2.2 NEARBY INDUSTRIAL TRANSPORTATION AND MILITARY FACILITIES

This section presents the results of a survey of the industrial and transportation facilities, and military installations and operations within the vicinity of Waterford 3. The purpose of the survey is to establish which potential accidents from present industrial, transportation and military facilities should be used for evaluating the design of plant safety related features. All facilities within five miles of the Waterford 3 site are included in this survey. Other facilities beyond this radius are included based on the type of activity and the distance and direction from the site.

2.2.1 LOCATIONS AND ROUTES

→(EC-5000082218, R301)
Figures 2.2-1 and 2.2-2 are site vicinity maps which show all nearby industrial and transportation facilities.

→(EC-39014, R307; LBDCR 15-048, R309)
Within five miles of Waterford 3 there are 23 industrial facilities which store or process toxic chemicals. These industrial facilities are shown in Figure 2.2-1 and described in Subsection 2.2.2.1.1 and in Table 2.2-3A.
←(EC-5000082218, R301; EC-39014, R307; LBDCR 15-048, R309)

There are no military installations near the Waterford 3 site. The closest military base is the Naval Air Station in Belle Chasse, Louisiana which is approximately 30 miles east-southeast of Waterford 3. There are no training flights or bombing runs associated with this base in the vicinity of the nuclear plant(1) nor is there any unique military aeronautical activity in the area of Waterford 3 that should affect the safety of the plant(2).

Highways and railroads in the vicinity of the site are shown in Figure 2.2-2 and described in Subsection 2.2.2.1.2.

The Reactor Building is approximately 1,000 ft. from the shoreline of the Mississippi River which is a major shipping route. A description of the shipping along the river is given in Subsection 2.2.2.4.

Location of airports and their associated air traffic patterns in the vicinity of Waterford 3 are shown in Figures 2.2-4, 2.2-5a and 2.2-5b respectively and described in Subsection 2.2.2.5.

→(EC-5000082218, R301; EC-39014, R307)
Pipelines within two miles of the site are shown in Figures 2.2-3A through 2.2-3G and described in Subsection 2.2.2.3. Oil and gas fields are shown in Figure 2.2-1 and are also described in Subsection 2.2.2.3.
←(EC-5000082218, R301; EC-39014, R307)

2.2.2 DESCRIPTIONS

2.2.2.1 Descriptions of Facilities

2.2.2.1.1 Industries

The section of the Mississippi River between Baton Rouge and New Orleans is a highly industrialized region. The proximity of oil and gas fields in coastal Louisiana and the

proximity of the Mississippi River, a major shipping route, makes this area an ideal location for a wide variety of industries. Between Baton Rouge and New Orleans there are approximately 63 industrial facilities located on or near the river[3]. Of these, approximately 52 are involved in refining oil and gas or in the production of diversified chemical products.

Table 2.2-1 provides a listing of the 15 industrial facilities within five miles of the site and shows the major products they produce, employment and their distance and direction from the Reactor Building. All of the companies listed in Table 2.2-1 with the exception of Louisiana Power & Light and the Union Pacific Railroad are involved in the production or storage of petrochemical and chemical products. The closest industrial property to Waterford 3 is Agrico Chemicals Co. (formerly Beker Industries) approximately 0.6 miles east of the site. Agrico, which has a total employment of 210 people, produces high analysis fertilizer materials such as diammonium phosphate and wet-process phosphoric acid. Occidental Chemical Company, approximately 0.8 miles to the east of the site, produces caustic sodas, chlorine and various chlorine based products and has an approximate total productive capacity of 1.12 billion pounds of chlorine annually[4]. Union Carbide Chemical and Plastics Plant approximately 1.2 miles to the east, employs 1,497 people and is the largest chemical plant within five miles of the site. This plant manufactures chemicals of the intermediate variety and has an approximate total productive capacity of 2.5 billion pounds of chemicals a year[4]. Shell Chemical Company, 2.5 miles east-northeast of the site and Shell Oil Company, 3.5 miles east-northeast of the site have a combined total employment of 1,406 and a combined productive capacity of 235 thousand barrels of oil per day, 1,620 million pounds of petrochemicals per year and 1,200 million pounds of chemicals a year[4]. Other industries in the area are classified in Table 2.2-1. (This is historical data, published in May, 1977).

2.2.2.1.2 Transportation Facilities

Transportation facilities and routes within the vicinity of Waterford 3 are shown in Figures 2.2-2 and 2.1-31.

a) Roads

The closest highway to Waterford 3 is Louisiana State Highway 18 (LA 18) approximately 600 ft. northeast of the Reactor Building. In 1976, the average daily traffic (ADT) count for LA 18 just west of Hahnville was 4,905[5] (see Figure 2.2-2). In June of 1973, the section of LA 18 between Hahnville and Edgard, (12.3 miles) was projected to have a 1997 traffic volume of 5,950[5].

Approximately one mile to the southwest of the Reactor Building is the newly constructed Route 3127 which presently serves as the major artery between U.S. Highway 90 in Boutte, La. and Route 3141 in Killona, La. just west of the site. By the early 1980's, Route 3127 has been completed all the way to Donaldsonville, 28 miles west-northwest of the site. There is no current ADT data available for Route 3127. In 1973, it was projected that by 1993 Route 3127 would have an average daily traffic volume of 16,560[5] west of the Route 3160 junction and 18,000[5] east of the junction (see Figure 2.2-2). Traffic volumes on both LA 18 and Route 3127 are expected to be substantially increased with the completion of Interstate 310 and the Hale Boggs Bridge crossing the Mississippi River (see Figure 2.1-31). Interstate 310

will connect Interstate 10 and US 61 on the east bank with Route 3127 and U.S. Highway 90 on the west (right descending) bank. The new bridge and I-310 is the only major access to both sides of the river between the Huey P. Long Bridge in New Orleans, 19 miles east-southeast and the Sunshine Bridge at Donaldsonville, 28 miles west-northwest of the site. The average daily traffic volume on I-310 (when completed) at the new bridge is projected to be 60,950.

The closest truck monitoring station in the vicinity of the site is located on LA 18 in Taft, La. In 1976 an average of 742 light trucks, 159 heavy trucks (six tires, three axle trucks) and 53 combination tractor trailer trucks were estimated as having passed this station each day[5].

Truck accidents in the vicinity of the site are summarized in Table 2.2-2.

b) Rail

→(EC-5000082218, R301)

The closest railroad to the site is the Union Pacific Railroad which runs across Entergy's property approximately 0.45 miles southwest of the Reactor Building. Other railroads within five miles, are the Illinois Central Gulf approximately 2.20 miles northeast of the site and the Louisiana and Arkansas approximately 3.25 miles northeast of the site (see Figure 2.2-2). The latter two railroads are across the river from Waterford 3.

In 1977, the Missouri Pacific Railroad (later acquired by the Union Pacific Railroad) had an average of 18 trains a day which pass by the site with approximately 100 cars per train[6]. The railroad services all the chemical plants on the west (right descending) bank of the river. Some of the products it ships are dry fertilizers (phosphate based), caustic soda, chlorine, and numerous amounts of industrial chemicals for Union Carbide[7].

In 1977, the Illinois Central Gulf Railroad (later acquired by the Canadian National Railway) operated two trains a day between Baton Rouge and New Orleans. Each train consisted of 85-95 cars. Ninety percent of the cargo was petroleum based products[8].

The Kansas City Southern Railway (formerly the Louisiana and Arkansas Railroad) is the farthest from the site, located approximately 3.25 miles to the northeast from the Reactor Building. In 1977, the railroad had four mainline trains and four work (dodger) trains daily. There was an average of 150 cars on the mainline trains, and 50-75 cars on the dodgers. The cargo on the trains ranged from wheat and lumber to petrochemical products and automobiles[9].

In 1975 there was a total of 65 accidents which occurred in the state of Louisiana on the Louisiana and Arkansas, the Illinois Central Gulf and the Missouri Pacific Railroads[10]. Two of those accidents occurred within approximately five miles of the site. One occurred on the Louisiana and Arkansas railroad in the vicinity of Norco, La. It involved a derailment in which there was $6,450 in equipment damage, $3,000 in track damage and no injuries[10]. The other accident involved a rear end collision between two freight trains on the Missouri Pacific Railroad, which is approximately 0.45 miles to the southwest of the site. One train was pulling 110 cars, the other 72 cars. The total estimated equipment and track damage was approximately $152,370[11]. There were no injuries and none of the derailed or damaged cars were loaded with hazardous materials[11].

←(EC-5000082218, R301)

In 1976 there were a total of 92 railroad accidents which occurred on the Louisiana and Arkansas, the Illinois Central Gulf or the Missouri Pacific in the State of Louisiana. Only one of these occurred within five miles of Waterford 3 in LaPlace, La. It was a derailment involving five cars carrying hazardous materials, one of which was damaged[(10)]. The accident had an estimated $122,750 worth of equipment damage and $500,000 worth of track damage and no injuries[(10)].

In 1977, there was a total of 141 accidents which occurred in the state of Louisiana on the Illinois Central Gulf, Union Pacific, and Louisiana and Arkansas Railroads[(10)]. Of these accidents, three or 2.1 percent occurred within approximately five miles of the site. Two of these occurred at Norco, which is east-northeast of the site and on the east side of the Mississippi River. One of these accidents, on March 10, 1977, involved a derailment of six cars of a train consisting of 12 loaded freight cars, 34 empty cars, and one caboose. It was due to defective or missing crossties. The damage to track, signal, way and structures amounted to $3,036.00. There were no hazardous materials on the train and no one was injured.

The second 1977 accident at Norco occurred on September 10th, and resulted in the derailment of five loaded freight cars in a train made up of 27 loaded cars, three empty freight cars and one caboose. This accident was also caused by defective or missing crossties and resulted in damages of $29,800.00 to equipment; $21,000.00 damages to track, signal, way and structures; and $40,000.00 damage to an unattended car parked on a siding. No hazardous materials were involved in this accident.

The third accident in 1977 occurred at Good Hope which is due east of the site and on the east side of the river. This accident occurred on October 21st and resulted in $3,100.00 worth of damages, made up of $1,500.00 damage to equipment and $1,600.00 damage to track, signal, way and structures. This train was made up of 123 loaded cars, one empty car, and one caboose. It involved a locomotive collision with a highway user at a grade crossing. There were no injuries and no hazardous materials were involved.

→(EC-5000082218, R301)

In 1978, there was a total of 135 train accidents in the State of Louisiana on the Illinois Central Gulf, Missouri Pacific, and Louisiana and Arkansas Railroads[(10)]. Of these accidents, two or 1.5 percent occurred within approximately five miles of the site.

←(EC-5000082218, R301)

The first of these accidents occurred at Montz which is directly across the Mississippi River from the site and on the east side of the river. This accident involved the collision of a train handling 64 empty freight cars with a highway user at a grade crossing. No hazardous materials were involved in this accident. There was $25,000 worth of damage to equipment and two persons were injured.

The second 1978 accident occurred at Norco. This involved a train on a siding which consisted of six loaded freight cars, three empty cars, and a caboose. Four of the loaded cars were derailed due to a bolt hole crack or break and this involved equipment damage amounting to $7,280.00. No hazardous materials were involved in this accident.

→(EC-5000082218, R301)

One of the most severe accidents within the vicinity of the site occurred on February 21, 1973 approximately 0.85 miles to the southeast of the site on the Missouri Pacific Railroad.

←(EC-5000082218, R301)

→(EC-5000082218, R301)

It was a head on collision between a west bound Texas & Pacific (T&P) Work Extra 523 and an east bound Missouri Pacific Extra 1902. Sixteen cars were derailed and three people were killed. The cause of the collision was the unauthorized intrusion of Work Extra 523 onto the main track from Occidental Chemical Corporation siding. Work Extra 523 had 33 loaded tank cars and three empty cars. Of the 33 loaded tank cars, fifteen contained chlorine for a gross weight (net plus weight of the tank car) of 2,929,040 lbs., seventeen contained caustic soda for a gross weight of 4,316,400 lbs. and one contained a sulfur chlorine compound with a gross weight of 235,820 lbs.(12) Work Extra 1902 had three locomotives, 21 loaded cars, 17 empty cars and a caboose. The loaded cars included two tank cars of weight of 225 tons and three cars containing sulphur with gross weight of 600 tons(12). The remaining cars were carrying miscellaneous materials such as bricks, stone, machinery, etc. Of the 16 derailed cars, five were empty, one was carrying caustic soda, one was carrying plastics, four were carrying unspecified chemicals, two were carrying acid, one was carrying fertilizer and two were carrying sulfur(12). One of the cars which contained sulfur collapsed at its center and some sulfur was spilled. In addition, several other tank cars on both trains were fractured or punctured. The lading of one tank car was adipic acid, a powder which will burn with a violent reaction if thrown into a fire(12).

←(EC-5000082218, R301)

c) River

The Reactor Building is approximately 1,200 ft. from the Mississippi River channel. A description of the shipping along the river, including types of ships and barges, and occurrence of shipping accidents is given in Subsection 2.2.2.4.

d) Air

Airports in the vicinity of Waterford 3 are shown in Figure 2.2-4, and their facilities and operations are described in Subsection 2.2.2.5.

2.2.2.2 Description of Products and Materials

→(EC-5000082218, R301)

A wide variety of products are produced, stored and transported within five miles of Waterford 3. Historical information by company on the products used or produced, the mode of shipment, frequency of shipment, average size of shipment and the maximum amount of hazardous material to be processed, stored or transported is given in Table 2.2-3. Information for this table was obtained by submitting questionnaires to the industries within five miles of Waterford 3(13). In some cases the industry's responses were qualified as being proprietary information, and therefore do not appear in Table 2.2-3.

←(EC-5000082218, R301)

→(EC-5000082218, R301; EC-39014, R307; LBDCR 15-048, R309)

In 2016, a survey was performed of industrial facilities which store or process toxic chemicals within a 5-mile radius of the Waterford 3 control room. Table 2.2-3A contains a list of the facilities surveyed, while Tables 2.2-3B and 2.2-3C contain the data furnished by these facilities. Table 2.2-3B lists the toxic chemicals stored or processed at each of these facilities, based on information furnished by the facilities. Table 2.2-3C contains data on chemicals transported to or from each facility by water.

In addition to the products used and manufactured in the area of Waterford 3, a large number of products are shipped past the site by water, rail, and truck. The Mississippi River is one of the major freight transportation routes in the United States. In 1989, 181,802,058 tons(14) of commodities were shipped past river mile 129. Table 2.2-5 lists the amount of hazardous commodities transported between River Mile 129 and 129.9 in 2013. These commodities consist mostly of petroleum products and other chemicals.

A description of the products transported by rail in the vicinity of the site is given in Subsection 2.2.2.1.2. Table 2.2-3D lists all hazardous materials which were transported on the tracks of the Union Pacific Railroad within a 5-mile radius of Waterford 3 in 2014. This list, which was furnished by the railroad(118), includes all cargos classified as hazardous by the U.S. Department of Transportation. Tables 2.2-3E and 2.2-3F show corresponding data for the Canadian National(118) and Kansas City Southern(118) Railways, respectively.

Commodities are also shipped by truck in the vicinity of the site. The majority of the truck traffic in the area services the chemical and refining companies in the vicinity of the site. Louisiana Route 18 passes within 714 feet of the control room air intake. LA 18 is a local road. Through traffic uses the nearby Route 3127. The two roads run parallel to each other in the immediate vicinity of Waterford 3 and are a little more than one mile apart. Data on shipments of hazardous materials past Waterford 3 in 2015 are listed in Table 2.2-3G.

←(EC-5000082218, R301; EC-39014, R307; LBDCR 15-048, R309)

2.2.2.3 Pipelines and Gas and Oil Fields

→(EC-5000082218, R301; EC-39014, R307; LBDCR 15-048, R309)

There are approximately 49 major pipelines operated by 11 different companies within 2 miles of Waterford 3. Products carried in these pipelines include natural gas, hydrogen, ammonia, LPG, ethane, gasoline, propane, and raw materials. The closest pipelines to the site are Bridgeline Holdings's 16-inch natural gas line, 0.3 miles to the west, Enterprise Pelican Pipeline L.P.'s two 20-inch natural gas lines to Waterford Station and Little Gypsy, approximately 0.4 miles to the East and to the West. These and other major pipelines carrying hazardous materials within a 2-mile radius of Waterford 3 are shown in Figures 2.2-3A through 2.2-3G. Table 2.2-6 gives a description of these pipelines, including the pipe size, type of product carried, year laid, operating pressure, depth of burial, type of isolation valve, and the distance and direction from the site to the nearest isolation valve and/or terminus of each pipeline. None of the pipelines listed in Table 2.2-6 are used for gas storage at higher than operating pressure.

←(EC-5000082218, R301; EC-39014, R307; LBDCR 15-048, R309)

→(EC-5000082218, R301)
←(EC-5000082218, R301)

There are four producing gas and oil fields within a five mile radius of Waterford 3 (see Figure 2.2-1). The closest field to the site is the Norco gas field 1.9 miles northeast of the site. The Norco gas field has one operating well (98,99). The two largest producing fields in the area are the Good Hope oil and gas field, 5.0 miles to the east of the site, and the Bonnet Carre oil and gas field, 4.6 miles to the north of the site. In 1987 the Good Hope oil and gas field had 34 oil wells which produced 3,373,601 barrels of oil, one gas well which produced 2,738,658 mcf (thousand cubic ft.) and one gas condensate well which produced 28,998 mcf (98,99). The Bonnet Carre field in 1987 had 9 oil wells which produced 383,221 barrels of oil, 25,671,781 mcf of gas, and 998 barrels of gas condensate (98,99). The remaining operating gas field in the area is the Lucy gas and oil field 2.2 miles west and west-southwest of the site. All of these fields are described in Table 2.2-7.

The closest producing well is located 3.3 miles to the west of the site in the Lucy oil and gas field. On November 11, 1975, this well was producing 316 mcf of gas per day[17].

2.2.2.4 Waterways

The Reactor Building is approximately 1,000 ft. from the shoreline of the Mississippi River, which is one of the major inland waterway shipping routes in the United States. In 1975, 161,751 vessels moving 201,600,768 tons of commodities (see Subsection 2.2.2.2) and carrying 10,462 passengers traveled in the section of the river between Baton Rouge, La. to, but not including New Orleans, La.[14]. Table 2.2-8 shows the type and drafts of vessels which moved on this section of the river in 1975. The type of ships range from self propelled tankers and dry-cargo ships with drafts of up to 40 ft. to non-self propelled dry cargo vessels and tankers with drafts of 18 ft. or less. The non-self propelled dry cargo vessels and tankers are the largest number of vessels which move along this route.

Table 2.2-8 is a conservative estimate of the number of ships which passed by Waterford 3 in 1975 for the reasons given in Subsection 2.2.2.2.

During the period between 1972 and 1976, 62 commercial vessel casualties were reported to the U.S. Coast Guard to have occurred between River Mile 115 to 135[18]. As defined by 46CFR4.05 a reportable casualty results whenever any of the following occur:

a) Actual physical damage to property in excess of 1,500 dollars

b) Material damage affecting the seaworthiness or efficiency of a vessel

c) Stranding or gounding (with or without damage)

d) Loss of life

e) Injury causing any persons to remain incapacitated for a period in excess of 72 hrs.; except injury to harbor workers not resulting in death and not resulting from vessel casualty or vessel equipment casualty[18].

Fifty-three of the 62 accidents reported between 1972-1976 involved some type of freighter, dry cargo barge or liquid tank barge. Eight had commodities specified such as liquid caustic soda, ammonia, styrene, adiponitrile, sulfuric acid, etc, which could be a potential hazard to the Waterford site. The remaining accidents either did not involve any cargo or the cargo was not specified. One accident reported was recorded as being due to an explosion and/or fire involving liquid bulk cargo and was caused by improper safety precautions in either loading inflammable liquid or fueling or repairs[18].

Because of the type of coding the U.S. Coast Guard was using between 1972 and 1975, the location of accidents reported to them: in those years designates the river mile to the nearest 10 miles (e.g., mile 346.6 = 350). It is difficult therefore, to specify the exact location of these accidents in relation to Waterford 3 for the period between 1972 and 1975. In 1976, the U.S. Coast Guard changed its coding so that the location of the accident was given to the nearest river mile. A description of the accidents which were reported in 1976 to have occurred between river mile 124 and 135 is given in Table 2.2-9. This table, however, only shows those accidents which were reported to the U.S. Coast Guard in Fiscal Year (FY) 1976 and is not necessarily a complete list of all the accidents which occurred during that period. Accidents are listed by the U.S. Coast Guard in the year they were reported to the U.S. Coast Guard not in the year they occurred. The date of occurrence is shown in column one of Table 2.2-9.

In FY 1976, there were seven accidents reported to have occurred on the Mississippi River between river mile 124 and 135. The closest accident to the plant which is located at river mile 129.6 occurred in April 1975 at river mile 128. The accident was a collision with a fixed object (piers, bridge, etc.) caused by restricted maneuvering in congested areas (docks, piers, etc). The accident involved a towboat and a liquid cargo barge carrying an unspecified cargo. Only one accident reported in FY 1976 had a specified cargo which could be considered hazardous to the plant. It occurred in February of 1976 at River Mile 127 AHP (Above the Head of Passes) and involved a liquid tank barge carrying liquids such as ammonia sulfate liquid fertilizer.[18]

→(EC-5000082218, R301)

Within approximately five miles of Waterford 3 there are eight docks and mooring locations[19]. All of these are listed in Table 2.2-10 and shown in Figure 2.2-2. The closest to the site is Entergy's fuel unloading dock at Waterford SES Units 1 & 2, approximately, 0.5 miles from the Reactor Building.

Others in the area include Occidental Chemical and IMC-Agrico liquid bulk loading and unloading dock, 0.7 miles to the east of the site, Union Carbide's petrochemical and liquid handling facility 1.5 miles to the east and Shell Oil Company dock facilities 3.6 miles to the east of the site. All others are shown in Figure 2.2.2 and described in Table 2.2-10.

←(EC-5000082218, R301)

The Circulating Water System intake canal for Waterford 3 (river mile 129.6) extends 100 ft. into the river from the shoreline and has a bottom elevation of -35 ft. MSL. The Mississippi River at this point is approximately 2,850 ft. wide. The deepest channel of the river in this area is at least 100 ft. in depth and 550 ft. in width and approximately 450 ft. from the shoreline[20].

Shipping in the Mississippi River does not follow any specified shipping channel but moves on the river according to the traffic and depth of the river [21]. Ships with drafts of 40

→(EC-5000082218, R301)

ft. and less pass by the site (see Table 2.2-8), so that it is possible that a ship or barge with a draft of 40 ft. or less could move in the waters near the intake structure. LP&L has a barge unloading dock just upriver from the intake structure at river mile 129.9 and Occidental Chemical and IMC-Agrico have one just downriver from the discharge structure at river mile 128.8. There will be some river traffic in the vicinity of these facilities. Pile dolphins have been constructured on either side of these structures as a warning to any vessels in the area.

←(EC-5000082218, R301)

2.2.2.5 Airports

Airports in the vicinity of Waterford 3 are shown in Figure 2.2-4. The closest airport to the site is the Triche airstrip located 2.2 miles east of the site. The airstrip is privately owned and there are three single-engine planes based at the airstrip. Two of the planes, Boeing Stearmans (biplane), are used for a crop spraying operation which are during the months of May through October with a peak in July and August. Most of the spraying is near Plaquemine, La. where many of the takeoffs and landings take place. The other plane, a Cessna 170b (1953 model), is primarily used for pleasure and contributes to most of the movements of Triche airstrip. The owners estimate that there are approximately 40-50 movements per month at the airstrip. The runway is a 2,500 ft. grass strip and is oriented in approximately a north-south direction (20 degrees east of north). During landing procedures the plane is almost always south of the airstrip, east of the site. There have been no accidents at the Triche airstrip since its beginning in August 1973[22].

Mollere airstrip 7.5 miles to the northwest of the site is another privately owned airstrip at which there are approximately 200 take-offs and landings per year. There is only one single-engine land airplane which uses the 2,500 ft. grass airstrip. The runway is oriented north and south. A left hand approach pattern is used when landing to the south and a right hand pattern when landing to the north. Presently, there are no future plans for the expansion of facilities at the airstrip[23].

Approximately 11.2 miles to the east-southeast is Seller's Field in Ama, La. It has a 3,300 ft. north-south grass runway used by a private air club. Presently 20 single-engine planes are based at the field which has approximately 780 operations a year. There are no plans for expansion of facilities at this field[24].

In St. John the Baptist Parish there are plans for the construction of a new FAA approved general aviation airport to accommodate private corporate planes belonging to businesses in the area. The airport is planned to have a 4,000 ft. runway in a north-south direction (170° and 350°). In 1982, 44 aircraft consisting of 35 single-engine planes, seven multi-engine planes and two rotorcraft and other types of aircraft, are forecasted to be based at this airport [25,84]. By 1997, this total is expected to increase to 103, with 76 single-engine aircraft, 23 multi-engine aircraft and four rotorcraft and other types of aircraft, 23 multi-engine aircraft and four rotocraft and other types of aircraft[25,84]. In 1982, the airport is forecasted to have 44,330 operations[25,84,85]. A forecast of aircraft operations at the St. John the Baptist Airport from 1982 to 1997 is given in Table 2.2-11.

The closest major airport to Waterford 3 is New Orleans International (Moisant), 11.5 miles east of the site. In 1976, New Orleans International had a total of 155,903 operations[26]. Table 2.2-12 lists aircraft operations at New Orleans International Airport from 1966 to 1976. A forecast by aircraft operations at New Orleans International Airport from 1980 to

2000 is shown in Table 2.2-13. Aircraft using the airport range in size from two seater single engine planes to large jets such as Boeing 747's.

There are three runways at New Orleans International Airport: a 9,227 ft. long runway oriented in approximately an east-west direction (100 degrees east of north); a north-south runway, 7,000 ft. in length; and a 4,542 ft. long strip in a southwest-northeast orientation(25). It is anticipated that by 1990 a new 8,000 ft. runway will be constructed and that the main runway will be extended to 10,500 ft.(25)

Other airports in the vicinity of Waterford 3 include Lakefront Airport, Westwego Airport, the U.S. Naval Air Station and Braithwaite (see Figure 2.2-4). None of these airports have approach patterns in the vicinity of the Waterford site. In addition, based on $1000d^2$* movements per year, they are far enough away that operations at these facilities should not pose a significant hazard to the site.

Aviation routes and approach patterns in the vicinity of Waterford 3 are shown on Figure 2.2-4, Figure 2.2-5a and Figure 2.2-5b respectively. The closest low altitude federal airway is approximately five miles to the north of the site(27). Within five miles of the site is the approach path to the main runway at New Orleans International Airport(28). It is estimated that approximately 35-40 percent of the traffic at the New Orleans International Airport will fly within five miles of the site. Most of this traffic will be less than 5000 feet above ground level(29). Other low attitude federal airways in the vicinity of the site and the approach patterns to the north-south runway at New Orleans International are shown in Figures 2.2-4 and 2.2-5.

Waterford 3 just barely falls within the boundaries of an air alert area, A-381, as shown in Figure 2.2-6(27). An alert area is an area where there is a high volume of a particular or unusual type of aircraft activity. Alert area A-381 encompasses the Gulf Coast and is designated as such because of the high level of seaplane and helicopter activity in the area going from the mainland to off-shore oil rigs.(2)

Aircraft accidents in the vicinity of the site or within five miles of New Orleans International Airport between 1966 and 1976 are listed in Table 2.2-14. The closest accident to the site took place in 1966 in La Place, Louisiana approximately five miles north of the site. It involved a Piper PA-18 in which no one was injured. An analysis of the probability of an aircraft collision with plant safety related structures and components is provided in Subsection 2.2.3.7.

2.2.2.6 Projections of Industrial Growth

Manufacturing is expected to continue its growth in St. John the Baptist and St. Charles Parishes. The area should remain attractive for development of refineries and petrochemicals because of the easy availability of oil resources in the Louisiana coastal areas. Depletion of petroleum resources in Louisiana could have negative effects on these

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* "d" is the distance in miles from the site.

industries, but the construction of the Louisiana Off-shore Oil Port (LOOP) should offset declining state resources. Additionally, the fresh water and navigational access provided by the Mississippi River is likely to continue to make the area attractive for industrial development [30]. Projections by the U.S. Department of Commerce [31] and projections prepared for the LOOP environmental impact assessment[32] were analyzed to determine future industrial employment trends. This analysis indicates that the coastal Louisiana employment in petrochemical industries is expected to grow rapidly, by four to five percent per year, while employment in refineries is expected to grow by about one percent per year until 1990, after which it should level off. Food products industries, which includes grain elevators and sugar producers are not expected to grow rapidly.

→(EC-5000082218, R301)

In general, the most rapid industrial development is projected to take place southeast and northeast of Waterford 3. There are some large vacant industrial sites within three miles of the site and these are expected to be developed for industrial use during the life of the plant. The properties consist of a 3,100 acre parcel owned by Koch Industries immediately to the west of Killona and the as yet undeveloped portions of the Occidental Chemical and Union Carbide properties. In addition, there are several industries within five miles of the nuclear site which are in the process of expanding or have plans to expand in the near future. By the fourth quarter of 1977, Shell will have invested 210 million dollars creating 160 new jobs and expanding its productive capacity by 480 million pounds of chemicals a year[4]. Union Carbide is investing 425 million dollars to expand its productive capacity by 1.5 billion pounds of chemicals a year and its employment by 50 people by July, 1978. Over the next three years Union Carbide plans to hire 30 more people and to increase its productive capacity by 60 million pounds of chemicals a year[4]. Other industries in the area which have plans to expand in the near future are: IMC-Agrico which plans to double its production of phosphoric acid and increase its employment from 210 to 280 people within the next five years[13] and Good Hope Refineries which is scheduled to expand its existing units, add new units and increase its employment by fifty people[13]. Big Three Industries, is planning to begin operation of an air separation plant in December of 1977. The plant which is located approximately four miles to the east-northeast of Waterford 3, will employ 25 people and will produce 325 tons/day of gaseous oxygen and 700 tons/day of gaseous nitrogen. Within two years after the start of the plant, it is expected that there will be a possible threefold increase in plant capacity and an increase in employment of about 40 people.[13]

←(EC-5000082218, R301)

2.2.3 EVALUATION OF POTENTIAL ACCIDENTS

→(EC-5000082218, R301)

Waterford 3 is situated in an industrialized area. Transportation storage, and use of some of the materials cited in Tables 2.2-3B through 2.2-3G and Table 2.2-5 present a potential for explosions, fires or release of toxic gases. The hazards associated with chemicals transported or stored in quantity in the vicinity of Waterford 3 were evaluated to assure appropriate design consideration. The spectrum of credible explosive events and missiles generated are addressed in Subsection 2.2.3.1. The main control room design coupled with administrative procedures prevents the incapacitation of main control room operators during postulated toxic gas episodes (see Section 6.4). The delayed ignition of flammable vapor clouds is considered in Subsection 2.2.3.2.

←(EC-5000082218, R301)

→(DRN 03-2055, R14; 05-149, R14)

Design Basis Events are potential accidents that have a probability of occurrence equal to or greater than 10^{-7} per year whose consequences can result in radionuclide releases in excess of 10CFR50.67 guidelines.

←(DRN 03-2055, R14; 05-149, R14)

→(DRN 01-231)
In addition to evaluating the consequences of potential accidents, evaluations have been performed postulating the impact of historical events on Waterford 3 prior to receipt of its operating license. Descriptions of these occurrences and their impact on the habitability of the Control Room are summarized in Appendix 2.2A and are provided for historical information only.
←(DRN 01-231)

2.2.3.1 Design Basis Explosive Events

Review of all combustible materials transported or stored within five miles of Waterford 3 revealed that several sources presented hazards which merit closer investigation. The sources of hazards are:

a) river transport of gasoline along the shipping channel which passes 1200 ft. north of the safety related structures, and

b) LPG shipments by truck passing the site at a closest distance of 634 ft. from the main control room, and

c) nearby gas pipelines, LPG lines, and/or flammable stationary sources.

→(DRN 01-464)
2.2.3.1.1 Design Basis Events Arising from Transportation of Explosives and/or Flammables on the Mississippi River
←(DRN 01-464)

The first case of gasoline transport is analyzed in the light of casualty statistics. Table 2.2-15 cites 146 casualties reported to the Coast Guard during fiscal years 1969-1971 for 140 river miles. Casualties are presented by nature of casualty code categories. Categories 13 through 20 concern all fires and/or explosions which occurred (none of which were catastrophic in nature). Table 2.2-16 illustrates the number of upbound and downbound vessels (58,486 and 58,606 respectively) for a total of 117,092 vessels passing by the site annually.

Using the information under certain broad assumption (e.g., uniform spacing and speed of traffic, collisions between all types of vessels equally likely, collisions in all parts of channel equally likely) the probability (P_C) that any given ship will have an explosion and/or fire as expressed in categories 13 through 20 of Table 2.2-15, within any one mile is

$$P_c = \frac{11\,(\text{fires and/or explosions}) / 3 \text{ years x } 1 \text{ river mile}}{1.17 \text{ x } 10^5 \text{ ships / year} \quad 140 \text{ river miles}}$$

→(EC-40308, R307)
= 2.2×10^{-7} incident per ship
←(EC-40308, R307)

The above frequency of fire and/or explosion incidents does not take into account any factors such as location of the accident, the actual vessel involved, and the cargo it carries. A closer examination of Table 2.2-15 reveals that location of accidents is a decisive factor influencing accidents. For instance, the stretch of river to the nearest 10 miles of River Mile 90 (AHP) accounts for 32.19 percent of all vessel casualties and 45 percent of all casualties in categories 13-20, River Mile 100 (AHP) and the nearest 10 miles, account for 12.33 percent of all casualties and 18.18 percent of all casualties in categories 13-20, while statistics for the 10 mile stretch centered about River Mile 130 (AHP) show no casualties for fiscal years 1969-1971. Waterford 3 is located at River Mile 129.5 (AHP). Thus the calculation of accident frequency is conservative due to favorable

River Mile location. Assuming a factor of 100 to account for this favorable location, the frequency of incidents may be reduced to

$P_c = 2.2 \times 10^{-9}$ incidents per ship

This frequency of occurrence of accidents involving fires and/or explosions is comparable to the probabilities for barge accidents in the moderate to severe categories of Table 3.2-17 in WASH-1239[33]. This number does not take into account the nature of the cargo or vessel. It is conservatively assumed that a frequency of one in 10 ships carries hazardous materials (see Amendment 26 to the Waterford 3 PSAR, Answer to Q2.41-2) the following probability is arrived at:

$P_e = 2.2 \times 10^{-10}$ incidents per ship giving rise to fire and/or explosion in the vicinity of River Mile 130 (AHP), of a vessel carrying hazardous cargo.

→(DRN 03-2055, R14; 05-149, R14)

For river traffic, the transport of gasoline poses the most significant hazard for fires and explosions, and although by itself it does not pose a hazard exceeding the 10CFR50.67 guide, it may be taken to be the Design Basis Accident issuing from the transportation of flammable and/or explosive cargo on the Mississippi River near the site.

←(DRN 03-2055, R14; 05-149, R14)

At the time of the PSAR, according to the Louisiana district office of Shell Oil Co. gasoline was shipped by the site in two ways (1) in ships which have a capacity of approximately 300,000 barrels or (2) in barges which hold 10,000 barrels each. These barges travel in groups of two or four. Therefore, the ships are the controlling factor in the remote occurrence of an incident. Gasoline has a density of 6.6 lbm/gallon and there are 42 gallons per barrel.

For the case of gasoline tankers, Table 2.2-5 indicates that 1.1×10^7 short tons are transported by the site annually. This quantity can be conservatively assumed to be transported by approximately 260 tankers per year with a capacity of 300,000 barrel (bbl).

Thus the total probability of incidents that may lead to fires and/or explosions of a ship with a 300,000 bbl capacity is

$$P_t \quad 2.2\text{x}10^{\ 10} \frac{\text{(incidents...)}}{\text{haz. vessels}} \text{x} \frac{\text{260 ships}}{\text{year}}$$

$$5.72 \text{ x } 10^{-8} \text{ incidents involving fire and / or explosions of a 300,000 bbl gasoline tanker, in the one mile vicinity of River Mile 130 (AHP), per year.}$$

While tankers with a capacity greater than 300,000 barrels move past the site, the probability of this large tanker exploding is well below 10^{-7} per year. The largest tanker according to the survey of industrial and transportation facilities is approximately 750.000 barrels. This tanker passes by the site only once in 1976.

According to Robert F. Benedict[34], the upper limit of flammability for gasoline is 7.9 percent. The highest limit of flammability for the gasoline family stated in Publication No. 503, "Limits of Flammability of Gases and Vapors"[35] published by the Bureau of Mines is

10.5 percent for cyclopropane. Mr. Benedict has stated that the density of gasoline vapor at the highest limits of flammability is unavailable, but that the combination of 10.5 percent limit of flammability and a gasoline vapor density of 0.245 lbm/ft^3 at this limit is conservative. (The 0.245 lbm/ft.^{3} corresponds to the vapor density of heptane.)

The free volume of a 3 x 10^5 bbl ship is 3 x 10^5 bbl x 42 gal/bbl x 0.1337 ft^3/gal = 1.68 x 10^6 ft^3. Using a conservative 10.5 percent gasoline-air mixture (i.e., 0.105 of volume) at a vapor density of 0.245 lbm/ft^3, the most hazardous cargo in a 300,000 bbl ship is 4.32 x 10^4 lb, or 21.6 tons of gasoline. Assume now a conservative estimate that the 21.6 tons of gasoline vapor yield a detonation identical to one of a TNT charge of equivalent weight. According to Stull(36), the scaled range is

$$Z \quad \text{distance from plant} \;\; (\text{ft}) / (\text{weight of TNT in lbm} \;\;)^{1/3}$$

$$1200 / \;\; (4.32 \text{ x } 10^4)^{1/3} \quad 34.2$$

From Figure 2.2-7, the peak overpressure for Z = 34.2 is 1.3 psi. The reflected pressure is 2.7 psi which is an acceptable overpressure for the safety related buildings.

These values are much more conservative than those obtained through an analysis using Brode's equations,(37,38) which are also conservative.

When dealing with the possibility of a deflagrative explosion, consider the exploding volume of 1.68 x 10^6 ft^3 as a spehere of radius 73.75 ft., with energy equipartitioned through the exploding volume. The explosive energy assuming 21.6 tons of TNT is

$$E_e \quad 21.6\text{ton} \times 2 \times 10^3 \frac{\text{lbm}}{\text{ton}} \times 500 \frac{\text{kcal}}{\text{lbm}} \times 3.968 \frac{\text{BTU}}{\text{kcal}} \quad 8.57 \times 10^7 \text{ BTU}$$

and the energy density

$$E \quad E_e \text{ / free volume} \quad \frac{8.57 \text{ x } 10^7 \text{ BTU}}{1.68 \text{ x } 10^6 \text{ ft}^3} \quad 51 \text{ BTU / ft}^3$$

In a deflagration type of explosion the maximum energy density imparted to potential missiles cannot exceed the energy density of the explosion, hence, the kinetic energy (K.E.) of a potential missile cannot exceed

$$\text{K.E. (BTU)} \quad \text{E (BTU / ft}^3\text{) x } M_m \text{(lbm)} / p_m \text{ (lbm / ft}^3\text{)}$$

where M_m and ℓ_m are the mass and density of the potential missile.

Thus, since the kinetic energy (K.E.) = 1/2 M_m V^2, (V = missile speed) the maximum range, (Rmax) of a missile (conservatively neglecting air resistance) is

→(DRN 01-464)

$$R_{\max} \quad \frac{V^2}{g} \quad \frac{(2K.E.)}{M_m} \times \frac{1}{g} \quad \frac{2EM_m}{p_m M_m} \times \frac{1}{g} \quad \frac{2E}{p_m g}$$

←(DRN 01-464)

The density of the missile is that of steel (489 lbm/ft^3) thus

$$Rmax \quad \frac{2 \text{ x } 51 \text{ (BTU / ft}^3) \text{ x } (778 \; \frac{\text{ft - lb}_f}{\text{BTU}}) \text{ x } 32.2 \; \frac{\text{lbm - ft}^2}{\text{lb}_f \text{ - sec}}}{32.2 \text{ (ft / sec}^2) \text{ x } (489 \text{ (lbm / ft}^3)}$$

$$162.28 \text{ ft.}$$

The above equations do not include consideration of air resistance or energy lost in rotation, which would decrease the range. Large ships are compartmentalized, so that the assumption of an instantaneous explosion of the entire ship is extremely conservative.

