Risk Assessment for the Intel Rio Rancho Facility: One-Time Event Risk Assessment

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FINAL REPORT

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Rio Rancho Facility

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1.0 INTRODUCTION

Intel Corporation (Intel) operates a semiconductor manufacturing facility in Rio Rancho, New Mexico. This facility is located near residential areas in Rio Rancho and Corrales, and some residents and other concerned citizens have raised questions regarding the safety of the facility. In a continuing effort to inform the community and Intel management, Intel has commissioned Environmental Resources Management (ERM) to conduct an independent evaluation of several potential ways in which the Intel facility may pose a risk to the health and safety of its neighbors. This volume of the comprehensive risk evaluation – the One-Time Event Risk Assessment – addresses ERM's evaluation of off-site risks related to possible releases or other accidents involving chemicals that are used at the Intel facility.

1.1 BACKGROUND INFORMATION

Intel operates three semiconductor fabrication plants – or "fabs" – at the Rio Rancho facility: Fab 7/C4, Fab 11, and Fab 11X. Wafer manufacturing in Fab 7 has been inoperative since June 2002 and C4 operations ended in June 2004. Fab 11 has three different manufacturing areas, designated Fab 11N, Fab 11S, and Fab 11W (for north, south, and west). Semiconductor manufacturing is completed through a series of layering steps on a silicon wafer. The major types of steps include diffusion, photolithography, layer deposition and wet/dry etching. The Rio Rancho, NM site manufactures memory and logic components on 8-inch and 12-inch wafer technology 24 hours a day, 7 days a week.

Chemicals used in the manufacturing process are brought to the facility by truck in the form of compressed gas cylinders, bulk compressed or liquefied gases, and bulk liquids, and are kept in indoor or outdoor chemical storage and handling areas near the fabs until they are used. Intel uses a "just-in-time" inventory management system, which means gases are ordered near the time that they will be used; thus, inventories of hazardous compressed gases are limited. An extensive chemical tracking system is in place to manage chemicals into and out of the factory. Some of the materials have hazardous properties. Some are toxic, others are flammable or pyrophoric (meaning they will ignite spontaneously if exposed to air), and others are corrosive.

All areas using chemicals have exhaust ventilations systems that are then routed to the appropriate air abatement equipment. Chemical monitoring systems, including visual inspection and electronic systems, to detect liquids or vapors in the event of a chemical spill are used, and the electronic systems are continuously monitored (24 hours a day, seven days a week) at a security station. Chemicals going into the factory as well as wastes coming out of the factory are in double contained piping. Liquid or solid waste streams from the manufacturing process may also contain hazardous chemicals and are kept on-site until they can be hauled away by a waste contractor for proper disposal. Some liquid wastes are treated on site in the appropriate waste treatment system to comply with established limits prior to being discharged to the City of Albuquerque's POTW.

This One-Time Event Risk Assessment examines impacts of the following possible incidents:

- Release of the contents of one or more compressed hazardous gas cylinders;
- Release of the contents of a bulk hazardous gas storage tank;
- Release of the contents of a bulk liquefied (cryogenic) gas storage tank;
- Fire resulting from an accident involving a bulk flammable gas storage tank; and
- Release of a bulk corrosive liquid with resulting spread of toxic fumes.

One-time event risk assessments are inherently limited because the assessment ultimately relies upon the preparer's best judgment as to the possible failure scenarios. However, ERM has conducted this assessment in accordance with EPA guidance and based on current knowledge and guidance, these incidents address the foreseeable accidental release scenarios. Every compressed gas, bulk gas, and bulk liquid that might be involved in the incidents listed above was evaluated, although individual modeling runs were not conducted for every chemical. Modeling was performed on a subset of chemicals that covered a broad range of chemical properties as well as hazard levels. This subset provides a benchmark for the facility.

Nontoxic or inert materials (e.g., helium and argon) were not evaluated because on-site incidents involving these materials would not result in health and safety threats beyond the facility boundaries. However, as discussed further in Section 2.1.2, bulk liquid nitrogen and bulk hydrogen are non-toxic but were evaluated due to the quantity maintained on-site.

The concentration of chemicals in liquid and solid waste streams is so dilute that accidents or releases involving wastes would have consequences far less severe than the chemicals and gases evaluated; therefore, ERM did not evaluate these waste streams.

1.2 METHODOLOGY OVERVIEW

The methodology used to assess the health risks from one-time release events at the Intel facility consists of the following steps, each of which is described in more detail later in this report:

- **Risk Screening** – The physical layout and chemical handling practices of the Intel facility were studied and chemicals stored and transported to the facility were reviewed for their general hazard potential;

- **Hazard Analysis** – Accepted risk assessment procedures – including a simple qualitative tool known as a "What-If Analysis" and a Checklist technique – were used to identify potential accidental release scenarios, probability of the release scenarios occurring, and control measures for preventing them;

- **Consequence Analysis** – Computer modeling was used to estimate off-site areas affected by toxic or flammable gas clouds or plumes from accidental releases;

- **Risk Evaluation** – Results of the hazard analysis and consequence analysis were used to estimate probabilities and consequences of the risk scenarios and to place the Intel facility one-time event release risks in context with other societal and industrial risks; and

- **Management Systems Evaluation** – Intel's management systems for preventing and mitigating chemical releases were reviewed and compared with the requirements of two federal hazardous chemical risk management regulations.

Figure 1-1 Risk Assessment Process (in accordance with EPA Guidance)

Risk Screening
What chemicals are stored and transported to the facility? What hazard potentials are associated with these chemicals?

⇩

Hazard Analysis
What potential accidental release scenarios could occur? What is the likelihood of the release scenario occurring? What control measures are in place for preventing these release scenarios?

⇩

Consequence Analysis
What area is affected by toxic or flammable gas clouds or plumes from the potential accidental releases?

⇩

Risk Evaluation
What are the probabilities and consequences from the releases in context with other risks?

The Risk Screening, covered in Section 2 of this report, consisted of site visits and evaluation of relative hazards based on the hazardous properties of materials stored and used at the facility, as well as the amount and location of each material. For example, an extremely toxic material was deemed a higher relative hazard than a nontoxic one; a material kept in large quantity was deemed a higher relative hazard than one for which only a small quantity is kept or used on-site; and a material stored outdoors near the Intel property boundary was deemed a higher relative hazard than one stored indoors near the center of the facility. A simple hazard index calculation was used to rank relative hazards of compressed and bulk hazardous gases. This ranking was then used to identify a subset of chemicals to be carried through the risk assessment. This subset of chemicals incorporates the most hazardous chemicals for a diverse range of chemical densities.

The next step in the assessment was a Hazard Analysis to identify the potential causes of accidental releases and to estimate probabilities and frequencies for various release scenarios. This analysis is detailed in Sections 3 and 4. Then, a Consequence Analysis was performed to determine the extent of the off-site impact of various hazardous gas release scenarios. Accidental releases were modeled mathematically using the U.S. Environmental Protection Agency (EPA) recommended computer model, RMP*COMP, to determine the distance from the release point to which hazardous airborne concentrations might extend. A Risk Evaluation was then conducted for the various hazard analyses and consequence analyses based on the fundamental definition of risk:

RISK = PROBABILITY x CONSEQUENCES

The risk of an accidental release causing a hazardous off-site airborne gas concentration was assessed in terms of the likelihood of a release (i.e., probability) and the off-site area affected (i.e., the consequence). The hazard analysis, release modeling, and consequence analysis for the assessment of compressed gases are described in Section 3. The same information is presented in Section 4 for bulk gases and bulk liquids. The risk evaluation for all the chemicals carried through the risk assessment is covered in Section 5.

The Intel Community Advisory Panel for the 1997 Risk Assessment (see Section 1.3 of this report for a discussion of the 1997 Risk Assessment) recommended the evaluation of an ultimate one-time release event, a release of all hazardous gases during a single incident. This analysis was conducted and is addressed in Section 6.

The hazardous materials management system for preventing hazardous chemical accidents is fundamental to the safety of any manufacturing operation. These management systems cannot be quantified in the above risk evaluation; however, since the systems inherently reduce the risk at the site, they need to be considered in the overall assessment. Therefore, Section 7 includes the Management System_Evaluation and reviews Intel's management systems for hazardous chemicals. Checklist protocols based on two federal risk management regulations were used for evaluating the technical content of Intel's management systems. The two federal programs used as guidelines include:

- Occupational Safety and Health Administration (OSHA) Process Safety Management (PSM) Rule (29 CFR 1910.119) and,
- U.S. EPA's Clean Air Act (CAA) Section 112(r) Accidental Release Prevention/Risk Management Plan (RMP) Rule (40 CFR Part 68).

