Risk Assessment of Hazardous Materials Transported by Rail through the WKU and Bowling Green, Kentucky Corridor

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RISK ASSESSMENT OF HAZARDOUS MATERIALS TRANSPORTED BY RAIL THROUGH THE WKU AND BOWLING GREEN, KENTUCKY CORRIDOR

A Capstone Experience/Thesis Project

Presented in Partial Fulfillment of the Requirements for
the Degree Bachelor of Science with
Honors College Graduate Distinction at Western Kentucky University

By:

Rebecca Center

*****

Western Kentucky University
2015

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Approved by

________________________________________
Advisor

Department of Public Health
ABSTRACT

There has been multiple risk assessments on highways for hazardous material, however there is few in hazardous rail transportation. In this study, I will create a risk assessment of the railway through WKU. Using the CAMEO system I will created threat zones and plot them in the city every half-mile to conclude where people and infrastructure will be affected the most. I discovered that there were large amounts of chemicals passing by, some are extremely dangerous to human and environmental health.

Keywords: Hazardous Materials, Railroad, Bowling Green, Risk Assessment, Analysis,
Dedicated To:
Ronald Center, my deceased father, who believed in me when I did not
And
Norma Fischer, my deceased grandmother, who was unable to witness my achievements
ACKNOWLEDGEMENTS

I want to thank my professors, Dr. Golla and Dr. Taylor, for all the numerous help that they have given me through this project. I would also like to thank Jonathan Skube for taking the time to show me how to use specific software. Lastly, I would like to give a great thanks to the staff at the Historic RailPark and Train Museum
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FIELDS OF STUDY

Major Field 1: Environmental Health Science

Major Field 2: East Asian Cultures and Religions

Major Field 3: Mandarin Chinese

TABLE OF CONTENTS

Abstract.............................................................................................................ii
Dedication..........................................................................................................iii
Acknowledgements............................................................................................iv
Vita.....................................................................................................................v
List of Figures..................................................................................................vii
Chapters:

1. Introduction.................................................................................................1
2. Methodology...............................................................................................4
3. Results.........................................................................................................8
4. Conclusion.................................................................................................15
5. Discussion........................................................................................................16

References........................................................................................................17

LIST OF FIGURES

<table>
<thead>
<tr>
<th>Figure</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Title........................................................................................................1</td>
</tr>
</tbody>
</table>
CHAPTER 1

INTRODUCTION

Since the development of the U.S. freight rail industry, it has experienced exponential growth due to practical demand; the industry has grown into a 60 billion enterprise with over 21 regional railroads and 510 local railroads. The rail industry uses 140,000 mile track line and it is able to move more cargo than any other system in the world (Freight Rail Today, n.d.).

These rail systems are efficient in moving large quantities to distances many miles away. 9% of products being transferred are consumer goods and miscellaneous items. However, 91% of the main shipping material consists of bulk commodities e.g., Agriculture, energy products, automobiles, construction materials, coal, food equipment, metals, minerals, paper, and Chemicals. The transportation of chemicals has lead to the discovery of the insurmountable incidences involving train accidents and derailments (Freight Rail Today, n.d.).

According to the United States’ National Transportation Safety Bureau in the United States, there is a train collision every 115 minutes, and more every two weeks there is a derailment involving chemical spills. Train incidents have been increasing steadily since the late ’90s (NTSB, 2012).

Recently, there have also been several train tragedies in Kentucky. In 2006 Sheperdsville, Kentucky, a severe train derailment occurred and resulted in the spill of hazardous material. Everyone within one mile of the accident had to be evacuated and the cleanup costs were more than 1 million dollars. More recently in 2012 a Louisville train
derailment resulted in insurmountable damage. Workers erroneously thought that the fire and vapor could be settled within several hours. But in reality it continued to spread, prompting the responders to quickly evacuate the public within range, including a town named West Point. Both of these incidents garnered extensive damage cost and legal allegations.

