2015

STUDY OF NONPETROLEUM HAZARDOUS LIQUIDS TRANSPORTED BY PIPELINE PURSUANT TO THE SAFETY, REGULATORY CERTAINTY, AND JOB CREATION ACT of 2011, SECTION 17

U.S. Department of Transportation (DOT) Pipeline and Hazardous Materials Safety Administration (PHMSA)

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Executive Summary

Section 17 of the *Pipeline Safety, Regulatory Certainty, and Job Creation Act of 2011* (Public Law 112-90, January 2, 2012) ("the Act") authorizes the Secretary of Transportation to conduct an analysis of the transportation of nonpetroleum hazardous liquids by pipeline to identify the extent to which pipelines are being used for such transportation and to evaluate the level of State regulation and the potential significant risk in the absence of regulation of pipelines that transport nonpetroleum hazardous liquids from chemical production facilities through publicly accessible areas. Additionally, Section 14 of the Act clarified PHMSA's authority to issue regulations for pipelines transporting nonpetroleum fuels, including biofuels that are flammable, toxic, corrosive, or that would be harmful to the environment if released in significant quantities.

This analysis was performed by the U.S. Department of Transportation (DOT) Pipeline and Hazardous Materials Safety Administration (PHMSA) in 2014-15. Data about nonpetroleum hazardous liquid pipelines was not readily available from PHMSA's existing databases since such pipelines have not been subject to the 49 CFR Part 195 regulations, with the exception of anhydrous ammonia and nonpetroleum fuel pipelines. In undertaking the study, PHMSA researched nonpetroleum chemicals and the chemical industry, reviewed previous rulemakings and interpretations, analyzed chemical release reports, and communicated with subject matter experts, including chemical industry associations, excavation damage prevention organizations, State pipeline safety agencies and associations, and large chemical producers. The key findings are summarized below.

Scope of Nonpetroleum Hazardous Liquid Pipelines in Areas Accessible to the Public

This study examines three nonpetroleum hazardous liquid product pipelines that are not regulated under 49 CFR Part 195. PHMSA identified a 1.4-mile chlorine pipeline in Texas, one proposed 5,000-foot sodium hydroxide pipeline in Tennessee, one three-mile sulfuric acid pipeline installed in parallel with a three-mile spent sulfuric acid pipeline in Louisiana, and one three-mile pipeline in California that transports sulfuric acid in one direction and spent sulfuric acid in the other through land that is accessible to the public. Pipelines installed on land that is not owned by the chemical producer or their customer are considered to be "accessible to the public" for this study. PHMSA found that nonpetroleum hazardous liquid pipelines are primarily located in industrial areas.

Pipelines transporting petrochemicals and certain short, low-stress hazardous liquid pipelines are not regulated under 49 CFR Part 195. Petrochemicals, intermediate and finished products manufactured by further processing petroleum or nonpetroleum feedstocks by the addition of chemicals (e.g. ethylene dichloride), are not in scope of this study. For the same reason, low stress pipelines less than one mile long that serve refining, manufacturing, or truck, rail, or vessel terminal facilities, and do not cross navigable waterways, are also not in the scope.

Nonpetroleum fuels are a subset of nonpetroleum hazardous liquids and are already regulated under 49 CFR Part 195. As such, the risk of nonpetroleum fuels is not analyzed in this study.

Level of State Regulation

Alabama appears to be the only State with the statutory authority to regulate the safety of nonpetroleum pipelines that are not subject to compliance with 49 CFR Part 195. Alabama is not aware that any such pipelines have been built to date in the State. In most States, including Texas and California, any pipeline that transports hazardous liquids would be subject to the State's excavation damage prevention laws. Several State laws, including Tennessee, limit applicability of their excavation damage prevention laws to "utilities." Chemical producers would not be considered a utility. Tennessee and other states would need to further review their laws to determine if chemical producers meet the definition of utility in their State.

Evaluation of Significant Risks to Public Safety, Property, or the Environment in Absence of Regulation

The risk analysis included an examination of the hazards each chemical poses, the potential consequences of an unintended pipeline release, and the likelihood of its occurrence. A relative risk analysis was performed between chlorine and anhydrous ammonia to provide a comparison of potential impact to the public. Anhydrous ammonia is the only hazardous liquid product regulated under 49 CFR Part 195 that is nonpetroleum and not a fuel.

The risk posed by chlorine, sodium hydroxide, or sulfuric acid liquid pipelines varies according to their chemical and physical properties. Many factors influence the impact of a release, including the ability to vaporize, flammability, concentration, wind speed, obstructions to the flow of the product, and quantity released. The properties also govern compatibility of the chemical with pipeline materials. 49 CFR Part 195 does not prescribe materials to be used to transport a given product, but 49 CFR 195.4 requires operators to select materials that are chemically compatible with the commodity being transported. Steel pipe is required to be used per 49 Part 195.8, unless the operator has notified DOT and DOT determines that use of the alternative material is not unduly hazardous. Depending on the specific physical/chemical characteristics of the material being transported, carbon steel might not be an appropriate material of construction for sodium hydroxide and sulfuric acid pipelines. The identified pipelines were constructed or are proposed to be constructed of steel. The risks posed by the analyzed chemicals are:

- **Chlorine**

  Chlorine, like anhydrous ammonia, is classified as a poisonous gas and regulated by DOT, OSHA, and EPA based on its hazard and risk.

  Liquid chlorine is not a flammable or explosive material, so it will not cause a fire on its own. However, as a strong oxidant, chlorine may readily react to stimulate combustion. Chlorine reacts with many substances. Although dry chlorine does not react with or corrode metals such as carbon steel, it may become corrosive with the presence of moisture because the chlorine reacts violently with water. The effects of chlorine depend on the duration and level of exposure. Relatively low levels, 5-15 ppm, can cause eye and throat irritation, and higher levels of 40-60 ppm can cause lung injury. A few minutes of exposure to 1,000 ppm can cause death.

By all Federal regulatory risk measures and program thresholds examined for this study, chlorine is classified as a hazardous chemical.

The study estimates that there are 11 miles of liquid chlorine pipelines in areas accessible to the public.

While no chlorine gas pipeline accidents have been reported to PHMSA, there have been significant liquid chlorine railcar accidents that resulted in fatalities and injuries. In 2004, a railcar accident in Macdona, TX, resulted in a chlorine vapor cloud that spread over 10 miles.[1]

- **Sodium hydroxide**

Sodium hydroxide is classified as a hazardous material by DOT, but poses a lower risk to the public than chlorine or other hazardous liquids regulated under 49 CFR Part 195.

Liquid sodium hydroxide will not readily vaporize and is not flammable, not combustible, has no flash point, no auto-ignition temperature, and no explosive limits. Sodium hydroxide is regarded as stable. Sodium hydroxide is odorless, but mucous membrane irritation occurs at the OSHA PEL (2 mg/m3), which provides warning for acute exposure. Very strong solutions of sodium hydroxide can cause severe burns and eye damage or, in extreme cases, blindness. Sodium hydroxide does not produce systemic toxicity. Health effects are due to its corrosive nature. Sodium hydroxide will react vigorously with some metals.

A high concentration of sodium hydroxide in water will generally result in toxic effects for aquatic organisms. However, a low concentration in water may not result in effects on aquatic organisms because the sodium hydroxide will be neutralized by other substances present in water, and, thus, the pH will not increase. When sodium hydroxide is neutralized in the environment, the substance is not persistent and it will not accumulate in organisms or in the food chain. Bioaccumulation will not occur.

Sodium hydroxide is a co-product with chlorine in the chlor-alkali process and produced in approximately equal amounts. The study estimates, absent better information, that there are 10 miles of liquid sodium hydroxide pipelines in areas accessible to the public.

The likelihood of failure of sodium hydroxide pipelines is assumed to be similar to that of hazardous liquid pipelines, although the consequences to the public would likely be lesser. A 2006 sodium hydroxide railcar accident in McKean County, PA, resulted in environmental damage in the form of significant fish kills for 11 miles downstream of the rail accident.[2] Sodium hydroxide is neutralized in the environment so it is not persistent and will not accumulate in organisms.

[1] http://www.ntsb.gov/investigations/AccidentReports/Reports/RAR0603.pdf
[2] http://www.fishandboat.com/water/streams/sinnemahoning/norfolk_report.pdf

- **Sulfuric acid (nonfuming) and Spent Sulfuric Acid**

  Sulfuric acid shows different properties depending on its concentration. Because of its corrosiveness, it is a hazardous material. It has a pungent odor and can cause severe skin burns, eye damage, and may harm aquatic life. Sulfuric acid pipelines pose a relatively lower risk to the public than chlorine or petroleum pipelines.

  The two identified sulfuric acid liquid pipelines contain 99 percent acid and 1 percent water. Sulfuric acid will not readily evaporate and is not flammable. Spent sulfuric acid typically contains 88 to 95 percent acid and up to 5 percent water, with the balance being hydrocarbons, including some light hydrocarbons that can vaporize and are flammable. Although the release and ignition of flammable fluids is a concern, the release of toxic materials poses a greater threat to the public. Sulfuric acid reacts violently with water.

  The study estimates about 6.4 miles of sulfuric acid pipelines and 6.4 miles of spent sulfuric acid pipelines may be in areas accessible to the public.

  The likelihood of failure of sulfuric acid pipelines is similar to that of hazardous liquid pipelines, although the consequences likely would be lesser since it is not flammable.

  In 1996 in a sulfuric acid railcar accident in Tennessee Pass, CO, 51,606 gallons of sulfuric acid were released and four people were evacuated. Drivers in the area and rescue workers sought treatment for exposure to fumes, with symptoms ranging from burning eyes to shortness of breath and nausea. Two million pounds of soda ash and lime were used to neutralize the acid.[3]

Preventative and Mitigative Measures to Manage Risks of Nonpetroleum Pipelines

While nonpetroleum hazardous liquids pipelines in areas accessible to the public are not regulated by PHMSA, certain measures are in place to prevent and mitigate the consequences of unintended releases.

Two industry associations, the Chlorine Institute (CI) and the American Chemistry Council (ACC), require members to participate in safety management system programs. The programs are designed to improve the health, safety, and environmental performance of the chemical industry. The chlor-alkali industry has developed technical standards for the design, construction, operation and maintenance of chlorine liquid and gas pipelines, published as the CI's *Pamphlet 60 Chlorine Pipelines.* The recommendations are applicable to pipelines that terminate outside the chlorine production facility or cross property not owned by the shipper or receiver of the chlorine.

Federal regulations require operators whose plants contain threshold quantities of chemicals to work closely with public and response agencies (e.g., the fire department). Due to this required relationship, it is expected that prudent chemical producers would communicate with fire departments to make them aware of any pipelines that transport hazardous liquids in areas accessible by the public, and that they

[3] http://www.sulphuric-acid.com/techmanual/Plant_Safety/safety_accidents.htm

would receive training on product-specific emergency response. This relationship is important to mitigate the potential consequences from an unintended release.

Excavation damage prevention laws, when applicable to nonpetroleum hazardous liquid pipelines, also serve to prevent and mitigate the consequences of unintended releases.

Study Results

The nonpetroleum hazardous liquid pipelines identified during this analysis include chlorine, sodium hydroxide, and sulfuric acid/spent sulfuric acid. Nonpetroleum fuels are already regulated under 49 CFR Part 195. Chlorine, sodium hydroxide, and sulfuric acid/spend sulfuric acid are categorized as hazardous materials by multiple Federal agencies based on chemical and physical properties. Accidental release of these chemicals poses varying risk to the public. Chlorine is toxic at a lower concentration than anhydrous ammonia, a nonpetroleum hazardous liquid regulated under 49 CFR Part 195. The potential impact area of chlorine is estimated to be similar to that of anhydrous ammonia, using vapor dispersion models developed through PHMSA’s R&D program. Under the EPA’s Emergency Planning and Community Right-to-Know Act (EPCRA), Sections 302 and 304, chlorine is listed as an extremely hazardous substance (EHS) when stored (1,000 lbs) or released (100 lbs), above the threshold planning quantity (TPQ). Releases of chlorine can result in vapor clouds that may encompass large areas. It is important to note that recent research shows that commonly used transport and dispersion models overestimated the consequences when compared to actual releases.

The vast majority of hazardous liquid pipelines transport petroleum products. PHMSA regulates nearly 190,000 miles of hazardous liquid petroleum pipelines, about 3,500 miles of hazardous liquid non-petroleum pipelines, and 22 miles of chlorine gas pipelines. The very few miles of liquid chlorine, sodium hydroxide, and sulfuric acid pipelines estimated to be located in areas accessible by the public are likely to be located in industrial areas. While the estimated miles of chlorine, sodium hydroxide, and sulfuric acid/spent sulfuric pipelines are very low, PHMSA regulates other gas products (i.e. hydrochloric acid, chlorine gas) that are transported through similarly few number of miles in areas accessible by the public.

1 Purpose

PHMSA prescribes safety standards and reporting requirements for pipeline facilities used in the transportation of hazardous liquids or carbon dioxide per 49 CFR Part 195. Hazardous liquids are defined in 49 CFR §195.2 as petroleum, petroleum products, anhydrous ammonia, or ethanol.

In Section 17 of the Act, Congress authorizes PHMSA to conduct an analysis of nonpetroleum hazard liquid pipelines as follows:

> *SECTION 17 - STUDY OF NONPETROLEUM HAZARDOUS LIQUIDS TRANSPORTED BY PIPELINE*
> *The Secretary of Transportation may conduct an analysis of the transportation of nonpetroleum hazardous liquids by pipeline facility for the purpose of identifying the extent to which pipeline facilities are currently being used to transport nonpetroleum hazardous liquids, such as chlorine, from chemical production facilities across land areas not owned by the producer that are accessible to the public. The analysis should identify the extent to which the safety of the pipeline facilities is unregulated by the States and evaluate whether the transportation of such chemicals by pipeline facility across areas accessible to the public would present significant risks to public safety, property, or the environment in the absence of regulation. The results of the analysis shall be made available to the Committee on Commerce, Science, and Transportation of the Senate and the Committee on Transportation and Infrastructure and the Committee on Energy and Commerce of the House of Representatives.*

In Section 14 of the Act, Congress expanded PHMSA's authority to issue regulations for pipelines transporting nonpetroleum fuels, such as biofuels. The Act amended "hazardous liquid" in 49 USC Section 60101(a)(4) to include "nonpetroleum fuel, including biofuel, that is flammable, toxic, corrosive or would be harmful to the environment if released in significant quantities."

This report covers all elements of the analysis set forth in Section 17 of the Act. The analysis also discusses nonpetroleum fuels as a subset of nonpetroleum hazardous liquids.

2 Methodology

PHMSA does not collect data about hazardous liquid pipelines that are not regulated under 49 CFR 195, nor is data readily available about these pipelines. Substantial research and communication with subject matter experts was required to identify nonpetroleum hazardous liquid pipelines in areas accessible by the public. Information about chemical hazards was readily available.

PHMSA's approach to analyzing the risk of nonpetroleum hazardous liquids consisted of:

- **Section 3.1 - Define the scope of nonpetroleum hazardous liquids and relevant pipeline facilities for this study**

Research the chemical industry to identify potential nonpetroleum hazardous liquids products transported by pipeline and the approximate mileage of such pipelines. Compare chlorine pipelines in the European Union (EU) to those in the U.S. Define "accessible to the public." Review historical rulemaking preambles and PHMSA interpretations related to the scope of hazardous liquid products and facilities that PHMSA excludes from 49 CFR Part 195. Apply a similar approach to define scope for nonpetroleum pipelines.

- **Section 3.2 - Locate nonpetroleum pipeline and pipeline releases in public areas**

  Obtain and review accident reports to identify nonpetroleum hazardous liquid material releases potentially from pipelines transporting products from chemical production facilities in areas accessible by the public. Consult with industry associations, chemical producers, and One-Call center associations to gain product background and locate nonpetroleum pipelines.

- **Section 3.3 - Determine extent to which States regulate nonpetroleum pipelines**

  The National Association of Pipeline Safety Regulators (NAPSR) provides information about the extent to which States map, regulate, or permit nonpetroleum pipelines not regulated under 49 CFR Part 195.

- **Section 3.4 - Evaluate risk of unregulated pipelines to the public**

  Analyze chemical and physical properties, estimate the potential consequences to the public of an unintended release, review case studies of hazardous material releases, and approximate the miles of pipeline in public areas and the likelihood of pipeline releases. Review PHMSA's accident database to evaluate the relative risk of chlorine gas, anhydrous ammonia (i.e. a regulated nonpetroleum hazardous liquid), and petroleum pipelines. Review current preventative and mitigative measures.

3 Analysis

3.1 Define Scope of Nonpetroleum Hazardous Liquids and Extent of Pipeline Facilities

This section describes the research conducted to define the scope of nonpetroleum hazardous liquids and the extent of the pipeline facilities for these chemicals. The research included a review of the chemical industry to identify potential products transported by pipeline, a comparison of chlorine pipelines in the E.U. and the U.S., and a review of historical rulemaking preambles related to the scope of hazardous liquid products.

Chemical manufacturing creates products by transforming organic and inorganic raw materials through chemical processes. Organic chemicals are carbon-based. The majority of organic chemicals are petroleum products or derivatives of petroleum products, called petrochemicals.

3.1.1 U.S. Chemical Industry Background

In the U.S. petrochemical industry, the organic chemicals with the largest production volumes are petroleum products: methanol, ethylene, propylene, butadiene, benzene, toluene and xylenes.[4] Pipelines transporting these petroleum products are currently regulated by PHMSA.

Nonpetroleum organic chemicals can be derived from biological material, plants, and animals. Nonpetroleum organic hazardous liquid chemicals produced in sufficient quantity to potentially be transported by pipelines are primarily nonpetroleum fuels, including biofuels. The EPA defines biofuels as fuels derived from renewable biological material. Methanol is an example of a nonpetroleum fuel, as it can be produced from a variety of feedstocks including organic materials. Methanol can also be produced from petroleum. Ethanol is produced both as a petrochemical, through the hydration of ethylene, or as a biofuel through biological processes that ferment organic material with yeast. Ethanol is the most widely produced biofuel. Coal and biofuels such as biobutanol and biodiesel are additional examples of nonpetroleum organic chemicals. PHMSA has previously stated[5] that ethanol and other biofuels are substances that “may pose an unreasonable risk to life or property” within the meaning of 49 U.S.C. 60101(a)(4)(B), and, accordingly, these materials constitute “hazardous liquids for purposes of the pipeline safety laws and regulations.”

Nonpetroleum biofuel pipeline data submitted to PHMSA’s National Pipeline Mapping System (NPMS) include 32 miles of liquid ethanol pipelines and a three-mile pipeline that transports a mixture of biodiesel, kerosene, and ethanol. The Energy Independence and Security Act (EISA) mandates increased production of biofuels. Production of biofuels and the construction of pipelines transporting biofuels are expected to increase in the future. Section 14 of the *Pipeline Safety, Regulatory Certainty, and Job Creation Act of 2011* recognized this and provided clarity that PHMSA has the authority to regulate all hazardous liquid nonpetroleum fuel pipelines, including those transporting biofuels. The language amending the definition of “hazardous liquid” to include “nonpetroleum fuel, including biofuel” is included in PHMSA’s Notice of Proposed Rulemaking, *Pipeline Safety: Safety of Hazardous Liquid Pipelines*, published on October 13, 2015. Because these products are regulated under 49 CFR Part 195, they will not be included in the risk analysis.

Other than nonpetroleum fuels, the nonpetroleum hazardous liquids that are the subject of this study are inorganic chemicals. Inorganic chemicals are mineral-based and are mainly used as inputs in manufacturing and industrial processes. The inorganic chemical industry produces basic chemicals such as chlor-alkali products.

