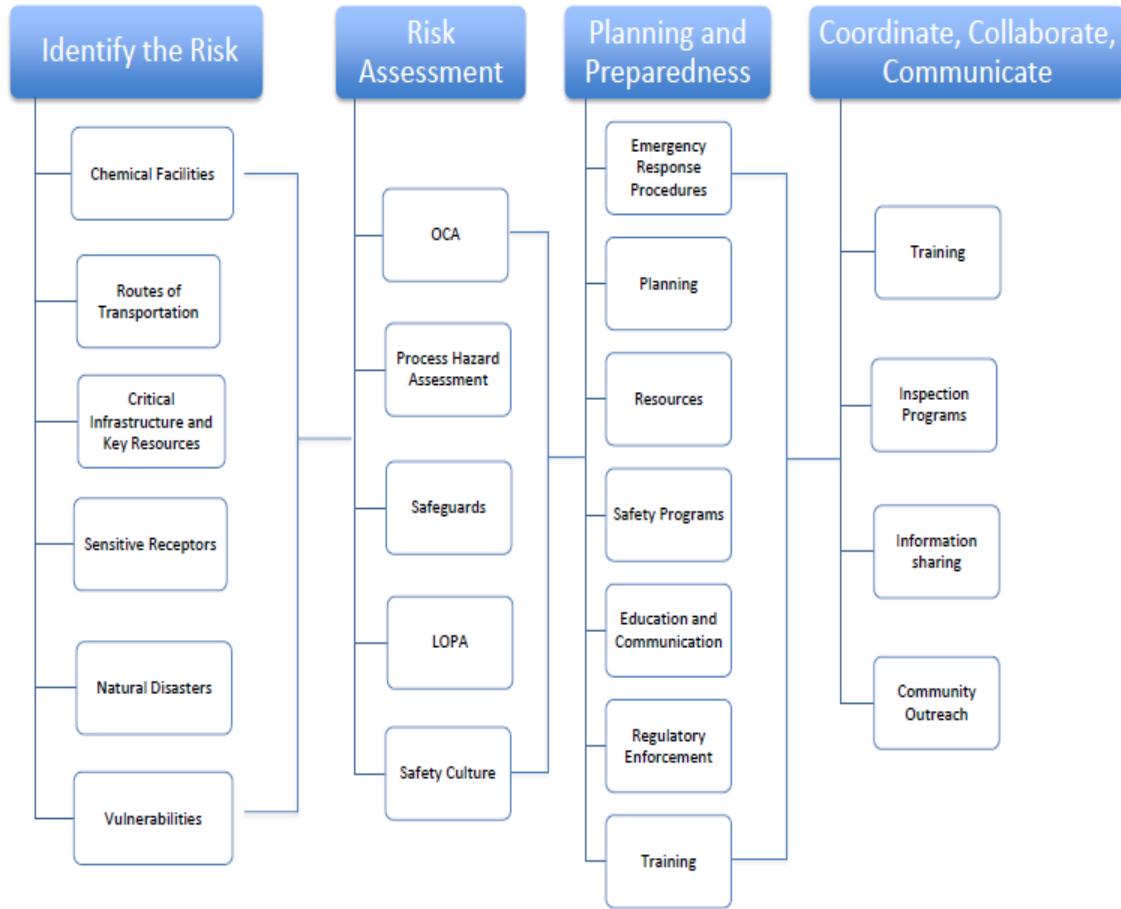
- Identification of routes of evacuation
- Identification areas for sheltering in place due to associated risks
- Implementation of emergency response procedures or plans for emergencies
- Implementation of emergency notifications procedures
- Identification of emergency response capabilities, resources, training, equipment
- Training and coordination for first responders, hospitals, emergency medical services, and regulatory agencies to hazardous materials emergencies; Evaluation and update to Regional and local Operational and Hazardous Materials Area Plans

(3) Coordinate and Communicate

- Engage in effective communication and coordination between emergency responders, facility operators, regulators, and members of the public within the community for emergency planning
- Train and prepare between all levels of first responders and receivers
- Train, prepare and provide communication to community regarding emergency preparedness
- Transparency with knowledge and information sharing related to chemical data, chemical hazards, and plume modeling

By enhancing coordination, collaboration and communication between emergency responders, emergency management professionals, regulatory agencies across all levels, industry, and communities' awareness would be more effective, focused, and would achieve clear goals and objectives towards preparedness and risk management. Figure 15 outlines the framework and for the basis of this process.

Figure 15. Proposed Framework



The proposed framework functions to identify the risk, provide risk assessment ideals, show the facilitate planning and preparedness process, and suggest steps for coordinating, collaborating, and communicating.