The Mississippi River Channel passes approximately 1200 ft. north of the Nuclear Plant Island Structure (NPIS). It is therefore concluded that missiles generated from the explosion of the 300,000 barrel ship cannot reach the NPIS with a large, destructive missile.

According to the U.S. Department of Commerce detonations cannot occur in gasoline tankers. In a detonation, the pressure pulse travels at sonic velocity (supersonic in the pre-shock medium) and the enthalphy change across the shock wave actually causes the combustion and blast propagation. To have a detonation the blast must be caused by an extremely high energy source and by suitable geometric configuration. The energy source necessary to achieve a deflagrative explosion is such that a shock wave is not formed and the flame propagates at a flame velocity which is much lower than sonic velocity.

Thus deflagrative explosion of a 300,000 barrel tanker whose cargo is a critical mixture of gasoline and air is a design basis for the safety related structures.

2.2.3.1.2 Design Basis Event Arising from the Transport of Explosives and/or Flammables by Truck

A review of truck traffic reveals that the governing explosive and/or flammable event would arise from a remote and unlikely accident to an LPG tank truck on route 18 at a critical distance of 462 feet north, east or west of the Nuclear Plant Island Structure.

At this distance, it is assumed that 10 percent of the fuel is vaporized to form an explosive mixture of propane and air. Thus a truck carrying 10,500 gallons of LPG, at a density of 36.21 lbm/ft^3, would yield

$$0.1 \text{ x } 10{,}500 \text{ gal x } 0.1337 \; \frac{\text{ft}^3}{\text{gal}} \text{ x } 36.2 \; \frac{\text{lbm}}{\text{ft}^3} \; = \; 5083 \text{ lbm of detonable propane vapor.}$$

If a conservative estimate of 240 percent TNT equivalent is used, the scaled range is

$$Z \quad \frac{462}{(12200)} \; 1/3$$

yielding a peak overpressure 3.0 psi and a peak reflected overpressure of 6.5 psi.

For an explosion to occur in the tank, the tank would have to contain just propane gas in a detonable mixture with air; i.e., five percent propane gas by volume. For a 10,500 gallon tank truck and propane gas density of 0.1154 lb/ft.^{3}, there would be:

$$0.05 \text{ x } 10{,}500 \text{ gal x } 0.1337 \frac{\text{ft}^3}{\text{gal}} \text{ x } 0.1154 \text{ lb / ft}^3 \quad 8.10 \text{ lbm of gas}$$

At 100 percent TNT equivalent we would have

$$E = 8.1\text{lb} \times 500 \frac{\text{kcal}}{\text{lb}} \times 3.984 \frac{\text{BTU}}{\text{kcal}} \text{ x } \frac{2.416\text{TNT}}{16 \text{ Propane}}$$

$$= 3.84 \times 10^4 \text{ BTU}$$

the energy density is

$$E \quad 3.84 \text{ x } 10^4 \text{ BTU / } 10{,}500 \text{ gal x } 0.1337 \frac{\text{ft}^3}{\text{gal}}$$

$$27.58 \text{ BTU / ft}^3$$

Thus, the maximum range (Rmax) of steel fragments is

$$R_{max} = \frac{2 \times 27.58 \frac{(\text{BTU})}{\text{ft}^3} \times \frac{(778\text{lb}_f - \text{ft})}{\text{BTU}} \times 32.2 \frac{(\text{lbmft})}{\text{lb}_f \text{ sec}^2}}{32.2(\text{ft / sec}^2) \times 489(\text{lbm / ft}^3)}$$

$$= 87.75\text{ft}$$

Thus there is no hazard from an LPG truck deflagrative explosion due to missiles.

In response to the NRC Staff's concern regarding the possibility of the formation of a fuel air mixture cloud due to a fuel tank-truck explosion on Highway 18 and its subsequent detonation over the plant, probabilities of accidents leading to different consequences were examined as follows:

The probability that an LP gas truck accident would take place within the stretch of road passing in the immediate vicinity of the plant was assessed from historical data, as reported in WASH 1238 (see Table 2.2-17) and is equal to 1.3 x 10^{-6} accidents per vehicle mile.

The probability per vehicle mile that an accident will occur that will have consequences ranging from minor to extreme varies substantially with the more severe accidents being considerably less probable.

Conservatively, it was assumed that the probability of a tank truck accident of the minor category represented a base estimate of the frequency of truck accidents in the Waterford 3 vicinity. The frequency with which these accidents would be accompanied by a spill or leak is 0.02 times less, this being the fraction of accidents involving tank trucks with

sufficient impact to cause rupture of the tank. As stated above, the probability of ignition and explosion from a spill is determined by DOT's Office of Hazardous Material to be 0.0113. The overall probability of an in-transit explosion of a LP gas truck is thus 2.94×10^{-10} explosions per vehicle mile. There are however different kinds of explosions/detonations with different consequences. Leaking vapor can ignite and explode immediately or can form low lying vapor air clouds which can explode after a delay.

Tank truck data (from Risk Analysis in Hazardous Materials Transportation, Volume 1, University of Southern California, PB-230810, March 1973) is rather inconclusive, but shows that out of forty-four (44) accidents, seventeen (17) occurred en-route. Of the en-route accidents, only one resulted in a large explosion which was at the accident scene. The other explosions occurring during unloading, or as a result of leaks were also localized at the accident scene. In lieu of adequate tank truck data, the corresponding rail data from the same reference has also been examined. This data does present evidence of one true delayed air-vapor detonation of out of seventy-seven (77) accidents reviewed.

When all of the tank-truck and rail accidents leading to leaks and fire with explosions are counted, only one out of sixty (55 rail and 5 tank-truck) is assessed to be a true air-vapor explosion/detonation resulting from significant quantities of vapor being released at the accident location. It is concluded therefore that for significant leaks of vapor the probability of a delayed air-vapor cloud detonation/explosion is between one to two orders of magnitude less than the probability of an immediate in situ explosion.

The data however is insufficient to determine whether such conclusion is also applicable to relatively small leaks of vapor. For such small leaks flammable air vapor clouds would be formed not far from the leak location even under light winds. Hence, it is not possible to determine from the data whether an explosion had really occurred at the leak location or its vicinity.

On the basis that 3,650 LP gas trucks pass the vicinity of the Waterford site per year, the yearly probability that an accident would occur within the mile of road closest to the plant, which would cause a fire or explosion at the accident location is determined to be 1.07×10^{-6}.

The probability that such an accident can lead to the delayed explosion/ detonation of a large air-vapor cloud is about 1.82×10^{-8}. This number is derived from multiplying 1.07×10^{-6} per year per mile by the probability that an explosion will be a delayed detonation/explosion of a large air vapor cloud which is determined to be about 0.017 from the previous arguments.

Another way to examine what the probability of a delayed detonation/deflagration of an air-vapor cloud is in the plant vicinity, is to recall that only accidents of some severity can lead to leaks capable of forming clouds of considerable size.

The probability per vehicle mile of severe accidents is lower than that for minor severity, and is reported in Table 2.2-17 to be 8×10^{-9}. Applying the same ratios for frequencies of leaks and spills and explosions, and multiplying by the truck traffic one arrives at a probability per mile per year of an accident leading with potential for delayed detonation of a significant cloud of 6.6×10^{-9}, a number which is comparable with that previously derived.

This probability is warranted to be too low to consider such event as part of design. However, the probabilities of a deflagration/detonation at the site of the accident; of a fire in the immediate vicinity of the accident, and of a relatively small leak leading to vapor clouds which can suffer delayed ignition and detonation are larger, and thus the plant's ability to withstand such hazards has been analyzed. Analysis of the in situ detonation and deflagrations in the vicinity of the accident are stated above. Thermal hazards from fires in the vicinity of the accident are addressed in Subsection 2.2.3.2.

The vapor clouds that can be formed by leaks of approximately 10 lb/sec or smaller, have been determined on the basis of atmospheric dispersion under 2.6 fps wind and Pasquill F meteorology, as well as gravity slumping, and their detonations have been found to present no hazards to the plant.

2.2.3.1.3 Nearby Gas Pipelines

2.2.3.1.3.1 Natural Gas Pipelines

A review of the pipelines carrying flammable and potentially explosive materials, within a five mile radius of Waterford 3 reveals that the most hazardous line is most likely to be Bridgeline's 26 inch natural gas line which is approximately 0.6 miles (3,168 ft.) from the plant. This line is taken as the line for the design basis accident analysis due to the proximity of the line and the potentially high transport rate of gas.

The natural gas transported is assumed to be methane.

The consequences of a complete severance of the 26 in. natural gas line are evaluated on the basis of the following assumptions:

a) Double ended rupture of the 26 in. pipe.

b) Gas escapes from both ends of the ruptured line.

c) Stagnation pressure upstream of break in both ends is the maximum operating pressure of the line ie, 550 psig.

d) The discharge from the break is divided into an initial transient when the flow from both broken ends may be choked, and steady flow (due to continued pump operation).

The gas line operates at a maximum flow rate of 6.5 x 10^6 ft^3/hr, (at standard temperature and pressure) or 1.56 x 10^8 ft^3/day. The density of methane (ρ CH_4) is 0.037 lbm/ft^3 (at standard temperature and pressure).

Therefore, the flow rate in the unruptured line is:

$$\frac{5.77 \text{ x } 10^6 \text{ lbm / day}}{1.6 \text{ lbm / ft}^3} \qquad 3.6 \text{ x } 10^6 \text{ ft}^3 \text{ / day} \qquad 42 \text{ ft}^3 \text{ / sec}$$

where 1.6 lbm/ft^3 is the approximate density of methane in the line at 550 psig and 105°F.

To determine whether choked flow exists, the natural gas is assumed to behave as an ideal gas, even though this assumption can lead to errors of as much as 50 percent in the estimation of densities (in the conservative direction).

For an ideal gas, the critical pressure, at which the mass flow rate in the break area cannot be increased regardless how low the back pressure is made is given by:

→(DRN 06-905, R15)

$$P^* \quad P_o \left[\frac{2}{k+1} \right]^{k/k \;\; 1}$$

←(DRN 06-905, R15)

where:

P_O is the upstream stagnation pressure, and
k is the ratio of specific heats

Similarly the critical density is given by

→(DRN 06-905, R15)

$$\rho^* \quad \rho_o \left[\frac{2}{k+1} \right]^{1/k \;\; 1}$$

←(DRN 06-905, R15)

Thus for the stagnation pressure of 565 psia, choked flow will exist as soon as the exit pressure is dropped below 308 psia. Thus choked flow will exist at the break. The shock wave which is created at the exit plane at the instant of the break will travel back through the line (both ends) at sonic speed until the whole line to the pump stations has been decompressed. At this time the flow can be assumed to unchoke.

To calculate the maximum flow rate out of the break, the equation of continuity at the critical (choking) plane can be used, thus

→(DRN 06-905, R15)

$$W(Lbm/sec) \quad \rho^* V^* A^*$$

←(DRN 06-905, R15)

where:

ρ^*, V^*, and A^* are the critical density, velocity and area respectively.

For an ideal gas

→(DRN 06-905, R15)

$$V^* \quad \sqrt{2kg_c RT_o/(k+1)}$$

←(DRN 06-905, R15)

and A* = A [for Mach No. = 1.0 (choked flow)] =

$$\frac{\pi}{4} \left[\frac{(26 \text{ inch.})}{(12 \text{ inch./ft})} \right]^2 \quad 3.69 \text{ ft}^2$$

At 105°F, using k ≈ 1.3 for natural gas, and $R \approx \frac{60\text{ft} \quad \text{lb}_f}{\text{lbm} \quad \text{R}}$

$$V^* \quad 1110 \text{ ft/sec}$$

Using the ideal gas law, the stagnation density corresponding to 565 psia and 105°F, is

$$\rho_o \quad \frac{P_o}{RT_o} \quad \frac{565}{60} \; \frac{(144)}{(565)} \quad 2.4 \text{ lbm / ft}^3$$

$$\rho^* \quad 0.629(2.4) \quad 1.51$$

Note that the actual density for methane ρ_o = 1.6 lbm/ft^3, thus, ρ * is really in the neighborhood of 1.00; hence the estimated maximum flow rate using ideal gas law will be conservative by about 50 percent.

Thus, W = ρ* V* A* = 1.51 x 1110 x 3.69 = 6185 lbm/sec

The initial transient flow will behave as a high momentum jet with rapidly decaying exit plane pressure which will not have sufficient time to form a hazardous detonable cloud. A small detonable cloud, however, may be present for a short duration on the order of minutes, but will not present a problem to the plant.

The steady flow condition is the one requiring closer investigation due to the (possible) long duration of release of methane at the pumping rate of 6.5 x 10^6 ft^3/hr or 67 lbm/sec. The duration of steady flow release is governed by the pipe inventory for length of pipe between pumping stations.

→(DRN 01-464)

The dimension of the detonable plume downwind of the break are evaluated for a Category F stability, and a constant, invariant wind speed of 2.6 ft/sec. The centerline (directly downwind) concentration χ_{cl} of the methane (excluding buoyancy) is determined by:

←(DRN 01-464)

$$X_{cl} \quad \frac{Q}{\pi \, \sigma \gamma \; \sigma zu}$$

Off-centerline concentrations (X) are determined by:

→(DRN 01-464)

$$x \quad x_{cl} \exp\left\{ \; 1/2\left[(Y/\sigma\gamma)^2 + (Z/\sigma_z)^2\right]\right\}$$

←(DRN 01-464)

Table 2.2-18 gives the dimension of the methane cloud downwind of the break neglecting buoyancy. The flow out of the break is 67 lbm/sec.

The potential cloud configuration (neglecting buoyancy) which can detonate is the fraction of the cloud which falls within the flammable limits (4.8 and 14.0 percent).

The maximum distance from the plume axis to the lower limit will occur at the point where centerline concentration is that of the high flammability limit (14.0 percent). This is given by y = 82 ft and z = 41 ft.

Thus the dimensions of the semiellipsoid (bounded by the ground) of the low concentration limit for flammability yields a cloud of the volume (V_1) equal to:

V_{low} = (2π/3) x 1582.5 x 82.2 x 41.1 = 1.12 x 10^7 ft^3

Similarly, the dimensions and volume (V_{high}) of the cloud at the high flammability limits are given by:

V_{high} (2π/3) x 816 x 48.12 x 24.06 = 1.98 x 10^6 ft^3

This yields the volume of the methane cloud within the flammable limits (V_{net}) as:

V_{net} = 1.12 x 10^7 - 1.98 x 10^6 = 9.22 x 10^6 ft^3

A realistic analysis leads to a consideration of buoyancy effects since methane is considerably lighter than air.

→(DRN 01-464)

As a result of buoyancy, escaping methane will rise with a vertical speed greater than the assumed wind speed. The vertical speed leads to additional significant dispersion of the cloud which reduces the horizontal downwind, horizontal cross wind and vertical dimensions of the cloud to 0.465 of the original dimensions [56].

←(DRN 01-464)

Thus the volume of the cloud at the low flammability limit is

$$V_{low} \quad \frac{4\pi}{3}(0.465\times1582.5)(0.465\times82.2)(0.465\times41.1)$$
$$2.25\times10^{6}\ \text{ft}^{3}$$

The dimensions of the cloud at the high flammability limit is similarly reduced.

$$V_{high} \quad \frac{4\pi}{3}\ (0.465\ \text{x}\ 816)\ (0.465\ \text{x}\ 48.12)\ (0.465\ \text{x}\ 24.06)$$
$$398.\ \text{x}\ 10^{5}\ \text{ft}^{3}$$

Thus the net volume of the detonable cloud using a more realistic approach is

$$V_{net} \quad 2.25\ \text{x}\ 10^{6}\ -\ 3.98\ \text{x}\ 10^{5}$$
$$1.85\ \text{x}\ 10^{6}\ \text{ft}^{3}$$

Since the determination of equivalent TNT mass of vapor clouds is not well documented, the approach of optimum gas/air mixtures is used. Lichty[55] lists the BTU/ft^3 content for a variety of gas/air mixtures at optimum mix. The highest value (for all gas/air mixtures) is given as 95 BTU/ft^3.

To obtain the mass equivalent of TNT, the value 1800 BTU/lbm is utilized [44].

$$M_{eq} \quad 1.85 \text{ x } 10^6 \text{ x } \frac{95}{1800} \quad 9.76 \text{ x } 10^4 \text{ lbm}$$

and the scaling parameter is

$$Z \quad \frac{3168 - 1104}{(9.76 \text{ x } 10^4)^{1/3}} \quad \frac{2064}{46.04} \quad 44.83$$

This results in an overpressure of about 1.00 psi (see Figure 2.2-7) and a reflected overpressure of

$$2.0 \text{ x } 1.00 \text{ x } \frac{7 \text{ x } 14.7 + 4 \text{ x } 1.00}{7 \text{ x } 14.7 + 1.00} \quad 2.1 \text{ psi}$$

These overpressure values are less than those for the gasoline tanker analyzed in Subsection 2.2.3.1.1 and the same conclusions apply.

The potential hazards from a fireball as opposed to a detonation are less severe than those of the LPG tank truck due to the distance involved. The diameter of the fireball resulting from a detonable cloud is obtained by assuming the most conservative 10 percent mixture of methane in air yielding a detonable cloud of mass

$$M_{det} \quad 1.85 \text{ x } 10^6 \text{ ft}^3 \ (0.1 \text{ x } 0.037 + 0.9 \text{ x } 0.07493)$$

$$1.85 \text{ x } 10^6 \text{ ft}^3 \text{ x } 0.071137 \text{ lbm/ft}^3$$

$$1.316 \text{ x } 10^5 \text{ x lbm x } \frac{(1\text{kg})}{2.2 \text{ lbm}}$$

$$5.98 \text{ x } 10^4 \text{ kg}$$

According to methods described in Subsection 2.2.3.2 the diameter of the fireball is
$D = 3.86\ (5.98 \text{ x } 10^4)^{0.32}$ meters.

= 130.4 meters

= 427 ft.

The duration of the fire is:

$t = 0.299\ (5.98 \text{ x } 10^4)^{0.32}$ seconds

= 10.01 seconds

A comparison of the distances of the LPG tank truck (see Subsection 2.2.3.2) and the methane cloud from the plant indicates that a fireball resulting from an LPG tank truck break is the dominant hazard and constitutes the design basis accident for this type of externally generated fire.

→(EC-5000082218, R301)

2.2.3.1.3.1.1 Hazard Assessment of 16-inch Bridgeline Natural Gas Line

←(EC-5000082218, R301)

The 1988 survey of pipelines within a 2-mile radius of Waterford 3 revealed only two new lines built since the previous survey in 1979. Both lines carry natural gas to the LP&L Waterford G.P. 1 & 2. One pipeline, the Waterford Lateral operated by the Bridgeline Gas Distribution Co., with a nominal pipe size of 16 inches, is fed by the 26-inch Bridgeline (formerly Texaco) main line. The other, operated by LP&L, has a nominal size of 14 inches and brings gas from the Acadian (formerly Sugar Bowl) 20-inch line. Since the 16-inch line is nearer to Waterford 3 and has a greater capacity, the results of a hazard assessment of this line envelope the 14-inch line. A simple scoping analysis was performed to assess the effect of a pipe break of the new line on Waterford 3, employing the methodology used in Subsection 2.2.3.1.3.1 for evaluating the effect of a break in the Bridgeline 26-inch pipeline.

→(EC-39014, R307)

The break was postulated to occur at the nearest isolation valve on the new line, which is 2,600 feet from the safety-related structures of Waterford 3. Although a portion of the pipeline passes slightly closer to the plant, as shown in Figure 2.2-3c, the pipe at this point is buried at a depth of three feet. A break in the buried pipe is highly unlikely. If such a break were to be postulated nevertheless, the resulting flow of gas to the surface would be considerably attenuated by the earthen cover. Therefore, the break at the isolation valve constitutes the maximum credible accident.

←(EC-39014, R307)

→(EC-5000082218, R301)

The final product of the previous analysis is the calculation of the peak overpressure which would be experienced by safety-related structures at Waterford 3. If the 16-inch line were assumed to have the same pumping rate as the 26-inch line, 6.5 x 10^6 scf/hr, the mass and the dimension of the detonable cloud would be the same as calculated in Subsection 2.2.3.1.3.1. This assumed rate is very conservative, inasmuch as the 26-inch pipeline feeds the 16-inch line.

←(EC-5000082218, R301)

Figure 2.2-7 presents a curve which relates the overpressure to the scaling parameter, Z. This parameter is calculated by the following equation, which is adapted from the one shown on page 2.2-23.

$$Z = \frac{R - r}{M^{1/2}}$$

Z = scaling parameter for determining overpressure
= 32.5

R = distance of pipe break to safety-related structure
= 2,600 feet

r = maximum distance of detonation from pipe break under assumed meteorological conditions
= 1,104 feet

M = equivalent mass of TNT
= 9.76×10^4 lbs

To increase the accuracy of interpolating the curve in Figure 2.2-7 to determine the overpressure, it is noted that the portion of the curve between lines representing 10 psi and 1 psi is nearly linear. The linear equation representing this portion of the curve can be written as

$$\log p = \log 300 - 1.5 \log Z$$

p = overpressure
= 1.6 psi

using the value of Z calculated above. This overpressure can be compared to that from one of the design basis explosive events discussed in Subsection 2.2.3.1.1, namely the explosion of a gasoline tanker on the Mississippi River. For that event, Z = 34.2 the value of which is not much different from the value obtained above. To compare the results of the new calculation with the tanker explosion, the overpressure for Z = 34.2 was re-calculated, using the above equation, and an overpressure of 1.5 psi was obtained. (The difference between this value and the 1.3 psi given in the previous section can be attributed to individual judgement in reading the graph in Figure 2.2-7.) Thus, the calculated overpressure from a rupture of the new pipeline is not significantly higher than that from the tanker explosion. It is considerably less than the 3.0 psi which was calculated in Subsection 2.2.3.1.2 for the postulated explosion of an LPG truck on Louisiana highway 18.

In summary, the pumping speed inside the new pipe would in reality be less than that assumed in this analysis, resulting in a detonable cloud both smaller in spatial dimension (therefore remaining at a greater distance from safety-related structures) and lower in explosive power. It is thus concluded that the potential hazard posed by the new pipeline is bounded by previously analyzed explosive events.

2.2.3.1.3.1.2 Hazard Assessment of Evangeline Natural Gas Pipeline Project

In April 1992, construction started on the Evangeline Pipeline. This pipeline supplies natural gas to the Waterford 1 and 2 and Little Gypsy Stations of LP&L. A 24 inch pipeline enters the LP&L property to the south-east of Waterford 3. The 24 inch pipeline connects to

two 20 inch pipelines at a pig trap station just south of the Texas and Pacific Railroad tracks. One 20 inch pipeline then runs parallel to and slightly west of the existing 26 inch Bridgeline pipeline to supply Little Gypsy. The other 20 inch pipeline runs parallel to the existing 16 inch LP&L pipeline to supply Waterford 1 and 2. The maximum natural gas flow rate in the 24 inch pipeline is 2.50 x 10^8 scf/day. With the exception of the pig trap station, the Evangeline Pipeline is buried for its entire length. Reference 100 provides a detailed description of the Evangeline Pipeline.

To assess the effect of the new pipeline on Waterford 3, pipe breaks are assumed to occur at the pig trap station and at the Waterford 1 and 2 header. These are the only two locations where the pipeline is above ground. A break in the buried pipe is highly unlikely. If such a break were to be postulated nevertheless, the resulting flow of gas to the surface would be considerably attenuated by the earthen cover. Therefore, the breaks at the pig trap station and at the Waterford 1 and 2 header constitute the maximum credible accident.

The effect of the pipe breaks is analyzed using the methodology used in Subsection 2.2.3.1.3.1 for evaluating the effect of a break in the Bridgeline 26 inch pipeline. The pig trap station is a minimum of 4000 feet from the safety-related structures of Waterford 3. The maximum natural gas pumping rate at the pig trap station is 2.50 x 10^8 scf/day or 2.89 x 10^3 scf/sec. Table 2.2-23 gives the dimensions of the methane cloud downwind of the break neglecting buoyancy. The overpressure at the Waterford 3 safety-related structures from a pipe break and subsequent explosion at the pig trap station is determined to be 0.96 psi.

For the analysis of the break in the pipeline at the Waterford 1 and 2 header, the overpressure results presented in Subsection 2.2.3.1.3.1.1 are bounding.

The Waterford 1 and 2 header is 2600 ft. from the Waterford 3 safety-related structures. The maximum flow rate in this section of the Evangeline Pipeline is 6.25 x 10^6 scf/hr. This is slightly less (96%) than the flow rate of 6.5 x 10^6 scf/hr that was used in the analysis of Subsection 2.2.3.1.3.1.1. If the new pipeline was assumed to have the flow rate of 6.5 x 10^6 scf/hr, the overpressure of 1.6 psi that was calculated in Subsection 2.2.3.1.3.1.1 would apply. In reality, the actual overpressure resulting from a break and explosion at the Waterford 1 and 2 header would be slightly less than 1.6 psi.

In summary, the explosion overpressures at the Waterford 3 safety-related structures due to breaks in the new Evangeline Pipeline, at the pig trap station and at the Waterford 1 and 2 header, are less than the 3.0 psi which was calculated in Subsection 2.2.3.1.2 for the postulated explosion of an LPG truck on Louisiana Highway 18. It is thus concluded that the potential hazard posed by the Evangeline Pipeline is bounded by previously analyzed explosive events.

→(DRN 02-865)

2.2.3.1.3.1.3 Hazard Assessment of Oxy-Taft Cogen Lateral Natural Gas Pipeline Project

In June 2002, construction started on the Oxy-Taft Cogen Lateral Pipeline. This pipeline supplies natural gas to the Occidental Chemical Corporation Cogeneration Units that are sited to the East of Waterford 3. The new pipeline is a relatively short pipeline that connects the new cogeneration units to an existing natural gas pipeline. The new 12.75 inch diameter pipeline enters the LP&L property to the south-east of Waterford 3 and runs along the east side of the LP&L property to connect to the cogeneration units. The maximum natural gas flow rate in the 12.75 inch diameter pipeline is 160 x 10^6 scf/day. With the exception of the section of pipeline at Bridgeline's existing surface site, the Oxy-Taft Cogen Lateral Pipeline is buried for its entire length to a depth of between six and twenty feet. Reference 107 provides a detailed description of the Oxy-Taft Cogen Lateral Pipeline.

To assess the effect of the new pipeline on Waterford 3, a pipe break is assumed to occur at the above surface section of the pipeline. A break in the buried pipe is highly unlikely. If such a break were to be

→(DRN 02-865, R12)
postulated nevertheless, the resulting flow of gas to the surface would be considerably attenuated by the earthen cover. Therefore, the break at the above ground section of the pipeline constitutes the maximum credible accident.

The effect of the pipe break is analyzed by comparing the break in the Oxy-Taft Cogen Lateral pipeline to the break in the Evangeline 24 inch pipeline, at the pig trap station, that is discussed in Subsection 2.2.3.1.3.1.2. The Evangeline pipeline pig trap station is a minimum of 4000 feet from the safety-related structures of Waterford 3 while the above ground section of the Oxy-Taft Cogen Lateral pipeline is a minimum of 4400 feet from the safety related structures. The maximum natural gas pumping rate for the Evangeline pipeline at the pig trap station is 250 x 10^6 scf/day while the maximum natural gas pumping rate for the Oxy-Taft Cogen Lateral pipeline is 160 x 10^6 scf/day. Since the postulated break in the Oxy-Taft Cogen Lateral pipeline is farther away from the Waterford 3 safety related structures and has a smaller gas flow than the Evangeline pipeline the overpressure from a postulated explosion will be less than the overpressure from the Evangeline pipeline explosion, i.e. less than 0.96 psi. This is less than the limiting overpressure of 3.0 psi, which was calculated in Subsection 2.2.3.1.2 for the postulated explosion of an LPG truck on Louisiana Highway 18. It is thus concluded that the potential hazard posed by the Oxy-Taft Cogen Lateral Pipeline is bounded by previously analyzed explosive events.
←(DRN 02-865, R12)

2.2.3.1.3.2 LPG Pipelines

→(EC-39014, R307)
The pipelines passing within 3000 meters of the plant safety related structures are shown on Figure 2.2-3c. Also shown in this figure is the location of isolation (or check) valves on the pipelines. Table 2.2-19 lists the expected releases that would occur for a break in the pipelines.
←(EC-39014, R307)

Analyses conducted of the potential effects on plant safety-related structures from escaping air-vapor clouds indicate that a break in the Texaco 6 in. LPG line closest to the plant or a break in the 8 in. Union Carbide LPG line would present about equal hazards.

This conclusion is based on the following analyses which are predicted on the following assumptions for the LPG (propane) lines.

The peak flow rate at t=0 results to be 87,000 lbm/ft^2 sec of liquid at a specific volume of 0.031 ft^3/lbm escaping with sonic velocity, i.e., 2570 ft/sec. This discharge will last a fraction of a second; i.e., the time for the wave to travel back to a location where frictional pressure drop equals the pressure drop to saturation. Thereafter steady blowdown will proceed at the conservative rate of the two phase critical mass flow until inertial flow is established.

To estimate the flow rate out of the break, Fauske's equation(58) for critical two phase mass velocity is used:

$$G_{crit} = (-\sigma g_c/(k_1 dv_g/dp+k_2 dx/dp+k_3 d\, v_f/dp))^{1/2}$$

where:

$$g_c = 32.2 \text{ lbm ft./lb}_f \text{ sec}^2$$

→(DRN 01-464, R11-A)

$$k_1 = (1 - x + \sigma x)x$$

$$k_2 = v_g(1 + 2\sigma x - 2x) + v_f\,(2\sigma x - 2\sigma - 2\sigma x + \sigma^2)$$

$$k_3 = (1 - x(\sigma - 2) - x^2(\sigma - 1))$$

←(DRN 01-464, R11-A)

and $\sigma = (v_g/v_f)^{1/2}$

Solution of Fauske's equation yields:

$$G_{crit} = 1433 \text{ lb/ft}^2 \text{ sec}$$

Hence for the given pipe area (0.196 ft^2) corresponding to a 6 in. line the flow rate out of the break is at most 566 lbm/sec, assuming that it gushes out of both ends of the broken pipeline.

At a subsequent time as the pressure in the line falls, the flow becomes inertial or alternatively inertial or two phase critical.

The portion of the piping not pump pressurized will drop rapidly to saturation pressure. The saturated liquid inertial flow, which is higher than the two phase critical flow for the same pressure, is approximately 30 lb/sec. Hence one can conservatively assume that a maximum of 30 lb/sec issue continuously from the unpressurized side of the break after the initial period of time required to depressurize the line to near saturation pressure. This time for a line length several miles long is just tens of seconds.

The pump pressurized side behaves equally for the 6 in. line, but differently for the 8 in. Union Carbide line since the pump at peak flow can deliver approximately 70 lb/sec. Hence from the pump side of the break a continuous flow of approximately 70 lb/sec can be expected for the 8 in. line and 30 lb/sec for the 6 in. line.

The total long term escape flow from the break can thus be taken as approximately 100 lb/sec. for the 8 in. Union Carbide break or 60 lb/sec for the 6 in. line. If the break on the latter occurs nearest the plant however, the automatic isolation valve would stop flow from the pressurized end, hence only 30 lb/sec would escape.

Since about 1/3 of this vaporizes, then the vapor flow corresponds to a uniform source of propane vapor of 36 lbm/sec or 9.0 ft^3 lb x (36 lbm/ sec) = 324 standard cubic feet per second which is available immediately for atmosphere dispersion in the 8 in. line case or 1/3 of that for the 6 in. line breaking at the worst location.

This vapor flow rate is of the same order of magnitude as that observed by Burgess and Zabetakis(59) in their investigation of a propane line break in Port Hudson, Missouri, and this lends credence to the simple model employed to compute the flow rate out of the break.

Another check on the validity of the model is obtained by comparison of predicted and observed total quantities of propane escaped from actual breaks. For instance, for the Port Hudson, Missouri break, the total release of liquid propane estimated by Burgess and Zabetakis during the first 24 minutes is 750 barrels.

For 100 lbm/sec and the specific volume of saturated liquid propane the barrels released the first 24 minutes are estimated at 100 lbm/sec (0.031 ft^3/lb) (1 barrel/5.61 ft^3) 24 min. (60 sec/min) = 795 barrels. This good agreement confirms that the contribution from the subcooled blowdown and critical two phase blowdown portion is negligible.

a) <u>Assumption in calculation:</u>

1) Double ended rupture or slot rupture with slot size equal to twice the flow area of the pipeline. Rupture occurs instantaneously at closest location to the plant.

2) The released LP liquid gas mixture initially escapes from the break at the critical velocity for single phase flow at the design pressure of the line, then drops to two phase critical flow at its saturation pressure and finally to inertial flow from one end and the flow passed by the pumps at the other end, when the pressure in the pipeline falls.

3) The temperature of the atmosphere is assumed to be 72°F. Higher temperatures would lead to higher vaporization of escaping LP fluid, but the initial flow rate would be less due to the higher quality at the exit plane.

4) Propane disperses toward the plant at 0.8 m/sec Pasquill F stability condition as an airborne cloud, or alternatively, it drifts by gravity toward the plant.

5) Regardless of the potential sources of ignition, a detonation of the resulting cloud is assumed to occur at selected centroids of the cloud, after the centerline concentration has reached the rich limit.

b) <u>Calculation of Flow Rate Out of the Break</u>

The propane in the line will, upon the instant of the break, decompress isentalphically to a saturation pressure of 125 psia essentially immediately because of the very large speed of sound in the liquid. A decompression wave will travel very rapidly away from the break leaving the fluid behind it at the saturation pressure. Since the propane would issue from the break at 72°F, approximately 1/3 of it would quickly vaporize, cooling the remainder to its boiling point of about -44°F. Hence the process of decompression is described by the throttling process in a pressure vs. enthalpy diagram. From such a diagram the exit plane quality, x, of the fluid can be estimated from:

$$v = v_f + x\, v_{fg}$$

where:

→(DRN 01-464)

$v = 2.4$ ft^3/lb, $v_f = 0.0275$ ft^3/lb, $v_{fg} = 6.6$ ft^3/lb,

$$x \quad \frac{v \quad v_f}{v_{fg}}$$

←(DRN 01-464)

Hence: $x = 0.36$

During the initial phase of the blowdown of the pipe (single phase flow) the maximum flow rate can be estimated from:

$$G_{Max} \quad \sqrt{-g_c\ (J/J')\ (\partial p/\partial v)_{s_o}}$$

Since the constant entropy and constant enthalpy lines essentially coincide from the initial condition to the saturated state of P = 125 psi, $v_f = 0.0319$ ft^3 /lbm, the partial derivative can be evaluated as the ratio of the differences

$$\frac{\Delta P}{\Delta v_s} \quad 1.06$$

where the initial v is taken along the isentrope at the initial pressure, $v_i \cong 0.0311.$

The same methodology applied to the events at Ruff Creek[60] and Austin[61] produced the following comparison.

At Ruff Creek a 0.0174 ft^2 break is computed to have a mass flow rate of 20.5 lb/sec during the first phase of the accident, lasting approximately 1-1/2 hour, and then a 5.5 lb/sec release rate for the remaining 14-1/2 hour. The predicted escape quantity of propane is 1,691 barrels, while approximately 1,800 barrels were observed to have escaped. In Austin, a 0.163 ft^2 break is computed to release an average of 117 lb/sec during the 1.17 hr required to isolate the broken section. The contents of the isolated section escape thereafter. In this case 6,307 barrels are predicted to have escaped versus the observed 5,540.

Two scenarios can be imagined for the ensuing clouds of propane-air mixtures forming after the break. The first one envisions a cloud formed by the propane being transported by atmospheric dispersion toward the plant site. The second one assumes that the propane forms a very tenacious layer close to the ground, wherein air entrainment only occurs at the air surface of the layer. This fog-like ground-hugging cloud advances toward the plant under its own gravity (cloud slumping) and because of sloping ground. It is to be noted that the ground actually slopes away from the plant.

c) Calculation of Detonable Cloud Size - Atmospheric - Dispersion

The dimension of the detonable plume downwind of a 325 ft^3/sec propane source, for Category F stability and a constant invariant wind speed of 2.6 ft/sec are given in Table 2.2-20.

The centerline (directly downwind) concentration of propane is determined by:

$$X_{cl} \quad \frac{Q}{\pi \sigma_y \sigma_z u}$$

where: Q = 325 ft^3 (STP) of propane per second

u = 2.6 ft/sec (0.8 m/sec)

and σ_y, σ_z are the plume dispersion standard deviations obtained from Ref. 71, which are shown on Figure 2.2-14.

The off-centerline concentrations are determined by:

$$X \quad X_{cl} \exp \left\{ -1/2 \left[(y/\sigma_y)^2 + (z/\sigma_z)^2 \right] \right\}$$

It is very important to determine which are the proper dispersion standard deviations to be used in solving for the equilibrium[1] concentrations.

Dispersion standard deviations for instantaneous "puff" releases and continuous constant releases are considerably different; the former being much smaller than the latter.

The reason for this is that the continuous release deviations account for a part of averaging process caused by wind vagaries resulting in meandering of the plume about its axis. The σ_y and σ_z then account for this effect. For a puff release this meandering averaging process is absent and the puff disperses more slowly. The case of a pipeline break is neither a puff release nor a continuous constant release, but rather a continuous release at an initially rapidly decreasing rate, followed by an almost constant release.

The meandering process would then be in effect and the proper dispersion standard deviations are the continuous release standard deviations.

The potential cloud configuration for a 6 in. LPG line is plotted in Figure 2.2-8.

The shaded portion represent the fraction of the cloud which falls within the detonable limits. These limits are reported in Reference 15 to be 7.0 percent and 2.8 percent, respectively. Also shown is the flammable cloud. The flammable limits are 9.0 percent and 2.2 percent, respectively.

The volume of the detonable cloud is calculated to be that of the difference between the ellipsoid enclosing all gas above the 2.8 percent mixture and the ellipsoid engulfing the gas above the 7.0 percent mixture level.

Volume of ellipsoid (2.8%) = 1.78×10^6 ft^3

Volume of ellipsoid (7%) = 4.2×10^5 ft ^{3}

Volume of detonable cloud = 1.35×10^6 ft^3

d) Calculation of Effects From Detonation

From an enthalpy of detonation release of 260 K cal/lb of propane air mixtures of 4.9 percent (enthalpy of detonation is insensitive to mixture ratios between four and five percent), and a volume of 900,000 cubic feet, it is possible to compute the total energy released in a hypothetical detonation of the entire detonable cloud, assuming that the whole cloud is at a mixture averaging 4.9 percent.

The total volume of propane in the detonable cloud is 4.42×10^4 ft^3 and the volume of air = 8.6×10^5 ft^3. The total weight of the mixture is approximately:

$$\frac{1.36 \times 10^6 \text{ ft}^3}{[(13.3)\ (0.951) + (0.049)(9.43)] \text{ ft}^3/\text{lb}} \quad 1.037 \times 10^5 \text{ lb}$$

$$\text{Total enthalpy released} \quad 2.69 \times 10^7 \text{ K cal}$$

$$\text{Equivalent TNT} \quad \frac{2.69 \times 10^7}{500 \text{ K cal}} \frac{\text{K cal}}{\text{lb TNT}} \quad 26.97 \text{ tons of TNT}$$

Comparison of this figure with the occurrence at Port Hudson, Missouri(59) shows that this estimate might really be the minimum hazard expected from the break, and that ground and atmospheric conditions may result in more propane being trapped in a detonable cloud.

