OCS STUDY
MMS 2009-021

Hydrogen Sulfide (H_2S) Gas Dispersion Potentials & Release Scenarios for Pacific OCS Region Oil & Gas Platforms & Pipelines Located in the Santa Barbara Channel and Santa Maria Basin, California

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U.S. Department of the Interior
Minerals Management Service

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EXECUTIVE SUMMARY

Oil and gas facilities located on the Pacific Outer Continental Shelf Region (POCSR) generally produce gas that contains varying concentrations of hydrogen sulfide gas. Gas containing high levels of H_2S is commonly referred to as sour gas. Minerals Management Service (MMS) regulations require that lessees, "Take all necessary and feasible precautions and measures to protect personnel from the toxic effects of H_2S and to mitigate damage to property and the environment by H_2S" (30CFR 250.490(a)(1)). Workers on the platforms are trained and drilled in the potential hazards of H_2S and there are extensive safety measures in place to reduce the potential for releases, enable rapid detection, and implement immediate response, if a release were to occur.

The primary focus of this analysis was to estimate the areal extent around a potential release source (wellhead, process vessel, piping, pipeline) for eleven (11) of the twenty three (23) platforms located on the POCSR that produce gas with H_2S concentrations greater than or equal to (≥) 100 parts per million (ppm), which could present a hazard to members of the public. Three H_2S exposure concentrations (100, 300, and 1,000 ppm), under two sets of atmospheric conditions, were addressed in the analysis. Modeling of potential release scenarios was conducted using the publicly available U.S. Environmental Protection Agency (EPA) Areal Locations of Hazardous Atmospheres (ALOHA) model.

Modeled H_2S hazard areas from uncontrolled well releases, process vessels, piping, and pipelines at each of the platforms do not extend to shore or to the vessel traffic lanes, and therefore are not expected to present a hazard to members of the public located either onshore or on vessels transiting within the vessel traffic lanes. Vessels under 100 feet in length that are not towing are not prohibited from transiting within U.S. Coast Guard established 500-meter (1,640 feet) platform "safety zones", which have been established for all 11 POCSR platforms assessed. Hence, there is a possibility that a vessel could transit near a platform and be exposed to an H_2S or flammable gas hazard.

The expected frequency of an uncontrolled release has been estimated to be "rare" (between once in 10,000 and once in 1,000,000 years). The hazard area is directional in nature and only extends downwind. People located within the hazard zones would be subject to serious health impacts depending on exposure level and exposure time.

An uncontrolled release of sour gas from Platform Hidalgo, which is located offshore between Pt. Conception and Pt. Arguello, was the only scenario that produced a potential H_2S hazard zone that extended beyond the U.S. Coast Guard's designated "safety zone." In this scenario, the maximum projected 100 ppm H_2S concentration hazard zone extended a distance of 2,676 feet downwind of the platform. For the other two modeled scenarios of uncontrolled releases of 300 ppm and 1,000 ppm H_2S from Platform Hidalgo, the modeled hazard areas extend to a maximum downwind distance of 1,317 ft and 597 feet, respectively, and do not extend beyond the "safety zone."

The estimated maximum H_2S hazard areas around the POCSR platforms located in the Santa Barbara Channel are smaller than those located north of Pt. Conception. The largest 100 ppm H_2S concentration hazard zone for platforms located in the eastern Santa Barbara Channel (Platforms Gail, Gilda, Grace, and Gina) has a maximum downwind distance of 813 feet. The estimated largest 300 ppm H_2S concentration hazard zone is 372 ft and the largest 1,000 ppm H_2S concentration hazard zone is 159 feet. As with Platform Hidalgo, it is possible that a vessel less than 100 feet in length could be within the hazard zone at the time of a release.

The expected frequency of a rupture of a processing vessel or piping on a platform has been estimated to be "unlikely." The H_2S hazard zones from these types of accidents are estimated to be much smaller than those from an uncontrolled release, with a maximum 100 ppm H_2S concentration hazard zone of 561 feet

immediately downwind from Platform Hidalgo and 336 feet immediately downwind for Platforms Gina, Gilda, Gail, Grace, Harmony, Heritage, and Hondo. It is possible that a vessel less than 100 feet in length could be within the hazard zone at the time of a release.

This study also addressed the potential hazard to the public of a release of sour gas from the pipelines from Platform Gail to Platform Grace and from Platform Hidalgo to Platform Hermosa. The estimated hazard areas for these two pipelines do not extend to land or the vessel traffic lanes. Releases from these pipelines present a larger hazard area than that of the platforms they connect. However, it is expected that the pipelines would be emptied of gas in less than 10 minutes, presenting a shorter exposure time than what was modeled. The maximum 300 ppm H_2S hazard zone distance estimated for a pipeline rupture was 7,392 feet for the pipeline connecting Platforms Hidalgo and Hermosa. This pipeline is located a minimum of 5.9 miles from shore and 4.9 miles from the vessel transit lanes. The Platform Gail to Grace pipeline was estimated to produce a maximum hazard zone of 1,416 feet for a 300 ppm H_2S concentration gas cloud. This pipeline is located a minimum of 9.9 miles from shore and 0.9 miles from the vessel transit lanes. The expected frequency of a pipeline rupture has been estimated to be “unlikely”.

This study also estimated the aerial extent around each platform where an accidental release of gas exceeds its lower flammability limit (LFL). This flammable gas cloud only presents a hazard if it comes in contact with an ignition source and ignites. None of the platform-related releases produce flammable gas clouds that would be expected to extend to land, the vessel traffic lanes, or outside the platform “safety zone. Numerous ignition sources exist on a POCSR platform that could ignite a gas release. Once the cloud travels beyond the platform, the only ignition source would be a vessel located within the flammable gas hazard zone. The estimated frequency of uncontrolled releases and ruptures occurring are “rare” and “unlikely”, respectively and the maximum distance estimated for a flammable gas cloud traveling downwind of a POCSR platform is 1,434 feet for the 60% Lower Flammability Limit (LFL) Hazard Zone at Platform Gail

Lastly, this study estimated the radiant heat hazard areas generated by a fire on the platforms, and determined that they would not extend to land, the vessel traffic lanes, or beyond the platform “safety zones.” The radiant heat hazard areas are not directional in nature, but instead extend in a circle around the platforms. It is possible for people located on vessels within these hazard zones to be impacted.

1.0 INTRODUCTION

Eleven (11) of the twenty three (23) platforms located on the Pacific Outer Continental Shelf Region (POCSR) produce gas that contains hydrogen sulfide (H_2S) in concentrations ≥100 parts per million (ppm). Gas containing large concentrations of H_2S is commonly referred to as "sour gas." H_2S is considered a broad-spectrum toxin, meaning that it can affect several different body systems at the same time, with the nervous system being the most susceptible. Exposure to lower concentrations of H_2S can result in eye irritation, sore throat, coughing, nausea, shortness of breath, and fluid in the lungs. Long-term, low-level exposure may result in fatigue, loss of appetite, headaches, irritability, poor memory, and dizziness (ATSDR, 2009). Accidental releases of sour gas from platform operations are expected to last for relatively short periods of time, lasting only a few minutes to approximately one hour. As a result, this analysis focused on potential H_2S exposure times of up to one hour, and their potential human health consequences.

Health effects from exposure to sour gas vary greatly, based upon differences in the concentrations present in the air. Effects can range from no long-term health effects at concentrations below 100 ppm (American Industrial Hygiene Association, 2009) to potentially fatal effects from inhaling a single breath of gas containing 1,000 ppm H_2S (Arthur D. Little, 2000).

Because of the toxicity of natural gas containing H_2S, the Minerals Management Service (MMS) has promulgated specific regulations (30CFR 250.490) for the control and management of hydrogen sulfide gas. The MMS also issued Notice to Lessees (NTL) NTL-P05 (MMS, 2003), which clarifies some of the requirements of 30CFR 250.490 for application in the POCSR. These regulations require that POCSR lessees "Take all necessary and feasible precautions and measures to protect personnel from the toxic effects of H_2S and to mitigate damage to property and the environment by H_2S." Platforms classified as having "H_2S present" are required to develop an H_2S Contingency Plan that must be submitted to the MMS for approval. The plan must address, among other things, safety procedures, training, responsibilities, actions to be taken in the event of a release, protective breathing equipment, notifications in the event of a release, and location of H_2S sensors and alarms. All platform workers, including contractors and visitors, that will remain on the platform for more than 24 hours must undergo special training in H_2S safety before commencing any work at the platform, and must renew this training annually. Visitors that will be on the platform for less than 24 hours must complete a briefing on H_2S safety. The regulations also require that each worker participate in at least one drill each week.

Additionally, MMS regulations require that H_2S detection and monitoring equipment be placed at certain locations on the platforms. Detectors must be capable of sensing a minimum of 10 ppm of H_2S in the atmosphere and activating audible and visual alarms when the concentration of H_2S reaches 20 ppm. Because sour gas is also corrosive, the regulations require that equipment and materials suitable for use with sour gas be used. MMS regulations also address other aspects of oil and gas development and production on platforms to minimize the potential for releases and other accidents, including the specification of materials, safety equipment, detection and warning systems, and emergency response requirements.

The primary focus of this analysis was to estimate the areal extent around a release source (wellhead, process vessel, piping, or pipeline) where H_2S concentrations could present a hazard to members of the public. Three H_2S exposure concentration levels were addressed in the analysis: 1,000 ppm, 300 ppm, and 100 ppm. In addition, the study estimated the areal extent around the platforms where an accidental release could become ignited (flammable gas cloud) as well as the area that could present a hazard to the public from radiant heat generated by a fire on a platform. Finally, the study addressed the potential hazard to the public from a release from gas pipelines transporting sour gas.

The initial step in this analysis was to gather data on all of the platforms located in the POCSR to determine which of these produce or process gas with H_2S concentrations ≥100 ppm. This information was obtained by the MMS from the individual lease operators and is presented in Table 1-1. POCSR platforms are located in four general geographic areas; north of Pt. Conception; the western Santa Barbara Channel, south of Goleta; the eastern Santa Barbara Channel between Carpinteria and Oxnard; and south of San Pedro Bay. As can be seen from Table 1-1, none of the platforms located south of San Pedro Bay produce or process gas with H_2S concentrations ≥100 ppm, and therefore were not addressed further in this study. Locations of the platforms in the POCSR addressed in this study are illustrated in Figure 1-1. Information on each platform's distance to shore and the vessel traffic lanes was obtained from MMS published information or calculated from MMS published maps illustrating platform locations (MMS 2009, MMS 1992) (Table 1-1). All distances expressed in miles refer to U.S. statute miles.

The U. S. Coast Guard has established 500 meter (0.31 miles/1,640 ft) "safety zones" around 15 of the platforms (CFR 33 Part 147). Vessels are prohibited from entering these safety zones. Exceptions include: (1) an attending vessel, (2) a vessel under 100 ft in length over all (LOA) and not engaged in towing, or (3) a vessel authorized by the Commander of the Eleventh Coast Guard District. The platforms with established safety zones are denoted in Table 1-1. All of the 11 platforms in the POCSR producing or processing gas with H_2S concentrations ≥100 ppm have U.S Coast Guard established safety zones.

Potential accident probabilities were estimated based upon data provided in published literature (Chambers Group 1986, A.D. Little 1984; 2000, URS 1986, CDC 1993, E&E 2007, FEMA 1989). Because of the uncertainty in these published estimates, each estimate was assigned into one of five categories of "likelihood of occurrence" that each cover a range of probabilities, *i.e.*, "extraordinary," "rare," "unlikely," "likely," and "frequent."

Modeling of release scenarios was conducted using the publically available U.S. Environmental Protection Agency (EPA) Areal Locations of Hazardous Atmospheres (ALOHA) model. ALOHA is a personal computer based modeling program designed for use by emergency response personnel responding to chemical releases, planning for emergencies, and training for responses. ALOHA models key hazards-toxicity (*i.e.*, flammability, thermal radiation (heat), and overpressure (explosion blast force)) for chemical releases that result in toxic gas dispersions, fires, and/or explosions. Based on previous dispersion analyses for oil and gas projects in the POCSR and state waters, two sets of atmospheric conditions were chosen for modeling each potential accidental gas release: (1) stable nighttime conditions with low two meter per second (2 m/s) wind and (2) neutral stability with moderate five meter per second (5 m/s) wind.

Table 1-1. H_2S Concentrations at Pacific Outer Continental Shelf Region Platforms and Distances to Shore and Vessel Traffic Lanes

Platform	Maximum H_2S in Vessel/Piping (ppm)	Maximum H_2S in Well (ppm)	Estimated Distance to Shore (Miles/Feet)	Estimated Distance to Vessel Traffic Lanes (Miles/Feet)
Platforms North of Pt. Conception				
Harvest[1,2]	**20,000**	**11,500**	**6.7/35,300**	**4.1/21,500**
Hermosa[1,2]	**14,700**	**10,000**	**7.5/35,900**	**4.9/26,000**
Hidalgo[1,2]	**41,000**	**41,000**	**5.9/31,100**	**6.0/31,500**
Irene[1]	**15,000**	**15,000**	**4.7/24,800**	**17.4/92,000**
Western Santa Barbara Channel Platforms				
Harmony[1,2]	**5,000**	**5,000**	**6.4/33,700**	**5.5/29,000**
Heritage[1,2]	**7,200**	**7,200**	**8.2/43,300**	**2.0/10,500**
Hondo[1,2]	**13,500**	**8,000**	**5.1/26,900**	**7.5/39,500**
Eastern Santa Barbara Channel Platforms				
A	10	<5	5.8/30,600	11.0/58,000
B	95	70	5.7/30,000	11.0/58,000
C	10	<5	5.7/30,000	11.0/58,000
Gail[1,2]	**20,000**	**20,000**	**9.9/52,200**	**0.9/4,700**
Gilda[1,2]	**4,000**	**800**	**8.8/46,400**	**4.0/21,000**
Gina[1,2]	**500**	**500**	**3.7/19,500**	**2.5/13,000**
Grace[1,2]	**800**	**800**	**10.5/55,400**	**3.0/16,000**
Habitat	0	0	7.8/41,100	8.4/44,500
Henry	15	15	4.3/22,700	11.9/63,000
Hillhouse	40	40	6.6/29,900	11.2/59,000
Hogan	5	<1	3.7/19,500	11.9/63,000
Houchin	5	<1	4.1/21,600	11.5/60,500
Platforms South of San Pedro Bay				
Edith[3]	0	0	8.5/44,800	-
Ellen[3]	<100	11	8.6/45,400	-
Elly[3]	20	0	8.6/45,400	-
Eureka[3]	0	0	9.0/47,500	-

Note[1]: Bolded platforms produce or process gas with H_2S concentrations ≥ 100 ppm.
Note[2]: Platforms have U. S. Coast Guard established 500 meter (0.31 miles/1,640 feet) buffer zones around them.
Note[3]: Edith, Ellen, Elly, and Eureka are located in the buffer zone separating the northbound and southbound traffic lanes.

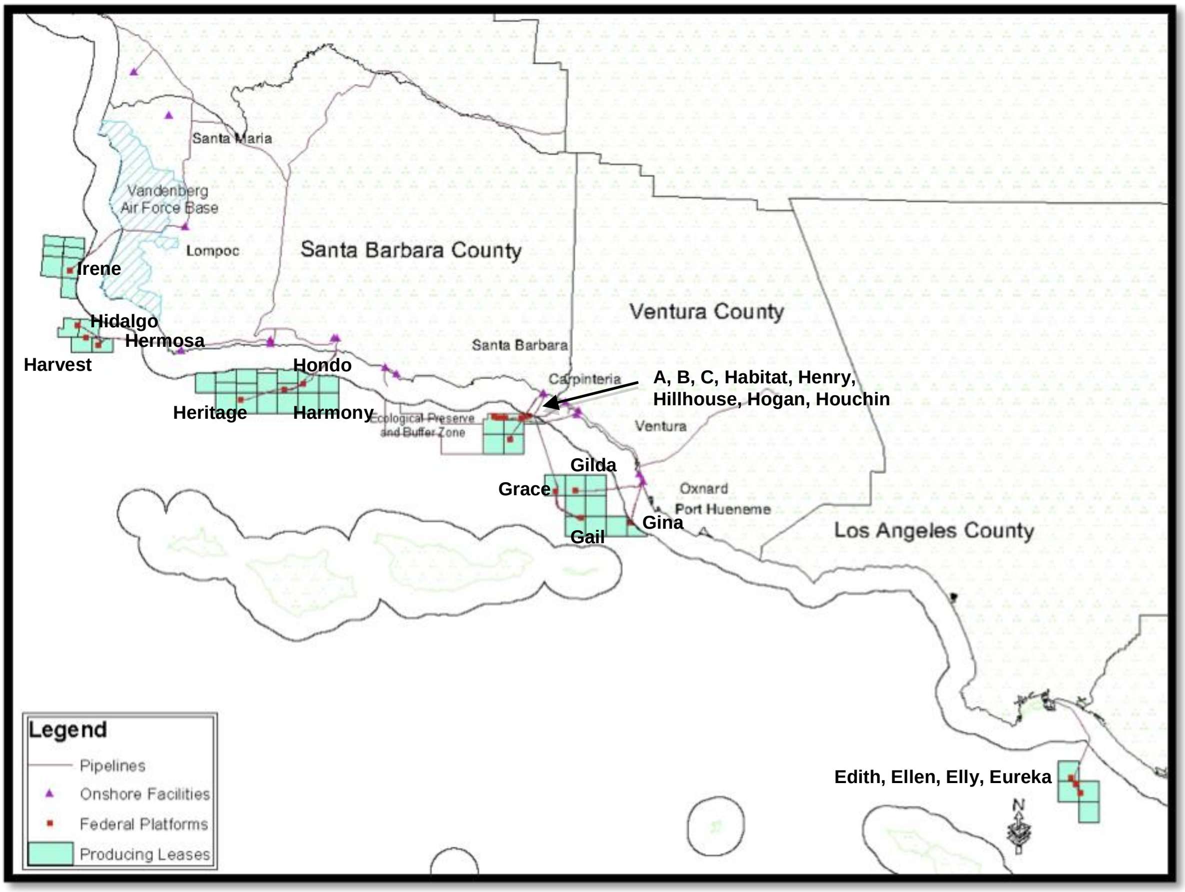

Figure 1-1. Figure Illustrating the Location of Pacific Outer Continental Shelf Region Platforms (Source: MMS 2004)

2.0 MODELING SCENARIOS

Of the twenty three (23) active oil and gas platforms within the POCSR, twenty two (22) are production facilities and one is a processing unit. As shown in Table 1-1, eleven (11) of the platforms produce or process gas with H_2S concentrations ≥100 ppm, the lowest concentration considered in this study. In addition to the POCSR platforms, it was determined that two pipelines, an 8-inch diameter gas pipeline connecting Platforms Gail and Grace and a 10-inch diameter pipeline connecting Platforms Hidalgo and Hermosa, transport gas with concentrations of H_2S ≥100 ppm.

Based on the H_2S gas concentration data from POCSR platforms and pipelines, relevant information on well and vessel pressures, piping diameters, gas processing vessel sizes, and the height of each platform above the ocean surface, eighteen (18) representative accidental gas release scenarios were developed: eleven (11) uncontrolled well release scenarios, five (5) vessel/piping release scenarios, and two (2) pipeline rupture scenarios.

Table 2-1 presents information on the eleven (11) uncontrolled well release scenarios, each representing the well at each platform with the highest H_2S concentration. For each of these accidental gas release scenarios, it is assumed that the uncontrolled release takes place at the pressure listed in Table 2-1 for a minimum of 60 minutes, with no decrease in flow rate during that time period. This is considered a worst-case scenario.

Table 2-2 presents information on the five (5) processing vessel/piping release scenarios that were modeled. These scenarios represent accidental gas releases that could occur from gas processing vessels or piping located on POCSR platforms. Two general types of release scenarios were considered: (1) a rupture that represents a gas release following the complete breakage of piping or a large hole in a processing vessel and (2) a leak that represents a small continuous gas release from a 1-inch diameter hole in platform piping or a processing vessel. For the large ruptures, both four (4) and six (6) inch diameter holes were modeled at 5,000, 15,000 and 41,000 ppm H_2S gas concentrations (Table 2-2). These H_2S gas concentrations were selected to represent the lower, middle and highest reported H_2S gas concentrations on POCSR platforms. The two smaller "leak" scenarios considered releases at 15,000 and 41,000 ppm H_2S gas concentrations.

Table 2-3 presents information on the two (2) modeled pipeline rupture scenarios. The first involves the 8-inch diameter pipeline connecting Platforms Gail and Grace and the second involves the 10-inch diameter pipeline connecting Platforms Hidalgo and Hermosa. These modeled pipeline gas releases assumed a worst-case scenario in which the gas release occurs through a hole of the same diameter as the pipeline (8-inch and 10-inch) and lasts until the pipeline is completely empty of all gas. A pipeline rupture can occur anywhere along the pipeline, including the riser, which is located above the water line alongside the platform or along the pipeline section transiting the seafloor, which is the majority of the line. Both pipeline ruptures were modeled to represent worst-case conditions. As a result, the pipeline rupture was assumed to occur at the water's surface on the pipeline riser.

The same eighteen (18) scenarios discussed above were also used to estimate the potential hazard area for a flammable gas cloud resulting from a gas release that is ignited. In addition, one scenario was developed to estimate the potential hazard of radiant heat from a fire on the platform. Based on a review of the platform sizes, this latter scenario assumes that an area 200 x 200 feet is burning, which is the approximate size of a POCSR platform.

