Combustible/Flammable Cargo Accident (Rail)

An accident involving fire or an explosion of combustible or flammable substances transported by rail occurs within the U.S., resulting in one fatality or greater.

Data Summary

Category	Description	Metric	Low	Best	High
Health and Safety	Fatalities	Number of Fatalities[1]	1	1	1
	Injuries and Illnesses	Number of Injuries or Illnesses[2]	0	20	52
Economic	Direct Economic Loss	U.S. Dollars (2011)[3]	$43,000	$900,000	$2.9 million
	Indirect Economic Loss	U.S. Dollars (2011)	See Discussion		
Social	Social Displacement	People Displaced from Home ≥ 2 Days	0	0	0
Psychological	Psychological Distress	Qualitative Bins	5	25	57
Environmental	Environmental Impact	Qualitative Bins	N/A		
LIKELIHOOD	Frequency of Events	Number per Year[4]	0.039	0.11	0.22

Note

The results for this analysis indicate an extremely low risk associated with combustible/ flammable cargoes transported by rail. However, this conclusion is tied to the assumptions which determine the scope of the event, the selection and interpretation of data, and the choice of results to be reported; and these limitations must be understood before using these results. The scoping of this hazard to only incidents resulting in fatalities may have resulted in an assessment that does not adequately address factors that affect risk. Additionally, the use of historic data depends upon the assumption that the future will resemble the past: with respect to combustible/ flammable rail cargo accidents, recent changes in the volume of cargo suggest that the use of historic data may not adequately describe current risk. Furthermore, the SNRA project team believes that the limitation of the current SNRA displacement metric to displacements of 48 hours or more may exclude information important to the characterization of this hazard.

The SNRA project team believes that the effects of these recognized limitations (which are shared by other technological/accidental hazards in the SNRA) upon the final reported estimates may be significant. To better understand the risk from this hazard, the SNRA project team

[1] Low, average, and high fatalities from the set of 1980-2014 U.S. historical combustible/flammable rail accidents resulting in one or more fatalities in Table 1.
[2] Low, average, and high from the set of 1980–2014 U.S. historical combustible/flammable rail accidents resulting in one or more fatalities in Table 1.
[3] Low, average, and high direct economic estimates from the set of 1980–2014 U.S. historical combustible/flammable rail accidents resulting in one or more fatalities in Table 1.
[4] Low, best, and high frequencies represent the 5th, mean, and 95th percentile of the uncertainty distribution for frequency, based upon four observations in 35 years and the assumption of a random (Poisson) process.

recommends further analysis that includes all factors included in the Pipeline and Hazardous Materials Safety Administration (PHMSA) data.

Overview

Recent rail accidents involving combustible/flammable cargoes such as Bakken crude oil have raised concerns about this hazard among many people in the U.S.[5] Increases in the volume of Bakken crude oil transported by rail coupled with high -profile accidents like the Lac-Mégantic, Quebec, Canada accident, have been major factors in driving this concern and risk perception.[6] Although the Lac-Mégantic accident falls outside of the scope of the SNRA because it occurred in Canada, the images associated with this accident still affect perception in the U.S. The Lac-Mégantic accident, which resulted in 47 fatalities, represents an actual worst-case scenario involving combustible/flammable rail cargoes.[7]

Five other dramatic accidents involving the rail transport of combustible substances occurred in 2014: although none resulted in fatalities, they further bolstered perceptions that rail shipments of combustible/flammable materials pose a risk of real risk.

However, as with other risks, the perception of risk often differs from the actual probability and likely impacts of risk.[8] For example, the PHMSA data from 1980 through 2014 that was leveraged for the 2015 SNRA contains only four accidents in the U.S. involving at least one fatality. Moreover, none of those incidents caused more than one fatality, or resulted in impacts on the other SNRA measures of impact comparable to those of many other accidental and natural hazards studied in the SNRA.[9] Consequently, the relative risk of a fatal accident involving combustible/flammable cargoes may not necessarily match the perception of risk.