The absolute upper limit of the detonable cloud would be a cloud where all the liquid propane which escapes from the break eventually vaporizes and mixes with air and the other over rich vapor in a detonable mixture.

Assuming that the heat to vaporize the liquid propane comes from the air then it would require approximately 4.15 lb of air at 72°F to vaporize one lb of propane at-44°F.

The resulting cold mixture would be 19.4 w/o or 11.4 percent by volume of propane, and it would be denser than the ambient air. Thus it is possible to visualize a ground layer of composition above the detonable limit, which when warming up will contribute appreciably more propane to the detonable cloud, than that calculated by the dispersion technique. This ground layer can eventually become dispersed in the atmosphere as it warms up or it can move under gravity effects. For lower atmospheric temperatures proportionately more air would be required to vaporize the propane. At near freezing temperatures (~32°F) vaporization would result in mixtures of seven percent by volume of propane, thus at the detonable limit.

Portions of the liquid ejected from the break would be expected to be vaporized while in the form of droplets in the jet escaping from the break, the remainder would eventually evaporate with the soil and the air providing the necessary heat.

Clearly the rate at which this fraction of the vapor is injected in the air is determined by:

1) the amount vaporized in the jet and immediate vicinity. This fraction would form a mixture heavier than air which would at the same time disperse in the air and also tend to settle into a "fog-like" ground layer. Since the instantly vaporized propane (amount flashing at break) would exhibit similar behavior, the fraction of propane liquid vaporized in the jet and immediate vicinity can be treated, at equilibrium, as additive to the constant vapor flow assumed for the initial dispersion calculation, which coupled itself with the treatment of just the flashed vapor.

2) the amount of propane which remains liquid and experiences delayed evaporation at the ground.

   The rate of evaporation of the ground liquid depends on the area and depth of the liquid. Since this in turn is determined by terrain, precise assessment of this rate is extremely difficult. It seems reasonable to assume that an equilibrium condition can be established whereby a like amount of liquid evaporates as that which exists from the break. Less evaporation would result in an ever increasing area (or depth) of the liquid. An estimate of the atmospheric clouds resulting from the delayed evaporation is presented below.

   Conservatively, however, it is possible to assume that all of the escaping propane would be atmospherically dispersed. Under this assumption, the resulting maximum detonable cloud would be that established by a constant escape of approximately 1000 ft^3/sec of propane for the 8 in. line (Union Carbide) and approximately 1/3 of that for the 6 in. line. For the maximum detonable cloud resulting from the 6 in. line, therefore, the contours shown in Figure 2.2-8 are applicable.

In the previous calculation; the heavier than air density of the propane mixtures had not been considered, but the limit in vertical dispersion was implied in the choice of $\sigma_z \approx 1/2\sigma_y$ characteristic of F stability conditions.

Reference 2 recommends values of $_z$ 1/5 $_y$. Table 2.2-21 and Figure 2.2-9 shows the dimensions of the propane plume down-wind of the assumed 1000 ft^3/sec source, with $^{\sigma}z \approx 1/5^{\sigma}y$.

This detonation would then be equivalent to the detonation of 4.56 x 10^5 lb = 0.228 ktons of TNT assuming 100 percent yield.

In actuality the yield will not be 100 percent. Reference 1 cites a yield of 7.5 percent. Work by Iotti, et. al., shows that indeed the yield of a gaseous detonation is lower than that of TNT. References 5 compares overpressures calculated by assuming gaseous point sources(47) to overpressures obtained by Kingery(64) for the same yield, and those measured by Kogarko, et. al.(38), for the given gaseous detonation. This comparison shows that Kingery's result would have been comparable to those of References 63 and 65, if a TNT yield of 50 percent had been employed. Thus a conservative estimate of the TNT equivalent to the detonation of the entire cloud can be obtained by using 50 percent yield and use of Kingery charts, see Figure 2.2-10. Thus the hypothetical detonation of the entire propane discharged by the line would result in consequences similar to the detonation of 0.114 kT of TNT. This detonation however cannot occur, and more realistically the true detonation will be somewhere between the 13.5 tons and the 114 tons of TNT, but closer to the 13.5 tons.

The 50 percent yield computed on the basis of the overall detonable mixture weight is a more conservative method of evaluating the hazards from potential cloud detonations than that advocated by Reference 79. According to the latter, for instance, the detonation of the detonable cloud depicted in Figure 2.2-9 would be equivalent to the detonation of 73 tons of TNT as compared to the 114 tons computed by the method employed.

Table 2.2-22 lists the pertinent shock wave parameters for the two yields. These parameters are obtained from Reference 64, assuming that the center of the detonation is 1550 ft. from the plant for the 13.5 ton detonation, and 3600 ft. from the plant critical structure for the 0.114 kton detonation.

Table 2.2-22 also lists the seismic parameters at the plant site due to air blast induced ground motions. These parameters are obtained from equations in Reference 37.

Plant critical structures are designed so that they are able to withstand the overpressures and ground motions listed in Table 2.2-22 hence it is concluded that the detonation itself of propane escaped from a break in the 6 in. or 8 in. LPG lines will not result in unacceptable consequences.

Later on it will be shown that cloud expansion effects following the detonation, will also pose no hazards to the plant.

e) <u>Calculation of Flammable (Detonable) Cloud Size - Ground Layer Formation and Dispersion Model</u>

The model described hereinafter follows the formation of the cloud assuming that all of the propane issues from the break as liquid, evaporates, and forms a cloud denser than air which then travels by gravity until it becomes neutrally buoyant, i.e., its travel velocity is equal to or less than the prevailing wind.

For a continuous release rate of liquid propane W, the maximum pool radius r_{max} is determined from the liquid pool area required to vaporize the LPG at a rate equal to the release rate, hence

$$r_{max} = \left[\frac{\ell_f W(h_g - h_f)}{\pi B}\right]^{1/2} \quad \text{(ft)} \qquad (1)$$

where B is the liquid evaporation rate determinable from the following equation[73], which is in metric units.

$$\frac{h}{k}\sqrt{\frac{\sigma}{\ell_f} = 30 - \left(\frac{B}{\ell_g \lambda w_b}\right)^{0.8}} \qquad (2)$$

In the preceding equation σ, k, ρ_f, ρ_g are the surface tension, the thermal conductivity, and saturated liquid and vapor densities of propane at -44°F.
W = 280 meters/hr, and $\lambda = h_g - h_f$ = heat of vaporization at -44°F.

The ground to liquid heat transfer coefficient, h, can be determined from the equation of natural convection of flat plates given in Reference 73.

$$\frac{h}{k_e} = 0.14\left[\frac{\rho_e^{\,2} g \beta_e \Delta t C_{pe}}{M_e k_e}\right]^{1/3} \qquad (3)$$

In equation (3) the subscript e refers to the film properties, and k_e, ρ_e, M_e, C_{pe}, are the thermal conductivity, liquid density, viscosity, and heat capacity of propane at $t_f = \frac{t_g - 44°F}{2}$ with t_g equal to the ambient temperature.

β_e is the volumetric expansion coefficient given by

$$\beta_e \qquad \frac{\rho_f - \rho_e}{\rho_e(t_e - t_f)} \qquad (4)$$

$$\text{and } t \qquad t_g - t_e$$

Inserting the appropriate values and converting to English units, one obtains for an ambient temperature of 523°F a boiloff rate of $B \qquad 33{,}800 \ \frac{BTU}{ft^2 hr.}$

This figure compares favorably with values which can be extrapolated from the Jacob experiments[73] on vaporization of propane from clean surfaces, and also with values reported in LNG studies[74].

The initial height of vapor cloud which is input to the gravity spreading analysis from an initial radius r_{max}, is computed by determining the amount of vapor injected in the air during the time it takes the prevailing wind to traverse the pool radius, if wind is present, hence

→(DRN 06-905, R15)

$$h_{in} = \frac{B r_{max}}{\rho_f \mu (h_g - h_f)} \qquad (5)$$

←(DRN 06-905, R15)

In case of no wind, the initial height, h_{in} is computed by determining the equivalent instantaneous volume of a spill which would give rise to the same r_{max} and h_{in}

→(DRN 06-905, R15)

$$V_{inst} = \frac{\pi r_{max}{}^2 h_{in}}{240} \qquad (6)$$

←(DRN 06-905, R15)

where the 240 is the volume ration between liquid and vapor at the -44°F with which the propane issues from the break. For an instantaneous spill several expressions for r_{max} are available. The one chosen here is from Reference 74.

→(DRN 06-905, R15)

$$r_{max_{inst}} = 1.23 \left(\frac{V_{inst}^3}{Q^2} \right)^{1/8} \qquad (7)$$

←(DRN 06-905, R15)

with all quantities in metric units. The liquid regression rate Q is given by:

$$Q = \frac{B}{\rho_f (h_g - h_f)} \qquad (8)$$

←(DRN 06-905, R15)

The gravity spread of the cloud can be computed by:

→(DRN 06-905, R15)

$$\frac{dR(t)}{dt} = \left\{ 2g \left[\left(\frac{\rho_c(t) - \rho_a}{\rho_a} \right) h(t) + S\Delta R \right]^{1/2} \right\} \qquad (9)$$

←(DRN 06-905, R15)

wherein $\rho_c(t)$ is the time varying cloud density assuming a homogenized cloud at each instant of time, p_a is the air density at ambient temperature, g the acceleration of gravity, S the slope of the ground in ft/ft, h(t) is the time varying cloud height and R(t) is either the radius of the cloud front at time t or the distance traveled by the advancing cloud front which is confined by banks to travel along a channel of width 2 W.

As the cloud spreads it will entrain air in an amount given by either

$$dQ(t) = \propto V_C \; 2 \; \pi r dr \qquad (10a)$$

When the cloud is expanding cylindrically or

→(DRN 06-905, R15)

$$dQ(t) = \propto V_C \, W \, dr \qquad (10b)$$

←(DRN 06-905, R15)

as the cloud spreads confined in a channel of width 2 W. In equations (10) V_C is the local entrainment velocity which is defined as

$$V_C \quad \frac{r}{R}\frac{dR}{dt} \qquad \text{for (10a)} \qquad \text{(lla)}$$

$$V_C \quad \frac{dR}{dt} \quad u \qquad \text{for (10b)} \qquad \text{(llb)}$$

Integration over time yields

→(DRN 06-905, R15)

$$Q(t) \quad \frac{2\pi}{3} R^2(t)\frac{dR(t)}{dt} \quad \text{for radial spreading} \qquad (12a)$$

←(DRN 06-905, R15)

$$Q(t) \quad \left\{\frac{\pi}{3}W^2 \quad \gamma W\left[R(t) \quad W\right]\right\}\alpha\left[\frac{dR}{dt} \quad u\right] \qquad (12b)$$

for initial radial spreading to W followed by axial spreading. Therein γ is a parameter which equals unity for triangulary shaped channels and 2 for rectangular cross section channels.

The wind velocity, u, is additive to the radial spreading velocity upwind of the break, but subtractive downwind of it. Thus its net effect is ignored in (12a).

The choice of the entrainment coefficient a is prompted by data reported for plumes[75,76] and work by Lofquist[(77)]. In Lofquist work, the important dimensionless parameters are the Reynolds number and the densimetric Froude number which he defines as

$$F \quad \frac{2\,(dR/dt)}{\sqrt{2gh\left(\dfrac{\rho - \rho_a}{\rho}\right)}} \qquad (14)$$

He finds that even for very low Reynolds numbers (10^5) the entrainment is simply related to the F number and is independent of the Reynolds number. Figure 2.2-11 shows the values of a derived from Lofquist work. Examination of equations (9) and (14) shows that in our case, wherein $ap=p_C$, F is always greater or at most equal to 2 since $p_C > p_a$ and S is positive.

From the figure than a is taken as 0.1 larger. Values reported by others are also in the neighborhood of 0.1 to 0.12. Hence a value of 0.1 can be chosen as conservative (less dispersion to lower Propane concentrations).

Mass conservation requires that

→(DRN 06-905, R15)

$$\frac{dM_c(t)}{dt} \quad \rho_a Q(t) + \frac{B}{h_g \quad h_f} \pi r_{max}^{\ 2} \tag{15}$$

←(DRN 06-905, R15)

where $M_c(t)$ is the mass of the cloud at time t.

Energy conservation further requires that:

$$\frac{d(CM_c T)}{dt} \qquad C_a \, \rho_a \; Q(t) \; T_a \; + \; Q_g \; + \; Q_w \; + \; Q_p \tag{16}$$

→(DRN 06-869, R15)

In equation (16) C, and T are the cloud heat capacity and temperature at time t, C_a and T_a the air heat capacity and ambient temperature in °R

Q_w is the heat of condensation or freezing of any water vapor, which is set to zero in the interest of maximizing cloud travel. Q_p is the heat content of the total propane at time t, which is computed from m_p being the effluent rate in lb/sec and $^P98$ being the heat content of propane vapor at -44°F referred to zero at °R.

←(DRN 06-869, R15)

Q_g is the heat transferred by the ground to the cloud. To minimize heat transfer, it can be assumed that this heat is transferred in the natural convection regime, where

$$Q_g \qquad h\pi \; R(t)^2 \left[T_g \; - \; T(t)\right] \tag{17}$$

with h given by equation (3).

Equations (9), (15) and (16) are solved numerically given an initial cloud radius, r_{max}, height, h_{in}, and temperature, -44°F, to yield the configuration of a homogeneous cloud as a function of time.

The progress of the cloud is either followed until the cloud concentration falls below the lower flammable limit (2.4 percent), assuming no atmospheric dispersion, or it can be stopped when the cloud velocity falls below the prevalent wind velocity at which point atmospheric dispersion would be assumed to commence.

With this approach only average (time and space) cloud properties can be obtained.

Figure 2.2-12 shows downwind and downslope distances achievable by a cloud of 2.4 percent concentration of propane for different wind velocities. Also shown is the cloud final height at that concentration.

These are for a variety of terrain configurations. The terrain configuration most resembling the Waterford site is that of open ground (i.e., large channel 1200 ft).

The results of Figure 2.2-12 which are obtained for an average ground slope of less than one percent show that under extraordinary conditions in which the wind velocity closely matches the cloud velocity, a ground confined cloud can travel long distances. Although molecular diffusion, which will take place between the air and the cloud has been ignored in the development of the previous equations, its contribution to decreasing the distance traveled by the cloud is not thought to be significant, except for the long distance clouds where it becomes the predominant effect.

→(DRN 06-869, R15)

In most instances however, the cloud will travel a distance of six to seven thousand feet or less in relatively narrow channels, and less as the channel width increases.

←(DRN 06-869, R15)

The final cloud height is relatively insensitive to the wind velocity (under the assumption of no atmospheric dispersion) and is in fact very much determined by the break outflow. The final height is further very much affected by the channel width. For large channels like the Waterford situation the cloud will not go far until atmospheric dispersion takes over.

The study also concluded that ground slope is not an important factor so long as it is limited to less than one to two percent. Much higher slopes would affect the results by increasing the equilibrium cloud speed.

Except for the analyses performed for the low wind velocities, it was shown that the cloud velocity falls below the wind speed rather soon. From that point on, clouds traveling long distances can only be obtained by assuming that atmospheric dispersion does not occur. This would of course only happen if the air flow is laminar (i.e. no disturbance), a condition which is extremely unlikely. Thus for Waterford it is concluded that atmospheric dispersion could dominate air-vapor transport.

At the point in which the cloud speed falls to the level of the wind speed, the more realistic assumption can be made that atmospheric dispersion begins. The concentration downwind can then be obtained from the equation for a continuous line source.

→(DRN 06-905, R15)

$$X \quad \sqrt{\frac{2}{\pi}} \quad \frac{Q}{Lu\sigma_z} \quad exp\left(\frac{z^2}{2\sigma_z}\right) \quad \left[erf\left(\frac{L/2 \quad y}{\sqrt{2\sigma_y}}\right) erf\left(\frac{L/2+y}{\sqrt{2\sigma_y}}\right)\right] \qquad (18)$$

←(DRN 06-905, R15)

→(DRN 06-869, R15)

in which Q is the source strength in ft^3/sec, u the wind speed in fps, L the width of the source which is taken to be that of the cloud spread across the wind at the point in time at which the cloud speed equals the wind speed.

For points along the wind direction, y = O, and equation (18) for ground level reduces to

←(DRN 06-869, R15)

→(DRN 06-905, R15)

$$X \quad 2\sqrt{\frac{2}{\pi}} \quad \frac{Q}{Lu\sigma_z} \quad erf \quad \frac{L/2}{\sqrt{2\sigma_y}} \qquad (19)$$

←(DRN 06-905, R15)

The virtual location of the line source is chosen upwind of the point at which the cloud and wind speed become equal, by solving the following equation

$$X_u \quad \frac{dR}{dt} \quad 2\sqrt{\frac{2}{\pi}\frac{Q}{uL_{\frac{u \quad dR}{dt}}s_z}} \quad \text{erf}\ \frac{L/2}{\sqrt{2}_{\sigma_y}} \qquad (20)$$

where X = dr/dt is the computed concentration, in volume fraction, at the time in which the wind velocity equals the cloud velocity. In equations (18), (19) and (20) the downwind distance does not appear explicitly, but is found by trial and error solution for σ_z and σ_y, the dispersion parameters which are functions of that distance. These are the same as those used in the previous section.

→(DRN 01-464)

Equation (18) has been used to calculate the width of a source and its distance upward that would produce concentrations of 2.4 percent of propane at a point. The results are shown on Figure 2.2-13 for both cases examined, i.e. $\sigma y^2 \simeq \sigma_z$ and $\sigma y \simeq 5\sigma_z$.

←(DRN 01-464)

From this figure it is clear that for winds in excess of 2.6 fps, sources located upwind at distances larger than 5000 or 10,000 ft, cannot produce concentrations higher than 2.4 percent of propane. Lower wind speeds could. However Figure 2.2-12 shows that for these low wind speeds the mass flow rate is large enough to result in significant entrainment prior to atmospheric dispersion. Conversely where entrainment is low, atmospheric dispersion is significant. The combination of the Figures 2.2-12 and 2.2-13 therefore indicate that a maximum credible cloud distance would be of the order of 5000 ft. These figures are of course applicable to the release of 100 lb/sec characteristic of the 8 in. line.

→(DRN 01-464)

That these are the maximum credible distances is further confirmed by the fact that the time required for the formation of such clouds is roughly comparable to the time required to isolate the break, which is approximately 1/2 hour. To generate much larger clouds the flow of propane from the break would have to continue uninterrupted at the assumed rate for much longer times.

←(DRN 01-464)

For these distances, no portion of the flammable cloud originating from the 8 in. line break would reach portions of the plant structures. Intakes would not be expected to take up flammable vapors. The same conclusion can of course be applied to the 6 in. break line.

The detonation of such clouds has been evaluated in the preceding sections and presents no hazard.

f) Calculation of Deflagration Hazards

The possible hazards from the deflagration of the clouds are next addressed.

A vapor cloud of flammable concentration may burn (deflagrate) or detonate (if within the detonable limits) or both types of combustion may occur in case of transition from deflagration to detonation. Volumetric explosions may also occur, particularly, if partial confinement of the cloud exists. More likely pockets of gas in a cloud may explode volumetrically if heated to the autoignition limit by radiated heat or shock waves.

In general, therefore, one should consider deflagration, detonation, and volumetric explosion to be the common modes of combustion. In our case due to the unconfined nature of the cloud the latter mode cannot occur, and it is only necessary to address detonations and deflagrations.

For detonations all of the thermodynamic properties, detonation velocities and flow properties behind the detonation front are calculable from standard thermodynamic equilibrium calculations.

→(DRN 01-464)

If one defines as U_1 and U_2 the velocity of the unburned gas and burned gas with respect to the stationary detonation wave, then with respect to a stationary observed U, U is the detonation velocity and W =U_1 - U_2 is the velocity of the gas behind the detonation wave front.

←(DRN 01-464)

Further the thermodynamic states behind the detonation front are described by the Hugoniot equation

$$DE \quad E_2 \quad E_1 \quad \frac{1}{2}(p_2 + p_1)(v_1 \quad v_2)$$

wherein p and v are the pressure and specific volume and E the energy and 1 and 2 denote the unburned and burned states respectively.

→(DRN 01-464)

The actual detonation involves a passage through a family of Hugoniot curves, which proceed from the curve corresponding to no chemical reaction wherein $\Delta E = E_2 - E_1 = C_V (T_2 - T_1)$, C_V is the average specific heat at constant volume between temperatures T_1 and T_2 before and after the passage of the wave front to the curve corresponding to complete chemical reaction in which case

←(DRN 01-464)

$$E_2 - E_1 \quad C_v \left(T_2 - T_1\right) - \Delta E_c$$

wherein ΔE_C is the energy released in the combustion process.

Figure 2.2-15 shows both Hugoniot curves. The Hugoniot curve for the complete reaction is distinguished by two branches. The branch from A to V is the "detonation" branch and the one from B to C is the "deflagration" branch. It has been shown that the only possible state detonation is the detonation proceeding at the minimum detonation velocity (see Reference 80). This is the Chapman Juguet detonation and the resulting detonation overpressure can be found by running a tangent line to the detonation branch from the original condition. The resulting C-J overpressure for stoichiometric propane air mixture has been determined to be p_2/p_1 = 17.8 from an initial state of 14.7 psi and 460°F.

That value is closely correspondent to that reported by J. H. Lee (Reference 81). Point A corresponds to the overpressure resulting from a adiabatic constant volume explosions. The value obtained of p_2/p_1 = 8.5 differs slightly from that quoted in various references including Reference 1, which reports 8.34. The difference is due to the initial state assumed for these calculations which was 0°C, whereas others generally used 25°C.

The intersection of the tangent line with the Hugoniot curve for no reaction is the Von Neumann spike which precedes the C-J detonation pressure. Its computed value is approximately p_2/p_1 = 28, again in close agreement with values reported in the literature.

The detonation velocity which is given by

$$U_1 \quad D \quad v_1 \sqrt{\frac{p_2 - p_1}{v_1 - v_2}} \tag{23}$$

is computed to be D = 5330 fps or 1610 mps, which is in reasonable agreement with literature data.

In the detonation branch the flow velocity of burned gas, W, is in the same direction as the detonation wave. In fact it can be shown that (Reference 82)

$$D = W + C \tag{24}$$

where C is the velocity of sound in the burned medium.

Since the detonation wave travels supersonically with respect to the unburned medium, no disturbance precedes it, hence the cloud size remains at its initial size as the detonation propagates, i.e. the gas expansion occurs afterwards and has the effect of a rarefaction wave which tries to overtake the detonation wave at sonic velocity in the burned medium. This observation has been made by others (Reference 81, page 12). Further discussion of the subsequent expansion is given later on.

Thus the effects of the detonation blast of the wave of the propane gas clouds has already been properly addressed in the preceding subsections.

The portion of the curve between A and B corresponds to no real physical state. The portion of the Hugoniot curve between B and C represents a decrease in pressure and increase in volume, corresponding to a rarefaction.

The burned gas flow velocity, W, therefore is always negative, i.e. the burned gas no longer moves in the same direction as the wave, but away from it.

The consequence of this is that in this deflagrative process a precompression wave is sent out into the explosive mixture to push that unburned gas with a velocity just sufficient to ensure that the gas may come to rest when it is swept over and burned by the deflagration front.

Physically no deflagration occurs past the point C (Reference 80) which is known as a Chapman Jougnet deflagration point. In fact weak deflagrations (essentially constant pressure explosions) are those to be considered for vapor clouds explosions, and are the ones that have been observed in experiments.

Whereas the C-J detonation velocity represents the minimum of all detonation velocities, the C-J deflagration velocity is in fact the largest possible deflagration velocity, which is calculable from equation (24).

For the propane-air mixture studied (stoichiometric) the C-J deflagration velocity was computed to be 168 fps.

For weak deflagrations however the deflagration velocity is the same as the laminar burning velocity, 1.5-2.0 fps, hence thousand times less than detonation velocities.

However the spatial deflagration velocity, which would be that seen by a stationary observer is higher than the deflagration velocity computed by equation (23). This is due to the displacement of the unburned gases ahead of the propagating flame caused by the specific volume increase across the flame front. Since this increase is about eight fold, the spatial deflagration velocity is roughly eight times that computed by equation (23).

Hence for a C-J deflagration spatial velocities of the order of 1300-1400 fps could occur. In actual tests however (References 79 and 83) the spatial flame velocity has been measured to be of the order of 30-40 fps, for mixtures difficult to detonate (like propane air) and ten times larger for mixtures rich in oxygen.

The effect of oxygen richness is not surprising since lack of inerts such as nitrogen has the effect of raising the Hugoniot curve for complete reaction to higher values. For instance the C-J detonation point for a stoichiometric propane-oxygen mixture would correspond to overpressure almost exactly double that occurring for the detonation of propane-air mixtures, with detonation velocities 30 percent higher. Similarly the C-J deflagration velocities for oxygen rich mixtures is expected to be higher than that for propane-air mixtures.

Hence C-J deflagrations of any kind exhibit velocities in excess of 1300 fps. The fact that no such spatial burning velocity has been observed confirms that C-J deflagrations do not occur, but that only weak deflagrations, i.e. basically constant pressure burning occur.

For these kind of deflagrations, the precompression sent into the unburned medium and surrounding air is in the nature of basically an acoustic wave. It does not steepen into an air shock unless spatial flame velocities of 300 fps or more are achieved, as shown on Figure 2.2-16 (taken from Reference 81).

Likewise there is no overpressure of great significance within the deflagrating cloud. For typical spatial burning velocities of 30 fps or less, overpressures of about 1 psi will occur just ahead of the flame front. Hence it is concluded that blast damages are insignificant for deflagrative burning of propane air clouds either near or far from the cloud. Hence for a deflagration the possible damage is limited to temperature.

In a detonation event, after passage of the initial detonation blast, the compressed products expand. Under the assumption that this expansion is isentropic, the final volume will be approximately 9.7 times initial volume (assuming K = 1.25) (for an oxygen rich detonation these rates would be more than double). This expansion in turn can generate a second shock in the air ahead of the expanding products of the detonation, which follows the initial shock caused by the hydrodynamic coupling of the detonation wave and the air.

This second shock is one order of magnitude smaller than the first air shock (see Reference 38) and exhibits the same decay with distance from the center of detonation as the first and much stronger shock.

Since the Waterford plant has been shown to withstand the first shock overpressures, it is also safe against the weaker second shock caused by the expanding detonation products.

During the preceding it has been tacitly assumed that the flammable cloud is entirely formed of a stoichiometric mixture of propane and air (or oxygen). This was of course the case for all experiments conducted (see References 38,79,81,82). In fact, the computed propane air clouds as shown on Figures 2.2-8 and 2.2-9 exhibit a range of mixtures which are only stoichiometric in a region which at ground level is centered about the 1300 ft and 3500 ft from the origin of the cloud. At closer distances to the origin of the cloud, ground level concentrations are overrich and farther away they are leaner than stoichiometric.

Since the propane plume downward of the 1000 ft^3 /sec source is shown to present the greatest hazard to the plant, Figure 2.2-9 has been modified to reflect the larger span of mixture concentrations within which a deflagration can occur. Whereas the detonable limits for propane air mixtures are 7.0 and 2.8 percent by volume of propane, the limits of deflagrations are 9.0 and 2.2 percent.

The volume of flammable mixture contained within the vapor cloud shown on Figure 2.2-9 is computed to be 1.95×10^7 ft^3, whereas the detonable volume is only 1.15×10^7 ft^3.

Hence 40 percent of the total flammable volume has concentrations below 2.8 percent, or below 0.7 times the stoichiometric concentration of 4.12 percent.

→(DRN 01-464)

The expansion of a mixture of less than 67 percent stoichiometric concentration (as well as that of concentrations above 120-130 percent of stoichiometric mixtures) is at least 30 percent less than the expansion of stoichiometric mixtures. This results basically from the lower flame temperature. The expansion given on Figure 2.2-15 as point B is thus applicable only to stoichiometric concentrations. Conservatively therefore the final volume of the de-flagrated vapor cloud can be estimated by expanding the volume of 2.8 percent or larger propane concentration to a final volume eight times larger, and the volume of lower concentration to a volume 5.5 times larger. The resultant final volume would be 1.35×10^8 ft^3.

←(DRN 01-464)

Assuming that the original cloud can be represented as a hemiellipsoid of 4564 ft, 143 ft, and 28.6 ft in the downwind, crosswind and vertical direction respectively, centered at 2734 ft from the break, and that the deflagration is centered at that point, the final dimension of the product cloud downward will be 6717 ft from the break.

The closest distance from the 8 in. pipeline to a safety structure in Waterford 3 is 7350 ft. Hence it is concluded that the deflagration of the "worst" cloud ensuing from a catastrophic break in such a line poses no hazard to the plant.

g) Summary Conclusion

To summarize the preceding sections, the transport of propane clouds toward the Waterford 3 site has been investigated from a purely atmospheric dispersion standpoint, gravity slumping, and a combination of atmospheric dispersion and gravity slumping.

Although the analyses demonstrate that it is possible for a flammable cloud to form in the vicinity of the plant site, deflagrations, fires or detonations of the cloud will pose no hazard to the plant.

2.2.3.1.3.3 Stationary Sources Presenting Explosive Hazards

→(DRN 01-231)

Table 2.2-3 indicates the types, quantities and locations of potentially hazardous materials as they are presently known (refer to Appendix 2.2A.1 for a historical assessment of hazards from Acrolein in tanks). Not all information has been located for the Union Carbide Company. However, Union Carbide has identified the two potentially most hazardous sources of material, and these have been listed. Of these two, the propylene tank which can contain as much as 5.78 x 10^6 lbs of propylene is the worst hazard and is located closest to the plant. Except for this tank, on the basis of the information presented in Table 2.2-3, the detonation of butene- 1 in the largest tank (assumed to be located approximately 6300 ft from the Waterford plant) has been determined to be the most severe realistic hazard. The detonation of the tank filled with butene-1 in concentrations within the flammable limits (1.6 to 9.3 volume percent in air) would correspond to the detonation of approximately 500-1000 lb of detonable mixture. Assuming 100 percent equivalency with TNT, the detonation of this mixture poses no hazard to the Waterford plant in terms of blast overpressures. From the work of Ahlers, shown on Figure 2.2-17, missiles and debris accompanying such detonation would also present no hazard.

←(DRN 01-231)

In addition, even though ammonia is not considered as a detrimental flammable/explosive material by the U S Dept. of Transportation, theoretically ammonia can ignite. Hence the hazards to the Waterford plant from the large liquid ammonia tanks located 3200 ft. away for the closest 10,000 ton tank and 4225 ft. away for the prospective 45,000 ton tanks have also been examined. In either case peak overpressures resulting from the detonation of the tanks (assumed to be full of detonable mixture of NH_3 and air) have been computed to be less than 1 psig, and missiles resulting from such event are on the average expected to fall short of the distance to the plant (from Ahlers work). Hence these tanks also present no hazards to the Waterford plant.

The relative closeness to the plant coupled with the very large size of the propylene tank deserves more consideration.

This tank is located in the northwest section of the Union Carbide plant. Although the exact location is not known, it is reasonably certain that the tank is no closer than 7400 ft. to safety related structure and components of the Waterford 3 plant.

Utilizing the methodology of Reference 79, the hazards to the plant resulting from the detonation of the entire tank contents can be evaluated, to assess very conservatively the upper limit of the effects of the tank detonation. Per Reference 79 the TNT mass equivalency of propylene is 225 percent. Even under the unrealistic assumption that the entire 5.78 x 10^6 lbs of propylene detonate, this detonation, which would be equivalent to the detonation of 6500 tons of TNT would result in a computed overpressure at the plant of 1.0 psi. A more realistic evaluation, which would consider that air needs to be mixed with propylene to form a detonable mixture, would indicate a yield of less than one tenth of the above. Hence the detonation of the propylene tank in situ, presents no hazard to the plant.

The hazards presented to the plant by a vapor cloud that might be formed as a result of the tank failure, with delayed ignition of the cloud are studied below.

Since the break area of the tank cannot be known, the hazards from such postulated events have been assessed for a number of breaks ranging from a catastrophic failure instantly releasing most of the contents of the tank, to a break size which would result in a release of 100 lb/sec. The latter was chosen since the hazards to the plant from similar propane sources, located at virtually identical distances, have been assessed and found to be acceptable.

According to Union Carbide only 2,600,000 lbs of propylene vapor can be released to form a cloud. The catastrophic failure of the tank, resulting in the instantaneous release of the 2.6 x 10^6 lbs is evaluated by following the gravity slumping of the ensuing cloud. The method used in Section 2.2.3.1.3.2.e) has been modified to account for instantaneous sources following the methodology of Reference 74.

The radius of the spill prior to gravity spreading is computed from equation (7), wherein the liquid regression rate, Q, is given by equation (8). For propylene, which has a boiloff rate of approximately 30,000 BTU/ft^2 hr, and a heat of vaporization of 180 BTU/lb, the liquid regression rate can be computed to be 3.8 x 10^{-4} mps. The instantaneous spill would then result in a pancake shaped cloud having an initial radius of 470 ft, and an initial height of 25 ft. This cloud expands as it slumps under its own weight. For the terrain configuration around the tank and the Waterford plant this expansion will be essentially a pure radial expansion.

The velocity with which the cloud advances is computed from equation (9) wherein the ground slope effect is neglected since it is minimal and in fact would tend to draw the cloud away from the plant. The amount of air which is entrained by the cloud surface as it advances is computed from equation (12a).

Solution of the mass and energy conservation equations (equations 15 and 16, respectively) yield the configuration of a homogeneous cloud as a function of time.

For the instantaneous spill resulting from the catastrophic tank failure, the radius of the cloud having a homogeneous lower flammable limit concentration is calculated to be 2440 ft.

The velocity of the cloud front at this time is 6 fps, which is still higher than the condition F meteorology wind speed of 2.6 fps. Hence gravity slumping is the dominant mode of dispersion. From the analyses of Subsection 2.2.3.1.3.2 f), it is clear that the

deflagration of this cloud would pose no hazard to the plant. Likewise detonation effects present no hazard.

For breaks which are intermediate between the catastrophic and that resulting in 100 lb/sec it has been calculated that the clouds of similar composition are not as extensive, i.e. more of the propylane disperses past the lower flammable limit. Hence they present less hazards to the plant than those resulting from a catastrophic break.

A similar observation has been made by Reference 74. It is therefore concluded that the propylene tank presents no hazard to the plant safety structures and components.

→

2.2.3.1.3.4 Hazard Assessment of the Air Products Hydrogen Pipeline Project

In the Fall of 1994 construction started on the Air Products and Chemicals, Inc. hydrogen pipeline project. This pipeline transports hydrogen from the Dupont Chemical, Inc. plant in Reserve to the Union Carbide Corp. plant in Taft. The 12.75 inch diameter pipeline enters the LP&L property to the southwest of Waterford 3, just south of the Union Pacific Railorad tracks. The pipeline then runs parallel to the railroad tracks and exits the LP&L property to the southeast of Waterford 3. There are no above ground sections of the pipeline on the LP&L property. The pipeline is buried to a minimum depth of five feet on the LP&L property. The closest above ground section of the pipeline is 3200 feet from the eastern boundary of the LP&L property. The estimated flow rate of hydrogen in the pipeline is 36.48 $(10)^6$ scf/day. References 101 through 105 provide a detailed description of the pipeline.

Key parameters related to the explosion of the new hydrogen pipeline were compared to key parameter related to the explosion of the Evangeline Natural Gas Pipeline (FSAR Section 2.2.3.1.3.1.2), at the pig trap station, to show that the explosion effects associated with the new hydrogen pipeline are much less severe than the explosive effects of the Evangeline Pipeline. Reference 106 shows the detailed comparison.

The key parameters that were compared are:

1. Size of the explosive cloud, based on the major semiaxis of the lean ellipsoid.

2. Distance from the center of mass of the explosive cloud to the Waterford 3 safety related structures.

3. Specific heating value of the air/gas mixture.

The results of the comparison were that:

1. The explosive cloud from the hydrogen pipeline rupture is much smaller than the cloud from the Evangeline pipeline rupture. The lean hydrogen cloud from a pipe break is approximately slightly more than one third the size, based on the major semiaxis, of the lean natural gas cloud from the Evangeline pipeline break.

2. The distance from the center of mass of the hydrogen cloud to the Waterford 3 safety related structures is much greater than the distance from the center of

←

mass of the natural gas cloud to the safety related structures. The distance from the center of the explosion to the safety related structures for the hydrogen pipeline is slightly greater than double the distance for the Evangeline pipeline.

3. The specific energy liberated from the stoichiometric combustion of both the hydrogen/air mixture and the natural gas/air mixture is identical.

The consequences of the potential hydrogen pipeline break and explosion are therefore less severe than the consequences of the break and explosion of the Evangeline natural gas pipeline, at the pig trap station. The allowable overpressure, on the Waterford 3 safety related structures, is 3.0 psi (design basis). The design basis overpressure event is the LPG tank truck explosion, on highway 18, as presented in FSAR Section 2.2.3.1.2. The maximum overpressure from an explosion on the Evangeline pipeline, at the pig trap station, is slightly less than 1.0 psi. The overpressure from an explosion on the new hydrogen pipeline would be much less than 1.0 psi, as shown above. It is thus concluded that the potential hazard posed by a break and explosion of the new hydrogen pipeline is well within the design basis of the Waterford 3 safety related structures and is in fact bounded by previously analyzed explosive events.

2.2.3.1.4 Potential Hazards From Externally Generated Missiles

→(DRN 03-2055, R14; 05-149, R14)

A review of hazardous chemicals which have a potential for generating missiles, that may arrive at the plant, shows that there are no events that may cause any damage to the plant which would result in radionuclide release in excess of 10CFR50.67 guidelines.

←(DRN 03-2055, R14; 05-149, R14)

All railroad lines in the vicinity of Waterford 3 have been considered in order to determine whether a "rocketing" tank car event could pose any threat to safety-related structures. The closest rail line which carries explosive materials is located at a distance of 0.45 miles (2375 ft.) from safety-related structures. This distance as greater the ranges of fragments of the train accident in Laurel, Mississippi[41]. The range of the "rocketing" car in Laurel, Mississippi, accident was 1100 ft. while small fragments had a maximum range of 1600 ft. Thus there are no hazards from "rocketing" rail cars or their fragments, for the Waterford 3 safety-related structures.

A spectrum of events was considered in analyzing the trajectories of externally generated missiles. The cases of deflagrative explosions for the 300,000 bbl. gasoline tanker and the 10,500 gal. LPG truck were discussed above. Detonations which propel missiles which are not fragments (of the tanks containing the explosives) were also considered.

Detailed analyses show that for a missile spectrum which consists of a wooden plank, a three in. diameter schedule 40 steel pipe, a 12 in. diameter schedule 40 steel pipe, a utility pole and one in. diameter reinforcing bar, the conservative limiting case is encountered when an overpressure wave picks up a 12 in. diameter, 15 ft. long pipe at the site boundary and propels it towards the plant.

The impulse delivered to the missile is calculated by obtaining the overpressure (due to the detonation) at the location where the missile is picked up, and multiplying it by the cross sectional area of the missile and by the positive duration (stagnation time) of the overpressure wave at that location. The speed of the missile is then obtained by dividing

the impulse by the mass of the missile. For conservatism the actual speed of the missile was multiplied by a factor of two and the modified value was used in calculations.

The velocities of impact at walls and roofs of safety-related structures were obtained by numerically solving the standard ballistic equations (42).

Comparison of the Waterford 3 results and EPRI data[43] show that since all walls and roofs of safety-related structures are at least two ft. thick, and the concrete strength is at least 4000 psi (28 day crushing test), there is no danger of penetration and/or spalling of walls and roofs of safety-related structures caused by missiles picked up by overpressure waves.

2.2.3.2 Delayed Ignition of Flammable Vapor Clouds

A combustion wave propagates by the process of heat transfer and diffusion, whereas a detonation wave is a shock wave which is sustained by the energy of the chemical reaction initiated by the temperature and pressure of the shock wave. Thus in order to have a detonation certain conditions are necessary in order to form shock waves.