VIII. DISCUSSION

As has been repeated throughout this thesis, it is absolutely essential that communities be fully aware of the hazards and risks associated with their chemical facilities. These facilities introduce the potential for hazardous chemical release that could pose a threat to life. Since each community member has a stake in his or her safety, it is important to realize that protecting the community is everyone's responsibility. It is crucial that all stakeholders recognize and understand the risks posed by chemical facilities, and that they then formulate plans to directly address those risks. Regulatory agencies must work together with industry to ensure that chemical facilities are compliant with regulations and to enforce compliance. Furthermore, communities should demand that chemical facilities are using inherently safer systems to enable the maximum possible protection for the community.

A number of key safety steps should be taken at each chemical facility, including:

1. A thorough hazard assessment conducted in concert with local emergency responders
2. Assured and documented compliance with regulatory laws
3. The deployment of inherently safer designs within plant systems
4. Demonstrated development of an ingrained corporate safety culture that is dedicated to ensuring the safety of the employees as well as the community and surrounding environment

An analysis of those goals and recommendations will directly reflect a facility's ongoing commitment to reducing risk. Avoiding any one of these key safety steps should entail consequences for the facility. Experience has shown that, on many occasions, the corporate response will claim that regulations are hurting competitiveness. A thorough risk analysis will reveal the cost of consequences associated with an offsite chemical release that, when considered in the context of the corporate risk portfolio will make the business's case for improving safety and process reliability. The language of risk can be used to motivate a profit-driven response that nudges the corporation toward inherently safer systems and toward embracing each of the steps proposed steps.

It is also essential for emergency management professionals to work with the community to prepare and promote awareness about their protection from chemical hazards and incidents. Emergency management professionals must engage communities, first responders, regulatory agencies, and industry to help support transparency and to prevent catastrophes and casualties in the event of a chemical emergency. Disasters happen, and so will hazardous materials spills; ensuring that there is a plan and practicing the plan, however, will greatly diminish the consequences of any accident. Effective safeguards will lower risk by reducing the potential size of a release and by better managing the consequences of any release. Having effective risk communication is also vital to improving community emergency response. The proper decision concerning shelter-in-place or evacuation must be prepared by emergency management professionals in the community through a knowledge-based understanding of the hazards. Communities that understand potential risks are better equipped with the knowledge required to protect themselves and their families.

A. LIMITATIONS

There are several factors that must be considered in order to implement the proposed framework successfully. First, the individuals most directly involved must be trained and educated so they have a complete understanding of risk. By understanding the concept of risk and processes that bring about the reduction of risk through a facility's PHA and OCA, these individuals will be able to work as competent partners with industry, and to make scientifically sound recommendations that would reduce risk. Understanding the technical aspects of a chemical process at a facility and validating safeguards are in place for risk reduction is even more important. The individual must work collaboratively with regulatory officials to ensure compliance of high-risk chemical facilities and that information and data sharing is fluid. By not fully understanding the process, a major node or a failure may be missed, which could lead to a catastrophic event failure.

Perhaps the more difficult challenge, however, is to ingrain a new safety culture within industries and communities. Changing an existing belief system cannot be done

overnight. The stewardship and involvement must come directly from management and leadership. Core values must be integrated into all aspects of the community. Safety culture must be developed and understood by behavior through values, attitudes, goals, and success within an organization's program. Without the support and understanding of safety culture at the top, businesses with inherently dangerous processes will continue to endanger not only their employees, but also the communities they surround.

The community must analyze and assemble information into an understandable framework that identifies overall chemical risks and communicates effectively both the challenges and the solutions. Communities must accurately identify existing risks to prepare for the hazards. The framework proposed in this thesis allows one to visually see the risks and vulnerabilities and assists the community with the beginnings of a preparedness plan.

Another challenging aspect will be for land-use officials to guarantee that existing hazards are considered during zoning and planning of a community. Effective risk communication would enable easy understanding and preparedness before a plan is implemented, but it must be done in steps that may appear to infringe upon developers' presumed rights. It must be kept in mind that the identification of a hazard could well dissuade potential buyers from purchasing, leasing, or renting in a high-hazard area. Clearly, communicating risk is the key.

Larger communities will have emergency management professionals that can fully understand risks and be able to apply the framework to ensure their emergency preparedness plan is adequately addressing risks and risk reductions for chemical facilities. Smaller and more rural communities, however, may not be as well resourced. Smaller communities need to coordinate with their LEPCs, or their local emergency management professionals can conduct an assessment and identify their chemical risks. Preparedness and awareness is perhaps even more important for these smaller communities where first responder resources may be limited.

Another limitation of this framework is that some regulatory laws are insufficient or inconsistent, and must be revised to sync with current industry best practices.

Regulations related to PSM and RMP must be aligned and focused on ensuring safety management. A more comprehensive process hazard analysis must be developed and followed through by facilities. Recommendations identified by the facility's PHA should be closely managed and reviewed by regulatory agencies to ensure that safety issues/improvements are not overlooked. Regulations should require facilities to reduce risks to the greatest extent feasible. This includes ensuring the consistent use and review of inherently safer designs. Regulations should also require the evaluation of the hierarchy of controls to achieve risk reductions in the process.