EPA Notebook Project

The following information about the inorganic chemical industry is drawn from the *Environmental Protection Agency (EPA) Office of Compliance Sector Notebook Project, Profile of the Inorganic Chemical Industry* (referred to in this paper as “the Notebook”) published in 1995,[6] and *The Chlorine*

[4] Shale Gas and New Petrochemicals Investment: Benefits for the Economy, Jobs, and US Manufacturing, American Chemical Council, March 2011 http://chemistrytoenergy.com/sites/chemistrytoenergy.com/files/ACC-Shale-Report.pdf
[5] Pipeline Safety: Miscellaneous Amendments to the Pipeline, FR Vol. 80, No. 47 Wednesday, March 11, 2015.
[6] http://www.epa.gov/compliance/resources/publications/assistance/sectors/notebooks/inrgchsn.pdf

Industry: A Profile Draft Report published in 2000.[7] While the information was published 15-20 years ago and the chemical business sector and markets have changed, the documents provides the necessary background to gain an understanding of potential inorganic nonpetroleum products potentially transported by pipeline in areas accessible by the public.

- The inorganic chemical industry manufactures over 300 different chemicals accounting for about 10 percent of the total value of chemical shipments in the U.S.

- Inorganic chemicals are used at some stage in the manufacture of a great variety of products. The chemical industry's products are used as basic chemicals for industrial processes, as chemical products to be used in manufacturing products, and as finished products for ultimate consumption. The largest use of inorganic chemicals is as processing aids in the manufacture of chemical and nonchemical products. Consequently, inorganic chemicals often do not appear in the final products.

- The inorganic chemical industry is characterized by a relatively large number of small facilities. A significant portion of inorganic chemicals are produced and used within the same plant in the manufacturing of organic chemicals.

Inorganic chemical facilities are typically located near consumers and to a lesser extent near raw materials. The largest use of inorganic chemicals is in industrial processes for the manufacture of chemicals and nonchemical products; therefore, facilities are concentrated in the heavy industrial regions along the Gulf Coast, both east and west coasts, and the Great Lakes region. Since a large portion of inorganic chemicals produced are used by the organic chemicals manufacturing industry, the geographical distribution of inorganic facilities is very similar to that of organic chemicals facilities. (See Figure 1).

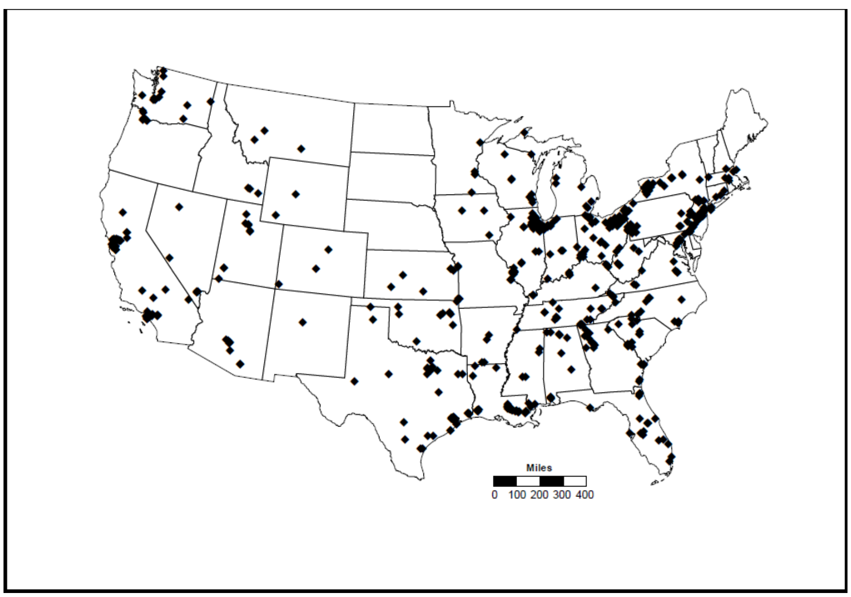

Figure 1: Inorganic Chemicals Facilities Distribution. Source: U.S. EPA Toxic Release Inventory Database, 1993

[7] http://www.epa.gov/ttnecas1/regdata/EIAs/chlorine%20profile.pdf

- The chlor-alkali industry produces mainly chlorine, caustic soda (sodium hydroxide), soda ash (sodium carbonate), sodium bicarbonate, potassium hydroxide, and potassium carbonate. In 1992, chlorine and caustic soda production accounted for about 80 percent of the chlor-alkali industry's value of shipments and, in terms of weight, were the eighth and ninth largest chemicals produced in the U.S., respectively.

- The alkali and chlorine industry consists of a relatively small number of medium to large facilities. The distribution of the chlor-alkali sector differs from that of the inorganic chemicals industry as a whole.

- Caustic soda and chlorine come from the same manufacturing industry because they are co-products that are produced in fixed proportions, primarily through the electrolysis of salt (brine).

- Chlorine gas is either used in gaseous form within the facility, transferred to customers via pipeline, or liquefied for storage or transport. Liquid chlorine is of a higher purity than gaseous chlorine and is either used within the facility or transferred via rail tank car, tank truck, or tank barge.

- Industry accounts for most of the direct chlorine consumption in the United States. The chemical industry consumes chlorine as an intermediate good in the production of other chemicals, such as polyvinyl chloride (PVC) resin. The pulp and paper and waste treatment industries use chlorine in direct applications. Households consume chlorine indirectly, as a component of other products such as PVC pipe, clean water, or cleaning products. Consumers of chlorine in 1998 are presented in the Figure 2 below.

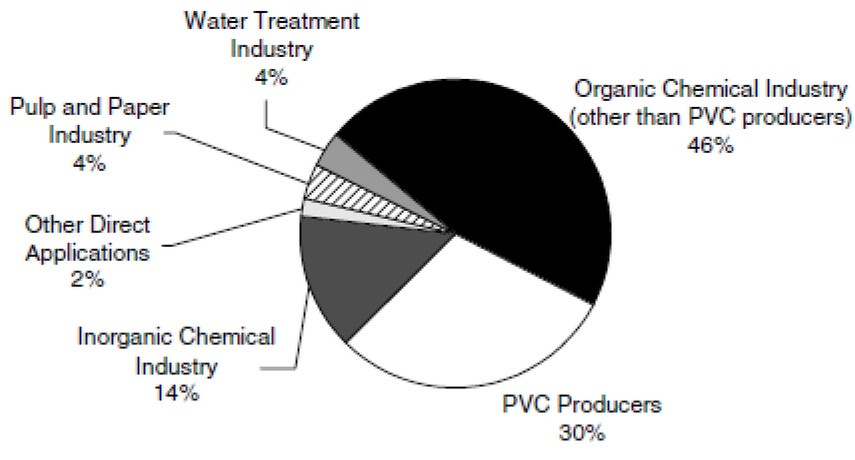

Figure 2: U.S. Chlorine Consumers, 1998. Source: U.S. EPA, The Chlorine Industry: A Draft Report

  - *PVC Industry* – In 1994, PVC accounted for approximately 34 percent of total chlorine demand. Chlorine is used primarily to manufacture ethylene dichloride, which is used in PVC production.

- *Organic Chemical Industry (Other than PVC producers)* – The major consumers in the organic chemical industry are the phosgene, derivatives, and titanium tetrachloride industries. Combined they represent more than 40 percent of chlorine consumption.

- *The Pulp and Paper Industry* – In 1994 they accounted for 9 percent of the U.S. chlorine consumption.

- Most chlor-alkali facilities are concentrated near the chemical industries along the Gulf Coast, followed by the Great Lakes region. There are some chlorine manufacturers that are not located in these regions. Other important areas are in the vicinity of the pulp mills of the Southeast and Northwest. In 1989, almost half of the chlorine plants in the U.S. (72 percent of domestic chlorine production) were located along the Gulf Coast. Two States, Louisiana and Texas, accounted for two-thirds of the domestic chlorine production.

CI Pamphlet 10

In addition to The Notebook, valuable information about the chlor-alkali industry was obtained from the CI. The CI provided PHMSA with a copy of *Pamphlet 10 North American Chlor-Alkali Industry Plants and Production Data Report for 2013*. Figure 3 is a map showing the location of operating chlorine and alkali plants in the U.S., Canada, and Mexico. In 1989, there were 25 companies operating 52 chlorine production plants. By 2013, there were 25 companies operating 44 plants.

Figure 3: Operating Chlorine and Alkali Plants. Source: The CI Pamphlet 10

Also from *Pamphlet 10, Table 12: Chlorine Capacity and Production in the United States (Short Tons)* shows that annual liquid chlorine production peaked in 2004. The same table shows that 84 percent of the chlorine was liquefied. *Table 19: United States Chlorine and Sodium Hydroxide Production Statistics* shows that 21 percent of the liquid chlorine produced in 2013 was shipped. Based on 2013 data in Pamphlet 10, the following statistics can be calculated: 21 percent of liquefied chlorine is shipped by rail, truck, and barge, and 79 percent of liquefied chlorine remains for in process use, supply between chemical plants, or supply to consumer. An estimate of the miles of chlorine pipelines in public areas is covered in section 3.4.3.2.

Chemical Industry Background – Sulfuric Acid[8]

Sulfuric acid is the chemical produced in the largest volume and is the most widely used chemical in industrial applications. It is used in the production of gasoline, fertilizer, phosphates, chemicals, paints, batteries, paper, pigments, steel, synthetic fibers, and hundreds of compounds. About 50 percent of sulfuric acid is used to make phosphoric acid, which is used in the production of phosphate fertilizers. Sulfuric acid is used in nearly every industrial process. It is very versatile due to its properties (acidity, reactivity and corrosivity), sulfur content, and affinity for water.

Fuming sulfuric acid, oleum, is an intermediate in the manufacture of sulfuric acid. Oleum is a solution of sulfur trioxide in sulfuric acid.[9] Oleum is typically transported by rail and road. The Association of American Railroads (AAR) Bureau of Explosives (BOE) Annual Rail Report published in August 2014 includes a listing of the top 125 hazardous commodities transported by rail in the U.S., Canada and Mexico and does not include oleum. Since oleum is not on the list, PHMSA concludes there is not significant quantity to be transported by pipeline. Oil refineries use 99 percent sulfuric acid for alkylation and 93 percent sulfuric acid for cooling water treatment. Weakened or contaminated sulfuric acid is referred to as spent sulfuric acid. Spent sulfuric acid can be regenerated back to relatively pure acid for reuse in the main process.

3.1.2 Comparison of Chlorine Pipelines in the United States to the European Union

In 2011, the European Commission, Directorate-General Environment published *Assessing the case for EU legislation on the safety of pipelines and the possible impacts of such an initiative.*[10] The study examined "the need for and the potential value added of Community legislative action on the safety of onshore pipelines." Pipeline network and incident data for their study was obtained from the European Gas Pipeline Incident Data Group (EGIG) and through consultation with industry associations including Euro Chlor (an association of chlor-alkali process plant operators in Europe).

The following is a comparison of the information in the report about chlorine pipeline transport in the Europe Union (EU) with information about chlorine pipeline in the U.S. from The Notebook:

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[8] http://www.essentialchemicalindustry.org/chemicals/sulfuric-acid.html
[9] http://en.wikipedia.org/wiki/Fuming_sulfuric_acid
[10] http://ec.europa.eu/environment/seveso/pdf/study_report.pdf

Table 1: Chlorine Pipeline Transport E.U. and U.S.	
E.U.	**U.S.**
The annual chlorine production in Europe was about 11 million short tons (U.S.) (2010).	By comparison, in 2010 The Chlorine Institute's *Pamphlet 10*[11] *Table 12 Chlorine Capacity and Production in the Unites States* shows that the U.S. chlor-alkali industry produced 10.7 million short tons (U.S.) of gas chlorine, of which 84 percent, or 9.0 million short tons, were liquefied. The U.S. chlorine production was about 10 percent smaller than the E.U. in 2010.
The biggest applications for chlorine in Europe are the manufacture of polyvinyl chloride (PVC), polyurethane, and polycarbonate plastics, representing about two thirds of the chlorine consumption.	The majority of U.S. chlorine production (70 percent) is used in the manufacturing of organic chemicals including: vinyl chloride monomer, ethylene dichloride, glycerine, glycols, chlorinated solvents, and chlorinated methanes. Vinyl chloride, which is used in the production of polyvinyl chloride (PVC) and many other organic chemicals, accounts for about 38 percent of the total domestic chlorine production. The pulp and paper industry consumes approximately 15 percent of U.S. chlorine production, and about eight percent is used in the manufacturing of other inorganic chemicals. Other major uses are disinfection treatment of water, and the production of hypochlorites.
The majority of chlorine in Europe is moved by pipelines, with rail and road transportation accounting for a little more than five percent of production. Producers and consumers of large-volume bulk chemicals are often located in relative proximity, to minimize transportation costs. Most movement of chlorine by pipeline therefore takes place within company premises, or between different companies within an industrial complex. In the latter case, the pipeline may follow or cross public roads. In a limited number of cases, pipelines supply a nearby consuming unit by passing through public domain in large industrial areas, like the Rotterdam and Antwerp Harbours, and some German highly industrialized areas.	In the U.S., more than two-thirds of all chlorine is consumed in the same manufacturing plant in the production of chemical intermediates.
A typical liquid chlorine pipeline in Europe has a	The two identified liquid chlorine pipelines are

[11] Pamphlet 10 North American Chlor-Alkali Industry Plants and Production Data Report for 2013

diameter of four inches or less connecting a producing unit to a consumer's unit. There is no distribution network. Excluding pipelines of less than 109 yards, the average length of a liquid chlorine pipeline is about 3.6 miles. There are no cross-country chlorine pipelines in the EU.	six inches in diameter and 1.4 miles long. They are buried and the maximum allowable operating pressure (MAOP) is 300 PSIG. They also connect the chlorine producer to the chlorine producer's facilities.
There might be between 5 and 10 of the pipelines in the EU, which at some point extend into public land with a combined length of 30 miles (upper estimate).	The details about the estimation of liquid chlorine pipelines mileage is estimated in Section 3.4.3.2. This study estimates 11 miles of liquid chlorine pipelines that extend into public lands.

3.1.3 PHMSA's Historical Definition of Hazardous Liquids and Petroleum Product

49 CFR Part 195 has applied to petroleum products and anhydrous ammonia transported in liquid form by pipeline since the Hazardous Liquid Pipeline Safety Act of 1979 authorized the Department of Transportation to regulate pipeline transportation of hazardous liquids. The current scope of 49 CFR Part 195 includes pipeline transporting hazardous liquids or carbon dioxide. Nonpetroleum hazardous liquid products currently regulated by PHMSA are limited to carbon dioxide and anhydrous ammonia.

The definitions in 49 CFR Part 195 of hazardous liquid, petroleum and petroleum product are:

> *Hazardous liquid* means petroleum, petroleum products, anhydrous ammonia, or ethanol.
> *Petroleum* means crude oil, condensate, natural gasoline, natural gas liquids, and liquefied petroleum gas.
> *Petroleum product* means flammable, toxic, or corrosive products obtained from distilling and processing of crude oil, unfinished oils, natural gas liquids, blend stocks and other miscellaneous hydrocarbon compounds.

PHMSA interpreted the definition of *petroleum product* in 1996 to exclude "petrochemical products" in the *Petroleum Products and Low-stress* Rule (Vol. 61, No.94 FR 24244). From the Federal Register notice:

> *"…the hazardous liquid pipeline transportation industry identified petroleum products as hydrocarbon compounds derived from processing natural gas or petroleum. This processing typically occurs at oil refineries, gas processing plants, and gasoline plants.*
>
> *Petroleum products include butane, propane, gasoline, heating oil, aviation fuel, kerosene, and diesel fuel. Also included are hydrocarbon feedstocks, such as ethylene and propylene that are the basis of hundreds of petrochemical products, including paints, plastics, synthetic fibers, and fertilizers.*
>
> *Prior to the definition, we did not consider the intermediate and finished products manufactured at petrochemical plants by further processing hydrocarbon feedstocks to be petroleum products. These petrochemical products are characterized by the addition of chemicals, such as chlorine, nitrogen, or oxygen, to the hydrocarbon feedstocks.*

> *In adopting the definition of petroleum product, we did not seek to expand this prior understanding of the term, only to clarify it. For this reason, the definition of petroleum product must be applied consistent with its regulatory background. Thus, petrochemical products that are made by chemical means using petroleum products as a raw material do not come under the definition.*

3.1.4 Apply Exclusion of 'Petrochemical Products' to Nonpetroleum Products Scope

Consistent with PHMSA's historical exclusion of "petrochemical products," nonpetroleum products will exclude petrochemical products from this report.

Chemical "production chains" illustrate the transformation of raw materials into products. The raw materials may consist of petroleum and nonpetroleum chemicals. For example, Figure 4 is a schematic of the chlor-alkali production chain, from the ACC's web site. Chlor-alkali and derivative products include chlorine, caustic soda (sodium hydroxide), vinyl chloride monomer, chlorinated solvents, calcium hypochlorite, ethylene dichloride, and phosgene derivatives. Following the top path, chlorine is produced and then mixed with ethylene (petrochemical) to produce ethylene dichloride. While ethylene dichloride is produced in very large quantities and could be transported by pipeline, PHMSA's previous definition classified ethylene dichloride as a "petrochemical product" and exempted it from scope of 49 CFR Part 195, so it is therefore not in scope of this report.