These conditions are inherently absent in free clouds (confined space may result in shock formation) and thus the probability of a detonation is extremely low. It is nevertheless possible that a detonation can be set off by shock waves generated either at a pipe break location as a result of the sudden decompression, or at openings in structures where deflagration has taken place. The former cannot result in a significant detonation since very little vapor would have escaped the break.

Deflagration, rather than detonation, of a flammable cloud would result in lower overpressures and dynamic pressures at the safety related structures. Such a firestorm and associated winds, would not cause damage due to overpressures.

The size and duration of fireballs is given by Strehlow and Baker[44] as

$D = 3.86\ W^{0.32}$ (diameter in meters)

$t = 0.299\ W^{0.32}$ (duration in seconds)

Where W is the weight in kilograms.

In the case of the LPG tank truck, it is conservatively assumed that the entire load vaporizes. The resulting propane cloud weighs.

$$W = 10{,}500 \text{ gal} \times 0.1337 \frac{\text{ft}^3}{\text{gal}} \times 36.2 \text{ lbm/ft}^3 \text{ (liquid propane)} \times \frac{\text{lkg}}{2.2\text{lbm}}$$

$$= 2.3 \times 10^4 \text{ kg}$$

→(DRN 01-464)

the diameter would be

$D = 3.86 \times (2.3 \times 10^4)^{0.32} = 96$ meters = 315 ft, and the duration of the

←(DRN 01-464)

fire would be

$t = 0.299 \times (2.3 \times 10^4)^{0.32} = 7.44$ sec.

If the cloud were to travel towards the plant and burn for the 7.44 seconds, it will get only 19.34 ft. closer. Thus conservatively assuming that the cloud ignites at the location of accident,(36) and that it travels 19.34 ft, it will still be approximately 125 ft. away from safety-related structures.

To calculate the heat load on the plant from a propane cloud 125 ft. away, the relation for radiation heat flux is used.

→(DRN 01-464, R11-A)

$Q = \sigma (T^4{}_f - T^4{}_{ambient})$ where $\sigma = 1.714 \times 10^{-9}$ BTU/hr ft^2°R^4 and a conservative flame temperature (17) T_f of 2198°K, while $T_{ambient}$ = 70°F or 529.7°R.

←(DRN 01-464, R11-A)

$Q = 1.714 \times 10^{-9}$ BTU/hr-ft^2-R^4 $[(2700)^4 - (529.7)^4]$ R^4

$= 4.18 \times 10^5$ BTU/hr-ft^2.

Thus, under conservative assumptions, where no credit for attenuating factors is taken, the heat load on the wall is 4.18×10^5 BTU/hr-ft^2 = 116.34 BTU/sec-ft.^{2}, for the short duration of 7.44 seconds. This will cause surface skin-heating effects on the outside walls, but the short durations involved will not compromise the integrity of any safety-related structure.

→(DRN 01-464, R11-A; 05-149, R14)

The deflagration of a propane vapor cloud does pose a hazard from rapid combustion or deflagration, and resulting effluent generation. However, it does not place the integrity of safety related structures in jeopardy, and cannot result in radionuclide release in excess of 10CFR50.67 guidelines and as such, it is not considered a design basis accident. Other sources of flammable vapor clouds are considered to present lesser hazards due to greater distances from the site and the conservatisms of the propane vapor cloud analyses.

←(DRN 01-464, R11-A; 05-149, R14)

2.2.3.3 Design Basis Toxic Chemicals

→(EC-5000082218, R301)

Information regarding the storage, transport and use of materials cited in Tables 2.2-3B through 2.2-3G, 2.2-5, and 2.2-6 indicates that there are several sources for release of toxic chemicals which have a potential for adversely affecting main control room habitability. In addition to chlorine detectors, a Broad Range Gas Detection System (BRGDS) has also been provided which is capable of detecting airborne concentrations of various organic and inorganic compounds. A discussion of the BRGDS has been presented in Subsection 6.4.4.2. The presence of detectable chemicals at the air intakes would trip these detectors resulting in the sounding of an alarm and the automatic isolation of the control room. The accidental releases of toxic gases from onsite and offsite facilities have been analyzed in detail and determined to pose no threat to control room operators.

Following guidance in Regulatory Guide 1.78 (June, 1974), consideration was limited only to those chemicals which are present within a distance of 5 miles from the main control room air intakes. The calculations were performed for the entire range of meteorological conditions presented in Section 2.3, and were based on main control room characteristics which are described in Section 6.4.

←(EC-5000082218, R301)

2.2.3.3.1 Volatility and Chemical Stability of Toxic Chemicals in the Air

→(EC-5000082218, R301)

Chemicals that are nonvolatile solids or liquids, or that spontaneously combust in air do not pose a threat to control room habitability. Consideration of these factors led to the elimination of many chemical sources from toxic hazard evaluation. The relevant physical and chemical data were obtained primarily from Sax's Dangerous Properties of Industrial Materials[45], the CRC Handbook of Chemistry and Physics[46], Lange's Hanbook of Chemistry[110], and Perry's Chemical Engineers' Handbook[111]. Substances such as sulfur were eliminated because they are solids. Aqueous solutions of nonvolatile solids such as sodium hydroxide were eliminated because, while the solvent may evaporate, the solute is nonvolatile. Chemicals with vapor pressures of less than 10 torr (mm Hg) at 100°F were eliminated, since Regulatory Guide 1.78 does not require consideration of such chemicals.

→(DRN 01-464, R11-A)

Other toxic materials were eliminated on the basis of RG 1.78, Table C-2. This was done by comparing the toxicity of the chemical, either on the basis of its IDLH value (if listed), the lowest toxic threshold concentration listed by Sax[45] or information in the Material Safety Data Sheet and other sources. When data was not available, the toxicity limit was estimated by one of the methods described in NUREG/CR-1741[94] or in Reference 112. The Waterford 3 control room satisfies the requirements for Type B for those chemicals which can be detected by the BRDGS, and for Type C for those which cannot. The initial elimination screening was based on the assumption that the chemicals would not be detected and, consequently, the sources of toxic chemicals were compared in the quantities for a Type C control room. The Waterford 3 control room has an air exchange rate of approximately 0.86 volumes per hour as compared with a value of 1.2 volumes per hour for the Type C control room considered in RG 1.78. The worst 5 percentile meteorology for the Waterford site corresponds most closely to Pasquill stability class G for which a multiplier of 0.4 is required by RG 1.78. Using these facts and adjusting for the toxicity of the specific chemicals if different than 50 mg/m^3 as used in Table C-2 of RG 1.78, the minimum quantity of each chemical that required consideration, according to RG 1.78, was then determined and compared to the maximum amount stored.

←(DRN 01-464, R11-A; EC-5000082218, R301)

2.2.3.3.2 Methods of Assessing Accidental Releases of Volatile Toxic Chemicals

Assessments of control room habitability following accidental releases of volatile toxic chemicals were performed for vapors that are heavier than air, both the release and the receptor of which are to be at ground level. For lighter-than-air gases and vapors, the release is assumed to be at the same elevation as the control room outside air intake. The methods of analysis followed the general guidance of Regulatory Guides 1.78 and 1.95, and utilized the detailed release and atmospheric transport model described in Reference 86. The general features of the analyses are described below.

→(DRN 01-464, R11-A; 02-87, R11-A; EC-5000082218, R301)

For stationary and mobile sources, the assumption was made that the largest container of a given toxic chemical at a particular site fails and instantaneously releases all of its contents into the environment. For chemicals whose boiling points are below their storage temperatures, the fraction which flashes was calculated from a heat, or enthalpy, balance. The rate of vaporization of the remaining liquid was determined by evaluating the rate of heat transfer into the liquid from the ground, air and solar radiation. If the boiling point of the liquid is higher than the ground temperature, the evaporation rate is calculated on the basis of the vapor pressure of the liquid, the wind velocity and the surface area of the spill. This area depends on the mass of the liquid as well as the topographical characteristics of the spill site. For example, a retaining wall may restrict the spread of liquid released from a stationary tank, and a drainage ditch may contain a spill from a truck. Since, in most cases, the surface of the ground cannot be described accurately or predicted in advance the area of the spilled liquid was calculated according to Van Ulden.[51][86] In those cases where the stored chemical was surrounded by a dike adequate to contain the entire volume of a possible spill, the area of the spill was restricted to the area of the dike.

←(DRN 01-464, R11-A; 02-87, R11-A; EC-5000082218, R301)

→(DRN 01-464, R11-A; 02-87, R11-A)
←(DRN 01-464, R11-A; 02-87, R11-A)

The liquid which remained after the initial flash was assumed to be in the form of a right circular cylinder with a radius equal to its height. Under the force of gravity, liquid is assumed to spread radially, its area being given by:

$$A(t) \quad \pi\left[r_o^2 \;+\; 2t\left[\frac{g\,V_o\left(\rho_1 - \rho\right)}{\pi\rho_1}\right]^{1/2}\right]$$

$$\text{and } V_o \quad \pi\; r_o^3$$

Where:

r_o = initial radius of the spill (cm)

g = gravitational constant = 981 cm/sec^2

V_o = volume of liquid remaining after initial flash (cm^3)

ρ_1 = density of that liquid (g/cm^3)

ρ = density of air (g/cm^3)

t = time (sec)

→(EC-5000082218, R301)

The area of the spill is assumed to increase linearly with time until the liquid reaches a depth of 1.0 cm, or until the area equaled the area confined by the dike. Spill areas calculated by the above equation are much greater than the sizes of spills which the U.S. Department of Transportation expects to actually occur.(52) Thus, the calculated evaporation rate is much greater than that which would occur following an actual spill.

The atmospheric transport and dispersion of the initial puff was calculated according to the general model presented in Regulatory Guides 1.78 and 1.95. The transport and dispersion of the continuous plume evolving from the surface of the spilled liquid was calculated by the model presented in Reference 86. This reference also contains a detailed discussion of the entire release and atmospheric transport model. The short-term Pasquill-Gifford dispersion coefficients were calculated by formulae presented in Reference 95. For heavier-than-air gases, both the intake and the release were assumed to be at ground level; however, the concentration at the intake was assumed to be no greater than that which would result if the gas were uniformly dispersed in the vertical direction up to the level of the intake.

←(EC-5000082218, R301)

→(EC-5000082218, R301)
The models described above were used to calculate concentrations of toxic chemicals outside the main control room air intakes. This was done for the entire range of meteorological conditions presented in Section 2.3
←(EC-5000082218, R301)

The concentration of a toxic chemical inside the main control room was calculated from the following equation:

$$C(t) \qquad e^{-vt} \int_{o}^{t} v e^{vt'} X(t')\, dt'$$

Where:

C (t) = chemical concentration inside the main control room at time t

X (t') = chemical concentration outside the air intake at time t'

v = Main control room air exchange rate

The toxic chemical concentrations calculated inside the main control room were assessed against their 'Immediately Dangerous to Life or Health' (IDLH) concentrations, which represent a maximum level from which one could escape within 30 minutes without any escape-impairing symptoms or any irreversible health effects.(87)

2.2.3.3.3 Evaluation of Stationary Chlorine Sources

→ (DRN 01-282)
Potential hazards posed by stationary sources of chlorine were evaluated by comparing such sources to the allowable quantities listed in Table 1 of Regulatory Guide 1.95. For the purpose of applying this Guide, Waterford 3 was assumed to have a Type II control room. Waterford 3 control room has local detectors, a normal air exchange rate of 0.66 vol/hr, (vs. 1 vol/hr in the Guide), and a measured leak rate of less than 0.06 vol/hr. The response time of the chlorine detectors is a function of the instantaneous chlorine concentration as well as ambient temperature. A calculation of the concentration build-up following a postulated release under various conditions indicates that the isolation time is less than or equal to 4 seconds, which is the isolation time stipulated by RG 1.95 for a Type II control room.
← (DRN 01-282)
The stationary source of chlorine posing the greatest potential hazard is a tank on the site of the Occidental Chemical Co. (Oxychem), which contains 400 tons and is located 1506 meters from the Waterford 3 control room. At this distance, the maximum allowable quantity calculated by log-log interpolation, in accordance with the guidance of RG 1.95, is 685 tons. A 600 ton chlorine tank at a distance of 1677 meters is also located at Oxychem; the maximum allowable quantity at this distance is 967 tons. The Waterford 3 control room therefore satisfies the guidance of RG 1.95.

The only mobile sources of chlorine posing a potential hazard are tank cars transported on the tracks of the Union Pacific Railroad. These were evaluated along with other toxic chemicals transported on the railroad, as discussed in Subsection 2.2.3.3.5.

2.2.3.3.4 Evaluation of Other Stationary Toxic Chemical Sources

The analysis of postulated accidents involving stationary sources of chemicals other than chlorine were performed in accordance with the guidance of RG 1.78, using the methods described in Subsections 2.2.3.3.1 and 2.2.3.3.2. The analyses modeled the detection of chemicals required to be monitored by the BRGDS. In case of a serious accident, operators were assumed to don breathing apparatus two minutes after the alarm.

→(EC-5000082218, R301)
Several of the respondents to the 2004 survey provided the location of the potentially hazardous sources on their plant plot plans or on the U.S. Geological Survey map of the area. In those cases, the distance from each source to the control room air intake was measured directly from the map. In other cases, the site was divided into zones, and the zone number of each source was given. In such cases the source was assumed to be located at the zone boundary nearest to the control room. Lacking more specific information, the source was assumed to be in the center of the facility.
←(EC-5000082218, R301)

To model the seasonal variation of ambient temperatures, 12 sets of data, one for each month, were constructed. Each data set included the 49 combinations of stability class and wind speed found in FSAR Tables 2.3-126 to –132. Stability classes E – G occur primarily at night. To calculate the average nighttime temperature, it was assumed that the temperatures at night are lower than the mean temperature for the entire day. It was also assumed that the nighttime temperature varied uniformly between the minimum temperature and the 24-hour mean temperature. Taking the average of these two temperatures yielded an approximate average nighttime temperature. The average ambient nighttime temperature for each month was thus calculated by taking the average of the mean temperature and the mean minimum temperature for each month, using data in FSAR 2.3-33. Since stability classes A-D may occur in the daytime, average daytime temperatures were calculated for those cases by substituting mean maximum for mean minimum temperatures in the process described above. Daytime ground temperatures were assumed to be 10° C higher than air temperatures while nighttime ground temperatures were assumed to be the same as the air temperatures.

The frequency of occurrence of a given set of meteorological parameters for a given wind direction was calculated as follows. Each value of the annual average joint frequency of wind speed and stability class, found in Tables 2.3-126 to -132, was divided by the fraction of time the wind was in that sector (i.e., the joint frequencies for the given compass direction were normalized to 1). Thus, each new value represented the probability of the joint occurrence of that particular wind speed and stability class combination, assuming the wind is in the given sector.

Accidents under each set of meteorological conditions for the given wind direction were then modeled. The control room was assumed to be habitable if the concentration inside did not exceed the IDLH Level by the time the operators were assumed to have donned breathing apparatus (two minutes after the alarm). If the control room was habitable under meteorological conditions occurring not less than 95% of the time for the given compass direction, the given source does not pose a hazard, according to the guidance of RG 1.78.

2.2.3.3.5 Analysis of Transient Sources

→(EC-5000082218, R301)

Transient sources (chemicals transported by truck, barge or rail in the Waterford 3 vicinity) were first analyzed in the same manner as the stationary sources. The release was postulated to occur at the point on the road, river channel or rail line closest to the plant. For those postulated accidents for which the habitability criteria discussed above were not met, a probabilistic risk analysis was performed as follows. The portion of the given transportation route within a five-mile radius of the control room was divided into a number of segments. An accident involving the total loss of lading of a single container was postulated to occur at the center of each segment. The probability that such an accident could cause the concentration in the control room to exceed the IDLH level within two minutes of detection was calculated, using the data on the joint frequency of occurrence of stability class, wind speed and direction in FSAR Tables 2.3-126 to -132. For a chemical that cannot be detected, the probability was calculated that the IDLH would be exceeded during 2 hours after the accident. (It is assumed that Waterford 3 would be notified by the St. Charles Parish Industrial Hotline within 2 hours of any major accidental release of toxic chemicals.) An overall annual probability of such an event was then calculated, using data on the frequency of shipment of that chemical in the particular transport mode.

←(EC-5000082218, R301)

2.2.3.3.6 Results

The hazardous chemical sources in the Waterford 3 vicinity, either stationary sources or transient sources treated as stationary, were analyzed using the methods described above. None of the stationary sources were found to pose a hazard under 95% percentile meteorological conditions.

→EC-5000082218, R301)

All chemicals frequently shipped by truck, ship or barge in the Waterford 3 vicinity, were analyzed, each cargo or shipping container being regarded as a stationary source. (RG 1.78 specifies the frequencies for each shipment mode that require consideration.). One of the river shipments was found to pose a hazard to Waterford 3 if treated as a stationary source. Six of the chemicals transported on the Union Pacific Railroad and one chemical transported by the Canadian National Railway posed potential hazards if treated as stationary sources. These were therefore analyzed by the probabilistic model described above. The results of these analyses are shown in Table 2.2-4A.

→(DRN 99-1089, R11; 01-076; 05-149, R14; 05-845, R14; EC-41671, R307)

These analyses showed that the overall probability that toxic chemicals frequently transported in the vicinity of Waterford 3 could pose a potential hazard to the Waterford 3 control room personnel is approximately 6.15×10^{-6} per year. Incapacitation of the operators will not necessarily lead to radiological releases in excess of 10CFR50.67 guidelines. The plant would have to experience a reactor trip and multiple system failures would have to occur to produce core damage. NUREG/CR-2650[(97)] suggests a value of 0.1 for the probability that incapacitation of the operators would lead to a radiological release in excess of 10CFR50.67 guidelines. With this factor, the probability that toxic chemicals frequently transported in the vicinity of Waterford 3 could cause a radiological release in excess of 10CFR50.67 guidelines is 6.15×10^{-7} per year. This probability may be compared to the guidance in Section 2.2.3 of Regulatory Guide 1.70 and Section 2.2.3 of the Standard Review Plan (NUREG-0800). As indicated there:

←(DRN 99-1089, R11; 01-076; 05-149, R14; 05-845, R14; EC-5000082218, R301; EC-41671, R307)

"...the identification of design basis events resulting from the presence of hazardous materials or activities in the vicinity of the plant is acceptable if the design basis events include each postulated type of accident for which the expected rate of occurrence of potential exposures in excess of the 10CFR100 guidelines is estimated to exceed the NRC staff objective of approximately 10^{-7} per year."

Furthermore,
"...the expected rate of occurrence of potential exposures in excess of the 10 CFR Part 100 guidelines of approximately 10^{-6} per year is acceptable if, when combined with reasonable qualitative arguments, the realistic probability can be shown to be lower." The model used to perform these probabilistic analyses employed a number of conservative simplifications.

- It was assumed that the operators will be immediately incapacitated by exposures to concentrations exceeding the IDLH. In fact, the IDLH is defined as a level to which a person can be exposed for 30 minutes without excape-impairing symptoms or permanent health effects.

→(DRN 01-282)

- The calculated release rate was maximized by assuming an instantaneous, complete rupture of the storage tank and an overly rapid expansion of the spill area.

←(DRN 01-282)
→(EC-5000082218, R301)

- The model assumes a delay of 2 hours before Waterford 3 is alerted by the St. Charles Parish industrial hot-line or through other agencies. It is most likely that the notification would occur sooner. The worst consequences of a release usually occur under low wind speeds; therefore there can be a considerable time lapse between the occurrence of an accident and the arrival of vapors at Waterford 3. The operators would be alerted and be able to take protective action during this period.

←(EC-5000082218, R301)

Since the probability is below the 10^{-6} per year criterion, the results indicate that the protective features described in the FSAR provide adequate protection for the control room operators.

2.2.3.4 Design Basis Fires in the Vicinity of the Site

See Subsection 2.2.3.2.

2.2.3.5 Collisions With The Intake Structure

Waterford 3 does not have a safety-related intake structure providing essential cooling water to the plant other than initial fill (see Subsection 10-4.5). Therefore, potential collisions with the intake structure have not been considered as design basis events.

2.2.3.6 Liquid Spills

For the reasons given in Subsections 2.2.3.3.1 and 2.2.3.3.2 liquid spills are not considered as design basis events for Waterford 3.

2.2.3.7 Aircraft Operations Evaluation

The information presented in Subsection 2.2.2.5 was evaluated to determine the level of hazard associated with aircraft activity near Waterford 3.

Security Related Information
Text Withheld Under 10 CFR 2.390

Security Related Information
Text Withheld Under 10 CFR 2.390

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4) Petrochemical Industry Survey, Economic Development Council, New Orleans, , May, 1977.

5) Mr. E. Wagner, Traffic Safety Engineer, Louisiana Department of Highways, Baton Rouge, Louisiana, March, 1977 and June, 1977.

6) Mr. Crabtree, Missouri Pacific Railroad, Personal Communication, April, 1977.

7) Mr. Wess Johnson, Missouri Pacific Railroad, Personal Communication, April, 1977.

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9) Mr. Lloyd Pence, Louisiana & Arkansas Railroad, Personal Communication, April, 1977.

10) Department of Transportation, Federal Railroad Administration, Letter, September 14, 1977, Updated in Letter, August 13, 1979.

11) Department of Transportation, Federal Railroad Administration, Factual Accident Report, Accident Investigation No. C-52-75, January 17, 1975.

12) National Transportation Safety Board, Railroad Accident Report, "Texas and Pacific Work Extra 523/Missouri Pacific Extra 1902 East Head on Collision," Taft, Louisiana, February 21, 1973.

13) Industrial Data Obtained as Follows:

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- Beker Industries, Taft, Louisiana, Letter, June 17, 1977
- Big Three Industries, Houston Texas, Letter, June 28, 1977
- E.I. DuPont De Nemours & Co., Ponchartrain Works, La Place, Louisiana, Letter, June 27, 1977
- General American Transportation Co., Good Hope, Louisiana, Personal Contact, June 7, 1977
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- Hooker Chemical Co, Taft, Louisiana, Letter, June 17, 1977 and Letter, March 8, 1979

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- Occidental Chemical Co., Taft, Louisiana, Personal Contact, June 3, 1977

- Shell Oil Co., New Orleans, Louisiana, September 15, 1977

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- Witco Chemical Co., Polymer Division, Taft, Louisiana, Letter, June 28, 1977

14) Crowell, Garret L., Chief, National Waterways and Harbors Office, Dept.2 of the Army, Corps of Engineers. Personal communication, March 10, 1988.

15) Mr. Lionel Ortego, Liquefied Petroleum Gas Commission, Baton Rouge, Louisiana, Personal Communication, December 12, 1983.

16) Pipeline Data was Obtained as Follows:

→(EC-5000082218, R301)

- Acadian Gas Company (A subsidiary of Enterprise Products Partners L.P.):
  Doug Kotar <DKotar@eprod.com> “RE: natural gas pipelines,” July 26, 2004, personal e-mail to Mark M. Brodeur, EMO – Gas & Oil Supply.
  Carey David <CDavid@eprod.com> “RE: Acadian pipelines,” 8/9/2004, personal e-mail to Robert Anigstein, Gemini Consulting Company.

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→ (LBDCR 15-048 R309)

MAJOR INDUSTRIES WITHIN FIVE MILES OF WATERFORD 3 **

← (LBDCR 15-048 R309)

Company Name	Approximate Distance* and Direction from the Reactor in Miles	Products	Employment
→ Shell Chemical - Taft	1.1 SE	Plasticizers & Stabilizers(1)	69
IMC Agrico ←	0.6 ESE & SE	Fertilizer Chemicals(2)	50
E.I. Du Pont de Nemours & Co. Pontchartrain Works	4.7 NW	Adiponitrile, Neoprene Chloroprene, Sodium Cyanide(2)	560
GATX	4.2 E	Storage of Petroleum Products, Food Oils(2)	163
Occidental Chemical Co.	0.8 E, ESE, SE, SSE & S	Caustic Soda; Chlorine; Sulfur Monochloride; Chlorinated Solvents; Perchlorethylene; Trichloroethylene(1)	666
→ Entergy Louisiana Little Gypsy SES	0.6 NNE	Generation of Electricity(2)	40
Entergy Waterford SES Units 1 & 2	0.36 NW	Generation of Electricity(2)	31
Koch Nitrogen Co. ←	1.2 SE	Anhydrous Ammonia & Liquid Nitrogen(2)	28
Shell Chemical Co.	2.5 ENE, E	Hydrogen Peroxide; Sulfolane; Hydrochloric acid; Calcium Chloride; Crude Epichlorohydrin; Acetone; Acrolein; Vinyl Chloride Monomer; Methyl-Ethyl Ketone; Secondary Butyl Alcohol; Glycerine; Soil Fumigant(1)	461

TABLE 2.2-1 (Sheet 2 of 3) (Revision 9 12/97)

MAJOR INDUSTRIES WITHIN FIVE MILES OF WATERFORD 3

Company Name	Approximate Distance* and Direction from the Reactor in Miles	Products	Employment
Shell Oil Co.	3.5 ENE, E	Ethylene; Gasoline; Jet Fuel; Fuel Oil; Asphalt; Other Refined, Petroleum Products(1)	945
→ Louisiana Resources Crawfish Gas Plant ←	2.8 ESE	Process Natural gas; produce raw product mix (Ethane, Propane, Butane and Gasoline)(2)	5
Union Carbide, Chemicals & Plastics Plant	1.2 E, ESE, SE & SSE	Cycloaliphatic Epoxides; Caprolactone; Misc. Olefins and Aromatics; Ethylene Oxide and Derivatives, Peracetic Acid; Epoxy Plasticizers; Glyoxal; Acrolein; Acrylic Acid; Acrylate Asters(1)	1,497
Praxair	1.2 E, ESE, SE & SSE	Industrial Gases(1)	31
→ Witco Chemical Co.	1.2 SE	White Mineral Oil, Petroleum Sulfonates Petrolatums(3)	57
TransAmerican Refining Corp.	4.2 ENE	Refined Petroleum Products	900
Air Products ←	1.1 ESE	Hydrogen	1

TABLE 2.2-1 (Sheet 3 of 3) (Revision 309 06/16)

MAJOR INDUSTRIES WITHIN FIVE MILES OF WATERFORD 3

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(1) 1975 Louisiana Directory of Manufacturers, State Industrial Directories Corp., New York, N.Y., 1975.

(2) Response to Ebasco Questionnaire Submitted June, 1977.

(3) Louisiana Chemical Industry Director, Louisiana Chemical Association, Baton Rouge, Louisiana, May 1976.

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*Distances were measured from the center of the Reactor Building to the nearest property line of the respective Industry, except for LP&L.

→ (LBDCR 15-048, R309)

** This Table contains historical information. The evaluation in section 2.2.2.2 is based on data shown in Tables 2.2-3A and 2.2-3B.

← (LBDCR 15-048, R309)

→

TRUCK TRAFFIC ACCIDENTS IN THE VICINITY OF WATERFORD 3 (1974-1986)

Year	Route	Mile Marker*	Number and Type of Vehicles if Known	Number of Fatalities	Number of People Injured	Comments
←						
1974	LA 0018	46.3	1 - Tractor trailer		0	Involved a farm tractor
	LA 0018	47.3	1 - Dump truck		2	
	LA 0018	47.5	2 - Dump truck & a flat bed truck		1	
	LA 0018	47.7	1 - Tractor trailer		1	
	LA 0018	47.8	1		0	Rear end collision at Gate 29 of the Union Carbide Plant
	LA 0018	47.9	1 - Flat bed truck		0	
1975	LA 0018	46.2	1		0	
	LA 0018	47.0	1		0	
	LA 0018	47.1	1		1	
	LA 0018	47.9	1 - Dump truck		0	
	LA 3141	0.9	1 - Tractor trailer		2	Involved a train at a railroad crossing
→						
1976	LA 0018	41.3	2		1	
	LA 0018	46.4	2		0	
	LA 0018	48.1	2		1	
	LA 0018	48.8	3		0	
	LA 0018	48.9	2		0	
	LA 0018	49.0	2		0	
	LA 0018	50.2	2		2	
	LA 0018	50.3	2		0	
	LA 0018	50.3	2		0	
	LA 0018	50.4	2		1	
	LA 0018	52.0	2		1	
	LA 0048	0.1	2		0	
	LA 0048	2.6	2		0	
	LA 0051	0.1	2		0	
	LA 0061	19.3	2		0	
	LA 0061	20.4	3		1	
	LA 0061	21.0	2		3	
	LA 0061	24.5	2		2	
	LA 3141	0.8	1 - Handling new cars		4	Involved a train at a railroad crossing

←

TABLE 2.2-2 (Sheet 2 of 13) Revision 2 (12/88)

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TRUCK TRAFFIC ACCIDENTS IN THE VICINITY OF WATERFORD 3 (1974-1986)

Year ←	Route	Mile Marker*	Number and Type of Vehicles if Known	Number of Fatalities	Number of People Injured	Comments
1977	LA 0018	46.7	2		0	
	LA 0018	47.4	2		0	
	LA 0018	47.7	2		0	
	LA 0018	47.8	2		1	
	LA 0018	48.7	2		0	
	LA 0018	50.0	2		0	
	LA 0018	51.1	2		0	
	LA 0018	51.3	2		1	
	LA 0018	51.8	2		1	
	LA 0018	51.8	2		0	
	LA 0018	52.2	2		0	
	LA 0048	0.4	2		2	
	LA 0061	19.3	2		0	
	LA 0061	19.3	2		1	
	LA 0061	20.4	2		0	
	LA 0061	20.5	2		0	
	LA 0061	20.5	2		0	
	LA 0061	20.5	2		1	
	LA 0061	20.5	2		0	
	LA 0061	21.0	2		2	
	LA 0061	26.1	2		0	
	LA 0061	26.1	2		2	

→

TRUCK TRAFFIC ACCIDENTS IN THE VICINITY OF WATERFORD 3 (1974-1986)

Year ←	Route	Mile Marker*	Number and Type of Vehicles if Known	Number of Fatalities	Number of People Injured	Comments
1978	LA 0018	50.5	2		1	
	LA 0018	51.0	2		0	
	LA 0018	51.1	3		2	
	LA 0018	51.3	2		0	
	LA 0018	51.3	2		0	
	LA 0018	52.0	2		2	
	LA 0044	47.8	2		2	
	LA 0048	0.2	2		1	
	LA 0048	0.4	2		0	
	LA 0048	0.4	2		0	
	LA 0048	0.8	3		0	
	LA 0048	1.0	2		2	
	LA 0048	1.0	2		0	
	LA 0048	1.2	2		0	
	LA 0048	1.4	3		1	
	LA 0048	1.6	2		1	
	LA 0048	2.1	2		1	
	LA 0048	2.2	2		0	
	LA 0048	2.3	2		0	
	LA 0048	2.5	2		0	
	LA 0051	0.1	2		0	
	LA 0061	19.3	2		1	
	LA 0061	19.9	2		0	
	LA 0061	20.0	2		2	
	LA 0061	20.4	3		2	
	LA 0061	20.5	2		2	
	LA 0061	20.5	3		2	

→

TRUCK TRAFFIC ACCIDENTS IN THE VICINITY OF WATERFORD 3 (1974-1986)

Year ←	Route	Mile Marker*	Number and Type of Vehicles if Known	Number of Fatalities	Number of People Injured	Comments
1978	LA 0061	20.6	2		0	
(Cont'd)	LA 0061	20.8	2		1	
	LA 0061	21.8	2		2	
	LA 0061	22.5	2		0	
	LA 0061	22.7	2		3	
	LA 0061	22.7	2		2	
	LA 0061	22.8	2		2	
	LA 0061	24.3	2		1	
	LA 0061	24.4	2		0	
	LA 0061	26.0	2		2	
	LA 0627	0.6	2		0	
	LA 3127	4.7	2		3	
	LA 3127	5.9	2		0	
	LA 3141	1.2	2		1	
1979	LA 0018	44.6	2		0	
	LA 0018	45.8	3		1	
	LA 0018	46.5	2		0	
	LA 0018	46.8	2		3	
	LA 0018	46.9	2		0	
	LA 0018	46.9	2		0	
	LA 0018	47.3	2		0	
	LA 0018	47.5	2		2	
	LA 0018	49.4	2		0	
	LA 0018	50.8	2		2	
	LA 0018	50.8	2		4	
	LA 0018	51.0	2		4	
	LA 0044	49.0	2		0	
	LA 0048	0.6	2		0	
	LA 0048	1.2	2		0	
	LA 0048	1.4	2		0	

TABLE 2.2-2 (Sheet 5 of 13) Revision 2 (12/88)

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TRUCK TRAFFIC ACCIDENTS IN THE VICINITY OF WATERFORD 3 (1974-1986)

Year ←	Route	Mile Marker*	Number and Type of Vehicles if Known	Number of Fatalities	Number of People Injured	Comments
1979	LA 0048	1.9	3		0	
(Cont'd)	LA 0048	2.2	2		1	
	LA 0048	2.8	2		0	
	LA 0051	0.1	2		0	
	LA 0061	19.3	2		0	
	LA 0061	19.3	2		1	
	LA 0061	19.3	2		1	
	LA 0061	19.3	2		0	
	LA 0061	19.5	2		3	
	LA 0061	19.6	2		2	
	LA 0061	19.7	2		0	
	LA 0061	19.9	2		0	
	LA 0061	20.5	2		0	
	LA 0061	20.5	2		4	
	LA 0061	21.8	2		1	
	LA 0061	21.8	3	3	3	
	LA 0061	22.7	2		4	
	LA 0061	23.9	2		0	
	LA 0061	24.3	2		0	
	LA 0061	24.5	2		1	
	LA 0061	24.6	2		3	
	LA 0061	25.4	2		0	
	LA 0061	25.5	2		0	
	LA 0061	26.1	2		0	
	LA 0627	0.3	2		0	
	LA 0627	1.0	2		2	
	LA 06363	0.6	2		0	
	LA 3142	1.3	2		0	

TABLE 2.2-2 (Sheet 6 of 13) Revision 2 (12/88)

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TRUCK TRAFFIC ACCIDENTS IN THE VICINITY OF WATERFORD 3 (1974-1986)

Year ←	Route	Mile Marker*	Number and Type of Vehicles if Known	Number of Fatalities	Number of People Injured	Comments
1980	LA 0018	47.0	2		0	
	LA 0018	48.3	2		0	
	LA 0018	50.2	2		0	
	LA 0018	50.5	2		0	
	LA 0018	50.5	2		0	
	LA 0018	50.7	2		0	
	LA 0018	51.8	2		0	
	LA 0044	46.4	2		0	
	LA 0044	49.7	2		2	
	LA 0044	50.1	2		0	
	LA 0048	0.9	2		0	
	LA 0048	1.7	2		0	
	LA 0048	2.2	2		0	
	LA 0051	0.1	2		0	
	LA 0051	0.1	2		0	
	LA 0051	0.1	2		2	
	LA 0051	0.1	2		0	
	LA 0051	0.3	2		0	
	LA 0051	0.4	2		0	
	LA 0061	19.3	4		1	
	LA 0061	20.2	2		1	
	LA 0061	20.2	2		0	
	LA 0061	20.5	2		0	
	LA 0061	22.3	2		0	
	LA 0061	22.7	2		0	
	LA 0061	22.7	2		1	
	LA 0061	22.7	2		0	
	LA 0061	22.8	4	2	3	

→

TRUCK TRAFFIC ACCIDENTS IN THE VICINITY OF WATERFORD 3 (1974-1986)

Year ←	Route	Mile Marker*	Number and Type of Vehicles if Known	Number of Fatalities	Number of People Injured	Comments
1980	LA 0061	23.0	2		1	
	LA 0061	23.1	2		1	
	LA 0061	24.2	2		0	
	LA 0061	24.2	3		0	
	LA 0061	24.6	2		2	
	LA 0061	25.0	2		0	
	LA 0061	26.0	2		0	
	LA 0061	26.0	2		1	
	LA 0061	26.2	2		1	
	LA 0061	26.2	2		0	
	LA 0061	26.4	2		0	
	LA 0061	26.5	2		2	
	LA 0061	26.5	2		0	
	LA 0627	0.2	2		0	
	LA 0627	0.4	2		0	
	LA 0628	2.3	2		0	
	LA 0628	5.3	2		0	
	LA 3127	4.2	2		0	
1981	LA 0018	44.7	2		1	
	LA 0018	44.7	2		0	
	LA 0018	46.1	2		0	
	LA 0018	47.7	2		0	
	LA 0018	48.3	2		5	
	LA 0018	49.8	2		1	
	LA 0048	0.9	2		0	
	LA 0048	2.2	2		0	
	LA 0048	2.2	2		0	
	LA 0061	20.4	2		0	
	LA 0061	20.4	2		2	
	LA OO61	20.4	2		0	
	LA 0061	20.7	2		1	

→

TRUCK TRAFFIC ACCIDENTS IN THE VICINITY OF WATERFORD 3 (1974-1986)

Year ←	Route	Mile Marker*	Number and Type of Vehicles if Known	Number of Fatalities	Number of People Injured	Comments
1981	LA 0061	20.7	2		2	
(Cont'd)	LA 0061	20.8	2		0	
	LA 0061	20.9	2		1	
	LA 0061	21.3	2		0	
	LA 0061	22.0	2		0	
	LA 0061	22.2	2		0	
	LA 0061	22.5	2		0	
	LA 0061	22.9	2		0	
	LA 0061	23.1	2		0	
	LA 0061	24.3	2		1	
	LA 0627	0.2	2		0	
	LA 0627	0.2	2		0	
	LA 0627	0.4	2		0	
	LA 0627	0.4	2		0	
	LA 3127	6.5	2		0	
1982	LA 0018	44.0	2		2	
	LA 0018	45.8	2		0	
	LA 0018	48.3	2		0	
	LA 0018	48.7	2		0	
	LA 0018	49.2	2		1	
	LA 0018	49.8	2		0	
	LA 0018	50.2	2		0	
	LA 0018	51.7	2		0	
	LA 0018	52.0	2		0	
	LA 0048	1.0	2		0	
	LA 0048	1.2	2		0	
	LA 0048	1.5	2		1	
	LA 0048	2.0	2		0	

→

TRUCK TRAFFIC ACCIDENTS IN THE VICINITY OF WATERFORD 3 (1974-1986)

Year ←	Route	Mile Marker*	Number and Type of Vehicles if Known	Number of Fatalities	Number of People Injured	Comments
1982 (Cont'd)	LA 0048	2.7	3		5	
	LA 0061	19.3	2		1	
	LA 0061	20.0	2		1	
	LA 0061	20.4	2		0	
	LA 0061	20.5	2		0	
	LA 0061	20.7	2		0	
	LA 0061	20.7	2		0	
	LA 0061	21.0	3		0	
	LA 0061	22.0	2		1	
	LA 0061	22.8	2		0	
	LA 0061	24.5	2		1	
	LA 0061	26.0	2		0	
	LA 0061	26.3	2		0	
	LA 0061	26.5	2		0	
	LA 0061	26.5	2		0	
	LA 0627	0.1	2		1	
	LA 0627	0.6	2		0	
	LA 0627	0.7	2		0	
	LA 0628	1.2	2		0	
	LA 3127	8.5	2		2	
	LA 3127	9.2	2		0	
1983	LA 0018	39.9	2		0	
	LA 0018	47.0	3		0	
	LA 0018	49.9	3		2	
	LA 0018	50.2	2		0	
	LA 0018	51.2	2		0	
	LA 0044	48.8	4		1	

TABLE 2.2-2 (Sheet 10 of 13) Revision 2 (12/88)

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TRUCK TRAFFIC ACCIDENTS IN THE VICINITY OF WATERFORD 3 (1974-1986)

Year ←	Route	Mile Marker*	Number and Type of Vehicles if Known	Number of Fatalities	Number of People Injured	Comments
1983	LA 0044	49.6	2		0	
(Cont'd)	LA 0044	49.7	2		0	
	LA 0044	50.1	2		0	
	LA 0048	2.1	2		0	
	LA 0048	2.5	2		0	
	LA 0048	2.6	2		2	
	LA 0048	2.8	2		2	
	LA 0061	20.1	2		1	
	LA 0061	20.4	2		0	
	LA 0061	20.5	2		0	
	LA 0061	20.7	3		3	
	LA 0061	21.0	2		0	
	LA 0061	21.3	2		0	
	LA 0061	21.8	3		0	
	LA 0061	22.5	2		4	
	LA 0061	22.6	2	1	1	
	LA 0061	23.5	2		0	
	LA 0061	24.0	3		4	
	LA 0061	24.2	2		0	
	LA 0061	24.4	2	1	0	
	LA 0061	24.7	2		0	
	LA 0061	25.8	2		0	
	LA 0061	26.4	2		0	
	LA 0628	0.2	2		5	
	LA 06361	0.4	2		0	
	LA 06363	0.9	2		0	