The changes that are coming with Executive Order 13650, *Improving Chemical Facility Safety and Security*, the realignment of OSHA's Process Safety Management program, and the EPA's Risk Management Program are expected to promote better strategic coordination and preparedness planning for communities. Tools for the emergency management professional on plume modeling and assessing risk will also be updated. These include the CAMEO software suite and RMP*Comp presented in this thesis. The combination of a comprehensive chemical database, the use of mapping tools that overlay plume models on the community, and data information management can enable the accurate assessment of community risks. In combination, these tools and capabilities provide essential guidance and support for an emergency management professional to successfully protect his or her community.

Risk decision making for emergency management professionals should be considered precautionary. Chemical facilities are expected to prevent high-consequence failures by enacting risk reduction strategies that render acceptably low probabilities for high-consequence events. High-risk incidents arise from high likelihood coupled with severe consequence. One can either enact practices that reduce likelihood and/or diminish consequences—preferably both. Such actions/practices are key factors in the acceptance of risk. Understandably, risks associated with natural disasters may be more acceptable than risks that are generated by business practices. Furthermore, the public's perception of risk may be different than that of an emergency management professional's. When communities are unaware of the risks or have risks unknowingly imposed upon them, anger and distrust follows.

Acceptable risk is also related to the degree a community depends upon a particular business or industry for jobs. If a community is highly dependent upon a particular facility, then the accidental risks related to that particular industry may be seen much differently in the eyes of that community. Yet the risk associated with the facility's technology still exists, and methods of lowering that risk must still be in place.

B. RECOMMENDATIONS FOR FUTURE RESEARCH

This study focused on the three main root causes of failures: identification of risks, effective regulation, and communication/collaboration at community level. High-risk chemical facilities are subject to more stringent regulatory rules because their process chemicals are listed and identified as having significant health and safety impacts. Future studies should include and identify those facilities that store and manage chemicals with similar health and safety hazards but are not required to be regulated under PSM or RMP because the chemical is not listed as a regulated substance. Other case studies could be used to help identify processes and chemicals that exhibit an inherent danger to the community. Further research could also be conducted utilizing this framework and comparing it to an existing community model or framework drawn from communities located in close proximity to nuclear power plants.

C. CONCLUSIONS

Most industrial chemical accidents are preventable. By utilizing a risk assessment approach, hazards and vulnerabilities can be identified and addressed to decrease the probability of an accident. Several conclusions can be drawn from this study. First, a framework for evaluating and understanding the risks associated with chemical facilities is necessary for establishing a community's vulnerability to a chemical release. Second, facilities must be required to conduct a thorough hazard assessment that contrasts their current practices with inherently safer designs and to implement those designs if they are found lacking. This will require collaboration between the facility and the regulatory agency to ensure safeguards are implemented. This leads to the third conclusion: effective risk reduction ensures that both the likelihood and the consequences associated with chemical hazards are reduced. Ultimately, the community must work together to

bridge the disconnect with industry and engage, plan, and prepare the community to minimize the risk of a chemical disaster.

APPENDIX A. NRC INCIDENT REPORTS, 2014

The following was retrieved from The Right-to-Know Network at <http://www.rtknet.org/db/erns/search>.

National Response Center (NRC) Database Incidents for Reporting Year : 2014, Level of Detail : Summary

NRC Search Results (2014)

Search Criteria Used (More)

Reporting Year	2014	GO
Level of Detail	Summary	GO
Type of Report Output	Text (HTML)	GO

Summary ?

Reporting Year: 2014
Total number of incidents: **21,629**
Total number of reported fatalities: **835**
Total number of reported hospitalizations: **1,099**
Total number of reported injuries: **1,321**
Total number of people evacuated: **18,735**
Total reported property damage: **\$50,012,848**
[Get list of incidents](#)

Incident Type ?

Type of incident	Number of incidents
Fixed site (e.g. incident at a building)	6,440
Continuous release	29
Storage tank, drilling platform, or pipeline	2,293
Unknown sheen on water	3,532
Mobile vehicle (plane, truck, train, ship, etc.)	8,444
Other or unknown	0

[Expand pie chart and table](#) to all categories

Top 5 cities for numbers of incidents

City Left Blank, LA	1,621
SEATTLE, WA	232
HOUSTON, TX	171
SAN DIEGO, CA	148
City Left Blank, TX	144

[Expand summary](#) to all cities

[Expand all summaries](#) to all values, not just top 5

END OF REPORT

This search was done on November 13, 2015. It was compiled from government data last released on September 22, 2014. The data were obtained from the U.S. Coast Guard's [National Response Center](#) database (NRC).

Top 5 dischargers for numbers of incidents ?

Discharger Left Blank	9,656
CSX TRANSPORTATION	303
TAYLOR ENERGY	235
CSX	130
CHEVRON	125

[Expand summary](#) to all dischargers

Top 5 CHRIS substances for numbers of incidents ?