Although the Intel facility is not subject to these programs because the amounts of chemicals stored at the facility are below the applicable thresholds, the general requirements of these rules offer a good example of industry-government consensus as to the key elements that constitute a thorough risk management program. These provisions were used for "benchmarking" Intel's hazardous substances risk management program.

1.3 RELATIONSHIP TO 1997 CATASTROPHIC RISK ASSESSMENT

Intel commissioned a previous comprehensive risk evaluation, including a catastrophic risk assessment, which was published in June 1997 by Radian International LLC (1). The 1997 Risk Assessment was provided to ERM, along with reaction and comments from Intel and from public reviewers. ERM reviewed the 1997 Catastrophic Risk Assessment and found no significant technical problems with the methodology or results. The protocols for a risk analysis related to accidental release of chemicals are well established and well documented. The 1997 catastrophic risk assessment relied on this existing body of information and the current study relies on the same background information and methodology. ERM has reviewed the changes that have occurred in the Intel process and material usage since publication of the previous report and has used that information to focus the current evaluation on the chemicals and processes with the greatest potential for impact to those residing near the Intel facility.

The 1997 Catastrophic Risk Assessment used a proprietary Radian computer model, referred to as CHARM, to evaluate the risks of various release scenarios. For the current assessment, ERM has used RMP*COMP, the default risk screening technique for the U.S. EPA's Off-Site Consequence Analysis under the Chemical Accident Prevention Provisions rule. RMP*COMP has been used to make the results of this evaluation more easily comparable to results of analyses conducted at other facilities under the U.S. EPA Chemical Accident Prevention Provisions rule (2).

The 1997 Catastrophic Risk Assessment identified three gases to represent all of the individual hazardous gases at a range of densities from light to heavy. The three gases previously evaluated were hydrogen fluoride, ammonia, and chlorine. ERM has conducted modeling using updated quantities of thirteen compressed and/or bulk gases. Ammonia and chlorine were again among the gases evaluated, but hydrogen fluoride is no longer used in gaseous form at the Intel facility. The thirteen gases evaluated by ERM in this assessment cover a range of densities and hazard levels, and represent nearly half of the thirty hazardous compressed and/or bulk gases used at the Intel facility. Descriptions of the gases used at the facility as well as the rationale for selecting the subset of gases to be modeled are provided in Sections 2.0 and 3.0.

1.4 SCOPE OF THE ONE-TIME EVENT RISK ASSESSMENT

This One-Time Event Risk Assessment for the Intel Rio Rancho facility addresses the larger volume, acutely hazardous chemicals present at the various gas pads, bulk quantities of hydrochloric acid, hydrogen, and cryogenic nitrogen at the facility, and transportation of chemicals by truck to and within the facility. The primary focus is on-site accidental releases of compressed and/or bulk hazardous gases. Some consideration of off-site transportation releases is also included. ERM has also evaluated the findings and recommendations from the previous risk assessment and has incorporated them as appropriate.

This report specifically addresses risk assessment related to accidental release of chemicals. The overall risk management process, illustrated in Figure 1-2, is a larger concept, of which risk assessment is only a component. A risk assessment identifies and evaluates cause and consequence scenarios to provide a quantitative measure of risk. This process allows a risk ranking of various accident scenarios. Once the risks have been ranked, the facility operator can select and implement appropriate risk control measures to minimize the occurrence of conditions that could cause an accident and take actions to mitigate the consequences of an accident, should one occur.

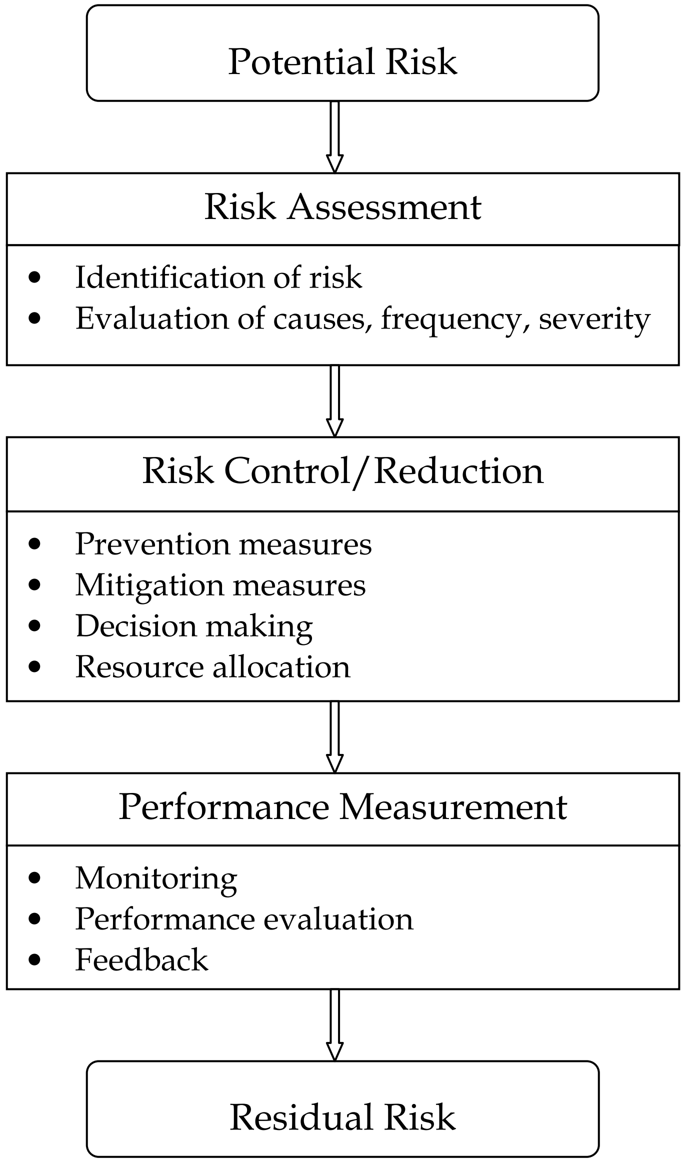
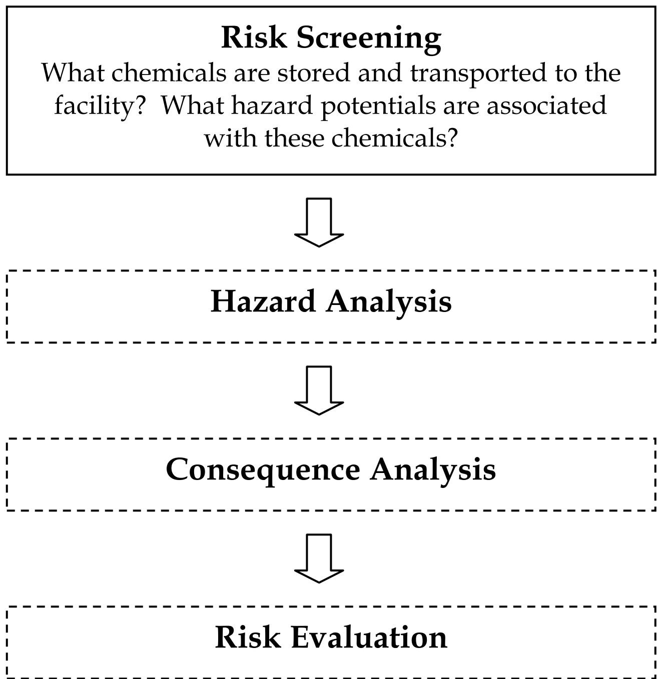


Figure 1-2
The Risk Management Process

2.0 HAZARDOUS MATERIALS INVENTORIES AND RISK SCREENING

This section addresses the first step of the Risk Assessment process, Risk Screening, as depicted below in Figure 2-1. In this section, the general hazard potential for each chemical stored at the Intel facility is developed. This hazard potential is based on the chemical inventory at the Intel facility as well as the chemical handling practices, including storage and transportation, coupled with the physical layout of the Intel facility.