Prior to using results from the SNRA to inform a decision with significant impacts in the real world, it is important for end users to review the underlying data and fully understand its limitations.

Event Background

The recent advent of the shale oil boom in the U.S. and accidents involving rail cargoes of Bakken crude oil have raised concern over the hazards of such cargoes.[10] In 2013, over 462,000 barrels of oil where shipped by rail out of North Dakota, one of several states with crude oil production.[11] In the U.S., rail companies transported approximately 435,560 carloads of crude oil

[5] Pipeline & Gas Journal. (2014). Rail transportation of oil: A growing congressional safety concern [Online document]. *Pipeline & Gas Journal, 241*. Retrieved from http://pipelineandgasjournal.com/rail-transportation-oil-growing-congressional-safety-concern; Nader: Bakken oil-related railroad accidents are "national emergency" [Web page]. Retrieved from http://kfgo.com/news/articles/2015/feb/18/nader-bakken-oil-related-railroad-accidents-are-national-emergency/.

[6] The train accident in Lac-Mégantic, Quebec, Canada resulted in 47 fatalities, and the destruction of 40 buildings and 53 vehicles. Transportation Safety Board of Canada. (2013). *Railway investigation report R13D0054: Runaway and main-track derailment.* Retrieved from http://www.tsb.gc.ca/eng/rapports-reports/rail/2013/r13d0054/r13d0054.pdf

[7] Ibid.

[8] Regarding perception, Pipeline & Gas Journal (2014), Nader (2015), *op. cit.* (footnote 5). As noted by the U.S. Department of Transportation (DOT) accident risk per shipment is extremely low: nearly one million shipments of HAZMAT shipments including Bakken crude oil occur in the U.S. every day without incident, indicating an extremely low probability of a serious accident resulting in a fatality, injury, environmental impact, or economic impact occurring for a shipment. Nader, R. (2015, February 18). US DOT. (2014, February 2). PHMSA's ongoing Bakken investigation shows crude oil lacking proper testing, classification: Pipeline and Hazardous Material Safety Administration issues proposed civil penalties to three companies [Web page]. Retrieved from http://www.dot.gov/briefing-room/phmsa%E2%80%99s-ongoing-bakken-investigation-shows-crude-oil-lacking-proper-testing

[9] 2012–2014 data was collected from the U.S. DOT PHMSA website (https://hazmatonline.phmsa.dot.gov/IncidentReportsSearch/) using the Incidents Reports Database Search function. 1980–2011 data was archival data collected by RMA for the original SNRA.

[10] Frittelli, J., Andrews, A., Parfomak, P. W., Pirog, R., Ramseur, J. L., & Ratner, M. (2014). U.S. rail transportation of crude oil: Background and issues for congress [Online document]. Retrieved from www.crs.gov

[11] Pumphrey, D., Hyland, L., & Melton, M. (2014). *Safety of crude oil by rail* [Online document]. Retrieved from http://csis.org/files/publication/140306_Pumphrey_SafetyCrudeOilRail_Web.pdf

in 2013. From 2012 to 2014 (the last full year for data), four accidents occurred in the U.S. involving rail cargoes of crude oil.[12] However, accidents involving crude oil cargos from 1980–2014 represent approximately 0.09 percent of all incidents.[13] Alcohol N.O.S.[14] cargoes represented 0.8 percent of all incidents or 977 incidents out of over 13,000.[15] Additionally, alcohol N.O.S. and crude oil represent two of the approximately 180 different flammable or combustible commodities represented in the set of incidents reported to PHMSA in the 1980-2014 period included in the SNRA analysis.[16]

Aside from the type of cargo, the PHMSA data provided information on what failed (e.g. valve failed) that resulted in the release of the cargo. Three of the four events analyzed involved the failure of the container.[17] Three of the failures resulted from accident damage from a collision.[18]

Assumptions

All data used to develop the risk analysis came from the publically available PHMSA database. The PHMSA database includes incident information from several modes of transportation including aviation and rail. The scope of this report includes rail incidents involving cargoes with hazardous class noun names that include combustible, explosive, or flammable.[19] Cargoes that fall within the scope previously described include crude oil (e.g., Bakken crude), xylene, ethanol, etc.[20] In addition to the restrictions to rail and to specific cargoes, the scope of the SNRA Combustible/Flammable Cargo Accident (Rail) was limited to incidents involving at least one fatality related to the cargo.

