## 2.2 NEARBY INDUSTRIAL, TRANSPORTATION AND MILITARY FACILITIES

This section of the U.S. EPR FSAR is incorporated by reference with the following supplements.

The U.S. EPR FSAR includes the following COL Item in Section 2.2:

> A COL applicant that references the U.S. EPR design certification will provide site-specific information related to the identification of potential hazards stemming from nearby industrial, transportation, and military facilities within the site vicinity, including an evaluation of potential accidents (such as explosions, toxic chemicals, and fires).

This COL Item is addressed as follows:

{This section also establishes whether the effects of potential accidents in the vicinity of the Callaway Plant Unit 2 site from present and projected industrial, transportation, and military installations and operations should be used as design basis events for plant design parameters related to the selected accidents.

In the discussions that follow, distances to the Callaway Site are measured from the midpoint between the Callaway Plant Unit 1 reactor and the Callaway Plant Unit 2 reactor unless stated otherwise. Significant facilities and activities within 5 mi (8 km) and major airports within 10 mi (16 km) of the Callaway site midpoint were identified. These facilities and activities, and significant facilities at greater distances, were evaluated in accordance with Regulatory Guide 1.206 (NRC, 2007b), Regulatory Guide 1.91 (NRC, 1978a), Regulatory Guide 4.7 (NRC, 1998), and relevant sections of both 10 CFR Part 100 (CFR, 2007d) and 10 CFR Part 50 (CFR, 2007b).

### 2.2.1 LOCATION AND ROUTES

The investigation of potential external hazard facilities and operations within 5 mi (8 km) of the Callaway Site identified one significant industrial facility (Mertens Quarry) for further evaluation. Callaway Plant Unit 1 and its associated onsite chemical storage facilities were identified as an internal hazard facility for further evaluation. Additionally, small quantities of gasoline and petroleum products (propane) are stored in aboveground tanks at two local service stations and one RV campground within 5 miles (8 km) of the site midpoint. No other commercial facilities have been identified within 5 miles (8 km) of the site that would be expected to store hazardous materials.

An evaluation of major transportation routes within the vicinity of the Callaway Site identified the following for further evaluation: six State roads and three County Roads with commercial traffic; 2 low altitude airways, 2 high altitude airways; and one navigable waterway.

Figure 2.2-1 is a site vicinity map that shows the location of the following facilities and transportation routes within 5 mi (8 km) of the Callaway Site:

- Mertens Quarry
- Missouri State Route (SR) 94
- SR D
- SR O
- SR AD/County Route (CR) 428

- SR CC
- SR VV
- CR 448
- CR 459
- Callaway Plant Unit 1
- Missouri River

An evaluation of nearby facilities and transportation routes within 10 mi (16 km) of the Callaway Site midpoint identified no military installations and no airports. The nearest military facility is a detachment of the Missouri National Guard at Fulton, approximately 11 miles (18 km) northwest, comprised of the 1140th Military Police Unit Headquarters and the 4175th Military Police Detachment (CID). These units consist of a total of 14 officers and 167 enlisted personnel (Missouri National Guard, 2007).

Figure 2.2-2 shows the following identified low level airway routes within 10 mi (16 km) of the Callaway Site midpoint:

- Airway V-12
- Airway V-175

Figure 2.2-3 shows the following identified high level airway routes within 10 mi (16 km) of the Callaway Site midpoint:

- Airway J105
- Airway J19-110-134

No facilities or activities beyond 5 miles (8 km) (10 mi [16 km] for airports) of the Callaway Site midpoint were identified for further evaluation based on their significance.

#### 2.2.1.1 References

**Airnav, 2007**. Airnav.com, Website: http://www.airnav.com/airports/, Date accessed: November 2, 2007.

**CFR, 2007b**. Title 10, Code of Federal Regulations, Part 50, Domestic Licensing of Production and Utilization Facilities, Nuclear Regulatory Commission, 2007.

**CFR, 2007d**. Title 10, Code of Federal Regulations, Part 100, Reactor Site Criteria, Nuclear Regulatory Commission, 2007.

**FAA, 2007a**. U.S. Department of Transportation, Federal Aviation Administration, IFR Enroute Low Altitude – U.S., 5 July 2007 to 30 Aug. 2007

**FAA, 2007a**. U.S. Department of Transportation, Federal Aviation Administration, IFR Enroute High Altitude – U.S., 5 July 2007 to 30 Aug. 2007

**DOE, 1996**. U.S. Department of Energy, DOE Standard, Accident Analysis for Aircraft Crash into Hazardous Facilities, October 1996, Reaffirmation May 2006

**MACOG, 2007**. Missouri Association of Councils of Government, http://macog.mo-acte.org/mm.htm, Retrieved: June 25, 2007

**Missouri National Guard, 2007**. Units and Detachments of the Missouri National Guard, www.moguard.com, (January 31, 2007)

**MoDOT, 2007**. Missouri Department of Transportation, Transportation Planning, Traffic Information (TR50), Sort Year 2006

**NIOSH 2006**. "NIOSH Pocket Guide to Chemical Hazards," National Institute for Occupational Safety and Health.

**NRC, 1978a**. Evaluations of Explosions Postulated To Occur on Transportation Routes Near Nuclear Power Plants, Regulatory Guide 1.91, Rev. 1, Nuclear Regulatory Commission, February, 1978.

**NRC, 1978b**. Standard Format and Content of Safety Analysis Reports for Nuclear Power Plants, Regulatory Guide 1.70, Revision 3, Nuclear Regulatory Commission, November, 1978.

**NRC, 1998**. General Site Suitability Criteria for Nuclear Power Stations, Regulatory Guide 4.7, Revision 2, Nuclear Regulatory Commission, April, 1998.

**NRC, 2007b**. Combined License Applications for Nuclear Power Plants, Regulatory Guide 1.206, Revision 0, Nuclear Regulatory Commission, April, 2007.

**RSMo, 2007**. Missouri Revised Statutes Chapter 251 Community Affairs, Planning and Development, http://www.moga.mo.gov/statutes/c251.htm - Last Modified: February 2007, Retrieved: June 25, 2007

**SB 193, 2007**. Missouri State Senate Economic Development, Tourism and Local Government Committee www.senate.mo.gov/07info/BTS_Web/Bill.aspx?SessionType=r&BillID=1208 - 17k, Retrieved: June 25, 2007

**US Army Corps of Engineers, 2007**. Waterborne Commerce of the United States Calender Year 2005, Part 2 Waterways and Harbors Gulf Coast, Mississippi River System and Antilles, www.iwr.usace.army.mil, (June 6, 2007)

**USDOT, 2007**. United States Department of Transportation, National Pipeline Mapping System, Callaway County Search, www.npms.phmsa.dot.gov, (June 5, 2007).

## 2.2.2 DESCRIPTIONS

Descriptions of the industrial, transportation, and military facilities located in the vicinity of the Callaway site are provided in this section. The facilities described include those facilities identified in Section 2.2.1 that could represent potential hazards for the Callaway Plant Unit 2 site.

Sections 2.2.2.1 through 2.2.2.9 are added as a supplement to the U.S. EPR FSAR.

#### 2.2.2.1 Description of Facilities

In accordance with 10 CFR 50.34 (CFR, 2007c) and Regulatory Guide 1.206 (NRC, 2007b), two facilities were identified for review: Callaway Plant Unit 1 and Mertens Quarry.

Table 2.2-1 provides a concise description of these facilities, including the primary functions and major products, as well as the number of persons employed.

#### 2.2.2.2 Description of Products and Materials

A more detailed description of the nearby facilities that were considered or selected for further review, including a description of the products and materials regularly manufactured stored, used, or transported, is provided in this Section.

##### 2.2.2.2.1 Callaway Plant Unit 1

The centerline of the existing Callaway Plant Unit 1 reactor is located approximately 1,350 ft (411 m), bearing 136.44 degrees of the centerline for Callaway Plant Unit 2. Callaway Plant Unit 1 is a pressurized water reactor (PWR) licensed by the NRC. Callaway Plant Unit 1 has a generating capacity of 1,284 MWe, and began commercial operation on December 19, 1984. The chemicals identified for possible analysis and their locations associated with Callaway Plant Unit 1 and Callaway Plant Unit 2 are presented in Table 2.2-2. The analysis of these chemicals is addressed in Section 2.2.3, and the disposition of hazards associated with these chemicals is summarized in Table 2.2-7.

Radiological hazards due to the release of radioactive material from Callaway Plant Unit 1 as a result of normal operation or an unanticipated event are addressed in Section 2.2.3.

##### 2.2.2.2.2 Manufacturing Facilities

No manufacturing or chemical plants exist within 5 miles (8 km) of the site midpoint. The nearest industrial facility is a 67-megawatt fossil-fueled power plant utilizing two coal-fired boilers at Chamois, 6 miles (10 km) south of the site and across the Missouri River.

##### 2.2.2.2.3 Mining Activities

The closest mining activity to the site midpoint is Mertens Quarry, a limestone quarry located 4.5 miles (7.2 km) northwest of the plant site. The quarry employs 15 persons and has a potential reserve of about 16.5 million short tons (15 million metric tons) of rock. The current rate of extraction is approximately 150,000 short tons (136,000 metric tons) per year.

Hazardous materials stored on site at the quarry include detonators (electrical caps), gel-type explosives (DynoAP), and ammonium nitrate prills (pellets) premixed with diesel oil (Table 2.2-3). All explosives are shipped by federally approved trucks. Detonators are stored regularly in quantities of <500 caps, and shipments are made weekly to bi-weekly. From 100 pounds (45 kg) to 5,500 pounds (2,500 kg) of gel type explosives are stored at the quarry and shipments occur weekly to bi-weekly. A maximum of 22 short tons (20 metric tons) of ammonium nitrate prills are stored at the quarry and shipments occur weekly to bi-weekly.

A closed limestone mine owned by AmerenUE is located approximately one mile (1.6 km) east of the site. No explosives are stored at the mine. The mine was registered with the Mining Enforcement and Safety Administration (MESA) by Midwest Pre Cote Company, a sub-contractor used in the construction of Callaway Plant Unit 1. This mine was not permitted by MDNR.

Four miles (6.4 km) south of the site midpoint and 0.5 miles (0.8 km) east of Steedman is an abandoned quarry, which tree and shrub overgrowth indicates to have been dormant for at least 15 years. Fire clay was once mined in the vicinity, and a number of abandoned fire-clay pits have been located.

#### 2.2.2.3 Pipelines

No pipelines or tank farms are located within 5 miles (8 km) of the site midpoint. The nearest pipeline, Southern Star Central Gas Pipeline's 8-inch (20 cm) diameter products pipeline, is approximately 7 miles (11 km) north of the site, runs from St. Charles to Columbia, Missouri, and carries natural gas. The pipeline route is shown on Figure 2.2-4 (USDOT, 2007).

#### 2.2.2.4 Description of Waterways

The Missouri River, approximately 5 miles (8 km) southeast of the site midpoint, is a transportation artery for barge traffic. Maximum cargo loads are a function of barge size and river depth. The largest cargo load reported by MEMCO Barge Lines was 1,350 short tons (1,220 metric tons) for Missouri River barges. Typical cargo loads are usually 1,250 short tons (1,130 metric tons), and the typical number of barges in a single tow may be as many as 9 depending on barge size, travel direction, and water levels. A total of 187,000 short tons (170,000 metric tons) of potentially hazardous commodities, listed in Table 2.2-4, were shipped on the Missouri River between Kansas City and St. Louis in 2005. (U.S. Army Corps of Engineers, 2007).

#### 2.2.2.5 Highways

Six State roads and three County roads are within 5 miles (8 km) of the center point coordinates of the plant site. They are listed in Table 2.2-5 and shown on Figure 2.2-1.

Average daily traffic (ADT) counts for 2006 provided by the Missouri Department of Transportation (MoDOT) (MoDOT, 2007) indicate traffic flow is primarily along State Routes O, CC, and 94. ADT counts for 2006 are shown on Figure 2.2-1 and described as follows: an ADT count of 1,482 vehicles was recorded on State Route O east of Fulton, and an ADT count of 902 vehicles was recorded east of the junction of State Routes CC and O. On State Route CC, 2 miles (3.2 km) south of State Route O at the immediate plant vicinity the ADT was 1,688 vehicles. An ADT count of 2,540 vehicles was recorded on State Route 94 southwest of Mokane. The traffic counts indicate that the bulk of the traffic turned north onto State Route CC as the ADT count decreased to 702 vehicles east of the State Route 94 and State Route CC intersection. Further east (east of State Route D), an ADT count of 732 vehicles was recorded on State Route 94 (MoDOT 2007).

The most hazardous materials that may be shipped by highway are labeled Class A explosives and include such materials as dynamite, blasting caps, and other high explosives. The maximum gross vehicle weight permitted on all highways by the Missouri Department of Transportation (MoDOT), including the weight of the load and the vehicle, is 80,000 pounds (36,300 kg) except where bridge structures are posted with lower weight limits. Missouri has adopted as State law Parts 390 through 397 of the Federal Motor Carrier Safety Regulations, which include provisions for the transportation of explosives (MoDOT, 2007). Any explosives shipped to Mertens quarry, the only known user of such materials within 5 miles (8 km) of the Callaway Site midpoint, are from I-70 south on State Route JJ to County Route 133; therefore, none of these explosives shipments gets any closer to the plant than Mertens Quarry at 4.7 miles (7.6 km) distance northwest. In general, shipments of explosives would be expected to be routed on US Interstate 70 and US Highway 54 unless there was a local delivery. The closest route to the plant site that would be used by firms shipping such materials locally would be State Route 94. State Route 94 at its closest point is located approximately 3.7 miles (6 km) from

the plant site. Whether explosives are shipped along State Route 94 is unknown as there are no federal, state, or local agencies that are required by law to keep records of transportation of hazardous materials and no data are available.