These are only 2 derailment examples among a myriad, and have caused major damage economically, environmentally, and socially. These accidents are preventable, and cost could been significantly reduced if they had utilized a risk assessment. Upon further research, there have been scarce risk assessments on railways in Kentucky.

The only study that included Kentucky was the HSEES surveillance of Rail events performed by the Centers for Disease Control and Prevention (CDC). The Health departments of 17 different states reported over 42,359 hazardous chemical releases during the years 2002-2006. 11,383 (26%) were transport related, 1,051 (9%) was by rail. Of these rail accidents, 78 (7%) released hazardous chemicals that affected an area of 200 feet or more (Hazardous Substances, 2007). These debilitating results have alarmed many, but taking action has been slow.

According to the Bowling Green Emergency Management Department, there hasn’t been extensive research into conducting a risk assessment. This is concerning considering 61,000 people live in the city, including a college, it has also become the third most populous city after Louisville (United States Census, 2015).
Purpose of Project:

The purpose of the project is to present a risk assessment over the railway running through the city of Bowling Green, Kentucky. The study’s objective is to obtain knowledge of unknown hazardous materials that are being transported by the nearby train. The research questions that are to be addressed through this research are the following: What are the types of hazardous materials being transported? What are the immediate dangers of a train derailment releasing hazardous materials? What is the likelihood of those scenarios happening? What is the risk of exposure for the population in close proximity?
CHAPTER 2

METHODOLOGY

This Risk Assessment also known as Hazards Analysis, utilizes the methodology of the Environmental Protection Agency. In this methodology there are three steps: Hazards Identification, Vulnerability Analysis, and Risk Analysis.

1. **Hazard Identification**:

   A hazard is defined as a situation that possess potential to cause harm to the public, the environment, and public/private property. So, the first step is to collect information on the transportation system, like the train, that have these certain risks. The necessary information included the types and quantities of transported hazardous material, the location of the hazardous materials, and the nature (chemical and physical) of hazards obtained.

   For this thesis, knowing the placard numbers and type were a must. I recorded from late May to early June for a total of 21 days. Using a camcorder, I recorded the Placard ID’s, train ID’s, and the times in which they traversed through the Bowling Green Corridor.

   The total number of cars that had placards were 78 out of the 83 total cars that were recorded. This revealed that 94% of trains than traveled in these months carried hazardous material. Of this graph, the largest type of hazard that was carried was Flammable, second largest was corrosive. The largest of Placards that were seen were on
Monday and Tuesday. The times in which the most Hazardous materials being transferred were between 11:45 a.m. and 2:00 p.m. During these times, 44 ID placards were identified.

2. Vulnerability Analysis:

Vulnerability Analysis identifies the location that is most susceptible to damage if/when hazardous materials are released. This step will provide information on the affected area (extent of vulnerability zone), including the environment and the conditions that it will influence. Also the size and character of populations. This step will also summarize the hazard identification by listing the major hazards and their toxicity.

The next step was to use Aloha to configure threat zones. To use this system, it required recognizing what Chemical was on the Cameo Chem and what its chemical and physical properties were. It was then processed in Aloha, which also included Atmosphere and source site application.

Atmosphere was taken from the average wind speed, temperature etc of Bowling Green. The source data was used based on the type of rail tank that the certain chemical was being carried in. Inferences were made on the hole size, which included length and width. For consistency, the hole was 4 in by 8 in. It was also inferred that the hole was 25% below the opening.

After putting in all the requirements, ALOHA was able to transfigure a threat zone, based on the AEGL’s( Acute Exposure Guidelines) that consist of three levels based off of airborne concentrations (ppm or mg/m). Level 1 is described as substances in the air
that is above average for a population, but has minor effects on the population. Level 2 is substances that are highly above the normal range and can cause severe to irreversible damage to a person’s health. Level 3 is when the substance has become lethal to human health.