Scope

The following are the parameters for data inclusion for the analysis:

1. Data set only includes incidents occurring within the U.S., U.S. territories, and possessions.[21]
2. Incidents must include at least one fatality.
3. Direct economic estimates were converted to 2011 dollars to allow for comparison with the existing SNRA 2011 data set.
4. Displacement data must be from incidents with displacements of 48hours or longer.
5. Incidents only involve rail as a means of transportation.
6. The analysis included incidents that use combustible, explosive, or flammable in the hazard noun name.[22]
7. To ensure data compatibility, to include but not limited to data collection methods and data collection standards, only PHMSA data is used.
8. Incidents only cover full years of data from 1980 to 2014.

[12] Ibid.
[13] PHMSA data for years 2012–2014 (https://hazmatonline.phmsa.dot.gov/IncidentReportsSearch/) expanded data set includes incidents without a fatality
[14] Alcohol Not Otherwise Specified
[15] PHMSA data for years 2012–2014 (https://hazmatonline.phmsa.dot.gov/IncidentReportsSearch/) expanded data set includes incidents without a fatality
[16] PHMSA data for years 2012–2014 (https://hazmatonline.phmsa.dot.gov/IncidentReportsSearch/) expanded data set includes incidents without a fatality
[17] PHMSA data for years 2012–2014 (https://hazmatonline.phmsa.dot.gov/IncidentReportsSearch/) as meets analytic scope.
[18] Ibid.
[19] Hazard class codes 1.1, 1.2, 1.4, all subclasses; 1.5, 1.7, 1.8, 1.9, 2, 2.1, 3, 4.1, 4.2, 4.4.
[20] PHMSA data for years 2012–2014 (https://hazmatonline.phmsa.dot.gov/IncidentReportsSearch/)
[21] Lands specified in the Homeland Security Act of 2002 as amended and the Stafford Act.
[22] Hazard class codes 1.1, 1.2, 1.4, all subclasses; 1.5, 1.7, 1.8, 1.9, 2, 2.1, 3, 4.1, 4.2, 4.4.

Specific Assumptions

The following are assumptions used for this analysis:

1. The scope of the SNRA 2015 Combustible/Flammable Cargo Accident (Rail) event allows for a meaningful representation of the risk to the Nation from this hazard.
2. Factors not included in the analysis do not produce statistically significant affects that could change the analysis.
3. The SNRA metric for psychological distress is a valid and meaningful measure for comparison among hazards, within the order of magnitude precision and generic limitations of the SNRA.

Data Cleaning

Data cleaning involved two specific measures. First, data cleaning involved the elimination of multiple lines of data that did not contain unique quantitative data. Second, data cleaning also included removing records that did not include a cargo with noun names falling within the scope of the analysis.

Frequency

From 1980 to 2014, a span of 35 years, only four incidents occurred that resulted in at least one fatality (SNRA minimum threshold for inclusion of a risk) due to the cargo out of over 13,000 incidents. All four incidents involved different cargoes.

Low, best, and high annual frequency estimates represent the 5th, mean, and 95th percentile of the frequency distribution based upon an assumption of a Poisson (random and independently occurring) process and four observations in 35 years.[23] The resulting low, best, and high estimates of 0.039, 0.114, and 0.222 incidents per year for a fatal combustible/flammable cargo rail accident are relatively low in comparison with many other hazards in the SNRA, including chemical (toxic inhalational hazard) accidents, dam failures, and the majority of the SNRA natural hazards.