Figure 2-1 Risk Assessment Process – Step 1



2.1 HAZARDOUS MATERIALS HANDLING AND INVENTORIES

ERM conducted a survey of the Intel facility to identify the hazardous chemicals used, their locations, process and storage characteristics, and to gather other information required for the risk assessment. The ERM survey was facilitated by the comprehensive and rigorous inventory control system Intel uses to document receipt and use of all chemicals. Hazardous chemicals were grouped into the following categories:

- Compressed hazardous (toxic and flammable) gas cylinders;
- Bulk hazardous gases;
- Bulk cryogenic gases;

- Bulk acidic, caustic, and solvent liquids; and

- Bulk lead and copper waste liquids.

The terminology used in the above list was adopted for convenience and to avoid confusion, although it is not entirely accurate from a technical sense. The term "compressed hazardous gas cylinders" is used here to denote gases in cylinders that can be moved around the site. The cylinders can be relatively small cylinders that can be handled and moved by one person with a wheeled dolly or they can be larger cylinders (referred to as Y cylinders) that are moved by forklifts and hoists.

Bulk hazardous and cryogenic gases are also compressed, but the use of those terms here refers to gases in larger containers that are stationary and cannot be moved. As identified later in this report, some gases are found at the Intel site both in small cylinders and in larger bulk containers. Finally, the term "hazardous" is here understood to imply conditions of either toxicity or flammability; asphyxiation is also truly a hazard, but is treated separately since there is only one material at the Intel site (bulk liquid nitrogen) that could conceivably represent an offsite asphyxiation hazard.

It should be noted that some inert and/or nonhazardous materials (e.g., helium and argon), which are contained in compressed gas cylinders and/or bulk containers, are also used at the Intel facility. These materials are not addressed in this report because ERM deemed that there is no credible off-site health or environmental risk associated with the transportation, handling, or use of these materials.

Finally, pipeline natural gas also was not addressed in this study even though an accidental or intentional pipeline rupture could represent a hazard beyond the Intel plant boundary. The scope of this study was focused on hazards that are relatively unique to the Intel facility; the natural gas pipeline infrastructure in the U.S. is both common and reliable and most citizens have a reasonably high comfort level with the associated hazards.

2.1.1 Compressed Hazardous Gas Cylinders

Compressed hazardous gases in pressurized cylinders are received by truck from several suppliers. Gas cylinders are delivered to eight locations at the Intel facility: Fab 11W, Fab 11N, Fab 11S, Fab 11X, Fab 7/C4, Fab 11X bulk gas pad, Praxair, and Air Products (see Figure 2-2 for locations of Fabs). Table 2-1 lists the compressed hazardous gas cylinders used at each fab. Note that only inert gases are used at Fab 7/C4;

therefore, this fab is not included in Table 2-1. A list of gases used at the Intel facility is provided in Appendix A.

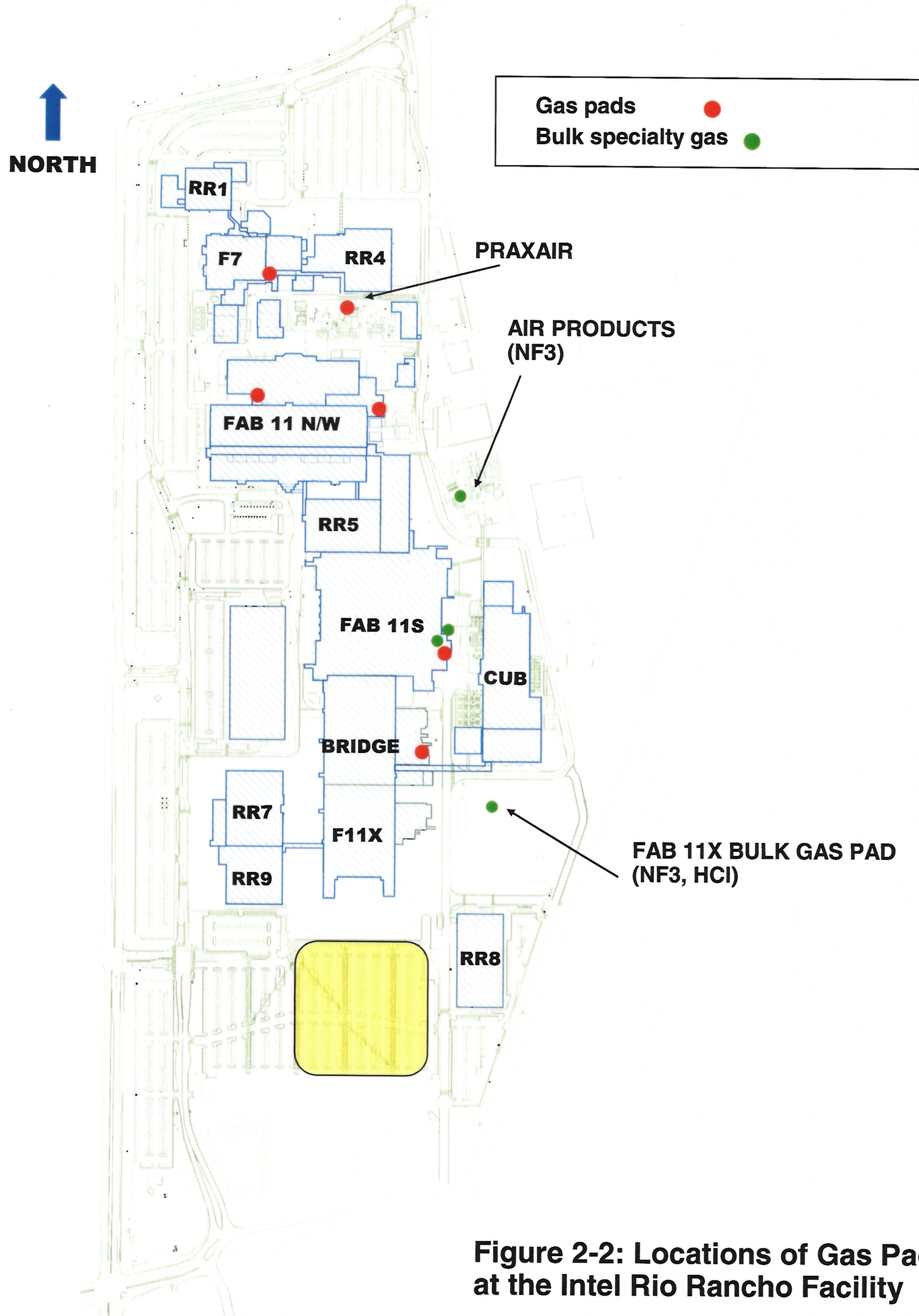


Figure 2-2: Locations of Gas Pads at the Intel Rio Rancho Facility

Table 2-1 Compressed Hazardous Gas Cylinders[1] Used at Intel Rio Rancho Facility[2]

Gas	Fab 11W	Fab 11N	Fab 11S	Fab 11X
Ammonia – NH_3	●	●	●	
Arsine – AsH_3		●	●	●
Boron Trichloride – BCl_3	●		●	
Boron Trifluoride – BF_3	●	●	●	●
Carbon Monoxide – CO	●	●		●
Chlorine – Cl_2	●	●	●	●
1% Diborane (B_2H_6) in Hydrogen				●
Dichlorosilane – SiH_2Cl_2	●	●	●	●
Difluoromethane – CH_2F_2	●	●		●
Ethane – C_2H_6	●			
1.2% Fluorine (F_2) in Inert Carrier	●	●	●	●
Fluoromethane – CH_3F				●
1% Germane (GeH_4) in Hydrogen				●
Germanium Tetrafluoride – GeF_4	●	●	●	●
Hexafluorobutadiene – C_4F_6				●
Hexafluoroethane – C_2F_6			●	●
Hydrogen Bromide – HBr	●	●	●	●
Hydrogen Chloride – HCl	●		●	●
Methane – CH_4	●			
Nitrogen Trifluoride – NF_3		●	●	●
Nitrous Oxide – N_2O	●	●	●	●
Octafluorocyclobutane – C_4F_8	●	●		●
Octafluorocyclopentene – C_5F_8	●	●		●
Phosphine – PH_3		●	●	●
Silane – SiH_4	●	●	●	●
Silicon Tetrafluoride – SiF_4	●	●	●	●
Sulfur hexafluoride – SF_6			●	
Tetrafluoromethane – CF_4			●	●
Trifluoromethane – CHF_3			●	
Tungsten Hexafluoride – WF_6			●	●

1: The term "compressed hazardous gas cylinders" is used here to denote gases in relatively small cylinders that can be transported around the site.
2: Based on 2002 Inventory.