The roads nearest the plant site are County Roads 428, 448, and 459, which are shown on Figure 2.2-1. County Road 428 is approximately 7,750 feet (3,360 m) to the northwest of the site midpoint, County Road 448 is approximately 1,900 feet (580 m) to the northeast, and County Road 459 is approximately 2,300 feet (700 m) to the southwest. Several propane companies may use County Roads 448 and 459 when delivering propane to residences near the plant site. Local propane delivery trucks are expected to range in size from 1,800 to 2,600 gallons (6,800 to 9,800 l).

#### 2.2.2.6 Railroads

There are no railroads within 5 mi (8 km) of the Callaway Site midpoint.

#### 2.2.2.7 Aircraft and Airway Hazards

Regulatory Guide 1.70 (NRC, 1978b), Regulatory Guide 1.206 (NRC, 2007b), and NUREG-0800 (NRC, 2007a) require that the risks due to aircraft hazards are sufficiently low. In accordance with Regulatory Guide 1.206 and Regulatory Guide 1.70, no airports were identified within a 5 mi (8 km) radius of the Callaway Site midpoint. Additionally, Regulatory Guide 4.7 Rev. 2 (NRC, 1998) requires that major airports within 10 mi (16 km) be identified. There are no airports located within 5 to10 mi (8 to16 km) of the Callaway Site midpoint. A review of the closest major airports in the region is presented in Table 2.2-6 to ascertain whether these airports are or may be of significance in the future.

##### 2.2.2.7.1 Airports

There are no airports within 10 miles (16 km) of the Callaway Site midpoint.

##### 2.2.2.7.2 Aircraft and Airway Hazards

Regulatory Guide 1.70, Regulatory Guide 1.206, and NUREG-0800 require the risks due to aircraft hazards are sufficiently low. Further, aircraft accidents that could lead to radiological consequences in excess of the exposure guidelines of 10 CFR 50.34(a) (1) with a probability of occurrence greater than an order of magnitude of 1E-7 per year should be considered in the design of the plant.

NUREG-0800, Section 3.5.1.6 provides a three part acceptance criteria test for concluding the probability of aircraft accidents to be less than 1E-7 per year: (1) meeting plant-to-airport distance and projected annual operations criteria; (2) plant is at least 5 mi (8 km) from military training routes; and, (3) plant is at least 2 statute mi (3.2 km) beyond the nearest edge of a federal airway.

There are no airports within 10 mi (16 km) of the Callaway Site midpoint. Three airports beyond 10 miles (16 km) from the Callaway Site midpoint were evaluated as shown on Table 2.2-6 and determined to meet the NUREG-0800, Section 3.5.1.6 plant-to-airport distance acceptance criteria. There are no military training routes within 5 mi (8 km) of the Callaway Site midpoint.

Two publicly owned airports, the Elton Hensley Memorial Airport in Fulton and the Hermann Municipal Airport in Hermann are shown on Figure 2.2-2 beyond the 10 mile (16 km) plant to airport perimeter. These low volume airports serve the general aviation market and do not warrant further evaluation. Three privately owned airports, the Redgate Ranch Airport, the

Sky-Go Farms Airport, and the Eu-Wish Airport were identified in the area, all beyond the 10 mile (16 km) plant to airport perimeter. These airports are not available to the general aviation market and do not warrant further evaluation (Airnav, 2007).

As shown on Figure 2.2-2, the centerline of Airway V12 is approximately 0.34 nautical mi (0.6 km) south of the Callaway Site midpoint (FAA, 2007a), and the centerline of Airway J19-110-134 is about 4.7 nautical mi (8.7 km) south of the Callaway Site midpoint as shown on Figure 2.2-3 (FAA, 2007b). The width of a federal airway is typically 8 nautical mi (14.8 km), 4 nautical mi (7.4 km) on each side of the centerline. When airway width is considered, the nearest edge of these two airways is closer than the 2 statute mi (3.2 km) from the Callaway Site midpoint acceptance criterion.

The centerline of V175 (Figure 2.2-2) is approximately 8.3 nautical mi (15.4 km) from the Callaway Site midpoint, placing the nearest edge of the airway further from Callaway Plant Unit 2 than the 2 statute mi (3.2 km) acceptance criterion. The edge of the high altitude airway, J105 (Figure 2.2-3), is also located further than 2 mi (3.2 km) from Callaway Plant Unit 2.

Due to the close proximity of the airways V12 and J19-110-134 to the Callaway Site midpoint, the acceptance criteria identified in Section 3.5.1.6 of NUREG-0800, requiring the plant to be at least 2 statute mi (3.2 km) beyond the nearest edge of a federal airway is not met. A calculation to determine the probability of off-airport aircraft accidents which could potentially result in radiological consequences for the U.S. EPR at the Callaway Plant Unit 2 site was conducted following the methodology presented in the DOE Standard, DOE-STD-3014-96 (DOE, 1996). The analysis was limited to off-airport incidents since the plant to airport and military training route criteria are within the acceptance values contained in the NUREG-0800, Section 3.5.1.6. The analysis resulted in an estimate of the off-airport aircraft crash frequency for the facility of 1.78E-4/yr. A total of 99.5% (1.77E-4) of this crash frequency estimate is attributable to general aviation while 0.5% (8.8E-7) is attributable to commercial aviation.

Because the impact frequency is calculated to be greater than 1E-7, a probabilistic risk assessment, which takes into account the core damage frequency, is presented in Section 19.2.

#### 2.2.2.8 Projections of Industrial Growth

No comprehensive land use or zoning plans exist covering the rural portions of Callaway County including the Callaway Site or vicinity. Legislation authorizing the establishment of Regional Planning Commissions was enacted in 1969 and appears in Chapter 251 of the Revised Statutes of Missouri (RSMo) Part 160 (RSMo, 2007). The functions of a Regional Planning Commission are "solely advisory to the local governments comprising the region" (RSMo 251.300). A total of 19 Regional Planning Commissions have been established in accordance with this legislation (MACOG, 2007). Callaway County is represented by the Mid-Missouri Regional Planning Commission. Comprehensive plans covering unincorporated areas of the State, including the area comprising the site and vicinity, have not been prepared. Enabling legislation establishing County Planning Commissions with the authority to create, adopt, amend and carry out a county plan (Senate Bill [SB] 193, 2007) became effective on August 28, 2007.

A review of recent development activity does not indicate any plans for new major industrial, military, or transportation facilities to be located within the vicinity of the Callaway Site with the exceptions of the future development of Callaway Plant Unit 2.

#### 2.2.2.9 References

**Airnav, 2007**. Airnav.com, Website: http://www.airnav.com/airports/, Date accessed: November 2, 2007.

**CFR, 2007b**. Title 10, Code of Federal Regulations, Part 50, Domestic Licensing of Production and Utilization Facilities, Nuclear Regulatory Commission, 2007.

**CFR, 2007d**. Title 10, Code of Federal Regulations, Part 100, Reactor Site Criteria, Nuclear Regulatory Commission, 2007.

**FAA, 2007a**. U.S. Department of Transportation, Federal Aviation Administration, IFR Enroute Low Altitude – U.S., 5 July 2007 to 30 Aug. 2007

**FAA, 2007a**. U.S. Department of Transportation, Federal Aviation Administration, IFR Enroute High Altitude – U.S., 5 July 2007 to 30 Aug. 2007

**DOE, 1996**. U.S. Department of Energy, DOE Standard, Accident Analysis for Aircraft Crash into Hazardous Facilities, October 1996, Reaffirmation May 2006

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**NRC, 1978b**. Standard Format and Content of Safety Analysis Reports for Nuclear Power Plants, Regulatory Guide 1.70, Revision 3, Nuclear Regulatory Commission, November, 1978.

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**USDOT, 2007**. United States Department of Transportation, National Pipeline Mapping System, Callaway County Search, www.npms.phmsa.dot.gov, (June 5, 2007).}

## 2.2.3 EVALUATION OF POTENTIAL ACCIDENTS

The U.S. EPR FSAR includes the following COL Item in Section 2.3:

> A COL applicant that references the U.S. EPR design certification will provide information concerning site-specific evaluations to determine the consequences that potential accidents at nearby industrial, transportation, and military facilities could have on the site. The information provided by the COL applicant will include specific changes made to the U.S. EPR design to qualify the design of the site against potential external accidents with an unacceptable probability of severe consequences.

This COL Item is addressed as follows:

{On the basis of the information provided in Section 2.2.1 and Section 2.2.2, the potential accidents to be considered as design-basis events and the potential effects of those accidents on the nuclear plant, in terms of design parameters (e.g., overpressure, missile energies) or physical phenomena (e.g., impact, flammable or toxic clouds) were identified in accordance with 10 CFR 20 (CFR, 2007a), 10 CFR 52.79(a)(1)(vi) (CFR, 2007g), 10 CFR 50.34 (CFR, 2007c), 10 CFR 100.20 (CFR, 2007e) 10 CFR 100.21 (CFR, 2007f), Regulatory Guide 1.70 (NRC, 1978b), Regulatory Guide 1.78 (NRC, 2001), Regulatory Guide 1.91 (NRC, 1978a), Regulatory Guide 1.206 (NRC, 2007b), and Regulatory Guide 4.7 (NRC, 1998). The events are discussed in the following sections.

Sections 2.2.3.1 and 2.2.3.2 are added as a supplement to the U.S. EPR FSAR.

### 2.2.3.1 Determination of Design-Basis Events

Design-basis events internal and external to the nuclear plant are defined as those accidents that have a probability of occurrence on the order of magnitude of 1E-7 per year, or greater, with the potential consequences serious enough to affect the safety of the plant to the extent that the guidelines in 10 CFR Part 100 (CFR, 2007d) could be exceeded. The following accident categories were considered in selecting design-basis events: explosions, flammable vapor clouds (delayed ignition), toxic chemicals, fires, collisions with intake structure, liquid spills, and radiological hazards. The postulated accidents that would result in a chemical release were analyzed at the following locations:

- Nearby transportation routes (State Routes 94, CC, and O, County Routes 448 and 459, and the Missouri River);
- Nearby explosives storage facilities (Mertens Quarry); and
- On site chemical storage.

#### 2.2.3.1.1 Explosions

Accidents involving detonations of high explosives, munitions, chemicals, or liquid and gaseous fuels were considered for facilities and activities in the vicinity of the plant or onsite,

where such materials are processed, stored, used, or transported in quantity. The effects of explosions are a concern in analyzing structural response to blast pressures. The effects of blast pressure from explosions from nearby railways, highways, navigable waterways, or facilities to critical plant structures were evaluated to determine if the explosion would have an adverse effect on plant operation or would prevent a safe shutdown.

The allowable and actual distances of hazardous chemicals transported or stored were determined in accordance with NRC Regulatory Guide 1.91, Revision 1, Evaluations of Explosions Postulated to Occur on Transportation Routes Near Nuclear Power Plants (NRC, 1978a). Regulatory Guide 1.91 cites 1 psi (6.9 kPa) as a conservative value of peak positive incident overpressure, below which no significant damage would be expected. Regulatory Guide 1.91 defines this safe distance by the relationship $R \geq kW1/3$ where R is the distance in feet from an exploding charge of W pounds of TNT; and the value k is a constant. The TNT mass equivalent, W, was determined following guidance in NUREG-1805 (NRC, 2004a), where $W=M_{Vapor} * \Delta H_C * Y_f/2000$ and $M_{Vapor}$ is the flammable vapor mass, $\Delta H_C$ is the heat of combustion and $Y_f$ is the explosion yield factor.

Conservative assumptions were used to determine a safe distance, or minimum separation distance, required for an explosion to have less than 1 psi (6.9 kPa) peak incident pressure. In each of the explosion scenario analyses, an explosion yield factor of 100% was applied to account for an in-vessel confined explosion. The yield factor is an estimation of the available combustion energy released during the explosion as well as a measure of the explosion confinement (NRC, 2004a). This is a conservative assumption because a 100% yield factor is not achievable (FMIC, 2005):

- For atmospheric liquids (i.e., gasoline, toluene, etc.) the storage vessel was assumed to contain the quantity of fuel vapors in air at the upper explosive limit. This is conservative because this scenario produces the maximum flammable mass given that it is the fuel vapor, not the liquid fuel that explodes (NRC, 2004a). These assumptions are consistent with those used in Chapter 15 of NUREG-1805 (NRC, 2004a).

- For compressed or liquified gases (i.e., propane, hydrogen), it was conservatively assumed that the entire content of the storage vessel will be between the upper and lower explosive limits, given that the instantaneous depressurization of the vessel would result in vapor concentrations throughout the explosive range at varying pressures and temperatures that could not be assumed. Therefore, the entire content of the storage vessel was considered as the flammable mass.

The onsite chemicals (Table 2.2-7), hazardous materials potentially transported on State Routes 94, CC, and O, and County Routes 448 and 459 (Table 2.2-8), and hazardous materials transported on navigable waterways (Table 2.2-9) were evaluated to ascertain which hazardous materials had the potential to explode, thereby requiring further analysis. The effects of selected explosion events from internal and external sources are summarized in Table 2.2-10 and in the following sections relative to the release source.

**Pipelines**

There are no pipelines within 5 miles (8km) of the Callaway Site midpoint.

**Waterway Traffic**

The nearest bank of the Missouri River is located approximately 5 miles (8 km) from the nearest Callaway Plant Unit 2 safety-related structure. The nature and quantities of hazardous materials that were transported on the Missouri River between Kansas City to the mouth in 2005 are

listed in Table 2.2-4 (U.S. Army Corps of Engineers, 2007). Although Table 2.2-4 lists fertilizers and mixes among the hazardous materials shipped on the Missouri River, no fertilizer mixtures are known to present specific explosion hazards without combining them with other commodities. Therefore, fertilizers and mixes potentially transported on navigable waters of the Missouri River do not threaten the safe operation of Callaway Plant Unit 2.