Table 2-1. H_2S Gas Concentrations, Processing Pressures, Release Diameters, and Height Above Sea Level Parameters Used in Modeling Uncontrolled Well Releases

Scenario	H_2S Concentration (ppm)	Well Pressure (psia)	Hole Diameter of Release (Inches)	Height of Release Above Sea Level (Feet)
Platforms North of Pt. Conception				
Platform Harvest	11,500	2,200	4.5	70
Platform Hermosa	10,000	2,200	4.5	55
Platform Hidalgo	41,000	2,200	4.5	55
Platform Irene	15,000	200	4.5	55
Western Santa Barbara Channel Platforms				
Platform Harmony	5,000	1,800	3.5	70
Platform Heritage	7,200	1,800	3.5	70
Platform Hondo	8,000	1,800	3.5	55
Eastern Santa Barbara Channel Platforms				
Platform Gail	20,000	1,500	3.5	55
Platform Gilda	800	400	3.5	50
Platform Gina	500	100	3.5	50
Platform Grace	800	200	3.5	55

Table 2-2. H_2S Gas Concentrations, Processing Pressures, Release Diameters, and Height Above Sea Level Parameters Used in Modeling Vessel/Piping Releases

Modeling Scenario	Model Characterization	H_2S Concentration (ppm)	Vessel/Piping Pressure (psia)	Hole Diameter of Release (Inches)	Height of Release Above Sea Level (Feet)
Rupture #1	High Level H_2S Concentration	41,000	80	6	55
Rupture #2	Mid Level H_2S Concentration	15,000	80	6	55
Rupture #3	Lower Level H_2S Concentration	5,000	80	4	55
Leak #1	High H_2S Leak Concentration	41,000	80	1	55
Leak #2	Low H_2S Concentration	15,000	80	1	55

Table 2-3. H_2S Gas Concentrations, Processing Pressures, Release Diameters, and Height Above Sea Level Parameters Used in Modeling Pipeline Releases

Scenario	Estimated Distance to Shore (Miles/Feet)	Estimated Distance to the Vessel Transit Lanes (Miles/Feet)	H_2S Gas Concentration (ppm)	Pipeline Pressure (psia)	Diameter of Release (Inches)	Height of Release Above Sea Level (Feet)
8-inch Pipeline Connecting Platform Gail to Platform Grace	9.9/52,200	0.9/4,700	15,000	740	8	0
10-inch Pipeline Connecting Platform Hidalgo to Platform Hermosa	5.9/31,100	4.9/26,000	25,000	800	10	0

3.0 MODELED ATMOSPHERIC RELEASE CONDITIONS

The severity and area of effect of hazards resulting from a gas release or fire is significantly affected by the atmospheric conditions present at the time of the incident. A release of gas that weighs about the same as air (*i.e*., neutrally buoyant gases) tends to disperse according to a Gaussian model. In the Gaussian model, gas concentration within any crosswind slice of a moving, neutrally buoyant gas cloud increases to a maximum and then decreases over time. For Gaussian releases, turbulence created by higher wind speeds tends to increase dispersion, resulting in a more rapid mixing of the gas with surrounding air. Thus, gas clouds released under higher wind speed conditions generally result in smaller hazard zones for toxic and flammable gases than would occur under lower wind speed conditions. For gases that are denser than air, since the gas initially sinks and remains near the land or sea surface, higher wind speeds sometimes result in larger hazard zones, because the gas cloud is limited in its ability to spread in all three dimensions.

Atmospheric stability is the tendency of the atmosphere to resist or enhance vertical motion. It is related to both the change of temperature with elevation, which is driven by wind speed, and surface characteristics (roughness). An unstable atmosphere enhances mechanical turbulence, whereas a stable atmosphere inhibits turbulence and a neutral atmosphere neither enhances nor inhibits turbulence. The turbulence of the atmosphere is by far the most important parameter affecting dilution of a gas. The more unstable the atmosphere, the greater the dilution of the concentrations of gases within the gas release. Stability classes are defined for different meteorological situations, including wind speed, daytime solar radiation, and nighttime cloud cover. Stable and very stable conditions can only occur at night. There are generally six categories of stability, each designated by a letter:

- Very unstable (A)
- Unstable (B)
- Slightly unstable (C)
- Neutral (D)
- Stable (E)
- Very stable (F)

Wind direction and speed data for the POCSR are collected by NOAA using offshore buoys. Data from 2008 for three buoys in the study area have been used to generate wind roses depicting wind direction and speed (Figures 3-1 through 3-3). The wind roses depict the direction from which the wind is coming. The three buoys and their locations are as follows:

- Station 46023 located 17 nautical miles (nm) northwest of Point Arguello
- Station 46054 located 38 nm west of Santa Barbara
- Station 46053 located 12 nm southwest of Santa Barbara

The Platforms located north of Point Conception (Harvest, Hermosa, Hidalgo, and Irene) are located between Stations 46023 and 46054. As illustrated in Figures 3-1 and 3-2, the prevailing wind in this area of the POCSR is from the northwest. Winds from the west and southwest are less frequent, and winds from an easterly direction are rare. These data are consistent with URS (1986), which stated that the predominant offshore wind direction is from the northwest, both during the daytime and nighttime.

Station 46053 is located just south of the western Santa Barbara Channel platforms (Harmony, Heritage, and Hondo), and west of the eastern Santa Barbara Channel platforms (Gail, Gilda, Gina, and Grace). As can be seen from Figure 3-3, the prevailing wind in the Santa Barbara channel is westerly. The wind blows from an easterly direction only rarely.

Dispersion modeling typically considers two cases: (1) stable atmospheric conditions with low wind speeds that can only occur at night and (2) neutral atmospheric conditions with higher wind speeds. Neutral or unstable atmospheric conditions generally occur more often than stable atmospheric conditions. Previous dispersion analyses for oil and gas projects in the POCSR and state waters have used wind speeds ranging between 2.5 m/s (5.6 mph) and 5 m/s (11.2 mph) for neutral stability conditions, and 1 m/s (2.2 mph) to 2 m/s (4.5 mph) for stable stability conditions (Arthur D. Little 1984; URS 1986; Chambers Group 1986; Arthur D. Little 1989; Arthur D. Little 2000; and Arthur D. Little 2002). Because the ALOHA model does not recommend using wind speeds less than 2 m/s, a 2 m/s wind speed was used in this investigation for stable stability conditions. A 5 m/s wind speed was used for analyzing dispersion during neutral stability conditions. An 800 foot inversion layer was also assumed for the stable condition, while no inversion layer was assumed for neutral stability conditions.

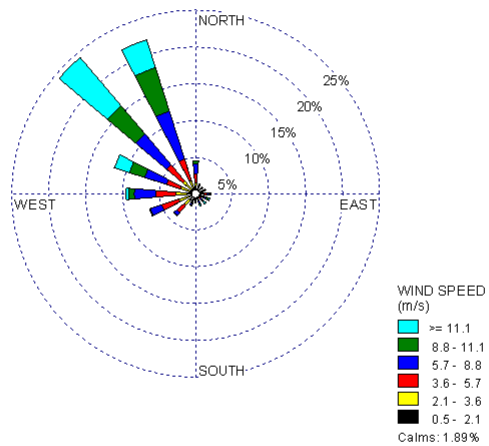

Figure 3-1. Wind Rose for Station 46023 located 17 nautical miles (nm) northwest of Point Arguello

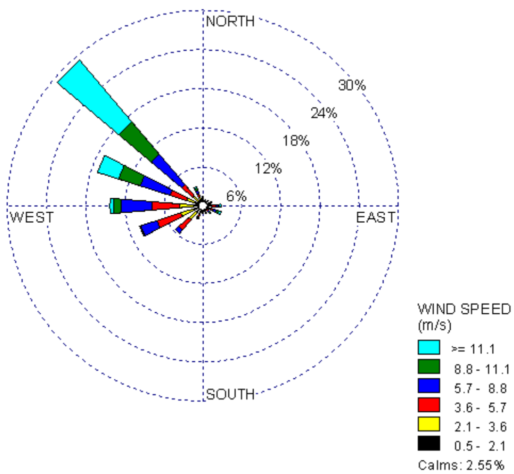

Figure 3-2. Wind Rose for Station 46054 located 38 nm west of Santa Barbara

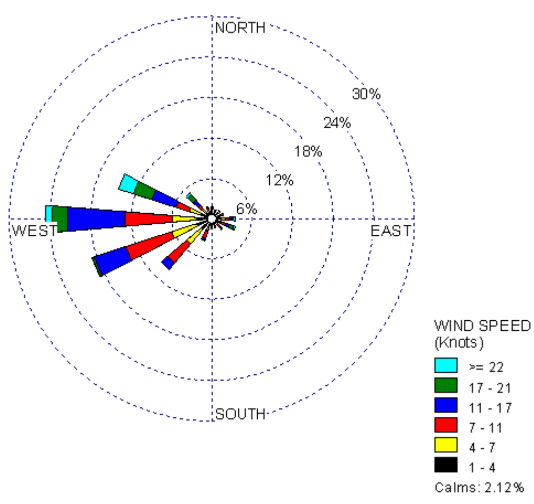

Figure 3-3. Wind Rose for Station 46053 located 12 nm southwest of Santa Barbara

4.0 FAILURE RATES

The purpose of a failure rate analysis is to estimate the likelihood of accidents occurring on the platforms, or involving the gas pipelines, that could result in the release of sour gas and/or a fire. This report classifies the likelihood (expected frequency) of accidental incidents within broad categories, rather than conducting an extensive analysis of each scenario, for several reasons. Specifically:

- To be consistent with previous environmental documents prepared for oil and gas projects located in the POCSR that have used broad categories to estimate the expected frequencies of postulated scenarios.[1]
- This analysis addresses potential accidental releases from 11 different platforms, each differing in age and design. A detailed review of potential failure rates for each individual POCSR platform is beyond the scope of this analysis.

In general, each frequency classification is used in conjunction with the criticality of the potential impact, in order to determine whether a particular accident presents a significant risk to the public. Tables 4-1 and 4-2 present the criticality and frequency classifications used in this analysis (County of Santa Barbara 2000) and Figure 4-1 presents the risk matrix used. Accidents falling in the shaded area of the matrix would be considered to have a significant impact on the public. Although classification names often vary, the classification categories themselves are well established.

Table 4-1. Criticality Classifications

Classification	Description of Public Safety Hazard
Negligible	No significant risk to the public, with no minor injuries
Minor	At most a few minor injuries
Major	Up to 10 severe injuries
Severe	Up to 100 severe injuries or up to 10 fatalities
Disastrous	More than 100 severe injuries or more than 10 fatalities

Source: County of Santa Barbara 2000

Finally, Table 4-3 provides a summary of the expected frequency of accidents gathered from the literature for the four types of incidents addressed in this analysis, *i.e*., uncontrolled releases, vessel/piping ruptures, vessel/piping leaks, and pipeline ruptures.

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[1] The idea of categorizing the expected frequency of incidents has been used in most of the environmental documents prepared for proposed oil and gas projects in the POCSR and state waters. It is also discussed in *Handbook of Chemical Hazard Analysis Procedures* (FEMA *et al.* 1989) and in *County of Santa of Santa Barbara Environmental Thresholds and Guidelines Manual* (County of Santa Barbara2000).

Table 4-2. Frequency Classifications

Frequency Classification		
Classification	**Frequency per year**	**Description of the Event**
Extraordinary	< Once in 1,000,000 years	Has never occurred but could occur
Rare	Between once in 10,000 and once in 1,000,000 years	Occurred on a worldwide basis, but only a few times
Unlikely	Between once in a 100 and once in 10,000 years	Is not expected to occur during the project lifetime
Likely	Between once per year and once in 100 years	Would probably occur during the project lifetime
Frequent	Greater than once in a year	Would occur once in a year on average

Source: County of Santa Barbara 2000

Figure 4-1. Risk Matrix

Consequences	***Probability (Frequency Per Year)***				
	Extraordinary (>1,000,000 years)	**Rare (>10,000 and <1,000,000 Years)**	**Unlikely (>100 and <10,000 Years)**	**Likely (>1 and <100 Years)**	**Frequent (>1/year)**
Disastrous (> 100 severe injuries or 10 fatalities)					
Severe (up to 100 severe injuries or 10 fatalities)					
Major (up to 10 severe injuries)					
Minor (a few minor injuries)					
Negligible (no minor injuries)					

Note: Incidents that fall in the shaded area of the risk matrix would be classified as significant
Source: County of Santa Barbara 2000

Table 4-3. Summary of Failure Rates from Previous Studies and Analyses

Document	Failure Rate			
	Uncontrolled Release	**Vessel/Piping Rupture**	**Vessel/Piping Leak**	**Pipeline Rupture**
Proposed ARCO Coal Oil Point Draft EIS/EIR (Chambers Group, Inc 1986)	Rare	Unlikely	Likely	Unlikely
Point Arguello Field and Gaviota Processing Facility Area Study and Chevron/Texaco Development Plans EIR/EIS (Arthur D. Little 1984)	Unlikely	Unlikely	Unlikely	Unlikely
San Miguel Project and Northern Santa Maria Basin Area Study Final EIS/EIR (URS 1986)	Extraordinary	Unlikely	Likely	Unlikely
Quantitative Risk Assessment (QRA) for Venoco's Platform Holly and Ellwood Facility (Arthur D. Little 2000)	Once per 17,000 yrs (Rare)	Once per 350 years (Unlikely)	Once per 200 years (Unlikely)	3.5×10^{-4} per mile yr (Unlikely)
A History of Oil- And Gas-Well Blowouts in California 1950-1990 (California Department of Conservation 1993)	One blowout per 1,992 wells drilled	-	-	-
Final EIS/EIR For The Cabrillo Port Liquefied Natural Gas Deepwater Port (Ecology and Environment, Inc. 2007)	-	-	-	2.5×10^{-4} per mile yr
U.S DOT, PHMSA Pipeline Safety Statistics from website	-	-	-	2.2×10^{-3} per mile yr for all incidents for offshore pipelines 6×10^{-4} per mile yr for all incidents for onshore pipelines
Handbook of Chemical Hazard Analysis Procedures (FEMA, *et al*. 1989)	-	-	-	1.5×10^{-3} per mile yr for all pipeline incidents, with 20% assumed to be ruptures

- Not analyzed or presented in this report.

4.1. Uncontrolled Well Releases

An uncontrollable flow of formation fluids (oil and/or gas) from a well bore is often referred to as a blowout. Uncontrolled well releases occur when formation fluids flow uncontrolled into a low-pressure subsurface zone (underground subsurface blowout) or to the surface (a surface blowout). Most commonly, an uncontrolled well release happens when there is insufficient well bore pressure to offset or control reservoir pressures. If the well bore's pressure is allowed to drop to a point where formation fluids from the reservoir enter the well bore, a "kick" will occur. A kick can be the beginning of an uncontrolled release. When a kick is detected during drilling operations, the blowout prevention equipment (BOPE) automatically closes, sealing the well bore and preventing additional formation fluids from entering the well and flowing up the wellbore.

Uncontrolled releases can occur during any phase of development, but the majority occur during oil field development drilling and well workovers. According to Vallejo-Arrieta (2002), approximately 66% of blowouts occur during drilling, of which 39% occur during exploratory drilling and 27% during oil field development drilling. For the remainder of the blowouts, approximately 6% occur during well completion work, 15% during well workovers, and 10% during actual production. Only one uncontrolled release has been reported occurring in the POCSR, a 1969 Unocal drilling incident that involved the release of crude oil. This uncontrolled release led to the enactment of significantly more stringent regulations to prevent such incidents from occurring in the future. A loss of well control incident that occurred in 2001 in the POCSR did not result in any release of oil or gas (MMS 2009).

As seen in Table 4-3, the expected frequency of uncontrolled releases has been classified from "unlikely" to "extraordinary." The reservoir characteristics of the oil and gas fields in the POCSR are well understood by the operators and MMS. As a result, well workovers or new completion wells are not anticipated to encounter unexpected conditions. Since an uncontrolled release has occurred within the POCSR and, on occasion, in the Gulf of Mexico, it would be inappropriate to classify the likelihood of a well blowout as "extraordinary." Therefore, this analysis conservatively categorizes uncontrolled well releases/blowouts as "rare." Table 4-4 lists the expected frequency categorization used in this analysis for not only uncontrolled releases from a well, but also for process vessels and piping and for gas pipelines.

Table 4-4. Expected Frequency Categorizations for Accidental POCSR Gas Release Scenarios Used in this Assessment

Release Description	Frequency Categorization
Uncontrolled Well Release	Rare
Vessel/Piping Rupture	Unlikely
Vessel/Piping Leak	Likely
Pipeline Rupture	Unlikely

4.2. Vessel/Piping Ruptures

A vessel/piping rupture is considered to be a complete failure of a vessel or piping, wherein a release of product occurs from a large hole in the vessel or from a complete break of the piping. Vessel/piping ruptures, therefore, result in a rapid release of material in a very short time. Each POCSR platform contains assorted storage and processing vessels, as well as connecting piping, that could become accidently damaged or eventually fail, resulting in the rapid release of sour gas. Gas containing H_2S is also corrosive; therefore, special corrosion-resistant steel alloys are routinely used in H_2S environments.

Historically, there have been very few accidents or incidents involving POCSR platforms. Between 1968 and 2005, only 51 incidents were recorded involving fires, and all were reported as minor. During the same time period, only eight accidental oil releases greater than 50 barrels (bbl) have occurred (MMS 2009).

As shown in Table 4-3, all the studies have classified the expected frequency of vessel/piping ruptures as "unlikely." This expected frequency of ruptures included all vessels on the platform, not just those containing gas. In concurrence with these studies, the expected frequency of vessel/piping ruptures was categorized as "unlikely" in this analysis (Table 4-4).

4.3. Vessel/Piping Leaks

A vessel/piping leak is similar to a rupture in a vessel, tank, or associated piping, as discussed above, except a leak originates from a relatively small hole and does not result in a catastrophic failure or rupture of the vessel or piping. Leaks tend to result in lower release rates that last for a longer period of time. Vessel/piping leaks occur far more frequently than vessel/piping ruptures. As illustrated in Table 4-3, vessel/piping leaks have been classified as either "likely" or "unlikely." The individual studies reviewed addressed specific projects involving several platforms. While the expected frequency of a leak on any given platform may be considered "unlikely," the expected frequency of a leak occurring on any of the POCSR platforms collectively would be more appropriately classified as "likely" (Table 4-4).

4.4. Pipeline Ruptures

There exists a substantial database on gas pipelines ruptures, with most of the data concerning onshore pipelines. The expected rupture rate is usually expressed in terms of "failures per mile of pipeline per year" (per mile year). As evident in the information presented in Table 4-3, pipeline rupture rate estimates vary by approximately one order of magnitude. Although data for offshore pipeline ruptures are limited, they were used in this assessment as the best available data. The following formula was used to estimate the failure, or rupture, frequency of a POCSR gas pipeline with ≥100 ppm H_2S gas.

$$P_F = OP_{DOT} \times F_{PR} \times P_M$$

Where:

P_F = Platform failure rate per mile per year

OP_{DOT} = Dept. of Transportation (DOT) failure rate for offshore pipelines = 2.2×10^{-3} per mile year (Table 4-3)

F_{PR} = FEMA *et al*. (1989) recommended estimate for a pipeline failure resulting in a pipeline rupture = 20% (0.2)

P_M = Miles of POCSR pipeline used in this assessment = 15.8 miles

Using this formula, the estimated pipeline failure/rupture rate employed in the modeling for this assessment was 7.0×10^{-3} pipeline ruptures per mile year, or approximately once every 140 years. This rate of occurrence was classified as "unlikely" (Table 4-4). Using this frequency estimate for this type of accidental release is consistent with the data referenced in Table 4-3.

5.0 CONSEQUENCE ANALYSIS

The primary purpose of this analysis was to estimate the potential hazard or risk to the public from the release of natural gas with an H_2S concentration ≥100 ppm at or near POCSR platforms. Secondarily, the analysis addressed the potential hazard to the public from flammable gas becoming ignited at or near a POCSR platform.

When any gas is released into the atmosphere, it is moved by the wind and mixed with the surrounding air. A gas that is lighter (less dense) than air tends to rise, while a gas that is heavier than air will initially sink. If the gas is flammable, it can be ignited as long as its concentration in the air is above its lower flammability level (LFL) and below its upper flammability limit (UFL) and there is a source of ignition. Once a gas disperses to a concentration below its LFL, it can no longer be ignited. If the gas is also toxic, it mixes with the surrounding air in the same way, reducing both its toxicity and flammability as it disperses.

The criteria used to assess the potential consequences from H_2S, flammable gas and radiant heat exposures are presented below.

5.1. H_2S Consequences

H_2S is considered a broad-spectrum toxin, meaning that it can affect several different body systems at the same time, with the nervous system being the most susceptible. H_2S forms a complex bond with iron in the mitochondrial cytochrome enzymes, thereby blocking oxygen binding and stopping cellular respiration. Since H_2S occurs naturally in the environment, as well as the intestinal systems of most mammals, the body contains enzymes that are capable of oxidizing H_2S into harmless sulfate. As a result, low levels of H_2S can be tolerated indefinitely. According to Ramasamy, *et al.*, (2005), at a threshold level of between 300 and 350 ppm, the body's oxidative enzymes become overwhelmed.