Guide to the Business of Chemistry 2014

FIGURE 2.3
Chlor-Alkali Chain

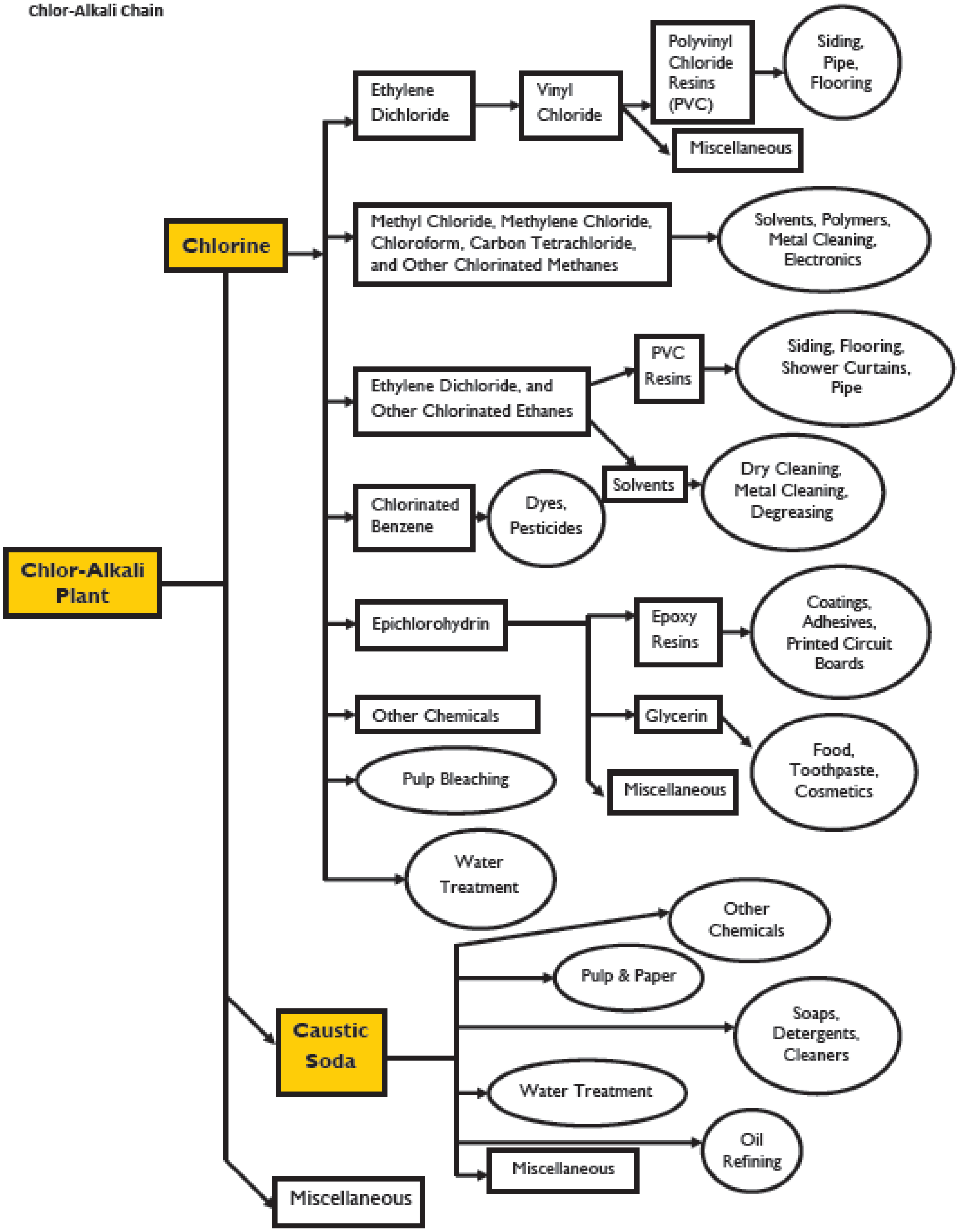

Figure 4: Chlor-Alkali Chemical Chain. Source: American Chemistry[12]

[12] http://www.americanchemistry.com/Jobs/EconomicStatistics/Industry-Profile/Chemical-Chains

3.1.5 Identify Chemicals Produced in Large Volumes – Commodity Chemicals

The chemical industry categorizes business segments as basic chemicals (also known as commodity chemicals), specialty chemicals, agricultural chemicals, pharmaceuticals, and consumer products.[13] Commodity chemical manufacturers produce large quantities of basic and relatively inexpensive compounds in large plants that often produce a single chemical. Commodity plants typically run continuously except when shut down for maintenance. Commodity chemicals are mainly sold within the chemical industry and to other industries before the chemicals ultimately become end products. Companies may use some of their commodity chemicals as intermediates, or they may sell them to a manufacturer. Companies may co-locate in industrial complexes when there are clusters of processes that use the output of one as the input to other. Due to the large volume produced and close proximity to downstream markets, commodity chemicals potentially could be transported by pipeline.

A source of recent, publically available U.S. production volumes of commodity chemicals was difficult to locate. The references used to identify inorganic, chemical products potentially transported by pipeline include the ACC's *2002 Guide to the Business of Chemistry*, *Chemical and Engineering News*, *July 10, 2006* (as cited on Wikipedia[14]) and *The Essential Chemical Industry – Online.*[15] The *Guide to the Business of Chemistry* lists the commodities in order of annual production volume. As a point of comparison with products regulated under 49 CFR Part 195 or Part 192, the product on this list with the lowest annual production currently is butadiene (#49), and the highest is ethylene (#3). For those not regulated, sulfuric acid is #1, chlorine is #9, and sodium hydroxide is #13. Appendix A is a summary of inorganic commodity chemicals identified through these sources and a ranking of them in terms of annual production volumes. This list formed the basis of chemicals for further evaluation through a review of accident reports. Details of the report review are covered in Section 3.2. Other inorganic nonpetroleum chemicals are produced in quantities unlikely to be transported by pipeline through public areas.

3.1.6 Facilities Excluded from Study – Transfer Pipelines

49 CFR §195.1(b)(3)(ii) exempts low stress pipelines that serve refining, manufacturing, or truck, rail, or vessel terminal facilities, if the pipeline is less than one mile long (measured outside facility grounds) and does not cross an offshore area or a waterway currently used for commercial navigation. Low stress is defined as pipelines operating under 20 percent specified minimum yield strength (SMYS) and less than 125 PSIG. 49 CFR §195.1(b)(9)(ii) also exempts pipelines located at material transportation terminals used exclusively to transfer hazardous liquid between non-pipeline modes of transportation (e.g., barge and railroad) or between a non-pipeline mode and a pipeline mode. PHMSA provided the justification for exempting these pipelines in the previously mentioned *Petroleum Products and Low-stress* Rule:

> *This piping is subject to Occupational Safety and Health Administration (OSHA) safety standards, including, when 10,000 pounds or more of flammable liquid are involved, the Process Safety Management regulations (29 CFR 1910.119) issued under the Clean Air Act*

[13] http://www.americanchemistry.com/Jobs/EconomicStatistics/Industry-Profile/Business-of-Chemistry-Segments
[14] http://en.wikipedia.org/wiki/Inorganic_chemistry#cite_ref-2
[15] http://www.essentialchemicalindustry.org/chemicals.html

> *Amendments of 1990. In addition, transfer lines between vessels and marine transportation-related facilities are subject to safety requirements of the U.S. Coast Guard (33 CFR 154 and 156). These requirements apply to transfer lines from the dock loading arm or manifold up to the first valve after the line enters the Spill Prevention Control and Countermeasure (SPCC) containment or secondary containment if the facilities are not protected by SPCC plans*.
>
> *… At the same time, the risk to the public from short low-stress transfer lines off plant or terminal grounds is generally low. A low operating stress is itself a safety factor against several accident causes. And the short length means the potential spill volume would be limited should an accident occur. Also, typically there is limited public exposure in the industrial areas where low-stress transfer lines are located. The risk of marine transfer lines is reduced even more by the U.S. Coast Guard regulations and inspection force.*

During the review of hazardous material releases, several transfer pipelines were identified that cross a single highway or railroad from the production facility to a loading area as shown in the Figure 5 below. There were no releases reports related to these types of crossings. PHMSA was not able to gain information about the operating pressure or percent SMYS of these transfer pipelines but assumes that they are low-stress. This study did not examine the extent of these pipeline crossings for the same reasons provided in the *Petroleum Products and Low-stress* Rule.

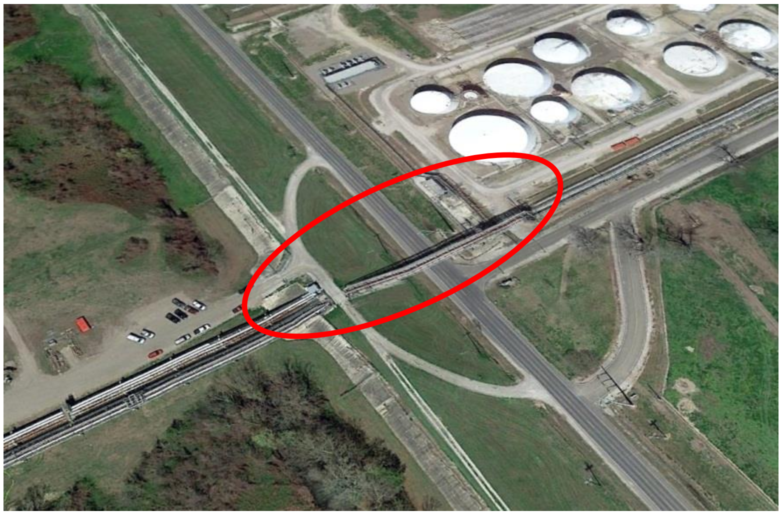

Figure 5: Transfer Pipeline to Barge Crossing Highway. Source: Google Earth

3.2 Locate Nonpetroleum Pipeline and Pipeline Releases in Public Areas

This section describes the research conducted to locate nonpetroleum hazardous liquid pipelines operating in public areas. Pipelines installed on land that is not owned by the chemical producer or their customer are considered to be “accessible to the public” for this study. The research included a review of material release report databases and communication with State and local governments, industry associations, and an excavation damage prevention association. Two in-service liquid chlorine pipelines, a proposed sodium hydroxide pipeline, and an in-service liquid sulfuric acid pipeline installed in parallel with a spent sulfuric acid pipeline were identified as a result of this extensive research.

3.2.1 Review Hazardous Material Release Reports

3.2.1.1 National Response Center – Hazardous Material Release Notification Database

The NRC is the Federal point of contact for reporting hazardous substance releases and oil spills that trigger Federal notification requirements under several laws, including the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), the Emergency Planning and Community Right-to-Know Act (EPCRA), the Hazardous Materials Transportation Act (HMTA), and several other Federal programs such as PHMSA's pipeline safety regulations 49 CFR Part 191 and Part 195. The EPA publishes the designated substances and their reporting threshold in the *List of Lists, Consolidated list of Chemicals Subject to Emergency Planning and Community Right-to-Know Act (EPCRA), Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) and Section 112(r) of the Clean Air Act.*[16] If an accidental chemical release exceeds the applicable minimal reportable quantity, facilities, including pipelines, must notify the NRC.

Due to the comprehensive notification requirements, the NRC database was used as the main source of hazardous liquid release data. Furthermore, a liquid was deemed "hazardous" if it was within the reporting threshold of any of the aforementioned Acts.

During the notification process, accidents are categorized by the type of facility where the release occurred. Facility types include pipelines, mobile (e.g. truck), fixed (e.g. refinery), rail, platform, continuous release (typically requires a permit), storage tank, vessel (e.g. barge), and unknown sheen (facility not known). The NRC reports are publically available on its web site at http://www.nrc.uscg.mil/.

Initial Screening of NRC Reports

Reports from January 1, 2002, through August 18, 2014, were reviewed to identify hazardous materials transported by pipelines. Of the nearly 300,000 reported material releases, over 15,000 were categorized as "pipeline" releases. This analysis covered all NRC "pipeline" reports.

During the notification process, the material released is categorized by a Chemical Hazard Response Information System (CHRIS) code. During the 2002-2014 time period, reports contained 719 distinct codes, which include petroleum and nonpetroleum substances. About 70 percent of the reports involved petroleum products or products that are most likely not in the liquid state. In an additional 27 percent of the reports, the material released was "unknown" or generally characterized as "other oil" or "no CHRIS code." Additional reports were determined not to be related to a chemical production facility because the responsible party was not a private enterprise or the material released was a petrochemical product. Petrochemical products are characterized by the addition of chemicals, such as chlorine, nitrogen, or oxygen, to the hydrocarbon feedstocks. Petrochemical products, for example ethylene dichloride and vinyl chloride, are not in scope of this study because they use ethylene as a feedstock.

[16] http://www2.epa.gov/sites/production/files/2013-08/documents/list_of_lists.pdf

Combined salt water, brine, and produced water pipeline releases were the most frequently reported nonpetroleum substance, with over 300 events. These releases were most significantly associated with two processes: salt water supply lines for chlorine plants and salt water related to oil and gas production (saltwater gathering pipelines). Salt water and brine pipelines are out of scope for this study because: (1) this study covers pipelines that transport products from production facilities not supplies to them, and (2) salt water disposal wells are not related to chemical production facilities.

Chemicals that were reported on average less than once per year were eliminated from further evaluation. The remaining materials were on the list of large volume chemicals in Appendix A and there were sufficient number of NRC notifications to warrant detailed evaluation. They are listed in Table 2.

Table 2: Nonpetroleum Hazardous Liquids Report Frequency > One per Year during 2002-2014

#	**CHRIS Code**	**Name of Material**	**# Pipeline Releases Reported**
1	CLX	Chlorine	41
2	SHC	Sodium hypochlorite	31
	SHP	Sodium hypochlorite (<15%)	19
3	SHD	Sodium Hydroxide	35
	CSS	Caustic soda solution (sodium hydroxide)	6
4	HCL	Hydrochloric acid	18
	HDC	Hydrochloric acid	2
5	SFA	Sulfuric acid	95
	SAC	Sulfuric acid, spent	3
7	PAC	Phosphoric acid	11
Total			**261 (<2% of Pipeline Reports)**

**NRC reports do not differentiate between plant pipelines and pipelines that are offsite.*

Detailed NRC Report Evaluation

A detailed screening of the remaining NRC reports was conducted to discern if the release occurred in areas accessible by the public. Terms from two data fields on the NRC report, *accident description* and *remedial measures*, were used to identify if the reported events occurred on in-plant process, transfer pipeline, or outside the plant. Examples of the terms used to eliminate these reports irrelevant to this study include: process line, in plant, transfer line, release into the air, loading, containment area, flow line, waste treatment, and water plant. Reports where the responsible party was not a chemical producer were eliminated. Through discussions with chemical producers or review of information on a company's website, additional events were determined not to be on pipelines accessible to the public. Google Earth was used to review the location listed on the remaining NRC reports. Only one pipeline was found where the release was in areas accessible to the public.

The pipeline identified from the detailed NRC report evaluation is a sulfuric acid pipeline in Baton Rouge, LA. The reports were submitted by Solvay, now referred to as Echo Services Inc. Discussion with the operator confirmed that a sulfuric acid and a spent sulfuric acid pipeline transport between Echo Services Inc.'s plant and the ExxonMobil refinery. There were eight release reports along the route between the Echo Service Inc.'s plant and the ExxonMobil facility. Figure 6 below shows that the area where the Echo Service Inc. and ExxonMobil Plant reside is an industrial area bordered by a residential area. Following public thoroughfares (not necessarily the actual pipeline path), the facilities are about three miles apart in areas accessible to the public.

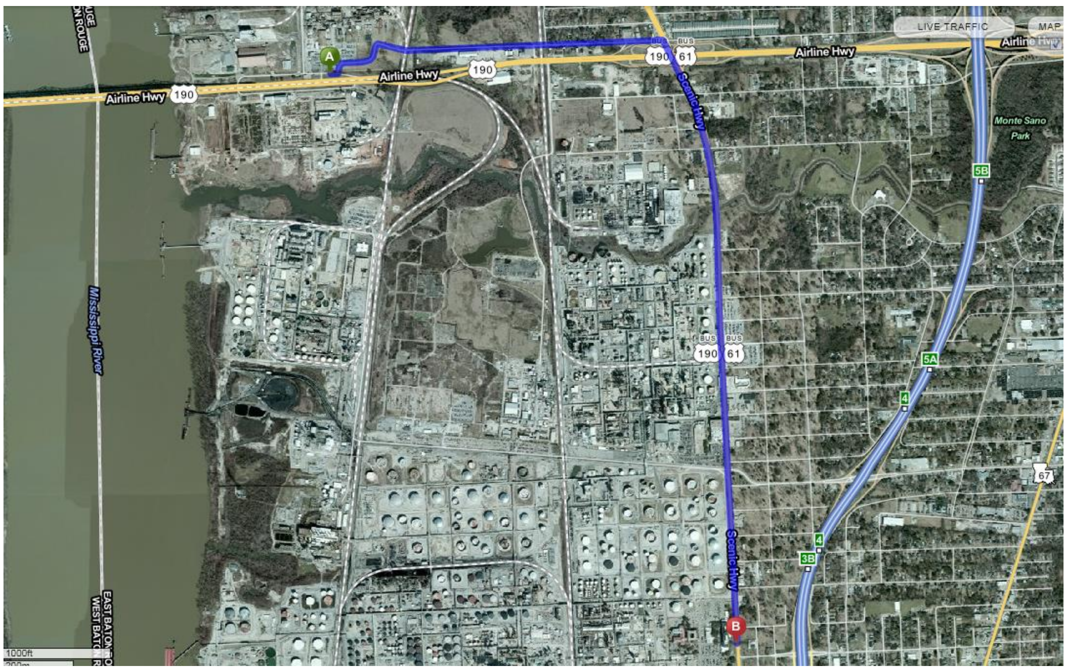

Figure 6: Industrial Area in the Vicinity of the Solvay Echo Service Inc. and ExxonMobil Plants. Source: Google Earth

3.2.1.2 Review of Toxic Chemical Release Inventory System

Congress established the Toxic Chemical Release Inventory System (TRI) under the Emergency Planning and Community Right-to-Know Act of 1986 (EPCRA), and later expanded it in the Pollution Prevention Act of 1990 (PPA). The PPA requires facilities to report information about the management of toxic release chemicals in waste and efforts made to eliminate or reduce those quantities. The TRI is a publicly available database containing information on toxic chemical releases and other waste management activities in the United States. These data have been collected annually in Section 8 of the TRI reporting Form R. Pursuant to the Emergency Planning and Community Right-to-Know Act, TRI includes self-reported facility release and transfer data for over 600 toxic chemicals. Facilities within Standard Industrial Classification (SIC) Codes 20-39 (manufacturing industries) that have more than

10 employees and that are above weight-based reporting thresholds are required to report TRI on-site releases and off-site transfers. [17]

Reports from 2000 to 2013 were reviewed. The data included a field for "piping leak," which is populated as either "true" or "false" but does not discern between process pipes or offsite pipes. No offsite pipeline releases for nonpetroleum hazardous liquids were identified in this database.

3.2.2 State Emergency Response Committees (SERC)

The State Emergency Response Commissions (SERC) are typically the administrative body for the implementation of the EPCRA. The EPCRA was included as Title III of the Superfund Amendments and Reauthorization Act (SARA) and is sometimes referred to as SARA Title III. The EPCRA provides for the collection and availability of information regarding the use, storage, production and release of hazardous chemicals to the public and emergency responders in your community.

Louisiana

The Louisiana State Police Emergency Services Unit is the primary agency in the State of Louisiana with both the regulatory and statutory authority for hazardous material and explosives. They provided PHMSA with the last 10 years of incident reports with chlorine releases. All reports with "pipe" in the incident details field were reviewed to determine if the pipe was outside plant property. The only reported pipeline chlorine report was at Westlake's Geismar, LA, facility. PHMSA contacted the facility and was informed that they do not have any pipelines that transport chlorine from the plant.

New York

The SARA Title III Program Manager for the State of New York provided that he was not aware of any releases from liquid chlorine pipelines in public areas in New York.

3.2.3 Industry Associations

PHMSA met with the ACC and the CI in September 2014 to discuss Section 17 of the Act. The ACC and the CI often work together on chlor-alkali issues. The ACC and the CI were unable to provide details about member companies' pipeline facilities outside of the chemical production facilities.

American Chemistry Council

The ACC is an industry trade association representing American chemical companies including the chlorine industry. The ACC provided PHMSA with Table 3.12 from the *Production of the Top 100 Chemicals from their 2002 Guide to the Business of Chemistry* and information about their Responsible Care program.

[17] EPA Office of Compliance Sector Notebook Project, Profile of the Inorganic Chemical Industry, September 1995

Chlorine Institute

The CI is a trade association representing the chlor-alkali industry. Their members are involved in the production, distribution, and use of chlorine, sodium and potassium hydroxides, and sodium hypochlorite, and the distribution and use of hydrogen chloride. The CI provided PHMSA with *Pamphlet 60 Chlorine Pipelines, Pamphlet 10 North American Chlor-Alkali Industry Plants and Production Data Report for 2013,* the CI's Member Safety & Security Commitment, and additional information about the chlor-alkali industry.

The Vinyl Institute

The Vinyl Institute is a U.S. trade association representing the leading manufacturers of vinyl, vinyl chloride monomer, vinyl additives and modifiers, and vinyl packaging materials. The Vinyl Institute provided that most plants are self-contained. The vinyl chloride is converted from natural gas and chlorine and then consumed on site. Vinyl chloride was initially within scope of this report but was subsequently removed when categorized as a petrochemical.

The Fertilizer Institute (TFI)

The Fertilizer Institute is a trade association representing producers, manufacturers, retailers, and transporters of fertilizer. The Fertilizer Institute provided that their members use sulfuric acid in the process of making phosphate fertilizer. Members either purchase elemental sulfur to produce the sulfuric acid on site or they purchase the sulfuric acid. Shipments are received via rail or truck. Their members do not ship sulfuric acid by pipeline. Sulfuric acid is short lived.