**Highways**

As described in Section 2.2.2.5 and listed in Table 2.2-5, the closest land transportation route to the Callaway Site midpoint that may be used by trucks carrying explosive materials through the area would be State Route 94. The maximum probable hazardous cargo for a single highway truck determined by MoDOT is approximately 50,000 pounds (23,000 kg) (equivalent TNT). The distance beyond which an exploding truck will not prevent a safe shutdown is 1,700 ft. (0.32 miles, 0.52 km) as indicated in Figure 1 of Regulatory Guide 1.91, Revision 1 (NRC, 1978a). Since the closest point of U.S. Highway 94 to the nearest Callaway Plant Unit 2 safety-related structure is approximately 4 miles (6.5 km) no hazard to the plant due to highway explosion is expected.

Table 2.2-8 details the hazardous materials potentially transported on State Routes 94, CC, and O, and County Routes 448 and 459. The materials that were identified for further analysis for explosion potential were: gasoline and liquid propane. The maximum quantity of the identified chemicals assumed to be transported on the roadway was 5,000 gallons (18,900 l) for gasoline and 2,600 gallons (9,800 l) for liquid propane. Potential confined in-vessel product vapor explosions were evaluated in accordance with the procedures described in NUREG 1805 (NRC, 2004a) with distance to the 1 psi (6.9 kPa) overpressure limit calculated in accordance with Reg. Guide 1.91 Revision 1 (NRC, 1978a). Results of these evaluations are presented in Table 2.2-10. By their nature, these materials are more appropriately considered potentially hazardous as a result of delayed vapor cloud ignition and, consequently are also addressed in Section 2.2.3.1.2 below.

**Onsite Chemicals Callaway Plant Unit 1 and Callaway Plant Unit 2**

Callaway Plant Unit 2 is located in close proximity to the existing Callaway Plant Unit 1, and its associated chemical storage locations. The chemicals utilized in Callaway Plant Unit 2 will be similar to the chemicals utilized in Callaway Plant Unit 1, and are not stored closer to safety-related Callaway Plant Unit 2 structures than the minimum separation distance. In many instances, chemical inventories will not increase, and additional storage locations will not be required. As shown on Table 2.2-2, additional chemical storage supporting Unit 2 operations will be required at or near the Unit 2 structures for fuel oil for the Emergency Power Generators, mineral oil sealed within the transformers, sodium hydroxide (50%) and sulfuric acid (98%) at the Turbine Building. Small quantities of Fyrquel EHC fluid, hydrazine (35%), and the organic amine will also be stored at the Unit 2 Turbine Building. The hazardous materials stored onsite that were identified for further analysis with regard to explosion potential were gasoline and hydrogen. Results of these evaluations are presented in Table 2.2-10.

**Nearby Facilities**

The closest mining activity to the site is at Mertens Quarry, a limestone quarry located 4.5 miles (7.2 km) from the Callaway Site midpoint. As described in Section 2.2.2.2.3, the quantity of explosives stored at the quarry site do not exceed the quantity shipped in a single truck load (50,000 pounds, 23,000 kg) (TNT equivalent). Since the distance from Mertens quarry to the nearest Callaway Plant Unit 2 safety-related structure is greater than the distance of the nearest safety-related structure to State Route 94 it is concluded that no hazard to the plant exists due to mining or detonation of mine explosives.

**Explosion Related Impacts Affecting the U.S. EPR Design**

The U.S. EPR design is acceptable for any site when reasonable qualitative arguments can demonstrate that the realistic probability of severe consequences from any external accident is less than 1E-6 per year. Regulatory Guide 1.91 (NRC, 1978a) cites 1 psi (6.9 kPa) as a conservative value of peak positive incident overpressure, below which no significant damage would be expected. Safety-related Callaway Plant Unit 2 structures are designed to withstand a peak positive overpressure of at least 1 psi without loss of function.

The analyses presented in this section demonstrate that the probability that a 1 psi (6.9 kPa) peak positive overpressure will be exceeded at a safety-related structure for any of the postulated explosion event scenarios is less than 1E-7, meeting the Regulatory Guide 1.91 requirements and this scenario will not need to be included as a design-basis accident. As a result, postulated explosion event scenarios will meet NRC requirements.

#### 2.2.3.1.2 Flammable Vapor Clouds (Delayed Ignition)

Flammable gases in the liquid or gaseous state can form an unconfined vapor cloud that could drift toward the plant before ignition occurs. When a flammable chemical is released into the atmosphere and forms a vapor cloud it disperses as it travels downwind. The parts of the cloud where the concentration is within the flammable range, between the lower and upper flammability limits, may burn if the cloud encounters an ignition source. The speed at which the flame front moves through the cloud determines whether it is a deflagration or a detonation. If the cloud burns fast enough to create a detonation an explosive force is generated.

The potential onsite chemicals are shown in Table 2.2-7. Hazardous materials potentially transported on State Routes 94, CC, and O, and County Routes 448 and 459 are shown on Table 2.2-8, and hazardous materials transported on navigable waterways are shown on Table 2.2-9. These chemicals were evaluated to ascertain which hazardous materials had the potential to form a flammable vapor cloud or vapor cloud explosion. For those chemicals with an identified flammability range, the Areal Locations of Hazardous Atmospheres (ALOHA) air dispersion model was used to determine the distances where the vapor cloud may exist between the upper flammability limit (UFL) and the lower flammability limit (LFL), presenting the possibility of ignition and potential thermal radiation effects (ALOHA, 2007).

The identified chemicals were also evaluated to determine the possible effects of a flammable vapor cloud explosion. ALOHA was used to model the worst case accidental vapor cloud explosion, including the safe distances and overpressure effects at the nearest safety-related Callaway Plant Unit 2 structure. To model the worst case in ALOHA, ignition by detonation was chosen for the ignition source. The safe distance was measured as the distance from the spill site to the location where the pressure wave is at 1 psi (6.9 kPa) overpressure.

Conservative assumptions were used in both ALOHA analyses with regard to meteorological inputs and identified scenarios. The following meteorological assumptions were used as inputs to the computer model, ALOHA: Pasquill stability class F (stable), with a wind speed of 1 m/sec; ambient temperature of 25°C; relative humidity 50%; cloud cover 50%; and an atmospheric pressure of 1 atmosphere. Pasquill Stability class F represents the most limiting 5% of meteorological conditions observed at a majority of nuclear plant sites. For each of the identified chemicals, it was conservatively assumed that the entire contents of the vessel leaked forming a 1 cm thick puddle. This provides a significant surface area to maximize evaporation and the formation of a vapor cloud.

Because the combined effects of dispersion and explosion are complex, a large set of ALOHA cases were used to model the effects of delayed-detonation events. For the propane cases, because propane flashes at ambient temperatures, every combination of six wind speeds, six stabilities, and four temperatures was considered. For hydrogen, which is a vapor under all conditions of interest, every combination of six wind speeds and six stability classes was run. In both cases, the final results were computed using the frequencies of the appropriate meteorological conditions during the years 2004 through 2006.

Because a 1psi (6.9 kPa) overpressure at the nearest safety-related structure could be exceeded by the propane truck explosion scenario under some meteorological conditions, the exposure rate, as defined in Regulatory Guide 1.91, was calculated. This detailed calculation considered the entire range of meteorological conditions during the period when the propane trucks might make deliveries, including the wind speed, wind direction, atmospheric stability, and ambient temperature. The exposure rate for this scenario was shown to be less than 1E-8 occurrences per year of overpressures of 1 psi (6.9 kPa) at the nearest safety-related structure.

The analyzed effects of flammable vapor clouds and vapor cloud explosions from internal and external sources are summarized in Table 2.2-11 and are described in the following sections relative to the release source.

**Pipelines**

There are no pipelines within 5 miles (8km) of the Callaway Site midpoint.

**Waterway Traffic**

Callaway Plant Unit 2 is located about 5 miles (8 km) from the north shore of the Missouri River. No chemicals or commodities presenting a plausible capability of forming a vapor cloud with delayed ignition and possibly exploding were transported on the Missouri River in 2005 (U.S. Army Corps of Engineers, 2007).

The results of flammable vapor cloud ignition and explosion analyses are summarized in Table 2.2-9.

**Highways**

The closest safety-related Callaway Plant Unit 2 structure is located approximately 0.32 miles (0.52 km) from County Route 448, the closest route along which potentially hazardous materials could be transported. The hazardous materials potentially transported on County Route 448 identified for further analyses were gasoline and liquid propane. The methodology presented previously in Section 2.2.3.1.2 was used for determining the safe distance for vapor cloud ignition and delayed vapor cloud explosion. Consistent with Regulatory Guide 1.91 (NRC, 1978a), it was conservatively estimated that the transport truck carried and released 5,000 gallons (18,900 l) for gasoline and 2,600 gallons (9,800 l) for liquid propane.

The results for the selected hazardous materials indicate that any plausible gasoline vapor cloud that may form and mix sufficiently under stable atmospheric conditions will be below LFL concentrations prior to reaching the closest Callaway Plant Unit 2 safety related structure. The maximum pool fire will be a danger to structures at a maximum distance of 300 ft. (90 m). Any plausible propane vapor cloud that may form and mix sufficiently under stable atmospheric conditions will also be below the LFL concentration before it reaches the closest Callaway Plant Unit 2 safety related structure. The distance to the LFL boundary for gasoline is 72 ft. (22 m) and for propane, 1115 ft. (340 m). Therefore, a flammable vapor cloud ignition involving hazardous materials with the potential to be transported on County Route 448, could not adversely affect the safe operation of Callaway Plant Unit 2 because of the fire hazard.

Each of the identified hazardous materials was also evaluated, using the methodology presented previously in this section, to determine the effects of a possible vapor cloud explosion. The minimum separation distances (i.e., safe distance) for gasoline is 300 ft. (90 m) and for liquid propane, 2285 ft. (696 m). The separation distance to a 1 psi (6.9 kPa) peak incident pressure for explosions involving gasoline was determined to be less than the shortest distance to a safety-related Callaway Plant Unit 2 structure at the closest approach on County Route 448. However, the separation distance to a 1 psi (6.9 kPa) peak incident pressure for explosions involving propane was determined to be greater than the shortest distance to a safety-related Callaway Plant Unit 2 structure at the closest approach on County Route 448. Therefore, a delayed flammable vapor cloud explosion involving gasoline transported on County Route 448, would not adversely affect the safe operation of Callaway Plant Unit 2. However, a delayed flammable vapor cloud explosion involving propane transported on County Route 448, could adversely affect the safe operation of Callaway Plant Unit 2. The exposure rate for such occurrences, calculated according to the Regulatory Guide 1.91 methodology, is less than 9E-9 occurrences per year, and thus this scenario does not need to be included in the design basis.

The results of flammable vapor cloud ignition and explosion analyses are summarized in Table 2.2-11.

**Onsite Chemicals**

Callaway Plant Unit 2 is located in close proximity to Callaway Plant Unit 1 and its associated chemical storage locations. The chemicals utilized in Callaway Plant Unit 2 will be similar to the chemicals utilized in Callaway Plant Unit 1, and are not stored closer to safety-related Callaway Plant Unit 2 structures than the minimum separation distance. The hazardous materials stored at the Callaway Plant Unit 1 site that were identified for further analysis with regard to the potential of delayed ignition and explosion of flammable vapor clouds were gasoline and hydrogen. Storage requirements to accommodate the needs of Callaway Plant Unit 2 for these two chemicals will not exceed the requirements for Callaway Plant Unit 1.

As described previously in Section 2.2.3.1.2, the ALOHA dispersion model was used to determine the distance a vapor cloud can travel before reaching the LFL boundary (i.e., the safe distance for exposure to thermal radiation heat flux) once a vapor cloud has formed from release of the identified chemical. The distances to the LFL boundary from the release point for the identified chemicals are gasoline, 72 ft. (22 m); and hydrogen 885 ft. (270 m). Each of these distances is less than the distance from a potential release site to the nearest safety-related Callaway Plant Unit 2 structure.

A vapor cloud explosion analysis was also performed using the methodology described in Section 2.2.3.1.2 to obtain minimum separation distances (i.e., safe distances) for the identified chemicals. With the exception of a postulated release of hydrogen, the results indicate that the minimum separation distance (i.e., the distance required for an explosion to have less than a 1 psi (6.9 kPa) peak incident pressure) are less than the shortest distance to a safety-related Callaway Plant Unit 2 structure from the storage location of these chemicals.

The minimum separation distance for the 5,000 gallon (18,900 l) gasoline tank truck is 360 ft. (110 m). The minimum separation distance for hydrogen is 1,010 ft. (308 m). Except for hydrogen, each of these chemicals is stored further away from Callaway Plant Unit 2 than the minimum separation distance. The gasoline filling operation occurs approximately 1,900 ft. (570 m) from the nearest safety-related Callaway Plant Unit 2 structure, which is the Ultimate Heat Sink. Hydrogen storage relative to the nearest safety-related Callaway Plant Unit 2 structure is 300 m (980 ft).