Exposure to lower concentrations of H_2S can result in eye irritation, sore throat, coughing, nausea, shortness of breath, and fluid in the lungs. However, long-term, low-level exposure may result in fatigue, loss of appetite, headaches, irritability, poor memory, and dizziness (ATSDR 2009). Table 5-1 summarizes the potential consequences of exposure to H_2S at varying concentrations.

Three levels of concern for adverse consequences have been used in modeling the consequences of an accidental release of gas containing H_2S. These are presented as the concentrations of H_2S present in the atmosphere, in ppm:

- **1,000 ppm.** This is the level of exposure at which it is believed that one breath could cause fatalities (Arthur D. Little 2000). This level of exposure has been used in past risk assessments of oil and gas projects offshore of California as part of their environmental impact assessment.

- **300 ppm.** This is the concentration that can result in significant health consequences and fatalities after 30 minutes or longer of exposure (SCAPA 2009).

- **100 ppm.** The American Industrial Hygiene Association (AIHA) has developed Emergency Response Planning Guideline (ERPG) values for many toxic gases. The ERPG-3 value is defined as "The maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to one hour without experiencing or developing life threatening health effects" (SCAPA 2009). The ERPG-3 concentration for H_2S is 100 ppm.

Table 5-1. H_2S Concentrations at Which Human Health Effects Occur

H_2S Concentration (ppm)	Human Effect Consequences
0.0047	Recognition threshold concentration at which 50% of most humans can detect the characteristic odor of hydrogen sulfide, normally described as resembling that of "a rotten egg"
10-20	Borderline concentration for eye irritation
50-100	Leads to eye damage
150-250	Olfactory nerve is paralyzed after a few inhalations; sense of smell disappears, often together with awareness of danger
320-530	Leads to pulmonary edema with the possibility of death.
500	30-60 minute exposure can result in headache, dizziness, and staggering followed by unconsciousness and respiratory failure.
530-1000	Causes strong stimulation of the central nervous system and rapid breathing, leading to lack of breath.
800	Lethal concentration for 50% of humans after 5 minutes exposure (LC50).
>1,000	Causes immediate collapse with loss of breathing (even following inhalation of a single breath of H_2S gas at this concentration)

Source: ATSDR (2009)

5.2. *Flammable Gas Consequences*

The natural gas produced by POCSR platforms consists primarily of methane, which is a flammable gas. A flammable gas can be ignited as long as its concentration in the atmosphere is above its lower flammability limit (LFL) and below its upper flammability limit (UFL). If the concentration is below the LFL, there is insufficient flammable gas present to support combustion, while if the concentration is above the UFL, the air/gas mixture inside the gas cloud does not contain sufficient oxygen to support combustion. Because methane gas is the primary component of any potential POCSR gas release, the LFL for methane has been chosen for all the flammable gas cloud modeling. The LFL and UFL values for methane are 5 percent and 15 percent, respectively (U.S Coast Guard 1991).

A flammable gas that encounters an ignition source will ignite and the flame will move through the cloud to the original release point, if gas is still being released. Once the flame reaches the source of the release it will continue to burn. From a hazard perspective, it is assumed that anyone located within the flammable gas cloud, when it ignites, would receive significant, life-threatening burns. It should be noted that gas clouds primarily composed of methane do not contain sufficient energy to result in unconfined vapor cloud explosions (UVCE) if ignited (Gugan 1978).

Within the vapor cloud itself, there are areas where the methane gas concentration is higher and lower than its average concentration within the cloud. This is called “concentration patchiness”, and because of this, there may be pockets within the cloud where flammable concentrations of gas may be present, even though the average cloud concentration has fallen below the LFL. To compensate for this possibility, ALOHA calculates the hazard zone for a flammable gas cloud at both 60% of the LFL concentration of the modeled gas, which is 3% for methane, and 100% of the LFL concentration of the modeled gas.

5.3. Radiant Heat Consequences

Fires produce radiant heat (thermal radiation) that can result in burns to exposed personnel. A thermal radiation level of concern is the threshold level above which a hazard may exist. The thermal radiation effects that individuals might experience depend primarily upon the length of time that individual is exposed to a specific thermal radiation level. Longer exposure durations, even at a lower thermal radiation level, can produce serious physiological effects. Table 5-2 lists some of the effects of thermal radiation exposure on bare skin at specific levels and durations. ALOHA's default thermal radiation values are based on a review of widely accepted sources (American Institute of Chemical Engineers 1994, Federal Emergency Management Agency *et al.* 1988). Three threshold values (measured in kilowatts per square meter and denoted as kW/m^2) have been calculated using ALOHA:

- 10 kW/m^2 (potentially lethal within 60 sec);
- 5 kW/m^2 (second-degree burns within 60 sec); and
- 2 kW/m^2 (pain within 60 sec).

Table 5-2. Thermal Radiation Burn Criteria

Radiation Intensity (kW/m^2)	Time for Severe Pain (Seconds)	Time for 2^{nd} Degree Burns (Seconds)
1	115	663
2	45	187
3	27	92
4	18	57
5	13	40
6	11	30
8	7	20
10	5	14
12	4	11

Source: U.S. EPA and NOAA (2007)

6.0 MODELING RESULTS

The ALOHA model was used to estimate the potential risk of H_2S gas, flammable gas, and radiant heat hazards to members of the public. ALOHA, publically available from EPA, is a personal computer-based software program designed especially for use by emergency personnel in responding to chemical releases, as well as for emergency planning and training. ALOHA can illustrate potential hazard regions as isopleths. In addition, ALOHA can model all three hazards of interest in this analysis: (1) toxic gas cloud, (2) flammable gas cloud, and (3) radiant heat from fire. For validation purposes, modeling results from ALOHA were compared to those from another well known model, SLAB. Results from this comparison analysis are in Appendix A.

6.1. ALOHA Description

ALOHA models three hazard categories: gas dispersion, fires, and explosions. Explosions are not addressed in this current analysis. ALOHA employs two internal models: (1) an air dispersion model used to estimate the movement and dispersion of gas clouds and (2) a fire model that is used to estimate the radiant heat generated by a fire. ALOHA also incorporates two separate air dispersion models: one for Gaussian gases and one for heavier-than-air gases. Each is discussed below.

Gaussian model

ALOHA uses the Gaussian model to predict how gases that are at or near the density of air will disperse in the atmosphere. According to this model, wind and atmospheric turbulence are the forces that move the molecules of a released gas through the air. As a cloud is transported downwind, "turbulent mixing" causes it to disperse, thereby expanding and spreading in the crosswind (horizontal) and vertical directions. According to the Gaussian model, a graph of gas concentration within any crosswind slice of a moving pollutant cloud looks like a bell-shaped curve, highest in the center and lower on the sides (Figure 6-1). At the point of a release, the gas concentration is the highest, and the gas has diffused and spread very little in the crosswind and vertical directions. A graph of the gas cloud’s concentration along a crosswind slice of the cloud, close to the source, looks like a spike. As the pollutant cloud drifts farther downwind, it continues to disperse and spread out with the "bell shape" becoming wider and flatter.

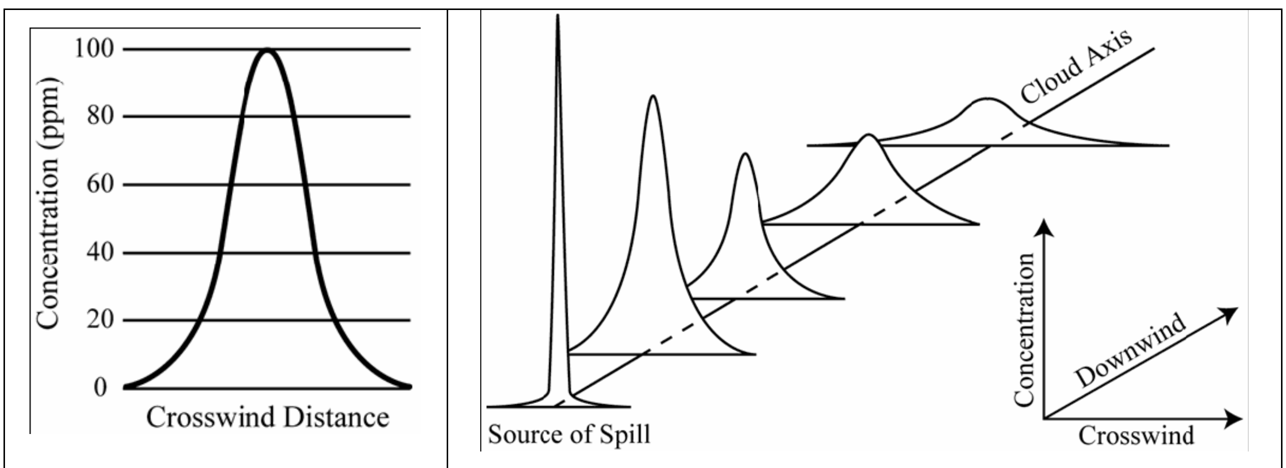


Figure 6-1. Distribution (left) and spread (right) in a Gaussian model

Heavy gas model
A gas that has a molecular weight greater than that of air (approximately 29 kilograms per kilomole, on average) will form a “heavy” gas cloud if sufficient gas is released. This can also occur for gases that: (1) are lighter than air at room temperature, but stored under high pressure, and therefore become cold and dense upon rapid expansion after release or (2) are stored in a cryogenic (low temperature) state. ALOHA considers any gas to be heavy if the density of the gas cloud is substantially greater than that of air, which is 1.1 kilograms per cubic meter.

When a gas that is heavier than air is released, it will initially "slump," or sink, and as the gas cloud moves downwind, gravity affects the spread and can result in some of the vapor moving upwind of its release point. Farther downwind, as the cloud becomes more dispersed and its density approaches that of air, it begins to behave like a neutrally buoyant gas. This takes place when the concentration of the heavy gas drops below approximately 10,000 ppm. For small releases, this will occur within a few feet of the release point. For larger releases, this typically occurs farther downwind.

The heavy gas dispersion calculations used in ALOHA are based on those used in the well-known heavy gas DEGADIS model (Spicer and Havens 1989). This model was selected for use in ALOHA because of its general acceptance and the extensive testing carried out by its authors (U.S. EPA and NOAA 2007).

When using ALOHA, the user can manually choose whether to predict the dispersion of a chemical as a Gaussian or heavy gas release, or allow ALOHA to choose automatically. The ALOHA model bases its determination mainly on molecular weight, size of the release, and temperature of the gas cloud. For this analysis, ALOHA was allowed to determine the most appropriate air dispersion model to use.

6.2. Consequence Modeling

ALOHA was utilized to model all three potential hazards, including toxic gas, flammable gas, and radiant heat. For the toxic gas hazard, the downwind distance and areal extent of three concentrations (1,000 ppm, 300 ppm, and 100 ppm) of an H_2S containing gas cloud were modeled for eighteen (18) scenarios. Release scenario parameters listed in Tables 2-1 through 2-3 were used as inputs for each model run under the two previously discussed sets of meteorological conditions (*i.e.*, stable nighttime with 2 m/s wind, neutral stability with 5 m/s wind). ALOHA calculates and plots the maximum downwind distance to each of the levels of concern (concentrations). Plots of the hazard zones for each of the scenarios are presented in Figures 6-2 through 6-19. The area shaded and outlined by red represents the area downwind of the release point that could contain released gas with a concentration of 1,000 ppm or more H_2S. The area shaded and outlined by orange represents the area downwind of the release point that could have released gas with a concentration of ≥300 ppm H_2S. Finally, the area shaded and outlined by yellow represents the area downwind of the release point with a concentration of ≥100 ppm H_2S. Dashed or solid lines along both sides of the yellow threat zone indicate uncertainty in the wind direction. Since the wind rarely blows constantly from any one direction, ALOHA displays "uncertainty lines" around the largest threat zone, which in this case is 100 ppm. The area located within the “uncertainty lines” is where ALOHA predicts the gas cloud to remain for 95% of the time, based on variable and uncertain wind directions.

As stated previously, an instantaneous exposure to a gas cloud having a concentration of ≥1,000 ppm H_2S, or a 30-minute exposure to a gas cloud having a concentration of ≥300 ppm, can be fatal. Exposure to a gas cloud with a concentration of 100 ppm H_2S is thought to be the level that the public can be exposed to for up to 60 minutes without experiencing any serious health problems (SCAPA 2009).

The hazard zones for the uncontrolled wellhead release were calculated as a worst-case possibility by using the well at each platform with the highest concentration of H_2S gas. Hence, if a different well on a particular platform were involved in an uncontrolled release, the resultant hazard zones would be smaller and the potential public exposure reduced. The modeled uncontrolled well releases for the eleven (11) POCSR platforms were assumed to be continuous releases of gas at a steady flow rate for a minimum of 60 minutes.

For the potential flammable gas hazard, the downwind distance and areal extent of both the 100% and 60% LFL methane gas concentrations were modeled for the 18 scenarios using ALOHA. As discussed in Section 5.2, the distance to the 60 percent of the LFL gas concentration was also calculated to compensate for the possibility of isolated pockets of higher concentration gas. Likewise, the release scenario parameters listed in Tables 2-1 through 2-3 were used as input for each model run under the two previously discussed sets of meteorological conditions. ALOHA calculates and plots the maximum downwind distance to each of the gas concentrations of concern for flammability.

As discussed in Section 5.2, a flammable gas cloud does not present a fire hazard unless it is ignited. As there are multiple potential ignition sources on POCSR platforms, the potential for ignition of a gas release on a POCSR platform is considered fairly high. If a flammable gas ignited and burned shortly after release, then this would prevent the formation of an extensive cloud of the released gas and its movement downwind. If the released gas cloud is not ignited on the platform, then it is unlikely that it would encounter any other ignition sources. The only potential ignition sources located beyond a platform would be from passing vessels.

As with the H_2S hazard zone modeling, the assumptions used for modeling flammable gas clouds from uncontrolled well releases at the eleven (11) POCSR platforms were the continuous releases of gas at a steady flow rate, for at least 60 minutes. The three vessel/piping rupture scenarios were combined into one worst-case scenario and the two vessel/piping leak model runs were combined into a second scenario, since there is no significant difference in the LFL of the gas in the assorted scenarios.

The potential H_2S and flammable gas hazards from the POCSR platforms are presented below, based on the three general locations of the platforms:

- ***North of Point Conception:*** Platforms Harvest, Hermosa, Hidalgo, and Irene
- ***Western Santa Barbara Channel:*** Platforms Harmony, Heritage, and Hondo, located south of Gaviota
- ***Eastern Santa Barbara Channel:*** Platforms Gail, Gilda, Gina, and Grace, located between Carpinteria and Oxnard

The potential radiant heat hazard from a fire on a platform is discussed separately in Section 6.2.4.

6.2.1. Platforms North of Point Conception

H_2S Hazard

The H_2S gas release hazard zones for the four platforms in this group (Harvest, Hermosa, Hidalgo, and Irene) are presented in Table 6-1 and Figures 6-2 through 6-5. For uncontrolled well releases, a 1,000 ppm, concentration H_2S gas cloud had an estimated hazard distance ranging between 147 and 597 feet in the downwind direction. For the 300 ppm and 100 ppm concentration H_2S hazard zones, estimated dispersions could be expected to travel between 426 and 1,317 feet and 897 and 2,676 feet, respectively.

In all cases, the smaller estimated hazard areas were associated with stable atmospheric conditions and the larger zones with neutral atmospheric conditions.

Platform Hidalgo has the highest concentration of H_2S of any of the eleven (11) POCSR platforms assessed and modeled. Because Platform Hidalgo has the well with the highest concentration of H_2S gas, as well as the highest wellhead pressure within this group of platforms, it generated the largest modeled H_2S hazard area. The maximum distance for a 1,000 ppm H_2S gas cloud to travel downwind from this platform is 597 feet under neutral atmospheric conditions. Likewise, the distance away from the platform that the gas cloud would need to travel to drop to H_2S concentrations of 300 ppm and 100 ppm were 1,317 feet and 2,676 feet, respectively. As illustrated in Table 1-1, these hazard areas, despite their distance from the platform, do not reach land or the vessel traffic lanes. For the 1,000 ppm analysis, Platform Hidalgo is the only one of the eleven (11) modeled platforms that has a potential H_2S hazard zone that extends beyond the 500 meter (0.31 mile/1,640 feet) safety zone established by the U.S. Coast Guard.

None of the projected worst-case H_2S hazard areas modeled for Platforms Harvest, Hermosa, and Irene would reach land or the vessel traffic lanes. The H_2S hazard zones for Platforms Harvest and Hermosa are similar, with estimated distances to an H_2S concentration of 100 ppm being 1,173 feet and 1,071 feet, respectively. The distances to an H_2S concentration of 300 ppm H_2S for these platforms (Harvest and Hermosa) are 570 feet and 519 feet, and the estimated distances for the 1,000 ppm H_2S concentration gas clouds are 255 feet and 225 feet, respectively. Platform Irene is located northwest of Point Arguello and is the northernmost platform. Its H_2S hazard zones for 100 ppm, 300 ppm, and 1,000 ppm concentrations extend 1,611 feet, 777 feet, and 351 feet, respectively. The expected frequency of an uncontrolled well release of H_2S gas is classified as “rare.”

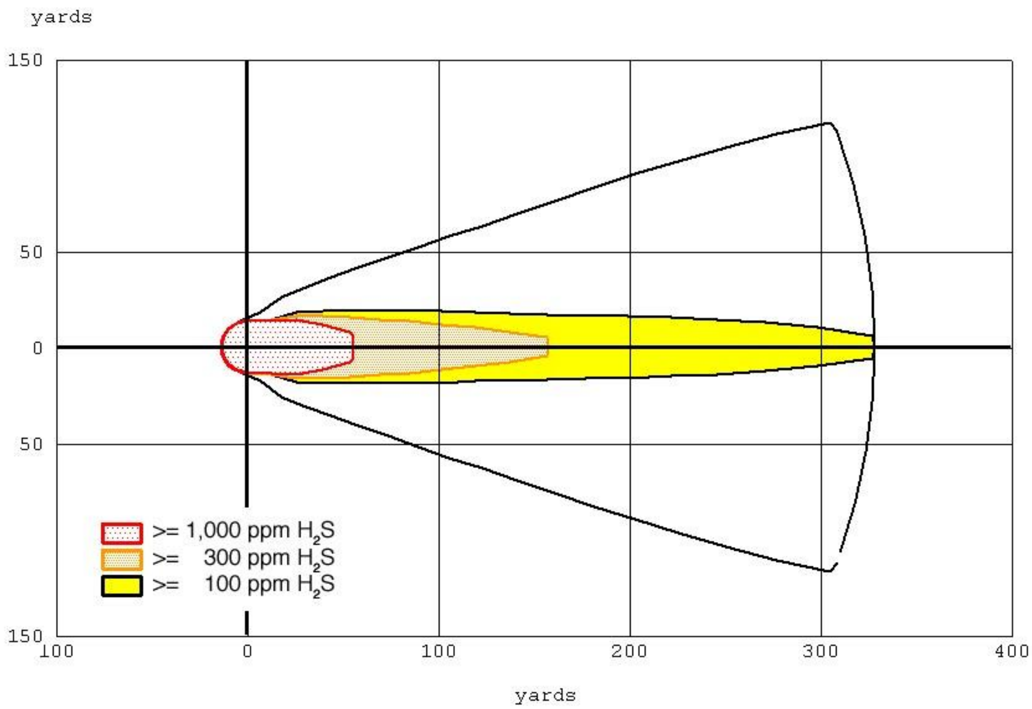
The worst-case H_2S hazard zones for vessel/piping ruptures on these platforms are presented in Table 6-1 and Figures 6-6 and 6-7. The estimated H_2S hazard area from a vessel/piping rupture on Platform Hidalgo would be the largest of all the platforms because Platform Hidalgo has the highest concentration of H_2S gas. Thus, the Rupture #1 scenario is representative of Platform Hidalgo. As can be seen from Table 6-1, the largest hazard zone around Platform Hidalgo from a vessel/piping rupture is 561 feet, which is significantly less than that from an uncontrolled well release at this platform. The Rupture #2 scenario would be considered representative of releases from the other three platforms in this group. The estimated H_2S hazard areas from this scenario, and therefore, from Platforms Harvest, Hermosa, and Irene, are less than those of the Rupture #1scenario (Platform Hidalgo) because of the lower concentration of H_2S in the gas. Vessel/piping ruptures would also not be expected to extend to land or to the vessel traffic lanes and would not extend beyond the platform “safety zones.” The two pipeline leak scenarios present H_2S hazard areas (Figures 6-8 and 6-9) that are less than those of the corresponding rupture scenarios and therefore, also do not extend to land or to the vessel traffic lanes and would not be expected to extend beyond platform “safety zones”. The piping leaks for all platforms in this area of the POCSR were estimated to range between 33 and 378 feet for the smallest 1,000 ppm H_2S gas hazard zone and the largest 100 ppm H_2S hazard zone, respectively. The expected frequency of vessel/piping ruptures is classified as “unlikely”.