The Sulphur Institute (TSI)

The Sulphur Institute (TSI) is a trade association representing all stakeholders engaged in producing, consuming, trading, handling, or adding value to sulfur. Their members only transport sulfuric acid by rail and road and do not transport sulfuric acid in areas accessible to the public by pipeline. The operator of the sulfuric acid pipeline identified through the NRC report review is not a member of TSI.

Methanol Institute (MI)

The Methanol Institute is a trade association of methanol producers, technology companies, distributors, terminal operators, and shippers. While natural gas is most often used, methanol can be made from any resource that can be converted first into synthesis gas. Through gasification, synthesis gas can be produced from anything that is or ever was a plant. This includes biomass, agricultural and timber waste, solid municipal waste, and a number of other feedstocks. The Methanol Institute provided that there are no MI members with liquid methanol pipelines in public areas.

Society of Chemical Manufacturers and Affiliates (SOCMA)

The Society of Chemical Manufacturers and Affiliates is a trade representing the specialty chemical industry. Members are manufacturers, not producers. As manufacturers, they do not engage in large-scale production. Specialty chemicals are transported by rail and truck.

3.2.4 Chemical Producers

Axiall Corporation

Axiall's web site[18] states that it is an industry leader in the chlor-alkali and the chlorovinyl chemical sectors. PHMSA contacted Axiall directly. Axiall provided that they have four production facilities. Their web site indicates that they work with many different companies to bring chlorine safely onto their site via chemical pipelines. Axiall provided that none of the facilities transport liquid chlorine by pipeline through areas accessible by the public. Axiall operates and submits annual reports to PHMSA for a chlorine gas pipeline they operate in Louisiana.

Olin Corporation

According to its web site,[19] Olin is the largest merchant supplier of chlorine, the largest producer of industrial bleach, and the third largest supplier of caustic soda in North America. Olin provided that they do not have any liquid chlorine pipelines that go across land areas not owned by Olin that are accessible to the public. Olin co-locates their facilities with manufacturers and pipes products directly to their operations.

NorFalco

Per NarFalco's web site,[20] they distribute sulfuric acid either by tank truck, tank car, or vessel.

Dupont

Dupont's web site[21] provides that they use tank trailers, rail cars, or barge to transport sulfuric acid.

3.2.5 U.S. DOT PHMSA Interpretation PI-15-0005– Products Subject to 49 CFR Part 195

In 2014, PHMSA issued an interpretation on the applicability of 49 CFR Part 195 of a proposed liquid sodium hydroxide pipeline. The aboveground, low-stress 5,000-foot pipeline is proposed to operate at 95 PSIG and cross underneath a county road through an open-to-air box culvert that separates the manufacturer's site, Polysilicon North America, from the producer's site, Olin. If liquid sodium hydroxide were to be regulated, PHMSA would need to assess if this low stress pipeline should be exempt under §195.1(b)(3)(ii) because it is less than one mile long and does not cross an offshore area or a waterway currently used for commercial navigation.

3.2.6 Excavation Damage Prevention Community

The Common Ground Alliance (CGA) is an excavation damage prevention trade association with members that represent all industry stakeholders, including facility owners, excavators, One-Call centers, regulators, locators, and public works, in an effort to prevent damage to underground utility infrastructure and ensure public safety and environmental protection. The CGA manages the Damage

[18] http://www.axiall.com/uploadedFiles/DevNewCo/Content/Products/Product_Stewardship/Chlorine%20PS%20Summary%20Ed1.pdf
[19] http://www.olin.com/
[20] http://www.norfalco.com
[21] http://www2.dupont.com/Sulfur_Technologies/en_US/products/sulfur_technologies/packages_transportation.html

Information Reporting Tool (DIRT). The CGA collects underground facility damage data to analyze data, to learn why events occur, and to learn how actions by industry can prevent them in the future. The DIRT data collection form does not include a field to collect data regarding the product transported through the infrastructure. The One-Call Systems International (OCSI) committee promotes facility damage prevention and infrastructure protection through education, guidance and assistance to One-Call centers internationally. The OCSI committee could not identify any nonpetroleum hazardous liquid pipelines in member databases.

The committee provided that many One-Call centers collect and maintain data about the service area or "registration area" where the underground utility owner wants to be notified but may not collect information as to the product being transported or transmitted. Since the data collected by the One-Call centers is proprietary, the One-Call center is not able to share information without approval from the facility owners. Several One-Call centers provided that they collect the information and determined that no such pipelines were identified in their system.

California

California has some data. Two CA One-Call members have nonpetroleum hazardous liquid pipelines. One transports styrene, which is outside of the scope of this project, as it is organic. The second pipeline is at the Stringfellow acid pits site in Riverside, CA. Substances disposed of at the superfund site included heavy metals such as chromium and cadmium, acids including sulfuric acid, and organics including DDT and TCE. The State of California Regional Water Quality Control Board (RWQCB) operates the pretreatment plants and a pipeline that pumps water from the contaminated site to the plant. The treated water is sent via pipeline to the Orange County Sanitation District, which provides secondary treatment before the water is released into the Pacific Ocean.

Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, Vermont

These States provided that they would collect the data, but no such pipelines are in their service area.

Minnesota

Minnesota has some data but is not at liberty to share.

3.2.7 Fire Departments

The programs under the EPA and OSHA (including EPCRA, RMP and PSM), which are discussed further in section 3.4, have certain requirements related to a facility's communication with local responders and the information that is provided to responders if a facility stores above the specified threshold of a hazardous material onsite at any given time. Most facilities that handle chlorine, with the exception of water utilities and other small users, are regulated under all three of these programs. Smaller users of chlorine may be covered by some of these programs. Because these programs are focused on the amount of product stored on-site at a given time, they do not specifically consider the amount of product shipped off site and by what mode it is shipped. Therefore, regulated facilities are not required to inform local responders whether or not they have distribution pipelines that transport hazardous materials. As such, data for pipelines transporting hazardous liquids was not available from this community for the purpose of this study.

Because of the requirements under these programs, local responders are aware of the specified hazardous materials stored onsite in their area. The CI provided that many chemical producers go beyond the regulatory requirements and provide emergency response training to local responders so they can become familiar with effective emergency response practices in the event a release does occur. For chlorine, the emergency response practices required for a pipeline incident would be the same as what is needed for an on-site release. Through this training, fire departments may become aware of any pipelines transporting hazardous materials from the chemical facility through areas accessible by the public.

3.3 Extent of State Regulation of Nonpetroleum Pipelines

The 2011 Act authorized PHMSA to examine the extent to which nonpetroleum pipelines are unregulated by the States. PHMSA is primarily responsible for pipeline safety regulations. The pipeline safety statutes provide for State assumption of the *intrastate* responsibilities under an annual certification. Intrastate pipelines are located totally within a State. To qualify for certification, a State must adopt the minimum Federal regulations and may adopt additional or more stringent regulations as long as they are not incompatible. They must have authority to regulate pipeline in their State laws. Fourteen States participated in the hazardous liquid pipeline safety program in 2014.

Federal pipeline statutes provide for exclusive Federal authority to regulate *interstate* pipelines. PHMSA may authorize a State to act as its agent to inspect interstate pipelines, but PHMSA retains responsibility for enforcement of the regulations. States with hazardous liquid interstate agreements regulate all products in scope of 49 CFR Part 195. States may adopt additional regulations for other products transported via intrastate pipelines.

The National Association of Pipeline Safety Regulators (NAPSR), an association representing State pipeline safety agencies, provided the following information regarding the extent to which they regulate nonpetroleum pipelines not in scope of 49 CFR Part 195. NAPSR provided information from 45 of the 49 States with State pipeline safety programs. They indicated that there may be other State agencies with authority to regulate certain aspects of nonpetroleum pipelines. A few State pipeline safety agencies reached out to other agencies in their State and identified environmental permitting requirements for these pipelines. States vary in their implementation of environmental regulations for pipeline construction and operation. Agencies administering the environmental regulations vary from State to State. The State agency tasked with the safety of the pipeline would most likely be the State pipeline safety agency. NAPSR provided the following about nonpetroleum hazardous liquid pipelines that are not regulated under49 CFR Part 195:

- **States that require a permit**
  - Alabama – Certificate of Convenience and Necessity is required if the pipeline owner is a transportation company or a utility. None have been permitted.
  - Illinois – Intrastate common carrier pipelines need a Certificate in Good Standing.

- Missouri – Missouri Dept. of Natural Resources issues Missouri State Operating Permits (MSOP) for oil and gas pipelines, or other pipelines that might be constructed to transport any product. The MSOP permits the construction of the project with the conditions that it be installed using best management practices related to storm water.
- Pennsylvania – Environmental permit.
- Texas – Does not require a permit to operate a pipeline transporting a non-jurisdictional fluid; however, some pipeline operators have requested and been granted permits, e.g., for pipelines transporting chlorine, acetone, and methanol. They do not inspect or regulate these pipelines.

- **States that map these pipelines**

  - New York – If the pipeline has recently gone through the siting process.
  - Pennsylvania – Yes.
  - Texas – Maps all pipelines that have a permit, whether they come under pipeline safety regulations or not. The Texas Railroad Commission's database included permits for two 1.4 mile liquid chlorine pipelines in Harris County, TX.

- **States that regulate the safety of these pipelines**

  - Alabama – Any substance or material that is in liquid state when transported by pipeline facilities and that may pose an unreasonable risk to life or property.

- **State pipeline safety agencies that require accident reporting:**

  - Alabama
  - Maryland

- **Most States were not aware of any accidents that occurred in public areas**

- **Applicability of State's damage prevention regulations**

  Some States' damage prevention regulations pertain to "utilities." If they do not have any nonpetroleum hazardous liquid pipelines, it may be difficult to determine if they would be considered a utility or not.

  - Illinois – Covered except in the City of Chicago.
  - Iowa – Unclear if these pipelines would be covered. Would depend on a legal interpretation of certain terms in the One-Call law, which has not been requested because there are no known off-plant-site nonpetroleum hazardous liquid pipelines from chemical production facilities in Iowa.
  - New York – No, Title 16 NYCRR Part 753 applies to an operator "who operates an underground facility to furnish any of the following services or materials: electricity, gases, steam, liquid petroleum products, telephone or telegraph communications, cable television, sewage removal, traffic control systems, or water."
  - North Carolina – Not covered.

  - North Dakota – Not covered, the ND One-Call Excavation Notice System law defines underground facility as "an underground line, pipeline, cable, facility, system, and its appurtenances used to produce, store, convey, gather, transmit, or distribute communications, data, electricity, power, television signals, heat, gas, oil, petroleum products, carbon dioxide, water, steam, sewage, hazardous liquids, and other similar substances."
  - Oklahoma – Not covered.
  - Rhode Island – Not covered, only public utilities.
  - Virginia – Not covered, only utilities.

- **NAPSR also provided the following information:**

  - Wisconsin – There may be some ethanol pipelines since they have many ethanol plants.
  - Wyoming – There is one abandoned phosphate pipeline running from north of Vernal, UT, to East of Rock Springs, WY. The distance is about 110 miles.

3.4 Risk Analysis

After extensive research, PHMSA identified one liquid chlorine pipeline, one proposed liquid sodium hydroxide pipeline, one liquid sulfuric acid pipeline installed in parallel with a spent sulfuric acid pipeline, and one pipeline that transports sulfuric acid one direction and spent sulfuric acid in the other direction. Liquid methanol, ethanol, and biodiesel pipelines were also identified but are not included in the risk analysis as they are currently regulated under compliance with 49 CFR Part 195. The remainder of nonpetroleum hazardous liquid chemicals identified through a review of NRC reports, including pipelines carrying sodium hypochlorite, hydrochloric acid, and phosphoric acid, were not further evaluated for potential transportation by pipeline in this report since no such pipelines were located through exhaustive research. The risks of chlorine, sodium hydroxide, and sulfuric acid/spent sulfuric acid pipelines in areas accessible to the public are examined in this section.

Risks associated with nonpetroleum hazardous liquid pipeline accidental releases include impact to workers, public and emergency responder safety (injuries and fatalities), property damage, and environmental harm. The potential consequences of pipeline releases vary based on a material's physical and chemical properties, the length of exposure, the amount of material released, and the characteristics of the surrounding environment. This risk analysis attempts to answer the following questions and present a summary of the findings:

- What are the hazards?
- What is the likelihood of an accidental release?
- What are the potential consequences?
- What preventative and mitigative measures are in place to reduce risk?

3.4.1 Chemical Hazards

Potential chemical hazards are fire, explosiveness, toxicity, corrosivity, and reactivity. In order to assess the potential hazards of chlorine, sodium hydroxide, and sulfuric acid, this study looks at various measures of a chemical's hazard severity: regulatory hazardous material classification, reporting/emergency response planning/risk management program thresholds, exposure limits, and chemical and physical properties.

3.4.1.1 Regulatory Hazard Classifications

The DOT determines which materials are hazardous in transport by ground, air, rail, and boat under 49 CFR Part 173 and characterizes the materials into nine *DOT Hazard Categories*. In CFR 49 Part 193, *petroleum product* means flammable, toxic, or corrosive. 49 CFR 195.2 references the following hazard categories in 49 CFR Part 173 to define:

- Corrosive product means "corrosive material" as defined by §173.136 Class 8-Definitions of this chapter.
- Flammable product means "flammable liquid" as defined by §173.120 Class 3- Definitions of this chapter.
- Toxic product means "poisonous material" as defined by §173.132 Class 6, Division 6.1- Definitions of this chapter.

Chlorine, sodium hydroxide, and sulfuric acid are all classified as hazardous materials under 49 CFR Part 172.101. Chlorine is primarily classified as a Class 2.3 poison gas. Sulfuric acid and sodium hydroxide are primarily classified as a Class 8 corrosive and sodium hydroxide. *Poison gas* is not defined in 49 CFR Part 195.

The table below details the DOT Hazard Categories and their relevance to this study.

Table 3: DOT Hazard Categories	
Class 1 Explosives	An explosive is a substance that undergoes very rapid chemical transformation producing large amounts of gases and heat. None of the products being assessed or currently regulated are classified as explosive.
Class 2 Gases	Class 2 gases are hazards by emission of gas due to pressure or chemical reaction. Gas is defined as any material that is a gas at 68 °F (20 °C) or less and 101.3 kPa (14.7 psia) of pressure (a material that has a boiling point of 68 °F (20 °C) or less at 101.3 kPa (14.7 psia)). Class 2 has three divisions: 2.1 flammable (gas or vapor explosion), 2.2 non-toxic/non-flammable compressed gas (including compressed gas, liquefied gas, pressurized cryogenic gas, compressed gas in solution, asphyxiant gas), and oxidizing gas, and 2.3 poisonous by inhalation. Chlorine, anhydrous ammonia, and propane are Class 2 gases.
Class 3 Flammable Liquid and Combustible	Flammability refers to the material's ability to

Liquid	produce sufficient vapors to be ignited and produce a flame under normal conditions. *Flammable liquids* are defined by dangerous goods regulations as liquids, mixtures of liquids or liquids containing solids in solution or suspension that give off a flammable vapor (have a flash point) at temperatures of 140°F or less. Combustibles can be readily ignited and sustain a fire. *Combustible liquid*s are liquids with a flash point between 140°F and 200°F that do not meet any other hazard class definition. Crude oil, sour crude, and gasoline are Class 3 hazards.
Class 4 Flammable Solid; Spontaneously Combustible: and Dangerous When Wet	Solids are not in scope of this study.
Class 5 Oxidizer and Organic Peroxide	Oxidizers are compounds that can release large amounts of oxygen causing combustion under certain conditions. These substances can be hazardous if they are combined with a source of combustion, such as a spark or flame.
Class 6 Poison (Toxic) and Poison Inhalation Hazard	*Poisons* are materials other than a gas that are known to be toxic to humans. Methods of toxicity include oral, dermal and inhalation. Death can be an immediate concern. Toxic effects depend on the exposure (length of time and the amount of chemical) and the toxicity of the material. According to FEMA's Nov. 5, 2012, Coffee Break Training newsletter,[22] "Approximately 90% of hazardous materials injuries are due to inhalation. In general, although some solids are very hazardous (on physical contact with skin or if ingested into the body), gases and liquids with high vapor pressures pose the highest risks to responders. These chemicals are more dangerous because they have the capability to become airborne, to disperse and travel through the atmosphere and to be inhaled."
Class 7 Radioactive	None of the products being assessed or currently regulated are classified as radioactive.
Class 8 Corrosive	Corrosive materials may destroy human tissue, metals, plastics, elastomers, and other materials. Common corrosives are halogens (chlorine),

[22] http://www.usfa.fema.gov/downloads/pdf/coffee-break/hm/hm_2012_3.pdf /

	strong acids (sulfuric acid), and strong bases (sodium hydroxide). Effects resulting from exposure to corrosives are permanent. Sulfuric acid and spent sulfuric acid are Class 8 hazards.
Class 9 Miscellaneous	None of the products being assessed or currently regulated are classified as miscellaneous.

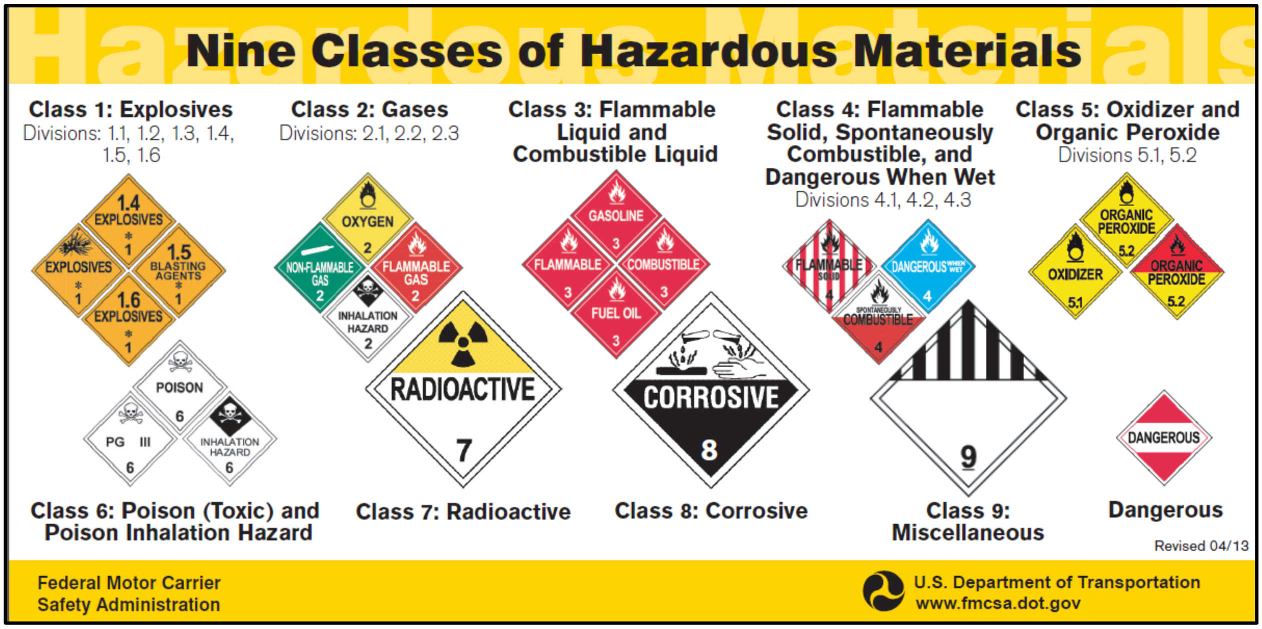

Figure 7: Classes of Hazardous Materials. Source: DOT

DOT Highly Volatile Liquid (HVL) is defined in 49 CFR Part 195 as a hazardous liquid that will form a vapor cloud when released to the atmosphere and that has a vapor pressure exceeding 276 kPa (40 psia) at 37.8 °C (100 °F). PHMSA's intent in defining HVLs is to require operators to model the extent of a vapor cloud, consider how it might move or expand to assess the potential hazard, and to implement protective measures. Chlorine, anhydrous ammonia, and propane are HVLs.