Health and Safety

The analysis of the four incidents resulted in an average of one fatality, given the occurrence of an incident resulting in any fatalities. Although the average (expected value) of the set was used as the best estimate for consistency with other hazards analyzed in the SNRA, for the Combustible/Flammable Cargo Accident (Rail) this value of one fatality was also the most likely value (mode) of the set. Injuries ranged from 0 to 52, with an average of 20.

Economic Impacts

Direct Economic Impacts

Direct economic impacts as defined in the SNRA include decontamination, disposal, and physical destruction costs including property (structure, contents, physical infrastructure and other physical property) and crop damage; one year's lost spending due to fatalities; medical costs; and business interruption directly resulting from the impacts of an event.

[23] The distribution for the unknown frequency λ of the Poisson process given four observations in 35 years was represented by a gamma(4, 1/35) distribution.

Direct economic impacts for the set of incidents meeting the threshold criteria of this SNRA event ranged from $42,500 to $2,886,612, with an average of $904,994, according to the measure of direct economic impact used by the SNRA.[24]

Indirect Economic Impacts[25]

Direct economic losses alone do not represent the full picture of the economic impacts to the Nation from a disaster or attack. Indirect and induced economic losses can be substantially larger than the direct economic losses that occur in the aftermath of an event.

- **Indirect economic impacts** include costs incurred by the suppliers and vendors in the associated expenditure sectors for the industries impacted by the direct costs. Indirect impacts also include positive offsets due to increased spending within sectors impacted by the direct costs.[26]
- **Induced economic impacts** include those incurred due to reduced spending by households with members employed in any of the directly or indirectly affected industries. Induced impacts can also include substitution effects or likely transfers of economic activity from one set of sectors to another set, such as avoidance of air or other travel or altered transportation mode preferences to other sectors following an attack on the commercial air transport sector.

Highly mature economic models exist for calculating estimates of indirect and induced economic losses for natural disasters, human and animal pandemics, technological accidents, terrorist attacks, and cyber events. However, there is at present no generally agreed or practical method for translating estimates produced by these disparate models into a single measure which can be meaningfully compared across all of the threats and hazards of the SNRA in a defensible fashion. Because such a measure would yield data of great value for multiple purposes beyond the context of the SNRA and similar assessments, it has been among the highest risk research priorities for DHS and its academic Centers of Excellence for over a decade. Should these efforts prove successful in coming years, the next iteration of the SNRA will include comparisons of total economic loss to the Nation across all of its threats and hazards.

Social Displacement

For the purposes of the SNRA, social displacement was defined as the number of people forced to leave home for a period of two days or longer. Note that there are limitations to this measure of social displacement, as the significant differences between temporary evacuations and permanent displacement due to property destruction are not captured.

For the limited data set of historical observations resulting in one or more fatalities, no incident resulted in a displacement of populations for 48hours or longer.

Psychological Distress

Psychological impacts for the SNRA focus on significant distress and *prolonged distress*, which can encompass a variety of outcomes serious enough to impair daily role functioning and quality

[24] Note that the definition of direct economic impact is specific to the SNRA family of assessments, and should not be used for other purposes using different definitions without translation into the definition specific to that purpose unless the differences are insufficiently to affect a decision or communication using these estimates.
[25] The SNRA's taxonomy of indirect and induced economic impacts comes from the DHS Terrorism Risk Assessments and so is retained here for consistency across DHS assessments. However, both combined will be referred to as 'indirect economic impacts' where it is not expected to impede clarity.
[26] These may include the waste management, environmental consulting, mortuary services, and medical industries, among others.

of life. An index for significant distress was created that reflected empirical findings that the scope and severity of an event is more important than the type of event.[27] The equation for this index uses the fatalities, injuries, and displacement associated with an event as primary inputs. A multiplicative factor elicited from subject matter experts weights the index for differing psychological impact based on the type of event, but as a secondary input.