The evaluation of the vapor cloud explosion events was performed for each of the identified chemicals in accordance with Regulatory Guide 1.91 (NRC, 1978a) to determine if any qualified as a design-basis event. That is, an accident that has a probability of occurrence on the order of magnitude of 1E-7 per year, or greater, with potential consequences serious enough to affect the safety of the plant to the extent that the guidelines in 10 CFR Part 100 could be exceeded. The expected rate of occurrence for exceeding the guidelines in 10 CFR Part 100 (on the order of magnitude of 1E-6 per year) is acceptable if, when combined with reasonable qualitative arguments, the realistic probability can be shown to be lower. In evaluating the propane spill, consideration was taken of the fact that liquid propane is stored and transported under pressure at ambient temperature, and will thus flash upon release. The flashing mixture forms a vapor/aerosol cloud, which must be modeled as a dense gas. The behavior is non-linear, so that standard assumptions as to what will constitute "worst case" meteorology are invalid. For this reason, the following inputs were used in the model:

- Pasquill Stability Classes A through F were used to represent the full range of stabilities. ALOHA does not use G stability, so that was represented by F stability.
- Wind speeds of 1, 2, 3, 4, 5, and 6 meters per second (2, 4, 7, 9, 11, and 13 mph) were selected to represent full range of wind speeds. Calms were represented by 1 meter per second (2.2 mph), while 6 meters per second (13 mph) was used to represent higher wind speeds.
- Air temperatures of –17.5°C, –2.5°C, 12.5°C, and 27.5°C (0.5°F, 27.5°F, 54.5°F, and 81.5°F) were used to represent the range of temperatures. The initial propane temperature was equal to the air temperature. Results for intermediate temperatures were interpolated from the computed ALOHA results for temperatures between –17.5°C and 27.5°C (0.5°F and 81.5°F) and the 27.5°C (81.5°F) results were used for higher temperatures.
- The tank was filled to capacity and a catastrophic tank failure was assumed.
- The maximum distance to a 1 psi (6.9 kPa) overpressure was computed for each of the 144 combinations of meteorological conditions.

The meteorological data for the years 2004 through 2006 were grouped by wind speed, wind direction, stability class and temperature and were used to weight the results. The range of wind directions was taken from an analysis of the portion of CR 448 within the required distance for each combination of wind speed, stability and temperature. All wind directions within 90° of the actual direction from the closest safety-related structure to the accident were used to account for the fact the explosion, once it occurs, propagates in all directions. The result of this calculation was combined with the shipment frequency and explosion rate to obtain the exposure rate as defined in Regulatory Guide 1.91. This accident rate is based upon USDOT (USDOT, 2007) accident data for the years 2002 through 2006. There were three explosions of UN 1075 (Petroleum Gases) truck shipments during that time, while the Hazardous Materials Survey (Bureau of Transportation Statistics and U. S. Census Bureau, 2004) report shows 4.227E9 ton-miles of propane shipped, and vendor inquiries indicate a maximum of 53 propane shipments of 2,600 gallons (9,800 l) per year along CR 448. Combining these values with the exposure distance calculated from ALOHA results and the relative configuration of CR 448 and the nearest safety-related structures gives a computed exposure rate of less than 9E-9 occurrences per year. Thus the propane explosion does not need to be considered in the design basis.

An analysis of meteorological conditions including wind speed and stability class resulting in potentially adverse conditions (i.e., causing a postulated hydrogen release and detonation to result in an overpressure exceeding 1 psi [6.9 kPa) were found to exist during 179 hours in the 25,712 hour period of record analyzed, for a conditional probability of 7E-3. A study of equipment failure rates (Shafagi, 2006) reported an applicable failure rate of 6.7E-5 per year. Combining this probability of failure with the probability of simultaneously adverse meteorological conditions results in an overall accident probability of 4.7E-7. This analysis can be shown to be conservative since it ignores the rapid plume rise that is expected in a gas only 7% as dense as air. Plume rise calculations performed in accordance with U.S. Atomic Energy Commission procedures (USACE, 1968) estimate a plume rise of 73 meters (240 ft.). Thus, the center of a potential detonation can be shown to be 308 meters (1015 ft.) from any Callaway Plant Unit 2 safety-related structure, which is further than the minimum safe distance. AmerenUE is considering relocating the central gas yard to a location approximately 490 ft. (149 m) northeast of the present location and approximately 1,200 ft. (366 m) southeast of the closest Unit 2 safety related structure. When implemented, this relocation will result in a safe separation distance between the hydrogen storage and any Unit 2 safety related structure.

The results of flammable vapor cloud ignition and explosion analyses are summarized in Table 2.2-11.

**Nearby Facilities**

No chemicals or commodities presenting a plausible capability of forming a vapor cloud with delayed ignition and possibly exploding were stored at nearby facilities closer than the safe separation distance or in quantities significantly larger than a transport vehicle. Therefore, a flammable vapor cloud ignition involving hazardous materials at nearby facilities would not adversely affect the safe operation of Callaway Plant Unit 2.

**Flammable Vapor Cloud (Delayed Ignition) Related Impacts Affecting the U.S. EPR Design**

The U.S. EPR design is acceptable for any site when reasonable qualitative arguments can demonstrate that the realistic probability of severe consequences from any external accident is less than 1E-6 occurrences per year. Regulatory Guide 1.91 (NRC, 1978a) cites 1 psi (6.9 kPa) as a conservative value of peak positive incident overpressure, below which no significant damage would be expected. Safety-related Callaway Plant Unit 2 structures are designed to withstand a peak positive overpressure of at least 1 psi (6.9 kPa) without loss of function.

The analyses presented in this section demonstrate that a 1 psi (6.9 kPa) peak positive overpressure will not be exceeded at a safety-related structure for any of the postulated flammable vapor cloud, delayed ignition event scenarios, except for propane. For the vapor cloud, delayed ignition event involving propane, it was demonstrated that the event probability is less than 1E-6. As a result, each of the postulated vapor cloud, delayed ignition event scenarios has been demonstrated to either not result in severe consequences, or to have an event frequency that is less than 1E-6 per year.

#### 2.2.3.1.3 Toxic Chemicals

Accidents involving the release of toxic chemicals from onsite storage facilities and nearby mobile and stationary sources were considered. Toxic chemicals known to be present on site or in the vicinity of the Callaway site, or to be frequently transported in the vicinity were evaluated. NRC Regulatory Guide 1.78, Revision 1, Evaluating the Habitability of a Nuclear Power Plant Control Room During a Postulated Hazardous Chemical Release (NRC, 2001), requires evaluation of control room habitability after a postulated external release of hazardous chemicals from mobile or stationary sources, offsite or onsite.

The potential onsite chemicals are listed in Table 2.2-7. Hazardous materials potentially transported on State Routes 94, CC, and O, and County Routes 448 and 459 are identified in Table 2.2-8. Hazardous materials transported on navigable waterways are identified in Table 2.2-9. These chemicals were evaluated to ascertain which hazardous materials were analyzed with respect to their potential to form a toxic vapor cloud after an accidental release.

The ALOHA model was used to determine the maximum distance various postulated vapor clouds would travel before they dispersed enough to fall below the associated National Institute of Occupational Safety and Health (NIOSH) defined Immediately Dangerous to Life and Health (IDLH) threshold values. The ALOHA model was also used to predict the post-release chemical concentrations in the control room to ensure that under a worst case scenario event the control room operators will have sufficient time to take appropriate action.

The IDLH is defined by the NIOSH as a situation that poses a threat of exposure to airborne contaminants when that exposure is likely to cause death or immediate or delayed permanent adverse health effects or prevent escape from such an environment. The IDLHs determined by NIOSH are established such that workers are able to escape such an environment without suffering permanent health damage.

Conservative meteorological assumptions were used to determine gasoline concentrations: Pasquill stability class F (stable), with a wind speed of 1 m/sec (2.2 mph); ambient temperature of 25°C (77°F); relative humidity of 50%; cloud cover, 50%; and an atmospheric pressure of 1 atmosphere (101 kPa). For each of the identified liquid chemicals, it was conservatively assumed that the entire contents of the vessel leaked to form a 1 cm (0.4 in.) thick puddle and toxic vapor cloud.

The effects of toxic chemical releases from internal and external sources are summarized in Table 2.2-12 and are described in the following sections relative to the release source.

**Pipelines**

There is no pipeline within the vicinity of the Callaway Site midpoint.

**Waterway Traffic**

Callaway Plant Unit 2 is located about 5 miles (8 km) from the north shore of the Missouri River. No chemicals or commodities presenting a plausible capability of forming toxic cloud were transported on the Missouri River in 2005 (U.S. Army Corps of Engineers, 2007).

**Highways**

The Callaway Plant Unit 2 control room is located 2,060 ft. (630 m) from County Route 448 at its closest approach. The hazardous materials potentially transported on County Route 448 that were identified for further analysis with regard to the potential of forming a toxic vapor cloud after an accidental release and traveling to the control room were gasoline and liquid propane.

The methodology presented in Section 2.2.3.1.3 was used to determine the distance from the release site to the point where the toxic vapor cloud reaches the IDLH boundary.

The maximum concentration of the evaluated chemicals attained in the control room during the first hour of the release was also determined for the identified hazardous materials. In each scenario, it was conservatively estimated that the transport vehicle lost the entire contents as provided in Regulatory Guide 1.91 (NRC, 1978a).

The worst-case release scenario in these analyses included a total loss of the largest vessel into an unconfined cloud or puddle under stable atmospheric conditions and low wind speed.

The evaluation of toxic chemical release events was performed for each of the identified chemicals to determine if any of these events would qualify as a design-basis event. That is, an accident that has a probability of occurrence on the order of magnitude of 1E-7 per year, or greater, with potential consequences serious enough to affect the safety of the plant to the extent that the guidelines in 10 CFR Part 100 could be exceeded.

An expected rate of occurrence for exceeding the guidelines in 10 CFR Part 100 (on the order of magnitude of 1E-6 per year) is acceptable if, when combined with reasonable qualitative arguments, the realistic probability can be shown to be lower. Further, Regulatory Guide 1.78 (NRC, 2001) provides that releases of toxic chemicals that have the potential to result in a significant concentration in the control room need not be considered for further evaluation if the releases are of low frequencies (1E-6 per year, or less) because the resultant low levels of risk are considered acceptable.

In evaluating the propane spill, consideration was taken of the fact that liquid propane is stored and transported under pressure at ambient temperature, and will thus flash upon release. The flashing mixture forms a vapor/aerosol cloud, which must be modeled as a dense gas. The behavior is non-linear, so that standard assumptions as to what will constitute "worst case" meteorology are invalid. For this reason, the following inputs were used in the model:

- Pasquill Stability Classes A through F were used to represent the full range of stabilities. ALOHA does not use G stability, so that was represented by F stability.
- Wind speeds of 1, 2, 3, 4, 5, and 6 meter per second (2, 4, 7, 9, 11, and 13 mph) were selected to represent full range of wind speeds. Calms were represented by 1 meter per second 2.2 mph), while 6 meters per second (13 mph) was used to represent higher wind speeds.
- Air temperatures of –17.5°C, –2.5°C, 12.5°C, and 27.5°C (0.5°F, 27.5°F, 54.5°F, and 81.5°F) were used to represent the range of temperatures. The initial propane temperature was equal to the air temperature. Results for intermediate temperatures were interpolated from the computed ALOHA results for temperatures between –17.5°C and 27.5°C (0.5°F and 81.5°F) and the 27.5°C (81.5°F) results were used for higher temperatures.
- The tank was filled to capacity and a catastrophic tank failure was assumed.
- The maximum distance to the IDLH (2100 ppm) was computed for each of the 144 combinations of meteorological conditions.

The meteorological data for the years 2004 through 2006 were grouped by wind speed, wind direction, stability class and temperature and were used to weight the results. The range of wind directions was taken from an analysis of the portion of CR 448 within the required distance for each combination of wind speed, stability and temperature. All wind directions within 30° of the actual direction from control room to the accident were used to account for the width of the plume. The result of this calculation was combined with the shipment frequency and rupture rate to obtain the exposure rate. This accident rate is based upon USDOT (USDOT, 2007) accident data for the years 2002 through 2006. There were ten incidents in which truck shipments of UN 1075 (Petroleum Gases) ruptured or experienced major releases during that time, while the Hazardous Material Survey (Bureau of Transportation Statistics and

U. S. Census Bureau, 2004) report shows 4.227E9 ton-miles of propane shipped, and vendor inquiries indicate a maximum of 53 propane shipments of 2,600 gallons (9,840 l) per year along CR 448. Combining these values with the exposure distance calculated from ALOHA results and the relative configuration of CR 448 and the control room intake gives a computed exposure rate of less than 7E-9 occurrences per year. Thus the propane toxicity does not need to be considered in the design basis.

Therefore, toxic vapor clouds resulting from chemical spills on County Route 448 will not adversely affect the safe operation of Callaway Plant Unit 2. The effects of toxic chemical releases are summarized in Table 2.2-12.

**Onsite Chemical Storages Callaway Plant Unit 1**

The hazardous materials stored onsite that were identified for further analysis with regard to the potential of the formation of toxic vapor clouds formed after an accidental release are gasoline, hydrazine (35% solution), hydrogen (asphyxiant), carbon dioxide, and liquid nitrogen (asphyxiant).

As described in Section 2.2.3.1.3, the identified hazardous materials were analyzed utilizing the ALOHA dispersion model to determine whether the formed vapor cloud will reach the control room intake and what the concentration of the toxic chemical will be at the control room intake after an accidental release.

Hydrogen and nitrogen concentrations were determined at the control room intake after a release of the largest vessel. In each case, the incremental concentration of these asphyxiants at the control room, 5,730 ppm for hydrogen and 73,900 ppm for nitrogen, would not displace enough oxygen for the control room to become an oxygen-deficient environment. The larger of the two, nitrogen, would reduce the oxygen content from 20.9% to 19.4%, which is not enough of a drop to cause oxygen deficiency symptoms to occur.

A probabilistic analysis was then performed for any identified chemicals that were analyzed to have significant potential consequences that could exceed the guidelines of 10 CFR Part 100. The evaluations did not identify any chemicals that merited probabilistic analysis. The effects of toxic chemical releases are summarized in Table 2.2-12.