3.4.1.2 EPA Reporting, Emergency Response Planning and Risk Management Plan Thresholds

The EPA's reporting, emergency response planning, and risk management plans each have threshold quantities that trigger actions. Chemicals with lower threshold quantities are hazardous in smaller quantities.

- **CERCLA RQ**

  Releases of CERCLA hazardous substances, in quantities equal to or greater than their reportable quantity (RQ), are subject to reporting to the NRC under CERCLA. Release can be liquid spills or vapor emissions. Such releases are also subject to State and local reporting under Section 304 of SARA Title III (EPCRA). The chlorine release quantity for this threshold is 10 times smaller than anhydrous ammonia, and those for sulfuric acid and sodium hydroxide are 10 times larger than anhydrous ammonia.

- **EPCRA 302 EHS TPQ**

  Certain emergency planning activities must be conducted when there are extremely hazardous substances (EHS) stored in quantities that exceed the threshold planning quantity (TPQ). Sodium hydroxide does not have a TPQ threshold.

- **EPCRA 313 TRI**

  Emissions, transfers, and waste management data for chemicals listed under section 313 must be reported annually as part of the community right-to-know provisions of SARA Title III (EPCRA) (40 CFR Part 372). Chlorine and anhydrous ammonia have 313 requirements.

- **EPA RMP Quantity**

  CAA 112(r) RMP TQ - Risk Management Plan (RMP) Rule implements Section 112(r) of the 1990 Clean Air Act amendments. RMP requires facilities that use extremely hazardous substances to develop a Risk Management Plan. These plans must be revised and resubmitted to the EPA every 5 years. Producers manufacturing chlorine and anhydrous ammonia have RMP thresholds.

3.4.1.3 Exposure Limits

Comparing the values on Table 4 illustrates that each of these chemicals are hazardous, with chlorine being hazardous at the smallest exposure limits. Exposure limits can be expressed in parts per million (ppm) only if the substance exists as a gas or vapor at normal room temperature and pressure.

- **Immediately Dangerous To Life or Health (IDLH) Value**

  An atmospheric concentration of any toxic, corrosive or asphyxiant substance that poses an immediate threat to life or would cause irreversible or delayed adverse health effects or would interfere with an individual's ability to escape from a dangerous atmosphere. [29 CFR 1910.120] Metric developed by National Institute for Occupational Safety and Health (NIOSH).

- **Acute Exposure Guideline Levels (AEGLs)**

  AEGLs estimate the concentrations at which most people will begin to experience health effects if they are exposed to a hazardous chemical for a specific length of time. For a given exposure duration, a chemical may have up to three AEGL values, each of which corresponds to a specific tier of health effects. AEGL-2 is the airborne concentration individuals could experience irreversible or other serious, long-lasting adverse health effects or an impaired ability to escape. AEGLs are used to understand the potential impact to the public of a short-term release. AEGLs are overseen by the EPA’s National Advisory Committee for the

Development of Acute Exposure Guideline Levels for Hazardous Substances (AEGL Committee).

- **Permissible Exposure Limits (OSHA PEL)**

  The OSHA PEL is a legal limit for exposure of an employee to a chemical substance usually expressed as time weighted average (TWA) or ceiling (C) in ppm, or mg/m^3.

- **Lethal Dose (LD_{50})**

  LD_{50} is the amount of a material, given all at once, which causes the death of 50 percent of a group of test animals due to oral or dermal toxicity. The LD_{50} is one way to measure the short-term poisoning potential (acute toxicity) of a material. Since different chemicals cause different toxic effects, comparing the toxicity of one with another is hard. Therefore, to compare the toxic potency or intensity of different chemicals, researchers measure the same effect. The result is expressed in mg/kg body mass.

- **Lethal Concentration (LC_{50})**

  LC_{50} refers to the concentrations of the chemical in air that kills 50 percent of the test animals during the observation period due to toxicity on inhalation. The result is expressed in mg/L of air for dusts and mists or in mL/m^3 of air (parts per million) for vapors.

3.4.1.4 Chemical and Physical Properties

The chemical and physical properties are the basis for the hazard profile. Table 4 lists some key properties gathered for comparison of risk to each other and to anhydrous ammonia and propane, two products regulated under 49 CFR Part 195 when transported by pipeline. The properties are color coded to illustrate if the property contributes to the chemical's hazard profile.

- **Vapor density**

  Vapor density is the density of a gas or vapor compared to the ambient atmosphere. If the density of a vapor or gas is greater than ambient air, it will tend to settle. If vapor density is close to, or less than, ambient air, it will rise or disperse in the atmosphere. Vapors with a molecular weight above 29 are heavier than air, and vapors with a molecular weight less than 29 are lighter than air. Vapor density is relative to air.

- **Vapor pressure**

  Vapor pressure is the measurement of a particular liquid chemical's tendency to vaporize. All liquids will evaporate. Chemicals with high vapor pressures tend to have larger vapor dispersion distances. There is a direct relationship between the vapor pressure of an evaporating substance and the maximum concentration that its vapor or gas may achieve when mixed with air in the open environment.

- **Boiling point**

  If a spilled liquid is in an environment above its boiling point, it will rapidly boil and expand, sometimes explosively. Ammonia and chlorine have low boiling points. When they are exposed to the air, they expand rapidly. Sulfuric acid has a high boiling point and so does not. Boiling point is measured at 1 atmosphere, °F.

- **Specific gravity**

  Specific gravity is the density of a chemical compared to that of water. If the specific gravity is less than 1g/cc, the chemical will float. If specific gravity is more than 1 g/cc, it will sink. Materials that sink are more difficult to clean up. Specific gravity is measured at 68 °F.

- **Odor threshold**

  Odor threshold is the minimum concentration of a substance in the air that can be detected by the human sense of smell. Odor provides a warning to the public that there has been a hazardous release.

- **Reactive Groups**

  Reactive groups are categories of chemicals that typically react in similar ways because they are similar in their chemical structure.

  - *Water and Aqueous Solutions* - These reactions can be hazardous and may result in flammable or toxic gas production, or generation of excessive heat that may cause pressurization to occur. Another reactive hazard is heat of mixing. Mixing substances such as sulfuric acid or sodium hydroxide with water may generate significant heat.

  - *Acids, Strong Oxidizing* - Materials in this group are generally soluble in water with the release of hydrogen ions. Gas-generating reactions occur with sulfites to give H_2S and SO_3.

Table 4 provides a summary of the regulatory program indicators, chemical and physical properties, exposure limits, and the EPA program thresholds. The three nonpetroleum products that are the subject of this study are provided in comparison with two chemicals that are regulated under 49 CFR Part 195, anhydrous ammonia and propane. The values were obtained from the National Oceanic and Atmospheric Administration CAMEO Chemicals tool,[23] The National Institute for Occupational Safety and Health (NIOSH) Pocket Guide to Chemical Hazards,[24] the EPA's List of Lists,[25] and the list of references at the end of this report.

[23] http://www.cameochemicals.noaa.gov/about
[24] http://www.cdc.gov/niosh/npg/default.html
[25] http://www2.epa.gov/epcra/consolidated-list-lists

Table 4: Chemical Properties and Regulatory Thresholds

	Chlorine (Cl_2)	**Sodium Hydroxide (NaOH)**	**Sulfuric Acid –Spent Sulfuric Acid (H_2SO_4)**		**Anhydrous Ammonia (NH_3)**	**Propane (C3H8)**
CAS Number	7782-50-5	1310-73-2	7664-93-9	7664-93-9	7664-41-7	74-98-6
CHRIS Code	CLX	CSS	SFA	SAC	AMA	PRP
Specific Gravity of Vapor @ 32 °F and 1 atm (air=1)	2.48[1]	Not available	3.4 [10]		0.6 [2]	1.52 [1]
Vapor Pressure at 100 °F	157 psia [2]	Not available	0.0009 mmHg [8]	Negligible [21]	211.9 psia [22]	188 psia [1]
Boiling Point (at 1 atm.)	-29.3 ° F [2]	2,530 °F @ 760 mm Hg[14]	518 °F [10]	554 °F [20]	-28 °F [1]	-43.67 °F [1]
Specific Gravity of Saturated Liquid @ 60 °F (water=1)	1.42 [2]	Solid 2.13 g/cm^3 [14]	1.84 [10]	1.84 [20]	0.617 [1]	0.51 [1]
Odor Threshold	0.3 ppm [4]	Odorless	Nearly odorless		5 ppm [23]	Odorless
Flammability Range (LEL - UEL	Nonflammable	Not available	Noncombustible Liquid 1- 8 % [21]		16 – 25% [1]	2.2 – 9.5 % [25][26]
Reactive Group (reaction with water)	Oxidizing Agents Halogenating Agents (generates hydrochloric acid gas)	A strong base. Forms an Aqueous Solution. (generates heat when mixed with water)	Strong Acids, Oxidizing (generates heat when mixed with water)		Weak base	Hydrocarbons, Aliphatic Saturated
Lethal Dose, 50% (LD_{50})	850 mg/kg (rat, inhaled) [5]	40 mg/kg mouse (i.p.) [7][14]	2,140 mg/kg rat [15][19]	N/A	N/A	N/A

Lethal Concentration (LC_{50})	293 ppm [3]	N/A	510 mg/m^3 2 hr rat [15]	N/A	7,338 ppm [3]	N/A
OSHA PEL	C 1 ppm (3 mg/m^3)	TWA 2 mg/m^3 [7]	TWA 1 mg/m^3 [15]		TWA 50 ppm (35 mg/m^3) [25]	TWA 1000 ppm (1800 mg/m^3) [24][25]
Immediate Danger to Life or Health (IDLH)	10 ppm [12]	10 mg/m^3 [7]	15 mg/m^3 [15]	15 mg/m^3	300 ppm [25]	2100 ppm
AEGL-2 @ 10 minutes	2.8 ppm [3]	Not available	8.7 mg/m^3 Interim [16]		220 ppm [3]	17,000 ppm [16]
DOT Hazard Label Class (primary and subsidiary hazards)	Poison Gas 2.3 Oxidizer 5.1 Corrosive 8	Corrosive 8	Corrosive 8	Corrosive 8	Poison Gas 2.3 Corrosive 8	Flammable Gas 2.1
DOT HVL (Form vapor cloud)	Yes	No	No		Yes	Yes
CERCLA RQ (Release reporting threshold)	10 lbs	1,000 lbs	1,000 lbs		100 lbs	N/A
EPCRA 302 EHS TPQ (emergency planning threshold)	100 lbs	N/A	1,000 lbs	1,000 lbs	500 lbs	N/A
EPCRA 313 TRI (annual EPCRA reporting)	Yes	No	No		Yes	No
EPA RMP Quantity	2,500 lbs[13]	N/A	N/A	N/A	10,000 lbs [13]	10,000 lbs [13]

Appendix B provides more detailed information, including a description of each chemical, air and water reactions, fire and health hazards, and a reactivity profile from the CAMEO Chemicals database for these chemicals.

3.4.2 Consequences

Potential consequences of an unintended release are influenced by the site-specific environment where the release occurs. For example, consequences can be higher in populated areas, near facilities that are difficult to evacuate, or if they impact a drinking water supply. This section assesses the potential consequences of unintended nonpetroleum hazardous liquid releases by examining PHMSA's definition of a high consequence area (HCA), through comparison of the potential impact radius (PIR) of anhydrous ammonia with chlorine, and reviewing case studies of actual releases.

3.4.2.1 High Consequence Areas

49 CFR Part 195 uses the concept of high consequence areas (HCAs) to identify locations where pipeline releases could have greater consequences to health and safety of the public, more property damage, or more impact on the environment. Regulations require a hazardous liquid pipeline operator to take specific steps to ensure the integrity of a transmission pipeline for which a release could affect an HCA and the protection of the HCA. An HCA is defined as:

> (1) A *commercially navigable waterway*, which means a waterway where a substantial likelihood of commercial navigation exists;
> (2) A *high population area,* which means an urbanized area, as defined and delineated by the Census Bureau, that contains 50,000 or more people and has a population density of at least 1,000 people per square mile;
> (3) An *other populated area,* which means a place, as defined and delineated by the Census Bureau, that contains a concentrated population, such as an incorporated or unincorporated city, town, village, or other designated residential or commercial area;
> (4) An *unusually sensitive area,* as defined in §195.6.

Through this analysis, PHMSA found that nonpetroleum hazardous material pipelines are typically located in industrial areas. Industrial parks are typically zoned and planned for the purpose of industrial operations. They are generally located away from the main residential areas of a city to try to reduce the potential impacts of industrial operations to residential areas. Because chemicals can be efficiently transported by barge, the production facility may be located near commercially navigable waterways. A site-specific assessment would need to be performed to determine if the pipeline is in an HCA. In general, chlorine, sodium hydroxide, and sulfuric acid pipelines are assumed to be less likely to be located in areas that meet the definition of an HCA than an average petroleum or anhydrous ammonia pipeline.

3.4.2.2 Comparison of Chlorine with Anhydrous Ammonia

Both chlorine and anhydrous ammonia liquids vaporize quickly when released to the atmosphere. In the event of a release of product, the most significant threat to the public would most likely be from a vapor cloud. The threat of ignition would be low, but the toxic effects can be very high. As chlorine is heavier than air and anhydrous ammonia is lighter than air, a release from a pipeline would have to take into account whether the pipe was above or below ground, the reactivity of the environment around the chlorine, and weather conditions. Vapor cloud dispersion models can be used to estimate the potential effect to the public of a release. There are various models to simulate different types of releases. Release effects are influenced by operating and environmental conditions (e.g. pipe diameter, operating pressure, rupture size, and meteorological conditions).

It is important to note that recent research, The Jack Rabbit Project (Jack Rabbit I or JRI), sponsored by the U.S. Department of Homeland Security (DHS) Transportation Security Administration (TSA), is designed to improve the understanding of rapid, large-scale releases of pressurized, liquefied toxic inhalation hazard (TIH) gases. This testing was done because the DHS and other agencies must better understand behavior and consequences of large-scale toxic inhalation hazard (TIH) chemical releases. Comparison among six commonly used transport and dispersion models show that they all overestimated the consequences when compared to actual releases.

Potential Impact Radius

In 2005, PHMSA published *Derivation of Potential Impact Radius Formulae for Vapor Cloud Dispersion Subject to 49 CFR Part 192*, which provides simplified equations for the calculation of the PIR, a circle within which the potential failure of a pipeline could have significant impact on people or property. The radius of impact is based on the distance to the toxic endpoint as defined under the EPA's RMP Rule (40 CFR 68 Appendix A). Anhydrous ammonia is lighter than air, so it rises, while chlorine is heavier than air, so it stays close to the ground longer. These equations incorporate the effects of the different materials' properties. These equations were used to compare a release of anhydrous ammonia with a release of chlorine at a flow rate (Q) equal to 35 lbm/min. At this flow rate, under equivalent conditions, chlorine has a PIR over three times larger in rural areas and twice as large in urban areas than anhydrous ammonia. This paper was published prior to the Jack Rabbit Project and may provide different results if it was performed subsequent to them.

Environment	Anhydrous Ammonia	Radius Anhydrous Ammonia (Q=35 lbm/min)	Chlorine	Radius Chlorine (Q=35 lbm/min)
Rural	$r = 0.073Q^{0.48}$	0.4 miles	$r = 0.23Q^{0.49}$	1.3 miles
Urban	$r = 0.064Q^{0.45}$	0.3 miles	$r = 0.10Q^{0.5}$	0.6 miles

Consequences of Anhydrous Ammonia Accidents[26]

As measured in terms of general public injuries using data from PHMSA's database of accident reports, the consequences from anhydrous ammonia accidents (4 injuries in 118 accidents) are over five times larger than the average of all hazardous liquid accidents (30 injuries in 4,931 accidents). Property damage and fatalities are lower than average of all hazardous liquid accidents.

[26] http://www.phmsa.dot.gov/portal/site/PHMSA/menuitem.6f23687cf7b00b0f22e4c6962d9c8789/?vgnextoid=fdd2dfa122a1d110VgnVCM1000009ed07898RCRD&vgnextchannel=3430fb649a2dc110VgnVCM1000009ed07898RCRD&vgnextfmt=print

	Number of Reports	PRPTY	Total Fatalities	Employee Fatalities	Contractor Fatalities	General Public Fatalities	Total Injuries	Employee Injuries	Contractor Injuries	General Public Injuries	Evacuations
AA 2002- Present	118	$ 11,620,222	0	0	0	0	4	0	0	4	482
All 2002- Present	4,931	$ 2,800,816,065	19	5	5	9	44	4	10	30	12,793
AA as % of Total	2.4%	0.4%	0.0%	0.0%	0.0%	0.0%	9.1%	0.0%	0.0%	13.3%	3.8%

This large public impact may be explained in light of FEMA's previously referenced statistic that states that approximately 90 percent of hazardous materials injuries are due to inhalation. Chlorine, like anhydrous ammonia, is an HVL, so it forms a vapor cloud upon release and can disperse over large areas. The potential consequences from chlorine releases under the same conditions could be along the same order of magnitude as that of anhydrous ammonia.

3.4.2.3 Case Studies

Through extensive research, only one chlorine pipeline accident was identified, and it occurred on a gas chlorine pipeline. While railcar accident profiles differ from pipeline accident profiles, the case studies are provided to gain an understanding of the type of consequences that may occur from an unintended chemical release in areas accessible by the public.

The examples given below represent some of the worst chemical spills involving these chemicals. For reference, the average size of hazardous liquid pipeline spills reported to PHMSA in 2014 was about 4,500 gallons, and the largest was about 370,000 gallons. The amount of liquid spilled and amount of gas vapor released depends on many factors such as operating pressure, size of pipe and hole, if the pipe was above or below ground, vapor pressure, viscosity, and oxidation rate.

Chlorine Accidents

No liquid or gas chlorine pipeline accidents in the U.S. were identified. The first case study was the only chlorine pipeline accident identified. The remainder of the case studies were chlorine rail accidents.

- **Champagnier, France, 2005**[27]

  In 2005, an 8-inch above-ground coated and thermally insulated chlorine gas pipeline exploded in Champagnier, France. The 2.2-mile long pipeline transported chlorine gas at 58 PSIG between a chlorine manufacturer and a consumer site. The pipeline was mainly located on company premises except for the crossing of a public road. The accident led to blast damage, and heavy fragments were thrown over 650' away. There were no casualties. The cause of the accident was the accumulation of an explosive mixture of hydrogen and chlorine gas, which ignited and detonated. Hydrogen had been produced by a chemical reaction due to water in the pipeline 4 years earlier, and overheating was caused by a recent failure of the pipeline's heat tracing system.

  Four other pipelines installed on the same above-ground rack as the chlorine transport line were damaged. No leaks were observed. Electric, telephone, and fire alarm cables also on

[27] http://www.aria.developpement-durable.gouv.fr/accident/29864_en/?lang=en

the rack were severed. Communication between the two control rooms of the manufacturer and user sites was lost. Below is a picture of the ruptured pipeline.