OUN: Unknown oil	4,737
NCC: Unknown / no chris code	2,601
ODS: Oils: diesel	2,539
OIL: Oils: crude	1,382
OHY: Hydraulic oil	1,335

[Expand summary](#) to all CHRIS substances

Top 5 discharger types for numbers of incidents

PRIVATE ENTERPRISE	10,280
UNKNOWN	8,601
PRIVATE CITIZEN	1,226
PUBLIC UTILITY	449
MILITARY	403

[Expand summary](#) to all discharger types

Top 5 incident causes for numbers of incidents

UNKNOWN	8,099
EQUIPMENT FAILURE	5,018
OTHER	3,904
OPERATOR ERROR	1,246
VESSEL SINKING	739

[Expand summary](#) to all incident causes

Search Criteria Used

Reporting Year	2014	GO
Sort Order	Incident ID	
Level of Detail	Summary	GO
Type of Report Output	Text (HTML)	GO

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APPENDIX B. WEST FERTILIZER TIER II REPORT

The following report on Adair Grain, Inc., DBA West Fertilizer Co., was retrieved at <https://assets.documentcloud.org/documents/690112/adair-grain-inc-2012-tier-2-report-tx-dshs.pdf>.

Tier Two

Reporting Period: January 1 to December 31, 2012

Emergency and Hazardous Chemical Inventory

Page 1

Specific Information by Chemical

Printed: April 18, 2013

Facility Name: ADAIR GRAIN, INC. DBA WEST FERTILIZER CO.

FACILITY IDENTIFICATION:

ADAIR GRAIN, INC. DBA WEST FERTILIZER CO.

Dept:

1471 N. JERRY MASHEK DRIVE

WEST, TX 76691 USA

County: McLennan

Number of employees: 7

Latitude: 31.814751

Longitude: 97.088112

Method: A1 - Address Matching (House Number)

Description: OT - Other

MAILING ADDRESS: P.O. BOX 399

WEST, TX 76691 USA

IDENTIFICATION NUMBERS:

Dun & Bradstreet: 007357080

NAICS: 325314 (Fertilizer (Mixing Only) Manufacturing)

Tier Two
Emergency and Hazardous Chemical Inventory
Specific Information by Chemical

Reporting Period: January 1 to December 31, 2012
Page 2
Printed: April 18, 2013

Facility Name: ADAIR GRAIN, INC. DBA WEST FERTILIZER CO.

CHEM NAME: AMMONIUM NITRATE

CAS: 6484-52-2

☐ Identical to previous year

☐ TRADE SECRET

☒ Pure ☐ Mix ☒ Solid ☐ Liquid ☐ Gas ☒ EHS

CHEMICAL COMPONENTS:

☒ EHS, CAS: 6484-52-2, Component: AMMONIUM NITRATE, 100% Wt

PHYSICAL & HEALTH HAZARDS:

☒ Fire ☐ Sudden Release of Pressure ☐ Reactivity ☒ Immediate (acute) ☒ Delayed (chronic)

INVENTORY:

Max Daily Amt code: 10 (500,000,000 - 999,999,999 pounds)

Avg Daily Amt code: 10 (500,000,000 - 999,999,999 pounds)

Max quantity in largest container: 180000 pounds

No. of days on-site: 365

STORAGE CODES & STORAGE LOCATIONS:

Container Type: R Pressure: 1 Temp: 4 Location: FERTILIZER PLANT WEST OF OFFICE Amount: 270 tons

CHEMICALS IN INVENTORY STATE FIELDS:

No additional chemical information is required by Texas

CHEM NAME: ANHYDROUS AMMONIA

CAS: 7664-41-7

☐ Identical to previous year

☐ TRADE SECRET

☒ Pure ☐ Mix ☐ Solid ☐ Liquid ☒ Gas ☒ EHS

CHEMICAL COMPONENTS:

☒ EHS, CAS: 7664-41-7, Component: AMMONIA GAS, 82% Wt

PHYSICAL & HEALTH HAZARDS:

☐ Fire ☒ Sudden Release of Pressure ☐ Reactivity ☒ Immediate (acute) ☐ Delayed (chronic)

INVENTORY:

Max Amt: 100000 pounds Max Daily Amt code: 05 (100,000 - 999,999 pounds)

Avg Amt: 100000 pounds Avg Daily Amt code: 05 (100,000 - 999,999 pounds)

Max quantity in largest container: 55000 pounds

No. of days on-site: 365

STORAGE CODES & STORAGE LOCATIONS:

Container Type: A Pressure: 1 Temp: 4 Location: SOUTH OF DRY FERTILIZER PLANT Amount: 110000 pounds

CHEMICALS IN INVENTORY STATE FIELDS:

No additional chemical information is required by Texas

CHEM NAME: GRAZONNEXT

CAS: 18584-79-7

☐ Identical to previous year

☐ TRADE SECRET

☐ Pure ☒ Mix ☐ Solid ☒ Liquid ☐ Gas ☒ EHS

CHEMICAL COMPONENTS:

☒ EHS, CAS: 18584-79-7, Component: 2,4-Dichlorophenoxyacetic acid, triisopropanolamine salt, 51.0 % Wt

PHYSICAL & HEALTH HAZARDS:

☐ Fire ☐ Sudden Release of Pressure ☒ Reactivity ☒ Immediate (acute) ☐ Delayed (chronic)

INVENTORY:

Max Daily Amt code: 02 (100 - 999 pounds)

Avg Daily Amt code: 02 (100 - 999 pounds)

Max quantity in largest container: 7.5 pounds

Tier Two
Emergency and Hazardous Chemical Inventory
Specific Information by Chemical

Reporting Period: January 1 to December 31, 2012

Page 3

Printed: April 18, 2013

Facility Name: ADAIR GRAIN, INC. DBA WEST FERTILIZER CO.

No. of days on-site: 365
STORAGE CODES & STORAGE LOCATIONS:
Container Type: N Pressure: 1 Temp: 4 Location: #23 CHEMICAL STORAGE WAREHOUSE Amount: 540 pounds
CHEMICALS IN INVENTORY STATE FIELDS:
No additional chemical information is required by Texas

CHEM NAME: RECLAIM

CAS: 57754-85-5

☐ Identical to previous year
☐ TRADE SECRET
☒ Pure ☐ Mix ☐ Solid ☒ Liquid ☐ Gas ☒ EHS

CHEMICAL COMPONENTS:

☒ EHS, CAS: 57754-85-5, Component: CLOPYRALID MONOETHANOLAMINE SALT, 40.9% Wt

PHYSICAL & HEALTH HAZARDS:

☒ Fire ☐ Sudden Release of Pressure ☐ Reactivity ☒ Immediate (acute) ☒ Delayed (chronic)

INVENTORY:

Max Daily Amt code: 01 (0 - 99 pounds)
Avg Daily Amt code: 01 (0 - 99 pounds)
Max quantity in largest container: 3 pounds
No. of days on-site: 365

STORAGE CODES & STORAGE LOCATIONS:

Container Type: N Pressure: 1 Temp: 4 Location: #23 CHEMICAL STORAGE WAREHOUSE Amount: 60 pounds

CHEMICALS IN INVENTORY STATE FIELDS:

No additional chemical information is required by Texas

CHEM NAME: REMEDY ULTRA

CAS: 64700-56-7

☐ Identical to previous year
☐ TRADE SECRET
☒ Pure ☐ Mix ☐ Solid ☒ Liquid ☐ Gas ☒ EHS

CHEMICAL COMPONENTS:

☒ EHS, CAS: 64700-56-7, Component: TRICLOPYR-2-BUTOXYETHYL ESTER, 60.5% Wt

PHYSICAL & HEALTH HAZARDS:

☐ Fire ☐ Sudden Release of Pressure ☒ Reactivity ☒ Immediate (acute) ☒ Delayed (chronic)

INVENTORY:

Max Daily Amt code: 02 (100 - 999 pounds)
Avg Daily Amt code: 02 (100 - 999 pounds)
Max quantity in largest container: 10 pounds
No. of days on-site: 365

STORAGE CODES & STORAGE LOCATIONS:

Container Type: N Pressure: 1 Temp: 4 Location: #23 CHEMICAL STORAGE WAREHOUSE Amount: 192 pounds

CHEMICALS IN INVENTORY STATE FIELDS:

No additional chemical information is required by Texas

CHEM NAME: SURMOUNT

CAS: 6753-47-5

☐ Identical to previous year
☐ TRADE SECRET
☐ Pure ☒ Mix ☐ Solid ☒ Liquid ☐ Gas ☒ EHS

Tier Two
Emergency and Hazardous Chemical Inventory
Specific Information by Chemical

Reporting Period: January 1 to December 31, 2012
Page 4
Printed: April 18, 2013

Facility Name: ADAIR GRAIN, INC. DBA WEST FERTILIZER CO.

CHEMICAL COMPONENTS:

☒ EHS, CAS: 6753-47-5, Component: PICLORAM TRIISOPROPANOLAMINE SALT, 13.2% Wt

PHYSICAL & HEALTH HAZARDS:

☐ Fire ☐ Sudden Release of Pressure ☒ Reactivity ☒ Immediate (acute) ☒ Delayed (chronic)

INVENTORY:

Max Daily Amt code: 01 (0 - 99 pounds)

Avg Daily Amt code: 01 (0 - 99 pounds)

Max quantity in largest container: 2.975 pounds

No. of days on-site: 365

STORAGE CODES & STORAGE LOCATIONS:

Container Type: N Pressure: 1 Temp: 4 Location: #23 CHEMICAL STORAGE WAREHOUSE Amount: 29.75 pounds