The Significant Distress Index is calculated from these inputs using a formula proposed by subject matter experts consulted for the SNRA project: $N_{SD} = C_{EF} \times (5\ Fat + Inj + \frac{1}{2}\ D)$, where N_{SD} represents the number of persons significantly distressed, C_{EF} is the expert assessed Event Familiarity Factor, *Fat* is the number of fatalities, *Inj* is the number of injuries and/or illnesses, and *D* is the number of persons displaced (Social Displacement).

- In words, this formula suggests that there are 5 significantly distressed persons for each life lost; 1 for each person injured; and 1 for each 2 people displaced. This formula was constructed to reflect the empirical finding that the most severe stressor of a disaster is losing a loved one, followed by injury, followed by displacement.
- The Event Familiarity Factor is intended to capture the extent to which the event entails an ongoing threat with uncertainty regarding long-term effects, is unfamiliar, or that people dread, exacerbating psychological impacts. This factor, ranging from 1.0 for familiar events to 1.3 for unfamiliar events, was provided by subject matter experts for each national-level event included in the SNRA.
- Uncertainty was captured by applying the index formula to the low, best, and high estimates of these three human impact metrics.

The numerical outputs of this index formula were used to assign events to bins of a risk matrix for a semi-quantitative analysis of psychological risk in the SNRA.

The Combustible/Flammable Cargo Accident (Rail) hazard event was added by the SNRA project subsequent to the 2011 iteration of the SNRA for which Event Familiarity Factors were elicited from subject matter experts. The SNRA project team assigned a provisional Event Familiarity Factor of 1.0 by analogy with other natural and accidental hazards in the existing SNRA, for the calculation of *provisional* psychological distress estimates. It must be stressed that this assignment has not been reviewed by the 2011 subject matter experts.

Environmental Impact

The SNRA environmental impact estimate, which was assessed in calendar year 2011 for the 23 original national-level events of the 2011 SNRA by subject matter experts from the U.S. Environmental Protection Agency (EPA), could not be assessed for the Combustible/Flammable Cargo Accident (Rail) hazard event which was added to the SNRA in calendar year 2015. A future iteration of the SNRA will assess the environmental impacts of this event on measures comparable with other SNRA threat and hazard events.

Discussion

Based upon the scope of the SNRA analysis and the specific data set selected by the SNRA project, the overall risk from a rail incident involving combustible/flammable cargoes is

[27] See Appendix G for references and additional discussion of the SNRA Psychological Distress metric.

comparatively low on every measure of risk assessed in the SNRA, relative to other threats and hazards in the existing SNRA data set.

Combustible/flammable cargo rail accidents resulting in fatalities have historically occurred only once every 10 years on average in the U.S., within the 1980–2014 historical observation period of the SNRA analysis. None of the four incidents meeting this threshold resulted in mass fatalities. Additionally, none of the incidents resulted in impacts on any other impact scale, which would meet the minimum threshold of inclusion for any other existing hazard in the SNRA. Although any such assessment must be made in recognition of the significant limitations of the SNRA methodology when leveraging historical data—particularly in view of recent evidence in a neighboring country of this hazard's potential to cause catastrophic mass fatality accidents—the differences in risk across impact measures between this hazard and other SNRA hazards sharing the same data and methodological limitations and constraints are striking. Objectively, these differences are greater than the order of magnitude considered to be the minimum resolution for risk judgments in the SNRA.