Figure 8: Ruptured pipeline. Source: DRIRE Rhône-Alpes

- **Graniteville, SC, 2005**[28, 29]

A train transporting chlorine gas, sodium hydroxide, and cresol was improperly diverted and collided with a train parked near the Avondale Mills plant in Graniteville, SC. The Avondale plant received daily deliveries of chlorine gas via rail for mill operations. The collision resulted in derailment of three engines and 18 freight cars. One chlorine tank car had a puncture and a tear 34 inches long and 5 inches wide at its widest point, releasing about 60 tons of the gas. The recorded loading pressure for the car was 22 PSIG. Each car contained 180,000 pounds (about 13,830 gallons) of chlorine. The liquefied gas rapidly vaporized, with volumetric expansion of 460:1. Because gaseous chlorine is 2 1/2 times heavier than air, the toxic cloud tended to settle in low areas around the railroad tracks and remained more concentrated in these areas.

911 received a call within 1 minute of the crash reporting "bleach gas smell and smoke on the ground." Within 6 minutes, the fire department chief stood 1,000 ft. from the crash and was forced to withdraw so as not to be overcome by chlorine fumes, which were spreading rapidly and approaching critically toxic levels. Within 13 minutes, the need for mass evacuation was recognized, and the fire chief relocated upwind of the accident. The

[28] http://www.dot.gov/sites/dot.dev/files/docs/DISASTER_RECOVERY_TrainWreckChlorineSpillGranitevilleSC.pdf
[29] http://www.ntsb.gov/investigations/AccidentReports/Reports/RAR0504.pdf

firehouse was engulfed in the toxic cloud, preventing the retrieval of emergency equipment. Emergency responders evacuated personnel and the public, established incident command, and activated Reverse 911 with instructions to shelter in place. Poor communication and other issues during emergency response contributed to the consequences from the accident.

There were nine fatalities. Six were employees of Avondale Mills and were found in different locations on the plant property. One fatality occurred in a home near the accident. One fatality was a driver who passed through a portion of the chlorine cloud. His health deteriorated from that point on. When inhaled, chlorine reacts with moisture in the respiratory tract and lungs to form hydrochloric acid, resulting in inflammation of these tissues. At least 250 people were treated for chlorine exposure. Over 5,400 residents within one mile of the crash site were forced to evacuate for nearly two weeks while the area was being decontaminated. Residents near the plant were evacuated for a several months. The accident cost the railroad between $30-40 million. Avondale Mills employed over 4,000 people, but the plant was permanently shut down less than a year after the accident. Below is a picture of the displaced rail cars from the NTSB report and a picture of the chlorine tank at the site of the rupture from *Industrial Fire World*.

Figure 9: Graniteville accident displaced rail cars and spilled chlorine cargo. Source: Environmental Protection Agency, Region 4, Southeast.

Figure 10: Rupture on Chlorine Tank Car. Source: Industrial Fire World, Green Cloud Rising

- **Macdona, TX, 2004[30]**

  Two trains collided, resulting in the derailment of four locomotives and 35 railcars. A 90-ton liquid chlorine railcar was punctured and immediately vaporized into a cloud of chlorine gas that engulfed the accident area to a radius of at least 700 feet before drifting. Sixty tons (120,000 lbs) of chlorine were released over three days. Also released were 78,000 gallons of urea fertilizer and diesel fuel from the locomotives. There were three fatalities, the train conductor and two residents in close proximity to the release. Forty-three people were hospitalized including six emergency responders. Fifty-seven thousand residents within a two-mile radius were evacuated. Access to nearby residents was blocked by the derailed train and by locked gates. Emergency responders did not have adequate personal protective equipment to enter the stricken area. The chlorine cloud eventually spread over 10 miles.

  Chlorine is normally shipped under ambient temperature as a liquid at its own vapor pressure. The pressure inside the chlorine railcar depends upon the temperature. At 75^{o}F, the pressure inside the railcar would be about 94 psi gage. If the pressure is suddenly released, a portion of the liquid chlorine would flash and vaporize.

[30] http://www.ntsb.gov/investigations/AccidentReports/Reports/RAR0603.pdf

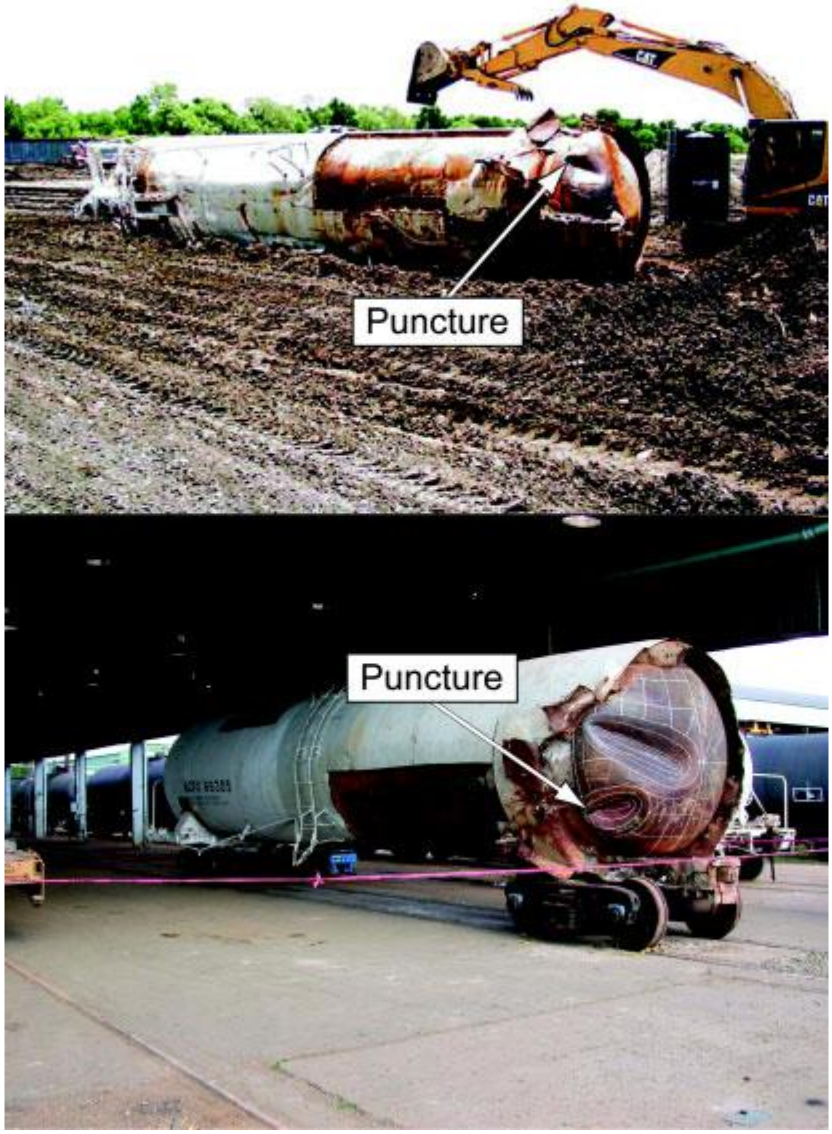

Figure 11: Chlorine tank car at accident site and after recovery. Source: Figure 4 from the NTSB Report

- **Festus, MI, 2002**

  A one-inch chlorine transfer hose used for rail car unloading operations ruptured. The rupture initiated a sequence of events that led to the release of 48,000 lbs of chlorine that lasted nearly 3 hours. From the Chemical Safety Board[31] *CHLORINE RELEASE (66 Sought Medical Evaluation)* report:

[31] http://www.csb.gov/assets/1/19/dpc_report.pdf

- Chlorine is a toxic chemical. When inhaled in high concentrations, chlorine gas causes suffocation, constriction of the chest, tightness in the throat, and edema of the lungs. At around 1,000 ppm, it is likely to be fatal after a few deep breaths.

- Depending on a number of factors—such as release volume, terrain, temperature, humidity, atmospheric stability, and wind direction and speed—a chlorine gas plume can travel several miles in a short time at concentrations well above IDLH. Dispersion modeling indicated that chlorine concentrations of 3 ppm could have extended to approximately 3.7 miles from the point of release.

- 63 people from the surrounding community sought medical evaluation at the local hospital; three persons were admitted and released the following day. Three workers also received minor skin exposure to chlorine during cleanup activities after the release.

- Below is a picture from the report that shows the chlorine plume moving offsite. As evident in the picture, the trees along the track prevented the plume from traveling very far into an area that would be accessible to the public.

Figure 12: Movement of chlorine plume offsite. Source: KTVI-TV, St. Louis, Missouri

Sodium hydroxide Accident

- **McKean County, PA, 2006**[32]

  A freight train derailed, and three tank cars carrying 50 percent sodium hydroxide ruptured, spilling 42,000 gallons. The solution traveled 30 miles through Sinnemahoning Portage Creek. Sodium hydroxide causes acute injury through caustic chemical burns. The chemical release resulted in an immediate and extensive fish kill in the thousands. The total kill area extended 11 miles downstream of the derailment site. Residents were advised against recreational water use for 10 days. Recovery of wild trout is expected to take an estimated 6 years, and nongame fish are expected to recover to pre-spill numbers in 3 years. Below is a photo of the derailment from the Division of Environmental Services Pennsylvania Fish and Boat Commission's report *Aquatic Biological Investigation in Response to the June 30, 2006 Norfolk Southern train Derailment and Sodium Hydroxide Release.*

Figure 13: 2006 Sodium Hydroxide Train Derailment. Source: Division of Environmental Services Pennsylvania Fish and Boat Commission

Sulfuric Acid Accidents

- **Northfield, MN, 2008**[33]

  A derailment of 28 rail cars near Northfield resulted in a leak of sulfuric acid. The acid was leaking slowly from only one tanker car. Emergency crews poured lime on the spilled acid

[32] http://www.fishandboat.com/water/streams/sinnemahoning/norfolk_report.pdf
[33] http://www.sulphuric-acid.com/techmanual/Plant_Safety/safety_accidents.htm

to neutralize it and built an earthen dam to contain it. An environmental crew also monitored air quality and tested the soil. The railroad didn't know how much sulfuric acid spilled or exactly how much the tanker contained, but the tanker held up to 14,000 gallons.

- **Santa Cruz, Mexico, 2005**[34]

  An estimated 24,000 gallons of sulfuric acid spilled from two train cars and contaminated the Santa Cruz River at about 3 p.m on Aug. 11. Private well-users in the vicinity were asked to not use water from their wells until the situation is mitigated. By midnight, August 11, the pH had decreased to four. After being treated with lime, the pH levels had risen to seven, neutral, by 11 a.m. Aug. 12.

- **Temagami, Ontario, Canada, 2000**[35]

  A 29 car freight train derailment, of which 25 contained sulfuric acid, resulted in the release of 780 tons of sulfuric acid. Immediate steps were taken to contain the spill by blocking off a culvert to stem the flow of water from the area. Once an assessment was completed, steps were taken to neutralize the acid. Downstream sampling indicated some impact to the inflow point of Hornet Lake. Sampling at the discharge point of the lake showed no impact.

- **Tennessee Pass, CO, 1996** [36]

  A thirty-nine car derailment resulted in the release of 51,606 gallons of sulfuric acid and 19,733 gallons of triethylene glycol. Four people were evacuated.

  According[37] to witnesses, sulfuric acid flowed downhill in several streams, which flooded the highway and formed pools in a parking lot. The acid did not reach the nearby river. Drivers and rescue workers sought treatment at nearby medical facilities for exposure to fumes, with symptoms ranging from burning eyes to shortness of breath and nausea. Two million pounds of soda ash and lime, needed to neutralize the acid, was brought in by truck and rail.

3.4.2.4 Consequences of All Hazardous Liquid Pipelines

According to PHMSA's Portal, during the last 2 years, from January 1, 2013, until February 25, 2015, there were 885 accidents, for all hazardous liquid pipelines, 328 of which met the threshold for "significant," which resulted in five injuries and one fatality. The accidents caused $376,851,521 in property damage.

[34] http://www.sulphuric-acid.com/techmanual/Plant_Safety/safety_accidents.htm
[35] http://www.sulphuric-acid.com/techmanual/Plant_Safety/safety_accidents.htm
[36] http://www.ntsb.gov/investigations/AccidentReports/Reports/RAB9808.pdf
[37] http://www.sulphuric-acid.com/techmanual/Plant_Safety/safety_accidents.htm

3.4.3 Likelihood

Likelihood is an estimate of the probability of occurrence. A chemical's compatibility with materials used in transportation can influence the probability of failure. The number of miles of pipeline also impacts the probability of occurrence. This section examines various factors that influence the likelihood of pipeline failure. Historical accident rates are often used to estimate the future probability of failure.

3.4.3.1 Material Compatibility

Accidental pipeline releases can result from a variety of causes, including natural disasters, excavation damage, other outside force damage, internal and external corrosion, mechanical or weld failure, design or construction errors, and operator error. Nonpetroleum pipelines would be subject to the same failure causes.

Some accident causes are irrespective of the product being transported, such as excavation damage. Some pipeline failure causes are specific to how an operator maintains and operates their pipeline. Other pipeline failure causes are influenced by the product being transported. Material compatibility is influenced by a product's corrosivity and reactivity.

The DOT regulations requiring material compatibility are performance based as opposed to prescriptive. The regulations do not prescribe the materials to be used to transport a given product but rather leave it up to the operator to select pipeline and pipeline components that are chemically compatible with the commodity being transported per 49 CFR 195.4. Steel pipe is required to be used per 49 Part 195.8 unless the operator has notified DOT and DOT determines that the alternative material is not unduly hazardous.

In addition to chemical compatibility, pipeline and pipeline components selection is driven by other material properties such as strength and elasticity. Economics is also a driving factor in material selection. Some materials that are more compatible with a chemical can be prohibitively expensive to use to transport via long pipeline. The following chart shows the compatibility of various products with metals, plastics, and elastomers. [38,39] The information is from *CAT Pumps Chemical Compatibly Guide*, from Cole Palmer Chemical Compatibility Rating, and *CI Pamphlet 164 Reactivity and Compatibility of Chlorine and Sodium Hydroxide with Various Material Edition 2*, 2007. The concentration of the sulfuric acid in the identified pipelines is 99 percent for sulfuric acid and 93 percent for the spent sulfuric acid. The concentration of the sodium hydroxide in the identified proposed pipeline is 32 percent. The liquid chlorine is described as "dry chlorine." The closest concentrations from the information from the guides were selected for the table below. From this chart, it can be deduced that sulfuric acid and sodium hydroxide are not highly compatible with common materials used for pipeline regulated under 49 CFR Part 195, such as carbon steel, but are compatible with more common plastics and elastomers used in pipeline components.

[38] CAT Pumps Chemical Compatibility Guide http://www.catpumps.com/products/pdfs/990331B_REF_Chemical%20Compat%20Guide(1).pdf

[39] http://www.coleparmer.com/Chemical-Resistance

The CI provided that they recently performed a test to calculate corrosion rate of 50 percent sodium hydroxide on A516 tank car carbon steel. The tests showed an average corrosion rate of 0.32, 0.38 and 0.42 mpy at 100°F, 120°F and 140°F, respectively. These rates are below PHMSA's threshold in 49 CFR Part 180 (2.5 mpy) that prescribe inspection and maintenance intervals for internal tank car coatings.

Table 5: Chemical Compatibility Table

Chemical	Materials						Plastics		Elastomers			
	Nickel Alum. Bronze	Carbon Steel	304 Stainless Steel	316 Stainless Steel	Hastelloy	Titanium	Acetal	Teflon	BUNA	Vitron	EPDM	Kalrez, Chemraz
Dry Chlorine	C	B	C	C	A	D	A	A	U	B	C	B
Sodium Hydroxide (50%)	C	D	A	A	A	A	C	A	U	A	A	A
Sulfuric Acid (75%)	U	D*	U	U	B	C	U	A	U	A	C	A
Propane (needs high inlet pressure)	A	B	A	A	B	A	B	A	A	A	U	A
Anhydrous Ammonia Liquid	U	B	B	A	A	B	U	A	B	U	A	A
Gasoline 'Heat" (low lubricity)	A	B	A	A	A	B	B	A	C	A	U	A

Legend
*93% and 98% sulfuric acid are also suitable for carbon steel per Sulphur Institute.

Source of Data - CAT Pumps Chemical Compatibility Guide	**Source of Data - Cole Palmer Chemical Compatibility Rating**
A-Good – Shows little or no effect after exposure to the chemical	A =Excellent
B-Fair – May be affected after exposure to the chemical. Swelling and/ or loss of physical properties is possible.	B = Good -- Minor Effect, slight corrosion or discoloration.
C-Questionable - May be affected after exposure to the chemical. Moderate or severe swelling and/ or loss of physical properties will limit life.	C = Fair -- Moderate Effect, not recommended for continuous use. Softening, loss of strength, swelling may occur.
U-Unsatisfactory – Is unsuitable when exposed to the chemical.	D = Severe Effect, not recommended for ANY use.
No Code - Information not available.	

3.4.3.2 Estimated Miles in Areas Accessible by the Public

Chlorine Pipelines

As previously cited from *CI Pamphlet 10*, 84 percent of chlorine was liquefied (leaving 16 percent in a gaseous state) in 2010. Using data from *Pamphlet 10*, 21 percent of the liquefied chlorine is shipped by rail, truck, or barge. The remaining 79 percent (or 66 percent of the total chlorine production) of the liquefied chlorine is consumed where it is produced, supplied to chemical plants located on the same or adjacent site with the chlorine consumer, or supplied to the consumer potentially by pipeline. More than two-thirds of all chlorine is consumed in the same manufacturing plant in the production of chemical intermediates.[40] This leaves 26 percent (or 22 percent of the total chlorine production) of the liquefied chlorine to potentially be transported by pipelines. Lacking information about the breakout of pipeline transport that does or does not cross areas accessible by the public, the study will assume that half do transport in areas accessible by the public (or 11 percent of the total chlorine production). This equates to about 0.7 times fewer liquid chlorine than gaseous chlorine for potential transport from the chlorine producer to the chlorine consumer via pipelines transported through areas accessible by the public. Two gaseous chlorine pipelines were identified in this study. The average length of the two chlorine gas pipelines in the NPMS is 11 miles in length.

In consideration of this information, an estimate of the potential number and average length of liquid chlorine pipelines will assume that there are the relatively the same mileage of liquefied chlorine pipelines as there are gas chlorine, or 11 miles.

The E.U. estimated that there are about 30 miles in Europe. Based on the differences between the E.U. and U.S. chlorine industries, 11 miles seems like a reasonable estimate. U.S. chlorine annual production volume is about 90 percent of the E.U. chlorine market, and the chlorine consumer markets differ somewhat. For example, a larger percentage of the chlorine production in the E.U. goes into the manufacture of PVC. The production facilities may also operate on different scales. According to Euro Chlor's[41] *Key Facts About Chlorine*, there are 70 chlorine plants in the E.U., while the CI *Pamphlet 10 Table 17: Miscellaneous Information* shows 44 plants operating in the U.S.

Sodium Hydroxide Pipelines

While the specific length of this proposed sodium hydroxide pipeline would exempt it from jurisdiction under 49 CFR Part 195, it is assumed that pipelines for this purpose could extend more than one mile, in keeping with the method used to calculate liquid chlorine pipelines.

Sodium hydroxide (NaOH) is also known as lye and caustic soda. Chlorine and caustic soda are co-products produced in proportional amounts. The map of the chlorine production facilities shows where sodium hydroxide is co-produced. From the EPA Notebook and *Chlorine Industry: A Profile Draft Report*, the largest users of caustic soda are the organic chemicals industry (30 percent) and

[40] EPA Inorganic Industry Profile
[41] http://www.eurochlor.org/media/14699/2011_livret_key-facts_uk.pdf

the inorganic chemicals industry (20 percent). The primary uses of caustic soda are in industrial processes, neutralization, and off-gas scrubbing; as a catalyst; and in the production of alumina, propylene oxide, polycarbonate resin, epoxies, synthetic fibers, soaps, detergents, rayon, and cellophane. The pulp and paper industry uses about 20 percent of total domestic caustic soda production for pulping wood chips and other processes. Caustic soda is also used in the production of soaps and cleaning products, and in the petroleum and natural gas extraction industry as a drilling fluid.