TABLE 2.2-2 (Sheet 11 of 13) Revision 2 (12/88)

→

TRUCK TRAFFIC ACCIDENTS IN THE VICINITY OF WATERFORD 3 (1974-1986)

Year ←	Route	Mile Marker*	Number and Type of Vehicles if Known	Number of Fatalities	Number of People Injured	Comments
1984	LA 0018	45.8	2		0	
	LA 0018	47.5	2		0	
	LA 0018	48.3	2		1	
	LA 0018	52.1	2		0	
	LA 0044	46.5	2		0	
	LA 0048	0.9	2		0	
	LA 0048	1.5	2		0	
	LA 0048	2.0	2		0	
	LA 0061	20.5	2		0	
	LA 0061	20.5	3		1	
	LA 0061	20.9	2		2	
	LA 0061	22.2	2		1	
	LA 0061	22.4	2		0	
	LA 0061	22.5	2		0	
	LA 0061	22.7	2		1	
	LA 0061	23.0	2		0	
	LA 0061	23.1	3		0	
	LA 0061	23.3	2		0	
	LA 0061	25.5	2	1	0	
	LA 0061	26.0	2		1	
	LA 0061	26.1	2		0	
	LA 0627	0.3	2		3	
	LA 0628	1.2	2		0	
	LA 0628	5.5	2		1	

TABLE 2.2-2 (Sheet 12 of 13) Revision 2 (12/88)

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TRUCK TRAFFIC ACCIDENTS IN THE VICINITY OF WATERFORD 3 (1974-1986)

Year ←	Route	Mile Marker*	Number and Type of Vehicles if Known	Number of Fatalities	Number of People Injured	Comments
1985	LA 0018	42.5	2		0	
	LA 0018	51.9	2		1	
	LA 0018	52.2	2		3	
	LA 0044	49.4	2		0	
	LA 0044	50.0	2		0	
	LA 0048	1.4	2		0	
	LA 0048	1.8	2		3	
	LA 0048	2.2	2		0	
	LA 0048	2.2	2		1	
	LA 0048	2.5	2		0	
	LA 0048	2.6	2		0	
	LA 0061	19.4	2		0	
	LA 0061	20.3	2		1	
	LA 0061	21.0	2		2	
	LA 0061	22.4	2		1	
	LA 0061	23.1	2		0	
	LA 0061	24.2	2		1	
	LA 0061	24.6	2		0	
	LA 0061	26.1	2		0	
	LA 0628	1.2	2		1	
	LA 0628	5.5	2		0	
	LA 3127	5.7	2		0	
	LA 3127	9.3	2		1	

→

TRUCK TRAFFIC ACCIDENTS IN THE VICINITY OF WATERFORD 3 (1974-1986)

Year ←	Route	Mile Marker*	Number and Type of Vehicles if Known	Number of Fatalities	Number of People Injured	Comments
1986	LA 0018	51.5	2		2	
	LA 0018	51.7	2		0	
	LA 0018	51.7	4		1	
	LA 0018	52.1	2		1	
	LA 0048	0.0	2		0	
	LA 0048	0.8	2		1	
	LA 0048	1.8	2		2	
	LA 0048	1.9	2		0	
	LA 0048	2.0	3		1	
	LA 0061	24.1	2		1	
	LA 0627	1.0	3		1	
	LA 0628	4.4	2		0	

*Mile markers are indicated in Figure 2.2-2

Source: State Traffic Safety Engineer, Louisiana Department of Transportation and Development
Baton Rouge, Louisiana, November 1987

TABLE 2.2-3 (Sheet 1 of 11) Revision 9 (12/97)

PRODUCTS USED, PRODUCED, STORED, BY INDUSTRIES WITHIN FIVE MILES OF WATERFORD 3*

COMPANY	DISTANCE** AND DIRECTION FROM THE SITE	TYPE OF ACTIVITY AND PRODUCTS PRODUCED	QUANTITIES PRODUCED	MATERIAL USED OR PRODUCED	MODE/FREQUENCY/ AVG QUANTITY OF EACH SHIPMENT	AMOUNT OF EACH MATERIAL USED OR PRODUCED	MAXIMUM AMOUNT OF EACH MATERIAL TO BE PROCESSED STORED OR TRANSPORTED AT ANY GIVEN TIME
→ Witco Chemical Co. Argus Division ←	1.1 SE	Chemical Production of plasticizers, tin stabilizers and thio-chemicals	Plasticizers-Approx. 36 million lbs/yr Tin Stabile-ziers-Approx. 12 million lbs/yr thiochemicals-approx. 13 million lbs/yr	Anhydrous Ammonia	Rail/monthly/ 32,000 gals	32,000 gals/month	30,000 gals
				Ammonium Sulfide	Rail & Truck/ 6 or 4 times a month/5,000 gal	1 million lbs/yr	2-25,000 gals Tank
				Carbon Bisulfide	Rail/once a week/ 20,000 gal	1,040,000 gals/yr	40,000 gal Storage Tank
				Chlorine	Pipeline/Batch Operation/2,000 lb/day	2,000 lb/day	No storage
				Dibutyltin Dichloride	Produced and consumed within the plant	800,000 lbs/yr	1,000 gals in two 50 gals receivers
				Dibutyltin Oxide	Truck/Intermittently/ 24,000 lbs in 300 lb drums	40,000 lbs/yr	10,000 lbs in 300 lbs/Lever Pack Drums
				Dimethyl Dithiodi Propionate	Truck/6 times a year/40,000 lbs	240,000 lbs/yr	5,000 gal in 12,000 gal Storage Tanks
				Dimethyl Tin Dichloride	Truck/8 times a year/5,000 lbs	300,000 lbs/yr	20,000 lbs -5,000 lbs in drums, rest in receivers
				Formic Acid	Truck/6 times a year/4,000 gals	24,000 gals/yr	10,000 gal Storage Tank

* This Table contains historical information based on data collected through 1979. The safety evaluations in Section 2.2.3.3.4 were based on data shown in Tables 2.2-3a and 2.2-3b.

** Distance in miles

TABLE 2.2-3 (Sheet 2 of 11) Revision 9 (12/97)

PRODUCTS USED, PRODUCED, STORED, BY INDUSTRIES WITHIN FIVE MILES OF WATERFORD 3*

COMPANY	DISTANCE** AND DIRECTION FROM THE SITE	TYPE OF ACTIVITY AND PRODUCTS PRODUCED	QUANTITIES PRODUCED	MATERIAL USED OR PRODUCED	MODE/FREQUENCY/ AVG QUANTITY OF EACH SHIPMENT	AMOUNT OF EACH MATERIAL USED OR PRODUCED	MAXIMUM AMOUNT OF EACH MATERIAL TO BE PROCESSED STORED OR TRANSPORTED AT ANY GIVEN TIME
→ Witco Chemical Co. Argus Division (Cont'd) ←				Hydrogen Peroxide (H_2O_2-70%)	Truck/8 times a month/4,000 gals	32,000 gals/yr	12,000 gal tank
				Hydrogen Peroxide (H_2O_2-50%)	Truck/4 times a year/4,000 gals	32,000 gals/yr	5,000 gal tank
				Isopropyl Ether	Truck/every 3 months/4,000 gals	12,000 gals/yr	7,000 gals
				2-Mercaptoethanol	Truck/4 times a year/38,000 lbs in 55 gal drums	80,000 lbs	40,000 lbs
				Methyl chloride	Truck/10 times a year/4,000 gals	40,000 gals/yr	40,000 lbs
				Methyl mercapto propionate	Truck/6 times a year/40,000 lbs	240,000 lbs/yr	7,000 gal Storage Tank
				Monobutyl and Dibutyltin Chloride	Manufactured and consumed in the plant	500,000 lbs/yr	4,000 lbs in 55 gallon drums
				Monomethyl tin Trichloride	Manufactured and consumed in the plant	100,000 lbs/yr	No storage
				Monobutyl Tin	Manufactured and consumed within the plant	40,000 lbs/yr	10,000 lbs
				Monochloroacetic Acid	Truck/NA*/40,000 lbs	2-3 million lbs/ yr	38900 lbs in two 19450 lb tanks
				Peracetic Acid	Pipeline/Contin- uous/ 30,000 lb/ day	30,000 lbs/day	No Storage

TABLE 2.2-3 (Sheet 3 of 11) Revision 9 (12/97)

PRODUCTS USED, PRODUCED, STORED, BY INDUSTRIES WITHIN FIVE MILES OF WATERFORD 3*

COMPANY	DISTANCE** AND DIRECTION FROM THE SITE	TYPE OF ACTIVITY AND PRODUCTS PRODUCED	QUANTITIES PRODUCED	MATERIAL USED OR PRODUCED	MODE/FREQUENCY/ AVG QUANTITY OF EACH SHIPMENT	AMOUNT OF EACH MATERIAL USED OR PRODUCED	MAXIMUM AMOUNT OF EACH MATERIAL TO BE PROCESSED STORED OR TRANSPORTED AT ANY GIVEN TIME
→ Witco Chemical Co. Argus Division (Cont'd) ←				Sodium Hydro-sulfide	Rail & Truck/ 6 times a month/ 40,000 lbs	More than 4 million lbs/yr	2-20,000 gal, 10,000 gal & 6,000 gal tanks
				Sodium Hydroxide	Truck/Daily/ 55,000 lbs	55,000 lbs/Day	35,000 gal Storage
				Stannic Chloride	Truck/Infrequent/ 5,000 lbs in 30 gal drums	1,200,000 lbs/yr	40,000 lbs
				Sulfuric Acid	Truck/1 per week 40,000 lbs	20,080,000 lbs/yr	24,000 gals
				Sulfuric Acid	Truck/1 per year/ 3,000 gals	3,000 gals/yr	52,000 lbs
				Tetrahydrofuran	Truck/four times year/3,000 gals	12,000 gals/yr	4,000 gal tank
				Toluene	Truck/once a month/3,000 gals	36,000 gals/yr	2-3,000 gal tanks
				Tri Butyltin oxide	Truck/infrequently/ 500 lbs lbs drums	4,000 lbs/yr	4,000 lbs in 500
				Trineophyltin oxide	Truck/once a month/40,000 lbs in 500 lbs drum	480,000 lbs/yr	45,000 lbs in 500 lbs drums lbs drum
→ IMC Agrico Chemical Co. ←	0.6 ESE	Chemical processing plant producing high analysis fertilizers specifically granular diammonium phosphate phoric acid	Diammonium phosphate- 1800 Short tons/Day Phosphoric acid As $P_2 O_5$ 950 short tons/day	Sulfur	Barge-2400 long tons/ Rail-86 long tons/ Truck-20 long tons A shipment every 3 or 4 days	700 tons/day	10,000 long tons

TABLE 2.2-3 (Sheet 4 of 11) Revision 9 (12/97)

PRODUCTS USED, PRODUCED, STORED, BY INDUSTRIES WITHIN FIVE MILES OF WATERFORD 3*

COMPANY	DISTANCE** AND DIRECTION FROM THE SITE	TYPE OF ACTIVITY AND PRODUCTS PRODUCED	QUANTITIES PRODUCED	MATERIAL USED OR PRODUCED	MODE/FREQUENCY/ AVG QUANTITY OF EACH SHIPMENT	AMOUNT OF EACH MATERIAL USED OR PRODUCED	MAXIMUM AMOUNT OF EACH MATERIAL TO BE PROCESSED STORED OR TRANSPORTED AT ANY GIVEN TIME
→ IMC Agrico Chemical Co. (Cont'd.) ←				Phosphoric Acid	Ship/1 every 50 days/3,000 tons	950 tons/day	9,000 tons $P_2 0_5$
				Ammonia	Barge/1 every 10 days/2,500 tons pipeline/on oc-casion/NA*	415 tons	10,000 tons
				Sulfuric Acid	Almost all of the sulfuric acid at the plant is pro-duced on site. Some is shipped by Barge/twice a month/NA and by Rail/twice a week 95 tons	2200 tons/day	6,000 tons
Chevron Oil Co.	4.1E	Laboratory & Petro-leum Storage	Not Applicable	Not applicable	Not applicable	This information is included with information on General American Transportation Corp.	
E.I Dupont De Nemours & Co. Pontchartrain Works	4.7NNW	Chemical manufactur-ing of adiponitrile; neoprene; chloroprene; Sodium Cyanide	Adiponitrile-60,000 tons/yr Neoprene-40,000 tons/yr Chloroprene-40,000 tons/yr Sodium Cyanide-Not Available	Butadiene	Rail/daily/ 500,000 lbs	500,000 lbs/day	1 million lbs. in tank storage
				Chlorine	Rail/Daily/ 720,000 lbs	720,000 lbs/day	1 million lbs in tank storage
				Dichlorobutene	Produced and used on site	360 million lbs/yr	Not available
				Chloroprene	Rail/daily 135,000 lbs	135,000 lbs/day	Not available

TABLE 2.2-3 (Sheet 5 of 11)

PRODUCTS USED, PRODUCED, STORED, BY INDUSTRIES WITHIN FIVE MILES OF WATERFORD 3*

COMPANY	DISTANCE** AND DIRECTION FROM THE SITE	TYPE OF ACTIVITY AND PRODUCTS PRODUCED	QUANTITIES PRODUCED	MATERIAL USED OR PRODUCED	MODE/FREQUENCY/ AVG QUANTITY OF EACH SHIPMENT	AMOUNT OF EACH MATERIAL USED OR PRODUCED	MAXIMUM AMOUNT OF EACH MATERIAL TO BE PROCESSED STORED OR TRANSPORTED AT ANY GIVEN TIME
General American Transportation Co. (GATX)	4.1E	Bulk storage terminal of petroleum products and food oil with a total combined storage of 5,600,000 bbls.	Not applicable	Acrylonitrile	Rail,Barge & Ship/NA/NA	Not Applicable	25,000 bbls
				Butadienne	Rail,Barge & Ship/NA/NA	Not Applicable	150,000 bbls
				Gas	Pipeline/NA/NA	Not Applicable	Not Applicable
				Gasoline	Ship/NA/NA	Not Applicable	500,000 bbls
				Crude Oil	Ship/NA/NA	Not Applicable	1,200,000 bbls
				Blend Stock	NA	Not Applicable	350,000 bbl
					Note: It is not possible to estimate the frequency or avg quantity of each shipment for the products stored at this site. In general, approx. 220 barges, 20 ships and 250 rail cars enter and leave this site a month. Average capacity for a barge or ship is 20,000 bbls and for rail is 30,000 gals.		

TABLE 2.2-3 (Sheet 6 of 11) Revision 9 (12/97)

PRODUCTS USED, PRODUCED, STORED, BY INDUSTRIES WITHIN FIVE MILES OF WATERFORD 3*

COMPANY	DISTANCE** AND DIRECTION FROM THE SITE	TYPE OF ACTIVITY AND PRODUCTS PRODUCED	QUANTITIES PRODUCED	MATERIAL USED OR PRODUCED	MODE/FREQUENCY/ AVG QUANTITY OF EACH SHIPMENT	AMOUNT OF EACH MATERIAL USED OR PRODUCED	MAXIMUM AMOUNT OF EACH MATERIAL TO BE PROCESSED STORED OR TRANSPORTED AT ANY GIVEN TIME
→ Trans America Refinery	3.9E	Refining of Crude Petroleum into gasoline, LPG, #2 Fuel Oil, and #6 Fuel Oil	75,000 -80,000 bbls per day combined	Crude oil, long residium, tel., gasoline, LPG,#2 Fuel Oil, and #6 Fuel Oil	received or shipped on a daily basis by either rail, barge or pipeline. Daily shipment varies from 20,000 to 750,000 bbls.	75,000 to 80,000 bbls/day of products	1,000,000 plus bbls of combined storage
Occidental Chemcial Co. ←	0.8SSE	Manufacture of Chlorine, Sodium Hydroxide, Sodium Chlorates, Sulfur Monochloride, Thionyl Chloride, Ammonia, and Nitrogen	p**	Sodium Chloride (Brine)	Pipeline/ NA/NA	-	-
				Chlorine	Railcar/Daily/ 90 tons Pipeline/Continuous 100 GPM (Liquid Form) Pipeline/Continuous 200 tons per day (Gaseous Form)	N/A	4,000 tons
				Sulfur	N/A	N/A	N/A
				Sulphur Dioxide	N/A	N/A	N/A
				Sodium Hydroxide (Dry Basis)	Tank Truck/ Daily 20 tons Railcar/ Daily/ 53 tons Barge/Daily/750 tons Ship / 3 per month/ 7,500 tons Pipeline / N/A/N/A	N/A	25,000 tons liquid, 50% by weight) 4,000 tons (liquid 13% by weight)
				Hydrochloric Acid	Tank Truck/Daily 7 tons	N/A	150 tons

PRODUCTS USED, PRODUCED, STORED, BY INDUSTRIES WITHIN FIVE MILES OF WATERFORD 3*

COMPANY	DISTANCE** AND DIRECTION FROM THE SITE	TYPE OF ACTIVITY AND PRODUCTS PRODUCED	QUANTITIES PRODUCED	MATERIAL USED OR PRODUCED	MODE/FREQUENCY/ AVG QUANTITY OF EACH SHIPMENT	AMOUNT OF EACH MATERIAL USED OR PRODUCED	MAXIMUM AMOUNT OF EACH MATERIAL TO BE PROCESSED STORED OR TRANSPORTED AT ANY GIVEN TIME
→ Occidental Chemical Co. (Cont'd) ←				Sulphur Mono-chloride	Railcar/Daily/90 tons	N/A	335 tons
				Thionyl Chloride	N/A	N/A	N/A
				Ammonia	Tank Truck/Daily/20 tons Railcar/ Daily/75 tons Barge/Monthly/25,000 tons Pipeline/ N/A/N/A	N/A N/A	7,500 tons
				Anhydrous Ammonia	Ship/9 per yr/50,000 tons Ship/9 per yr/30,000 tons	N/A	90,000 tons(in two 45,000 ton tanks)
				Hydrogen	Pipeline (Intra-plant)/Daily/N/A	N/A	None
				Sodium Chlorates	Tank Truck/Daily/ 7 tons,Railcar/ Daily/18 tons	N/A	3,000 tons
				Sulfuric Acid	N/A	N/A	N/A
				Nitrogen	Tank Truck/1 every 2 days/20 tons, Pipe-line/N/A/N/A	N/A	60 tons
Kaiser Aluminum & Chemical Corp., Norco Coke Cal-	4.3 E	Calcination of Pet-roleum Coke	150,000 tons/ year	Green Petroleum Coke	Conveyor belt/ continuous/25 tons/ hour	150,000 tons/year of calcinized coke	1,000 tons storage

TABLE 2.2-3 (Sheet 8 of 11) Revision 9 (12/97)

PRODUCTS USED, PRODUCED, STORED, BY INDUSTRIES WITHIN FIVE MILES OF WATERFORD 3*

COMPANY	DISTANCE** AND DIRECTION FROM THE SITE	TYPE OF ACTIVITY AND PRODUCTS PRODUCED	QUANTITIES PRODUCED	MATERIAL USED OR PRODUCED	MODE/FREQUENCY/ AVG QUANTITY OF EACH SHIPMENT	AMOUNT OF EACH MATERIAL USED OR PRODUCED	MAXIMUM AMOUNT OF EACH MATERIAL TO BE PROCESSED STORED OR TRANSPORTED AT ANY GIVEN TIME
→ Entergy Louisiana Little Gypsy SES***	0.6 NNE	Generation of Electricity	1229 Mwe	Natural Gas	Pipeline/Continu-ous/NA	The materials listed are used up and stored as needed for the normal oper-ation of the plant.	N/A
				#2 Fuel Oil	Barge/As needed/ NA		150,000 bbls
←				Ammonia	Truck/As needed/ 28,000 lbs		40,000 lbs
				Chlorine	Truck/As needed/ 450 lbs in 150 lb bottles		6 to 9 bottles at 150 lbs/ bottle
				Hydrogen	Truck/As needed/ 1,600 lbs in tank tubes		9 tubes totaling 50,000 SCF
				Nitrogen	Truck/As needed/ 24 bottles		48 bottles
				Sulfuric Acid	Truck/As needed/ 4,000 gals		17,000 gals in two 6,000 gals tank and one 5,000 gal tank
				Sodium Hydroxide	Truck/As Needed/ 4,000 gals		12,000 gals in two 6,000 gal tanks
				Hydrazine (35% Aqueous Solution)	Truck/As Needed/ 150 gals in 30 gal drums		300 gals in 30 gal drums
→ Entergy Louisiana - Waterford SES Units 1 & 2*** ←	0.36WNW	Generation of Electricity	860 Mwe	Natural Gas	Pipeline/As Required/ NA	The materials listed are used up and stored as needed for the normal operation of the plant	4 MMCFH

*** Information on this facility includes data collected in 1983-84. It is therefore not duplicated in Table 2.2-3a.

TABLE 2.2-3 (Sheet 9 of 11)

PRODUCTS USED, PRODUCED, STORED, BY INDUSTRIES WITHIN FIVE MILES OF WATERFORD 3*

COMPANY	DISTANCE** AND DIRECTION FROM THE SITE	TYPE OF ACTIVITY AND PRODUCTS PRODUCED	QUANTITIES PRODUCED	MATERIAL USED OR PRODUCED	MODE/FREQUENCY/ AVG QUANTITY OF EACH SHIPMENT	AMOUNT OF EACH MATERIAL USED OR PRODUCED	MAXIMUM AMOUNT OF EACH MATERIAL TO BE PROCESSED STORED OR TRANSPORTED AT ANY GIVEN TIME
Entergy Louisiana - Waterford SES Units 1 & 2***(Cont'd)				#6 Fuel Oil	Barge/As Needed/ NA		430,000 bbls+ 380,000 bbl
				Ammonia	Truck/As Needed/ 28,000 lbs		40,000 lbs
				Hydrogen	Truck/As Needed/ 1600 lbs in tank tubes		6 tubes total-ing 35,000 SCF
				Nitrogen	Truck/As Needed/ 24 Bottles		48 Bottles
				Sulfuric Acid	Truck/As Needed/ 4,000 gals		1,000 gal + 2 6,000 gal Storage Tanks = 13,000 gal total
				Sodium Hydroxide	Truck/As Needed/ 4,000 gals		2 x 6,000 gal + 1 x 4,000 Storage Tank = 16,000 gal total
				Hydrazine (35% Aqueous Solution)	Truck/As Needed/ 450 gals in 30 gal drums		300 gals in 30 gallon drums
				CE COS ES-301	250 gal		500 gal
				Kerosene	8 drums - 55 gal		12 drums

***Information on this facility includes data collected in 1983-84. It is therefore not duplicated in Table 2.2-3a.

TABLE 2.2-3 (Sheet 10 of 11) Revision 9 (12/97)

PRODUCTS USED, PRODUCED, STORED, BY INDUSTRIES WITHIN FIVE MILES OF WATERFORD 3*

COMPANY	DISTANCE** AND DIRECTION FROM THE SITE	TYPE OF ACTIVITY AND PRODUCTS PRODUCED	QUANTITIES PRODUCED	MATERIAL USED OR PRODUCED	MODE/FREQUENCY/ AVG QUANTITY OF EACH SHIPMENT	AMOUNT OF EACH MATERIAL USED OR PRODUCED	MAXIMUM AMOUNT OF EACH MATERIAL TO BE PROCESSED STORED OR TRANSPORTED AT ANY GIVEN TIME
→ Koch Nitrogen Co.	0.8 SSE	Produce Anhydrous Ammonia and Liquid Nitrogen	Ammonia-300 tons/day Liquid Nitogen-10 tons/day	Hydrogen	Pipeline/continuous/ 5,000 lbs/hr	60 tons/day	5,000 lbs/hr
				Ammonia	Rail, Barge and truck/every 6 hrs/40 tons per load	300 tons/day	7,000 tons
← Shell Chemical Co.	2.5 E	p**					
Shell Oil Co.	3.5 E	p**					
→ Louisiana Resources Crawfish Gas Plant	2.8 ESE	Process natural gas, produce raw product mix (Ethane, propane, Butane and Gasoline.)	Total Raw product mix (natural gas liquids)- 2,500 bbls/day	Natural Gas	Pipeline/ Continuous 100 MMSCFD***	100 MM SCFD	150 MM SCFD
				Raw product mix (liquids)	Pipeline/ Continuous 2,500 bbls/day	2,500 bbls/day	200 barrels of storage
← Union Carbide	1.2 ESE	Manufacture of Organic Chemicals such as Olefins; Aromatics; Ethylene-amines; Alkylamines; Glyoxal; Peracetic Acid; and Pernatives, Ethelene Oxide; Glycol and Acrylic Esters	Annual pro-duction is approximately 2,335,000 lbs	Raw Materials used include: Naptha, Ehtane, Caustic, Chlorine, Alcohols, Ammonia, Nitric Acid, Acetaldehyde, Phenol, Ethylene, Methanol and Propylene	Drums/Daily/1,000 lbs, Tank Truck Daily/40,000 lbs Railcar/Daily 180,000 lbs Barge/Daily/35,000,000 lbs. Tankers/3 per month/2,000,000 lbs	Total amount of potentially hazardous material produced or used in production is approximately 3,129,000,000 lbs	Maximum amount stored at one time is approximately 429,000,000 lbs
→ Praxair ←	1.2 ESE	Package Industrial Gases	N/A	N/A	N/A	N/A	N/A

TABLE 2.2-3 (Sheet 11 of 11)

PRODUCTS USED, PRODUCED, STORED, BY INDUSTRIES WITHIN FIVE MILES OF WATERFORD 3*

COMPANY	DISTANCE** AND DIRECTION FROM THE SITE	TYPE OF ACTIVITY AND PRODUCTS PRODUCED	QUANTITIES PRODUCED	MATERIAL USED OR PRODUCED	MODE/FREQUENCY/ AVG QUANTITY OF EACH SHIPMENT	AMOUNT OF EACH MATERIAL USED OR PRODUCED	MAXIMUM AMOUNT OF EACH MATERIAL TO BE PROCESSED STORED OR TRANSPORTED AT ANY GIVEN TIME
Witco Chemical Co.	1.2 SE	Manufacturing polyolefin (polybutylene)	50 million lbs/yr	Aluminum alkys	Truck/2 per month/ 5,000 gal	1‘20,000 gals/hr	12,000 gals
				Butene-1	Rail/1 every other day/30,000 gals	Max of 5,475,000 gals/yr	200,000 gals- 50,000 gals in tank storage and 150,000 gals in 5-30 gals rail cars
				Dowtherm-G	Truck/1every 4 months/4,000 gals in 55 gal drums	17,600 gals/hr	8,000 gal-4,000 gals in process & 4,000 gals in 55 gal drums
				Ethylene	Truck/2per month/ 10,000 lbs	120,000 lbs/yr	10,000 lbs in 2- 5,000 lb tube trailers
				Heptane	Truck/1 per month/ 5,000 gals	60,000 gals/hr	5,000 gals
				Hydrogen	Truck/1 per month/ as needed to top off storage tanks	N/A	50,000 cu ft in tube Banks
				Titanium Trich- loride	Truck/1 every 4 months/10,000 lbs. in 500 lb drums	40,000 lbs/yr	15,000 lbs in 500 lb drums

*NA = Not Available
**P = Proprietary Information
***MMSCFD = Million Standard Cubic Feet Per Day
Source: Response to Ebasco Questionnaire Submitted June, 1977

→ (EC-5000082218, R301; EC-39014, R307; LBDCR 15-048, R309)

INDUSTRIAL FACILITIES STORING SIGNIFICANT QUANTITIES OF TOXIC MATERIALS WITHIN FIVE MILES OF WATERFORD 3

Company	Local Facility	Location	Distance[1] (Miles)	Direction
Air Liquide America	Norco Plant	Norco	4.16	ENE
	Taft Plant	Taft	1.14	ESE
ArcelorMittal Steel	Bayou Steel	LaPlace	2.90	N
CGB	CGB Marine Supply	LaPlace	3.96	N
Entergy-Louisiana	Waterford Units 1, 2, and 4	Kilona	0.426	WNW
	Little Gypsy SES	Montz	0.8	NE
Enterprise Products Partners LLC	Norco Fractionation Plant	Norco	4.4	E
Galata Chemicals	Taft Plant	Taft	1.37	SE
Koch Nitrogen	Taft Terminal	Taft	0.88	SE
Hexion Inc.	Norco Plant	Norco	2.57	E
Mosaic Phosphates Company	Taft Plant	Taft	0.68	ESE
MOTIVA Enterprises LLC	Norco Refining	Norco	3.64	E
Occidental Chemical	Taft Plant	Taft	0.93	ESE
Praxair Distribution		Taft	1.31	ESE
Shell Oil Company	Norco Chemical Plant –East Site	Norco	3.80	E
	Norco Chemical Plant – West Site	Norco	2.57	ENE
St. Charles Parish	Waterworks District 1	New Sarpy	4.53	E
St. John the Baptist Parish	Wastewater Treatment River Road	LaPlace	4.97	NNW
Union Carbide Corp.	Taft/Star Complex	Taft	1.37[2]	ESE
W. R. Grace	SHAC Catalyst Plant	Norco	2.57	ENE
Valero Refining	St. Charles Refinery	Norco	4.13	E
Waguespack Oil Company	Bulk Fuel Supply	LaPlace	4.80	N
Western International	Bulk Fuel Supply	Taft	1.27	E

Note 1: Distance from WSES-3 control room fresh air intake to center of facility, unless otherwise noted.
Note 2: Distance from WSES-3 control room fresh air intake to nearest stationary source of toxic chemicals at facility.

←(EC-5000082218, R301; EC-39014, R307; LBDCR 15-048, R309)

TABLE 2.2-3B (Sheet 1 of 20) Revision 309 (06/16)

→ (EC-5000082218, R301; EC-39014, R307; LBDCR 15-048, R309)

HAZARDOUS MATERIALS STORED OR PROCESSED IN THE WATERFORD 3 VICINITY

Facility	Chemical Name	2016 Amount (lbs)*	Storage Temperature (Degrees F)	Area/Height of Dike (ft^2/ft)	Distance (Miles)	Direction
Air Liquide Norco Facility	Ammonia	3600	N/A		4.16	ENE
Air Liquide Taft Facility	Ammonia	5000	N/A		1.14	ESE
CGB Marine Supply	Gasoline	2748	95	1152	3.96	N
	Diesel Fuel	3156	95	1152		
	Liquid Oxygen Bulk	14261	95	N/A		
	Propane	2460	95	N/A		
Enterprise Norco Fractionation Plant	N-Butane	715800	Ambient	No Dike	4.4	E
	Isobutane	4928400	Ambient	No Dike		
	Propane	643200	Ambient	No Dike		
	Ethane	10400	Ambient	No Dike		
	Pentane	2993400	Ambient	No Dike		
	Methanol	3635	Ambient	No Dike		
Galata Taft Plant	Ammonia	29762	Ambient	2.0 ft	1.37	SE
	Ammonia	156000	Ambient	2.0 ft		
	Methyl Acrylate	72000	Ambient	4.0 ft		
	Formic Acid	150000	Ambient	3.6 ft		
	Heptane	150000	Ambient	2.9 ft		
	Hydrochloric Acid (37%)	20000	Ambient	1.5 ft		
	Methyl Chloride	180000	Ambient	3.6 ft		
	Monochloroacetic acid (70-80%)	335000	Ambient	2.9 ft		
	Hydrogen Peroxide (35%)	44500	Ambient	3.6 ft		
Hexion	Allyl Chloride	1004119	Ambient	24600 (4')	2.57	E

← (EC-5000082218, R301; EC-39014, R307; LBDCR 15-048, R309)

TABLE 2.2-3B (Sheet 2 of 20) Revision 309 (06/16)

→ (EC-5000082218, R301; EC-39014, R307; LBDCR 15-048, R309)

HAZARDOUS MATERIALS STORED OR PROCESSED IN THE WATERFORD 3 VICINITY

Facility	Chemical Name	2016 Amount (lbs)*	Storage Temperature (Degrees F)	Area/Height of Dike (ft^2/ft)	Distance (Miles)	Direction
	Allyl Chloride	517749	Ambient	5600 (4')		
	Butane	264917	Ambient	No Dike		
	1-Butanol	202794	Ambient	12000 (1')		
	o-CRESOL	262881	Ambient	8000 (4')		
	Chlorine	391191	Ambient	12000 (1')		
	1,2,3-Trichloropropane	4000787	Ambient	13000 (4')		
	Epichlorohydrin	8523078	Ambient	14400 (4')		
	Hydrochloric acid	1865198	Ambient	10000 (6')		
	2-Butanone	67181	Ambient	12000 (1')		
	Methyl isobutyl ketone	66931	Ambient	12000 (1')		
	Phenol	267888	Ambient	12000 (1')		
	Propylene	82997	Ambient	No Dike		
	Toluene	61462	Ambient	CSS		
	1,2,3-Trichloropropane	776624	Ambient	5600 (4')		
	Hydrochloric acid (10%)	678843	Ambient	CSS		
Koch Taft Terminal	Ammonia	108891000	-28	246,894 ft^2	0.88	SE
	Off Road Diesel	772	Ambient	N/A		
	Nitrogen	1800	Ambient	N/A		
	Oxygen	600	Ambient	N/A		
	Mobil Gargoyle Arctic SHC 226 (Compressor Oil)	5641	Ambient	N/A		
Little Gypsy SES	Anhydrous Ammonia	5000	Ambient	No Dike	0.80	NE

← (EC-5000082218, R301; EC-39014, R307; LBDCR 15-048, R309)

TABLE 2.2-3B (Sheet 3 of 20) Revision 309 (06/16)

→ (EC-5000082218, R301; EC-39014, R307; LBDCR 15-048, R309)

HAZARDOUS MATERIALS STORED OR PROCESSED IN THE WATERFORD 3 VICINITY

Facility	Chemical Name	2016 Amount (lbs)*	Storage Temperature (Degrees F)	Area/Height of Dike (ft^2/ft)	Distance (Miles)	Direction
	Sulfuric Acid	92134	Ambient	No Dike		
	Caustic	97767	Ambient	No Dike		
Mosaic Taft Plant	Gasoline	3036	Ambient	No Dike	0.68	ESE
	Diesel Fuel	34712	Ambient	No Dike		
Motiva Norco Refinery	Ammonia	54000			3.64	E
	Bromine	15148000				
	1,3-Butadiene	15148000				
	Butane	10397764				
	Chlorine	114000				
	Cyclohexane	1000000				
	Dimethyl disulfide	14000				
	Ethyl benzene	4000000				
	Ethyl Mercaptan	34000				
	n-Hexane	2500000				
	Hydrochloric Acid (37%)	200000				
	Isobutane	500000				
	Isopentane [Butane, 2-methyl-]	9950000				
	Isoprene	3350000				
	Methanol	18000				
	2-Methyl-1-butene	2250000				
	3-Methyl-1-butene	720000				
	Methyl mercaptan	38000				

← (EC-5000082218, R301; EC-39014, R307; LBDCR 15-048, R309)

→ (EC-5000082218, R301; EC-39014, R307; LBDCR 15-048, R309)

HAZARDOUS MATERIALS STORED OR PROCESSED IN THE WATERFORD 3 VICINITY

Facility	Chemical Name	2016 Amount (lbs)*	Storage Temperature (Degrees F)	Area/Height of Dike (ft^2/ft)	Distance (Miles)	Direction
	2-Methylpropene	4630000				
	Methyl tert-butyl ether	10000000				
	Pentane	5725000				
	1-Pentene	14866622				
	cis-2-Pentene	950000				
	trans-2-Pentene	1820000				
	Propadiene	28000				
	Propane	4100000				
	Tetrachloroethylene	12000				
	Toluene	18000				
	1,1,1-trichloroethane	4000				
	Vinyl acetylene [1-Buten-3-yne]	92000				
	Xylene	14500000				
	Methane	16000				
	Hydrogen	800000				
	Propylene	1128000				
	Butene	638000				
Occidental Taft Plant	Chlorine	1200000	41	2 ft/16,800 ft^2	1.04	ESE
	Hydrochloric acid (36%)	238190	Ambient	5 ft/24 ft^2		
	Chloroform	7426	113	7 ft/1800 ft^2		
Praxair Distribution	Acetylene	6000	Ambient	No Dike	1.31	ESE

← (EC-5000082218, R301; EC-39014, R307; LBDCR 15-048, R309

TABLE 2.2-3B (Sheet 5 of 20) Revision 309 (06/16)

→ (EC-5000082218, R301; EC-39014, R307; LBDCR 15-048, R309)

HAZARDOUS MATERIALS STORED OR PROCESSED IN THE WATERFORD 3 VICINITY

Facility	Chemical Name	2016 Amount (lbs)*	Storage Temperature (Degrees F)	Area/Height of Dike (ft^2/ft)	Distance (Miles)	Direction
	Ethylene	1380	Ambient	No Dike		
St. Charles Waterworks	Chlorine	10000	Ambient	10'-12'	4.53	E
	Sulfuric Acid	61382	Ambient	10'-12'		
	Purate	45703	Ambient	10'-12'		
	Hydrofluorosilicic Acid	41700	Ambient	10'-12'		
St. John the Baptist Waste Water Treatment	Chlorine	4000	Ambient	Open storage rm	4.97	NNW
Shell Norco Chemical Plant - East Site	1-Butene	1000000			3.64	E
	Butane	1000000				
	cis-2-Butene	1000000				
	Isobutane	1000000				
	Isopentane	1000000				
	Methane	1000000				
	trans-2-Butene	1000000				
	1,3-Butadiene	8000000				
	Butane	8000000				
	Isopentane	8000000				
	Pentane	8000000				
	Propane	2880000				
	Propylene	2880000				
	Butane	2880000				
	Ethane	2880000				

← (EC-5000082218, R301; EC-39014, R307; LBDCR 15-048, R309)

TABLE 2.2-3B (Sheet 6 of 20) Revision 309 (06/16)

→ (EC-5000082218, R301; EC-39014, R307; LBDCR 15-048, R309)

HAZARDOUS MATERIALS STORED OR PROCESSED IN THE WATERFORD 3 VICINITY

Facility	Chemical Name	2016 Amount (lbs)*	Storage Temperature (Degrees F)	Area/Height of Dike (ft^2/ft)	Distance (Miles)	Direction
	Ethylene	2880000				
	Isobutane	2880000				
	Methane	2880000				
	Hydrogen	2880000				
	Isopentane	100000				
	Isoprene	100000				
	Pentane	100000				
	Propylene	1800000				
	Pentane	1800000				
	trans-2-Butene	1800000				
	Propane	1800000				
	Methane	1800000				
	Isopentane	1800000				
	Isobutane	1800000				
	Hydrogen	1800000				
	Ethylene	1800000				
	Ethane	1800000				
	cis-2-Butene	1800000				
	Acetonitrile	520000				
	Methanol	26000				
	Butane	2880000				
	1,3-Butadiene	2880000				

← (EC-5000082218, R301; EC-39014, R307; LBDCR 15-048, R309

→ (EC-5000082218, R301; EC-39014, R307; LBDCR 15-048, R309)