After delivery, the gas cylinders are unloaded and moved to various gas pads – the areas where gas cylinders are kept while in use. The cylinders are connected through valves, pressure regulators, and metering equipment to orbital welded, 316 Stainless Steel tubing that transports the gases to the various manufacturing tools within the fabs. The gas pads are completely enclosed rooms within the fab manufacturing buildings, with the following exceptions:

- Two silane gas pads at Fab 11S are in their own separate buildings;
- Silane gas pad at Fab 11N at the gas unloading dock area;
- Ammonia gas pad outside Fab 11S at the gas unloading dock area;
- Silane gas pad at Fab 11X;
- Fab 11X bulk gas pad; and
- Air Products gas pad.

The smaller compressed hazardous gas cylinders (which can be moved by one person using a wheeled dolly) are kept in standard industrial gas cabinets, closed except for controlled venting. The connections from the cylinders to the process tubing are contained within the gas cabinets, along with the cylinder valves and pressure regulators. These cabinets provide secondary containment for the cylinders in the event of a leak. The larger compressed hazardous gas cylinders (referred to as Y cylinders) are stored in forklift transport saddles until connected to a gas distribution panel. The gas distribution panels are contained within gas cabinets, similar to the gas cabinets for the smaller cylinders.

The gas cabinets, which either house the entire cylinder if it is a small cylinder or house the gas distribution panel for the larger Y cylinders, are maintained under a slight vacuum provided by venting through induced draft fans that lead to dedicated gas pad scrubbers. The scrubbers remove the gases from the vent air stream in the event of leaks. As an additional precaution, many cylinder outlet lines are fitted with a flow-limiting orifice to restrict the gas release rate in the event of a major fitting leak, failure of valve closure, or break in the tubing downstream of the orifice. The enclosed, exhausted gas cabinets have hazardous gas detection in the exhaust stream to provide automated shutdown in the event of a leak.

A hoist system is used to move a larger Y cylinder from the storage saddle into a fixed saddle where it is connected to the gas distribution panel. In some cases, the fixed saddle is equipped with heater blankets and if the gas is toxic, the cylinder valve and connection are set up in an exhaust enclosure connected to an emergency scrubber. The valve exhaust enclosures provide secondary containment in the event of a leak, and they are equipped with hazardous gas detection in the exhaust stream to provide automated shutdown in the event of a leak.

The gas cylinders themselves are vessels that must meet the design, fabrication, maintenance, and manufacturing specifications of the U.S. Department of Transportation (DOT). Maintenance requirements include periodic testing, inspection, and retesting by gas suppliers.

2.1.2 Bulk Gases

Intel stores certain gases in bulk containers (i.e., larger, stationary containers). Hexafluoroethane and nitrogen trifluoride were previously identified as stored in compressed hazardous gas cylinders but they are also stored on-site in bulk stationary containers. The chemicals that are kept in both cylinder and bulk containers (hexafluoroethane and nitrogen trifluoride) were further evaluated in this assessment by including the inventories of the bulk containers together with the compressed hazardous gas cylinders previously discussed. Throughout the remainder of the report, these gases will be collectively referred to as compressed hazardous gases.

In addition, the following gases are used in manufacturing operations at the Intel facility and are stored in bulk containers:

- Nitrogen
- Oxygen
- Hydrogen.

The bulk gases are stored outdoors at the Air Products and Praxair Nitrogen plants, with a few satellite nitrogen and hydrogen tanks across the site.

Oxygen was not evaluated although two tanks are located approximately 25 feet from a hydrogen tank. While not a flammability hazard itself, this location poses some additional hazard should a simultaneous accidental release of hydrogen and oxygen occur. However, a concrete separation wall between the hydrogen and oxygen tanks should function effectively as a firewall in the event of a hydrogen leak and fire; thus, the site was determined to not require additional evaluation.

Nitrogen was further evaluated only because a large inventory of liquid nitrogen is stored on-site near the eastern property boundary. A large spill might cause a nitrogen gas plume or cloud that would displace oxygen from the affected area and could pose an asphyxiation hazard.

Hydrogen was further evaluated because of its flammability and because some of it is stored near the large liquid nitrogen tank and near the oxygen tanks. In addition to direct off-site consequences resulting from a fire or explosion involving the hydrogen tank, such an incident could cause an accidental release of the larger nitrogen inventory.

Several safety features are designed into the bulk gas storage tank systems, including:

- Gas detection monitoring for both hydrogen (four detectors) and oxygen (two detectors) with remote indication and alarm. The bulk hydrogen systems have local and remote emergency shutoff systems. The detection systems and remote shutoffs are located at the Security Command Centers and are continuously supervised 24 hours per day, 7 days per week; ;

- Local and remote tank level indication and alarm;

- Observation rounds and recording of readings; and

- Redundant controls and pressure relief devices.

The bulk gas storage tanks and their peripherals were designed taking many hazards into account. These tank systems are typical industrial facility designs used by gas suppliers in other similar installations around the country and have not been associated with any catastrophic incidents.

<u>Nitrogen</u>

The large cryogenic nitrogen tank near the east property boundary consists of a stainless steel inner shell and a carbon steel outer shell with perlite insulation in the annular space between the shells. Pressure within the tank is maintained at a low level, approximately 1 psig. The tank itself and its foundation are built to code requirements, including consideration of the local earthquake zone classification. A retaining wall located down grade from the nitrogen storage tank should effectively prevent an accidental release of frigid liquid nitrogen from spilling over the Intel property line and rolling into the valley below, instead containing a release and allowing the nitrogen to boil off without impacting off-site areas.

Other smaller nitrogen tanks are located in the bulk gas area near Fabs 11W and 11X. These smaller tanks are protected by vehicle barriers and well away from the property boundary. Due to their smaller volumes and distance from the property line, they pose no credible off-site hazard.

<u>Hydrogen</u>

Although there are several hydrogen tanks at the Intel facility, most represent no credible off-site hazard. One 6,000-gallon stainless steel hydrogen tank was evaluated. This tank is located in the inert gases area northeast of Fab 11S, which is the same area as the large nitrogen tank previously discussed. This hydrogen tank is a horizontal bullet-type tank of standard design for this service and has a maximum allowable working pressure of 150 psig, although Intel operates the tank at 85 psig. The tank rests on a concrete pad. A fence surrounding the tank at a radius of about 30 feet marks the approximate limit of the flammability hazard zone. A concrete wall between the hydrogen and oxygen tanks would function as a firewall in the event of a hydrogen leak and fire. Vehicle barriers are in place between the tank area and the nearby roadway area to keep vehicles at a safe distance from the tanks.

2.1.3 Bulk Liquids

Bulk liquids may leak or spill from their containers and contaminate land, surface waters, and groundwater, or produce vapors that affect the surrounding air. Intel handles bulk liquids throughout the Rio Rancho facility, including spent solvents, caustics (acids and bases), copper and lead wastes, and other various chemicals. The tanks deemed to present the most probable hazard to the site or nearby residents are two 10,000-gallon tanks adjacent to the Central Utility Building that contain a 37% hydrochloric acid solution; these tanks were evaluated because of the potential release of hydrogen chloride vapor to the air from a spill. A detailed hazard analysis was not applied to the other bulk liquid tanks because the hazardous constituent concentrations are so low that they pose much less threat than the hydrochloric acid tanks.

The bulk liquid hydrochloric acid tanks are vertical, cylindrical fiberglass-reinforced plastic tanks. The tanks have a secondary containment wall that could hold the entire contents of the tanks in the event of a spill. This secondary containment would allow collection of the spilled acid into another tank or tanker truck, or dilution and/or neutralization of the acid to mitigate the emission of hydrogen chloride from the concentrated solution. The acid could also be routed to an acid waste neutralization system for disposal.

2.2 *RISK SCREENING*

On the basis of the site survey screening, the One-Time Event Risk Assessment conducted by ERM focused on the compressed hazardous gases (combining the hazardous gas cylinders and the bulk hazardous gases), the large cryogenic nitrogen tank and the hydrogen tank in the same area, and the 37% hydrochloric acid storage tanks. These systems were selected based on the properties of the materials contained, their quantities, and locations. As representatives of their chemical categories, the levels of hazard posed by these materials were judged to be representative of other similar materials on-site.