According to the CI's *Pamphlet 10 Table 19: United States Chlorine and Sodium Hydroxide** Production Statistics,* almost all sodium hydroxide produced is liquid. Production data on dry caustic is not available because the number of producers is too limited. This is compared to 84 percent of liquid chlorine production. The CI provided that based on their production numbers and AAR rail shipment numbers, approximately 18 percent of chlorine was shipped by rail in 2013 and approximately 54 percent of sodium hydroxide was shipped by rail in the same year.

Lacking information regarding the potential for sodium hydroxide pipelines or the potential for them to cross into public areas, this study will estimate that the miles of sodium hydroxide pipelines are proportional to liquid chlorine pipelines after giving consideration to the percent of liquid versus gas production and percent transported by rail (100/84 liquid production * 54/18 rail transportation) * 11 miles liquid chlorine pipelines = 10 miles. Even though relatively equal amounts of chlorine and sodium hydroxide are produced, they have much different uses, demands and distribution channels. Therefore, one cannot assume the same amount of sodium hydroxide is distributed by pipeline as chlorine.

Sulfuric Acid/Spent Sulfuric Acid Pipelines

The sulfuric acid/spent sulfuric acid pipelines identified in this study are used in petroleum refining. This study assumes, for the purpose of developing an estimate of the number of miles of sulfuric acid/spent sulfuric acid pipelines in areas accessible to the public, that these pipelines would be used in petroleum refining operations. Refineries use 99 percent concentrated sulfuric acid as an alkylation process catalyst in the production of gasoline and 93 percent sulfuric acid for cooling water treatment. The alkylation process contaminates and dilutes the sulfuric acid catalyst, generating an 85 percent to 90 percent spent sulfuric acid stream. The spent sulfuric acid is removed from the refineries via pipeline or tank truck. The sulfuric acid is thermally decomposed and the spent acid is regenerated into fresh sulfuric acid, which is recycled back to the refinery.

Spent sulfuric acid regeneration can take place on the refinery site in sulfuric acid regeneration equipment operated by the refinery or in a commercial sulfuric acid regeneration plant, which may serve several refiners. The choice depends on economic factors and the proximity of the refinery to an existing commercial regeneration plant. Sulfuric acid can be transported by rail, truck, barge, or pipeline.

PetroStrategies, Inc., a consulting, research and training organization focusing on the oil and gas industry provides on their web site[42] that the alkylation process uses either a sulfuric acid alkylation

[42] http://www.petrostrategies.org/Learning_Center/hf_alkylation_concerns.htm

unit (SAAU) or a hydrofluoric alkylation unit (HFAU). There are 129 U.S. refineries, of which 49 use HFAU. Assuming the remainder employs SAAU, there are potentially 80 refineries that could have sulfuric acid/spent sulfuric acid pipelines similar to those identified.

ECO Services indicates that they are the largest provider of sulfuric acid regeneration services per their web site.[43] ECO Services can deliver sulfuric acid regeneration by rail, truck, or barge and via pipeline in only two locations. Therefore, it is assumed that pipeline transport is more the exception than the norm. The Sulphur Institute provided that both of the sulfuric acid pipelines located in this study have existed for many years. They do not believe there are any other sulfuric acid pipelines in areas accessible to the public.

An estimate of the number of miles of sulfuric acid/spent sulfuric acid pipelines assumed the following:

- Three miles set of sulfuric acid/spent sulfuric acid pipelines were identified between ECO Service Inc.'s plant and ExxonMobil's refinery in Baton Rouge, LA.
- Three miles of a pipeline in Long Beach, CA, that sends sulfuric acid to a refinery and then returns the spent sulfuric acid through the same pipeline to the regeneration/production facility. The pipeline is installed underground and is located in areas accessible to the public.
- The Sulphur Institute members represent about 70 percent refineries in the U.S.
- The alkylation process at an estimated 80 refineries use SAAU units.
- The 3 miles pipeline that flow sulfuric acid one direction and spent sulfuric acid the opposite direction will be considered 1.5 miles for each product for a total of 4.5 miles.
- 49 CFR Part §195.1(b)(3)(ii) exempts low-stress pipelines that serve refining facilities, if the pipeline is less than one mile long (measured outside facility grounds) and does not cross an offshore area or a waterway currently used for commercial navigation. It is likely that if other sulfuric acid pipelines were in operation, they would be less than one mile long.

The likelihood of significantly more sulfuric acid pipelines related to refineries appears to be very low. For this report the number of miles of sulfuric acid and spent sulfuric acid pipelines is estimated as:

- 70 percent of the 80 refineries (56 refineries) have a total of 4.5 miles of sulfuric acid pipelines and 4.5 miles of spent sulfuric acid pipelines or 0.08 miles per refinery. Using the same rate, the remaining 30 percent of the 80 refineries (24 refineries) who are not SI members would have an additional 1.9 miles of sulfuric acid and spent sulfuric acid pipelines.
- Total miles = 6.4 miles of sulfuric acid pipelines and 6.4 miles of spent sulfuric acid pipelines in areas accessible by the public.

Compared in general with petroleum pipelines, nonpetroleum pipelines transport products across extremely short distances, through smaller diameter pipelines, and through more uniformly industrial areas. Nonpetroleum pipelines would be classified as intrastate pipelines as they are

[43] http://www.eco-services.com/products-and-services/#Regeneration

located entirely within one State. Petroleum pipelines typically transverse long distances through rural, industrial, suburban, and urban areas.

3.4.3.3 Miles of PHMSA Regulated Gas and Hazardous Liquid Pipelines

The following table shows the relative mileage of gas transmission and hazardous liquid pipelines regulated under PHMSA jurisdiction. Some products that PHMSA regulates when transported in the gaseous state are not regulated when transported as a liquid. While the types of hazardous liquids regulated under 49 CFR Part 195 are more limited, all corrosive gases, irrespective of their categorization (petrochemicals/nonpetroleum, organic/inorganic), are regulated under 49 CFR Part 192.

PHMSA estimates a range of 11 miles of chlorine and sodium hydroxide pipelines and 9 miles of sulfuric and spent sulfuric acid parallel pipelines. Relative to other pipelines that are regulated under 49 Part 195, the miles of these nonpetroleum pipelines are extremely small. There are over 3,300 miles of anhydrous ammonia pipelines and almost 5,200 miles of CO_2 pipelines. Alternatively, there only 22 miles of chlorine gas pipelines regulated under 49 Part 192.

PHMSA does regulate gas products even though they are transported through very few miles of pipeline. For example, the table below shows that PHMSA regulates nine miles of HCL gas and two miles of ethane gas.

Table 6: Pipeline Miles of Products

Hazardous Liquid Products	Miles	Gas Products	Miles
Crude Oil	62,860	Natural Gas	302,376
Refined Products	59,940	Hydrogen	1555
Natural Gas Liquids (NGL)	24,535	Ethylene Gas	736
Liquefied Petroleum Gas (LPG)	22,949	Propane Gas	159
Other Highly Volatile Liquid (OHV)	12,616	Nitrogen	129
Carbon Dioxide	5,030	Methane/Landfill Gas/Biogas	121
Anhydrous Ammonia	3,370	Carbon Monoxide	93
Fuel Grade Ethanol	32	Dry Gas	85
Methanol	30	Acetylene	25
TOTAL	**191,363**	Synthetic Gas	44
		Chlorine Gas	22
		Fuel Gas	11
		Fluid Catalytic Cracking Refinery Gas	10
		HCL	12
		Natural Gasoline	5
		C-4 Vents	4
		Methanol	4
		Oxygen	2
		Ethane Gas	2
		TOTAL	305,395

3.4.3.4 Likelihood of Failure of Pipelines Regulated Under 49 CFR Part 195

Accidents on hazardous liquid pipelines are characterized as low frequency, high consequence events. Clearly the more miles of pipelines transporting a hazardous material product, the greater the likelihood of an unintended release of that specific product. Normalized accident rates are a calculation of the number of accidents that occur per mile or per volume transported. According to PHMSA's web site, from January 1, 2013, to February 25, 2015, there were 885 accidents reported on over 191,000 miles of hazardous liquid pipelines. This results in an incident rate of one per 2,170 miles per year.

No incidents were reported on PHMSA Annual Reports for the two gas chlorine pipelines during 1984-2014. The two gas chlorine pipelines were a total of 22 miles in length. Using the average incident rate per mile of all hazardous liquid pipelines (one per 2,170 miles), the 1.4 miles of liquid chlorine pipelines would experience an accident once every 1,550 years. On the other hand, using the average rate of failure of another nonpetroleum product with very few miles, biodiesel, the annual accident rate would be estimated to be very high. One accident was reported on the biodiesel pipeline in its first year of operation with a resulting accident rate of one per three miles per year. Applying this accident rate to the three miles of liquid chlorine pipelines would result in an accident once every other year. This wide range of accident rates illustrates the difficulty in predicting the likelihood of failure of low mileage pipelines.

Failure Causes of Hazardous Liquid Pipelines

The chart below shows the failure causes of all hazardous liquid pipeline accidents reported to PHMSA during 2010-2014. These failure causes would be applicable to liquid chlorine pipelines as well although the percent of failure breakdown would likely be different.

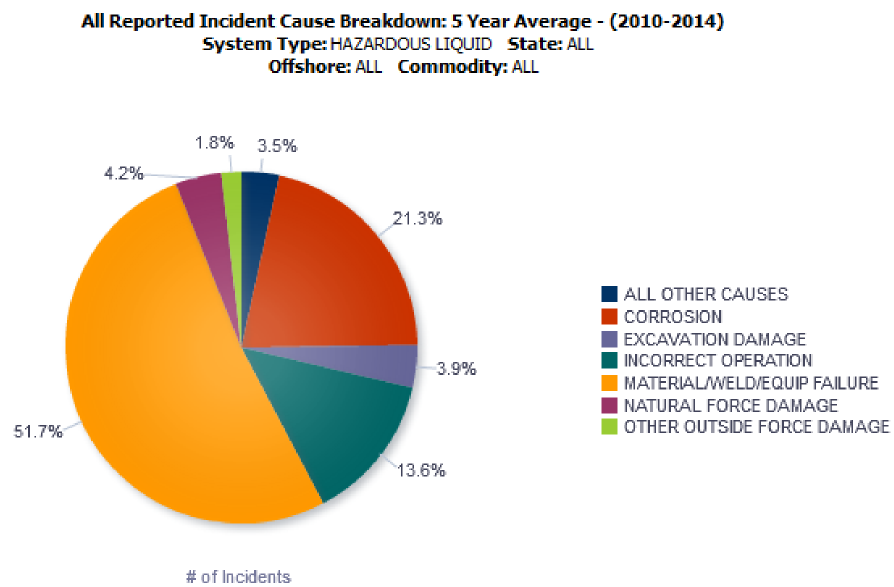

Figure 14: Failure Causes All Hazardous Liquid Pipelines, All Reported Accidents

3.4.4 Preventative and Mitigative Measures

Under 49 CFR Part 195, pipeline operators are required to develop and implement programs and processes that focus specifically on safe operating and maintenance activities. These include system design and construction, operator qualifications, pipeline and pipeline rights-of-way inspections, public education and awareness, emergency responder outreach, and excavation damage prevention programs. Pipeline operators are required to adhere to numerous other regulations and safety standards, and their compliance is audited by Federal and State regulatory agencies.

A chemical facility producing chlorine, sodium hydroxide, or fuming sulfuric acid would be regulated under the EPA RMP and OSHA PSM regulations if they meet the threshold quantity. A facility's RMP must include procedures for informing the public and the fire department, should an accident occur. Under PSM, operators must establish and maintain adequate communication with police, fire, and other public officials. Non fuming sulfuric acid would be regulated under EPCRA section 302. The presence of EHS, in quantities in excess of the TPQ, requires certain emergency planning activities to be conducted. Through these requirements, a prudent plant operator would be expected to communicate with fire departments about the presence of any pipelines transporting hazardous materials in areas accessible to the public.

The chemical industry provided that they voluntarily implement risk reduction measures to prevent pipeline incidents and to mitigate their risks. The measures include:

- **Chlorine Institute *Pamphlet 60* for Chlorine Pipelines**

  The CI publishes industry standards for chlorine pipelines.

  Pamphlet 60 Chlorine Pipelines Edition 7, August 2013, "provides recommendations on the design, construction, operation and maintenance of carbon steel pipelines that transport chlorine liquid or gas. The recommendations are applicable to pipelines that terminate outside the chlorine shipper's property or crosses property not owned by the shipper or receiver of the chlorine."[44] The document recommends that operators use 49 CFR Part 195 as a minimum standard for design, inspection, and testing of liquid pipelines where relevant, while recognizing that they are not subject to its jurisdiction.

  Pamphlet 6 Pipeline Systems for Dry Chlorine, Edition 16, March 2013, is the CI's industry standard for pipelines entirely within a plant. The standard contains information on selection of pipe, valves and fittings for suitable use for dry chlorine (gas or liquid) within the range of -150° F to 300° F.

- **Chlorine Institute Stewardship Program**

  The CI's members who produce or handle chlorine are required to annually sign the CI's Member Safety & Security Commitment. In signing the commitment, they agree to adopt the CI's safety and stewardship initiatives, including pamphlets, checklists, and incident

[44] The Chlorine Institute Pamphlet 60 Chlorine Pipelines Edition 7, August 2013.

sharing. The commitment covers all aspects of chlorine handling and transportation, including distribution pipelines. The CI provided that, "By signing this form, our members are committed to promoting and demonstrating safe and secure practices when producing, transporting and using chlorine, as well as implementing a stewardship program with the ultimate goal of eliminating chlorine incidents. Not only do our members commit to following these policies and practices themselves, but they also ensure their customers have a risk management program in place to promote safe and proper handling of chlorine."

Information on the Institute's stewardship program is on their web site at: www.chlorineinstitute.org.

- **Chlorine Institute Transportation Issue Team**

  The CI's Transportation Issue Team's mission is to foster continuous improvements to safety and security as it relates to the production, distribution, and use of chlorine, sodium and potassium hydroxides, and sodium hypochlorite; and the distribution and use of hydrogen chloride, including hydrochloric acid and anhydrous hydrogen chloride. These products may be transported in bulk by rail in tank cars, by highway in cargo tanks and smaller containers – 150 LB cylinders and one ton containers, by ISO portable containers (DOT 51), by waterway in barge, and by pipeline. The Transportation Issue Team tracks incident data for chlorine (bulk rail and highway), sodium hydroxide and potassium hydroxide (caustic) bulk rail, caustic bulk highway, hydrochloric acid bulk rail and hydrochloric acid bulk highway. The team is responsible for Pamphlet 60. All CI pamphlets are revised on a 5-year cycle. The various task groups working under the Transportation Issue Team develop recommendations and guidance, with final approval by the Issue Team, in order to achieve the goals for these products and modes. Because there are no chlorine pipeline incidents on record, the team does not have that data to analyze. If any chlorine pipeline accidents were to occur, information learned would be considered in the next revision of the pamphlet.

  Information about the Transportation Issues Team is located on the CI's web site at: http://www.chlorineinstitute.org/transportation/incident-statistics.cfm.

- **American Chemistry Council Responsible Care**®

  Members are required to participate in the ACC's Responsible Care® Initiative. The ACC provides on their web site that the intent of the Responsible Care® initiative is to improve health, safety, and environmental performance of the chemical industry. Each company's CEO signs a commitment to uphold the program elements. The four elements are (1) adhering to a set of guiding principles, (2) publicly reporting performance measures, (3) implementing a Responsible Care Product Safety Code, Process Safety Code, and Security Code and (4) implementing a Responsible Care management system to improve their performances in the fields of community awareness and emergency response, security, distribution, employee health and safety, pollution prevention, and process and product safety independent from legal requirements. The companies' programs are certified by a third party. The program focuses on plant process safety. The liquid chlorine pipeline operator identified in the research for this report provided to PHMSA that they do include these pipelines in their Responsible Care® program. The ACC did not determine if other companies would include pipelines outside of plant property in their Responsible Care® program.

4 Analysis Results

Through extensive research and outreach, PHMSA identified three nonpetroleum hazardous liquid products transported via pipeline in areas accessible to the public that are not regulated under 49 CFR Part 195. The pipelines for these products are two 1.4-mile liquid chlorine pipelines in Texas, one proposed 5,000-foot liquid sodium hydroxide pipeline in Tennessee, and one three-mile sulfuric acid pipeline that runs parallel with a three-mile spent sulfuric acid pipeline in Louisiana.

The EPA requires chemical producers to report hazardous material releases that exceed regulatory thresholds to the NRC. The sulfuric acid pipeline and parallel spent sulfuric acid pipeline were identified through review of approximately twelve years of NRC reports. Based on the reporting requirements and lack of other accidental releases reported on pipelines in areas accessible by the public reported to the NRC, the subject pipelines have not resulted in a high level of consequences to the public.

The liquid chlorine pipeline was identified in Texas's permit database. The proposed sodium hydroxide pipeline was the subject of a PHMSA interpretation where the operator was seeking clarification as to the jurisdiction of the pipeline.

PHMSA was not able to obtain conclusive information from chemical producers or industry associations, so PHMSA estimated the potential mileage in areas accessible by the public using information about the chemical industry and the identified pipelines. While lack of primary sources of nonpetroleum pipeline mileage may not increase risk, lack of information may result in specious conclusions.

Level of State Regulation

Alabama is the only State with the statutory authority to regulate other nonpetroleum pipelines in addition to those currently regulated under 49 CFR Part 195, anhydrous ammonia and carbon dioxide. Alabama is not aware of any such pipelines in their State. In most States, any pipeline that transports hazardous liquids would be regulated under the State's excavation damage prevention laws. Several State laws, including those in Tennessee, limit applicability of their excavation damage prevention laws to "utilities." If the pipelines were identified in other similar States, they would need to further assess their laws to determine if chemical producers meet the definition of utility.

Scope of Nonpetroleum Hazardous Liquid Pipelines in Areas Accessible to the Public

Nonpetroleum fuels are a subset of nonpetroleum hazardous materials. PHMSA has previously stated biofuels pipelines are subject to 49 CFR Part 195 jurisdiction. Section 14 of the Act provides clarity that PHMSA has the authority to regulate nonpetroleum fuel pipelines. The regulatory language revisions are included in the Notice of Proposed Rulemaking, *Pipeline Safety: Safety of Hazardous Liquid Pipelines,* published on October 13, 2015. Since PHMSA regulates these pipelines, they are not included in the risk analysis.

PHMSA exempts petrochemical products made by chemical means using petroleum products as a raw material from the scope of products subject to 49 CFR Part 195. Petrochemical products made by chemical means using petroleum products as a raw material (e.g. ethylene dichloride) are out of scope of this study.

Furthermore, 49 CFR Part 195 exempts low stress pipelines less than one mile long that serve refining, manufacturing, or truck, rail, or vessel terminal facilities and do not cross navigable waterways. Nonpetroleum pipelines meeting this criterion were excluded from the study.

Evaluation of Significant Risks to Public Safety, Property or the Environment

The risk analysis looked at the hazards each chemical poses, the potential consequences to the public, and the likelihood of occurrence. While chemical production facilities are typically located in industrial areas, land development since their construction may increase the risk to the public from unintended releases. The causes of nonpetroleum pipeline failures are the same as the causes of petroleum pipelines: natural disasters, excavation damage, other outside force damage, internal and external corrosion, mechanical or weld failure, design or construction errors, and operator error.