The first chemical to be identified was Propane, a colorless, combustible gas that is shipped as liquefied gas under vapor pressure. Propane is the most abundant chemicals found, besides Butane. Contact with this liquid can cause frostbit. Butane has minor effects on human health, only extreme irritation and drowsiness. However, it is highly flammable and reactive in both air and water and can hover to the ground due to it being heavier than air. It can easily be ignited by heat, sparks or flames.

Similar to Propane in both chemical and physical properties is Butane. Butane’s AEGL Acute Exposure Guidelines) are concerned about explosions and fire. In the red and orange area, the public must take severe caution to explosion. The areas in the yellow have a lower risk, nevertheless, butane would stills serious. Ethyl Acrylate will be similar to Butane, but less severe.

The next one was the least common among Flammability, Ethyl Acrylate. It’s also a colorless flammable liquid. Like with Butane, Ethyl Acrylate is heavier than air. This chemical can cause drowsiness, lethargy, headache, nausea, and convulsions. However, it is highly flammable and can polymerize. If the chemical polymerizes it can explode. Polymerization is the process in which two monomers (single atoms) connect to form polymers or molecules. When it is intentioned, this process has desirable physical attributes including elastic and tensile strength. These actions emit exothermic heat, so the probability of explosion is high if it’s not strictly controlled.
In addition to assessing the Ethyl Acrylate, Chlorine, a deathly, greenish-yellow, odorous gas was also observed as part of this assessment. As a highly noxious gas, chlorine was the deadliest chemical identified as part of this assessment. Direct contact with chlorine will immediately result in third-degree tissue burns. To make matters worse, chlorine’s chemical structure is highly reactive and will ignite other combustible materials, e.g., soil. Because Chlorine is heavier than air, it would hover lower to the ground making reactions highly plausible. Chlorine’s AEGL’s possess a relatively severe risk. In the instance of a train derailment, those within a chlorine red or orange area must to evacuate immediately. Although the dangers within yellow chlorine areas are significantly reduced.

**Risk Analysis:**

Risks analysis identifies the potential severity of negative impacts on the environment and human health. After these hazardous chemicals were identified and threat zones were identified the next step was to identify their initial isolation and plot it. Before Marplot, plotting a location every half-mile in Bowling Green was required. To do that. Using the Geological Survey and mapped those using specific coordinates was the most efficient method. Although the markers totaled as 10, 8 were used due to two of them being outside of Bowling Green and out of range.

An initial isolation is the immediate evacuation of the area in all direction. Depending on the chemical the size can range greatly. An initial isolation it different when addressing a large or small spill, or with fire. However, for this research a large spill with
no fire is used. The first chemical that was plotted was Butane, which had an 800 m initial isolation.
CHAPTER 3

RESULTS

Specific Hazmat Placards Observed by Day of the Week

<table>
<thead>
<tr>
<th>Day of Week</th>
<th>Placard ID</th>
<th>Corrosive</th>
<th>Dangerous when Wet</th>
<th>Flammable</th>
<th>Inhalation Hazard</th>
<th>Misc. Hazards</th>
<th>Non-Flammable</th>
<th>Oxidizer</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monday</td>
<td>6</td>
<td></td>
<td></td>
<td>25</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>31</td>
</tr>
<tr>
<td>Tuesday</td>
<td>11</td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>5</td>
<td>25</td>
</tr>
<tr>
<td>Wednesday</td>
<td>4</td>
<td>2</td>
<td>9</td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
<td>4</td>
<td>21</td>
</tr>
<tr>
<td>Thursday</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Friday</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>21</td>
<td>2</td>
<td>40</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>9</td>
<td></td>
<td>78</td>
</tr>
</tbody>
</table>

Total Number of Placards by Time

4 2 34 16 19 1 1 12
Ethyl Acrylate
Chlorine
Ethylene Oxide
## Exposure Scenarios Modeled with ALOHA in the CAMEO System