**Toxic Chemical Related Impacts Affecting the U.S. EPR Design**

The U.S. EPR design is acceptable for any site when reasonable qualitative arguments can demonstrate that the realistic probability of severe consequences from any external accident is less than 1E-6 per year. The analyses presented in this section demonstrate that toxic chemical concentrations that could present an immediate hazard to plant personnel will not result from postulated chemical releases, with the exception of propane. For propane it was demonstrated that the event probability is less than 1E-6. As a result, each of the postulated toxic chemical release scenarios has been demonstrated to either not result in severe consequences, or to have an event frequency that is less than 1E-6 per year.

#### 2.2.3.1.4 Fires

Accidents leading to high heat fluxes or smoke, and non-flammable gas or chemical bearing clouds from the release of materials, as the consequence of fires in the vicinity of the plant were considered. Fires in adjacent industrial plants and storage facilities, oil and gas pipelines, brush and forest fires, and fires from transportation accidents were evaluated as events that could lead to high heat fluxes or to the formation of such clouds.

The quantified risks to the Callaway Site presented in this study are within the threshold of acceptable risks defined by the U.S. Nuclear Regulatory Commission (1E-7). The evaluation of these risks included such events as fires at nearby facilities, on-site fuel oil fires, and wildfires.

Nearby Facilities

The nearest industrial site is Mertens Quarry located 4.5 miles (7.2 km) from Callaway Plant Unit 2. This site does not store flammable gases or chemicals. Potential fires at local outlets for gasoline and propane are bounded by the transportation accident evaluations.

Onsite Chemical Storage/Callaway Plant Unit 1

The potential consequences of a fire at the 300,000 gal (1,140 cu m) No. 2 fuel oil tank on the Callaway Plant Unit 1 control room were presented in Callaway Plant Unit 1 FSAR. No. 2 fuel oil is very stable and the probability of an accident occurring that would ignite the oil is very small. As noted in the Callaway Plant Unit 1 FSAR, the fuel oil storage tank is designed and constructed in accordance with applicable fire codes and is contained within a diked area which would contain a burning pool of oil. The evaluation concluded that there would be no risks from toxic gases or temperature rise due to radiant heat fluxes from the rapidly rising plume at the Callaway Plant Unit 1 control room located approximately 500 feet (150 m) from the fuel oil tank. This conclusion can be extended to the Callaway Plant Unit 2 control room located approximately 1,900 feet (580 m) from the fuel oil storage tank.

Wildfires

Wildfires are unlikely natural hazards in Missouri, unlike in the fire-prone western states. Wildfires risks are addressed in the Callaway County Natural Hazards Mitigation Plan (Mid Missouri Planning Commission, 2005). Regarding wildfires the plan states:

> Wildfires are rare in the county and when they do occur they tend to be limited in their spatial extent thus minimizing their impact. Therefore, wildfires do not threaten the County to the same degree as floods, tornadoes, and other hazards. However, it would be imprudent not to plan for wildfires. While it is improbable that wildfires would impact the region in a catastrophic way similar to communities in the western U.S., it is not impossible to think that it could happen.

The Missouri Department of Conservation (MDC), State Fire Marshal recommends that a "defensible space" surrounding a structure be established. The defensible space is comprised of three zones:

Zone 1 extends to a distance of 30 feet (9 m) from the structure on level ground, further on slopes. This zone is the area of maximum modification designed as a barrier to fire.

Zone 2 is extends from the outer boundary of Zone 1 to a distance of 70 feet (21 m) from the structure on level ground, further on slopes. This is a zone of fuel reduction.

Zone 3 extends several hundred feet (more than 30 m) beyond the boundary of Zone 2 and is an area of traditional forest management (MDC, 2002).

An area of woodland, cropland, and grassland surrounds developed portions of the Callaway Site. Cleared areas meeting the minimum MDC recommendations extend on all sides of Callaway Plant Unit 2, and provide a substantial defensible zone in the unlikely event of a fire originating in the woodlands or grasslands or spreading to those areas as result of on or offsite activities. The protected area of the Callaway Plant Unit 2 powerblock includes a cleared area of

sufficient size to afford substantial protection in the event of a fire, and it is not expected that there would be any hazardous effects from fires or heat fluxes associated with wild fires.

**Fire Related Impacts Affecting the U.S. EPR Design**

The U.S. EPR design is acceptable for any site when reasonable qualitative arguments can demonstrate that the realistic probability of severe consequences from any external accident is less than 1E-6 occurrences per year. The use of cleared defensible space around safety-related Callaway Plant Unit 2 structures will ensure that external fire related impacts will not have severe consequences.

#### 2.2.3.1.5 Collisions with Intake Structure

The Callaway plant is located approximately 5 miles (8 km) and 340 (104 m) feet above the Missouri River. A Collector Well River Intake System located on the Missouri River provides makeup water for the Circulating Water System (CWS) and the Essential Service Water System (ESWS) at the plant. These structures are not required for safe shutdown of the plant. Water required for emergency shutdown of the plant is provided by the Essential Service Water Emergency Management System (ESWEMS) which draws from an excavated, onsite retention pond. This Category 1 ESWEMS pond and associated mechanical draft cooling towers and pumping facilities comprise the ultimate heat sink. It can be postulated that a barge or ship could damage one of the collector well intake structures to the extent that it could not function; however, each collector well is designed with redundant pumps and capacity such that remaining unaffected collector wells could pick up additional load until repairs could be made. In addition, the normal CWS cooling tower basins contain enough water to allow an orderly transition from normal circulating water and ESWS to the ESWEMS for an orderly and safe shutdown.

**Intake Structure Collision Impacts Affecting the U.S. EPR Design**

The U.S. EPR design is acceptable for any site when reasonable qualitative arguments can demonstrate that the realistic probability of severe consequences from any external accident is less than 1E-6 occurrences per year. The location of the excavated safety-related ESWEMS pond on the plateau 340 ft. (104 m) above and 5 miles (8 km) from the Missouri River make it impossible for a vessel to impact a safety-related ESWEMS structure or system required for an orderly and safe shutdown. As a result, collisions with an intake structure will not result in severe consequences.

#### 2.2.3.1.6 Liquid Spills

The accidental release of oil or liquids that may be corrosive, cryogenic, or coagulant were considered to determine if the potential exists for such liquids to be drawn into the plant's intake structure and circulating water system or otherwise affect the plant's safe operation. The accidental release of petroleum products or corrosive liquids upstream of the Callaway Collector Well River Intake System structures will not affect operation of the plant. Normal operation of the Collector Well System draws water from the river and the alluvial aquifer beneath and adjacent to the Missouri River rather than the surface water of the river. Liquids with a specific gravity less than unity, such as petroleum products, will float on the surface of the river and consequently are not likely to be drawn down into the alluvial aquifer and the Collector Well System. Liquids with a specific gravity greater than unity could be drawn into the alluvial aquifer. However, such liquids would be diluted by the large quantity of river flow and further filtered by the alluvial aquifer before reaching the collector wells. The River Intake is monitored; therefore, continued inflow of contaminants would be detected before any damage occurs.

**Liquid Spill Impacts Affecting the U.S. EPR Design**

The U.S. EPR design is acceptable for any site when reasonable qualitative arguments can demonstrate that the realistic probability of severe consequences from any external accident is less than 1E-6 occurrences per year. In the case of liquid spills, the location of the excavated safety-related ESWEMS pond on the plateau 340 feet (104 m) above and 5 miles (8 km) from the Missouri River make it impossible for a liquid spill on the Missouri River to affect a safety-related ESWEMS structure or system required for an orderly and safe shutdown. As a result, liquid spills will not result in severe consequences.

#### 2.2.3.1.7 Radiological Hazards

The release of radioactive material from Callaway Plant Unit 1 as a result of normal operations or an unanticipated event would not threaten the safety of the plant or personnel at Callaway Plant Unit 2. The control room habitability system for the U.S. EPR provides the capability to detect and protect main control room personnel from external fire, smoke, and airborne radioactivity. In addition, safety-related structures, systems, and components for the U.S. EPR have been designed to withstand the effects of radiological events and the consequential releases that would bound the contamination from a release from either of these potential sources.

**Radiological Hazard Impacts Affecting the U.S. EPR Design**

The U.S. EPR design is acceptable for any site when reasonable qualitative arguments can demonstrate that the realistic probability of severe consequences from any external accident is less than 1E-6 occurrences per year. In the case of radiological hazards, the control room habitability system for the U.S. EPR provides the capability to detect and protect main control room personnel from external fire, smoke, and airborne radioactivity. In addition, safety-related structures, systems, and components for the U.S. EPR have been designed to withstand the effects of radiological events and the consequential releases that would bound the contamination from a release from either of these potential sources. As a result, radiological hazards will not result in severe consequences.

### 2.2.3.2 Effects of Design-Basis Events

As concluded in the previous sections, the only event requiring further analysis for consideration as a design-basis is related to the frequency of aircraft impact in the vicinity of the Callaway Site. A probabilistic analysis which presents the probability of aircraft accidents which could potentially result in radiological consequences for the U.S. EPR at the Callaway Site is presented in Section 19.2.}

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## Table 2.2-1—{Description of Facilities, Products and Materials}

| Site | Concise Description | Primary Function | Number of Persons employed | Major Products or Materials |
|---|---|---|---|---|
| Mertens Quarry | Quarry approximately 150,000 tons (136,000 metric tons) per year of limestone from an estimated reserve of 16.5 million tons (15 million metric tons) | Produce limestone products for sale | 15 | Crushed and broken limestone |
| Callaway Plant Unit 1 | Callaway Plant Unit 1 is a 3,565 MWt, 1,284 MWe, Westinghouse pressurized water reactor licensed by the Nuclear Regulatory Commission. | Nuclear Power Generator | 867 | Electrical Power |

## Table 2.2-2—{Callaway Plant Unit 1 and Callaway Plant Unit 2, Onsite Chemical Storage}

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| Material | Toxicity Limit (IDLH) | Callaway Plant Unit 1 | | Callaway Plant Unit 2 | | Location | Annual Frequency[1] |
|---|---|---|---|---|---|---|---|
| | | Quantity | Largest Container | Quantity | Largest Container | | |
| Boric Acid | None established | 40 Drums | 330 pound (150 kg) drum | Included | | Storeroom and Aux. Bldg | 2/year |
| Fuel Oil | None established | 500,000 gal (1.89E6 l) | 300,000 gal (1.13E6 l) | | | 300,000 gal (1.13E6 l) located 500 ft (150 m) from the Control Room, 300 ft (91 m) from the ESWS tower, Plant W of Demineralizer Bldg<br>2-100,000 gal (3.8E5 l) south of diesel generator building | 4/year (one unit, 8/year (2 units) |
| | | | | 220,000 gal (8.3E5 l) | 55,000 gal (2.1E5 l) | 4-55,000 gal (2.1E5 l) in separate tank rooms with 3-hr fire walls adjacent to Emergency Power Generating Buildings | |
| Diesel Fuel | None established<br>5 mg/m$^3$ OSHA-PEL | 5,800 gal (2.2E4 l) | 3,000 gal (1.1E4 l) Underground (Note 2)<br>2,800 gal (1.1E4 l) Tech Support Center Diesel Generator Underground (Note 2) | Included | | Unit 1 Security Diesel Generator Building<br>Plant North of Tech Support Center | 1/year |
| Diesel Fuel | None established<br>5 mg/m$^3$ OSHA-PEL | 1,000 gal (3.8E3 l) | 1,000 gal (3.8E3 l) Above ground,<br>700 gal (2.6E3 l) #2, 300 gal (1.1E3 l) #1 | Included | | West of Unit 1 Stores Building | 25/year |
| Gasoline | 300 ppm (TWA)/ 500 ppm (STEL) | 2,000 gal (7.6E3 l) | 2,000 gal (7.6E3 l) | Included | | West of Unit 1 Stores Building | 12/year |





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## Table 2.2-2—{Callaway Plant Unit 1 and Callaway Plant Unit 2, Onsite Chemical Storage}

(Page 2 of 4)

| Material | Toxicity Limit (IDLH) | Callaway Plant Unit 1 | | Callaway Plant Unit 2 | | Location | Annual Frequency[1] |
|---|---|---|---|---|---|---|---|
| | | Quantity | Largest Container | Quantity | Largest Container | | |
| Sodium Hypochlorite (12% solution) | None established | 11,500 gal (4.4E4 l) | 5,500 gal (3.0E4 l)<br>5,500 gal (2.1E4 l) | 8,800 gal (3.3E4 l) | 8,000 gal (3.1E4 l) | Water Treatment<br>Circulating/Service | 15/year (1 unit)<br>35/year (2 units) |
| Hydrazine (35% solution) | 50 ppm | 5X (360 gal tote) (1.36E3 l) | 360 gal tote (1.36E3 l) | 360 gal tote (1.36E3 l) | 360 gal tote (1.36E3 l) | Turbine Building & Stores | 12/year (1 unit)<br>24/year (2 units) |
| Lubricating Oil (Shell Turbo 32) | None established | 25,100 gal (9.50E4 l) | Main Turbine LO Storage 15,000 gal (5.68E4 l) | 25,000 gal (3.8E4 l) | 15,000 gal (3.8E4 l) | Unit 1 and Unit2 Turbine Buildings in block wall room with fire protection | As necessary to maintain inventory |
| Liquid Nitrogen | Asphyxiant | 8,000 gal (3.0E4 l) | 6,700 gal (2.5E4 l) | Included | | >300 ft from the nearest Category 1 structure | 24/year (1 unit)<br>36/year (2 units) |
| Oxygen | None established | 52,000 scf (1.5E3 $m^3$) | 49,400 scf (1.4E3 $m^3$) | Included | | Approximately 350 feet (107 m) from the Unit 1 Powerblock | 5/year (1 unit)<br>10/year (2 units) |
| Mineral Oil | 2,500 $mg/m^3$ | 90,500 gal (3.43E5 l) | 11,000 gal (4.46E4 l) | 160,000 gal (6.1E5 l) | 11,000 gal (4.46E4 l) | Eng. Safety Features Xfmr XNB01/02<br>50 ft (15 m) from Control Bldg | As necessary to maintain inventory |
| 50% Sodium Hydroxide | 10 $mg/m^3$ (NIOSH)<br>2 $mg/m^3$ (PEL) | 26,000 gal (9.8E4 l) | 16,000 gal (6.1E4 l) | 26,000 gal (9.8E4 l) | 16,000 gal (6.1E4 l) | 10,000 gal (3.8E3 l) Unit 1 and Unit 2 Turbine Buildings, 16,000 gal (6.1E3 l) Unit 1 and Unit 2 Demineralized Water Buildings | 4/year (1 unit)<br>8/year (2 units) |
| Sulfuric Acid (98% solution) | 15 $mg/m^3$ | 34,000 gal (1.3E5 l) | 14,000 gal (5.7E4 l) | 34,000 gal (1.3E5 l) | 30,000 gal (1.1E5 l) | 14,000 gal (1.1E5 l) Circulating and Service Water Pumphouse<br>10,000 gal Unit 1 and Unit 2 Turbine Buildings<br>10,000 gal Unit 1 and 2 Demineralized Water Buildings | 56/year (1 unit)<br>100/year (2 units) |
| Fyrquel EHC fluid | 1000 $mg/m^3$ as Triphenyl Phosphate | 750 gal (2.8E3 l) | 600 gal (2.3E3 l) | 750 gal (2.8E3 l) | 600 gal (2.3E3 l) | Unit 1 and Unit 2 Turbine Buildings | As necessary to maintain inventory |
| Monoethanolamine (99%) ETA | 30 ppm | 400 gal (1.5E3 l) | 400 gal (1.5E3 l) tote | 400 gal (1.5E3 l) | 400 gal (1.5E3 l) tote | Unit 1 and Unit 2 Turbine Buildings | 1/year |