The level of risk to the public posed by chlorine, sodium hydroxide, or sulfuric acid pipelines vary according to their chemical and physical properties and are summarized as follows:

- **Chlorine**

  Chlorine, like anhydrous ammonia, is classified as a poisonous gas and regulated by the DOT, OSHA, and the EPA based on its hazard and risk.

  Liquid chlorine is not a flammable or explosive material so it will not cause a fire on its own. However, as a strong oxidant, chlorine may readily react to stimulate combustion. Chlorine reacts with many substances. Although dry chlorine does not react with or corrode metals such as carbon steel, it reacts violently with water. The effects of chlorine depend on the duration and level of exposure. Relatively low levels, 5-15 ppm, can cause eye and throat irritation and by 40-60 ppm can cause lung injury. A few minutes of exposure to 1,000 ppm can cause death. By all Federal regulatory risk measures and program thresholds examined for this study, chlorine is classified as a hazardous chemical.

  The study estimates that there are 11 miles of liquid chlorine pipelines in areas accessible to the public.

  While no chlorine gas pipeline accidents have been reported to PHMSA, there have been significant liquid chlorine railcar accidents that resulted in fatalities and injuries. In 2004 a railcar accident in Macdona, TX, resulted in a chlorine vapor cloud that spread over 10 miles.[45]

- **Sodium hydroxide**

  Sodium hydroxide is classified as a hazardous material by DOT but poses a lower risk to the public than chlorine or other hazardous liquids regulated under 49 CFR Part 195.

  Liquid sodium hydroxide will not readily vaporize and is not flammable, combustible, has no flash point, no auto-ignition temperature, and no explosive limits. Sodium hydroxide is regarded as stable. Sodium hydroxide is odorless, but mucous membrane irritation occurs at the OSHA PEL (2 mg/m3), which provides warning for acute exposure. Very strong solutions of sodium hydroxide can cause severe burns and eye damage or, in extreme cases, blindness. Sodium hydroxide does not produce systemic toxicity. Health effects are due to its corrosive nature. Sodium hydroxide will react vigorously with some metals.

  A high concentration of sodium hydroxide in water will generally result in toxic effects for aquatic organisms. However, a low concentration in water may not result in effects on aquatic organisms because the sodium hydroxide will be neutralized by other substances present in water and thus the pH will not increase. When sodium hydroxide is neutralized in the environment, the substance is not persistent and it will not accumulate in organisms or in the food chain. Bioaccumulation will not occur.

  Sodium hydroxide is a co-product with chlorine in the chlor-alkali process and produced in approximately equal amounts. The study estimates, absent better information, there are 10 miles of liquid sodium hydroxide pipelines in areas accessible to the public.

  The likelihood of failure of sodium hydroxide pipelines is assumed to be similar to that of hazardous liquid pipelines, although the consequences to the public would likely be lesser. A 2006 sodium hydroxide railcar accident in McKean County, PA, resulted in environmental damage in the form of significant fish kills for 11 miles downstream of the rail accident.[46] Sodium hydroxide is neutralized in the environment so it is not persistent and will not accumulate in organisms.

- **Sulfuric acid (nonfuming) and Spent Sulfuric Acid**

  Sulfuric acid shows different properties depending on its concentration. Because of its corrosiveness, it is a hazardous material. It has a pungent odor and can cause severe skin burns, eye damage, and may harm aquatic life. Sulfuric acid pipelines pose a relatively lower risk to the public than chlorine or petroleum pipelines.

  The two identified sulfuric acid liquid pipelines contain 99 percent acid and 1 percent water. Sulfuric acid will not readily evaporate and is not flammable. Spent sulfuric acid typically

[45] http://www.ntsb.gov/investigations/AccidentReports/Reports/RAR0603.pdf
[46] http://www.fishandboat.com/water/streams/sinnemahoning/norfolk_report.pdf

contains 88 to 95 percent acid and up to 5 percent water, with the balance being hydrocarbons, including some light hydrocarbons that can vaporize and are flammable. Although the release and ignition of flammable fluids is a concern, the release of toxic materials poses a greater threat to the public. Sulfuric acid reacts violently with water.

The study estimates about 6.4 miles of sulfuric acid pipelines and 6.4 miles of spent sulfuric acid pipelines may be in areas accessible to the public.

The likelihood of failure of sulfuric acid pipelines is similar to that of hazardous liquid pipelines, although the consequences are likely would be lesser since it is not flammable.

In 1996 in a sulfuric acid railcar accident in Tennessee Pass, CO, 51,606 gallons of sulfuric acid was released and four people were evacuated. Drivers in the area and rescue workers sought treatment for exposure to fumes with symptoms ranging from burning eyes to shortness of breath and nausea. Two million pounds of soda ash and lime were used to neutralize the acid.[47]

Preventative and Mitigative Measures to Manage Risks of Nonpetroleum Pipelines

While nonpetroleum hazardous liquids pipelines in areas accessible to the public are not regulated by PHMSA, certain measures are in place to prevent and mitigate the consequences of unintended releases.

Two industry associations, the CI and the ACC, require members to participate in safety management system programs. The programs are designed to monitor and improve the safety performance of the chemical industry. These organizations provide a channel for communication, evaluation, and sharing of information about chlorine and sodium hydroxide pipelines and pipeline failures.

The chlor-alkali industry developed technical standards for the design, construction, operation and maintenance of chlorine liquid and gas pipelines, the CI's *Pamphlet 60 Chlorine Pipelines.* The recommendations are applicable to pipelines that terminate outside the chlorine production facility or cross property not owned by the shipper or receiver of the chlorine.

The CI requires members to annually sign the Member Safety & Security Commitment, which covers all aspects of chlorine handling and transportation, including distribution pipelines. By signing this form, members commit to promoting and demonstrating safe and secure practices when producing, transporting, and using chlorine, as well as implementing a stewardship program with the ultimate goal of eliminating chlorine incidents.

The ACC requires members commit to their follow the Responsible Care© program. The program's purpose is to improve health, safety, and environmental performance of the chemical industry. It requires companies to implement a Responsible Care Product Safety Code, Process Safety Code, and Security Code. The companies' programs are certified by a third party.

[47] http://www.sulphuric-acid.com/techmanual/Plant_Safety/safety_accidents.htm

The EPA RMP and OSHA PSM regulations for chemical plants that contain threshold quantities of chemicals require operators to work closely with public and response agencies (e.g. the fire department). Since a relationship is required to be established, it is expected that prudent chemical producers make fire departments aware of any pipelines that transport hazardous liquids in areas accessible by the public.

Excavation damage prevention laws, when applicable to nonpetroleum hazardous liquid pipelines, also serve to mitigate risk.

Conclusion

The vast majority of hazardous liquid pipelines transport petroleum products. PHMSA regulates nearly 190,000 miles of hazardous liquid petroleum pipelines. In comparison, this study found only an estimated 34 total miles of nonpetroleum hazardous liquid pipelines. These include chlorine, sodium hydroxide, and sulfuric acid/spent sulfuric acid. The minimal total mileage of these pipelines means that the risks from these nonpetroleum hazardous liquids are not generally associated with pipeline transportation.

PHMSA found that these lines are primarily located in industrial areas. Industrial parks are typically zoned and located away from the main residential areas of a city to reduce potential impacts on residential areas, resulting in limited public exposure to these lines. Pipelines in industrial areas are also already subject to various means of oversight, including State agencies, the U.S. EPA and the U.S. Coast Guard.

In addition, chemical industry associations require members to participate in safety management system programs and have developed technical standards for the design, construction, operation, and maintenance of applicable pipelines. Federal regulations also require operators whose plants contain threshold quantities of chemicals to work closely with public and response agencies. Releases are also prevented and mitigated by excavation damage prevention laws that apply to nonpetroleum hazardous liquid pipelines.

In conclusion, while nonpetroleum hazardous liquid pipelines can pose some possible risks to the public, the very small exposure in pipeline mileage, typical location in industrial areas, and existing safety measures all help to prevent and mitigate the consequences of unintended releases.

REFERENCES

1. Handbook of Compressed Gases, Compressed Gas Association, Inc., Second Edition, 1981, Van Nostrand Reinhold Company.
2. Chlorine Handbook, Diamond Alkali Company, Cleveland, Ohio, undated.
3. Development of the Table of Initial Isolation and Protective Action Distances for the 2012 Emergency Response Guidebook, Argonne National Laboratory, December 2013.
4. Odor Threshold in Google, chlorine 4. Chemical and Physical Information.
5. Lethal Dose Table, toxin © UC Regents, LHS Living by Chemistry, 2004.
6. Sodium Hydroxide, Wikipedia, 3/25/15.
7. CDC, Sodium Hydroxide, May 1994.
8. Graphs published by General Chemical.
9. Sulfuric Acid, Wikipedia, accessed 3/25/15.
10. Occupational Health Guideline for Sulfuric Acid, U.S, Department of Labor, September 1978.
11. T. Kapias and R.F. Griffiths, Sulfur Trioxide and Oleum, Chapter 37.
12. MSDS, Matheson Tri-Gas, June 18, 2007.
13. U.S. EPA List of Regulated Chemicals and Threshold Quantities for Accidental Release Prevention (40 C.F.R. Part 68).
14. Sodium hydroxide, Wikipedia.
15. CDC, Sulfuric Acid.
16. EPA website AEGL Values 2014.
17. Sulfuric acid, Cornerstone Chemical Company, undated.
18. Oleum, Sulfur Trioxide, and Sulfuric Acid, Aristatek.com.
19. TOXICOLOGICAL PROFILE FOR SULFUR TRIOXIDE AND SULFURIC ACID, Agency for Toxic Substances and Disease Registry, December 1998.
20. Spent Sulfuric Acid, MSDS, Valero, 6/10/2011.
21. Spent Sulfuric Acid, MSDS, Chemtrade, March 1, 2014.
22. The Engineering ToolBox, Pressure and Temperature Chart of Ammonia – NH_3.
23. Occupational Safety and Health Guideline for Ammonia, 1992.
24. CDC- NIOSH Pocket Guide to Chemical Hazards – Ammonia.
25. MSDS, Ferrellgas Material Safety Data Sheet – Propane, Liberty, MO, July 2008.
26. MSDS for propane, Airgas http://www.airgas.com/msds/001045.pdf

Appendix A – Inorganic Commodity Products

The table in Appendix A is a compilation of inorganic products that are produced in large volumes according to the references listed in columns C - E. Column F shows the number of reports that were identified in the NRC database. Column B provides the rationale for determining if the chemical was to be further evaluated.

A	B	C	D	E	F
Chemical	**Further Evaluated for Report?**	**Essential Chemical Industry[48]**	**Chemical and Engineering News, July 10, 2006[49]**	**2002 Guide to the Business of Chemistry (ranking by tonnes produced includes organic and inorganic chemicals)**	**Number of NRC Pipeline Reports (CHRIS Code) 2002-2014**
Aluminum sulfate	No - < one release per year		x	64	1 ALM
Ammonia	No - PHMSA regulates anhydrous ammonia	x	x	8	325 AMA
Ammonium nitrate	No - < one release per year		x	23	1 AMN
Ammonium sulfate	No - < one release per year		x	41	0
Bromine	No, bromine is transported in lead lined, heavily reinforced steel tanks since it is capable of dissolving metals.	x			0

[48] http://www.essentialchemicalindustry.org/chemicals.html
[49] http://en.wikipedia.org/wiki/Inorganic_chemistry#cite_ref-2

Calcium carbonate	No - Solid	x		48	0
Calcium Hydroxide (Lime)	No - < one release per year			5	0
Carbolic acid (phenol)	No - < one release per year			43	5 PHN
Carbon dioxide	No - PHMSA regulates CO2 liquid			20	13 CDO
Chlorine	Yes - PHMSA regulates chlorine gas pipelines but not liquid	x	x	9	41 CLX, 31 SHC, 19 SHP
Diammonium Phosphate	No - < one release per year			12	0
Fluorine	No - The fluorine is usually used immediately or it can be transported as a gas in stainless steel cylinders.	x			0
Hydrogen	No - PHMSA regulates hydrogen gas	x	x	62	N/A
Hydrogen chloride (hydrochloric acid)	Yes, HCL - PHMSA regulates gas anhydrous hydrogen chloride and hydrochloric acid pipelines. Solutions of hydrogen chloride in water are known as hydrochloric acid.	x	x	32	18 HCL, 2 HDC
Hydrogen fluoride (Hydrofluoric acid)	No, Hydrogen fluoride is a gas at room temperature. Its solution in water is known as hydrofluoric acid. Shipped by railcar or in smaller tanks.	x			8 HFA

Hydrogen peroxide	No, transported by truck or rail. Less than one per year.	x	x		0
Iodine	No, not produced on a large enough scale to justify a pipeline.	x			0
Methanol	No, already regulated under 49 CFR Part 195			26	14 MAL, 10 No CHRIS Code NCC
Nitric acid	No - Transported in tanks, corrodes most metals	x	x	19	4
Nitrogen	No - not designated as hazardous	x	x	2	N/A
Oxygen	No - not designated as hazardous	x	x	4	N/A
Phosphoric acid	Yes	x	x	10	11 PAC
Phosphorus	No - Solid	x			1 PPW
Sodium carbonate (soda ash)	No - Solid	x	x	11	N/A
Sodium chlorate	No - < one release per year		x	75	0
Sodium hypochlorite (bleach)	Yes				75
Sodium hydroxide (caustic soda)	Yes	x	x	13	35 SHD, 6 CSS
Sodium silicate	No - < one release per year		x	67	0
Sodium sulfate	No - < one release per year		x	94	0
Sulfur	No - Solid	x		16	N/A
Sulfuric acid	Yes	x	x	1	3 SAC, 95 SFA
Titanium dioxide	No - not designated as hazardous	x	x	57	0
Urea (carbamide)	No - < one release per year			24	0

Appendix B – Hazards of Chlorine, Sodium Hydroxide, Sulfuric Acid, and Anhydrous Ammonia

Appendix B provides additional information about the hazards of chlorine, sodium hydroxide and sulfuric acid including a general description of each chemical, air and water reactions, fire and health hazards, and a reactivity profile. This information is from the CAMEO Chemicals database.

Chlorine	
General Description	A greenish yellow gas with a pungent suffocating odor. Toxic by inhalation. Slightly soluble in water. Liquefies at -35°C and room pressure. Readily liquefied by pressure applied at room temperature. Density (as a liquid) 13.0 lb / gal. Contact with unconfined liquid can cause frostbite by evaporative cooling. Does not burn but, like oxygen, supports combustion. Long-term inhalation of low concentrations or short-term inhalation of high concentrations has ill effects. Vapors are much heavier than air and tend to settle in low areas. Contact CHEMTREC to activate chlorine response team 800-424-9300. Used to purify water, bleach wood pulp, and to make other chemicals.
Air & Water Reactions	Water dissolves about twice its volume of chlorine gas, forming a mixture of hydrochloric acid and hypochlorous acids. Will be corrosive due to acidity and oxidizing potential.
Fire Hazard	May ignite other combustible materials (wood, paper, oil, etc.). Mixture with fuels may cause explosion. Container may explode in heat of fire. Vapor explosion and poison hazard indoors, outdoors or in sewers. Hydrogen and chlorine mixtures (5-95%) are exploded by almost any form of energy (heat, sunlight, sparks, etc.). May combine with water or steam to produce toxic and corrosive fumes of hydrochloric acid. Emits highly toxic fumes when heated. Avoid plastics and rubber. Avoid heat and contact with hydrogen gas or powdered metals. (EPA, 1998)
Health Hazard	Poisonous; may be fatal if inhaled. Contact may cause burns to skin and eyes. Bronchitis or chronic lung conditions. (EPA, 1998)
Reactivity Profile	CHLORINE reacts explosively with or supports the burning of numerous common materials. Ignites steel at 100° C in the presence of soot, rust, carbon, or other catalysts.

Sodium Hydroxide	
General Description	A dark, thick liquid. More dense than water. Contact may severely irritate skin, eyes, and mucous membranes. Toxic by ingestion. Corrosive to metals and tissue. Density 13 lb / gal.
Air & Water Reactions	Slowly absorbs carbon dioxide from the air to give solid products as crusts or precipitates. Water soluble. Dilution with water liberates heat, possibly enough to

	cause local boiling and spattering.
Fire Hazard	Non-combustible, substance itself does not burn but may decompose upon heating to produce corrosive and/or toxic fumes. Some are oxidizers and may ignite combustibles (wood, paper, oil, clothing, etc.). Contact with metals may evolve flammable hydrogen gas. Containers may explode when heated.
Health Hazard	Causes severe burns of eyes, skin, and mucous membranes. (USCG, 1999)
Reactivity Profile	Strongly basic. Reacts rapidly and exothermically with organic and inorganic acids, with organic and inorganic acid anhydrides, including oxides of nonmetals such as sulfur dioxide, sulfur trioxide, phosphorus trioxide, phosphorus pentaoxide, and with organic and inorganic acid chlorides.

Sulfuric Acid	
General Description	Sulfuric acid is a colorless oily liquid. It is soluble in water with release of heat. It is corrosive to metals and tissue. It will char wood and most other organic matter on contact, but is unlikely to cause a fire. Density 15 lb / gal. Long term exposure to low concentrations or short term exposure to high concentrations can result in adverse health effects from inhalation. It is used to make fertilizers and other chemicals, in petroleum refining, in iron and steel production, and for many other uses.
Air & Water Reactions	Reaction with water is negligible unless acid strength is above 80-90% then heat from hydrolysis is extreme, may cause severe burns [Merck, 11th ed. 1989].
Fire Hazard	It is highly reactive and capable of igniting finely-divided combustible materials on contact. Avoid heat; water and organic materials. Sulfuric acid is explosive or incompatible with an enormous array of substances. Can undergo violent chemical change at elevated temperatures and pressure. May react violently with water.
Health Hazard	Corrosive to all body tissues. Inhalation of vapor may cause serious lung damage. Contact with eyes may result in total loss of vision. Skin contact may produce severe necrosis. Fatal amount for adult: between 1 teaspoonful and one-half ounce of the concentrated chemical. Even a few drops may be fatal if the acid gains access to the trachea. Chronic exposure may cause tracheobronchitis, stomatitis, conjunctivitis, and gastritis. Gastric perforation and peritonitis may occur and may be followed by circulatory collapse. Circulatory shock is often the immediate cause of death. Those with chronic respiratory, gastrointestinal, or nervous diseases and any eye and skin diseases are at greater risk. (EPA, 1998)
Reactivity Profile	N/A

Spent Sulfuric Acid	
General Description	A black oily liquid. Corrosive to metals and tissue. Density 15 lb /gal.
Air & Water Reactions	N/A
Fire Hazard	Some of these materials may burn, but none ignite readily. May ignite combustibles (wood, paper, oil, clothing, etc.). Substance will react with water (some violently),

	releasing corrosive and/or toxic gases and runoff. Flammable/toxic gases may accumulate in confined areas (basement, tanks, hopper/tank cars, etc.). Contact with metals may evolve flammable hydrogen gas. Containers may explode when heated or if contaminated with water. Substance may be transported in a molten form. (ERG, 2012)
Health Hazard	Contact with eyes or skin causes severe burns, the severity depending on the strength of the acid. Ingestion can cause severe irritation of mouth and stomach. (USCG, 1999)
Reactivity Profile	SULFURIC ACID, [SPENT] is diluted and partly neutralized sulfuric acid recovered from industrial use. Likely to contain multiple impurities. Reacts an acid and as a weak oxidizing agent. Chars wood and most other organic matter, but is unlikely to cause a fire.