CHEMICALS IN INVENTORY STATE FIELDS:

No additional chemical information is required by Texas

CHEM NAME: YUMA

CAS: 2921-88-2

☐ Identical to previous year

☐ TRADE SECRET

☒ Pure ☐ Mix ☐ Solid ☒ Liquid ☐ Gas ☒ EHS

CHEMICAL COMPONENTS:

☒ EHS, CAS: 2921-88-2, Component: CHLORPYRIFOS, 44.9% Wt

PHYSICAL & HEALTH HAZARDS:

☒ Fire ☐ Sudden Release of Pressure ☒ Reactivity ☒ Immediate (acute) ☒ Delayed (chronic)

INVENTORY:

Max Daily Amt code: 02 (100 - 999 pounds)

Avg Daily Amt code: 02 (100 - 999 pounds)

Max quantity in largest container: 10 pounds

No. of days on-site: 365

STORAGE CODES & STORAGE LOCATIONS:

Container Type: N Pressure: 1 Temp: 4 Location: #23 CHEMICAL STORAGE WAREHOUSE Amount: 400 pounds

CHEMICALS IN INVENTORY STATE FIELDS:

No additional chemical information is required by Texas

FACILITY STATE FIELDS:

Texas requests the following:

☐ Confidential Chemical Storage Locations Included

☐ EPCRA 302 Submission

☐ Initial

☐ Updated

☒ Annual

TXT2 Number:: 66940

STATE / LOCAL FEES: \$50.00

☒ I have attached a site plan

☐ I have attached a list of site coordinate abbreviations

☐ I have attached a description of dikes and other safeguard measures

Facility Name: ADAIR GRAIN, INC. DBA WEST FERTILIZER CO.

Certification (Read and sign after completing all sections)

I certify under penalty of law that I have personally examined and am familiar with the information submitted in pages one through 5,
and that based on my inquiry of those individuals responsible for obtaining this information, I believe that the submitted information is true, accurate, and complete.

Donald Adair

Name and official title of owner/operator
OR owner/operator's authorized representative

Signature

2/26/2013

Date signed

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APPENDIX C. WEST FERTILIZER RISK MANAGEMENT PLAN

The following report was retrieved from The Right-to-Know Network at http://www.rtknet.org/db/rmp/rmp.php?facility_id=100000135597&datatype=T&reptype=f&database=rmp&detail=4&submit=GO.

SEE NEXT PAGE

Facility Name: WEST FERTILIZER CO.
EPA Facility Identifier: 1000 0013 5597

Plan Sequence Number: 1000022888

Section 1. Registration Information

Source Identification

Facility Name: WEST FERTILIZER CO.
Parent Company #1 Name:
Parent Company #2 Name:

Submission and Acceptance

Submission Type: Re-submission
Subsequent RMP Submission Reason: 5-year update (40 CFR 68.190(b)(1))
Description:
Receipt Date: 30-Jun-2011
Postmark Date: 30-Jun-2011
Next Due Date: 30-Jun-2016
Completeness Check Date: 30-Jun-2011
Complete RMP: Yes
De-Registration / Closed Reason:
De-Registration / Closed Reason Other Text:
De-Registered / Closed Date:
De-Registered / Closed Effective Date:
Certification Received: Yes

Facility Identification

EPA Facility Identifier: 1000 0013 5597
Other EPA Systems Facility ID:

Dun and Bradstreet Numbers (DUNS)

Facility DUNS:
Parent Company #1 DUNS:
Parent Company #2 DUNS:

Facility Location Address

Street 1: 1471 JERRY MASHEK DRIVE
Street 2:
City: WEST
State: TEXAS
ZIP: 76691
ZIP4:
County: MCLENNAN

Facility Latitude and Longitude

Latitude (decimal): 31.817778
Longitude (decimal): -097.088611
Lat/Long Method: GPS - Unspecified
Lat/Long Description: Intake Pipe
Horizontal Accuracy Measure: 15
Horizontal Reference Datum Name: World Geodetic System of 1984
Source Map Scale Number:

Facility Name: WEST FERTILIZER CO.
EPA Facility Identifier: 1000 0013 5597

Plan Sequence Number: 1000022888

Owner or Operator

Operator Name:	GENERAL MANAGER
Operator Phone:	(254) 826-5309

Mailing Address

Operator Street 1:	P.O. BOX 399
Operator Street 2:	
Operator City:	WEST
Operator State:	TEXAS
Operator ZIP:	76691
Operator ZIP4:	
Operator Foreign State or Province:	
Operator Foreign ZIP:	
Operator Foreign Country:	

Name and title of person or position responsible for Part 68 (RMP) Implementation

RMP Name of Person:	GENERAL MANAGER
RMP Title of Person or Position:	GENERAL MANAGER
RMP E-mail Address:	