Fatalities and Illnesses/Injuries

The data set of over 13,000 incidents indicates that fatalities due to the cargo as opposed to fatalities due to collisions are uncommon.[28] Additionally, injuries are relatively rare with only 149 out of over 13,000 incidents involving an injury.[29]

Psychological Distress

The methodological approach for psychological distress used in the SNRA represents a first attempt to include psychological impacts in a strategic, national-level risk assessment focused on national preparedness. While this approach is straightforward and transparent, it also has important limitations that should be considered when interpreting the psychological distress results:

Additional analysis is required to verify and validate this approach, and the sensitivity of the results to the selection of weights in the formula should also be explored. Experts consulted about psychological impacts emphasized *extreme caution* in using the SNRA's measure of psychological distress, and the need for additional research.[30]

- Quantitative assessments of psychological factors generally involve an extreme level of complexity requiring specific controls. The methodological approach for psychological distress used in the SNRA does not include controls for factors such as preexisting psychological conditions, gender, age, culture, or other significant factors.
- The index approach currently does not include a component for translating economic losses into psychological distress. If estimates of homes destroyed and jobs lost (rather than overall direct economic losses) are obtained as impact estimates for various national-level events, it would be possible to capture financial loss as part of the equation for psychological distress in future iterations of the SNRA.

[28] PHMSA data for years 2012 – 2014 (https://hazmatonline.phmsa.dot.gov/IncidentReportsSearch/) expanded to include events without a fatality.
[29] Ibid.
[30] The U.S. Department of Homeland Security (DHS) and its partner organizations leveraged previously funded social and behavioral science research to better understand how to anticipate, prepare for, counteract, and mitigate the effects of terrorist acts, natural disasters, and technological accidents. Additional research is required to further explore psychosocial factors that enable resilience and affect recovery in individuals, organizations, communities, and at the societal level.

- The current social displacement measure (counting people as displaced if they are forced to leave home for two or more days) does not differentiate between short term displacement (i.e., short-term evacuation) and long-term permanent displacement (i.e., the home is destroyed). Ideally, the psychological impact index would differentiate these two types of displacement, because the long term displacement is much more impactful for "significant distress" and "prolonged distress" psychological impacts.
- The duration of distress is an important factor which is not considered in the current approach. Most people do recover over time, although individuals vary greatly in the speed with which they rebound.
- The psychometrics for the measure of psychological distress used in the SNRA is unknown.

The SNRA approach represents the first attempt to include psychological impacts in a DHS strategic, national-level risk assessment. However, the approach and inputs have not been extensively verified and validated by the broader community of academic researchers focused on psychosocial effects of disasters. As with all of the methodology and analysis introduced by the 2011 and 2015 iterations of the SNRA, the psychological distress estimates should be considered provisional pending full peer and stakeholder review.

Social Displacement

The limitation of the SNRA combustible/flammable rail accident hazard event to only those incidents with a fatality and displacements of 48 or more hours resulted in no cases of social displacement by the measure used in the SNRA. Expanding the data set to include incidents without a fatality added only two incidents with displacement of 48 or more hours.[31] However, when the incident set parameters included all cases of displacement, only 139 of over 13,000 incidents included a displacement,[32] or less than 0.1 percent of all incidents.

Environmental Impact

Although the SNRA measure of environmental impact could not be assessed for the Combustible/Flammable Cargo Accident (Rail) event in the 2015 SNRA, the project team examined other measures and indicators of environmental impact. The SNRA project team used reports from the Congressional Research Service (CRS), the Center for Strategic & International Studies (CSIS), and PHMSA in the qualitative analysis.

The concentration of oil released in a relatively small area, when transported by rail, could result in a serious environmental impact.[33] Spills from rail cargoes for the analyzed data set range from 500 liquid gallons (LGA) to 31,856 LGA.[34] However, while large, these quantities pale in comparison to the Exxon Valdez spill (10.92 million LGA) and the largest pipeline spill (1.68 million LGA).[35] Although volume of spill represents only one factor that affects environmental impacts, it still provides a means for comparing effects. By this measure, the environmental impacts of rail spills in the historical data set used by the SNRA are small by comparison with historical spills from other forms of transportation.