To screen the relative accidental release hazard of the compressed hazardous gases, a hazardous release screening index was calculated, based on the hazard level, quantity present at the facility (including cylinder and bulk, if appropriate), and molecular weight of each gas, as follows:

$$\text{Hazardous Release Screening Index} = \frac{\text{Amount of Gas at Intel Facility x Molecular Weight}}{\text{IDLH}}$$

The total amount of gas at the facility at any time was used since the overall hazard is dependent on the maximum amount of gas that might be released. The molecular weight was used as a relative measure of the dispersion properties of the gas. The IDLH is the concentration of a gas in air that is considered "Immediately Dangerous to Life and Health" after a 30-minute exposure; IDLH values are developed by the National Institute of Occupational Safety and Health. For gases with no IDLH, an IDLH value was estimated based on the characteristics of the gas. Information on the estimation of IDLH values is contained in Appendix A.

Table 2-2 compares the hazardous release screening indices for compressed hazardous gases used at the Intel facility. Note that hydrogen is excluded from this table, even though cylinders of hydrogen gas in nitrogen carrier are used at most fabs; this material was excluded because the hazard of an incident involving hydrogen is addressed separately in Section 4.1.3 for a much larger container and the potential hazard from the cylinders of hydrogen is much less severe than from the larger container. The gases in Table 2-2 are listed in order of decreasing hazardous release screening index. The hazardous release screening does not have any physical significance or regulatory standard of comparison; the equation listed above is used to create a quantitative value for each gas in order to compare the relative hazards that each gas might pose. For example, tungsten hexafluoride has the highest index value and therefore might be expected to present the greatest potential hazard to neighbors of the facility.

Table 2-2 Compressed Hazardous Gases – Comparison of Hazardous Release Screening Index

Gas	On-Site Inventory[1] (lbs)	Molecular Weight (g/g-mol)	IDLH (ppm)	Hazardous Release Screening Index
Tungsten Hexafluoride – WF_6	3,380	298	4	251810
Chlorine – Cl_2	6,000	71	10	42600
Dichlorosilane – SiH_2Cl_2	1,650	101	5	33330
Boron Trichloride – BCl_3	1,193	117	5	27916
Octafluorocyclopentene – C_5F_8	117	212	2	12402
Hydrogen Bromide – HBr	4,480	81	30	12096
Silicon Tetrafluoride – SiF_4	552	104	6	9568
Silane – SiH_4	1,287	32	5	8237
Hexafluoroethane – C_2F_6	24,665	138	1,000	3404
Nitrous Oxide – N_2O	2,680	44	50	2358
Hydrogen Chloride – HCl	1,780	36.5	50	1299
Nitrogen Trifluoride – NF_3	11,022	71	1,000	783
Octafluorocyclobutane – C_4F_8	2,240	200	1,000	448
1% Germane (GeH_4) in Hydrogen	1	77	0.2	385
Sulfur Hexafluoride – SF_6	2,300	142	1,000	327
Germanium Tetrafluoride – GeF_4	6	149	3	298
Trifluoromethane - CHF_3	3,000	70	1,000	210
Tetrafluoromethane – CF_4	2,300	88	1,000	202
Ammonia – NH_3	2,430	17	300	138
Arsine – AsH_3	5	78	3	130
Hexafluorobutadiene – C_4F_6	240	162	667	58
Boron Trifluoride – BF_3	5	68	25	14
Phosphine – PH_3	19	34	50	13
Difluoromethane – CH_2F_2	162	52	1,000	8.4
1.2% Fluorine (F_2) in Inert Carrier	5	38	25	7.6
Carbon Monoxide – CO	310	28	1,200	7.2
1% Diborane (B_2H_6) in Hydrogen	1	28	15	1.9
Fluoromethane – CH_3F	12	34	1,000	0.4
Ethane – C_2H_6	10	30	1,000	0.3
Methane – CH_4	4	16	1,000	0.1

1: Based on 2002 Inventory.

Thirteen of the thirty compressed hazardous gases used at the Intel facility were further evaluated for off-site risk using the U.S. EPA recommended computer model for Off-Site Consequence Analysis under the Chemical Accident Prevention Provisions rule. The thirteen gases were selected primarily because they are included in the database of the U.S. EPA computer model, RMP*COMP (the remaining 17 gases are not included in the chemical database for RMP*COMP because they are not regulated as either toxic or flammable substances under this rule). The thirteen gases evaluated by ERM are:

- Ammonia – NH_3;
- Arsine – AsH_3;
- Boron trichloride – BCl_3;
- Boron trifluoride – BF_3;
- Chlorine – Cl_2;
- Diborane – B_2H_6;
- Dichlorosilane – SiH_2Cl_2;
- Ethane – C_2H_6;
- Fluorine – F_2;
- Hydrogen chloride - HCl;
- Methane – CH_4;
- Phosphine – PH_3; and
- Silane – SiH_4.

These thirteen gases cover a broad range of densities (two are lighter than air, six have densities approximately equal to air, and five are significantly heavier than air) and hazard levels (IDLH ranging from 3 ppm to 1,000 ppm), and, as seen in Table 2-2, comprise a representative sampling of the hazardous gases used at the Intel facility.

3.0 *RISKS ASSOCIATED WITH COMPRESSED HAZARDOUS GASES*

Determination of the risks to neighbors of the Intel Rio Rancho facility from operations associated with compressed hazardous gases involves the following two steps:

1. Identification and quantification of the hazards, termed Hazard Analysis, and

2. Evaluation of the outcome of a particular hazard, referred to as Consequence Analysis.

The methodology for performing a Hazard Analysis is described below in Section 3.1. The results of the Hazard Analysis for compressed hazardous gases at the Intel facility is then given in Sections 3.1.3 and 3.1.4 for fixed facility incidents and transportation incidents, respectively. The third step for determining risk, Consequence Analysis, incorporates the findings from the Hazard Analysis and is detailed in Section 3.2. Figure 3-1 depicts how these steps are incorporated in the overall Risk Assessment process.

Figure 3-1 Risk Assessment Process – Steps 2 and 3 for Compressed Hazardous Gases

Risk Screening

⇩

Hazard Analysis
What potential accidental release scenarios could occur?
What is the likelihood of the release scenario occurring?
What control measures are in place for preventing these release scenarios?

⇩

Consequence Analysis
What area is affected by toxic or flammable gas clouds or plumes from the potential accidental releases?

⇩

Risk Evaluation

3.1 HAZARD ANALYSIS

In the Hazard Analysis process, plausible potential accidental release scenarios are identified and the probabilities of such incidents estimated. This section presents the Hazard Analysis for compressed hazardous gases at the Intel Rio Rancho facility. The hazards for both fixed facilities and transportation were examined. For fixed facility releases, the scope of Hazard Analysis was confined to accidental releases large enough to have potential off-site consequences; smaller release incidents that would be confined to the site were not evaluated. Similarly, only large transportation incidents were included.

Fixed facility incidents refer to accidental releases that occur after the chemicals have been delivered to the site. Transportation incidents refer to situations that occur both on- and off-site when a delivery truck is in motion. These include failures caused by motor vehicle accidents and those from other causes, such as sabotage.

Both on-site transportation and off-site transportation within 5 miles of the Intel facility were considered. This distance was chosen since the current risk assessment addresses potential risks to neighbors of the facility, and accidents farther than 5 miles from the facility would not be expected to impact the health or safety of Intel's neighbors.

3.1.1 *Hazard Identification*

A "What-If Analysis" technique was used to identify the failure modes for compressed hazardous gases. This is a common risk assessment technique, and is described by the Center for Chemical Process Safety of the American Institute of Chemical Engineers in their book *Guidelines for Hazard Evaluation Procedures* (3). This technique involves a review of the site-specific processes by an assessor who is knowledgeable in the field of industrial accidents. The assessor looks at individual equipment components and processes and asks, "What if" a certain component failed, a certain operation was conducted improperly, and similar questions. Each of these questions becomes an accidental release scenario. For the Intel facility, various accidental release scenarios were identified in terms of possible causes and the control measures needed to prevent the incidents from occurring.

<u>Natural External Forces</u>

External forces can be a potential cause of an accidental release. However, a detailed analysis of causes such as earthquake and flood was beyond the scope of the current study. The results of such incidents cannot be reasonably predicted since there is no history of such incidents causing the kinds of releases considered in this study. In general, if such an occurrence caused a release, the magnitude of the consequences would be similar to those already developed for the other causes discussed in this report.