Emergency Contact

Emergency Contact Name:	GENERAL MANAGER
Emergency Contact Title:	GENERAL MANAGER
Emergency Contact Phone:	(254) 826-5309
Emergency Contact 24-Hour Phone:	(254) 826-5979
Emergency Contact Ext. or PIN:	
Emergency Contact E-mail Address:	N/A

Other Points of Contact

Facility or Parent Company E-mail Address:	
Facility Public Contact Phone:	
Facility or Parent Company WWW Homepage Address:	

Local Emergency Planning Committee

LEPC:	Mclennan County LEPC
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Full Time Equivalent Employees

Number of Full Time Employees (FTE) on Site:	7
FTE Claimed as CBI:	

Covered By

OSHA PSM :	
EPCRA 302 :	Yes
CAA Title V:	
Air Operating Permit ID:	

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OSHA Ranking

OSHA Star or Merit Ranking:

Last Safety Inspection

Last Safety Inspection (By an External Agency) 22-Jun-2011
Date:
Last Safety Inspection Performed By an External Craig Rogers, Security Truck Services,LLC
Agency:

Predictive Filing

Did this RMP involve predictive filing?:

Preparer Information

Preparer Name:
Preparer Phone:
Preparer Street 1:
Preparer Street 2:
Preparer City:
Preparer State:
Preparer ZIP:
Preparer ZIP4:
Preparer Foreign State:
Preparer Foreign Country:
Preparer Foreign ZIP:

Confidential Business Information (CBI)

CBI Claimed:
Substantiation Provided:
Unsanitized RMP Provided:

Reportable Accidents

Reportable Accidents: See Section 6. Accident History below to determine
if there were any accidents reported for this RMP.

Process Chemicals

Process ID: 1000027947
Description:
Process Chemical ID: 1000033407
Program Level: Program Level 2 process
Chemical Name: Ammonia (anhydrous)
CAS Number: 7664-41-7
Quantity (lbs): 54000
CBI Claimed:
Flammable/Toxic: Toxic

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Process NAICS

Process ID:	1000027947
Process NAICS ID:	1000028248
Program Level:	Program Level 2 process
NAICS Code:	42451
NAICS Description:	Grain and Field Bean Merchant Wholesalers

Section 8. Program Level 2

Description:

The company has implemented a prevention program that includes Safety Information, Hazard Review, Operating Procedures, Training, Compliance Audits and Incident Investigation.

Program Level 2 Prevention Program Chemicals

Prevention Program Chemical ID:	1000019518
Chemical Name:	Ammonia (anhydrous)
Flammable/Toxic:	Toxic
CAS Number:	7664-41-7

Prevention Program Level 2 ID:	1000019212
NAICS Code:	42451

Safety Information

Safety Review Date (The date of the most recent review or revision of the safety information):	07-Jun-2011
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Safety Compliance Regulations or Design Codes/Standards

NFPA 58 (or state law based on NFPA 58):	
OSHA (29 CFR 1910.111):	Yes
ASTM Standards:	
ANSI Standards:	Yes
ASME Standards:	
None:	
Other Regulation, Design Code, or Standard:	
Comments:	

Hazard Review

Hazard Review Date (The date of completion of most recent review or update):	07-Jun-2011
Change Completion Date (The expected or actual date of completion of all changes resulting from the hazard review):	

Major Hazards Identified

Toxic Release:	Yes
Fire:	
Explosion:	
Runaway Reaction:	
Polymerization:	
Overpressurization:	Yes
Corrosion:	Yes
Overfilling:	Yes
Contamination:	
Equipment Failure:	Yes
Loss of Cooling, Heating, Electricity, Instrument Air:	

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Earthquake:	Yes
Floods (Flood Plain):	
Tornado:	Yes
Hurricanes:	
Other Major Hazard Identified:	

Process Controls in Use

Vents:	
Relief Valves:	
Check Valves:	Yes
Scrubbers:	
Flares:	
Manual Shutoffs:	Yes
Automatic Shutoffs:	
Interlocks:	
Alarms and Procedures:	
Keyed Bypass:	
Emergency Air Supply:	
Emergency Power:	
Backup Pump:	
Grounding Equipment:	
Inhibitor Addition:	
Rupture Disks:	
Excess Flow Device:	Yes
Quench System:	
Purge System:	
None:	
Other Process Control in Use:	

Mitigation Systems in Use

Sprinkler System:	
Dikes:	
Fire Walls:	
Blast Walls:	
Deluge System:	
Water Curtain:	
Enclosure:	
Neutralization:	
None:	Yes
Other Mitigation System in Use:	

Monitoring/Detection Systems in Use

Process Area Detectors:	
Perimeter Monitors:	
None:	Yes
Other Monitoring/Detection System in Use:	

Changes Since Last PHA or PHA Update

Reduction in Chemical Inventory:	
Increase in Chemical Inventory:	
Change Process Parameters:	