HAZARDOUS MATERIALS STORED OR PROCESSED IN THE WATERFORD 3 VICINITY

Facility	Chemical Name	2016 Amount (lbs)*	Storage Temperature (Degrees F)	Area/Height of Dike (ft^2/ft)	Distance (Miles)	Direction
	1,3-Butadiene	24000				
	Butane	24000				
	Isobutane	24000				
Shell Norco Chemical Plant - West Site	Butene	16000000			2.57	ENE
	Butane	16000000				
	2-Butene	16000000				
Union Carbide Taft/Star Complex	1,1-Dimethylethoxy-2-Propanol	1000	Ambient		1.37	ESE
	1,2-Dichloroethane	25000	Ambient			
	1,2-Propanediol	500000	Ambient			
	1,3-Butadiene	10000000	Ambient			
	1,4-Piperazinediethanol	10000000	Ambient			
	1-Butanol	10000000	Ambient			
	1-Octanol	25000	Greater than ambient			
	1-Piperazineethanol	10000000	Greater than ambient			
	1-Propene	25000	Ambient			
	2-(2-(2-Ethoxyethoxy)Ethoxy)Ethanol	500000	Greater than ambient			
	2-(2-(2-Ethoxyethoxy)Ethoxy)Ethanol	50000	Greater than ambient			
	2-(2-Methoxyethoxy)Ethanol	10000000	Ambient			
	2,5,8,11-Tetraoxatridecan-13-Ol	500000	Greater than ambient			
	2-Ethylhexene	1000	Ambient			

← (EC-5000082218, R301; EC-39014, R307; LBDCR 15-048, R309

TABLE 2.2-3B (Sheet 8 of 20) Revision 309 (06/16)

→ (EC-5000082218, R301; EC-39014, R307; LBDCR 15-048, R309)

HAZARDOUS MATERIALS STORED OR PROCESSED IN THE WATERFORD 3 VICINITY

Facility	Chemical Name	2016 Amount (lbs)*	Storage Temperature (Degrees F)	Area/Height of Dike (ft^2/ft)	Distance (Miles)	Direction
	2-Ethylhexyl Acrylate	10000000	Ambient			
	2-Ethylhexyl Alcohol	10000000	Ambient			
	2-Methylnaphthalene	75000	Ambient			
	2-Methylpentane	10000	Ambient			
	2-Phosphono-1,2,4-Butanetricarboxylic	25000	Ambient			
	2-Propanoic Acid, Ethyl Ester	500000	Ambient			
	2-Propanol: 1-Propoxy	5000	Ambient			
	2-Propanone	200000	Ambient			
	2-Propenoic Acid, 2-Carboxyethyl Ester	50000	Ambient			
	3d Trasar 73218	10000	Ambient			
	3-Methyl Butanol	750	Ambient			
	3-Methyl Pentane,Methylcyclopentane	10000	Ambient			
	4-Hydroxy-3-Methoxymandelic Acid	10000	Ambient			
	Accudri Sf6 Sulfur Hexafluoride	5000	Ambient			
	Acetaldehyde	500000	Ambient			
	Acetic Acid	500000	Ambient			
	Acetic Acid Buffer	50000	Greater than ambient			
	Acetylene	5000	Ambient			
	Acrolein	1000000	Greater than ambient			
	Acrylamide Copolymer In Hydrocarbon Oil	75000	Ambient			
	Acryl-Ex Ec-3259a	25000	Ambient			

← (EC-5000082218, R301; EC-39014, R307; LBDCR 15-048, R309

TABLE 2.2-3B (Sheet 9 of 20) Revision 309 (06/16)

→ (EC-5000082218, R301; EC-39014, R307; LBDCR 15-048, R309)

HAZARDOUS MATERIALS STORED OR PROCESSED IN THE WATERFORD 3 VICINITY

Facility	Chemical Name	2016 Amount (lbs)*	Storage Temperature (Degrees F)	Area/Height of Dike (ft^2/ft)	Distance (Miles)	Direction
	Acryl-Ex Ec-3354a	100000	Ambient			
	Acryl-Ex Ec-3466a	10000	Ambient			
	Acrylic Acid	500000	Ambient			
	Acrylic Acid	500000	Ambient			
	Additives	10000	Ambient			
	Additives	1000	Ambient			
	Additives	5000	Ambient			
	Aeea Make	1000000	Ambient			
	Alcohols, C6-12, Ethoxylated Propoxylated	1000	Ambient			
	Alkenes, C6	25000	Ambient			
	Allyl Alcohol	10000	Greater than ambient			
	Aluminum Titanium Chloride (Alti3cl12)	10000	Ambient			
	Aluminum: Trihexyl	10000	Ambient			
	Amine Mix	5000	Ambient			
	Aminoethylpiperazine	10000000	Ambient			
	Ammonia	1000000	Ambient			
	Anthracite Filter Media	1000000	Ambient			
	Argon	1000	Ambient			
	Benzene**	4200000	Ambient			
	Benzene: 1,1'-Oxybis	500000	Ambient			
	Benzene: 1,2,4-Trimethyl	10000	Ambient			

← (EC-5000082218, R301; EC-39014, R307; LBDCR 15-048, R309

TABLE 2.2-3B (Sheet 10 of 20) Revision 309 (06/16)

→ (EC-5000082218, R301; EC-39014, R307; LBDCR 15-048, R309)

HAZARDOUS MATERIALS STORED OR PROCESSED IN THE WATERFORD 3 VICINITY

Facility	Chemical Name	2016 Amount (lbs)*	Storage Temperature (Degrees F)	Area/Height of Dike (ft^2/ft)	Distance (Miles)	Direction
	Benzene: 1,2,4-Trimethyl	25000	Ambient			
	Butanoic Acid, Butyl Ester	500000	Ambient			
	Butene	10000000	Ambient			
	Butyl Acetal	500000	Ambient			
	Butyl Acrylate	10000000	Ambient			
	Butyl Isobutyrate	500000	Ambient			
	Butyraldehyde	10000000	Ambient			
	C4 Hydrocarbons	300000	Ambient			
	C5 mixed Hydrocarbons	1400000	Ambient			
	C9+ Hydrocarbons	1800000	Ambient			
	Carbon Dioxide	25000	Greater than ambient			
	Carbon Monoxide	2900	Greater than ambient			
	Carbonic Dihydrazide	25000	Ambient			
	Carbowax Peg 8000	500000	Ambient			
	Carboxylic Acid	25000	Ambient			
	Chevron Automatic Transmission Fluid, Dextron Ii	5000	Ambient			
	Chlorodifluoromethane	10000	Greater than ambient			
	Cocoamide Dea	1000	Ambient			
	Coconut Oil, Reaction Products With Diethanolamine	1000	Ambient			
	Compressor Oil	5000	Ambient			

← (EC-5000082218, R301; EC-39014, R307; LBDCR 15-048, R309

TABLE 2.2-3B (Sheet 11 of 20) Revision 309 (06/16)

→ (EC-5000082218, R301; EC-39014, R307; LBDCR 15-048, R309)

HAZARDOUS MATERIALS STORED OR PROCESSED IN THE WATERFORD 3 VICINITY

Facility	Chemical Name	2016 Amount (lbs)*	Storage Temperature (Degrees F)	Area/Height of Dike (ft^2/ft)	Distance (Miles)	Direction
	Dea Product	10000000	Ambient			
	Deg Make	500000	Greater than ambient			
	Deta	10000000	Ambient			
	Dicyclopentadiene**	300000	Ambient			
	Diesel Fuel	75000	Ambient			
	Diethylaluminum Chloride	10000	Ambient			
	Diethylene Ether	1000000	Ambient			
	Diethylene Glycol	10000000	Ambient			
	Diethylene Glycol	500000	Ambient			
	Diethylenetriamine	10000000	Ambient			
	Dimethyl Sulfide	50000	Ambient			
	Diphenyl	500000	Ambient			
	Distillates (Petroleum), Straight-Run Middle	11250	Greater than ambient			
	Dmag Compressor Oil	5000	Ambient			
	Ethane	500000	Greater than ambient			
	Ethanol	10000000	Ambient			
	Ethanol: 2-((2aminoethyl)Amino)-	10000000	Ambient			
	Ethanol: 2-(Diethylamino)-	25000	Ambient			
	Ethanol: 2,2'-Iminobis	10000000	Ambient			
	Ethene	500000	Greater than ambient			

← (EC-5000082218, R301; EC-39014, R307; LBDCR 15-048, R309

TABLE 2.2-3B (Sheet 12 of 20) Revision 309 (06/16)

→ (EC-5000082218, R301; EC-39014, R307; LBDCR 15-048, R309)

HAZARDOUS MATERIALS STORED OR PROCESSED IN THE WATERFORD 3 VICINITY

Facility	Chemical Name	2016 Amount (lbs)*	Storage Temperature (Degrees F)	Area/Height of Dike (ft^2/ft)	Distance (Miles)	Direction
	Ethene, Homopolymer	10000000	Ambient			
	Ethoxylated Nonylphenol Hydrotreated Light Distill	25000	Ambient			
	Ethyl Acrylate	10000000	Ambient			
	Ethylene Glycol	500000	Ambient			
	Ethylene Oxide	10000000	Less than Ambient but not cryogenic			
	Ethylenediamine	10000000	Ambient			
	Exxon Low Sulfur Diesel 2 Fuel Oil	1000000	Ambient			
	Fatty Acid	5000	Ambient			
	Fatty Alcohol Sulfate	5000	Ambient			
	Formaldehyde	5000	Greater than ambient			
	Fx5920 Dynamar	50000	Ambient			
	Gasoline	500000	Ambient			
	Glycol Ethers_Tcr&D	5000	Ambient			
	Hafnium Chloride	10000	Ambient			
	Heavy Aromatic Solvent Naphtha, Petroleum	75000	Ambient			
	Heavy Paraffinic Distillate	1000	Ambient			
	Helium	25000	Ambient			
	Hexane	200000	Ambient			
	Hexene	10000000	Ambient			
	Hydrochloric Acid (35%)	75000	Ambient			

← (EC-5000082218, R301; EC-39014, R307; LBDCR 15-048, R309

TABLE 2.2-3B (Sheet 13 of 20) Revision 309 (06/16)

→ (EC-5000082218, R301; EC-39014, R307; LBDCR 15-048, R309)

HAZARDOUS MATERIALS STORED OR PROCESSED IN THE WATERFORD 3 VICINITY

Facility	Chemical Name	2016 Amount (lbs)*	Storage Temperature (Degrees F)	Area/Height of Dike (ft^2/ft)	Distance (Miles)	Direction
	Hydrogen	75000	Ambient			
	Hydrogen Methane	5000	Greater than ambient			
	Hydrogen Peroxide (3%-17%)	25000	Ambient			
	Hydrogen Sulfide,Ucc	5000	Ambient			
	Hydroquinone And Monomethyl Ether_312	10000	Ambient			
	Hydrotreated Light Distillate	25000	Greater than ambient			
	Hydrotreated Light Naphthenic	1000	Ambient			
	Hypochlorous Acid, 1,1-Dimethylethyl Ester	500000	Ambient			
	Inv Chemcat_Paint Flammable Or Combustible	500000	Greater than ambient			
	Inv Chemcat_Paint Thinner Flammable & Combustible	50000	Ambient			
	Isobutyl Alcohol	1000000	Ambient			
	Isobutyraldehyde	10000000	Ambient			
	Isopentane	1000000	Ambient			
	Isopropyl Ether	10000000	Ambient			
	Lube Oils	500000	Ambient			
	Magnesium Chloride	10000	Ambient			
	Methane	500000	Ambient			
	Methanol	10000000	Ambient			
	Methoxydihydropyran	1000000	Ambient			
	Methoxytriglycol	10000000	Ambient			

← (EC-5000082218, R301; EC-39014, R307; LBDCR 15-048, R309)

TABLE 2.2-3B (Sheet 14 of 20) Revision 309 (06/16)

→ (EC-5000082218, R301; EC-39014, R307; LBDCR 15-048, R309)

HAZARDOUS MATERIALS STORED OR PROCESSED IN THE WATERFORD 3 VICINITY

Facility	Chemical Name	2016 Amount (lbs)*	Storage Temperature (Degrees F)	Area/Height of Dike (ft^2/ft)	Distance (Miles)	Direction
	Methyl Mercaptan	10000000	Ambient			
	Methyl-, Polymer With Oxirane	10000	Ambient			
	Methylmercaptopropionaldehyde	10000000	Less than Ambient but not cryogenic			
	Mineral Oil	25000	Ambient			
	Mineral Oil (White)	10000	Ambient			
	Monoethanolamine	10000000	Ambient			
	Monomethyl Ether	500000	Ambient			
	Morpholine	1500	Ambient			
	Mpeg 260	10000000	Ambient			
	N,N-Bis(1,4-Dimethylpentyl)-P-Phenylenediamine	50000	Ambient			
	N,N'-Bis(2-Hydroxyethyl)(Coconut Oil Alkyl)Amine	1000	Ambient			
	Nalco 22131 Traced Boiler Prod	50000	Ambient			
	Nalco Flocculant 71301	25000	Ambient			
	Nalco J-660m	50000	Greater than ambient			
	Naphtha**	3000000	Greater than ambient			
	Naphthalene**	600000	Ambient			
	Naphthalene: 1-Methyl	75000	Ambient			
	Nitrogen	50000	Ambient			
	Nitrous Oxide	5000	Ambient			

← (EC-5000082218, R301; EC-39014, R307; LBDCR 15-048, R309)

TABLE 2.2-3B (Sheet 15 of 20) Revision 309 (06/16)

→ (EC-5000082218, R301; EC-39014, R307; LBDCR 15-048, R309)

HAZARDOUS MATERIALS STORED OR PROCESSED IN THE WATERFORD 3 VICINITY

Facility	Chemical Name	2016 Amount (lbs)*	Storage Temperature (Degrees F)	Area/Height of Dike (ft^2/ft)	Distance (Miles)	Direction
	Nonane	5000	Ambient			
	Non-Hazardous Ingredients	75000	Ambient			
	Nonylphenoxypoly (Ethyleneoxy) Ethanol	50000	Ambient			
	N-Phenyl-Alpha-Naphthylamine	5000	Ambient			
	Para-Nonylphenol	10000000	Greater than ambient			
	Para-Tert-Octylphenol	10000000	Greater than ambient			
	PEG-1450 Molten	1000000	Greater than ambient			
	PEG -3350 Molten	500000	Greater than ambient			
	PEG -4000 Molten	1000000	Greater than ambient			
	PEG -4600 Molten	500000	Greater than ambient			
	PEG -8000 Molten	10000000	Greater than ambient			
	Pentaethylene Glycol	10000000	Ambient			
	Phenol: 2,6-Bis(1,1-Dimethylethyl)-4-Methyl	5000	Ambient			
	Phenothiazine	50000	Ambient			
	Phosphoric Acid	10000	Ambient			
	Pm 5935	5000	Ambient			
	Pm 6206	10000	Less than Ambient but not cryogenic			
	Poly(2-Ethylhexyl Acrylate)	10000	Greater than ambient			

← (EC-5000082218, R301; EC-39014, R307; LBDCR 15-048, R309

TABLE 2.2-3B (Sheet 16 of 20) Revision 309 (06/16)

→ (EC-5000082218, R301; EC-39014, R307; LBDCR 15-048, R309)

HAZARDOUS MATERIALS STORED OR PROCESSED IN THE WATERFORD 3 VICINITY

Facility	Chemical Name	2016 Amount (lbs)*	Storage Temperature (Degrees F)	Area/Height of Dike (ft^2/ft)	Distance (Miles)	Direction
	Poly(Oxy-1,2-Ethanediyl), Alpha-Hydro-Omega-Hydrox	500000	Ambient			
	Poly(Oxy-1,2-Ethanediyl), Alpha-Hydro-Omega-Hydrox; Potassium Phosphate	500000	Greater than ambient			
	Poly(Oxy-1,2-Ethanediyl), Alpha-Methyl-Omega-Hydro	500000	Ambient			
	Polyalkylene Glycol Monobutyl Ether	5000	Ambient			
	Polydimethylsiloxanes	25000	Ambient			
	Polydimethylsiloxanes	5000	Ambient			
	Polyolefin	5000	Ambient			
	Polypropylene Glycol	25000	Greater than ambient			
	Propane	10000000	Ambient			
	Propionic Acid	50000	Ambient			
	Proprietary Additives	25000	Ambient			
	Push Liquid Alive Bacteria, Pike Systems	10000	Ambient			
	Pyridine	50000	Ambient			
	Pyridinium Acetate	500000	Ambient			
	Regal R&O 150	5000	Ambient			
	Sd_Masterbatch Dfda-0033 Base Ingredients	1000000	Ambient			
	Sd_Masterbatch Dfda-0046 Base Ingredients	500000	Ambient			
	Sd_Masterbatch Dfdt-0073 Base Ingredients	500000	Ambient			
	Sd_W_Weston 399 (1147)	100000	Ambient			
	Severely Hydrotreated Petroleum Oil	1000	Ambient			

← (EC-5000082218, R301; EC-39014, R307; LBDCR 15-048, R309

TABLE 2.2-3B (Sheet 17 of 20) Revision 309 (06/16)

→ (EC-5000082218, R301; EC-39014, R307; LBDCR 15-048, R309)

HAZARDOUS MATERIALS STORED OR PROCESSED IN THE WATERFORD 3 VICINITY

Facility	Chemical Name	2016 Amount (lbs)*	Storage Temperature (Degrees F)	Area/Height of Dike (ft^2/ft)	Distance (Miles)	Direction
	Silane: Dichlorodimethyl-, Reaction Product With Silica	10000	Ambient			
	Silica	25000	Ambient			
	Sodium Dihydrogen Phosphate	25000	Ambient			
	Sodium Hydroxide (Na(Oh))	1000000	Ambient			
	Sodium Hypochlorite (11%) Solution	500000	Ambient			
	Sodium Methylate (25%)	100000	Ambient			
	SSR Coolant	1000	Ambient			
	Steam Condensate	10000000	Greater than ambient			
	Steel Shot	1000	Ambient			
	Stoddard Solvent	5000	Ambient			
	Sulfuric Acid	50000	Ambient			
	Sulfuric Acid	25000	Greater than ambient			
	Sulfuric Acid	25000	Ambient			
	Surgard 1700	5000	Ambient			
	Synthetic Detergent	10000	Ambient			
	Taft_Oxo_Heavies	500000	Ambient			
	Tetraethylene Glycol	500000	Ambient			
	Tetraethylenepentamine	10000000	Ambient			
	Toluene**	2000000	Ambient			
	Trade Secret Compound	25000	Ambient			
	Triethanolamine	10000000	Ambient			

← (EC-5000082218, R301; EC-39014, R307; LBDCR 15-048, R309

→ (EC-5000082218, R301; EC-39014, R307; LBDCR 15-048, R309)

HAZARDOUS MATERIALS STORED OR PROCESSED IN THE WATERFORD 3 VICINITY

Facility	Chemical Name	2016 Amount (lbs)*	Storage Temperature (Degrees F)	Area/Height of Dike (ft^2/ft)	Distance (Miles)	Direction
	Triethylaluminum	50000	Ambient			
	Triethylene Glycol	500000	Ambient			
	Triethylenetetramine	10000000	Ambient			
	Trimethyl Aluminum (9.8%)	10000	Ambient			
	Ucartherm Heat Transfer Fluid	50000	Ambient			
	Ucon Hydraulic Fluid Aw-32	1000	Ambient			
	Ucon Lub 50-Hb-170	5000	Ambient			
	Undecane	100000	Ambient			
	Unk	25000	Ambient			
	Unspecified Non-Volatile Compound, Environmental S	10000	Ambient			
	Unspecified Or Proprietary Volatile Compound, Envi	25000	Greater than ambient			
	Unspecified Or Proprietary Volatile Compound, Envi	10000	Ambient			
	Used Compressor Oil, Sn-2883	10000	Ambient			
	Vinyl Methyl Ether	500000	Greater than ambient			
	Wastewater With Organics	10000000	Ambient			
	Xrm-594	1000	Ambient			
	Zinc Chloride	1250	Ambient			
	Ztaft_Unidentified Components	50000	Ambient			
Valero St. Charles Refinery	1,2,4-Trimethylbenzene	135700			4.13	E
	1,3-Butadiene	1826				

← (EC-5000082218, R301; EC-39014, R307; LBDCR 15-048, R309

TABLE 2.2-3B (Sheet 19 of 20) Revision 309 (06/16)

→ (EC-5000082218, R301; EC-39014, R307; LBDCR 15-048, R309)

HAZARDOUS MATERIALS STORED OR PROCESSED IN THE WATERFORD 3 VICINITY

Facility	Chemical Name	2016 Amount (lbs)*	Storage Temperature (Degrees F)	Area/Height of Dike (ft^2/ft)	Distance (Miles)	Direction
	2,2,4-Trimethylpentane	4172652				
	Benzene	748397				
	Ethyl benzene	224099				
	Isopropyl Benzene	15283				
	Toluene	3907008				
	Xylene	3517164				
	Hexane	917038				
	1-Methylnaphthalene	88899				
	2-Methylnaphthalene	171252				
	Biphenyl	2423				
	Naphthalene	195095				
	Phenol	932				
Wagoil Bulk Fuel Supply	Gasoline	61057	Ambient	N/A	4.80	N
	Diesel Fuel	70139	Ambient	N/A		
Waterford Units 1, 2, and 4	Ammonia	1706	120	No Dike	0.426	WNW
	Hydrogen	179838	Ambient	No Dike		
	Sodium Hydroxide	213170	120	3ft		
	Sulfuric Acid	184147	Ambient	3ft		
	Diesel Fuel	63125	Ambient	N/A		
Western Intl Bulk Supply Facility	Acetylene	466961			1.27	E
	Diesel Fuel	70139				

← (EC-5000082218, R301; EC-39014, R307; LBDCR 15-048, R309

TABLE 2.2-3B (Sheet 20 of 20) Revision 309 (06/16)

→ (EC-5000082218, R301; EC-39014, R307; LBDCR 15-048, R309)

HAZARDOUS MATERIALS STORED OR PROCESSED IN THE WATERFORD 3 VICINITY

Facility	Chemical Name	2016 Amount (lbs)*	Storage Temperature (Degrees F)	Area/Height of Dike (ft^2/ft)	Distance (Miles)	Direction
W. R. Grace SHAC Plant	Isopentane	125000	Ambient	1872	2.57	ENE
	Titanium Tetrachloride	200000	Ambient	440		

* Projection based on survey performed in 2015

** Union Carbide Taft/Star Complex only – component of dripolene (pyrolysis gas)

← (EC-5000082218, R301; EC-39014, R307; LBDCR 15-048, R309

→ (EC-5000082218, R301; LBDCR 15-048, R309)

TABLE 2.2-3C Revision 309 (06/16)

HAZARDOUS MATERIALS SHIPPED ON THE MISSISSIPPI RIVER BY INDUSTRIAL FACILITIES IN THE WATERFORD 3 SES VICINITY

Facility	Chemical Name	Largest loading of single vessel (tons)[1]	Temp	Frequency (per month)
Koch Nitrogen Company	Anhydrous Ammonia	20,000	-28°F	2
		2,500	-28°F	15
Motiva Refinery—Norco	Pyrolysis gasoline blend[2]	25,000 bbl		
	Gasoline	≤350,000 bbl		
	No 6 Oil	≤300,000 bbl		
	Cat Cracker Feed[3]	≤300,000 bbl		
	Pitch	25,000 bbl		
	Benzene Concentrates	25,000 bbl		
	Jet - A	≤300,000 bbl		
	Diesel	≤300,000 bbl		
	Gas Oil	≤300,000 bbl		
	Naphtha	≤300,000 bbl		
	Methyl tert-butyl ether	≤300,000 bbl		
	Gasoline Components	≤300,000 bbl		
	Butadiene	250,000 bbl		
	Propylene	15,000 bbl		
	Hydrochloric or Sulfuric Acid	5,000 bbl		
	Caustic	10,000 bbl		
	Pitch	25,000 bbl		
Union Carbide Industrial Chemicals—Taft	Acetic acid	2,100		16
	Butadiene	1,250		4
	Butyl acrylate	150		14
		1,250		3
	n-Butyl alcohol (n-butanol)	2,000		94
		2,150		12
	Dripolene	3,500		29
	Ethyl acrylate	1,250		5
	Ethylenediamine	150		11
		400		7
	Ethylene dichloride	2,000		61
	Hexene	850		16
		2,500		10
	Naphtha	3,000		80
		30,500		14

NOTES:

1 Unless other units specified — when two values appear, the larger is for a ship, the smaller is for a barge

2 Contains benzene, toluene, dicyclopentadiene, isoprene and other C6 and longer aliphatic hydrocarbons.

3 Extra heavy gas oil, light and heavy flash gas oil (long chain aliphatic and olefinic hydrocarbons C8 and higher)

→ (LBDCR 15-048, R309)

4 This table contains historical information. Refer to Table 2.2-5 for latest Mississippi River data.

← (EC-5000082218, R301; LBDCR 15-048, R309)

→(DRN 02-1834, R12-C; EC-5000082218, R301; EC-39014, R307; LBDCR 15-048, R309)

HAZARDOUS MATERIALS CARRIED ON UNION PACIFIC RAILROAD IN 2014 IN VICINITY OF WATERFORD 3

HazMat Response Code	HazMat Description	Total Loads
4910165	PETROLEUM CRUDE OIL OR PETROLEUM OIL OR SHALE OIL, CRUDE	57,338
4910191	PETROLEUM CRUDE OIL OR PETROLEUM OIL OR SHALE OIL, CRUDE	30,454
4935230	POTASSIUM HYDROXIDE, SOLUTION OR POTASSIUM HYDROXIDE (CAUSTIC POTASSIUM)	3,778
4935240	SODIUM HYDROXIDE SOLUTION OR SODIUM (SODA), CAUSTIC (SODIUM HYDROXIDE), LIQUID LESS THAN OR EQUAL TO 55% CONCENTRATION	2,880
4910164	PETROLEUM CRUDE OIL OR PETROLEUM CONDENSATE	2,707
4907265	STYRENE MONOMER, STABILIZED OR STYRENE, LIQUID	2,361
4920353	ETHYLENE OXIDE OR ETHYLENE OXIDE WITH NITROGEN OR ETHYLENE OXIDE	1,785
4920523	CHLORINE OR CHLORINE GAS, LIQUEFIED	1,538
4932059	FORMALDEHYDE SOLUTIONS OR FORMALDEHYDE, LIQUID OR CONCENTRATE	1,396
4925206	4-THIAPENTANAL OR METHYLMERCAPTOPROPIONALDEHYDE	1,212
4916141	PHOSPHORUS, WHITE, DRY OR PHOSPHORUS, WHITE, UNDER WATER OR PHOSPHORUS, WHITE, IN SOLUTION OR PHOSPHORUS, YELLOW, DRY OR PHOSPHORUS, YELLOW, UNDER WATER OR PHOSPHORUS, YELLOW, IN SOLUTION OR PHOSPHORUS, NEC	1,189
4945770	SULFUR, MOLTEN OR SULPHUR, LIQUID	1,023
4935640	HEXAMETHYLENEDIAMINE, SOLID OR HEXAMETHYLENEDIAMINE, ANHYDROUS	882
4966110	ENVIRONMENTALLY HAZARDOUS SUBSTANCES, SOLID, N.O.S. OR ADIPIC ACID (HEXANEDIOIC ACID) (1, 4BUTANEDICARBOXYLIC ACID)	835
4920355	METHYL MERCAPTAN OR METHYL MERCAPTAN GAS	736
4904210	AMMONIA, ANHYDROUS	720
4909130	BUTANOLS OR BUTYL ALCOHOLS, VIZ. N-BUTYL ALCOHOL (BUTYRIC ALCOHOL OR 1-BUTANOL), SEC-BUTYL ALCOHOL (METHYL- ETHYL CARBINOL OR 2- BUTANOL) OR TERT-BUTYL ALCOHOL (TRIMETHYL-CARBINOL OR 2-METHYL-2 PROPANOL) NOT FIT FOR HUMAN CONSUMPTION	696
4905437	PETROLEUM GASES, LIQUEFIED OR PROPYLENE	636
4905752	LIQUEFIED PETROLEUM GAS, NEC, COMPRESSED	636
4960215	ENVIRONMENTALLY HAZARDOUS SUBSTANCES, LIQUID, N.O.S. OR ALCOHOLS, FATTY OR CYCLIC , ETHOXYLATED	632
4914108	COMBUSTIBLE LIQUID, N.O.S. OR ACRYLATES, BUTYL, ETHYLHEXYL, HYDROXYETHYL, HYDROXYPROPYL OR ISOBUTYL	618
4907270	VINYL ACETATE, STABILIZED OR VINYL ACETATE	586
4930040	SULFURIC ACID OR OIL OF VITRIOL 93-100% CONCENTRATION	562
4913250	COMBUSTIBLE LIQUID, N.O.S. OR OCTYL ALCOHOL (2-ETHYLHEXANOL, OR 2ETHYLHEXYL ALCOHOL), ISOOCTYL ALCOHOL, PRIMARY NORMAL OCTYLALCOHOL (ALCOHOL C-8, CAPRYLALCOHOL, CAPRYLIC ALCOHOL, HEPTYL CARBINOL, OCTOIC ALCOHOL, OCTYLIC ALCOHOL OR 1-OCTANOL)	550
4907215	ETHYL ACRYLATE, STABILIZED OR ETHYL ACRYLATE	521
4931405	ACRYLIC ACID, STABILIZED OR ACRYLIC ACID	484

←(DRN 02-1834, R12-C; EC-5000082218, R301; EC-39014, R307; LBDCR 15-048, R309)

→(DRN 02-1834, R12-C; EC-5000082218, R301; EC-39014, R307; LBDCR 15-048, R309)

HAZARDOUS MATERIALS CARRIED ON UNION PACIFIC RAILROAD IN 2014 IN VICINITY OF WATERFORD 3

HazMat Response Code	HazMat Description	Total Loads
4932004	FORMALDEHYDE SOLUTIONS OR FORMALDEHYDE, LIQUID OR CONCENTRATE	455
4960196	ENVIRONMENTALLY HAZARDOUS SUBSTANCES, LIQUID, N.O.S. OR ETHYLENE GLYCOL (ETHYLENE ALCOHOL OR GLYCOL)	405
4909328	FLAMMABLE LIQUIDS, N.O.S. OR METHOXYDIHYDROPYRAN	392
4931487	ALKYLPHENOLS, LIQUID, N.O.S. OR NONYL PHENOL	316
4907250	METHYL METHACRYLATE MONOMER, STABILIZED OR METHYL METHACRYLATE MONOMER	293
4905704	BUTADIENES, STABILIZED OR BUTADIENES AND HYDROCARBON MIXTURES, STABILIZED OR BUTADIENE FROM PETROLEUM, INHIBITED	286
4905795	VINYL METHYL ETHER, STABILIZED OR VINYL METHYL ETHER (METHYL VINYL ETHER OR MVE)	241
4935665	ETHANOLAMINE OR ETHANOLAMINE SOLUTIONS OR DIETHANOLAMINE, MONO- ETHANOLAMINE, TRIETHANOL-AMINE OR ETHANOLAMINE STILL BOTTOM MIXTURES	236
4912215	BUTYL ACRYLATES, STABILIZED OR ACRYLATES, BUTYL, ETHYLHEXYL, HYDROXYETHYL, HYDROXYPROPYL OR ISOBUTYL	233
4931303	ACETIC ACID, GLACIAL OR ACETIC ACID SOLUTION OR ACETIC ACID, GLACIAL OR LIQUID	231
4921005	EPICHLOROHYDRIN OR GLYCEROL-DICHLOROHYDRIN	221
4906420	ACRYLONITRILE, STABILIZED OR ACRYLONITRILE (VINYL CYANIDE) (PROPENENITRILE)	206
4966474	ENVIRONMENTALLY HAZARDOUS SUBSTANCES, LIQUID, N.O.S. OR GLYCOL BOTTOMS	184
4918335	HYDROGEN PEROXIDE, STABILIZED OR HYDROGEN PEROXIDE, AQUEOUS SOLUTIONS, STABILIZED OR HYDROGEN PEROXIDE (HYDROGEN DIOXIDE)	179
4960131	ENVIRONMENTALLY HAZARDOUS SUBSTANCES, LIQUID, N.O.S. OR CHEMICALS, NEC CLASS 9 MISCELLANEOUS HAZARDOUS MATERIALS	157
4966109	OTHER REGULATED SUBSTANCES, LIQUID, N.O.S. OR METHYLENE DIPHENYL DIISOCYANATE	157
4930228	HYDROCHLORIC ACID OR HYDROCHLORIC ACID SOLUTION OR MURIATIC (HYDROCHLORIC) ACID	146
4960133	ENVIRONMENTALLY HAZARDOUS SUBSTANCES, SOLID, N.O.S. OR CHEMICALS, NEC CLASS 9 MISCELLANEOUS HAZARDOUS MATERIALS	143
4935263	CORROSIVE LIQUID, BASIC, ORGANIC, N.O.S. OR CHEMICALS, NEC CLASS 8 CORROSIVE MATERIALS	137
4901350	ROCKET MOTORS OR ROCKET OR MISSILE PROPELLING UNITS (ROCKET MOTORS), OR JET THRUST (JATO) UNITS, OTHER THAN JET TYPE ENGINES, CLASS A EXPLOSIVES	129
4935601	AMINES, LIQUID, CORROSIVE, N.O.S. OR POLYAMINES, LIQUID, CORROSIVE, N.O.S. OR CHEMICALS, NEC CLASS 8 CORROSIVE MATERIALS	119
4905715	BUTYLENE OR BUTENE (BUTYLENE) GAS, LIQUEFIED, OR ISOBUTENE (ISOBUTYLENE), LIQUEFIED	116

←(DRN 02-1834, R12-C; EC-5000082218, R301; EC-39014, R307; LBDCR 15-048, R309)

→(DRN 02-1834, R12-C; EC-5000082218, R301; EC-39014, R307; LBDCR 15-048, R309)

HAZARDOUS MATERIALS CARRIED ON UNION PACIFIC RAILROAD IN 2014 IN VICINITY OF WATERFORD 3

Response Code	HazMat Description	Total Loads
4909124	ISOBUTANOL OR ISOBUTYL ALCOHOL OR ISOBUTYL ALCOHOL (ISOBUTANOL, ISOPROPYLCARBINOL OR 2-METHYLPROPANOL-1) NOT FIT FOR HUMAN CONSUMPTION	108
4960203	ENVIRONMENTALLY HAZARDOUS SUBSTANCES, LIQUID, N.O.S. OR COAL TAR CREOSOTE (CREOSOTE OR DEAD OIL) OR DISTILLATE OR SOLUTION, COAL TAR AND COAL TAR CREOSOTE (CREOSOTE OR DEAD OIL)	106
4906620	PROPYLENE OXIDE	98
4935614	DIETHYLENETRIAMINE	98
4907412	ALLYL CHLORIDE	89
4921598	PHENOL, MOLTEN OR CARBOLIC ACID (PHENOL)	88
4912210	DIESEL FUEL OR GAS OIL OR HEATING OIL LIGHT OR PETROLEUM DISTILLATE FUEL OIL, DIESEL OIL OR GAS OIL, NOT SUITABLE FOR ILLUMINATING PURPOSES	87
4930247	PHOSPHORIC ACID SOLUTION OR PHOSPHATIC FERTILIZER SOLUTION, CONTAINING NOT MORE THAN 77 PERCENT OF PHOSPHORIC ANHYDRIDE BY WEIGHT	87
4909152	ALCOHOLS, N.O.S. OR ETHYL ALCOHOL, ANHYDROUS, DENATURED IN PART WITH PETROLEUM PRODUCTS AND/OR CHEMICALS, PETROLEUM PRODUCTS AND/OR CHEMICALS NOT TO EXCEED FIVE PERCENT NOT FIT FOR HUMAN CONSUMPTION	86
4932378	HYPOCHLORITE SOLUTIONS OR SODIUM HYPOCHLORITE SOLUTION	85
4908255	PENTANES OR PETROLEUM ISOPENTANE	84
4915276	COMBUSTIBLE LIQUID, N.O.S. OR DIETHYLENE GLYCOL MONOETHYL ETHER	83
4960105	ENVIRONMENTALLY HAZARDOUS SUBSTANCES, SOLID, N.O.S. OR PHENOL, ALKYL	82
4931485	ALKYLPHENOLS, SOLID, N.O.S. OR MOLTEN OR PHENOL, ALKYL	74
4961609	ELEVATED TEMPERATURE LIQUID, N.O.S. OR ELECTRODE BINDER	72
4904509	CARBON DIOXIDE, REFRIGERATED LIQUID OR CARBON DIOXIDE GAS, LIQUEFIED OR CARBONIC ACID GAS	67
4921575	TOLUENE DIISOCYANATE	65
4936015	CORROSIVE LIQUIDS, TOXIC, N.O.S. OR CORROSIVE LIQUIDS, POISON, N.O.S. OR CHEMICALS, NEC CLASS 8 CORROSIVE MATERIALS	65
4914256	PETROLEUM DISTILLATES, N.O.S. OR PETROLEUM PRODUCTS, N.O.S. OR PETROLEUM NAPHTHA, NAPHTHA DISTILLATE OR NAPHTHA SOLVENTS	63
4907245	METHYL ACRYLATE, STABILIZED OR METHYL ACRYLATE	62
4935628	ETHYLENEDIAMINE OR ETHYLENEDIAMINE (1, 2- DIAMINOETHANE)	62
4963705	ENVIRONMENTALLY HAZARDOUS SUBSTANCE, LIQUID, N.O.S. OR METHYLENE DIPHENYL DIISOCYANATE	62
4930024	HYDROGEN FLUORIDE, ANHYDROUS	61
4936556	BATTERIES, WET, FILLED WITH ACID OR STORAGE BATTERIES, ELECTRIC, ASSEMBLED, NEC	60
4905748	ISOBUTYLENE OR BUTENE (BUTYLENE) GAS, LIQUEFIED, OR ISOBUTENE (ISOBUTYLENE), LIQUEFIED	58

←(DRN 02-1834, R12-C; EC-5000082218, R301; EC-39014, R307; LBDCR 15-048, R309)

→(DRN 02-1834, R12-C; EC-5000082218, R301; EC-39014, R307; LBDCR 15-048, R309)

HAZARDOUS MATERIALS CARRIED ON UNION PACIFIC RAILROAD IN 2014 IN VICINITY OF WATERFORD 3

HazMat Response Code	HazMat Description	Total Loads
4918769	SODIUM CARBONATE PEROXYHYDRATE OR SODIUM PERCARBONATE	57
4935645	HEXAMETHYLENEDIAMINE SOLUTION OR HEXAMETHYLENEDIAMINE (1, 6-DIAMINOHEXANE OR 1, 6-HEXANEDIAMINE) SOLUTION	57
4961605	ELEVATED TEMPERATURE LIQUID, N.O.S. OR ASPHALT (ASPHALTUM), BY-PRODUCT OR PETROLEUM, LIQUID, OTHER THAN PAINT, STAIN OR VARNISH	57
4961617	ELEVATED TEMPERATURE LIQUID, N.O.S. OR FUEL OIL, BUNKER "C"	47
4909205	ISOPROPANOL OR ISOPROPYL ALCOHOL OR ISOPROPANOL SOLUTION OR ISOPROPYL ALCOHOL SOLUTION OR PROPYL ALCOHOL (N-PROPYL ALCOHOL OR 1PROPANOL) OR ISOPROPYL ALCOHOL (DIMETHYLCARBINOL, IPA, ISOPROPANOL, SECPROPYL ALCOHOL OR 2-PROPANOL) NOT FIT FOR HUMAN CONSUMPTION	45
4961618	ENVIRONMENTALLY HAZARDOUS SUBSTANCES, LIQUID, N.O.S. OR ALCOHOLS, FATTY OR CYCLIC, ETHOXYLATED	44
4901174	ROCKETS OR ROCKET HEADS, EXPLOSIVE, OR WAR HEADS	41
4908194	ISOPROPYLAMINE OR ISOPROPYLAMINES, VIZ. DIISOPROPYLAMINE OR MONOISOPROPYLAMINE	39
4960173	ENVIRONMENTALLY HAZARDOUS SUBSTANCES, SOLID, N.O.S. OR DIETHANOLAMINE, MONOETHANOLAMINE, TRIETHANOLAMINE OR ETHANOLAMINE STILL BOTTOM MIXTURES	39
4908177	GASOLINE OR MOTOR SPIRIT OR PETROL OR GASOLINES, BLENDED, CONSISTING OF MOTOR FUELS CONTAINING 50 PERCENT OR MORE OF GASOLINES	36
4914109	COMBUSTIBLE LIQUID, N.O.S. OR ADDITIVES, FUEL OIL, GASOLINE, OR LUBRICATING OIL, CONTAINING LESS THAN 50 PERCENT BY WEIGHT OF PETROLEUM	36
4909243	ETHYL METHYL KETONE OR METHYL ETHYL KETONE OR METHYL BUTYL KETONE, METHYL ISOBUTYL KETONE, METHYLPROPYL KETONE, ETHYL AMYL KETONE OR MESITYL OXIDE	35
4909313	1-METHOXY-2-PROPANOL OR PROPYLENE GLYCOL MONOMETHYL ETHER	35
4907219	DICYCLOPENTADIENE	33
4909190	HEPTANES OR HEPTANES SOLUTIONS	33
4935204	CORROSIVE LIQUIDS, TOXIC, N.O.S. OR SODIUM HYDROSULFATE (SODIUM HYDROSULFIDE OR SODIUM SULPHYDRATE)	33
4912114	FLAMMABLE LIQUIDS, N.O.S. OR DICYCLOPENTADIENE	31
4923114	CHLOROACETIC ACID, SOLUTION OR ACID, CHLOROACETIC (CHLOR-ACETIC OR MONOCHLOROACETIC)	30
4935280	AMMONIA SOLUTIONS OR AMMONIUM HYDROXIDE OR AQUA AMMONIA, NEC	30
4912213	FUEL OIL OR PETROLEUM DISTILLATE FUEL OIL, DIESEL OIL OR GAS OIL, NOT SUITABLE FOR ILLUMINATING PURPOSES	29
4905761	METHYL CHLORIDE OR REFRIGERANT GAS R40	28
4925233	TOXIC LIQUID, INORGANIC, N.O.S. OR SODIUM BICHROMATE SOLUTION	28
4907419	FLAMMABLE LIQUIDS, TOXIC, N.O.S. OR CHEMICALS, NEC CLASS 3 (FLAMMABLE AND COMBUSTIBLE LIQUIDS)	26