A 10-inch diameter pipeline transports sour gas from Platform Hidalgo to Platform Hermosa, where the H_2S is removed during gas processing. The estimated sizes of the H_2S hazard areas resulting from a pipeline rupture or failure are presented in Table 6-1 and Figure 6-10. The estimated hazard distance generated for this modeling scenario assumed a worst-case situation and placed the pipeline rupture at the water surface on the pipeline riser. Any gas release occurring underwater would result in some released gas, including H_2S, being absorbed by the surrounding seawater, thereby reducing the overall size of the

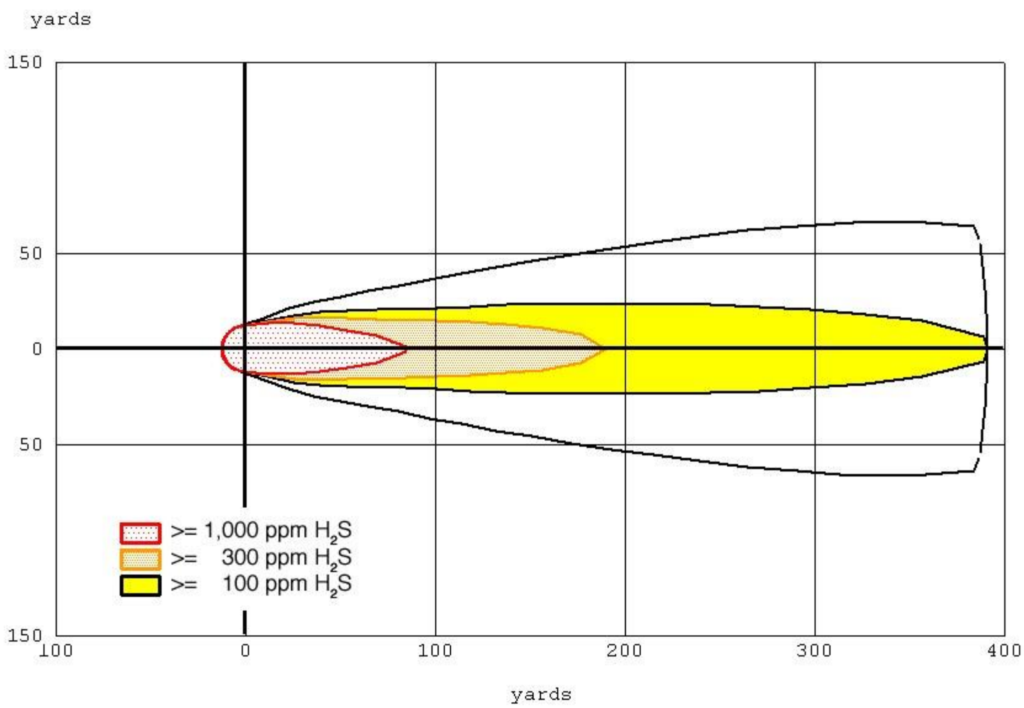
Table 6-1. Estimated Maximum Distances for H_2S Hazard Zones from Uncontrolled Well Releases, Vessel/Piping Ruptures, and Pipeline Ruptures from POCS Platforms Located North of Point Conception

Scenario	Figure No.	Hazard Zone (Feet)					
		1,000 ppm		300 ppm		100 ppm	
		Stable Atmospheric Conditions	Neutral Atmospheric Conditions	Stable Atmospheric Conditions	Neutral Atmospheric Conditions	Stable Atmospheric Conditions	Neutral Atmospheric Conditions
Uncontrolled Well Releases							
Platform Harvest	6-2	165	255	471	570	984	1173
Platform Hermosa	6-3	147	225	426	519	897	1071
Platform Hidalgo	6-4	495	597	1110	1317	2349	2676
Platform Irene	6-5	210	351	***606***	777	1428	1611
Vessel /Piping Releases							
Rupture #1 (41,000 ppm H_2S)	6-6	174	66	321	126	561	216
Rupture #2 (15,000 ppm H_2S)	6-7	105	42	192	75	336	132
Leak #1 (41,000 ppm H_2S)	6-8	117	45	216	84	378	144
Leak #2 (15,000 ppm H_2S)	6-9	78	33	138	48	243	93
Pipeline Rupture							
Pipeline Rupture #2 (Platform Hidalgo to Hermosa)	6-10	1,386	615	7392	3978	-	-

gas cloud. In addition, a complete rupture of a gas pipeline would be expected to result in the rapid release of all gas contained in the pipeline and a rapidly decreasing release rate, as the pressure in the pipeline decreases. As presented in Section 2, the assumptions used in the ALOHA pipeline rupture modeling were that the entire pipeline contents would be released at a constant pressure, using the original pipeline pressure. This is an extremely conservative assumption, so the hazard zone distances estimated by the modeling and presented in Table 6-1 would be considered an extreme worst case. Also, modeling results indicate that most of the gas in the pipeline would be released within the first ten minutes of a rupture. For this reason, the100 ppm H_2S concentration hazard zone resulting from a 60-minute gas release has not been presented.

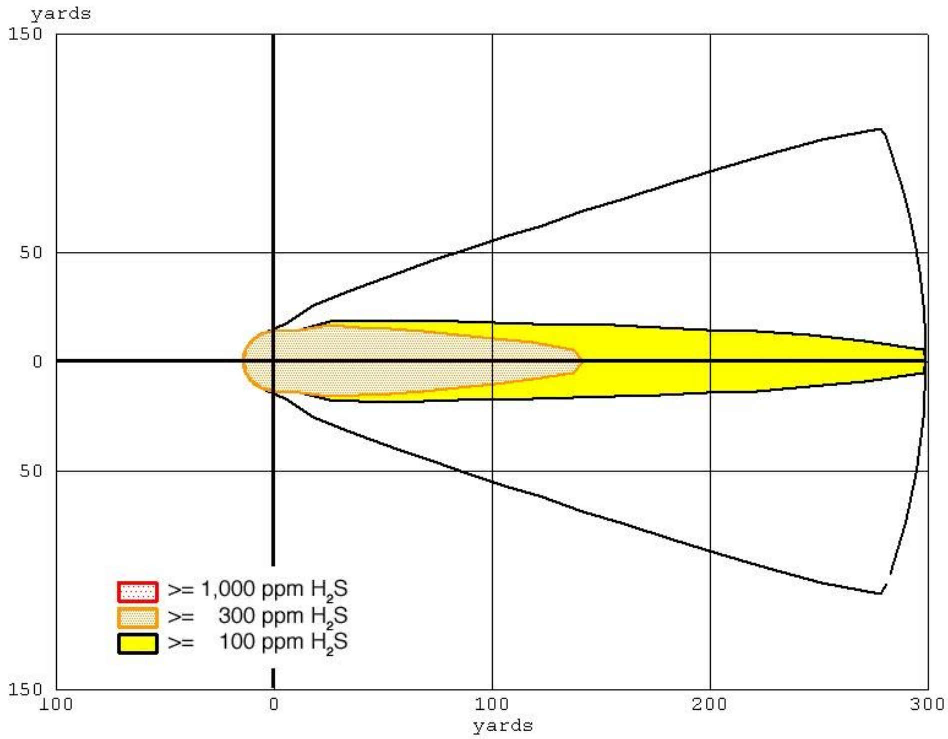


Stable Nighttime Atmospheric Stability Conditions

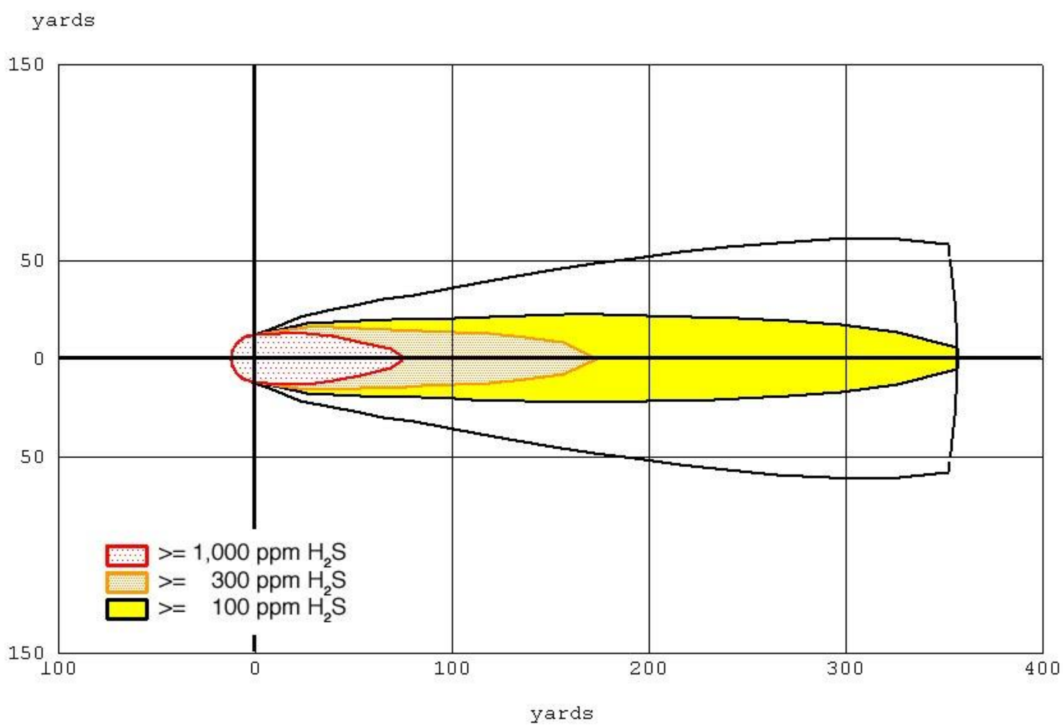


Neutral Atmospheric Stability Conditions

Figure 6-2. Estimated Platform Harvest Uncontrolled Well Release (20,000 ppm) H_2S Hazard Zones

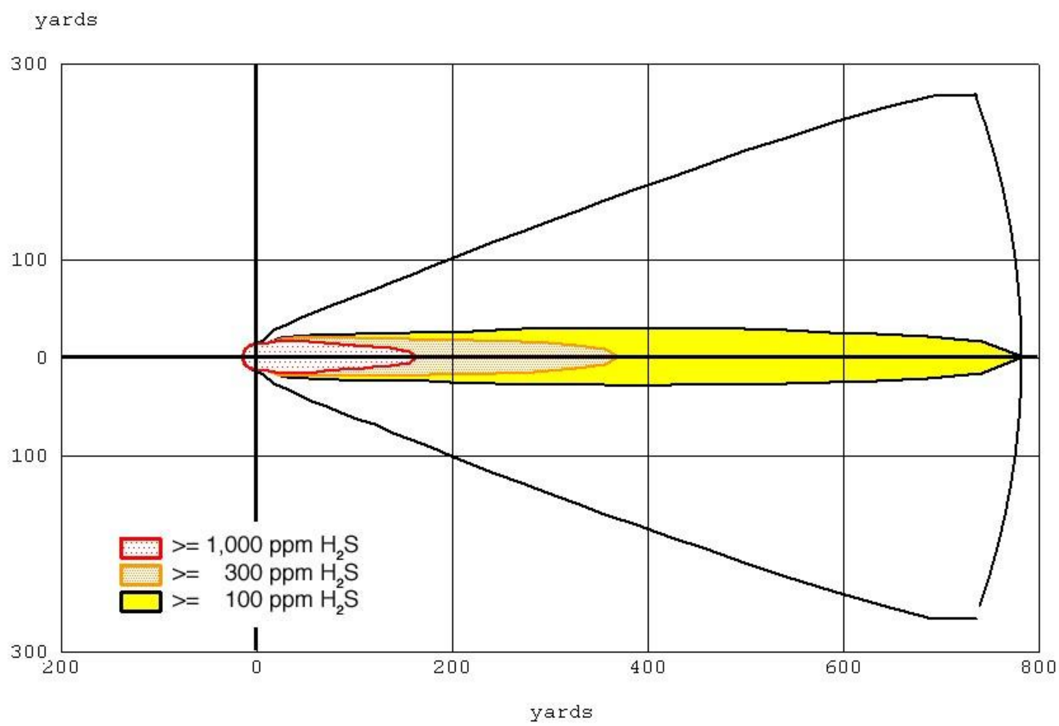


Stable Nighttime Atmospheric Stability Conditions

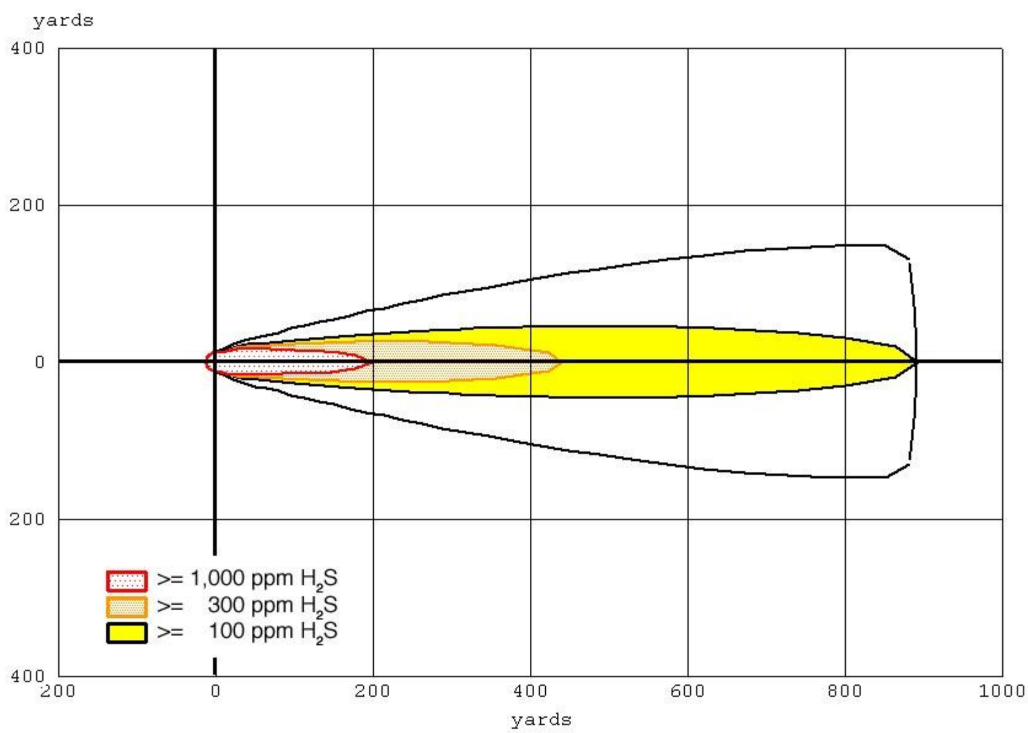


Neutral Atmospheric Stability Conditions

Figure 6-3. Estimated Platform Hermosa Uncontrolled Well Release (14,700 ppm) H_2S Hazard Zones

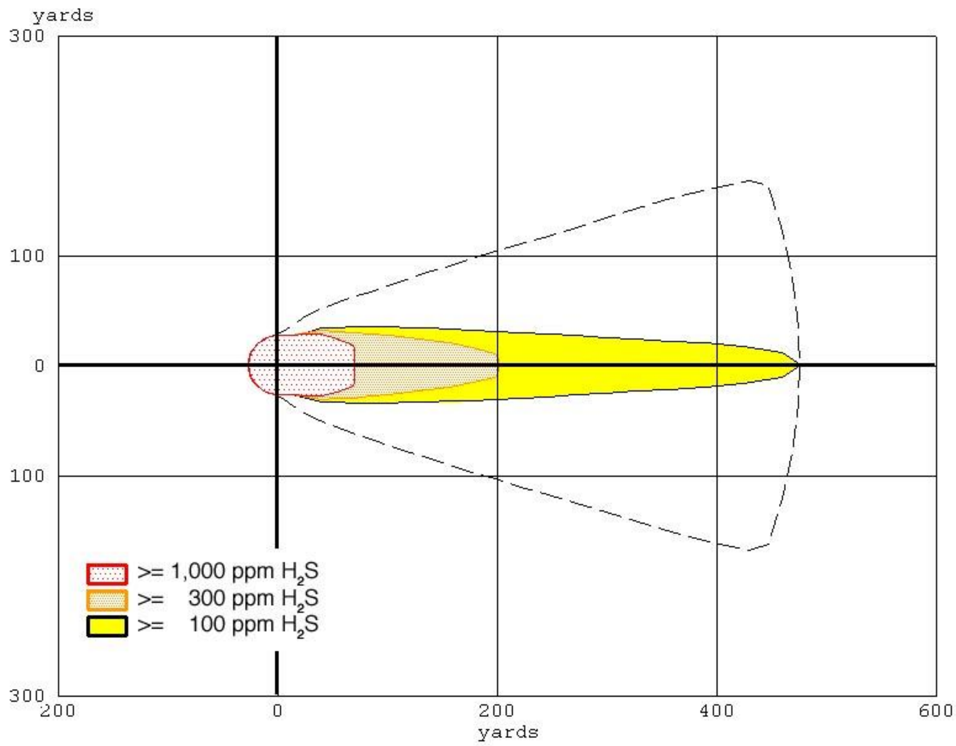


Stable Nighttime Atmospheric Stability Conditions

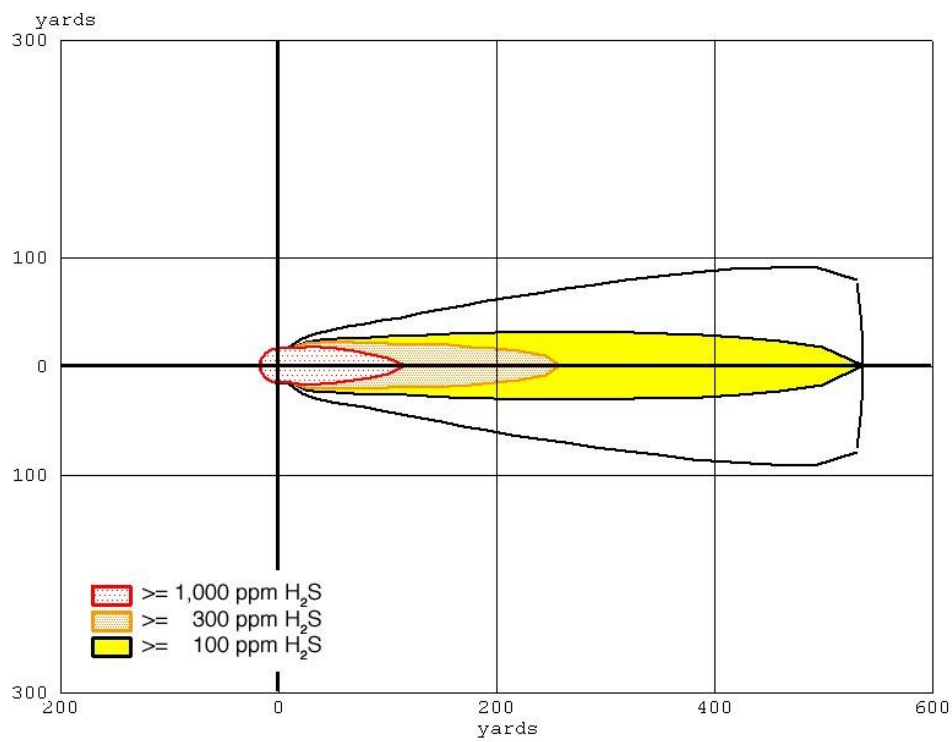


Neutral Atmospheric Stability Conditions

Figure 6-4. Estimated Platform Hidalgo Uncontrolled Well Release (41,000 ppm) H_2S Hazard Zones

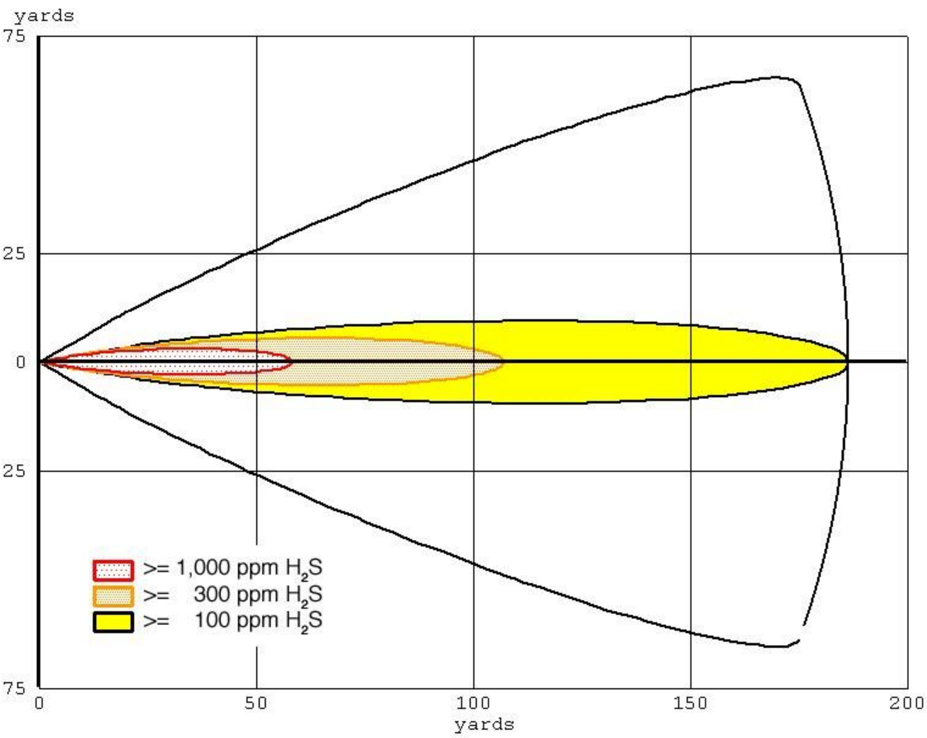


Stable Nighttime Atmospheric Stability Conditions

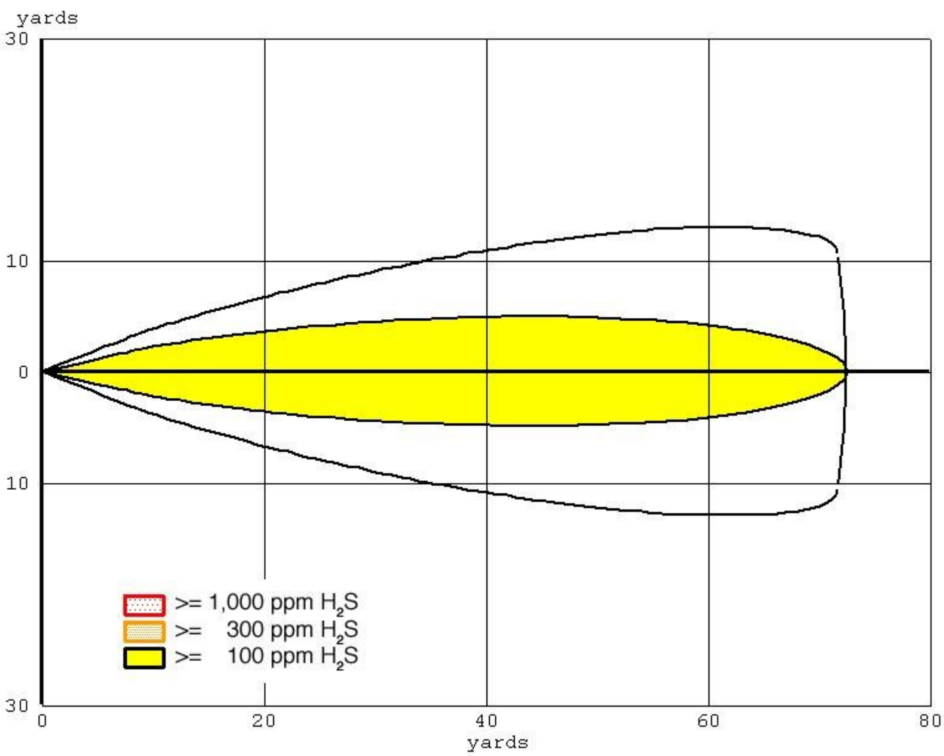


Neutral Atmospheric Stability Conditions

Figure 6-5. Estimated Platform Irene Uncontrolled Well Release (15,000) H_2S Hazard Zones