### Exposure Scenario in CAMEO system of Chlorine

<table>
<thead>
<tr>
<th>Location</th>
<th>Chemical</th>
<th>Population</th>
<th>Housing</th>
<th>Coordinates (N)</th>
<th>Coordinates (W)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Chlorine/Large Spill</td>
<td>963</td>
<td>409</td>
<td>36°57'21&quot;</td>
<td>86°28'59&quot;</td>
</tr>
<tr>
<td>2</td>
<td>Chlorine/Large Spill</td>
<td>1,005</td>
<td>456</td>
<td>36°57'21&quot;</td>
<td>86°28'42&quot;</td>
</tr>
<tr>
<td>3</td>
<td>Chlorine/Large Spill</td>
<td>1,424</td>
<td>594</td>
<td>36°58'30&quot;</td>
<td>86°28'22&quot;</td>
</tr>
<tr>
<td>4</td>
<td>Chlorine/Large Spill</td>
<td>2,866</td>
<td>1,373</td>
<td>36°58'54&quot;</td>
<td>86°27'54&quot;</td>
</tr>
<tr>
<td>5</td>
<td>Chlorine/Large Spill</td>
<td>6,439</td>
<td>1,537</td>
<td>36°59'18&quot;</td>
<td>86°27'26&quot;</td>
</tr>
<tr>
<td>6</td>
<td>Chlorine/Large Spill</td>
<td>8,623</td>
<td>1,826</td>
<td>36°59'4&quot;</td>
<td>86°27'02&quot;</td>
</tr>
<tr>
<td>7</td>
<td>Chlorine/Large Spill</td>
<td>5,646</td>
<td>2,051</td>
<td>36°59'59&quot;</td>
<td>86°26'27&quot;</td>
</tr>
<tr>
<td>8</td>
<td>Chlorine/Large Spill</td>
<td>3,174</td>
<td>1,159</td>
<td>37°00'11&quot;</td>
<td>86°25'58&quot;</td>
</tr>
</tbody>
</table>