←(DRN 02-1834, R12-C; EC-5000082218, R301; EC-39014, R307; LBDCR 15-048, R309)

→(DRN 02-1834, R12-C; EC-5000082218, R301; EC-39014, R307; LBDCR 15-048, R309)

HAZARDOUS MATERIALS CARRIED ON UNION PACIFIC RAILROAD IN 2014 IN VICINITY OF WATERFORD 3

HazMat Response Code	HazMat Description	Total Loads
4914168	FUEL OIL OR PETROLEUM RESIDUAL FUEL OIL OR DIESEL OIL	26
4910135	COAL TAR DISTILLATES, FLAMMABLE OR CRUDE LIGHT OIL OF COAL TAR	25
4915207	COMBUSTIBLE LIQUID, N.O.S. OR OCTYL ALCOHOL (2-ETHYLHEXANOL, OR 2ETHYLHEXYL ALCOHOL), ISOOCTYL ALCOHOL, PRIMARY NORMAL OCTYL ALCOHOL (ALCOHOL C-8, CAPRYL ALCOHOL, CAPRYLIC ALCOHOL, HEPTYL CARBINOL, OCTOIC ALCOHOL, OCTYLIC ALCOHOL OR 1-OCTANOL)	25
4961388	ENVIRONMENTALLY HAZARDOUS SUBSTANCES, LIQUID, N.O.S. OR ALCOHOLS, FATTY OR CYCLIC, ETHOXYLATED	25
4908183	HEXANES	24
4915209	COMBUSTIBLE LIQUID, N.O.S. OR OCTYL ALCOHOL (2-ETHYLHEXANOL, OR 2ETHYLHEXYL ALCOHOL), ISOOCTYL ALCOHOL, PRIMARY NORMAL OCTYL ALCOHOL (ALCOHOL C-8, CAPRYL ALCOHOL, CAPRYLIC ALCOHOL, HEPTYL CARBINOL, OCTOIC ALCOHOL, OCTYLIC ALCOHOL OR 1-OCTANOL)	24
4925151	ACRYLAMIDE SOLUTION	24
4914050	COMBUSTIBLE LIQUID, N.O.S. OR FUEL OIL, NO. 4	23
4930251	METHACRYLIC ACID, STABILIZED OR ACID, GLACIAL METHACRYLIC	23
4908119	BUTYRALDEHYDE	22
4909128	BUTYL ACETATES	22
4918311	AMMONIUM NITRATE OR AMMONIUM NITRATE FERTILIZER, DRY	22
4918775	HYDROGEN PEROXIDE, AQUEOUS SOLUTIONS OR HYDROGEN PEROXIDE (HYDROGEN DIOXIDE)	21
4931304	ACETIC ANHYDRIDE OR ACETIC ANHYDRIDE (ACETIC OR ACETYL OXIDE)	21
4903520	FIREWORKS OR PYROTECHNICS, NEC	20
4907425	HYDROCARBONS, LIQUID, N.O.S. OR RESINOUS PETROLEUM RESIDUE	20
4920504	HYDROGEN CHLORIDE, REFRIGERATED LIQUID OR HYDROGEN CHLORIDE, ANHYDROUS, LIQUEFIED	20
4932032	CORROSIVE LIQUID, BASIC, ORGANIC, N.O.S. OR SLUDGE, ACID OR ALKALI, CONTAINING NOT LESS THAN 75 PERCENT WATER (AN UNREFINED LIQUID WASTE OBTAINED AS A RESIDUE OF THE METAL FINISHING INDUSTRY)	19
4909150	DIETHYL KETONE	18
4909159	ETHANOL OR ETHYL ALCOHOL OR ETHANOL SOLUTION OR ETHYL ALCOHOL SOLUTION OR ETHANOL SOLUTIONS OR ETHYL ALCOHOL SOLUTIONS OR ETHYL ALCOHOL (COLOGNE SPIRITS, ETHANOL, ETHYL HYDROXIDE, FERMENTATION ALCOHOL, GRAIN ALCOHOL OR SPIRITS OF WINE) NOT FIT FOR HUMAN CONSUMPTION	18
4935641	AMINES, LIQUID, CORROSIVE, N.O.S. OR POLYAMINES, LIQUID, CORROSIVE, N.O.S. OR ADDITIVES, FUEL OIL, GASOLINE, OR LUBRICATING OIL, CONTAINING LESS THAN 50 PERCENT BY WEIGHT OF PETROLEUM	18
4941147	VEHICLE, FLAMMABLE LIQUID POWERED OR VEHICLE, FLAMMABLE GAS POWERED OR VEHICLE, FUEL CELL, FLAMMABLE LIQUID POWERED OR VEHICLE, FUEL CELL, FLAMMABLE GAS POWERED OR ENGINES, INTERNAL COMBUSTION OR ENGINES, FUEL CELL OR VEHICLES, MOTOR (AUTOMOBILES)	17

←(DRN 02-1834, R12-C; EC-5000082218, R301; EC-39014, R307; LBDCR 15-048, R309)

TABLE 2.2-3D (Sheet 6 of 14) Revision 309 (06/16)

→(DRN 02-1834, R12-C; EC-5000082218, R301; EC-39014, R307; LBDCR 15-048, R309)

HAZARDOUS MATERIALS CARRIED ON UNION PACIFIC RAILROAD IN 2014 IN VICINITY OF WATERFORD 3

HazMat Response Code	HazMat Description	Total Loads
4914855	ALCOHOLS, N.O.S. OR OCTYL ALCOHOL (2-ETHYLHEXANOL, OR 2ETHYLHEXYL ALCOHOL), ISOOCTYL ALCOHOL, PRIMARY NORMAL OCTYL ALCOHOL (ALCOHOL C-8, CAPRYL ALCOHOL, CAPRYLIC ALCOHOL, HEPTYL CARBINOL, OCTOIC ALCOHOL, OCTYLIC ALCOHOL OR 1-OCTANOL)	16
4960216	ENVIRONMENTALLY HAZARDOUS SUBSTANCES, LIQUID, N.O.S. OR ALCOHOLS, FATTY OR CYCLIC , ETHOXYLATED	16
4905726	LIGHTERS OR LIGHTER REFILLS OR LIGHTERS, CIGAR, CIGARETTE OR PIPE, NEC	15
4907420	FLAMMABLE LIQUID, TOXIC, N.O.S. OR ACETONITRILE, CRUDE	14
4909267	N-PROPANOL OR PROPYL ALCOHOL, NORMAL OR PROPYL ALCOHOL (N-PROPYL ALCOHOL OR 1PROPANOL) OR ISOPROPYL ALCOHOL (DIMETHYLCARBINOL, IPA, ISOPROPANOL, SECPROPYL ALCOHOL OR 2-PROPANOL) NOT FIT FOR HUMAN CONSUMPTION	14
4914247	PETROLEUM DISTILLATES, N.O.S. OR PETROLEUM PRODUCTS, N.O.S. OR OIL, PETROLEUM, NEC	14
4961166	ENGINES, INTERNAL COMBUSTION OR VEHICLE, FLAMMABLE GAS POWERED OR VEHICLE, FLAMMABLE LIQUID POWERED OR ENGINES, FUEL CELL OR VEHICLE, FUEL CELL, FLAMMABLE GAS POWERED OR VEHICLE, FUEL CELL, FLAMMABLE LIQUID POWERED OR INTERNAL COMBUSTION ENGINES	14
4909210	ISOPROPYL ACETATE	13
4909268	N-PROPYL ACETATE OR PROPYL ACETATE	13
4910489	FLAMMABLE LIQUIDS, N.O.S. OR RESINOUS PETROLEUM RESIDUE	13
4905414	METHYLAMINE, ANHYDROUS OR DIMETHYLAMINE, MONOMETHYLAMINE OR TRIMETHYLAMINE, ANHYDROUS	12
4910102	ALCOHOLIC BEVERAGES OR ALCOHOL, IN BOND (FREE OF INTERNAL REVENUE TAX), OTHER THAN DENATURED ALCOHOL OR METHANOL	12
4917403	SULFUR, MOLTEN OR SULPHUR, LIQUID	12
4921056	PESTICIDES, LIQUID, TOXIC, FLAMMABLE, N.O.S. OR CHEMICALS, NEC CLASS 6.1 POISONOUS MATERIALS	12
4921244	NITRILES, LIQUID, TOXIC, N.O.S. OR CHEMICALS, NEC CLASS 6.1 POISONOUS MATERIALS	12
4966333	SAFETY DEVICES OR AIR BAG INFLATORS OR SEAT BELT PRE-TENSIONERS OR AIR BAG MODULES OR SYSTEMS, AUTOMOBILE CRASH PROTECTION, GAS GENERATING TYPE, INFLATABLE RESTRAINTS	12
4905754	COMPRESSED GAS, FLAMMABLE, N.O.S. OR HYDROCARBON GAS, NEC	11
4909160	ETHYL ACETATE	11
4909249	TRIPROPYLENE	11
4920518	METHYL BROMIDE	11

←(DRN 02-1834, R12-C; EC-5000082218, R301; EC-39014, R307; LBDCR 15-048, R309)

TABLE 2.2-3D (Sheet 7 of 14) Revision 309 (06/16)

→(DRN 02-1834, R12-C; EC-5000082218, R301; EC-39014, R307; LBDCR 15-048, R309)

HAZARDOUS MATERIALS CARRIED ON UNION PACIFIC RAILROAD IN 2014 IN VICINITY OF WATERFORD 3

HazMat Response Code	HazMat Description	Total Loads
4905540	TRIMETHYLAMINE, ANHYDROUS OR DIMETHYLAMINE, MONOMETHYLAMINE OR TRIMETHYLAMINE, ANHYDROUS	10
4918448	TRICHLOROISOCYANURIC ACID, DRY OR TRICHLORO-S-TRIAZINETRIONE (TRICHLOROISOCYANURIC ACID)	10
4921016	PHOSPHORUS TRICHLORIDE OR PHOSPHORUS CHLORIDE OR TRICHLORIDE	10
4931313	CORROSIVE LIQUIDS, FLAMMABLE, N.O.S. OR ACETIC ACID, GLACIAL OR LIQUID	10
4932003	FORMALDEHYDE SOLUTIONS OR UREA FORMALDEHYDE CONCENTRATE	10
4935654	PIPERAZINE	10
4904584	LIQUEFIED GAS, N.O.S. OR COMPRESSED GASES, NEC, OTHER THAN POISON	9
4907280	VINYLIDENE CHLORIDE, STABILIZED OR VINYLIDENE CHLORIDE, INHIBITED	9
4904304	1,1,1,2-TETRAFLUOROETHANE OR REFRIGERANT GAS R134A OR COMPRESSED GASES, NEC, OTHER THAN POISON	8
4904820	FIRE EXTINGUISHERS OR FIRE EXTINGUISHERS, CHEMICAL, HAND OR STATIONARY, METAL, OTHER THAN WHEELED	8
4908195	DIISOPROPYL ETHER OR ISOPROPYL ETHER (DIISOPROPYL ETHER)	8
4960121	ENVIRONMENTALLY HAZARDOUS SUBSTANCES, LIQUID, N.O.S. OR CHEMICALS, NEC CLASS 9 MISCELLANEOUS HAZARDOUS MATERIALS	8
4960142	ENVIRONMENTALLY HAZARDOUS SUBSTANCES, LIQUID, N.O.S. OR UREA FORMALDEHYDE CONCENTRATE	8
4961614	ELEVATED TEMPERATURE LIQUID, N.O.S. OR PARAFFIN OR PETROLEUM WAX , NEC	8
4907428	HYDROCARBONS, LIQUID, N.O.S. OR OIL, PETROLEUM, NEC	7
4907840	METHYLAMINE, AQUEOUS SOLUTION OR DIMETHYLAMINE, MONOMETHYLAMINE, TRIMETHYLAMINE OR TRIMETHYLAMINE HYDROCHLORIDE, AQUEOUS	7
4910185	FLAMMABLE LIQUIDS, N.O.S. OR CHEMICALS, NEC CLASS 3 (FLAMMABLE AND COMBUSTIBLE LIQUIDS	7
4915185	COMBUSTIBLE LIQUID, N.O.S. OR CHEMICALS, NEC CLASS 3 (FLAMMABLE AND COMBUSTIBLE LIQUIDS	7
4905712	ETHYL CHLORIDE CLASS 2.1 UN1037 ETHYL CHLORIDE	6
4908105	ACETONE OR ACETONE SOLUTION OR ACETONE, NEC, SYNTHETIC, VIZ. ACETONE (DIMETHYLKETONE, KETOPROPANE, PYROACETIC ETHER, OR 2-PROPANONE)	6
4910176	PAINT OR ENAMEL, OTHER THAN WATCH DIAL	6
4910256	PETROLEUM DISTILLATES, N.O.S. OR PETROLEUM PRODUCTS, N.O.S. OR PETROLEUM NAPHTHA, NAPHTHA DISTILLATE OR NAPHTHA SOLVENTS	6
4910280	RESIN SOLUTION OR COMPOUNDS, RESIN, NOT COMMERCIALLY SUITABLE FOR EXTRUDING OR MOLDING PURPOSES, IN FLAKE, LIQUID, LUMP, POWDER OR SOLID MASS FORM, RESIN CONTENT NOT EXCEEDING 50 PERCENT BY WEIGHT	6

←(DRN 02-1834, R12-C; EC-5000082218, R301; EC-39014, R307; LBDCR 15-048, R309)

TABLE 2.2-3D (Sheet 8 of 14) Revision 309 (06/16)

→(DRN 02-1834, R12-C; EC-5000082218, R301; EC-39014, R307; LBDCR 15-048, R309)

HAZARDOUS MATERIALS CARRIED ON UNION PACIFIC RAILROAD IN 2014 IN VICINITY OF WATERFORD 3

HazMat Response Code	HazMat Description	Total Loads
4912043	METHYL ISOBUTYL CARBINOL OR METHYL ISOBUTYL CARBINOL NOT FIT FOR HUMAN CONSUMPTION	6
4921475	TOXIC LIQUIDS, ORGANIC, N.O.S. OR CHEMICALS, NEC CLASS 6.1 POISONOUS MATERIALS	6
4936330	MALEIC ANHYDRIDE OR MALEIC ANHYDRIDE, MOLTEN OR MALEIC ACID OR MALEIC ANHYDRIDE	6
4960218	ENVIRONMENTALLY HAZARDOUS SUBSTANCES, SOLID, N.O.S. OR BIPHENYL (DIPHENYL)	6
4963330	ENVIRONMENTALLY HAZARDOUS SUBSTANCES, LIQUID, N.O.S. OR COAL TAR CREOSOTE (CREOSOTE OR DEAD OIL) OR DISTILLATE OR SOLUTION, COAL TAR AND COAL TAR CREOSOTE (CREOSOTE OR DEAD OIL)	6
4905709	AEROSOLS OR COMPRESSED GASES, NEC, OTHER THAN POISON	5
4905716	1,1-DIFLUOROETHANE OR REFRIGERANT GAS R152A OR FLUOROETHANE GASES, FLAMMABLE, VIZ. DIFLUOROETHANE OR DIFLUOROMONOCHLOROETHANE (CHLORODIFLUOROETHANE OR DIFLUOROCHLOROETHANE)	5
4907614	ESTERS, N.O.S. OR CHEMICALS, NEC CLASS 3 (FLAMMABLE AND COMBUSTIBLE LIQUIDS)	5
4910320	FLAMMABLE LIQUIDS, N.O.S. OR PULP MILL LIQUID	5
4910349	FLAMMABLE LIQUIDS, N.O.S. OR COMPOUNDS, PETROLEUM TREATING, CRUDE, NEC	5
4910445	1-HEXENE OR OIL, PETROLEUM, NEC	5
4912675	PROPYLENE TETRAMER	5
4913112	COMBUSTIBLE LIQUID, N.O.S. OR COMPOUNDS, RESIN, NOT COMMERCIALLY SUITABLE FOR EXTRUDING OR MOLDING PURPOSES, IN FLAKE, LIQUID, LUMP, POWDER OR SOLID MASS FORM, RESIN CONTENT NOT EXCEEDING 50 PERCENT BY WEIGHT	5
4916305	ALUMINUM PHOSPHIDE	5
4932061	CORROSIVE LIQUID, BASIC, INORGANIC, N.O.S. OR METAM SODIUM	5
4932393	ZINC CHLORIDE, SOLUTION OR ZINC CHLORIDE, LIQUID	5
4961387	ENVIRONMENTALLY HAZARDOUS SUBSTANCES, LIQUID, N.O.S. OR ALCOHOLS, FATTY OR CYCLIC, ETHOXYLATED	5
4966134	ENVIRONMENTALLY HAZARDOUS SUBSTANCES, SOLID, N.O.S. OR DIPHENYL OXIDE OR DIPHENYL ETHER	5
4905782	PROPYLENE CLASS 2.1 UN1077 PROPYLENE	4
4907406	ALDEHYDES, FLAMMABLE, TOXIC, N.O.S. OR ALDEHYDES, FLAMMABLE, POISON, N.O.S. OR ACETALDEHYDE (ACETIC ALDEHYDE, ALDEHYDE, ETHANAL OR ETHYL ALDEHYDE)	4
4909219	FLAMMABLE LIQUIDS, N.O.S. OR GLYCOL ETHERS, NEC	4
4910101	PAINT OR ALUMINUM PAINT	4
4910287	ADHESIVES OR ROOFING CEMENT, NEC	4
4912604	ADHESIVES OR ADHESIVES, NEC, ADHESIVE CEMENTS, NEC, ADHESIVE GLUES, NEC, OR ADHESIVE PASTES, NEC, OR RUBBER CEMENT	4
4918723	SODIUM CHLORATE	4

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HAZARDOUS MATERIALS CARRIED ON UNION PACIFIC RAILROAD IN 2014 IN VICINITY OF WATERFORD 3

HazMat Response Code	HazMat Description	Total Loads
4921053	PESTICIDES, LIQUID, TOXIC, FLAMMABLE, N.O.S. OR NEMATOCIDE, LIQUID, VIZ. DICHLOROPROPENEDICHLOROPR OPANE MIXTURE	4
4921466	NITROANILINES	4
4925275	TOXIC LIQUIDS, ORGANIC, N.O.S. OR POISONOUS LIQUIDS, ORGANIC, N.O.S. OR CHEMICALS, NEC CLASS 6.1 POISONOUS MATERIALS	4
4930216	BATTERY FLUID, ACID OR SULFURIC ACID OR SULFURIC ACID SOLUTION OR ELECTROLYTE ACID, CONTAINING NOT TO EXCEED 47 PERCENT SULPHURIC ACID	4
4931461	CORROSIVE SOLID, ACIDIC, INORGANIC, N.O.S. OR CHEMICALS, NEC CLASS 8 CORROSIVE MATERIALS	4
4931466	CORROSIVE LIQUID, ACIDIC, ORGANIC, N.O.S. OR CHEMICALS, NEC CLASS 8 CORROSIVE MATERIALS	4
4931497	CORROSIVE LIQUID, ACIDIC, INORGANIC, N.O.S. OR IRON SULPHATE (FERRIC SULPHATE), OTHER THAN DRY (FERRIC SULPHATE SOLUTION)	4
4932309	ALKYL SULFONIC ACIDS, LIQUID OR ARYL SULFONIC ACIDS, LIQUID	4
4960118	ENVIRONMENTALLY HAZARDOUS SUBSTANCES, LIQUID, N.O.S. OR FATTY ALCOHOLS, ANIMAL FAT OR ANIMAL, FISH, PETROLEUM, SEA-ANIMAL OR VEGETABLE OILS, NEC, INEDIBLE, WHEN BLENDED WITH EACH OTHER, LIQUID OR SOLIDIFIED NOT FIT FOR HUMAN CONSUMPTION	4
4961602	ELEVATED TEMPERATURE LIQUID, N.O.S. OR CHEMICALS, NEC CLASS 9 MISCELLANEOUS HAZARDOUS MATERIALS	4
4905789	BUTANE OR BUTANE GAS, LIQUEFIED	3
4909230	METHANOL OR METHANOL (METHYL OR WOOD ALCOHOL), LIQUID NOT FIT FOR HUMAN CONSUMPTION	3
4910167	FLAMMABLE LIQUIDS, N.O.S. OR XYLENE (DIMETHYLBENZENE OR XYLOL),OTHER THAN SOLUTION	3
4910223	FLAMMABLE LIQUIDS, N.O.S. OR DRESSING OR BLACKING, AUTOMOBILE TOP, CURRIERS, HARNESS, SHOE, INCLUDING SHOE WHITENER (CLEANER), STOVE (STOVE POLISH) OR LEATHER, OTHER THAN BELT	3
4910241	ISOPROPANOL OR ISOPROPYL ALCOHOL OR COMPOUNDS, ORGANIC (PRODUCTS OF AMMONIATION OF FATTY ACIDS), VIZ. FATTY AMINE OR DIAMINE ACETATES, OR FATTY AMIDES, AMINES, DIAMINES OR NITRILES, OR FATTY QUATERNARY COMPOUNDS, SUCH AS DIFATTY DIMETHYL OR FATTY TRI	3
4914110	GAS OIL OR PETROLEUM DISTILLATE FUEL OIL, DIESEL OIL OR GAS OIL, NOT SUITABLE FOR ILLUMINATING PURPOSES	3
4916229	ORGANOMETALLIC SUBSTANCE LIQUID, PYROPHORIC, WATER-REACTIVE OR CHEMICALS, NEC CLASS 4.2 DANGEROUS WHEN WET MATERIALS	3
4916456	SODIUM OR METALLIC SODIUM	3
4918774	AMMONIUM NITRATE, LIQUID OR AMMONIUM NITRATE FERTILIZER, LIQUID	3
4921012	CARBAMATE PESTICIDES, LIQUID, TOXIC, FLAMMABLE OR CHEMICALS, NEC LASS 6.1 POISONOUS MATERIALS	3

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HAZARDOUS MATERIALS CARRIED ON UNION PACIFIC RAILROAD IN 2014 IN VICINITY OF WATERFORD 3

HazMat Response Code	HazMat Description	Total Loads
4925202	TETRACHLOROETHYLENE OR PERCHLOROETHYLENE	3
4936540	CORROSIVE LIQUIDS, N.O.S. OR CHEMICALS, NEC CLASS 8 CORROSIVE MATERIALS	3
4960159	ENVIRONMENTALLY HAZARDOUS SUBSTANCE, LIQUID, N.O.S. OR ADDITIVES, FUEL OIL, GASOLINE, OR LUBRICATING OIL, CONTAINING LESS THAN 50 PERCENT BY WEIGHT OF PETROLEUM	3
4963389	ENVIRONMENTALLY HAZARDOUS SUBSTANCES, SOLID, N.O.S. OR ZINC BORATE, DRY	3
4966996	ENVIRONMENTALLY HAZARDOUS SUBSTANCE, LIQUID, N.O.S. OR PETROLEUM NAPHTHA, NAPHTHA DISTILLATE OR NAPHTHA SOLVENTS	3
4821060	WASTE TOXIC LIQUIDS, FLAMMABLE, ORGANIC, N.O.S.	2
4907232	ETHYL METHACRYLATE, STABILIZED OR ETHYL METHACRYLATE	2
4909153	CHLOROBENZENE OR CHLOROBENZENE (CHLOROBENZOL) OR MONOCHLOROBENZENE (MONOCHLOROBENZOL)	2
4910181	EXTRACTS, FLAVORING, LIQUID OR FLAVORING COMPOUNDS, NEC, LIQUID OR PASTE, FLAVORING EXTRACTS OR IMITATION FLAVORS, NEC, DRY	2
4910265	PAINT RELATED MATERIAL OR SOLVENTS, ADHESIVE, GUM, LACQUER, PAINT, OTHER THAN SPRAY PAINT, PLASTIC, RESIN OR VARNISH	2
4910282	RESIN SOLUTION OR PLASTICS, RESINS OR GUMS, NEC, LIQUID	2
4912079	CYCLOHEXANONE	2
4914252	PETROLEUM DISTILLATES, N.O.S. OR PETROLEUM PRODUCTS, N.O.S. OR PETROLEUM NAPHTHA, NAPHTHA DISTILLATE OR NAPHTHA SOLVENTS	2
4921476	TOXIC SOLIDS, ORGANIC, N.O.S. OR POISONOUS SOLIDS, ORGANIC, N.O.S. OR CHEMICALS, NEC CLASS 6.1 POISONOUS MATERIALS	2
4921680	ORGANOTIN PESTICIDES, SOLID, TOXIC OR INSECTICIDES, INSECT REPELLENTS, ANIMAL REPELLENTS OR VERMIN EXTERMINATORS, NEC, OTHER THAN AGRICULTURAL INSECTICIDES	2
4921706	CRESOLS, LIQUID OR CRESYLIC ACID, INCLUDING META, ORTHO OR PARA (CRESOL)	2
4930229	CORROSIVE LIQUID, ACIDIC, ORGANIC, N.O.S. OR CHEMICALS, NEC CLASS 8 CORROSIVE MATERIALS	2
4930248	PHOSPHORIC ACID SOLUTION OR PHOSPHORIC ACID	2
4931499	CORROSIVE LIQUID, ACIDIC, ORGANIC, N.O.S. OR PETROLEUM ALKYLATE DETERGENT INTERMEDIATE	2
4932324	PHOSPHORUS PENTOXIDE OR PHOSPHORIC ANHYDRIDE	2
4935235	SODIUM HYDROXIDE, SOLID OR SODIUM (SODA), CAUSTIC (SODIUM HYDROXIDE), OTHER THAN LIQUID	2
4935624	ISOPHORONEDIAMINE OR CHEMICALS, NEC CLASS 8 CORROSIVE MATERIALS	2
4960160	ENVIRONMENTALLY HAZARDOUS SUBSTANCES, LIQUID, N.O.S. OR OIL, PETROLEUM, NEC	2
4960206	ENVIRONMENTALLY HAZARDOUS SUBSTANCES, LIQUID, N.O.S. OR DIETHANOLAMINE, MONOETHANOLAMINE, TRIETHANOLAMINE OR ETHANOLAMINE STILL BOTTOM MIXTURES	2

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HAZARDOUS MATERIALS CARRIED ON UNION PACIFIC RAILROAD IN 2014 IN VICINITY OF WATERFORD 3

HazMat Response Code	HazMat Description	Total Loads
4904501	AIR, COMPRESSED	1
4904515	COMPRESSED GAS, N.O.S. OR COMPRESSED GASES, NEC, OTHER THAN POISON	1
4904552	CHLORODIFLUOROMETHANE OR REFRIGERANT GAS R22 OR FLUOROMETHANE GASES, NONFLAMMABLE, VIZ. DICHLORODIFLUOROMETHANE (DIFLUORODICHLOROMETHANE), DICHLOROMONOFLUOROMETHANE (DICHLOROFLUOROMETHANE OR FLUORODICHLOROMETHANE), MONOCHLORODIFLUOROMETHANE	1
4904565	NITROGEN, COMPRESSED OR NITROGEN GAS, COMPRESSED	1
4904895	REFRIGERANT GAS R404A OR REFRIGERANTS, NEC, GAS OR LIQUID, NONFLAMMABLE	1
4905423	BUTANE OR BUTANE GAS, LIQUEFIED	1
4905746	HYDROGEN, COMPRESSED CLASS 2.1 UN1049 HYDROGEN GAS	1
4905777	RECEPTACLES, SMALL, CONTAINING GAS OR GAS CARTRIDGES OR COMPRESSED GASES, NEC, OTHER THAN POISON	1
4905784	PROPYLENE	1
4907010	FLAMMABLE LIQUIDS, N.O.S. OR ETHYL NITRATE	1
4907204	METHYL ACRYLATE, STABILIZED OR METHYL ACRYLATE	1
4909114	FLAMMABLE LIQUIDS, N.O.S. OR ISOPROPANOL AND TOLUENE SOLUTIONS, NEC NOT FIT FOR HUMAN CONSUMPTION	1
4909116	BUTYL ACETATES OR BUTYL ACETATE, SECONDARY	1
4909145	1,2-DICHLOROETHYLENE OR DICHLOROETHYLENE	1
4909237	METHANOL OR METHANOL, CONTAMINATED, HAVING VALUE ONLY FOR REFINING NOT FIT FOR HUMAN CONSUMPTION	1
4909348	XYLENES OR XYLENE (DIMETHYLBENZENE OR XYLOL),OTHER THAN SOLUTION	1
4909353	TERPENE HYDROCARBONS, N.O.S. OR PINENE	1
4909382	PETROLEUM DISTILLATES, N.O.S. OR PETROLEUM PRODUCTS, N.O.S. OR OIL, PETROLEUM, NEC	1
4909386	FLAMMABLE LIQUIDS, N.O.S. OR OCTENE	1
4910145	FLAMMABLE LIQUIDS, N.O.S. OR BOND BREAKING COMPOUND, CONSISTING OF NAPHTHA, PETROLEUM RESINS AND VEGETABLE OILS	1
4910156	PAINT RELATED MATERIAL OR PAINT OILS, NEC	1
4910240	ETHANOL OR ETHYL ALCOHOL OR ETHANOL SOLUTIONS OR ETHYL ALCOHOL SOLUTIONS OR ALCOHOL, IN BOND (FREE OF INTERNAL REVENUE TAX), OTHER THAN DENATURED ALCOHOL OR METHANOL	1
4910242	PETROLEUM DISTILLATES, N.O.S. OR PETROLEUM PRODUCTS, N.O.S. OR PETROLEUM DISTILLATE FUEL OIL, DIESEL OIL OR GAS OIL, NOT SUITABLE FOR ILLUMINATING PURPOSES	1
4910251	PAINT OR PAINTS, STAINS OR VARNISHES, NEC, BRONZING LIQUIDS, LACQUERS OR SHELLACS, LIQUID OR PASTE	1
4910267	PAINT RELATED MATERIAL OR PLASTICS, RESINS OR GUMS, NEC, LIQUID	1
4910364	EXTRACTS, AROMATIC, LIQUID OR FLAVORING COMPOUNDS, NEC, LIQUID OR PASTE, FLAVORING EXTRACTS OR IMITATION FLAVORS, NEC, DRY	1

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HAZARDOUS MATERIALS CARRIED ON UNION PACIFIC RAILROAD IN 2014 IN VICINITY OF WATERFORD 3

HazMat Response Code	HazMat Description	Total Loads
4910423	PERFUMERY PRODUCTS OR PERFUMERY	1
4910460	ADHESIVES OR POLISHING WHEEL CEMENT OR GLUE	1
4914121	COMBUSTIBLE LIQUID, N.O.S. OR CHEMICAL PLANT WASTE, NEC	1
4914348	XYLENES OR XYLENE (DIMETHYLBENZENE OR XYLOL),OTHER THAN SOLUTION	1
4915378	COMBUSTIBLE LIQUID, N.O.S. OR OIL, PETROLEUM, NEC	1
4915407	COMBUSTIBLE LIQUID, N.O.S. OR ETHYLENE GLYCOL MONOBUTYL ETHER	1
4915473	COMBUSTIBLE LIQUID ,N.O.S. OR N-METHYL PYRROLIDONE	1
4915747	COMBUSTIBLE LIQUID, N.O.S. OR ISOPHORONE	1
4916163	SELF-HEATING SOLID, ORGANIC, N.O.S. OR CHEMICALS, NEC CLASS 4.2 DANGEROUS WHEN WET MATERIALS	1
4916179	SODIUM DITHIONITE OR SODIUM HYDROSULFITE	1
4917344	SOLIDS CONTAINING FLAMMABLE LIQUID, N.O.S. OR CHEMICALS, NEC CLASS 4.1 FLAMMABLE SOLIDS	1
4918477	OXYGEN GENERATOR, CHEMICAL	1
4918746	SODIUM NITRATE OR SODIUM (SODA) NITRATE (CHILE SALTPETER, CALICHE OR SODA NITER)	1
4918807	ZINC BROMATE OR ZINC SALTS, NEC	1
4921060	TOXIC LIQUIDS, FLAMMABLE, ORGANIC, N.O.S. OR POISONOUS LIQUIDS, FLAMMABLE, ORGANIC, N.O.S. OR CHEMICALS, NEC CLASS 6.1 POISONOUS MATERIALS	1
4921203	TOXIC LIQUIDS, CORROSIVE, ORGANIC, N.O.S. OR POISONOUS LIQUIDS, CORROSIVE, ORGANIC, N.O.S. OR CHEMICALS, NEC CLASS 6.1 POISONOUS MATERIALS	1
4921209	BENZYL CHLORIDE	1
4921648	THIOGLYCOL OR MERCAPTOETHANOL	1
4923421	BARIUM COMPOUNDS, N.O.S. OR CHEMICALS, NEC CLASS 6.1 POISONOUS MATERIALS	1
4925089	COPPER BASED PESTICIDES, SOLID, TOXIC OR CHEMICALS, NEC CLASS 6.1 POISONOUS MATERIALS	1
4925224	CHLOROFORM OR CHLOROFORM (TRICHLOROMETHANE), NEC, TECHNICAL GRADE	1
4925258	TOXIC, LIQUIDS, ORGANIC, N.O.S. OR SOLUTION, COPPER PLATING	1
4925277	TOXIC, LIQUIDS, ORGANIC, N.O.S. OR WEED KILLING ACIDS, LIQUID	1
4925304	ISOCYANATES, TOXIC, N.O.S. OR ISOCYANATE SOLUTIONS, TOXIC, N.O.S. OR ISOCYANATE	1
4930026	FLUOROSILICIC ACID OR HYDROFLUOROSILICIC ACID	1
4930066	SULFURIC ACID, FUMING OR FUMING SULFURIC ACID, LESS THAN 30% IN STRENGTH	1
4931421	AMINES, LIQUID, CORROSIVE, N.O.S. OR POLYAMINES, LIQUID, CORROSIVE, N.O.S. OR PETROLEUM ALKYLATE DETERGENT INTERMEDIATE	1
4931446	CORROSIVE LIQUIDS, N.O.S. OR ADDITIVES, FUEL OIL, GASOLINE, OR LUBRICATING OIL, CONTAINING LESS THAN 50 PERCENT BY WEIGHT OF PETROLEUM	1

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→(DRN 02-1834, R12-C; EC-5000082218, R301; EC-39014, R307; LBDCR 15-048, R309)

HAZARDOUS MATERIALS CARRIED ON UNION PACIFIC RAILROAD IN 2014 IN VICINITY OF WATERFORD 3

Response Code	HazMat Description	Total Loads
4931451	PHOSPHOROUS ACID OR ACID, NEC, LIQUID, ORGANIC	1
4931702	CORROSIVE LIQUID, ACIDIC, ORGANIC, N.O.S. OR PETROLEUM ALKYLATE DETERGENT INTERMEDIATE	1
4932031	CORROSIVE LIQUID, BASIC, INORGANIC, N.O.S. OR SLUDGE, ACID OR ALKALI, CONTAINING NOT LESS THAN 75 PERCENT WATER (AN UNREFINED LIQUID WASTE OBTAINED AS A RESIDUE OF THE METAL FINISHING INDUSTRY)	1
4932057	CORROSIVE SOLID, ACIDIC, INORGANIC, N.O.S. OR CHEMICALS, NEC CLASS 8 CORROSIVE MATERIALS	1
4932060	CORROSIVE LIQUID, BASIC, INORGANIC, N.O.S. OR METAM SODIUM	1
4932327	CORROSIVE SOLIDS, N.O.S. OR COMPOUNDS, CLEANING, SCOURING OR WASHING, NEC, GRANULAR OR POWDER	1
4932342	FERRIC CHLORIDE, SOLUTION OR IRON CHLORIDE, CRUDE, LIQUID, NOT LESS THAN 50 PER CENT WATER	1
4935002	CORROSIVE LIQUIDS, TOXIC N.O.S. OR TERTIARY AMINES, NEC	1
4935258	CORROSIVE LIQUID, BASIC, INORGANIC, N.O.S. OR CHEMICALS, NEC CLASS 8 CORROSIVE MATERIALS	1
4936353	CORROSIVE SOLIDS, TOXIC, N.O.S. OR CORROSIVE SOLIDS, POISON, N.O.S. OR CHEMICALS, NEC CLASS 8 CORROSIVE MATERIALS	1
4936512	BATTERIES, WET, NON-SPILLABLE OR STORAGE BATTERIES, ELECTRIC, ASSEMBLED, NEC	1
4936535	PAINT OR COMPOUNDS, PAINT, LACQUER, VARNISH, ADHESIVE, OR RUST PREVENTIVE PIPE LINE COATING INCREASING, REDUCING, REMOVING OR THINNING, NEC	1
4936566	BATTERIES, WET, FILLED WITH ACID OR BATTERIES OR CELLS, ELECTRIC, STORAGE, LEAD ACID GEL OR STARVED ELECTROLYTE TYPE	1
4941144	POLYMERIC BEADS, EXPANDABLE OR POLYSTYRENE, OTHER THAN LIQUID	1
4945195	POLYCHLORINATED BIPHENYLS, SOLID OR SOIL, CHEMICAL WASTE CONTAMINATED, NEC, DRY	1
4960104	ENVIRONMENTALLY HAZARDOUS SUBSTANCES, SOLID, N.O.S. OR CATALYST, ALUMINA, SPENT	1
4960109	ENVIRONMENTALLY HAZARDOUS SUBSTANCES, SOLID, N.O.S. OR CHEMICALS, NEC CLASS 9 MISCELLANEOUS HAZARDOUS MATERIALS	1
4960114	ENVIRONMENTALLY HAZARDOUS SUBSTANCES, LIQUID, N.O.S. OR CHLORINATED HYDROCARBON RESIDUE SUITABLE ONLY FOR FURTHER PROCESSING	1
4960156	ELEVATED TEMPERATURE LIQUID, N.O.S. OR PHTHALIC ANHYDRIDE (ACID PHTHALIC ANHYDRIDE)	1
4960168	ENVIRONMENTALLY HAZARDOUS SUBSTANCES, LIQUID, N.O.S. OR WELL PACKING FLUID, NEC	1
4960180	ENVIRONMENTALLY HAZARDOUS SUBSTANCES, LIQUID, N.O.S. OR SODIUM NITRITE	1
4960198	ENVIRONMENTALLY HAZARDOUS SUBSTANCES, SOLID, N.O.S. OR SOLIDS OR DEBRIS, OTHER THAN SOIL LOW-LEVEL RADIOACTIVE CONTAMINATED, NEC, DRY	1