<u>Sabotage/Terrorism</u>

Sabotage and terrorism have also been considered as potential causes of a one-time release. Because of the unpredictable nature and lack of history of such incidents in the present context, sabotage has been handled qualitatively in this study. The consequences of a release caused by sabotage would appear to be comparable to the types of impacts defined for the other release scenarios in this study. The Intel facility is not considered a likely target for terrorist activity since terrorists favor targets that are in high-profile areas, have high population densities, and require minimal expenditure of resources planning with maximum impact.

The likelihood of sabotage and terrorism can be reduced by a number of management and physical systems, including general site security and some of the specific security procedures already in place at the Intel facility. A formal security review of the Intel facility has recently been completed. Since revealing the details of these security procedures is itself counterproductive to maintaining that security, exact details cannot be disclosed in this report. However, in general, the procedures involve limited and controlled access to plant areas provided by various security personnel and physical systems. Limited access includes the overall site as well as individual gas pads, fab areas, and other chemical use areas. The plant also employs various types of surveillance, including special alarm systems for releases and closed circuit television monitoring of gas pads.

If a sabotage event or terrorist act occurred, the impacts could be equal to or greater than those resulting from the failure of the largest bulk storage system of the most hazardous substance, which is evaluated in this section. However, the impacts are not likely to exceed those addressed in Section 6 on the ultimate one-time release scenario.

3.1.2 Probability Analysis

After scenario identification, the next step in the One-Time Event Risk Assessment is to determine the probabilities of failure for the various scenarios. Probability estimates were developed using data from a variety of published information sources (3,4,5,6,7) and proprietary industry sources. The probability analyses all required some technical assumptions.

Each failure event has a probability, which is a relative value indicating the chance of an event occurring within a specific time interval. Probability values range from 0 to 1, corresponding to no chance of an event to a certainty of an event, respectively. Probability data for rare events are limited. Catastrophic failures of gas cylinders, for example, are so rare that little substantial data exist upon which to base a probability calculation. Probabilities for the failure modes identified in this study were compiled from the open technical literature and derived from site-specific experience and the experience of some major suppliers.

A probability of 0.01 (or 1/100) per year indicates that there is 1 chance in 100 that the event will occur in one year. This probability can also be expressed as a frequency; that is, the event will likely occur once in a 100-year span.

The total probability that a given event will occur is expressed by the equation:

$$P_{event} = P_A * P_B * \ldots * P_i * \ldots * P_n$$

where:

P_{event} = probability of a specific event;
P_A = probability of condition A;
P_B = probability of condition B;
P_i = probability of each other condition required for the event to occur; and
P_n = probability of the final condition required for the event to occur.

Equations describing the required conditions for various release scenarios are summarized in Table 3-1.

Table 3-1 Probability Calculation Equations for Compressed Hazardous Gas Accidental Release Events

Event	Equation
Outdoor Release of Compressed Hazardous Gas	$P_{event} = P_C * P_O * P_M$
Indoor Release of Compressed Hazardous Gas	$P_{event} = P_C * P_I * P_S * P_M$
Transportation Release of Compressed Hazardous Gas	$P_{event} = P_A * P_{OB} * P_{CA} * P_M$

P_C = probability of cylinder failure

P_O = probability of cylinder being outdoors

P_I = probability of cylinder being indoors

P_S = probability that gas scrubber will not function as designed

P_M = probability of specified meteorological conditions

P_A = probability of transportation accident

P_{OB} = probability that particular gas of interest is on-board truck when accident occurs

P_{CA} = probability of cylinder failure during transportation accident

Considering only the probability of the failure that causes the release is not sufficient to define the probability of the specified impact. The dispersion of a released gas is governed not only by the initial conditions of the release, such as the size of the container orifice from which the gas is released, but also by the meteorological conditions at the time of release. The probability that the impact will occur thus depends also on the probability of various meteorological conditions at the time of release.

Three fundamental types of accidental release involving compressed hazardous gases might occur at the Intel Rio Rancho facility:

- Fixed facility outdoor release of compressed hazardous gases;
- Fixed facility indoor release of compressed hazardous gases; and
- Transportation incident with compressed hazardous gases.

The *Handbook of Chemical Hazard Analysis Procedures*, published by the U.S. EPA, OSHA, and U.S. DOT, contains generic failure data for major types of process equipment as well as roadway accident data (5). These data are provided as a guide for comparing various risk scenarios at a process facility or during transport of hazardous materials. Various data and calculations associated with the probability estimates are presented in Appendix B. The results of applying the calculations to scenarios in this study are presented in Table 3-2.

Table 3-2 Probability of Failure Conditions Used in Hazard Analysis for Intel's Compressed Hazardous Gases

Event	Probability	Frequency
Gas Cylinder Failure		
- Minor Leak	0.0000045 / year	222,222 years
- Major Leak	0.00000038 / year	2,631,600 years
Major Transportation Accident	0.0000000072 / mile	138,890,000 miles
Cylinder Failure Due To Transportation Accident		
- Off-site Accident	0.5 / incident	1 failure per 2 incidents
- On-site Accident	0.25 / incident	1 failure per 4 incidents

For this Hazard Analysis, data also were obtained from sources in the compressed gas industry. Similar to Intel, they have not experienced any catastrophic releases from compressed gas cylinders. Using these industry data, failure rates for several subcatastrophic events were determined. Catastrophic events would have even lower probabilities than the subcatastrophic events.

3.1.3 Fixed Facility Incidents

In considering compressed hazardous gas incidents, it is important to distinguish between outdoor and indoor incidents. Cylinders are outdoors during delivery to the Intel facility and during offloading. After that, most cylinders of the hazardous gases evaluated in this study are kept indoors within specially vented gas pad areas until they are empty, though some nitrogen trifluoride, hydrogen chloride, and ammonia gas cylinders are kept outdoors (but typically have scrubbed exhaust).

Tetrafluoromethane and nitrous oxide are the only compressed hazardous gases stored outside at the Fab 11X bulk gas pad and these cylinders are not equipped with scrubbed exhaust as the chemicals are considered inert.

Outdoor releases from gas cylinders are more threatening to the community than indoor releases. However, the probability of an outdoor release is lower than the probability of an indoor release because the fraction of time a "typical" cylinder is outdoors while on-site and during transport within the five-mile radius is small compared to the time the cylinder is indoors.

Tables 3-3 and 3-4 present hazard scenarios for Intel's compressed hazardous gas cylinders stored outdoors and indoors, respectively. In these tables, the results of the "What-If" analysis are shown in terms of failure modes and effects. The first column shows the postulated failure mode. The actions that could cause the failure event are shown in the second column. The consequence column describes the release in specific terms, such as whether the release is sudden or prolonged, large or small. The final two columns list prevention and mitigation measures currently employed by Intel for each postulated failure. Tables 3-3 and 3-4 show that significant controls are in place to prevent or mitigate the cases that ERM identified or hypothesized.

Table 3-3 Cylinder Release What-If Analysis for Cylinders Located Outdoors

What-If Event	Cause	Consequences	Prevention	Mitigation
Cylinder rupture	Overpressure from fire	Rapid release of cylinder contents	Fusible plug No flammables or combustible materials within 50 feet	Buildings provide barriers to delay dispersion and increase dilution before gas goes off-site
	Transfer of material from higher pressure source that exceeds cylinder pressure rating	Rapid release of cylinder contents	Design precludes higher pressure system from connection to cylinder	Buildings provide barriers to delay dispersion and increase dilution before gas goes off-site
	Cylinder dropped or knocked over	Release of cylinder contents	Cylinder designed to withstand drop impact force if dropped or struck Special cart for handling	Buildings provide barriers to delay dispersion and increase dilution before gas goes off-site
Cylinder hole	Corrosion	Rapid release or slow release of cylinder contents	Cylinder construction materials based on intended contents and design specifications Vendors inspect and leak check each cylinder prior to delivery Intel visually inspects cylinders upon receipt then places them in monitored enclosures	Buildings provide barriers to delay dispersion and increase dilution before gas goes off-site Leaking cylinder placed in secondary containment and returned to supplier
	Puncture (e.g., forklift)	Rapid release or slow release of cylinder contents	Special cylinder cart used for small cylinders Cylinder designed to withstand drop impact force if dropped or struck Cylinders stored within gas cabinets or in fenced areas	Leaking cylinder placed in secondary containment and returned to supplier
Cylinder valve break	Cylinder dropped or knocked over	Release of cylinder contents	Cylinder valve cover designed to withstand force if dropped or struck Operator training Special cylinder cart Vendors inspect and leak check each cylinder prior to delivery	Emergency response procedure