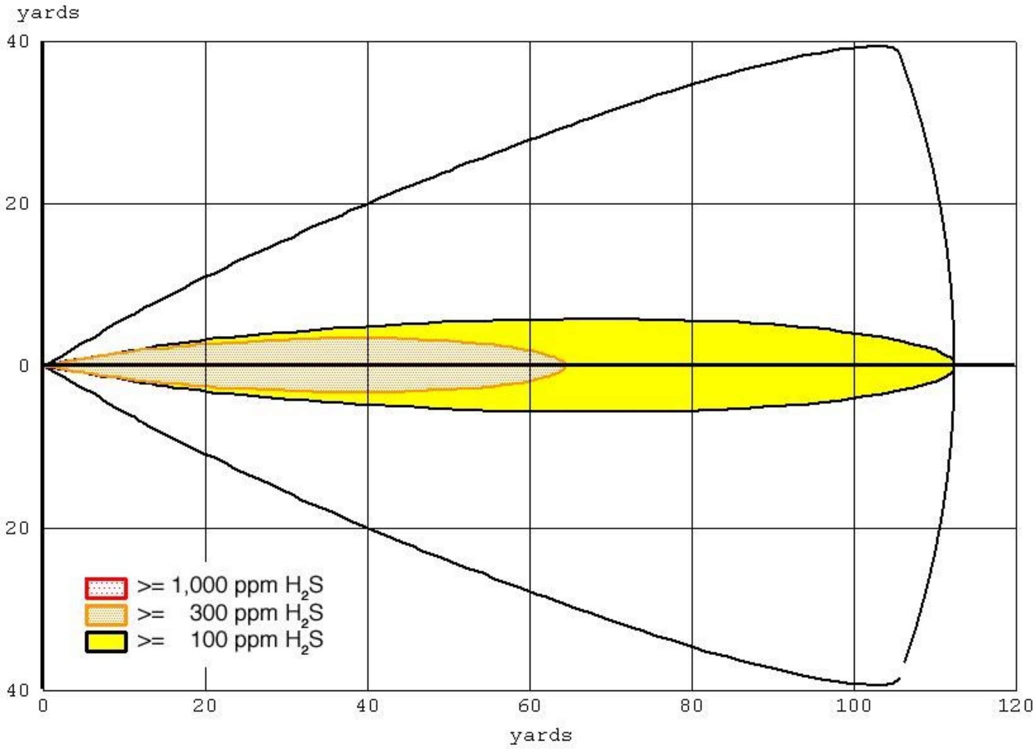


Stable Nighttime Atmospheric Stability Conditions



Neutral Atmospheric Stability Conditions

Figure 6-6. Estimated Vessel/Piping Rupture #1 (41,000 ppm) H_2S Hazard Zones

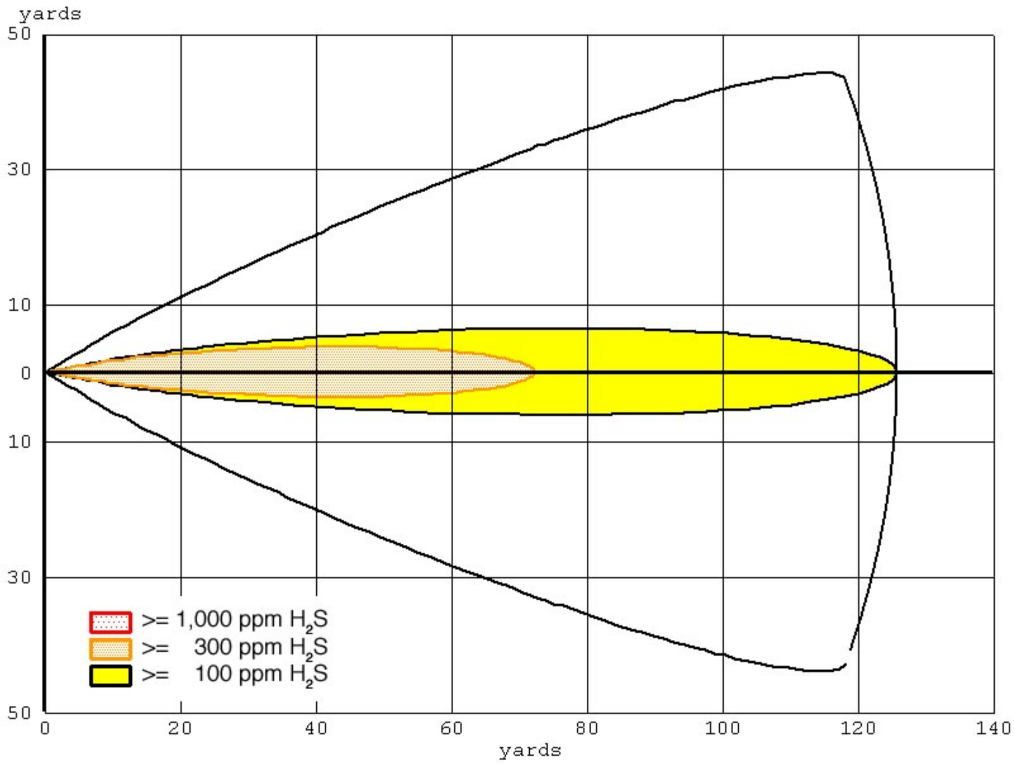


Stable Nighttime Atmospheric Stability Conditions

Not plotted by ALOHA due to short distance.

Neutral Atmospheric Stability Conditions

Figure 6-7. Estimated Vessel/Piping Rupture #2 (15,000 ppm) H_2S Hazard Zones

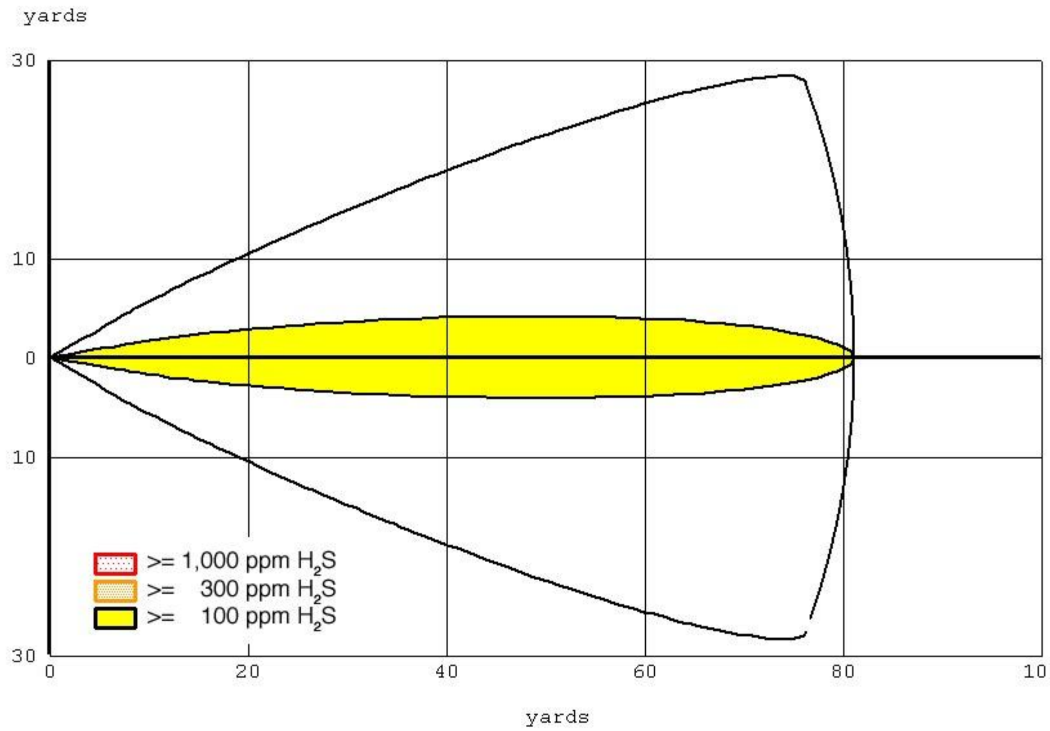


Stable Nighttime Atmospheric Stability Conditions

Not plotted by ALOHA due to short distance.

Neutral Atmospheric Stability Conditions

Figure 6-8. Estimated Vessel/Piping Leak #1 (41,000 ppm) H_2S Hazard Zones

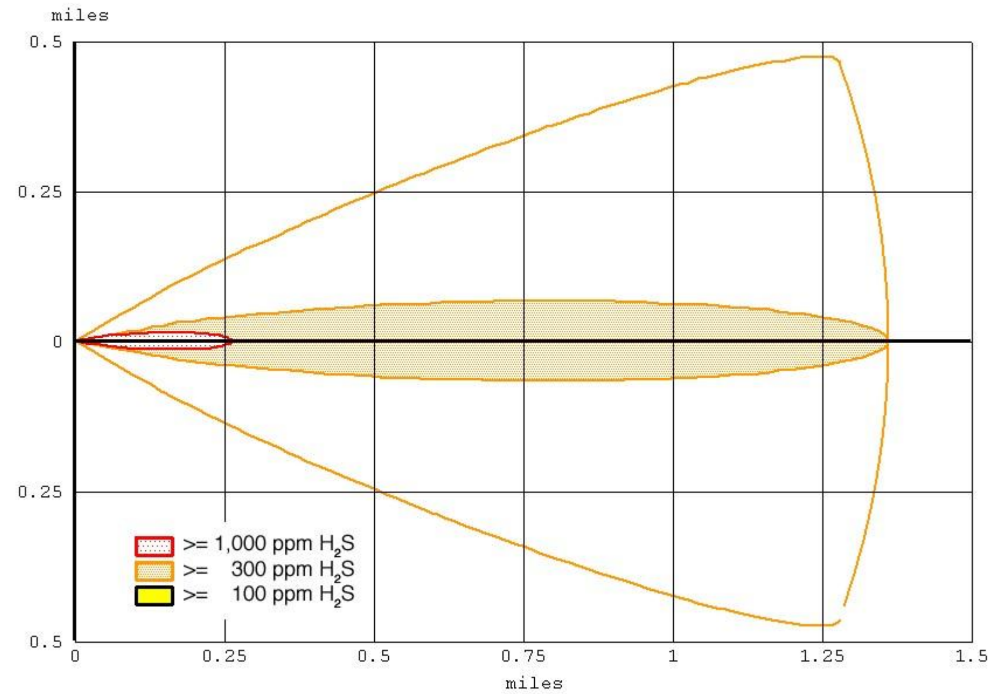


Stable Nighttime Atmospheric Stability Conditions

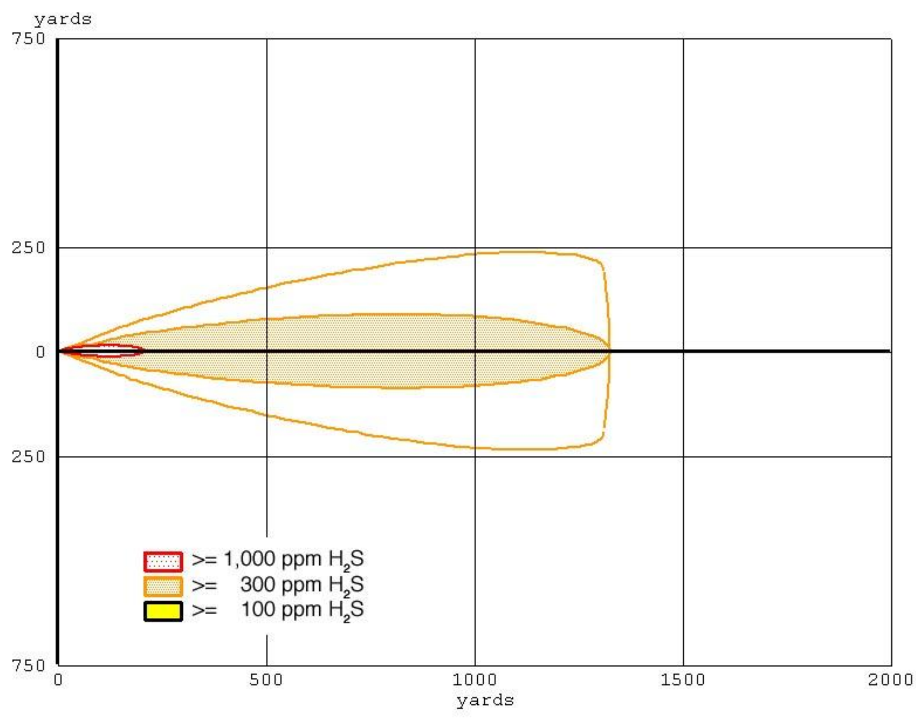
Not plotted by ALOHA due to short distance.

Neutral Atmospheric Stability Conditions

Figure 6-9. Estimated Vessel/Piping Leak #2 (15,000 ppm) H_2S Hazard Zones



Stable Nighttime Atmospheric Stability Conditions



Neutral Atmospheric Stability Conditions

Figure 6-10. Estimated Platform Hidalgo to Hermosa Pipeline Rupture (25,000 ppm) H_2S Hazard Zones

The modeling estimated that the maximum potential downwind distance for the 1,000 ppm concentration H_2S gas hazard zone is 1,386 feet. This distance is less than the established U.S. Coast Guard Safety Zone for these platforms. For the 300 ppm H_2S concentration hazard zone, the estimated distance is 1.4 miles (7,392 feet) under stable atmospheric conditions, which typically only occur during the night.

The Platform Hidalgo to Platform Hermosa pipeline is located a minimum of 5.9 miles (31,100 feet) from shore and 4.9 miles (26,000 feet) from the vessel traffic lanes, thus a release from the pipeline would not be expected to present a hazard to the public onshore or on a vessel transiting through the vessel traffic lanes. Finally, the expected frequency of a pipeline rupture was estimated to be “unlikely”.

The wind direction in this region of the California coast is predominantly from the northwest (Figures 3-1 and 3-2) and hence, any release of gas would most likely move in a southeasterly direction paralleling the vessel traffic lanes and shore. However, the wind can blow from any direction. It is possible that a vessel less than 100 feet LOA could transit near any of the platforms or pipeline. For a vessel to be impacted, a series of things would have to happen. First, an uncontrolled release would have to occur and the expected frequency of such an event occurring has been classified as “rare” from platforms and “unlikely” from pipelines. Second, the vessel would have to be located within the hazard zone which means it would have to be near and downwind of the platform or pipeline.

Flammable Gas Hazard

The potential hazard zones for flammable gas clouds from uncontrolled well releases at Platforms Harvest, Hermosa, Hidalgo, and Irene are approximately the same for all four platforms and are presented in Table 6-2. The larger flammable gas cloud hazard distances, under neutral atmospheric conditions, were estimated to be 456 to 480 feet and 663 to 762 feet for the 100% LFL and 60% LFL, respectively. Under stable atmospheric conditions, which only occur at night, the maximum hazard zones for flammable gas were estimated to range between 261 to 267 feet and 411 to 444 feet for the100% LFL and 60% LFL, respectively. As with the estimated H_2S hazard zones for uncontrolled well releases at the POCSR platforms, the estimated flammable gas hazard areas for these platforms do not reach land, the vessel traffic lanes, or extend outside the U.S. Coast Guard established platform “safety zones”. The expected frequency of an uncontrolled release has been estimated to be “rare”.

The worst-case potential hazard zone for flammable gas clouds from processing vessels/piping ruptures at these four platforms were estimated to extend to a maximum downwind distance of 171feet and 222 feet for the 100% LFL and 60% LFL, respectively under stable atmospheric conditions (Table 6-2). Under neutral atmospheric conditions, the minimum potential hazard zones for vessel/piping ruptures are 66 feet and 84 feet for the 100% LFL and 60% LFL, respectively (Table 6-2).

For potential vessel/piping leaks occurring at these platforms, the estimated maximum downwind distance for the flammable gas cloud to extend from the release source was estimated to be 114 feet and 150 feet for the 100% LFL and 60% LFL, respectively (Table 6-2). Both of these worst-case scenarios occurred under stable atmospheric conditions, which only occur during the night. Under neutral atmospheric conditions, which can occur either during the night or day, the estimated maximum downwind distance for vessel/piping ruptures and leaks were 66 feet and 45 feet, respectively for 100% LFL and 84 feet and 57 feet, respectively for 60% LFL (Table 6-2). Obviously for these latter scenarios, the flammable gas cloud would be restricted to the immediate area of the platform. The expected frequency of a vessel/piping rupture has been estimated to be “unlikely”.

The worst-case hazard zone for a flammable gas cloud from a pipeline failure was estimated for the pipeline connecting Platform Hidalgo to Platform Hermosa and used the same assumptions that were used for modeling H_2S hazard zones presented above. The maximum downwind distances that a flammable gas cloud was estimated to travel, under stable (nighttime) atmospheric conditions, are 2,154 feet for 60%

LFL and 1,692 feet for 100% LFL. Under neutral atmospheric conditions, the distances were estimated to be 1,035 feet and 783 feet for the 60% LFL and 100% LFL, respectively.

The Platform Hidalgo to Platform Hermosa pipeline is located approximately 3.9 miles (31,100 feet) from shore and 4.9 miles (26,000 feet) from the vessel traffic lanes (Table 2-3). As a result, a flammable gas release from a pipeline failure and rupture of the Platform Hidalgo to Platform Hermosa pipeline would not be expected to present a hazard to the public, either onshore or if on a vessel within the vessel traffic lanes. The expected frequency of a pipeline rupture has been estimated to be "unlikely".

Table 6-2. Estimated Maximum Distances for Flammable Gas Hazard Zones from Uncontrolled Well Releases, Vessel/Piping Ruptures, and Pipeline Ruptures from POCS Platforms Located North of Point Conception

Scenario	Flammable Gas Hazard Zone (Feet)			
	100% LFL		60% LFL	
	Stable Atmospheric Conditions	Neutral Atmospheric Conditions	Stable Atmospheric Conditions	Neutral Atmospheric Conditions
Uncontrolled Well Releases				
Platform Harvest	267	456	444	663
Platform Hermosa	267	456	444	663
Platform Hidalgo	267	456	444	663
Platform Irene	261	480	411	762
Vessel /Piping Releases				
Rupture	171	66	222	84
Leak	114	45	150	57
Pipeline Rupture				
Pipeline Rupture #2 (Pipeline Connecting Platform Hidalgo to Hermosa)	1,692	783	2,154	1,035

6.2.2. Western Santa Barbara Channel Platforms

H_2S Hazard

The estimated maximum distances for the H_2S hazard zones for uncontrolled H_2S contaminated gas releases for Platforms Harmony, Heritage and Hondo are presented in Table 6-3 and Figures 6-11 through 6-13. The largest H_2S hazard zones are produced by Platform Hondo, which are 621 feet for the 100 ppm H_2S concentration dispersion, 300 feet for the 300 ppm H_2S concentration dispersion, and 135 feet for the 1,000 ppm H_2S concentration dispersion. Platform Heritage's H_2S hazard zones are slightly less than those of Platform Hondo and are 579 feet for the 100 ppm H_2S concentration hazard zone, 279 feet for the 300 ppm H_2S concentration hazard zone, and 126 feet for the 1,000 ppm H_2S concentration hazard zone. Platform Harmony produces the smallest H_2S hazard zones, which are 453 feet, 219 feet, and 99 feet for the 100 ppm, 300 ppm and 1,000 ppm H_2S concentration dispersions, respectively. All of these maximum H_2S hazard zones occur during neutral atmospheric conditions. Under stable atmospheric conditions the estimated hazard zones for each of the three H_2S gas concentration clouds at these platforms are slightly smaller (Table 6-3). None of these estimated gas dispersion hazard zone areas extend far enough to reach land, the vessel traffic lanes, or outside the platforms' U.S. Coast Guard "safety zones" (Table 1-1). The expected frequency of an uncontrolled well release of H_2S gas is classified as "rare".