←(DRN 02-1834, R12-C; EC-5000082218, R301; EC-39014, R307; LBDCR 15-048, R309)

TABLE 2.2-3D (Sheet 14 of 14) Revision 309 (06/16)

→(DRN 02-1834, R12-C; EC-5000082218, R301; EC-39014, R307; LBDCR 15-048, R309)

HAZARDOUS MATERIALS CARRIED ON UNION PACIFIC RAILROAD IN 2014 IN VICINITY OF WATERFORD 3

HazMat Response Code	HazMat Description	Total Loads
4961161	ENVIRONMENTALLY HAZARDOUS SUBSTANCES, LIQUID, N.O.S. OR PLASTICIZERS, PAINT, LACQUER, VARNISH, GUM, PLASTIC, RESIN OR ADHESIVE	1
4961163	ENVIRONMENTALLY HAZARDOUS SUBSTANCES, SOLID, N.O.S. OR INSECTICIDES, AGRICULTURAL, NEC, OTHER THAN LIQUID	1
4961604	BENZALDEHYDE	1
4961606	ELEVATED TEMPERATURE LIQUID, N.O.S. OR OIL, PETROLEUM, NEC	1
4962113	ENVIRONMENTALLY HAZARDOUS SUBSTANCES, LIQUID, N.O.S. OR NAPHTHALENE, OTHER THAN CRUDE (NAPHTHALIN OR TAR CAMPHOR, OTHER THAN CRUDE)	1
4962127	ELEVATED TEMPERATURE LIQUID, N.O.S. OR RUBBER EXTENDER OR PROCESSING OIL, PETROLEUM BASE	1
4966702	LITHIUM METAL BATTERIES OR LITHIUM BATTERY OR BATTERIES, ELECTRIC, NEC	1

←(DRN 02-1834, R12-C; EC-5000082218, R301; EC-39014, R307; LBDCR 15-048, R309)

→(EC-5000082218, R301; EC-39014, R307; LBDCR 15-048, R309)

TABLE 2.2-3E (Sheet 1 of 3) Revision 309 (06/16)

HAZARDOUS MATERIALS CARRIED THROUGH GOOD HOPE, LA IN 2014 ON CANADIAN NATIONAL RAILWAY

UN Number	Proper Shipping Name	Total Number of DG Units
NA1993	COMBUSTIBLE LIQUID, N.O.S.	6472
UN1824	SODIUM HYDROXIDE SOLUTION	5012
UN1230	METHANOL	4647
UN1789	HYDROCHLORIC ACID	4436
UN1267	PETROLEUM CRUDE OIL	3145
NA3082	OTHER REGULATED SUBSTANCES, LIQUID, N.O.S.	2818
UN1040	ETHYLENE OXIDE	2180
UN3082	ENVIRONMENTALLY HAZARDOUS SUBSTANCE, LIQUID, N.O.S.	1698
UN1075	LIQUEFIED PETROLEUM GASES	1690
UN1017	CHLORINE	1561
UN1805	PHOSPHORIC ACID	1551
UN1086	VINYL CHLORIDE, STABILIZED	536
UN2055	STYRENE MONOMER, STABILIZED	515
UN1090	ACETONE	460
UN1170	ETHANOL	454
UN2051	2-DIMETHYLAMINOETHANOL	441
UN3257	ELEVATED TEMPERATURE LIQUID, N.O.S.	426
UN2078	TOLUENE DIISOCYANATE	404
UN1032	DIMETHYLAMINE, ANHYDROUS	384
UN1093	ACRYLONITRILE, STABILIZED	366
UN1063	METHYL CHLORIDE	334
UN1202	DIESEL FUEL	330
UN2370	1-HEXENE	314
UN1052	HYDROGEN FLUORIDE, ANHYDROUS	292
UN1083	TRIMETHYLAMINE, ANHYDROUS	289
UN3426	ACRYLAMIDE SOLUTION	278
UN1005	AMMONIA, ANHYDROUS	249
UN1547	ANILINE	247
UN3220	PENTAFLUOROETHANE	241
UN1198	FORMALDEHYDE SOLUTIONS, FLAMMABLE	216
UN1830	SULFURIC ACID	214
UN3295	HYDROCARBONS, LIQUID, N.O.S.	208
UN1077	PROPYLENE	207
UN1100	ALLYL CHLORIDE	196
UN2215	MALEIC ANHYDRIDE	190
UN1114	BENZENE	173

TABLE 2.2-3E (Sheet 2 of 3) Revision 309 (06/16)

HAZARDOUS MATERIALS CARRIED THROUGH GOOD HOPE, LA IN 2014 ON CANADIAN NATIONAL RAILWAY

UN Number	Proper Shipping Name	Total Number of DG Units
UN1010	BUTADIENES, STABILIZED	154
UN1673	PHENYLENEDIAMINES	154
UN2218	ACRYLIC ACID, STABILIZED	137
UN2924	FLAMMABLE LIQUIDS, CORROSIVE, N.O.S.	137
UN3159	1,1,1,2-TETRAFLUOROETHANE	133
UN2023	EPICHLOROHYDRIN	126
UN2734	AMINES, LIQUID, CORROSIVE, FLAMMABLE, N.O.S	125
UN2035	1,1,1-TRIFLUOROETHANE, COMPRESSED	111
UN1897	TETRACHLOROETHYLENE	91
UN1993	FLAMMABLE LIQUIDS, N.O.S.	89
NA2448	SULFUR, MOLTEN	88
UN1840	ZINC CHLORIDE, SOLUTION	86
UN1846	CARBON TETRACHLORIDE	82
UN3163	LIQUEFIED GAS, N.O.S.	81
UN1829	SULFUR TRIOXIDE, STABILIZED	81
UN1203	GASOLINE	80
UN1018	CHLORODIFLUOROMETHANE	77
UN1992	FLAMMABLE LIQUIDS, TOXIC, N.O.S.	73
UN1987	ALCOHOLS, N.O.S.	67
NA3077	OTHER REGULATED SUBSTANCES, SOLID, N.O.S.	66
UN1832	SULPHURIC ACID, SPENT	58
UN2056	TETRAHYDROFURAN	51
UN1051	HYDROGEN CYANIDE, STABILIZED	47
UN2031	NITRIC ACID	44
UN2312	PHENOL, MOLTEN	44
UN1061	METHYLAMINE, ANHYDROUS	42
UN1268	PETROLEUM DISTILLATES, N.O.S.	29
UN1715	ACETIC ANHYDRIDE	28
UN1307	XYLENES	24
UN1814	POTASSIUM HYDROXIDE, SOLUTION	23
UN2810	TOXIC, LIQUIDS, ORGANIC, N.O.S.	21
UN2581	ALUMINUM CHLORIDE, SOLUTION	18
UN3092	1-METHOXY-2-PROPANOL	17
UN1942	AMMONIUM NITRATE	16
UN2733	AMINES, FLAMMABLE, CORROSIVE, N.O.S.	13
UN1184	ETHYLENE DICHLORIDE	9

TABLE 2.2-3E (Sheet 3 of 3) Revision 309 (06/16)

HAZARDOUS MATERIALS CARRIED THROUGH GOOD HOPE, LA IN 2014 ON CANADIAN NATIONAL RAILWAY

UN Number	Proper Shipping Name	Total Number of DG Units
UN1263	PAINT	9
UN1221	ISOPROPYLAMINE	5
UN3065	ALCOHOLIC BEVERAGES	4
UN2789	ACETIC ACID, GLACIAL	3
UN3264	CORROSIVE LIQUID, ACIDIC, INORGANIC N.O.S.	3
UN1036	ETHYLAMINE	3
UN1760	CORROSIVE LIQUIDS, N.O.S.	2
UN3256	ELEVATED TEMPERATURE LIQUID, FLAMMABLE, N.O.S.	2
UN2831	1,1,1-TRICHLOROETHANE	1
UN1958	1,2-DICHLORO-1,1,2,2- TETRAFLUOROETHANE	1
UN1021	1-CHLORO-1,2,2,2-TETRA- FLUOROETHANE	1
UN1709	2,4-TOLUYLENEDIAMINE, SOLID	1
N/A	FREIGHT ALL KINDS - CONTAINS DANGEROUS GOODS	1
UN2811	TOXIC SOLID, ORGANIC, N.O.S.	1

←(EC-5000082218, R301; EC-39014, R307; LBDCR 15-048, R309

→(EC-5000082218, R301; EC-39014, R307; LBDCR 15-048, R309)

TABLE 2.2-3F (Sheet 1 of 4) Revision 309 (06/16)

HAZARDOUS MATERIALS CARRIED ON KANSAS CITY SOUTHERN RAILWAY THROUGH ST. CHARLES PARISH AND ST. JOHN THE BAPTIST PARISH IN 2014

STCC CODE	STCC DESCRIPTION	TOTAL SHIPMENTS
4905704	BUTADIENE, INHIBITED	2117
4905752	PETRO GAS LQD	991
4920353	ETHYLENE OXIDE	983
4905424	BUTANE GAS LQD	822
4930040	SULPHURIC ACID	704
4909205	ALCOHOL PROPYL	643
4961605	ASPH PETRO LIQ	431
4960131	CHEM,NEC HZ 9	401
4910242	FUEL OIL DISTL	271
4913128	ALCOHOL OCTYL	262
4913263	ISO-NONYL-ALCOH	257
4909382	PETRO OIL, NEC	251
4961388	FATTY ALCS OTH	243
4960147	ROSIN	222
4930247	FERT SOLUTION	212
4962127	RUBBER EXTENDER	191
4920523	CHLORINE GAS	169
4935240	CAUSTC SODA, LIQ	166
4920508	SULPHUR DIOXIDE	152
4921598	CARBOLIC ACID	145
4960146	PITCH TALL OIL	145
4906620	PROPYLENE OXIDE	108
4966109	METH DIPHENYL	107
4936330	MALEIC ACID	106
4910165	PETROLEUM OIL CRUDE	103
4960196	ETHYLENE GLYCOL	99
4961161	PLSTCRS, PLORV	92
4912114	DIYLOPNTDNE	82
4936659	STABILIZERS	80
4931702	PETRO ALKYLATE	76
4912275	VINYL TOLUENE	71
4908110	BENZENE, BENZOL	70
4960160	PETRO OIL, NEC	68
4914256	NAPHTHA, PETROLEUM	65
4910186	SULFATE TURPENT	63
4907250	METHYL METHACRYLATE	60

←(EC-5000082218, R301; EC-39014, R307; LBDCR 15-048, R309)

→(EC-5000082218, R301; EC-39014, R307; LBDCR 15-048, R309)

TABLE 2.2-3F (Sheet 2 of 4) Revision 309 (06/16)

HAZARDOUS MATERIALS CARRIED ON KANSAS CITY SOUTHERN RAILWAY THROUGH ST. CHARLES PARISH AND ST. JOHN THE BAPTIST PARISH IN 2014

STCC CODE	STCC DESCRIPTION	TOTAL SHIPMENTS
4966301	NONYL PHENOL	60
4960203	COAL TAR CREOSO	56
4910201	CHEM, NEC CL3	55
4910185	CHEM, NEC CL3	54
4907241	STYR/ETHYLBENZENE	53
4905712	ETHYL CHLORIDE	51
4914247	PETRO OIL,NEC	45
4908183	HEXANE	44
4961387	FATTY ALCS OTH	41
4910256	NAPHTHA, PETROLEUM	40
4918775	HYDROGEN PEROXIDE	40
4909215	JET FUELS	38
N/A	MIL IMPEDIMENTA	38
4930066	FMG SULFRC ACID	35
4921455	NITROBENZENE	34
4904326	REFRIGERANTS	32
4905782	PROPYLENE	30
4910444	ROSIN SOLUTION	26
4907230	ISOPRENE	22
4909130	BUTYL ALCOHOL	21
4945770	SULPHUR LIQUID	21
N/A	MIL IMPEDIMENTA	20
4910320	PULP MILL LIQ	19
4930228	MURIATIC ACID	17
4909266	PINENE	17
4910306	XYLEN/TOLUEN SO	16
4935204	SDM HYDROSULFID	14
4913117	DIISOPROPYL BEN	13
4910180	CHEM, NEC CL3	13
4950167	MIL IMPEDIMENTA	12
4921575	TOLUENE DIISOCY	12
4961390	FATTY ALCS OTH	10
4920355	METHYL MERCAPTA	10
4932393	ZINC CHLORIDE	9
4962104	FATTY ALCS OTH	8
4912408	SULFATE TURPENT	8

←(EC-5000082218, R301; EC-39014, R307; LBDCR 15-048, R309)

→(EC-5000082218, R301; EC-39014, R307; LBDCR 15-048, R309)

TABLE 2.2-3F (Sheet 3 of 4) Revision 309 (06/16)

HAZARDOUS MATERIALS CARRIED ON KANSAS CITY SOUTHERN RAILWAY THROUGH ST. CHARLES PARISH AND ST. JOHN THE BAPTIST PARISH IN 2014

STCC CODE	STCC DESCRIPTION	TOTAL SHIPMENTS
4935665	DIETHANOLAMINE	7
4907219	DIYLOPNTDNE	7
4909190	HEPTANE	7
4931486	PHENOL, ALKYL	7
4933301	MOPHL	7
4950150	FAK	6
4909249	TRIPROPYLENE	6
4921410	ANILINE OIL	5
4904210	AMMON ANHYDROUS	5
4909305	TOLUENE TOLUOL	5
4918723	SODIUM CHLORATE	5
4925202	PERCHLOROETHYLE	5
4936656	NAPHTHENIC SODM	5
4941147	MIL IMPEDIMENTA	5
4950155	AL FRT RTE SHPM	5
4961619	ASPH PETRO LIQ	5
4905510	DIMETHYLAMINE	4
4905792	VINYL CHLORIDE	4
4907265	STYRENE, LIQUID	4
4912035	POLYETHYLBENZEN	4
4912675	PROPYLN TETRAMR	4
4950130	FREIGHT FORWARD	4
4909243	METHYL ETHYL KE	3
4910115	AROMATIC CONCEN	3
4912498	RESID FUEL OIL	3
4935601	CHEM, NEC HZ 8	3
4936219	ZRCNM SLFT, BASC	3
4960159	ADDITIVES, FUEL	3
4961166	MIL IMPEDIMENTA	3
4963325	CHEM, NEC HZ 9	3
N/A	MIL IMPEDIMENTA	3
4961384	FATTY ALCS OTH	3
4904503	ARGON GAS,LIQ	2
4914009	GLYCOL ETHERS	2
4915185	CHEM, NEC CL3	2
N/A	MIL IMPEDIMENTA	2

←(EC-5000082218, R301; EC-39014, R307; LBDCR 15-048, R309)

→(EC-5000082218, R301; EC-39014, R307; LBDCR 15-048, R309)

TABLE 2.2-3F (Sheet 4 of 4) Revision 309 (06/16)

HAZARDOUS MATERIALS CARRIED ON KANSAS CITY SOUTHERN RAILWAY THROUGH ST. CHARLES PARISH AND ST. JOHN THE BAPTIST PARISH IN 2014

STCC CODE	STCC DESCRIPTION	TOTAL SHIPMENTS
4960133	CHEM, NEC HZ 9	2
4904258	MIL IMPEDIMENTA	1
4904565	MIL IMPEDIMENTA	1
4904820	MIL IMPEDIMENTA	1
4905421	GAS PROPANE	1
4909135	DIMTYL FORMAMID	1
4909251	METHYL ACETATE	1
4912285	NAPHTHA, PETRO	1
4930251	ACD GLCL MTHRYL	1
4931466	CHEM, NEC HZ 8	1
4932376	SDM BISULPHITE	1
4935218	SULP LIQ SKIM	1
4936019	AMMON CMPD,ORGN	1
N/A	MIL IMPEDIMENTA	1
4960101	SYN PLSTC LQD	1
4960215	FATTY ALCS OTH	1
4961615	ADDITIVES, FUEL	1
4961625	PETROLEUM RESIN	1

←(EC-5000082218, R301; EC-39014, R307; LBDCR 15-048, R309)

→(EC-5000082218, R301; EC-39014, R307; LBDCR 15-048, R309)

TABLE 2.2-3G Revision 309 (06/16)

HAZARDOUS MATERIAL SHIPPED BY TRUCK ON LOUISIANA HIGHWAY 18 IN THE WATERFORD 3 VICINITY IN 2015

Facility	Chemical Name	Shipments per Year	Maximum Amount in a Single Shipment Container
Hexion	Allyl Chloride	520	45m
	Epichlorohydrin	14	45m
	Hydrochloric acid	154	45m
St. Charles Waterworks	Chlorine	12	2000 lbs
St. John the Baptist Waste Water Treatment	Chlorine	48 tons/yr	2000 lbs
W. R. Grace SHAC Plant	Titanium Tetrachloride	56	39,683 lbs

←(EC-5000082218, R301; EC-39014, R307; LBDCR 15-048, R309)

→(EC-5000082218, R301)

TABLE 2.2-4 HAS BEEN INTENTIONALLY DELETED.

←(EC-5000082218, R301)

TABLE 2.2-4A Revision 307 (07/13)

→(DRN 01-076, R11-A; 02-1834, R12-C; EC-5000082218, R301; EC-41671, R307)

MATERIALS TRANSPORTED NEAR WATERFORD 3 POSING POTENTIAL HAZARDS

Route	Chemical	Average lading (tons)	Annual Shipments[e]	Annual Hazard Probability[a]
Mississippi River	Ammonia	2500[b]	940	1.93E-06
Union Pacific Railroad	Chlorine (from EC-S97-025)	88.7[c]	5521	1.71E-06
	Hydrogen Chloride	100	390	2.72E-10
	Methylamine	100	305[d]	1.12E-10
	Perchloroethylene same as (Tetrachloroethylene)	100	403	4.63E-09
	Sulfur Dioxide	100	123	1.68E-09
	Sulfur Monochloride	100	84	1.30E-12
Canadian National	Sulfur Trioxide	100	495	2.45E-06
	Nitric Acid	100	312	5.75E-08
Total Annual Hazard Probability				6.15E-06

[a] Annual probability of accident causing hazard to control room habitability from shipments of given commodity

[b] Average lading of ammonia barge based on quantity reported by Koch Nitrogen Company

[c] Based on 1987 UPRR report

[d] Sum of anhydrous methylamine and methylamine in aqueous solution

[e] The number of annual shipments used in determining the annual hazard probability conservatively assumes previous annual shipping data when the number of shipments for a given chemical decreased in the 2012 survey

←(DRN 01-076, R11-A; 02-1834, R12-C; EC-5000082218, R301; EC-41671, R307)

→(DRN 02-1834, R12-C; EC-5000082218, R301)

TABLE 2.2-4B HAS BEEN INTENTIONALLY DELETED.

←(DRN 02-1834, R12-C; EC-5000082218, R301)

→(DRN 02-1834, R12-C; EC-5000082218, R301; EC-39014, R307; LBDCR 15-048, R309)

TABLE 2.2-5 (Sheet 1 of 2) Revision 309 (06/16)

HAZARDOUS FREIGHT TRANSPORTED ON THE MISSISSIPPI RIVER BETWEEN MILE 129 AND 129.9 IN 2013

CODE	DESCRIPTION	ANNUAL TONS

Security Related Information
Withheld Under 10 CFR 2.390

←(DRN 02-1834, R12-C; EC-5000082218, R301; EC-39014, R307; LBDCR 15-048, R309)

→(DRN 02-1834, R12-C; EC-5000082218, R301; EC-39014, R307; LBDCR 15-048, R309)

TABLE 2.2-5 (Sheet 2 of 2) Revision 309 (06/16)

HAZARDOUS FREIGHT TRANSPORTED ON THE MISSISSIPPI RIVER BETWEEN MILE 129 AND 129.9 IN 2013

CODE	DESCRIPTION	ANNUAL TONS
3286	Plastics	19,819
3292	Starches, Gluten, Glue	14,150
3297	Chemical Additives	9,250
3299	Chem. Products NEC	60,708

←(DRN 02-1834, R12-C; EC-5000082218, R301; EC-39014, R307; LBDCR 15-048, R309)

Security Related Information
Withheld Under 10 CFR 2.390

TABLE 2.2-6 (Sheet 1 of 4) Revision 309 (06/16)

→(EC-5000082218, R301; EC-39014, R307; LBDCR 15-048, R309)

MAJOR PIPELINES CARRYING HAZARDOUS MATERIALS WITHIN TWO MILES OF WATERFORD 3

Security Related Information
Withheld Under 10 CFR 2.390

←(EC-5000082218, R301; EC-39014, R307; LBDCR 015-048, R 309)

TABLE 2.2-6 (Sheet 2 of 4) Revision 309 (06/16)

→(EC-5000082218, R301; EC-39014, R307; LBDCR 15-048, R309)

MAJOR PIPELINES CARRYING HAZARDOUS MATERIALS WITHIN TWO MILES OF WATERFORD 3

Security Related Information Withheld Under 10 CFR 2.390

←(EC-5000082218, R301; EC-39014, R307; LBDCR 015-048, R 309)

TABLE 2.2-6 (Sheet 3 of 4) Revision 309 (06/16)

→(DRN 02-865; EC-5000082218, R301; EC-39014, R307; LBDCR 15-048, R309)

MAJOR PIPELINES CARRYING HAZARDOUS MATERIALS WITHIN TWO MILES OF WATERFORD 3

Security Related Information
Withheld Under 10 CFR 2.390

←(EC-5000082218, R301; EC-39014, R307; LBDCR 015-048, R 309)

TABLE 2.2-6 (Sheet 4 of 4) Revision 309 (06/16)

→(DRN 02-865; EC-5000082218, R301; EC-39014, R307; LBDCR 15-048, R309)

MAJOR PIPELINES CARRYING HAZARDOUS MATERIALS WITHIN TWO MILES OF WATERFORD 3

Security Related Information Withheld Under 10 CFR 2.390

←(EC-5000082218, R301; EC-39014, R307; LBDCR 015-048, R 309)

TABLE 2.2 7 Revision 301 (09/07)

→(EC 5000082218, R301)

OIL AND GAS FIELDS WITHIN FIVE MILES OF WATERFORD 3[1]

←(EC 5000082218, R301)

Security Related Information Withheld Under 10 CFR 2.390

[4]Includes both natural gas and casing head gas

Sources: Louisiana Annual Oil and Gas Report, 1985, Louisiana Department of Natural Resources Office of Conservation, Baton Rouge, LA

Production Audit Section, Louisiana Department of Natural Resources, Baton Rouge, LA, July 1987

TABLE 2.2-8

TRIPS AND DRAFTS OF VESSELS ON THE MISSISSIPPI RIVER, BETWEEN BATON ROUGE TO, BUT NOT INCLUDING, NEW ORLEANS, LA. 1975*

Direction	Upbound						Downbound					
	Self Propelled Vessels			Non-Sel Propelled Vessels			Self Propelled Vessels			Non-Self Propelled Vessels		
Draft** (ft.)	Passenger And Dry Cargo	Tanker	Towboat or Tugboat	Dry Cargo	Tanker	Total	Passenger And Dry Cargo	Tanker	Towboat or Tugboat	Dry Cargo	Tanker	Total
40	57	144				201	41	16				57
39		118				118	34	29			1	64
38	18	111				129	63	38			6	107
37	46	79				125	58	29			5	92
36	86	66				152	68	46			12	126
35	50	53				103	81	96			4	181
34	45	42				87	63	73			1	137
33	56	38		3		97	58	72				130
32	20	46		3		69	63	53				116
31	25	28		2		55	52	32	1			85
30	35	47		91		173	64	68	2			134
29	36	41		3		80	42	49	2		1	94
28	33	26		5		64	41	62	2			105
27	30	37		3	3	73	37	64	1			102
26	79	56		28	13	176	45	145	4		1	195
25	45	53		30	7	135	60	130			3	193
24	56	57	8	18	7	146	47	198	6	1	2	254
23	71	68	3		2	144	75	68	1			144
22	70	82	1	1		154	73	60			12	145
21	67	66	1			134	80	60	1	2		143
20	84	73	2	7	3	169	60	54		2	12	129
19	77	38	65	5	5	190	41	17	61	1	1	121
18 and less	336	180	12,453	40,903	24,226	78,098	336	102	12,328	41,083	24,176	78,025
Total	1,422	1,549	12,533	41,102	24,226	80,872	1,582	1,561	12,409	41,083	24,090	80,879

* This table is a conservative estimate of the number of vessels which pass by Waterford 3 during the year. See Section 2.2.2.2 of the text for a full explanation.

** Draft is the distance from water level to the lowest point of the vessel underwater and is measured when the vessel is completely stopped either tied to a dock or at anchor.

Source: Waterborne Commerce of the United States, Calendar Year 1975, Part 2 Waterways and Harbours, Gulf Coast River System and Antilles Department of the Army Corps of Engineers, Vicksburg, Mississippi, 1975.

TABLE 2.2-9

COMMERCIAL VESSEL CASUALITIES ON THE MISSISSIPPI RIVER BETWEEN MILE 124 AND 135 REPORTED IN FISCAL YEAR 1976*

Date of Accident	Location (River Mile)	Type of Vessels Involved	Weather	Visibility	Nature and Cause of Accident
4/75	126	Tug or towboat involved in river towing (pushing) and a single skin liquid tank barge	Overcast	2 miles and over	Collision with vessel caused by misjudgement of wind, current or speed by licensed tugboat personnel
4/75	128	Tug or towboat involved in river towing (pushing) and an unspecified liquid cargo barge	Clear	2 miles and over	Collision with a fixed object (piers, bridges, etc) caused by restricted maneuvering in congested areas, docks, piers etc.
9/75	125	Deck loading barge and a non-self propelled dredge	Partly Cloudy	2 miles and over	Foundering caused by restricted maneuvering in congested area (docks, piers, etc)
12/75	134	Four vessels were involved: - foreign freight involved - a tug or towboat involved - in river towing (pushing); & - two open hopper cargo barges	Clear	2 miles and over	Collision of the vessels due to equipment failure on the freighter and restricted channel movement
1/76	131	Three vessels were involved: - tug or towboat; - two open hopper cargo barges	Clear	2 miles and over	Grounding with damage due to failure ascertain position
2/76	127	Three ships were involved: - a liquid cargo barge with an unspecified cargo; - a self unloaded tank barge carrying ammonia sulfate liquid fertilizer or other such liquids; and - a tug or towboat involved in river towing (pushing)	Clear Clear	2 miles and over	Collision with a vessel anchored or moored (only if not docking/undocking) caused by the misjudgement of current by licensed tugboat personnel
7/76	126	Tugboat or towboat	Clear	Unknown	Flooding or swamping without sinking due to equipment failure

*This table only shows those accidents which were reported to the U.S. Coast Guard in Fiscal Year 1976 and is not necessarily a complete list of all the accidents which occurred during that period. Accidents are listed by the Coast Guard in the year they were reported, not in the year they occurred. The date of occurrence is shown in Column 1.

Source: U.S. Coast Guard, Information and Analysis Staff, Washington, D. C., July, 1976.

TABLE 2.2 10 Revision 9 (12/97)

MISSISSIPPI RIVER TERMINALS, DOCKS, MOORING LOCATIONS AND WAREHOUSES IN THE VICINITY OF WATERFORD 3

Owner or Operator	Location	AHP Mileage	Type of Service
Du Pont de Nemours & Co., Inc., Ponchartrain Works	La Place, La.	135.7	Barge only
Entergy Louisiana Waterford SES Units 1 & 2	Taft, La.	129.9	Fuel Unloading Dock
Entergy Louisiana Little Gypsy SES	Taft, La.	129.6	Fuel Unloading Dock
Occidental & IMC Agrico	Taft, La.	128.8	Liquid and Bulk loading and unloading
Union Carbide Corp.	Taft, La.	127.8	Petro Chemicals; liquid handling for barges and tanker ships
Shell Chemical Co.	Norco, La.	126.9	Dock Facilities for barge load ing or unloading via pipelines
Shell Oil Co.	Norco, La.	126.0	Loading/unloading petroleum products
General American Transportation Corp	Good Hope, La.	125.4	Liquid storage of oil, chemicals, and vegetable oils

Source: U. S. Army Corps of Engineers, New Orleans, Louisiana, December 1976.

TABLE 2.2-11

FORECAST OF AIRCRAFT OPERATIONS FOR THE ST. JOHN THE BAPTIST PARISH AIRPORT

Year	Operations of Aircraft Based on the Study Area[1]	Itinerant Operations[2]	Total Operations
1982	28,600	15,730	44,330
1987	40,950	22,523	63,473
1992	53,300	29,315	82,615
1997	66,950	36,823	103,773

Notes

1) Based on 650 operations per year per aircraft based on the study area.

2) Estimated to be 55% of based aircraft operations.

Source: Chief of Houston Airports District Office, Department of Transportation, Federal Aviation Administration, Houston, Texas, May 16, 1977. Adjusted for the revised operational date of 1982 rather than 1980[84] and for the inclusion of itinerant operations[85].

TABLE 2.2-12

AIRCRAFT OPERATIONS FOR NEW ORLEANS INTERNATIONAL AIRPORT

	ITINERANT					LOCAL			
Year	Air Carrier	Air Taxi	General Aviation	Military	Total	General Aviation	Military	Total	Annual Total Operations
1966	87,614		36,461	i,608	125,683	13,429	2,313	15,742	141,425
1967	96,810		37,290	1,400	135,500	11,934	2,159	14,093	149,593
1968	io6,318		38,559	1,122	145,999	12,162	2,228	14,390	160,389
1969	119,958		39,263	1,362	160,583	12,484	2,269	14,753	175,336
1970	112,ii6		32,671	1,352	146,139	9,611	2,301	11,912	158,051
1971	110,757	4,366	32,453	1,399	148,975	10,075	11808	11,883	160,858
1972	109,319	10,488	31,333	1,117	152,257	11,604	1,316	12,920	165,177
1973	106,931	9,243	32,099	1,246	149,519	14,892	1,316	16,517	166,036
1974	91,080	13,697	33,835	11286	139,898	5,521	1,502	7,023	146,921
1975	85,574	15,235	34,234	1,375	136,418	5,664	21062	7,726	144,144
1976	93,311	15,936	36,481	1,327	147,055	7,287	1,561	8,848	155,903

Source: Department of Transportation, Federal Aviation Administration, Southwest Region, Fort Worth, Texas, Letter, October 26, 1977

TABLE 2.2-13

AIRCRAFT OPERATIONS FORECASTS FOR
NEW ORLEANS INTERNATIONAL AIRPORT

Year	Air Carrier	Commuter	All-Cargo	General Aviation	Military	Total
1980	116,600	13,500	1,400	49,700	4,000	185,200
1985	127,700	16,000	1,800	52,700	4,000	202,200
1990	137,000	18,100	2,200	54,700	4,000	216,000
1995	148,200	20,500	2,500	57,700	4,000	232,900
2000	168,300	22,100	2,900	60,700	4,000	258,000

Source: Chief of Houston Airports District Office, Department of Transportation, Federal Aviation Administration, Houston, Texas, May 16,1977.

TABLE 2.2-14

AIRCRAFT ACCIDENTS OCCURING ON OR WITHIN FIVE MILES OF NEW ORLEANS INTERNATIONAL AIRPORT, 1966 - 1976 *

		Aircraft			
Date	Location	Make	Model	People Injured	Injury Index
02/27/66	New Orleans, LA	Douglas	DC-8	None	None
10/22/66	New Orleans, LA	Douglas	DC-8	111	Minor
08/02/66	La Place, LA	Piper	PA-18	None	None
03/30/67	Kenner, LA	Douglas	DC-8	19	Fatal
09/03/67	New Orleans, LA	Lockheed	188A	None	None
02/27/67	New Orleans, LA	Beech	C-45H	None	None
09/18/67	Kenner, LA	Cessna	210	None	None
01/03/68	New Orleans, LA	Douglas	DC-6B	None	None
09/26/69	New Orleans, LA	Boeing	727	1	Fatal
03/20/69	New Orleans, LA	Douglas	DC-3A	16	Fatal
08/30/70	Kenner, LA	Cessna	210J	None	None
09/05/70	New Orleans, LA	Mooney	M20C	1	Serious
06/01/71	New Orleans, LA	Cessna	A185E	None	None
03/28/72	Kenner, LA	Piper	PA-28	None	None
12/28/72	New Orleans, LA	Beech	B95	None	None
07/26/72	New Orleans, LA	Boeing	727	None	None
08/20/74	Kenner, LA	Cessna	210E	1	Serious
01/05/75	Kenner, LA	Piper	PA-31	None	None

* 1976 Incomplete - Form Files as of 6/10/77

Source: Chief of Information Systems Division, Bureau of Technology National Transportation Safety Board, Washington, DC., June 13, 1977

TABLE 2.2-15 (Sheet 1 of 3)

VESSEL CASUALTIES ON THE MISSISSIPPI RIVER
BETWEEN NEW ORLEANS AND BATON ROUGE
FISCAL YEARS 1969-1971

NATURE OF CASUALITY	LOCATION OF CASUALITY (nearest 10 miles)															
	90	100	110	120	130	140	150	160	170	180	190	200	210	220	230	Total
1	4	1	1	1						1	2	1			1	12
2	1															1
3				1		1	1					1				4
4	8	4	1	3				1	1	2	1		1	2		24
5	3			1										1		5
6	2													1		3
7	3	1							1					1	2	8
8	3		1											1	1	6
9	5	2		2								4		1		14
10																0
11																1
12																0
13				1											1	2
14	1	1														2
15																0
16																0
17				1												1
18																0
19																0
20	4	1		1												6
21		1											2	1	1	5
22	1								1	1	1		1	1	5	11
23	1	2	2					1								6
24	2		1	1										3	1	8
25																0
26																0
27	1															1
28	2	1	1	1								2			1	8
29	2		1											1	1	5
30	4	1														5
31		3	1	2										2		8
Total	47	18	9	15	0	1	1	2	3	4	4	8	4	15	15	146

Nature of Casualty, code numbers 1 - 31, explained on following page.
*Waterford 3 is located at river mile 129.5.

TABLE 2.2-15 (Sheet 2 of 3)

Nature of Casualty

01 - Collision with vessel, meeting situation

02 - Collision with vessel, crossing situation

03 - Collision with vessel, overtaking situation

04 - Collision with vessel anchored or moored (use only if not docking/ undocking)

05 - Collision with vessel while docking or undocking

06 - Collision with vessel in fog (Takes precedence over 01, 02, 03)

07 - Collision with vessel, NOC (including minor bumps tug and vessel)

08 - Collision with Floating or Submerged objects (other than ground)

09 - Collision with Fixed Objects, piers, bridges

10 - Collision with ice or ice fields

11 - Collision with aids to navigation, fixed or floating

12 - Collision, other than with vessel, NOC (Offshore Rigs - Seaplanes)

13 - Explosion and/or fire involving liquid bulk cargo (includes vapors)

14 - Explosion and/or fire involving general cargo

15 - Explosion and/or fire involving vessel's fuel (includes vapors)

16 - Fire, vessel structure

17 - Fire, vessel equipment (only when damage to vessel structure is incidental, minor or absent) including crank case explosions, FY 71

18 - Explosion, boiler (whether or not fire results)

19 - Explosion, pressure vessels and compressed gas cylinders

20 - Explosion and/or fire - not otherwise classified

21 - Groundings with damage

22 - Groundings, no damage (cannot have monetary damage to vessel listed)
Nature of Casualty (Cont'd)

TABLE 2.2-15 (Sheet 3 of 3)

Nature of Casualty (Cont'd)

23 - Founderings

24 - Capsizing with or without sinking

25 - Flooding, swamping, without sinking

26 - Heavy weather damage and weather generally (FY 69 rarely used; heavy weather not nature)

27 - Cargo Damage, no damage to vessel

28 - Material failure, vessel structure

29 - Material failure, machinery and associated engineering equipment

30 - Material failure, equipment (other) including cargo gear, propeller shaft

31 - Casualty not otherwise classified, undetermined or insufficient information earthquake barge breakaway

FY 69 - Enemy action, vessel disabled due to fouled propeller, fishing vessel or tug

TABLE 2.2-16 (Sheet 1 of 2)

TIME AND DRAFTS OF VESSELS
MISSISSIPPI RIVER
BATON ROUGE, LA., TO BUT NOT INCLUDING NEW ORLEANS, LA., 1970

		SELF PROPELLED			NON-SELF PROPELLED		
DIRECTION	DRAFT (feet)	Passenger & Dry Cargo	Tanker	Towboat	Dry Cargo	Tugboat or Tanker	TOTAL
UPBOUND	40	2					2
	39	4					4
	38	20					20
	37	88					88
	36	37	5				42
	35	17	9				26
	34	16	11				27
	33	18	19				37
	32	36	19				55
	31	24	23				47
	30	47	25		41		113
	29	20	35				55
	28	30	33			1	64
	27	23	26			4	53
	26	79	36		32		147
	25	37	44		16		97
	24	61	57			4	122
	23	69	51				120
	22	81	66	1			148
	21	85	59				144
	20	119	82				201
	19	93	68				161
	18 & LESS	403	252	9156	27,570	19,332	56,713
	TOTAL	1409	920	9156	27,669	19,332	58,486

TABLE 2.2-16 (Sheet 2 of 2)

DIRECTION	DRAFT (feet)	SELF PROPELLED Passenger & Dry Cargo	SELF PROPELLED Tanker	Towboat	NON-SELF PROPELLED Dry Cargo	NON-SELF PROPELLED Tugboat or Tanker	TOTAL
DOWNBOUND	40	9	25				34
	39	18	37				55
	38	35	37				72
	37	36	20				56
	36	42	35				77
	35	61	69				130
	34	57	69				126
	33	69	58				127
	32	88	64			13	165
	31	77	67				144
	30	110	58				168
	29	54	44				98
	28	52	49				101
	27	31	34				65
	26	46	43		1		90
	25	50	35				85
	24	33	31				64
	23	48	26		2		76
	22	143	19		4		166
	21	53	18				71
	20	78	30		1	1	110
	19	37	17		2		56
	18 & LESS	185	40	9163	27,754	19,328	56,470
	TOTAL	1412	925	9163	27,764	19,342	58,606

DRAFT = distance from water level to the lowest point of the vessel underwater, measured when the vessel is completely stopped.

SOURCE: "WATERBORNE COMMERCE OF THE UNITED STATES, PART II" for 1970, p.164, by Department of the Army Corps of Engineers.

TABLE 2.2-17

RAIL, TRUCK AND BARGE ACCIDENT PROBABILITY*

Security Related Information Withheld Under 10 CFR 2.390

TABLE 2.2-18

CENTERLINE CONCENTRATION FOR METHANE PLUME
OF 67 LBM/SEC SOURCE, STABILITY CLASS F,
WIND SPEED 2.6 FT./SEC ASSUMING NO BUOYANCY

Security Related Information
Withheld Under 10 CFR 2.390

TABLE 2.2-19

RELEASES FROM RUPTURED PIPELINES

Security Related Information Withheld Under 10 CFR 2.390

TABLE 2.2-20

DIMENSION OF PROPANE PLUME DOWNWIND OF 325 FT^3/SEC SOURCE (6 IN. LPG LINE)
STABILITY CATEGORY F, WIND SPEED 2.6 FT/SEC

Security Related Information Withheld Under 10 CFR 2.390

TABLE 2.2-21

DIMENSION OF PROPANE PLUME DOWNWIND OF 1000 FT^3/SEC SOURCE, (8 IN. LPG LINE)
STABILITY CATEGORY F, WIND SPEED 2.6 FT/SEC

Security Related Information
Withheld Under 10 CFR 2.390

TABLE 2.2 22

BLAST AND SEISMIC PARAMETER FOR SHOCK WAVES
FROM PROPANE DETONATIONS

Security Related Information Withheld Under 10 CFR 2.390

TABLE 2.2-23 Revision 6 (12/92)

DIMENSION OF METHANE PLUME DOWNWIND OF 2893 FT 3/SEC SOURCE
STABILITY CATEGORY F, WIND SPEED 2.6 FT/SEC NO BUOYANCY

Security Related Information Withheld Under 10 CFR 2.390

rd - rich detonable limit
ld - lean detonable limit