### Exposure Scenario Model in CAMEO system of Butane

<table>
<thead>
<tr>
<th>Location</th>
<th>Chemical</th>
<th>Population</th>
<th>Housing</th>
<th>Coordinates (N)</th>
<th>Coordinates (W)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Butane/Large Spill</td>
<td>533</td>
<td>231</td>
<td>36°57'21&quot;</td>
<td>86°28'59&quot;</td>
</tr>
<tr>
<td>2</td>
<td>Butane/Large Spill</td>
<td>114</td>
<td>48</td>
<td>36°58'01&quot;</td>
<td>86°28'42&quot;</td>
</tr>
<tr>
<td>3</td>
<td>Butane/large Spill</td>
<td>1,074</td>
<td>465</td>
<td>36°58'30&quot;</td>
<td>86°28'22&quot;</td>
</tr>
<tr>
<td>4</td>
<td>Butane/large Spill</td>
<td>2,583</td>
<td>1,265</td>
<td>36°58'54&quot;</td>
<td>86°27'54&quot;</td>
</tr>
<tr>
<td>5</td>
<td>Butane/Large Spill</td>
<td>5,139</td>
<td>907</td>
<td>36°59'18&quot;</td>
<td>86°27'26&quot;</td>
</tr>
<tr>
<td>6</td>
<td>Butane/Large Spill</td>
<td>5,204</td>
<td>1,834</td>
<td>36°59'4&quot;</td>
<td>86°27'02&quot;</td>
</tr>
<tr>
<td>7</td>
<td>Butane/Large Spill</td>
<td>1,964</td>
<td>590</td>
<td>36°59'59&quot;</td>
<td>86°26'27&quot;</td>
</tr>
<tr>
<td>Location</td>
<td>Chemical</td>
<td>population</td>
<td>housing</td>
<td>Coordinates (N)</td>
<td>Coordinates (W)</td>
</tr>
<tr>
<td>----------</td>
<td>----------</td>
<td>------------</td>
<td>---------</td>
<td>-----------------</td>
<td>-----------------</td>
</tr>
<tr>
<td>1</td>
<td>Ethyl Acrylate/Large Spill</td>
<td>0</td>
<td>0</td>
<td>36°57'21&quot;</td>
<td>86°28'59&quot;</td>
</tr>
<tr>
<td>2</td>
<td>Ethyl Acrylate/Large Spill</td>
<td>23</td>
<td>22</td>
<td>36°57'21&quot;</td>
<td>86°28'42&quot;</td>
</tr>
<tr>
<td>3</td>
<td>Ethyl Acrylate/Large Spill</td>
<td>335</td>
<td>237</td>
<td>36°58'30&quot;</td>
<td>86°28'22&quot;</td>
</tr>
<tr>
<td>4</td>
<td>Ethyl Acrylate/Large Spill</td>
<td>124</td>
<td>71</td>
<td>36°58'54&quot;</td>
<td>86°27'54&quot;</td>
</tr>
<tr>
<td>5</td>
<td>Ethyl Acrylate/Large Spill</td>
<td>889</td>
<td>61</td>
<td>36°59'18&quot;</td>
<td>86°27'26&quot;</td>
</tr>
<tr>
<td>6</td>
<td>Ethyl Acrylate/Large Spill</td>
<td>626</td>
<td>292</td>
<td>36°59'4&quot;</td>
<td>86°27'02&quot;</td>
</tr>
<tr>
<td>7</td>
<td>Ethyl Acrylate/Large Spill</td>
<td>9</td>
<td>2</td>
<td>36°59'59&quot;</td>
<td>86°26'27&quot;</td>
</tr>
<tr>
<td>8</td>
<td>Ethyl Acrylate/Large Spill</td>
<td>85</td>
<td>36</td>
<td>37°00'11&quot;</td>
<td>86°25'58&quot;</td>
</tr>
</tbody>
</table>
CHAPTER 4

CONCLUSION

During the study observation sampling period, 83 trains were observed. 73 of 83 the trains were carrying hazmat placards. The 76% of the total trains carrying hazmat placards transversed either on Monday (42%) or Tuesday (34%). These materials came at a similar time each day in the window from 11:45 am to 2:00 pm. In May and June, 94% of total trains traveling were carrying hazardous materials in the early afternoon. The chemicals ranged from “Flammability” to “Inhalation Hazards.” However, the Flammability hazards were observed mostly frequently, with a total amount of 40. The least commonly observed, in order of decreasing frequency, were “Inhalation hazards”, “Miscellaneous hazards”, and “Non-Flammable.”

In order to obtain an accurate measurement of damage for each chemical (Butane, Ethyl Oxide, Chlorine, and Ethyl Acrylate), plotting every half-mile in the city of Bowling Green was essential. The chemicals that had the most impact on the surrounding population and housing were Chlorine, and Butane. Chlorine affected 8,623 people and 1,826 housing units. Butane affected 5,204 people and 1,834 housing units. During Marplot the most affected population and housing were in the same area. This area is the intersection of College Street and State Street.
CHAPTER 5

DISCUSSION

The hypothesis was that there weren’t any chemicals being transported that was especially hazardous to human and environmental health. However, from the report the hypothesis was rejected, confirming the null hypothesis. The null hypothesis stated an exuberant amount of life-threatening chemicals were being transported.

For every train that runs through Bowling Green, KY there is a .88 chance it is carrying a hazard. An inhalation hazard has a lower probability of .036 to travel through this particular corridor. For these hazards they are a high risk but low probability, while other chemicals like Butane are high probability and lower risk.

From this report, it has been judged that the trains carry an extensive amount of chemicals, both high and low risk, through Bowling Green.
References