Platform Hondo has the highest concentration of H_2S gas of the three platforms in this group, at 13,500 ppm. Platform Harmony has the lowest at 5,000 ppm (Table 1-1). Hence, the Rupture #2 and Leak #2 scenarios are representative of the highest or worst-case vessel/piping accidental releases for this group of platforms and the Rupture #3 scenario represents the lowest case vessel/piping release in this region of the POCSR. As illustrated in Figures 6-7 and 6-9 and shown in Table 6-3, the maximum downwind distance that a 15,000 ppm H_2S gas release from either a vessel/piping rupture or leak is 336 feet. This is the maximum downwind distance to reach the outer edge of the 100 ppm H_2S concentration gas cloud. The maximum downwind distance to the 1,000 ppm H_2S concentration cloud is 105 feet. For the 5,000 ppm concentration H_2S vessel/piping rupture, the maximum downwind distance is 192 feet to reach the outer edge of 100 ppm H_2S concentration potential hazard zone (Table 6-3 and Figure 6-14). The minimum downwind distance for any of these vessel/piping accidental releases is 33 feet for the 1,000 ppm H_2S concentration dispersion.

The predominant wind direction in the western Santa Barbara Channel (Figure 3-3) is from the west, which would tend to push a released gas cloud parallel to the coast and away from the vessel traffic lanes. As shown by Figure 3-3, the wind can blow from any direction at times. There are no pipelines transporting sour gas in this group of platforms.

Flammable Gas Hazard

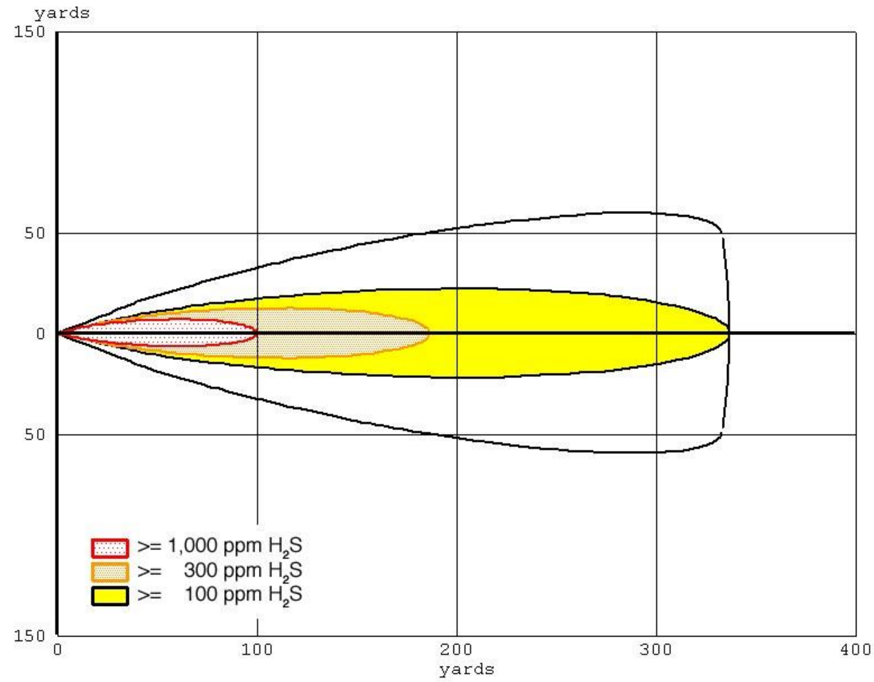
The potential hazard zones for flammable gas clouds from uncontrolled well releases at Platforms Harmony, Heritage, and Hondo, are presented in Table 6-4. Since the representative release scenarios for all three platforms assumed the same pressure and release opening size, the modeling resulted in the flammable gas cloud hazard zones being the same for all three platforms. The H_2S concentration in the gas has very little affect on the LFL of the gas. The largest flammable gas cloud hazard distances, under neutral atmospheric conditions, were estimated to be 327 feet and 456 feet for the 100% LFL and 60% LFL, respectively. Under stable atmospheric conditions, the maximum hazard zones for flammable gas were estimated to be 261 feet and 375 feet for the 100% LFL and 60% LFL, respectively. As with the estimated H_2S hazard zones for uncontrolled well releases at the POCSR platforms, the estimated flammable gas hazard areas for these platforms do not reach land, the vessel traffic lanes, or extend outside the U.S. Coast Guard established platform "safety zones". The expected frequency of an uncontrolled release has also been estimated to be "rare".

The worst-case potential hazard zone for flammable gas clouds from processing vessels/piping ruptures at these three platforms are identical to those estimated for the four platforms to the north since the same gas, methane, was modeled under identical model scenario assumptions. These were estimated to extend to a maximum downwind distance of 171feet and 222 feet for the 100% LFL and 60% LFL, respectively (Table 6-4). For potential vessel/piping leaks occurring at these platforms, the estimated maximum downwind distance for the flammable gas cloud to extend from the release source was estimated to be 114 feet and 150 feet for the 100% LFL and 60% LFL, respectively (Table 6-4). Both of these worst-case scenarios occurred under stable atmospheric conditions, which only occur during the night. Under neutral atmospheric conditions, which can occur either during the night or day, the estimated maximum downwind distance for vessel/piping ruptures and leaks were 66 feet and 45 feet, respectively for 100% LFL and 84 feet and 57 feet, respectively for 60% LFL (Table 6-4). Obviously for these latter scenarios, the flammable gas cloud would be restricted to the immediate area of the platform. The expected frequency of a vessel/piping rupture has been estimated to be “unlikely”.

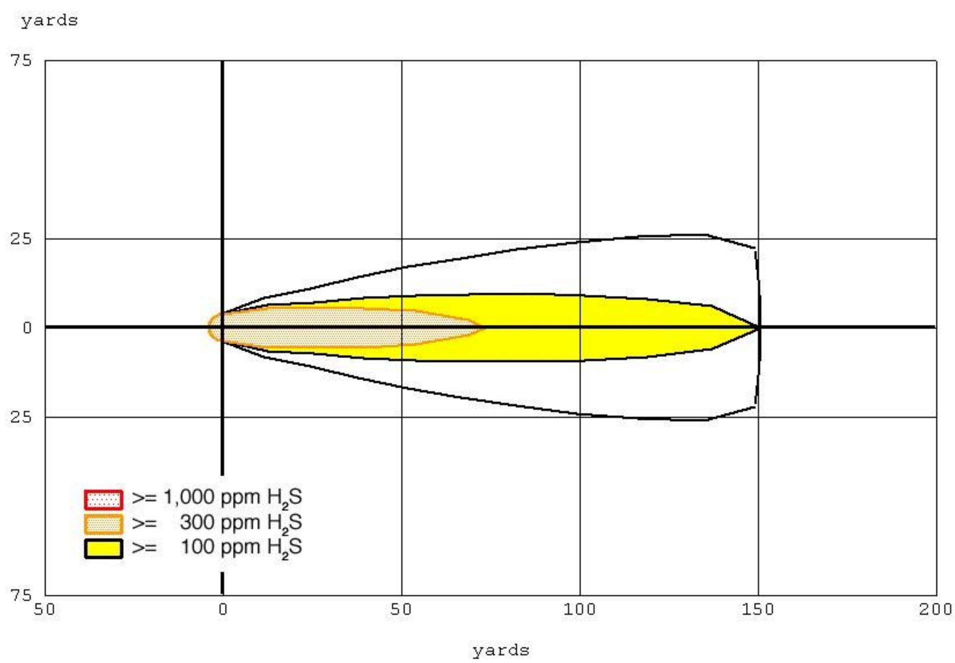
While there are no pipelines that transport sour gas among these platforms, there are pipelines that transport gas with low levels of H_2S. The pipeline rupture #2 scenario was used to represent these pipelines in evaluating potential flammable gas clouds. The maximum downwind distance that the flammable gas cloud was estimated to travel under stable (nighttime) atmospheric conditions is 2,154 feet for 60% LFL and 1,692 feet for 100% LFL. Under neutral atmospheric conditions, the distance was estimated to be 1,035 feet and 783 feet for the 60% LFL and 100% LFL, respectively. The pipelines between these platforms are located a minimum of 5.1 miles (26,900 feet) from shore and 2 miles (10,560 feet) from the vessel traffic lanes. As a result, a flammable gas release from a pipeline rupture would not be expected to present a hazard to the public, either onshore or if on a vessel within the vessel traffic lanes. The expected frequency of a pipeline rupture has been estimated to be “unlikely”.

Table 6-3. Estimated Maximum Distances for H_2S Hazard Zones from Uncontrolled Well Releases and Vessel/Piping Ruptures from POCS Platforms in the Western Santa Barbara Channel Region

Scenario	Figure No.	Hazard Zone (Feet)					
		1,000 ppm		300 ppm		100 ppm	
		Stable Atmospheric Conditions	Neutral Atmospheric Conditions	Stable Atmospheric Conditions	Neutral Atmospheric Conditions	Stable Atmospheric Conditions	Neutral Atmospheric Conditions
Uncontrolled Well Releases							
Platform Harmony	6-11	75	99	177	219	381	453
Platform Heritage	6-12	102	126	228	279	489	579
Platform Hondo	6-13	111	135	246	300	525	621
Vessel /Piping Ruptures							
Rupture #2 (15,000 ppm H_2S)	6-7	105	42	192	75	336	132
Rupture #3 (5,000 ppm H_2S)	6-14	60	33	111	42	192	75
Leak #2 (15,000 ppm H_2S)	6-9	78	33	138	48	243	93
Pipeline Rupture							
There are no pipelines transporting sour gas in this group of platforms.							

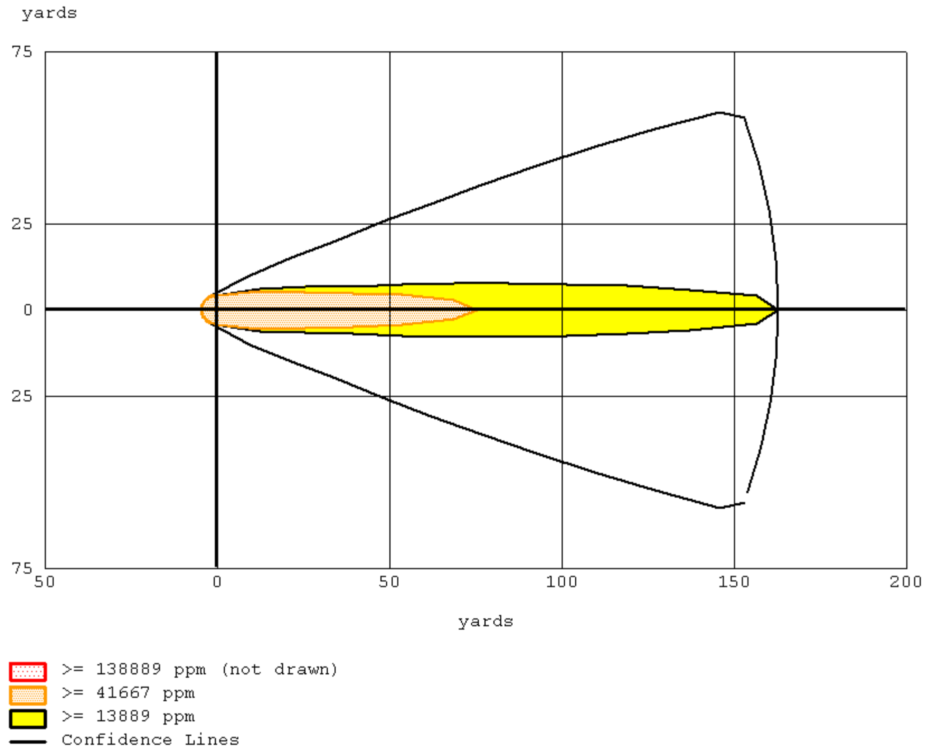


Stable Nighttime Atmospheric Stability Conditions

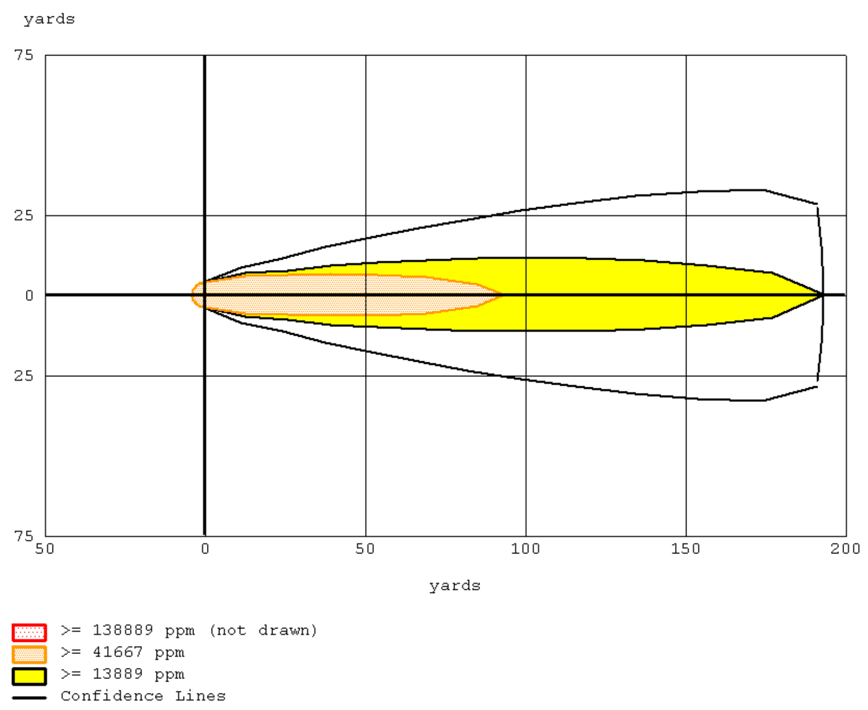


Neutral Atmospheric Stability Conditions

Figure 6-11. Estimated Platform Harmony Uncontrolled Well Release (5,000 ppm) H_2S Hazard Zones

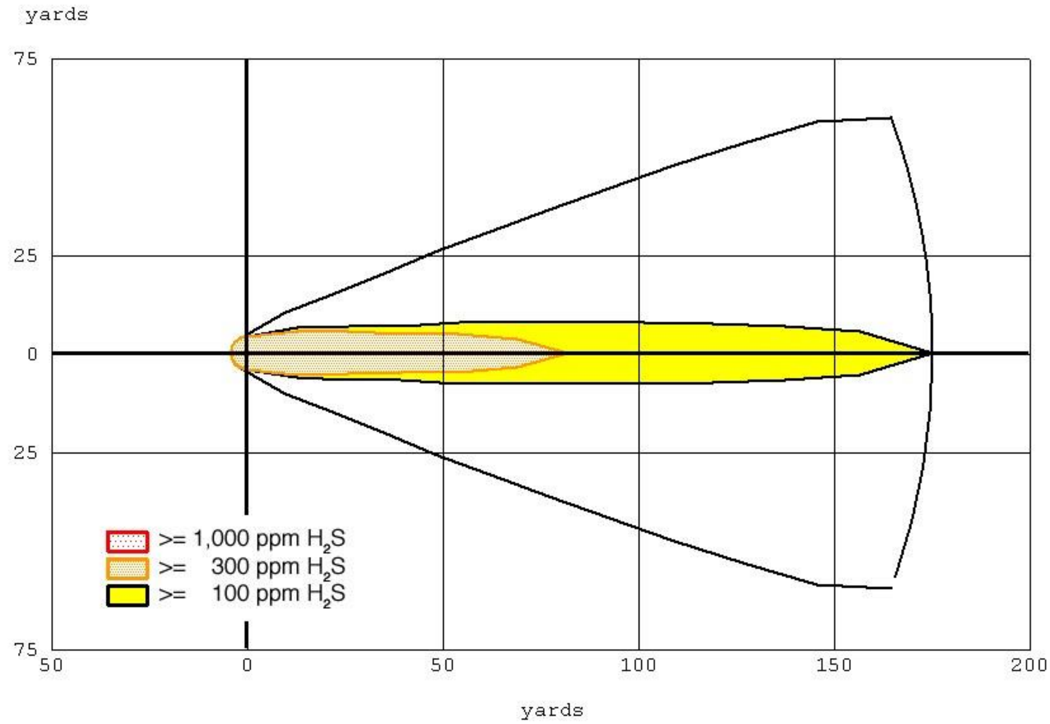


Stable Nighttime Atmospheric Stability Conditions

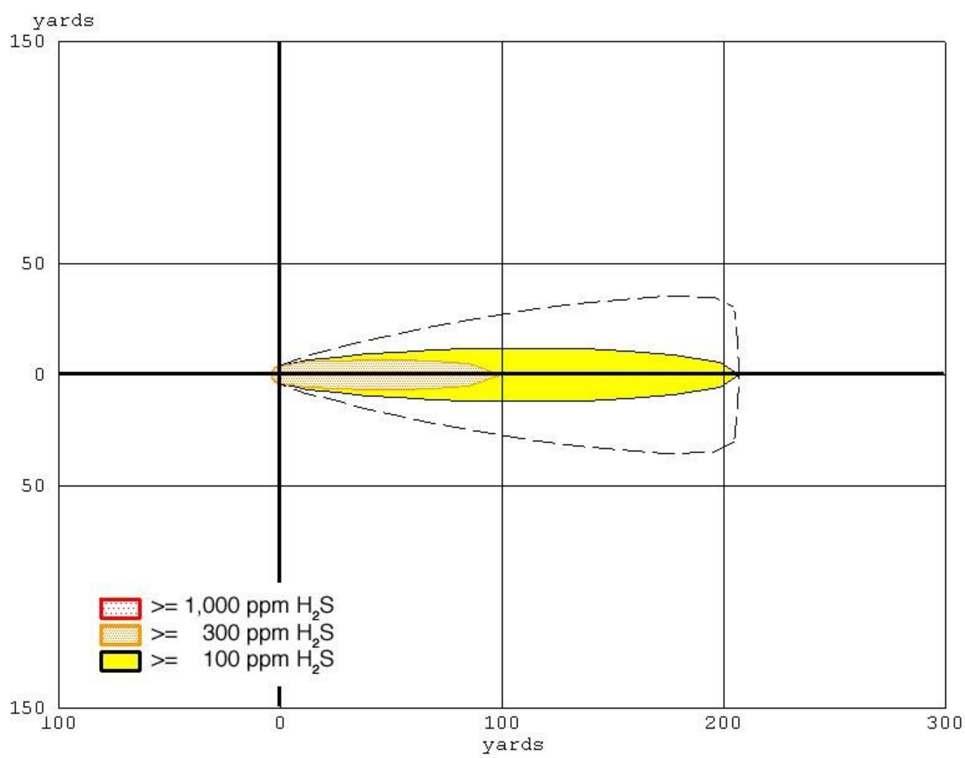


Neutral Atmospheric Stability Conditions

Figure 6-12. Estimated Platform Heritage Uncontrolled Well Release (7,200 ppm) H_2S Hazard Zones

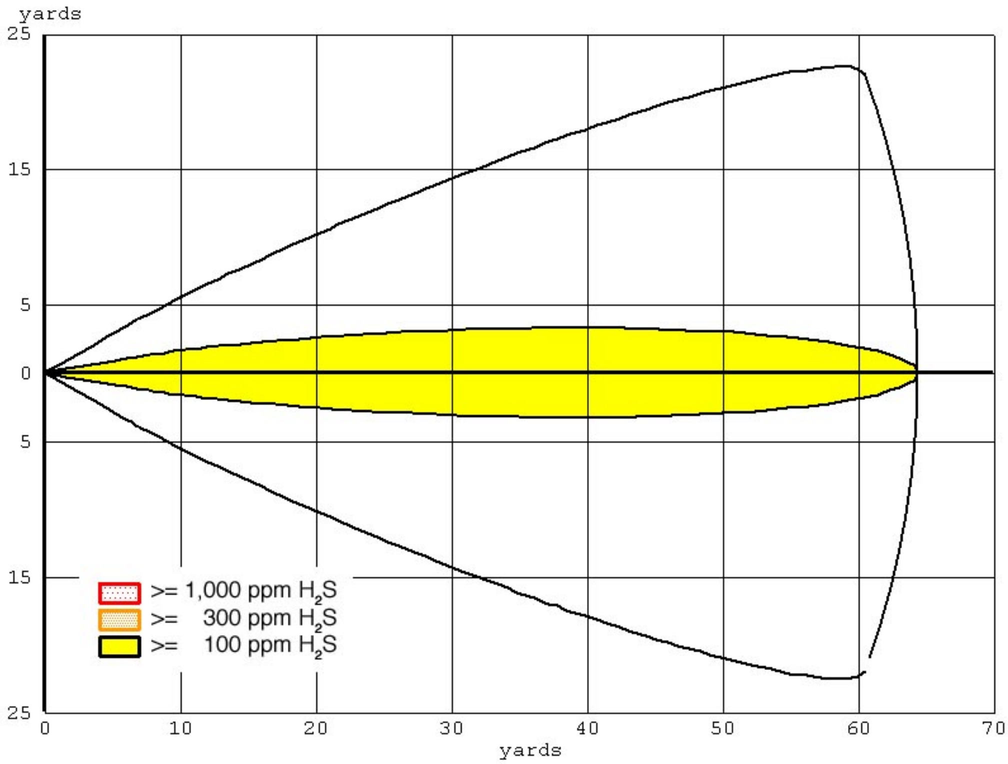


Stable Nighttime Atmospheric Stability Conditions



Neutral Atmospheric Stability Conditions

Figure 6-13. Estimated Platform Hondo Uncontrolled Well Release (13,500 ppm) H_2S Hazard Zones



Stable Nighttime Atmospheric Stability Conditions

Not plotted by ALOHA due to short distance.