What-If Event	Cause	Consequences	Prevention	Mitigation
			Intel visually inspects cylinders upon receipt then places them in monitored enclosures	
Cylinder valve leak	Corrosion	Slow release of cylinder contents	Cylinder valve construction materials based on intended contents Supplier inspection and testing Intel acceptance inspections	Leaking cylinder placed in secondary containment and returned to supplier
	Worn valve stem packing	Slow release of cylinder contents	Cylinder valve construction materials based on intended contents Supplier inspection and testing Intel acceptance inspections	Leaking cylinder placed in secondary containment and returned to supplier

Table 3-4 Cylinder Release What-If Analysis for Cylinders Located Indoors

What-If Event	Cause	Consequences	Prevention	Mitigation
Cylinder rupture	Overpressure from fire	Rapid release of cylinder contents to confined area	Fusible plug No flammables or combustible materials within 50 feet	Cylinder in closed gas cabinet Gas cabinet in closed room Gas cabinet and room vent through scrubber and backup scrubber is available
	Transfer of material from higher pressure source that exceeds cylinder pressure rating	Rapid release of cylinder contents to confined area	Design precludes higher pressure system from connection to cylinder	Cylinder in closed gas cabinet Gas cabinet in closed room Gas cabinet and room vent through scrubber and backup scrubber is available
	Cylinder dropped or knocked over	Release of cylinder contents to confined area	Cylinder designed to withstand drop impact force if dropped or struck Special cart for handling	Cylinder in closed gas cabinet Gas cabinet in closed room Gas cabinet and room vent through scrubber and backup scrubber is available Leaking cylinder placed in secondary containment and returned to supplier
Cylinder hole	Corrosion	Release of cylinder contents to confined area	Cylinder construction materials based on intended contents Supplier inspection and testing Intel acceptance inspections	Cylinder in closed gas cabinet Gas cabinet in closed room Gas cabinet and room vent through scrubber and backup scrubber is available Leaking cylinder placed in secondary containment and returned to supplier

What-If Event	Cause	Consequences	Prevention	Mitigation
	Backflow of reactive mixture into cylinder	Chemical reaction within cylinder causing rapid corrosion and rupture	Maintain separate systems for incompatible materials	Cylinder in closed gas cabinet Gas cabinet in closed room Gas cabinet and room vent through scrubber and backup scrubber is available Leaking cylinder placed in secondary containment and returned to supplier
Cylinder valve break	Cylinder dropped or knocked over	Release of cylinder contents to confined area	Cylinder valve cover designed to withstand force if dropped or struck Operator training Special cylinder cart	Cylinder in closed gas cabinet Gas cabinet in closed room Gas cabinet and room vent through scrubber and backup scrubber is available Leaking cylinder placed in secondary containment and returned to supplier
Cylinder valve leak	Corrosion	Release of cylinder contents to confined area	Cylinder valve construction materials based on intended contents Supplier inspection and testing Intel acceptance inspections	Cylinder in closed gas cabinet Gas cabinet in closed room Gas cabinet and room vent through scrubber and backup scrubber is available Leaking cylinder placed in secondary containment and returned to supplier
	Worn valve stem packing	Slow release of cylinder contents	Cylinder valve construction materials based on intended contents Supplier inspection and testing Intel acceptance inspections	Leaking cylinder placed in secondary containment and returned to supplier

The most significant compressed hazardous gas cylinder controls at the Intel facility are:

- All compressed gas cylinders must meet U.S. DOT regulations and specifications. The cylinders are constructed to withstand the fill pressures and handling during transport and use. Gas suppliers test all cylinders every 5 to 10 years (as required by DOT) and inspect every cylinder before it leaves the warehouse. Intel performs a visual inspection of every cylinder upon receipt.

- Hazardous gas cylinders, connections, and gas panels considered in this study are installed within closed gas cabinets that isolate them from the gas pads in which they are located, except for controlled venting from the room through the gas cabinet to a gas scrubber. The pressure in each gas pad is negative with respect to the outside so that any leak will not leave the room. Both the gas cabinets and the gas pads vent through the scrubber in the event of a leak. A backup scrubber is installed on all gas pads to ensure that one is always operational.

- Hazardous gas cylinders, connections, gas panels and distribution lines are equipped with Gas Leak Detection Systems that send an alarm active signal to a continuously (24 hours per day, 7 days per week) supervised Security Command Center console. Life Safety Systems such as fire detection, environmental exhaust systems and other safety monitor systems also report into the Security Command Center consoles. Security notifies the Emergency Response Team (ERT) on all active alarms, and ERT then takes appropriate response measures.

- Helium leak checks on gas lines are performed for each cylinder change.

- The cylinders are located in rooms with cinder block walls, concrete floors, and steel infrastructure with no nearby flammable or combustible materials. In addition, all areas are equipped with fire protection.

- Outdoor hazardous gas cylinders are also away from flammable or combustible materials except during brief periods of transportation when the cylinders are near the fuel tank on the vehicle.

- Three levels of qualifications are required before a person can be fully certified to handle compressed gases at Intel. The most basic qualification only allows a person access to the gas pads. The intermediate level allows a person to remove the cylinder from the truck, using a special hand truck to prevent dropping the cylinder. The highest level of certification allows the technician to change out, maintain, and adjust the connections and metering equipment at each gas cabinet station.

- Access to the gas pads is limited and continuously monitored via closed circuit security cameras. A scan card reader on the entrance door requires two people with the appropriate safety training and authorization to open the door.

- Intel uses a "just-in-time" inventory management system, so gases are ordered near the time that they will be used; thus, inventories of hazardous compressed gases are limited.

The probability of an accidental hazardous gas release at the Intel facility was determined by multiplying the gas cylinder failure probabilities shown in Table 3-2 by the number of cylinders of hazardous gas handled per year, accounting for both indoor and outdoor releases. The results of this calculation are shown in Table 3-5. Only major leaks have the potential to create off-site impacts. Because of the controls used on cylinders indoors at the Intel facility, only major outdoor leaks have a realistic probability of causing off-site impacts. ERM assumed that each cylinder is outdoors half the time even though most of the cylinders are kept indoors nearly all the time they are at the Intel facility; this assumption accounts for the few cylinders that are kept outdoors and ensures that the analysis overestimates the risk. The cumulative probability of a major leak outdoors is about 0.0003 per year; stated as a frequency, a major outdoor gas leak from a single gas cylinder at the Intel Rio Rancho facility might be expected every 3,300 years.

Table 3-5 Fixed Facility Incident Probabilities for Compressed Hazardous Gases

Gas	Amount of Gas in Cylinder[1] (lbs)	Number of Cylinders Handled per Year[1]
Ammonia – NH_3	55	17
	500	4
Arsine – AsH_3	0.88	46
Boron Trichloride – BCl_3	42.5	18
	35	232
Boron Trifluoride – BF_3	0.86	31
	0.57	9
	0.29	53
Carbon Monoxide	15.5	20
Chlorine – Cl_2	100	139
Diborane – B_2H_6	0.086	4
Dichlorosilane – SiH_2Cl_2	50	60
Difluoromethane – CH_2F_2	9	15
Ethane – C_2H_6	10	1
Fluorine – F_2	0.52	6
	0.10	16
Fluoromethane – CH_3F	6	12
Germane – GeH_4	0.367	4
Germanium Tetrafluoride – GeF_4	0.4	13
	1.37	10
Hexafluorobutadiene – C_4F_6	30	8
Hexafluoroethane – C_2F_6	23,540	1
	1,125	1
Hydrogen Bromide – HBr	140	44
Hydrogen Chloride – HCl	65	13
	500	2
Methane – CH_4	4	1
Nitrogen Trifluoride – NF_3	4,379	12
	432	16
	50	36
Nitrous Oxide – N_2O	600	14
	70	214
Octafluorocyclobutane – C_4F_8	140	29
Octafluorocyclopentene – C_5F_8	4.41	41
	19	3
Phosphine – PH_3	2.866	4
	0.19	62
	0.06	37
	0.37	8
Silane – SiH_4	33.1	126
Silicon Tetrafluoride – SiF_4	55	50
	1.85	7
	0.51	23
Sulfur Hexafluoride – SF_6	1,150	2
Tetrafluoromethane – CF_4	575	4
Trifluoromethane – CHF_3	1,500	2
Tungsten Hexafluoride – WF_6	130	105
Total Cylinders Handled, per year		**1,575**
Probability of Major Leak, per year, per cylinder		**0.00000038**
Total Probability of Major Leak, per year		**0.0006**
Probability of Major Leak in Outdoor Cylinder, per year		**0.0003**
Frequency of Major Leak in Outdoor Cylinder, years		**3,342**

1: Based on 2002 Inventory.