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## Table 2.2-2—{Callaway Plant Unit 1 and Callaway Plant Unit 2, Onsite Chemical Storage}

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| Material | Toxicity Limit (IDLH) | Callaway Plant Unit 1 | | Callaway Plant Unit 2 | | Location | Annual Frequency[1] |
|---|---|---|---|---|---|---|---|
| | | Quantity | Largest Container | Quantity | Largest Container | | |
| Hydrogen | None established | 110,400 scf (3.13E3 $m^3$) | 9,200 scf (261 $m^3$) | Included | | Approximately 350 feet (107 m) from the Unit 1 Powerblock | 26/year (1 unit) 52/year (2 units) |
| Carbon Dioxide | 40,000 ppm | 6 ton (5.4 mt) | 6 ton (5.4 mt) | Included | | Approximately 350 feet (107 m) from the Unit 1 Powerblock | 13/year |
| Soda Ash (Sodium Carbonate) | None established | 500 lb (230 kg) | 50 lb (23 kg) bag | Included | | Storeroom | As necessary to maintain inventory |
| BULAB 7016 (HEDP) | None established | 1700 gal (6.4E3 l) | 1700 gal (6.4E3 l) | 2500 gal (9.5E3 l) | 2500 gal (9.5E3 l)<br>300 gal (1.1E3l) in totes at ESWS towers | Unit 1 and Unit 2 Circulating Water Pumphouse ESWS cooling towers | 8/year (1 unit) 13/year (2 units) |
| BULAB 7034 (copolymer) | None established | 3200 gal (1.2E4 l) | 3200 gal (1.2E4 l) | 5000 gal (1.9E4 l) | 5000 gal (1.9E4 l)<br>500 gal (1.1E3l) in totes at ESWS towers | Unit 1 and Unit 2 Circulating Water Pumphouse ESWS cooling towers. | 8/year (1 unit) 15/year (2 units) |
| BULAB 9051 (phosphoric acid, 75%) | 1,000 mg/$m^3$ | 1700 gal (6.4E3 l) | 1700 gal (6.4E3 l) | 2500 gal (1.9E4 l) | 2500 gal (9.9E3 l) 300 gal (1.1E3 l) in totes at ESWS towers | Unit 1 and Unit 2 Circulating Water Pumphouse ESWS Cooling towers. | 8/year (1 unit) 15/year (2 units) |
| BULAB 9027 (sodium tolytriazole, 50%) | None established | 1100 gal (4.2E3 l) | 1100 gal (4.2E3 l) | 1100 gal (4.2E3 l) | 1100 gal (4.2E3 l)<br>100 gal (380 l) in totes at ESWS towers | Unit 1 and Unit 2 Circulating Water Pumphouse ESWS Cooling towers | 2/year (1 unit) 3/year (2 units) |
| BULAB 6040 (sodium bromide, 40%) | None established | 3200 gal (1.2E4 l) | 3200 gal (1.2E4 l) | 5000 gal (1.9E4 l) | 5000 gal (1.9E4 l)<br>500 gal (1.9E3 l) in totes at ESWS towers | Water Treatment Plant/ Unit 1 and Unit 2 Circulating Water Pumphouse ESWS Twrs | 15/year (1 unit) 25/year (2 units) |





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## Table 2.2-2—{Callaway Plant Unit 1 and Callaway Plant Unit 2, Onsite Chemical Storage}

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| Material | Toxicity Limit (IDLH) | Callaway Plant Unit 1 | | Callaway Plant Unit 2 | | Location | Annual Frequency[1] |
|---|---|---|---|---|---|---|---|
| | | Quantity | Largest Container | Quantity | Largest Container | | |
| BULAB 8006 (biopenetrant) | None established | 1100 gal (4.2E3 l) | 1100 gal (4.2E3 l) | 1100 gal (4.2E3 l) | 1100 gal (4.2E3 l)<br><br>100 gal (380 l) in totes at ESWS towers | Water Treatment Plant/ Unit 1 and Unit 2 Circulating Water Pumphouse<br>ESWS Cooling towers | 6/year (1 unit)<br>8/year (2 units) |
| 3-methoxypropyl amine (MPA) (40%) | None established (TWA 5 ppm) (STEL 15 ppm) | 400 gal (1.5E3 l) | 400 gal (1.5E3 l) tote | 400 gal (1.5E3 l) | 400 gal (1.5E3 l) tote | Turbine Building | 11/year |

Legend:
OSHA: Occupational Safety and Health Administration
PEL: Permissible Exposure Limit
TWA: Time weighted average exposure limit
STEL: Short Term Exposure Limit
Note 1: All shipments are by Ground
Note 2:The 3,000 gal (1.1E4 l) and 2,800 gal (1.1E4 l) diesel fuel tanks are underground. Therefore, the toxicity event is bounded by the 1,000 gal (3.8E3l) diesel fuel delivery truck.





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## Table 2.2-3— {Mertens Quarry, Onsite Hazardous Materials Storage}

| Material | Quantity, lb (kg) | Shipping Mode | Annual Frequency |
|---|---|---|---|
| Detonators (electrical caps) | < 500 | Ground | Up to 52 |
| DynoAP | Up to 5500 (2,495) | Ground | Up to 52 |
| Ammonium Nitrate prills | 44,000 (19,958) | Ground | Up to 52 |

## Table 2.2-4—{Hazardous Chemical Waterway Freight, Missouri River}

| Material | Toxicity Limit (Immediately Dangerous to Life or Health) | Total Quantity 1,000 short ton (1,000 metric ton) (Note 1) |
|---|---|---|
| Asphalt and Tar Pitch | 80 mg/m$^3$ as coal tar pitch volatiles (NIOSH, 2006) | 180 (163) |
| All Fertilizers and Mixes | None established (Note 2) | 4 (3.6) |
| Metallic Salts | None established | 3 (2.7) |
| TOTAL | | 187 (169.3) |

Note 1: The quantities shown represent the total quantity in thousand short tons transported along the Missouri River between Kansas City and St. Louis on an annual basis (US Army Corps of Engineers, 2007).

Note 2: There are no established toxicity limits for broad categories. Further, no fertilizer mixtures are known to present specific explosion hazards in the absence of combining them with other commodities.

## Table 2.2-5—{State (SR) and County (CR) Routes and Distances from the Callaway Site}

| State Route | Distance from Site, mi (km) |
|---|---|
| SR D | 3.55 (5.71) |
| SR O | 1.72 (2.77) |
| SR AD/CR428) | 5.04 (8.11)/0.33 (0.53) |
| SR CC | 0.80 (1.29) |
| SR VV | 4.36 (7.02) |
| SR 94 | 3.82 (6.15) |
| CR 448 | 0.37 (0.60) |
| CR 459 | 0.46 (0.74) |

## Table 2.2-6—{Aircraft Operations – Significance Factors}

| Airport | Number of Operations (Note 1) | Distance from Site (d) | Significance (Acceptance) Factor (Note 2) |
|---|---|---|---|
| Columbia Regional (COU) | 32,493 (2006)<br>41,293 (2025 projected) | 24 mi<br>(38.6 km) | 576,000 |
| Jefferson City Memorial (JEF) | 31,495 (2006)<br>39,600 (2025 projected) | 23 mi<br>(37.0 km) | 529,000 |
| Lambert – St. Louis International (STL) | 286,407 (2006)<br>384,636 (2025 projected) | 77 mi<br>(123.9 km) | 5,929,000 |

Note 1: Reference: Federal Aviation Administration (FAA) FAA Operations and Performance Data: APO Terminal Area Forecast, December 2006

Note 2: NUREG 0800 Part 3.5.1.6 Acceptance Criterion $1000d^2$ operations per year for sites outside 10 mi (16 km)

## Table 2.2-7—{Onsite Chemicals Disposition}

(Page 1 of 2)

| Material | Toxicity Limit (IDLH) | Flammability | Explosion Hazard? | Vapor Pressure | Disposition |
|---|---|---|---|---|---|
| Boric Acid | None established | Not flammable | None listed | N/A-solid | No further analysis required |
| Fuel Oil | None established | Not flammable (flash point 100$^0$F, 38$^0$C) | None listed | No. 2: 0.019 psi @60$^0$F 0.03 kPa @ 15.5$^0$C | No further analysis required-low vapor pressure (Note 1) |
| Diesel Fuel | None established | 1.3-6.0% | None listed | 0.100 psi @ 100°F/ 0.7 kPa @ 37.8°C | No further analysis required-low vapor pressure (Note 1) |
| Gasoline | (300 ppm (TWA)/ 500 ppm [STEL]) | 2.8-14.4% | Vapor may explode | 7.4 psia/ 51 kPa | Toxicity Analysis Flammability Analysis Explosion Analysis |
| Sodium Hypochlorite (12% solution) (Note 2) | None established | Not flammable | None listed | 0.23 psi @ 68$^0$F/ 1.6kPa @20$^0$C | No further analysis required |
| Hydrazine (35% solution) (Note 3) | 50 ppm As hydrazine | 2.9-98% As hydrazine | None listed | 0.28 psi @ 77$^0$F/ 1.9 kPa @ 25$^0$C | Toxicity Analysis |
| Lubricating Oil (Shell Turbo 32) | None established | Not flammable | None listed | 0.100 psi @ 100°F/ 0.7 kPa @ 37.8°C | No further analysis required |
| Liquid Nitrogen | Asphyxiant | Negligible | None listed, if exposed to heat | 760 mm Hg @ -196°C | Toxicity-consider as asphyxiant |
| Oxygen | None established | Not Flammable | None listed | 760 mm Hg @ -183°C | No further analysis required |
| Mineral Oil | 2,500 mg/m$^3$ | Not flammable | None listed | 0.100 psi @ 100°F/ 0.7 kPa @ 37.8°C | No further analysis required-low vapor pressure (Note 1) |
| Sodium Hydroxide (50% solution) | None established | Not flammable | None listed | Not available | No further analysis required |
| Sulfuric Acid (98% solution) | 15 mg/m$^3$ | Not flammable | None listed | <0.00120 mm Hg | No further analysis required- low vapor pressure[1] |
| Fyrquel EHC fluid | 1000 mg/m$^3$ as Triphenyl Phospate | Not flammable | None listed | 0.17 mm Hg @ 68°F (20°C) | No further analysis required- low vapor pressure (Note 1) |
| Monoethanolamine | 30 ppm | 5.5-17% | None listed | 0.022 psi @ 100°F/ 0.15 kPa @ 37.8°C | No further analysis required- low vapor pressure (Note 1) |
| Hydrogen | None established | 4.0-75% | Vapor may explode | 29.030 @ -418°F/ 200 kPa @ 214°C | Toxicity-consider as asphyxiant Flammability Analysis Explosion Analysis |
| Carbon Dioxide | Asphyxiant | Not flammable | None listed | Sublimes @ -78.5$^0$C | Toxicity-consider as asphyxiant |
| Soda Ash (Sodium Carbonate) | None established | Not flammable | None listed | N/A-solid | No further analysis required |
| BULAB 7016 (HEDP) | None established | Not flammable | None listed | Not available | No further analysis required |
| BULAB 7034 (copolymer) | None established | Not flammable | None listed | Not available | No further analysis required |

## Table 2.2-7—{Onsite Chemicals Disposition}

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| Material | Toxicity Limit (IDLH) | Flammability | Explosion Hazard? | Vapor Pressure | Disposition |
|---|---|---|---|---|---|
| BULAB 9051 (phosphoric Acid 75%) | 1,000 mg/m$^3$ | Not flammable | None listed | 0.11 psi (0.76 kPa) | No further analysis required-low vapor pressure (Note 1) |
| BULAB 9027 (Sodium tolytriazole 50%) | None established | Not flammable | None listed | Not available | No further analysis required |
| BULAB 6040 (sodium bromide 40%) | None established | Not flammable | None listed | N/A-solid | No further analysis required |
| BULAB 8006 (biopenetrant) | None established | Not flammable | None listed | Not available | No further analysis required |
| 3-methoxypropylamine (Nalco) (MPA 40%) | None established (TWA 5 ppm) (STEL 15 ppm) | Not flammable | None listed | Not available | No further analysis required |

TLV-TWA: Threshold Limit Value-Time-Weighted Average

STEL: Short term exposure limit

IDLH: Immediately Dangerous to Life and Health threshold value

Chemical information was obtained from manufacturer Material Safety Data Sheets (MSDS), except for the STEL value for gasoline (OSHA, 2005).