Neutral Atmospheric Stability Conditions

Figure 6-14. Estimated Vessel/Piping Rupture #3 (5,000 ppm) H_2S Hazard Zones

Table 6-4. Estimated Maximum Distances for Flammable Gas Hazard Zones from Uncontrolled Well Releases, Vessel/Piping Ruptures, and Pipeline Ruptures from POCS Platforms Located in the Western Santa Barbara Channel

Scenario	Flammable Gas Hazard Zone (Feet)			
	100% LFL		60% LFL	
	Stable Atmospheric Conditions	Neutral Atmospheric Conditions	Stable Atmospheric Conditions	Neutral Atmospheric Conditions
Uncontrolled Well Releases				
Platform Harmony	261	327	375	456
Platform Heritage	261	327	375	456
Platform Hondo	261	327	375	456
Vessel /Piping Releases				
Rupture	171	66	222	84
Leak	114	45	150	57
Pipeline Rupture				
Pipeline Rupture #2	1,692	783	2,154	1,035

6.2.3. Eastern Santa Barbara Channel Platforms

H_2S Hazard

The estimated H_2S hazard zones for uncontrolled H_2S contaminated gas releases for the four platforms (Gail, Gilda, Gina, and Grace) in this region of the POCSR are presented in Table 6-5 and Figures 6-15 through 6-18. The largest H_2S hazard zones are from Platform Gail and are 813 feet for the 100 ppm H_2S concentration dispersion cloud, 372 feet for the 300 ppm H_2S concentration dispersion cloud, and 159 feet for the 1,000 ppm H_2S concentration dispersion cloud. The H_2S hazard zones from the other three platforms (Gina, Grace, and Gilda) are considerably less than those for Platform Gail because they have significantly less H_2S in their produced gas. None of these three platforms produce an uncontrolled release H_2S hazard area for the ≥1,000 ppm H_2S concentration because none of the Platforms have gas concentrations ≥1,000 ppm H_2S. Platform Gina's H_2S hazard zones are 177 feet and 309 feet for the 300 ppm and 100 ppm H_2S concentration dispersions, respectively. Platform Grace's H_2S hazard zones are 99 feet and 174 feet for the 300 ppm and 100 ppm H_2S concentration dispersions, respectively and Platform Gilda's H_2S hazard zones are 96 feet for the 300 ppm H_2S concentration dispersion and 186 feet for the 100 ppm H_2S concentration dispersion. As illustrated in Table 1-1, all of the platforms in this area of the POCSR are located more than 3.7 miles (19,500 feet) from shore and 0.9 miles (4,700 feet) from the vessel traffic lanes. The estimated hazard zones for all of these platforms are also less than the U.S. Coast Guard "safety zones" established for these platforms.

Platform Gail has the highest concentration of H_2S contaminated gas (20,000 ppm) of any of the four platforms in this area of the POCSR. Hence, the vessel/piping Rupture #2 and vessel/piping Leak #2 scenarios are considered representative for this group of platforms, with the largest hazard area being 336 feet downwind for the 100 ppm H_2S concentration gas cloud. The largest 1,000 ppm and 300 ppm H_2S concentration hazard zones only extend 105 feet and 192 feet, respectively. All of these releases would be expected to be restricted to the general platform area and do not extend beyond the U.S. Coast Guard established “safety zones” for these platforms. The expected frequency of an uncontrolled well release of H_2S gas is classified as “rare”.

The predominant wind direction in this area of the POCSR is from the west (Figure 3-3), which would tend to move a released gas cloud toward the coast but away from the vessel traffic lanes. During the winter months the wind sometimes blows from the east or southeast, which would move the gas cloud away from the coast. As shown by Figure 3-3, the wind can blow from any direction at times.

An 8-inch diameter pipeline transports sour gas from Platform Gail to Platform Grace. The estimated H_2S hazard areas are presented in Table 6-5 and Figure 6-19. As with the modeled pipeline rupture for the Platform Hidalgo to Hermosa pipeline, the potential hazard distances illustrated in Figure 6-19 and presented in Table 6-5 assumed worst-case conditions, with the pipeline rupture occurring as a continuous release at a continuous release pressure above water in the pipeline riser.

The modeling estimated that the maximum downwind distance for the 1,000 ppm concentration H_2S gas potential hazard zone for a pipeline rupture was 834 feet. For the 300 ppm H_2S concentration hazard zone, the estimated maximum downwind distance was 1,416 feet (0.3 miles) under stable atmospheric conditions, which typically only occur during the night. The pipeline is located over 9.9 miles from shore and 0.9 miles from the vessel traffic lanes (Table 2-3), thus a release from the pipeline would not be expected to present a hazard to the public either onshore or when transiting through the vessel traffic lanes. As with the Platform Hidalgo to Platform Hermosa pipeline, the expected frequency of a pipeline rupture has been estimated to be “unlikely”.

Flammable Gas Hazard
The potential hazard zones for flammable gas clouds from uncontrolled well releases at Platforms Gail, Gilda, Gina, and Grace,, are presented in Table 6-6. The largest flammable gas cloud hazard distances were from Platform Gail during stable (nighttime) atmospheric conditions, and were estimated to be 1,095 feet and 1,434 feet for the 100% LFL and 60% LFL, respectively. Under neutral atmospheric conditions, the maximum hazard zones for flammable gas form Platform Gail were estimated to be 426 feet and 555 feet for the100% LFL and 60% LFL, respectively. Platform Gilda had the second largest flammable gas cloud hazard distances (483 feet to the LFL and 789 feet to 60% LFL) and Platform Grace the third largest flammable gas cloud hazard distances (390 feet to the LFL and 504 feet to 60% LFL). Platform Gina had the smallest flammable gas cloud hazard distances (273 feet to the LFL and 354 feet to 60% LFL). As with the estimated H_2S hazard zones for uncontrolled well releases at the POCSR platforms, the estimated flammable gas hazard areas for these platforms do not reach land, the vessel traffic lanes, or extend outside the U.S. Coast Guard established platform “safety zones”. The platform closest to shore is Platform Gina, which is located 3.7 miles (19,500 feet) away and the closest platform to the vessels lanes is Platform Gail, which is located 0.9 miles (4,700 feet) away (Table 1-1). The expected frequency of an uncontrolled release has been estimated to be “rare”.

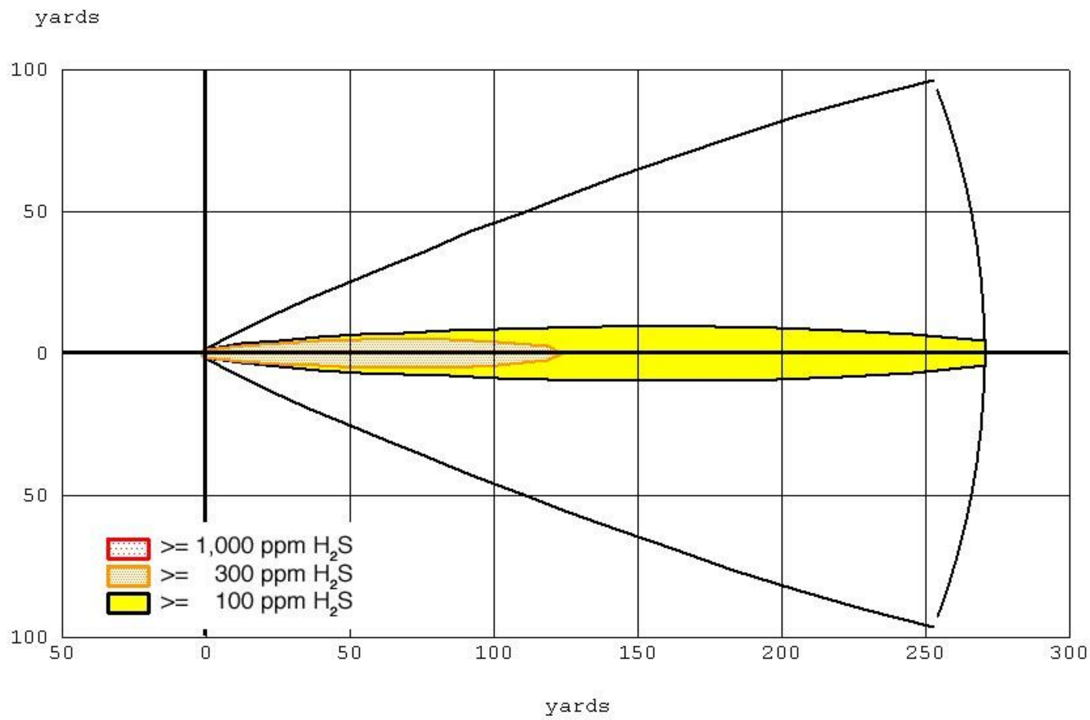
The worst-case potential hazard zone for flammable gas clouds from processing vessels/piping ruptures at these four platforms are identical to those estimated for the seven platforms to the north since the same gas (methane) was modeled under identical model scenario assumptions. These were estimated to extend to a maximum downwind distance of 171feet and 222 feet for the 100% LFL and 60% LFL, respectively (Table 6-6). For potential vessel/piping leaks occurring at these platforms, the estimated maximum downwind distance for the flammable gas cloud to extend from the release source was estimated to be 114 feet and 150 feet for the 100% LFL and 60% LFL, respectively (Table 6-6). Both of these worst-case scenarios occurred under stable atmospheric conditions, which only occur during the night. Under neutral atmospheric conditions, which can occur either during the night or day, the estimated maximum downwind distance for vessel/piping ruptures and leaks were 66 feet and 45 feet, respectively for 100% LFL and 84 feet and 57 feet, respectively for 60% LFL (Table 6-6). Obviously for these latter scenarios, the flammable gas cloud would be restricted to the immediate area of the platform. The expected frequency of a vessel/piping rupture has been estimated to be "unlikely".

The worst-case hazard zone for a flammable gas cloud from a pipeline failure was estimated for the pipeline connecting Platform Gail to Platform Grace and used the same assumptions that were used for modeling H_2S hazard zones presented above. The maximum downwind distance that the flammable gas cloud was estimated to travel under stable (nighttime) atmospheric conditions is 1,593 feet for 60% LFL and 1,278 feet for 100% LFL. Under neutral atmospheric conditions, the distance was estimated to be 729 feet and 555 feet for the 60% LFL and 100% LFL, respectively.

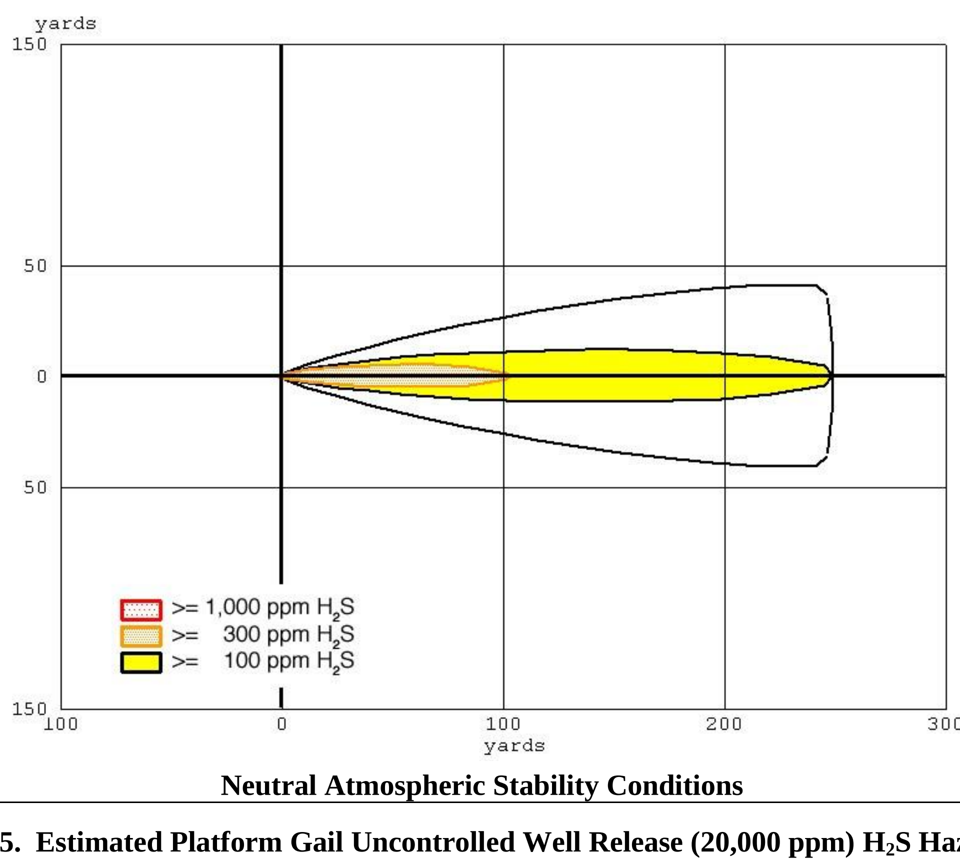
The Platform Gail to Platform Grace pipeline is located a minimum of 9.9 miles (52,200 feet) from shore and 0.9 miles (4,700 feet) from the vessel traffic lanes (Table 2-3). As a result, a flammable gas release from a pipeline failure and rupture of the Platform Gail to Platform Grace pipeline would not be expected to present a hazard to the public, either onshore or if on a vessel within the vessel traffic lanes. The expected frequency of a pipeline rupture has been estimated to be "unlikely".

Table 6-5. Estimated Maximum Distances for H_2S Hazard Zones from Uncontrolled Well Releases, Vessel/Piping Ruptures, and Pipeline Ruptures from POCS Platforms in the Eastern Santa Barbara Channel Region

Scenario	Figure No.	Hazard Zone (Feet)					
		1,000 ppm		300 ppm		100 ppm	
		Stable Atmospheric Conditions	Neutral Atmospheric Conditions	Stable Atmospheric Conditions	Neutral Atmospheric Conditions	Stable Atmospheric Conditions	Neutral Atmospheric Conditions
Uncontrolled Well Releases							
Platform Gail	6-15	159	111	372	312	813	750
Platform Gilda	6-16	-	-	96	69	150	186
Platform Gina	6-17	-	-	177	69	309	120
Platform Grace	6-18	-	-	99	39	174	66
Vessel /Piping Ruptures							
Rupture #2 (15,000 ppm H_2S)	6-7	105	42	192	75	336	132
Rupture #3 (5,000 ppm H_2S)	6-14	60	33	111	42	192	75
Leak #2 (15,000 ppm H_2S)	6-19	78	33	138	48	243	93
Pipeline Failure/Rupture							
Pipeline Rupture #1 (Platform Gail to Grace)	6-19	834	336	1416	620	-	-



Stable Nighttime Atmospheric Stability Conditions

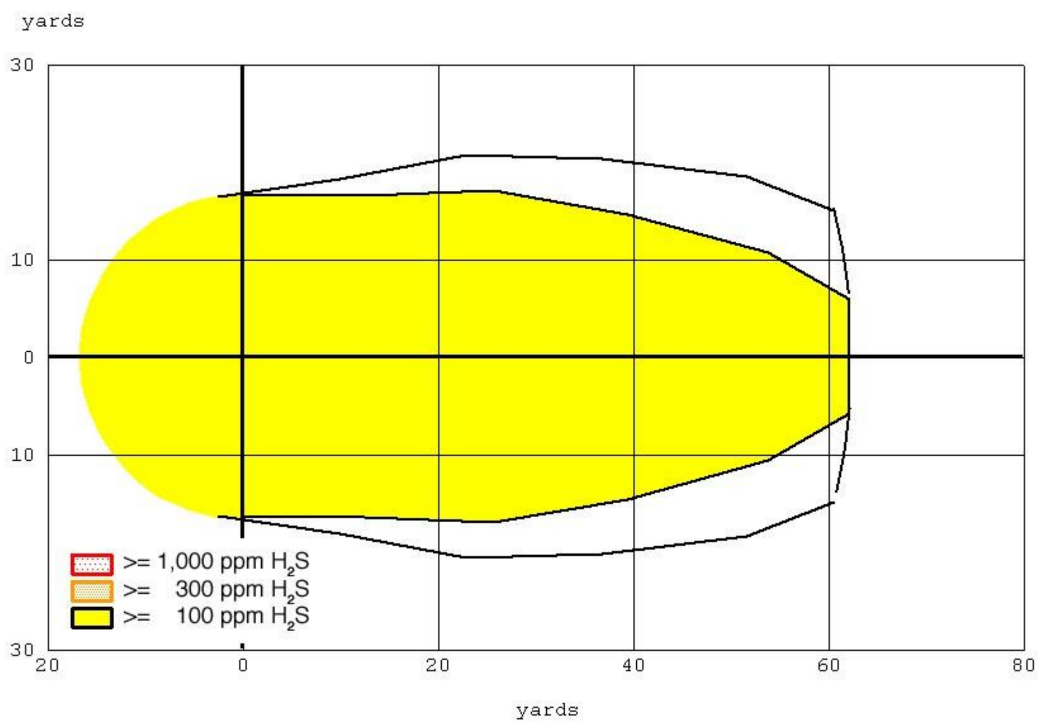


Neutral Atmospheric Stability Conditions

Figure 6-15. Estimated Platform Gail Uncontrolled Well Release (20,000 ppm) H_2S Hazard Zones

Not plotted by ALOHA due to short distance.

Stable Nighttime Atmospheric Stability Conditions

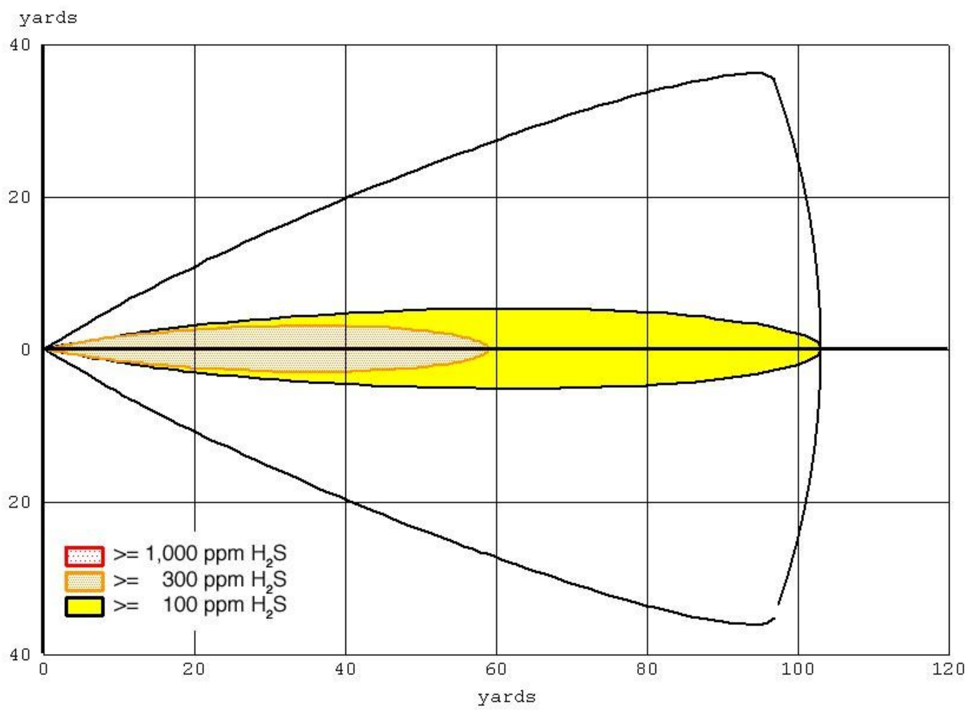


Neutral Atmospheric Stability Conditions

Figure 6-16. Estimated Platform Gilda Uncontrolled Well Release (800 ppm) H_2S Hazard Zones

Not plotted by ALOHA due to short distance.