[31] PHMSA data for years 2012–2014 (https://hazmatonline.phmsa.dot.gov/IncidentReportsSearch/) expanded to include events without a fatality.
[32] Ibid.
[33] Congressional Research Service analysis. Frittelli, J., Andrews, A., Parfomak, P. W., Pirog, R., Ramseur, J. L., & Ratner, M. (2014). U.S. rail transportation of crude oil: Background and issues for Congress [Online document]. Retrieved from www.crs.gov
[34] PHMSA data for years 2012–2014 (https://hazmatonline.phmsa.dot.gov/IncidentReportsSearch/) as meets analytic scope.
[35] Pumphrey, D., Hyland, L., & Melton, M. (2014). Ibid. Energy Information Administration, U.S. Crude Oil Supply & Disposition (www.eia.gov) a barrel of oil is equal to 42 gallons.

Potential Mitigating Factors

Several factors could mitigate higher potential fatality and injury rates such as speed limits in more populous areas, which would mitigate catastrophic accidents. For example, the Lac-Mégantic accident occurred in part due to the train traveling in excess of 65 MPH into a corner rated for 35 MPH.[36] Thus, speed limits in populous areas may reduce fatality or injury risk for this hazard event.

Limitations and Other Recommendations

The limited scope of this assessment does not adequately address specific risks from specific cargoes. In addition, the lack of prior studies focused on specific cargoes limited the ability of the SNRA project team to compare different types of cargo. Different cargoes do present different specific hazards and risks. However, the SNRA analysis indicates that the transportation of any form of combustible/flammable cargo by rail presents comparatively low risks on all SNRA impact measures, within the limitations of the SNRA method and the historic incident data set leveraged by the SNRA.

The SNRA does not indicate what variables may have been mitigating what may be an otherwise substantial, but unknown, risk from some very dangerous cargoes. The SNRA project team was unable, within the compressed timeframe of the 2015 SNRA, to locate sufficient data or prior analysis to indicate whether it is predominately a single variable (e.g., speed limits), or combinations of factors, that have mitigated the historic likelihood of catastrophic incidents by this modality.

Future research should include specific efforts into variable analysis to help develop an understanding of which variables mitigate hazards. Such an effort could help identify single points of failure if they exist. However, any effort to study the different variables would likely need to be a more complex analysis, using advanced statistical methods such as stepwise regression analysis.

Additional unknowns which the SNRA analysis indicated as important for further research:

- Risk factors such as speed limits, because of the potential to provide significant insight into risks associated with rail cargoes.
- Risk factors other than type of cargo, such as rail infrastructure.

As with all analysis and findings conducted for the SNRA, any further analytic efforts should include a scientific peer review process to mitigate potential bias, and ensure that the results are valid and reliable.

[36] Transportation Safety Board of Canada. (2013). *Railway investigation report R13D0054: Runaway and main-track derailment*. Retrieved from http://www.tsb.gc.ca/eng/rapports-reports/rail/2013/r13d0054/r13d0054.pdf

Table 1: PHMSA Data Set

Report Number	Date of Incident	Incident City	State	Commodity Short Name	Hazardous Class	Quantity Released (LGA)	Total Amount of Damages	Total Hazmat Fatalities	Non-Hazmat Fatalities	Total Hazmat Hospitalized Injuries	Total Hazmat Non-Hospitalized Injuries	Total Hazmat Injuries	Total Evacuated	Total Evacuation Hours	Major Artery Closed	Major Artery Hours Closed
I-1996030174	6/8/86	San Antonio	TX	Butadienes inhibited	Flammable gas	31,856	0	1	0	0	0	0	0	0	No	0
X-2009070185	2/1/96	Cajon	CA	Butylacrylate	Flammable - combustible liquid	500	300,000	1	0	2	50	52	50	0	No	0
I-1986070066	10/15/05	Texarkana	AR	Propylene	Flammable gas	22,736	26,542	1	0	20	1	21	1,012	17	Yes	34
I-2005120302	6/19/09	Cherry Valley	IL	Alcohols N.O.S.	Flammable - combustible liquid	11,051	2,700,000	1	0	2	6	8	999	20	Yes	48