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Installation of Process Controls:
Installation of Process Detection Systems:
Installation of Perimeter Monitoring Systems:
Installation of Mitigation Systems:
None Recommended:
None: Yes
Other Changes Since Last PHA or PHA Update:

Review of Operating Procedures

Operating Procedures Revision Date (The date of the most recent review or revision of operating procedures): 07-Jun-2011

Training

Training Review Date (The date of the most recent review or revision of training programs): 07-Jun-2011

The Type of Training Provided

Classroom:
On the Job: Yes
Other Training:

The Type of Competency Testing Used

Written Tests:
Oral Tests:
Demonstration: Yes
Observation: Yes
Other Type of Competency Testing Used:

Maintenance

Maintenance Review Date (The date of the most recent review or revision of maintenance procedures): 07-Jun-2011
Equipment Inspection Date (The date of the most recent equipment inspection or test): 07-Jun-2011
Equipment Most Recently Inspected or Tested: ALL

Compliance Audits

Compliance Audit Date (The date of the most recent compliance audit): 22-Jun-2011
Audit Completion Date (The expected or actual date of completion of all changes resulting from the compliance audit): 22-Jun-2011

Incident Investigation

Incident Investigation Date (The date of the most recent incident investigation (if any)):
Incident Investigation Changes Date (Expected or actual date of completion of all changes resulting from the investigation):

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Most Recent Change Date: (The date of the most recent change that triggered a review or revision of safety information):

Confidential Business Information

CBI Claimed:

Section 9. Emergency Response

Written Emergency Response (ER) Plan

Community Plan (Is facility included in written community emergency response plan?): Yes

Facility Plan (Does facility have its own written emergency response plan?): Yes

Response Actions (Does ER plan include specific actions to be taken in response to accidental releases of regulated substance(s)?): Yes

Public Information (Does ER plan include procedures for informing the public and local agencies responding to accidental release?): Yes

Healthcare (Does facility's ER plan include information on emergency health care?): Yes

Emergency Response Review

Review Date (Date of most recent review or update of facility's ER plan): 07-Jun-2011

Emergency Response Training

Training Date (Date of most recent review or update of facility's employees): 07-Jun-2011

Local Agency

Agency Name (Name of local agency with which the facility ER plan or response activities are coordinated): FIRE DEPT

Agency Phone Number (Phone number of local agency with which the facility ER plan or response activities are coordinated): (000) 000-0911

Subject to

OSHA Regulations at 29 CFR 1910.38: Yes

OSHA Regulations at 29 CFR 1910.120:

Clean Water Regulations at 40 CFR 112:

RCRA Regulations at CFR 264, 265, and 279.52:

OPA 90 Regulations at 40 CFR 112, 33 CFR 154, 49 CFR 194, or 30 CFR 254:

State EPCRA Rules or Laws: Yes

Other (Specify):

Executive Summary

EXECUTIVE SUMMARY

WEST FERTILIZER CO.
WEST, TX.

For further information contact General Manager

Risk Management Plan - EXECUTIVE SUMMARY

1. The Facility Policy

The owners, management, and employees of the WEST FERTILIZER CO. are committed to the prevention of any accidental releases of anhydrous ammonia. If an accidental release should occur, the facility is prepared to work with the local fire company, or other authorities, to mitigate any release and minimize the impact of the release to people and the environment.

2. Facility Information

Ã The primary activity at the facility is the storage of fertilizers for sale to farmers.

Ã Anhydrous ammonia is received, stored, and distributed for both direct

3. The worst-case release scenario and the alternative release scenario.

a. The worst-case release scenario would be the release of the total contents of a storage tank released as a gas over 10 minutes.

b. The alternative release scenario based on the most likely potential incident is a release from a break in a transfer hose.

4. The accidental release prevention program

The facility has implemented the provisions of "Safety Requirements for the Storage and Handling of Anhydrous Ammonia, Kk-611.1", published by The American National Standards Institute, Inc., and the standards of the U.S. Occupational Safety and Health Administration (OSHA), 29 CFR 1910.111, "Storage and handling of Anhydrous Ammonia".

5. The Five-year Accident History

a. There have been no accidental releases of anhydrous ammonia in the past five years that:

Ã Have caused any deaths, injuries, or significant property damage at the facility; nor

Ã To our knowledge, have resulted in offsite deaths, injuries, evacuations, sheltering in place, property damage, or environmental damage.

6. The Emergency Response Program

The facility has:

a. A written Emergency Action Plan, in accordance with OSHA standard, 29 CFR 1910.38;

b. Provided state and local authorities the emergency planning and community right-to-know information as required under SARA Title III (EPCRA).

c. A written emergency response program, in accordance with OSHA standard 29 CFR 1910.120, including pre-emergency

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planning and employee training.

7. Planned Changes to Improve Safety

Safety improvement is an on-going process at the facility. Periodic evaluations are performed to assess the maintenance of safe conditions. There are no additional specific anhydrous ammonia safety recommendations for implementation at this time.

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