Stable Nighttime Atmospheric Stability Conditions

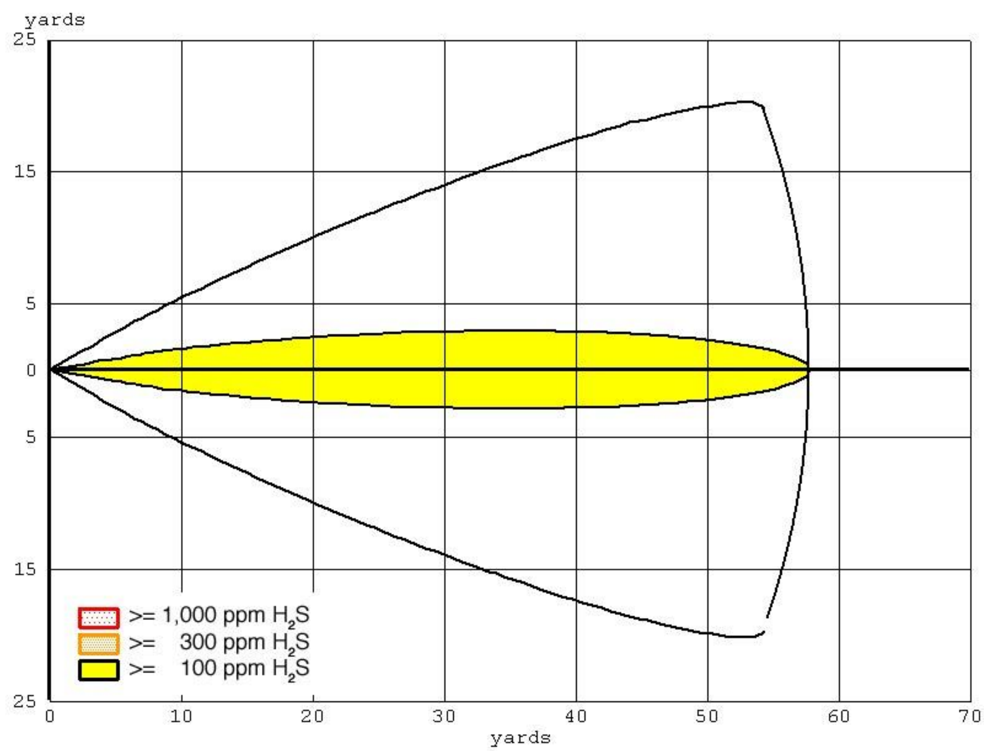


Neutral Atmospheric Stability Conditions

Figure 6-17. Estimated Platform Gina Uncontrolled Well Release (500 ppm) H_2S Hazard Zones

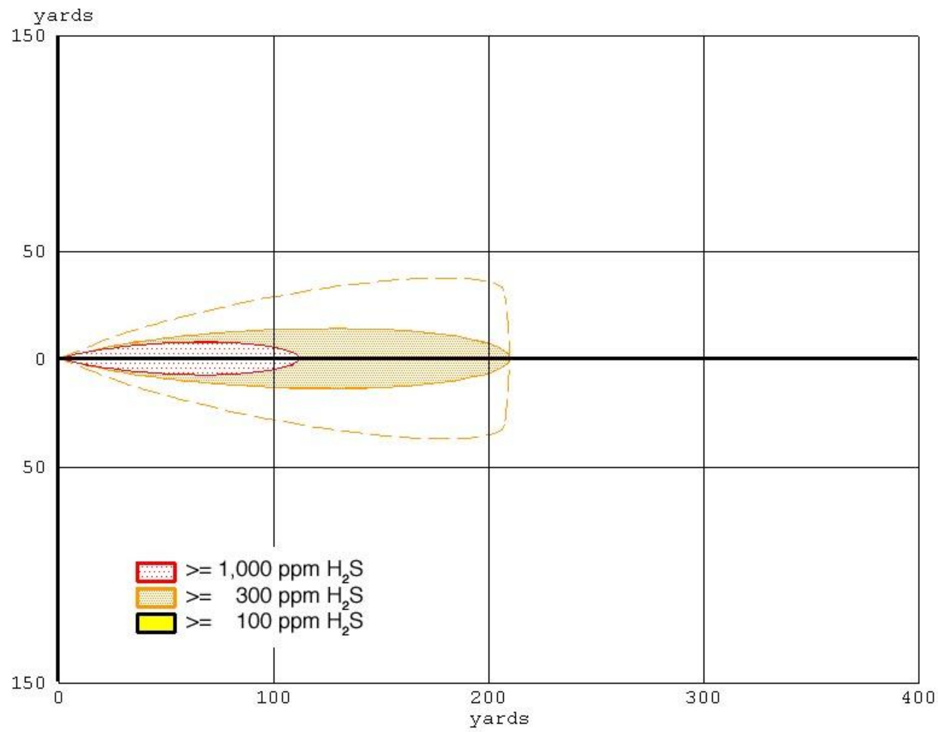
Not plotted by ALOHA due to short distance.

Stable Nighttime Atmospheric Stability Conditions

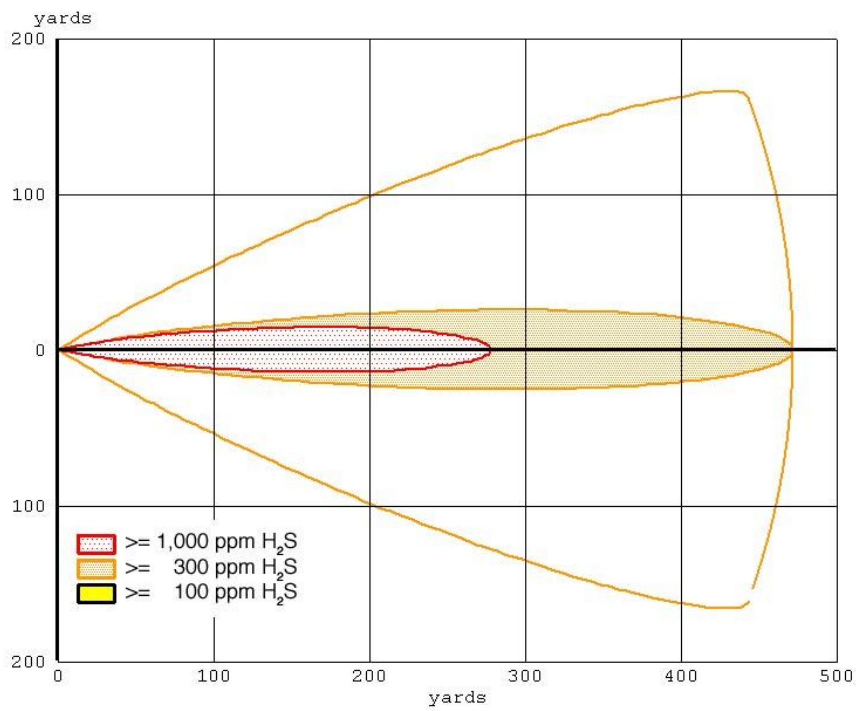


Neutral Atmospheric Stability Conditions

Figure 6-18. Estimated Platform Grace Uncontrolled Well Release (800 ppm) H_2S Hazard Zones



Stable Nighttime Atmospheric Stability Conditions



Neutral Atmospheric Stability Conditions

Figure 6-19. Estimated Platform Gail to Grace Pipeline Rupture (15,000 ppm) H_2S Hazard Zones

Table 6-6. Estimated Maximum Distances for Flammable Gas Hazard Zones from Uncontrolled Well Releases, Vessel/Piping Ruptures, and Pipeline Ruptures from POCS Platforms Located in the Eastern Santa Barbara Channel

Scenario	Flammable Gas Hazard Zone (Feet)			
	100% LFL		60% LFL	
	Stable Atmospheric Conditions	Neutral Atmospheric Conditions	Stable Atmospheric Conditions	Neutral Atmospheric Conditions
Uncontrolled Well Releases				
Platform Gail	1,095	426	1,434	555
Platform Gilda	264	483	408	789
Platform Gina	273	105	354	238
Platform Grace	390	150	504	195
Vessel /Piping Releases				
Rupture	171	66	222	84
Leak	114	45	150	57
Pipeline Rupture				
Pipeline Rupture #1 (Pipeline Connecting Platform Gail to Grace)	1,278	555	1,593	729

6.2.4. Radiant Heat

A fire on a POCSR platform would produce radiant heat. ALOHA was used to estimate the extent of the potential hazard zone for three levels of radiant heat concern (energy/heat levels). These hazard zones differ from both the H_2S and flammable gas hazard zones in that the radiant heat hazard zones extend in all directions (a circle) around the fire while the H_2S and flammable gas cloud hazard zones only extend in a downwind direction. For analysis purposes, it has been assumed that an area 200 feet by 200 feet is on fire, which represents the average dimensions of a POCSR platform. The distance and exposure time for each of the three potential hazard zones are presented in Table 6-7 below.

Based upon the ALOHA modeling predictions, the radiant heat hazard zones from a POCSR platform fire are not expected to reach shore, the vessel traffic lanes, or extend outside the U.S. Coast Guard established “safety Zones” for the eleven (11) platforms considered in this analysis. The extent of the radiant heat hazard footprints is illustrated in Figure 6-20.

Table 6-7. Thermal Radiation, Human Health Consequences, and Estimated Maximum Distance from the Center of the Fire from Potential Pacific Outer Continental Shelf Region Platforms

Thermal Radiation Level (kW/m^2)	**Human Health Consequence**	**Estimated Maximum Distance from the Center of the Fire** (Feet)
10	Potentially lethal within 60 sec	600
5	Second-degree burns within 60 sec	850
2	Pain within 60 sec	1,300

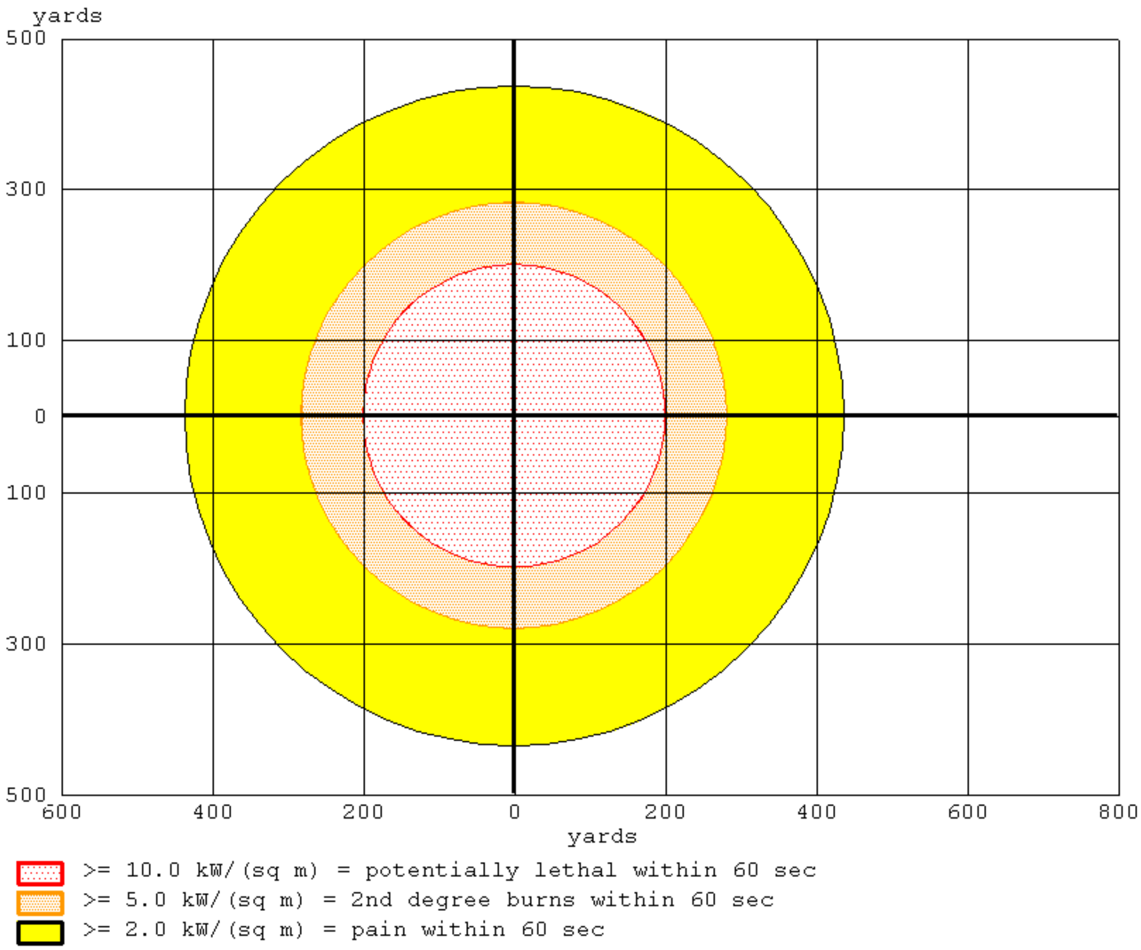


Figure 6-20. Estimated Platform Fire Radiant Heat Hazard Zones

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7.0 CONCLUSIONS

The conclusions presented in this section are based on the results of ALOHA-generated hazard zone modeling. The modeling scenario parameters employed for uncontrolled releases and for process vessels and associated platform piping releases used the highest concentrations of H_2S gas identified for each platform. Hence, the hazard zones predicted by the model can be considered the worst potential release cases for each of the platforms. Study conclusions applicable to all eleven POCSR assessed platforms are presented below. Study conclusions applicable to platforms located North of Point Conception, in the Western Santa Barbara Channel, or the Eastern Santa Barbara Channel are presented in Sections 7.1, 7.2, and 7.3, respectively.

- ALOHA modeling results indicated that potential POCSR platform H_2S gas releases are not able to produce maximum downwind H_2S hazard zones or flammable gas clouds from any type of accidental releases (uncontrolled well release, platform vessels/piping ruptures and leaks, and pipeline failures/ruptures) that extend to members of the public located onshore or on a vessel located within the vessel traffic lanes.
- People onboard vessels located inside the U.S. Coast Guard (USCG) established 500-meter platform "safety zones" could be exposed to hazardous or flammable gas clouds from uncontrolled well releases or platform associated process vessels or piping releases if they are located downwind of the release and inside the hazard zone.
- Platforms and gas pipelines located north of Point Conception present the largest H_2S hazard zones of all POCSR Platforms and therefore pose a risk to people aboard vessels in close proximity to the platforms.
- The frequency of occurrence for a major H_2S release from OCSR Oil and Gas Facilities or gas pipelines are considered "rare" to "unlikely".
- The expected frequency of a flammable gas cloud occurring from an uncontrolled well release, vessel/piping rupture, and a pipeline rupture have been estimated to be "rare", "unlikely", and "unlikely", respectively. A flammable gas cloud does not pose a hazard unless it encounters and ignition source and becomes ignited. An unconfined flammable gas cloud composed primarily of methane does not contain sufficient energy to produce an unconfined vapor cloud explosion (UVCE).
- Radiant heat hazards noted in the modeling analysis would only be expected during the catastrophic effects of a full platform fire and are not expected to extend far outside the platform footprint nor outside the USCG established platform "Safety Zones"

7.1. Platforms North of Point Conception

- Platforms located north of Point Conception (Hidalgo, Harvest, Hermosa, and Irene) present the largest H_2S hazard zones of all the platforms studied. Platform Hidalgo has the largest H_2S potential downwind hazard zones (2,676 feet, 1,317 feet, and 597 feet for 100 ppm, 300 ppm, and 1,000 ppm, H_2S concentration gas dispersions, respectively) of all platforms studied. It is the only platform that has the potential to generate an H_2S hazard zone that extends outside the USCG platform "safety zones".

- A failure or rupture in the10-inch pipeline transporting sour gas from Platform Hidalgo to Platform Hermosa is estimated to generate a maximum downwind hazard zone for 1,000 ppm and 300 ppm concentration H_2S gas clouds of 1,386 feet and 7,392 feet, respectively.
- Modeling results for flammable gas clouds from uncontrolled well releases and platform vessel/piping ruptures or leaks indicate that the maximum downwind distance is 762 feet and 480 feet for the 60% LFL and 100% LFL, respectively, at Platform Irene under stable neutral atmospheric conditions.
- Modeling results for flammable gas clouds from a pipeline rupture or failure indicate that the maximum downwind distance was estimated to be 2,154 feet for 60% LFL and 1,692 feet for 100% LFL. People onboard a vessel located within this distance from the pipeline rupture could be affected if the gas cloud is ignited.

7.2. Western Santa Barbara Channel Platforms

- Platform Hondo, which had the highest well and vessel/piping H_2S concentrations in this group, was estimated to produce maximum downwind hazard zones of 621 feet, 300 feet, and 135 feet for 100 ppm, 300 ppm, and 1,000 ppm H_2S concentration gas clouds, respectively.
- There is no pipeline transporting gas with H_2S concentrations $\geq$100 ppm between platforms in this group and thus, there is no H_2S hazard from these pipelines.
- Modeling results for flammable gas clouds from uncontrolled well releases and vessel/piping ruptures or leaks indicate that the maximum downwind distance is 456 feet and 327 feet for the 60% LFL and 100% LFL, respectively, for all three platforms in this group.
- People located on a vessel may be exposed to a flammable gas cloud if located less than 0.09 miles (456 feet) of Platforms Heritage, Harmony, or Hondo.

7.3. Eastern Santa Barbra Channel Platforms

- Platform Gail, which had the highest well and vessel/piping H_2S concentrations in this group, was estimated to produce maximum downwind hazard zones of 813 feet, 372 feet, and 159 feet for 100 ppm, 300 ppm, and 1,000 ppm H_2S concentration gas clouds, respectively.
- Modeling results for flammable gas clouds from uncontrolled well releases and from vessel/piping ruptures or leaks indicate that the maximum downwind distance is 1,434 feet and 1,095 feet for the 60% LFL and 100% LFL, respectively, for Platform Gail.
- A failure or rupture in the 8-inch pipeline transporting sour gas from Platform Gail to Platform Grace is estimated to generate a maximum downwind hazard zone for 1,000 ppm and 300 ppm concentration H_2S gas clouds of 834 feet and 1,416 feet, respectively.
- Modeling results for flammable gas clouds from a pipeline rupture or failure indicate that the maximum downwind distance was estimated to be 1,593 feet for 60% LFL and 1,278 feet for 100% LFL

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APPENDIX A. MODEL COMPARISON

1. Introduction

The ALOHA (Areal Locations of Hazardous Atmospheres) model was used to estimate the potential risk of H_2S, flammable gas, and radiant heat hazards to members of the public. ALOHA, publically available from EPA, is a personal computer based program designed especially for use by emergency personnel in responding to chemical releases, emergency planning, and training. ALOHA is easy to use and can illustrate potential hazard regions as isopleths. ALOHA can model all three hazards of interest, toxic gas cloud, flammable gas cloud, and radiant heat from fire. A description of ALOHA is presented in Section 6-1. Because ALOHA was developed to be used by emergency personnel, it uses conservative assumptions that tend to overpredict rather than underpredict the extent of hazard zones. To verify this assumption, several of the gas release scenarios were also run using the SLAB model.

SLAB is a personal computer model available from EPA that simulates the atmospheric dispersion of denser-than-air releases (Ermak 1990). SLAB can model continuous, finite duration, and instantaneous releases from four different types of sources:

- A ground level evaporating pool,
- An elevated horizontal jet,
- A stack or elevated vertical jet, and
- A ground-based instantaneous release.

While the model is designed to treat denser-than-air gas releases, it will also simulate cloud dispersions of neutrally buoyant gas releases and includes lofting of the cloud as it becomes lighter-than-air. SLAB takes into consideration initial mixing with air due to turbulent mixing from a high-pressure jet release gas source. SLAB also does not calculate release rates that must be determined by some other means or model. SLAB does not model radiant heat from fires.

2. Model Comparison

ALOHA and SLAB were both used to model the uncontrolled release scenarios from Platforms Gail and Hidalgo. Two scenarios were run for SLAB for each platform: the first had the gas release take place on the platform at an elevation of 55 ft above sea level and the second scenario had the release take place at sea level. Chems-Plus, a model developed by Arthur D. Little, Inc. was utilized to calculate the release rates from each uncontrolled release. The downwind distances to the gas concentrations of concern were then calculated at sea level. Results of the ALOHA and SLAB runs for the two scenarios are shown in Tables A-1 and A-2.

Table A-1. SLAB and ALOHA Comparison – Platform Gail

Gas Cloud Concentration (ppm)	Downwind Distance (feet)			
	Stable Conditions		Neutral Conditions	
	SLAB	ALOHA	SLAB	ALOHA
1,000	0/430	159	0/518	111
300	0/531	372	0/771	312
100	342/630	813	342/958	750

SLAB run for release on platform (first value) and at sea level (second value)

Table A-2. SLAB and ALOHA Comparison – Platform Hidalgo

Gas Cloud Concentration (ppm)	Downwind Distance (feet)			
	Stable Conditions		Neutral Conditions	
	SLAB	ALOHA	SLAB	ALOHA
1,000	0/735	495	0/820	510
300	825/925	1,110	760/1,227	1,104
100	840/1,069	2,028	1,358/1,532	2,349

Note: SLAB run for release on platform (first value) and at sea level (second value)

As presented in these tables, if an uncontrolled release were to occur on the platform, SLAB calculated that the concentration of H_2S in the released gas cloud decreased in concentration to <1,000 ppm before reaching sea level. In addition, for Platform Gail the concentration of the released gas cloud decreased to <300 ppm before reaching sea level.

For three of the four scenarios, the downwind distance that the released gas cloud had to travel to attain a concentration of <100 ppm was greater for ALOHA than for SLAB. SLAB tended to calculate a greater downwind distance when the release was at sea level and a shorter downwind distance when the release was on the platform.

Based on the desire to be conservative in the estimated area of affect, it was decided that ALOHA would be used in this analysis. That decision was based on:

- The estimated downwind distances that gas clouds needed to travel to reach an H_2S concentration of 100 ppm appeared to be greater in the majority of cases when using ALOHA. It was determined that for this analysis it was preferable to be conservative in our modeled predictions of potential hazard zones.
- ALOHA is self-contained and does not require the use of additional models to calculate release rates which could introduce additional variability in modeled results.
- ALOHA has the ability to automatically plot the hazard zones.