Note 1: Chemicals with vapor pressures less than 10 torr (10 mm Hg, 0.193 psi, or 1.3 kPa) were not considered. Chemicals with vapor pressures this low are not volatile. Under normal conditions, these chemicals cannot enter the atmosphere fast enough to reach hazardous concentrations hazardous and, therefore, are not considered to be an air dispersion hazard (NOAA, 2007).

Note 2: Sodium hypochlorite is stable under normal conditions. Chlorine may be present at low concentration as a decomposition product or at higher levels from the reaction between sodium hypochlorite and a strong acid, if released concurrently and allowed to mix. Vapor pressure given is composed primarily of water vapor. Source (chlorine) concentration input for toxicity analysis is indeterminate.

Note 3: Physical properties differ from those of the pure substance. Vapor pressure: 0.06 psi (0.41 kPa) from hydrazine, 0.22 psi (1.5 kPa) from water.

## Table 2.2-8— {Hazardous Material, Roadway Transportation, Disposition}

| Material | Toxicity Limit (IDLH) | Flammability | Explosion Hazard? | Vapor Pressure | Disposition |
|---|---|---|---|---|---|
| Gasoline | 300 ppm (TWA) / 500 ppm (STEL) | 1.4-7.6% | Vapor may explode | 7.4 psia/ 51 kPa | Toxicity Analysis Flammability Analysis Explosion Analysis |
| Diesel Fuel | None established | 1.3-6.0% | None listed | 0.100 psi @ 100°F/ 0.7 kPa @ 37.8°C | No further analysis required-low vapor pressure (Note 1) |
| Fuel Oil | None established | Not flammable | None listed | No. 2: 0.019 psi @60$^0$F 0.03 kPa @ 15.5$^0$C | No further analysis required-low vapor pressure (Note 1) |
| Lubricating Oil (Shell Turbo 32) | None established | Not flammable | None listed | Low: Flash point 420$^0$F (215$^0$C) | No further analysis required-low vapor pressure (Note 1) |
| Liquid Nitrogen | Asphyxiant | Negligible | None listed, only if exposed to heat | 760 mm Hg @ -196°C | Toxicity-consider as asphyxiant (Note 2) |
| Mineral Oil (transformer oil) | 2,500 mg/m$^3$ | Not flammable | None listed | <0.01 psi (0.07kPa) | No further analysis required-low vapor pressure (Note 1) |
| Sodium Hydroxide (50% solution) | None established | Not flammable | None listed | Not available | No further analysis required |
| Sulfuric Acid (98% solution) | 15 mg/m$^3$ | Not flammable | None listed | <0.00120 mm Hg | No further analysis required-low vapor pressure (Note 1) |
| Propane | 2,100 ppm | 2.2-9.5% | Vapor may explode | 25.4 psi @ -20°F/ 175 kPa @ -6.7°C | Toxicity Analysis Flammability Analysis Explosion Analysis |

TLV-TWA: Threshold Limit Value-Time-Weighted Average
STEL: Short term exposure limit
IDLH: Immediately Dangerous to Life and Health threshold value
Chemical information was obtained from the individual chemical manufacturer Material Safety Data Sheet (MSDS).
Note 1: Chemicals with vapor pressures less than 10 torr, 0.193 psi, were not considered. Chemicals with vapor pressures this low are not very volatile. That is, under normal conditions, chemicals cannot enter the atmosphere fast enough to reach concentrations hazardous to people and, therefore, are not considered to be an air dispersion hazard (NOAA, 2007).
Note 2: Bounded by the on-site storage of liquid nitrogen.

## Table 2.2-9— {Hazardous Material, Navigable Waterway Transportation, Disposition}

| Material | Toxicity Limit (IDLH) | Flammability | Explosion Hazard | Vapor Pressure | Disposition |
|---|---|---|---|---|---|
| Asphalt and Tar Pitch | 80 mg/m$^3$ as coal tar pitch volatiles | Not flammable | None listed | <0.01 kPa @ 20°C (Note 2) | No further analysis required- low vapor pressure[1] |
| All Fertilizers and Mixes | None established[3] | Not applicable[3] | Not applicable[3] | Not applicable[4] | No further analysis required |
| Metallic Salts | None established[3] | Not flammable | None listed | Not available | No further analysis required |

.TLV-TWA: Threshold Limit Value-Time-Weighted Average
STEL: Short term exposure limit
IDLH: Immediately Dangerous to Life and Health threshold value
Note 1: Chemicals with vapor pressures less than 10 torr, 0.193 psi, were not considered. Chemicals with vapor pressures this low are not volatile. Under normal conditions, such materials cannot enter the atmosphere fast enough to reach hazardous concentrations and, therefore, are not considered to be an air dispersion hazard.
Note 2: The vapor pressure for Coal-Tar Pitch was obtained from INCHEM. (INCHEM, 2002)
Note 3: There are no established toxicity limits for broad categories.
Note 4: No fertilizer mixtures are known to present specific explosion hazards without combining them with other commodities.

## Table 2.2-10—{Explosion Event Analysis}

| Source | Pollutant Evaluated | Quantity | Heat of Combustion (Btu/lb)/ (kj/kg) | Distance to Nearest Callaway Unit 2 Safety Related Structure | Distance at 1 psi (6.9 kPa) Peak Incident Pressure |
|---|---|---|---|---|---|
| **County Route 448** | Gasoline | 5,000 gal/ (18,900 l) | 18,720/ 43,514 | 1,700 ft (520 m) | 320 ft/ 100 m |
| | Propane | 2,600 gal/ (9,840 l) | 19,782/ 45,982 | | 2285 ft/ 696 m (Note 1) |
| **State Route 94** | ANFO | 50,000 lb (22,700 kg) | 1,550/ 3,609 | 4 miles 6.4 km | 1,700 ft/ 520 m |
| **On-Site (Includes Callaway Plant Unit 1)** | Gasoline | 2,000 gal (7,570 l) | 18,720/ 43,514 | 1,900 ft (570 m) | 250 ft 75 m |
| | Hydrogen | 9,200 scf (261 $m^3$) | 50,080/ 116,411 | 975 ft (300 m) | 1010 ft/ 308 m |
| **Nearby Facilities** | ANFO | 44,000 lb/ (19,960 kg) | 1,550/ 3,609 | 4.5 miles 7.2 km | 1,590ft/ 480 m |

Note 1: This event was determined not to be a credible event based on an event probability of less than 1E-7. Refer to Section 2.2.3.1.2 for the analysis of this event.

## Table 2.2-11—{Flammable Vapor Cloud Events (Delayed Ignition) and Vapor Cloud Explosion Analysis}

| Source | Pollutant Evaluated & Quantity | Distance to Nearest Safety Related Callaway Plant Unit 2 Structure | Distance to UFL | Distance to LFL | Safe Distance for Vapor Cloud Explosions | Peak Overpressure at Nearest Safety Related Callaway Plant Unit 2 Structure |
|---|---|---|---|---|---|---|
| **County Route 448** | Gasoline 5,000 gal/ (18,900 l) (Note 1) | 1,700 ft/ 2URB Ultimate Heat Sink | <33 ft <10 m | 72 ft 22 m | 360 ft 110 m | <0.5 psi |
| | Propane 2,600 gal/ (9,800 l) | | 328 ft 100 m | 1115 ft 340 m | 2300 ft 700 m | 1.73 psi |
| **On-site (Includes Callaway Plant Unit 1)** | Gasoline 2,000 gal (7,600 l) | 1,900 ft (570 m) 2URB Ultimate Heat Sink | <33 ft <10 m | 50 ft 15 m | 246 ft 75 m | <0.5 psi |
| | Hydrogen 9,200 scf / (261 $m^3$) | 975 ft (300 m) 2URB Ultimate Heat Sink | 300 ft 91 m | 885 ft 270 m | 1010 ft 308 m | 1.15 psi |

Note 1: Gasoline was modeled in ALOHA as n-heptane. N-heptane is used as a substitute for gasoline because the molecular weight and physical properties are similar.

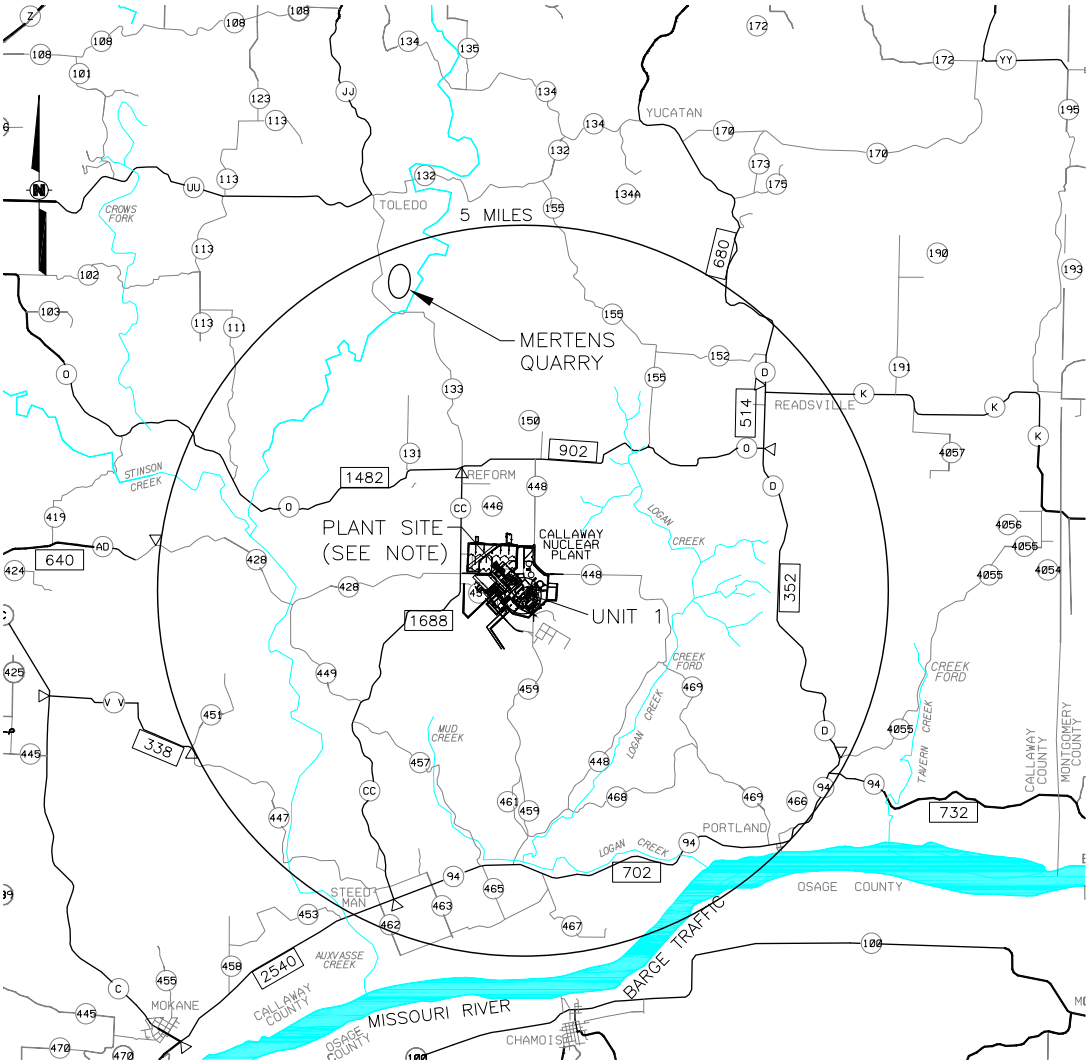
Note 2: This event was determined not to be a credible event based on an event probability of less than 1E-7. Refer to Section 2.2.3.1.2 for the analysis of this event.

## Table 2.2-12—{Toxic Vapor Cloud Analysis}

| Source | Chemical | Quantity | IDLH | Distance to Callaway Plant Unit 2 Control Room | Distance to IDLH | Maximum Control Room Concentration (Note 3) |
|---|---|---|---|---|---|---|
| **County Route 448** | Gasoline | Gasoline 5,000 gal/ (18,900 l) | 300 ppm TLV-TWA /500 ppm STEL | 2,060 ft (630 m) | 770 ft 235 m (Note 5) | 104 ppm (Note 5) |
| | Propane | Propane 2,600 gal/ (9,800 l) | 2,100 ppm | | 3136 ft (956 m) | 5,600 ppm |
| **Onsite (Includes Callaway Plant Unit 1)** | Gasoline (Note 1) | 2,000 gal/ (7,600 l) | 750 ppm (300 ppm TWA /500 ppm STEL) | 2,040 ft (620 m) | 770 ft 235 m (Note 5) | 107 ppm (Notes 2, 5) |
| | Hydrazine (35% solution) | 360 gal/ (1,360 l) | 50 ppm as hydrazine | 1,200 ft (366 m) | 712 ft 217 m (Note 4) | 20.1 ppm (Note 4) |
| | Hydrogen | 9,200 $ft^3$/ (261 $m^3$) | Asphyxiant | 1,350 ft (410 m) | Asphyxiant | 5,730 ppm |
| | Liquid Nitrogen | 8,000 gal/ (30,000 l) | Asphyxiant | 1,500 ft (460 m) | Asphyxiant | 73,900 ppm |
| | Carbon Dioxide | 6 ton (5.4 mt) | 40,000 | 1,614 ft (492 m) | 1,610 ft (491 m) | 39,600 ppm |

TLV-TWA: Threshold Limit Value-Time-Weighted Average
STEL: Short term exposure limit
IDLH: Immediately Dangerous to Life and Health threshold value
Note 1: This toxicity event is bounded by the 5,000 gallon gasoline delivery tank truck.
Note 2: ALOHA does not report values after 1 hour because it assumes that the weather conditions or other release circumstances are likely to change after an hour.
Note 3: Concentrations at ground level at intake location.
Note 4: ALOHA Calculations used pure hydrazine, which is conservative.
Note 5: Gasoline evaporation modeled as n-Heptane.

## Figure 2.2-1—{Location Map, Facilities, Land, and Water Transportation Routes}




LEGEND:

455 ROADS / HIGHWAYS

RIVERS, STREAMS / CREEKS

TRAFFIC COUNT INTERVAL

2540 AVERAGE DAILY TRAFFIC COUNT

SCALE

2 0 2 MILES

NOTE:

REFERENCE CENTER POINT OF PLANT SITE IS DEFINED AS THE MIDPOINT BETWEEN EXISTING REACTOR FOR CALLAWAY PLANT UNIT 1 AND REACTOR FOR CALLAWAY PLANT UNIT 2.

REFERENCE:

MISSOURI STATE FIELD MONITORING TEAM MAP, CALLAWAY PLANT: FMT–001–STATE.DGN REV C, 04/25/05.

MO. DOT, TRANSPORTATION PLANNING, TRAFFIC INFORMATION (TR50), 5/10/2007

063624A30

**Figure 2.2-2—{Low Altitude Air Routes and Airports}**

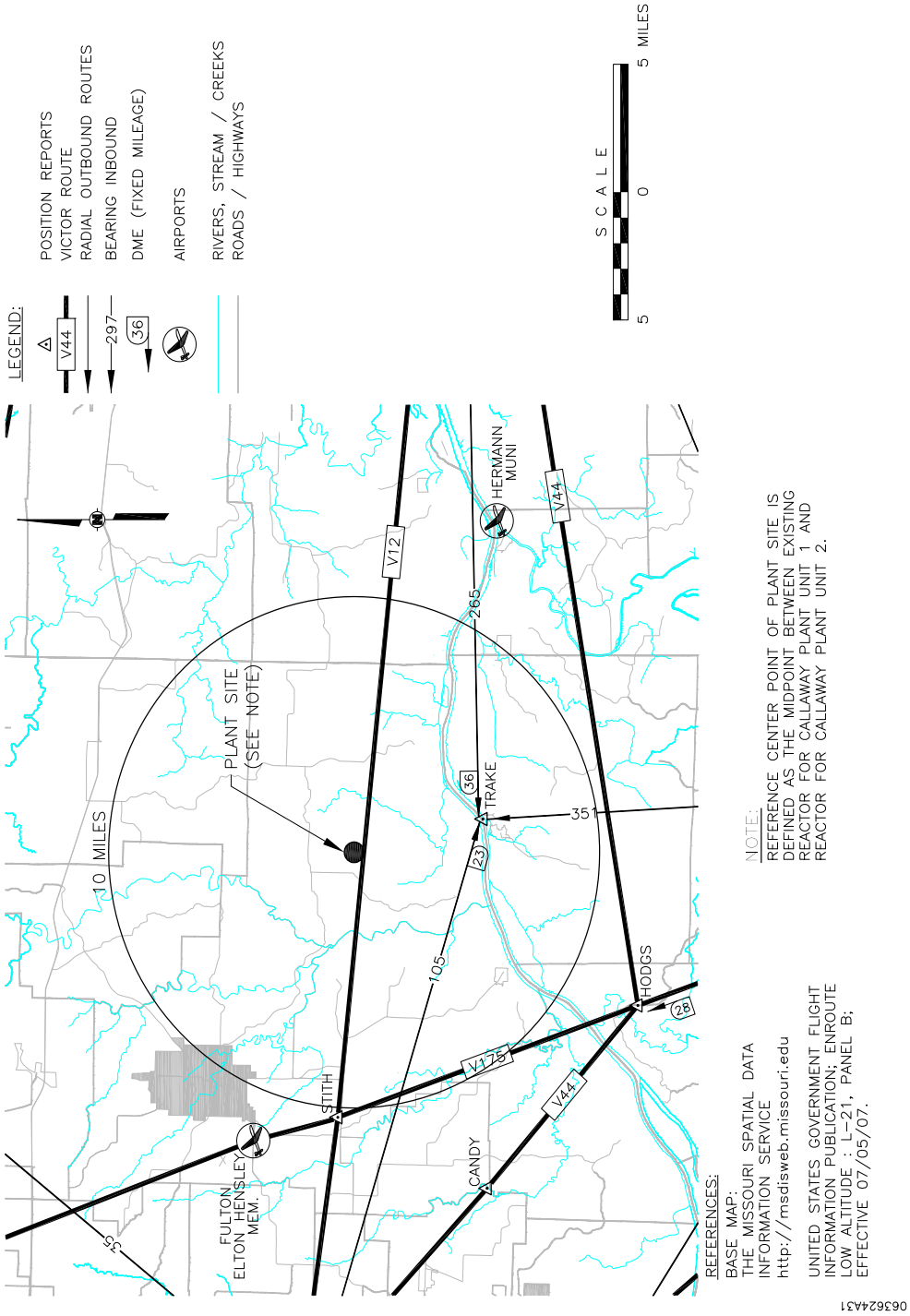
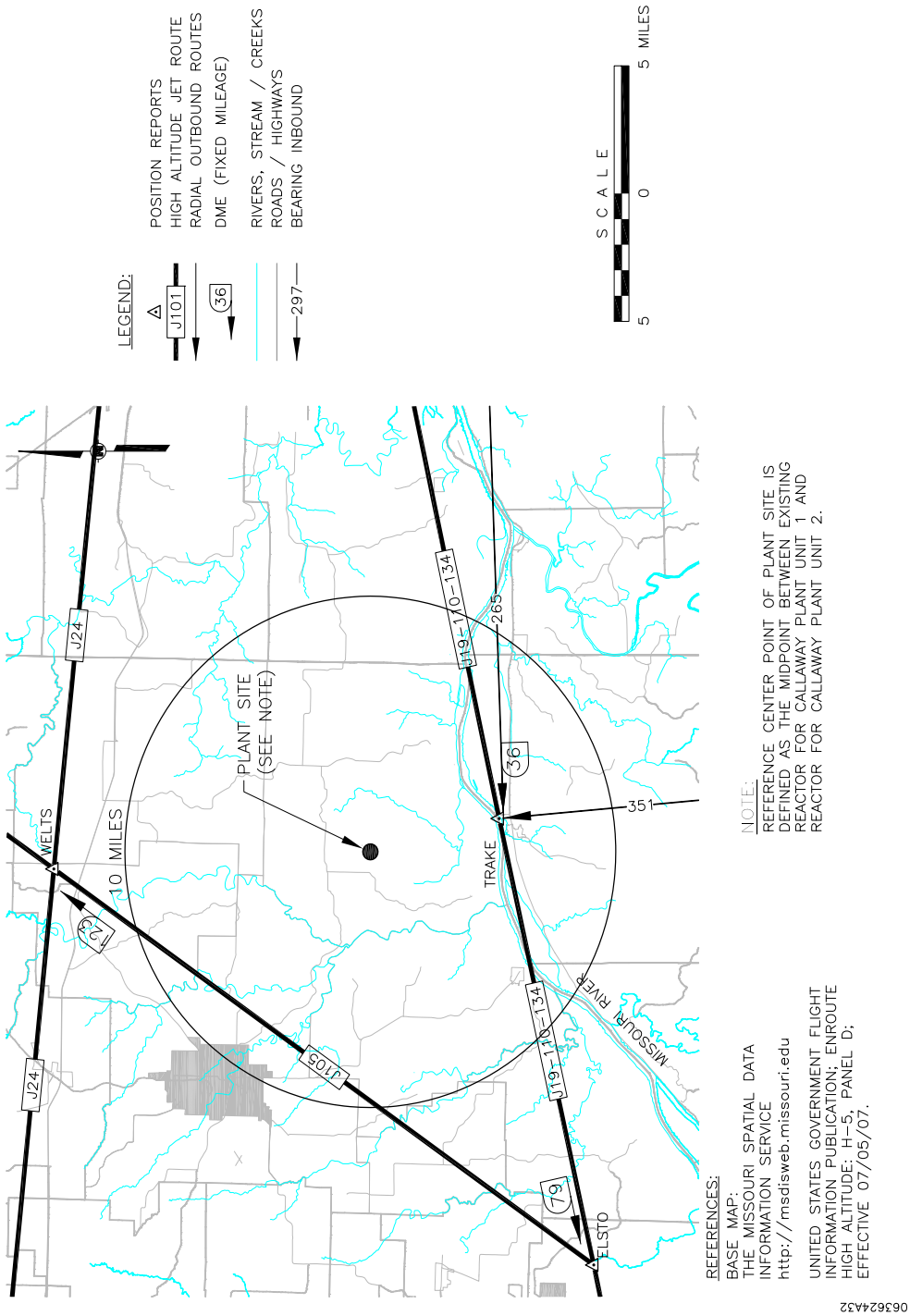
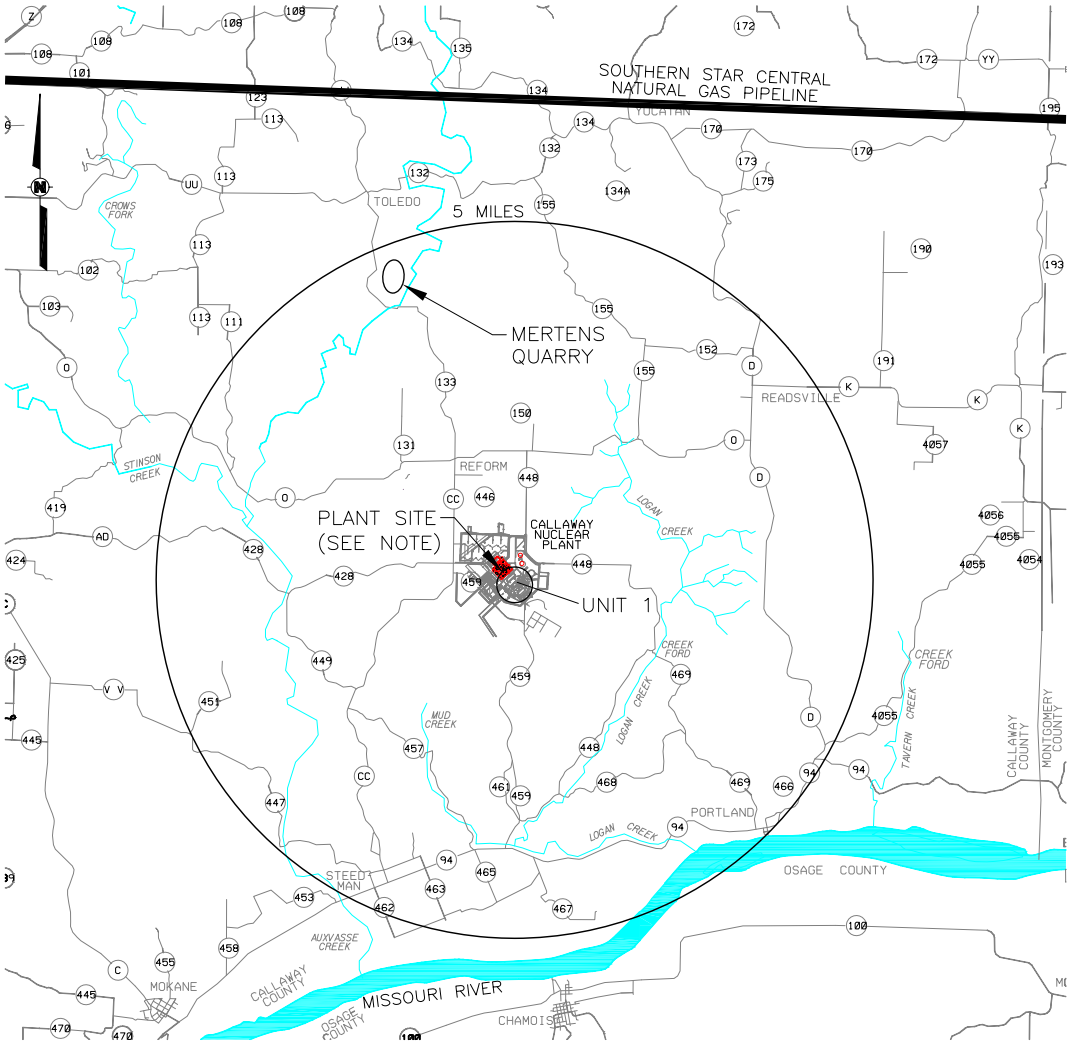


**Figure 2.2-3—{IFR Enroute High Altitude Air Routes}**



## Figure 2.2-4—{Location of Nearest Pipeline}




LEGEND:

455 ROADS / HIGHWAYS

RIVERS, STREAMS / CREEKS

SCALE

2 0 2 MILES

NOTE:

REFERENCE CENTER POINT OF PLANT SITE IS DEFINED AS THE MIDPOINT BETWEEN EXISTING REACTOR FOR CALLAWAY PLANT UNIT 1 AND REACTOR FOR CALLAWAY PLANT UNIT 2.

063624A33

REFERENCE:

MISSOURI STATE FIELD MONITORING TEAM MAP, CALLAWAY PLANT: FMT–001–STATE.DGN REV C, 04/25/05.