3.1.4 Transportation Incidents

Intel's concern with accidental releases during the transport of hazardous materials, with a focus on toxic and flammable gases, encompasses both on-site and off-site transportation. In either case, the direct responsibility for prevention and mitigation of a transportation incident resides with the chemical supplier. However, if a transportation incident occurred anywhere near the Intel facility, there is the potential that local residents could be adversely impacted. Therefore, limited consideration of these incidents was deemed appropriate for this study in order to compare them with the fixed facility risks.

All chemicals are transported to Intel by truck. After arrival at the site by public roadways, on-site transport is over paved roadway and yard areas to the various unloading locations. Any transportation accident has two distinct components that might contribute to an accidental release. The first is a roadway incident and the second is what happens to the compressed hazardous gas cylinder as a result of the incident.

Whether a truck is on or off the Intel property influences the consequences of the incident. Off-site incidents have the potential for more serious consequences because of their proximity to the general public, and the probabilities of off-site incidents are higher since the setting and conditions cannot be well controlled. However, in addition to Intel's commitment to utilizing reputable, safe chemical suppliers, the trucks are subject to stringent U.S. DOT regulations for transporting chemicals.

An on-site transportation incident would be much less likely and less severe than an off-site incident because the truck would be traveling at much slower speeds on the Intel facility and encountering fewer road hazards. The routing and controls for on-site transportation are within Intel's control. To ensure that appropriate control measures are applied, Intel engages reputable suppliers, controls on-site routing and speed limits, maintains on-site road and yard conditions, and provides on-site security and supervision. Once a vehicle is ready to unload, Intel adheres to site-specific unloading procedures.

The most obvious potential cause of an accidental release from transportation is a motor vehicle accident involving a collision or rollover. There are, however, other potential causes. These are listed in Table 3-6, along with categories of typical control measures.

Table 3-6 Potential Cause Categories for Transportation Accidental Releases

Failure Event	Control Measure
Motor vehicle accident involving collision or roll-over	Driver training and qualification In-transit procedures Vehicle maintenance Routing according to road conditions and traffic load
Improper loading and securing of shipment	Shipping personnel training and qualification Shipping procedures and supervision
Latent defect in shipping container	Container inventory and control procedures Container maintenance procedures Shipping procedures
Sabotage or vandalism to vehicle or its contents	Driver training and qualification In-transit procedures Shipping procedures and supervision Unloading procedures and supervision
Vehicle involvement in fire other than that caused by roadway accident	Driver training and qualification In-transit procedures Vehicle maintenance On-board fire protection equipment Routing

The probability of a transportation incident depends on both the probability of an accident and the probability that the accident will result in an accidental release. Probability data for chemical transportation accidents in general were obtained from the *Handbook of Chemical Hazard Analysis Procedures* (5). Values of average incidents per miles traveled were presented for accidents of differing severities. These probabilities were used along with the distances specified for on-site and off-site travel of Intel chemical deliveries to calculate the frequency of incidents that might occur with Intel chemical transportation.

For off-site accidents, a distance of 5 miles from the Intel facility was selected as the basis for the calculations. For on-site incidents, the distance of 0.5 mile from the plant entry gate on Sara Road to the general delivery area around Fab 11 was used. This is the longest delivery distance within the site property. The total distance for a given material depends on these travel distances and the total deliveries per year.

The incidence of compressed hazardous gas releases from transportation accidents depends on the potential for an accident, the severity of the accident, and the potential for a cylinder to be damaged enough to cause a release. Since Intel's suppliers have not experienced such an event, there are no historical data upon which to base a probability. Therefore, a probability was calculated using various assumptions.

The major accident rate for trucks – obtained from the *Handbook of Chemical Hazard Analysis Procedures* (5) – is 0.0000000072 per mile. Stated another way, there is one major truck accident – on average – for every 138.9 million truck miles driven. This probability is then adjusted for the frequency and distance of deliveries applicable to Intel. Thus, multiplying this accident rate by the travel distances described above (5 miles per trip for off-site incidents and 0.5 mile per trip for on-site incidents) and by the number of compressed hazardous gas deliveries per year gives the estimated number of accidents. Intel receives compressed gas shipments twice per day, five days per week, on average; Table 3-5 shows that Intel receives approximately 1,575 gas cylinders per year, so each shipment carries, on average, about 3 cylinders. In the absence of actual failure data for cylinders, ERM assumed a relatively high rate of accidents resulting in an accidental release. Assuming that 50% of major off-site accidents and 25% of major on-site accidents result in cylinder failure, the probability for hazardous gas releases from transportation accidents is approximately 0.0000094 per year for off-site incidents (within 5 miles of the Intel facility) and approximately 0.000000468 for on-site incidents. The cumulative probability of a cylinder failure attributable to a transportation accident is about 0.0000099. In terms of frequency, a transportation accident – either on-site or off-site – resulting in a gas cylinder failure might be expected once every 100,000 years.

3.2 CONSEQUENCE ANALYSIS

The consequence analysis for compressed and/or bulk hazardous gas release from the Intel Rio Rancho facility was used to determine the effects of accidental releases in terms of areas affected by a specified airborne concentration of a given gas. The impacts of accidental releases of thirteen hazardous gases were modeled using RMP*COMP. Modeling provides the hazardous endpoint distance of the gas from the point of release. From this information, the "vulnerability zone" can be determined. U.S. EPA defines the vulnerability zone as a circle around the release site corresponding to the maximum distance reached by a specified airborne concentration (4).

The vulnerability zone is a useful concept for emergency preparedness and planning. However, the zone encompasses an area much larger than would directly be affected by the gas plume or cloud in any given release. The vulnerability zone is generated by rotating any given plume 360° around the release point. For a given release incident, the actual plume would be oriented along an axis in only one direction at a time, depending on the prevailing wind. In addition, only that portion of the plume that crosses the property line causes off-site impacts.

The U.S. EPA Chemical Accident Prevention Provisions rule (2) calls for worst-case modeling of an instantaneous release of a full vessel inventory. However, the likelihood of such a worst-case incident is remote at facilities, such as Intel, that have certain safeguards in place. One of Intel's most notable controls is a flow-restricting orifice on toxic gas cylinders to reduce the gas release rate during most plausible release scenarios. U.S. EPA recognizes this and provides for "alternative case" release scenario modeling. The alternative case is defined by U.S. EPA (15) as a scenario that is more likely to occur than the worst-case release scenario. The modeling conducted by ERM used the alternative case release scenario in RMP*COMP. While the alternative case allows for incorporation of some mitigation factors, it still overestimates the distance to endpoints because many defaults for the alternative case are worse than actual conditions and not all of the mitigating factors are taken into account. The following table summarizes the default parameters used for the worst-case and alternative scenarios in RMP*COMP.

Table 3-7 Required Parameters for RMP*COMP Modeling

Parameter	Worst-Case Scenario	Alternative Case Scenario
Wind Speed/Stability	1.5 meters per second and F stability	3 meters per second and D stability[1]
Ambient Temperature/Humidity	25°C and 50% humidity	25°C and 50% humidity
Height of Release	Ground level (toxic substances)	Ground level (toxic substances)
Surface Roughness	Urban or rural	Urban or rural
Temperature of Released Substance	Liquids to be released at the highest daily maximum temperature or at process temperature.	Substances can be released at a process or ambient temperature that is appropriate for scenario.

1: Class D is a neutral atmospheric stability class; neutral conditions are associated with relatively strong wind speeds and moderate solar radiation.

The above table demonstrates that minimal differences exist between the worst-case and alternative scenarios. In addition, when options were available, ERM selected parameters that resulted in higher impacts (e.g., ERM selected rural surface roughness instead of urban because a flat terrain resulted in higher impacts). ERM also modeled a 1-minute release scenario and a 10-minute release scenario to assess both an "instantaneous" and slower release. While the alternative scenario allows for a slower release rate, which accounts for the decreased release rate resulting from the application of a restricted flow orifice, the instantaneous releases were also evaluated.

The modeling inputs used for this analysis are summarized in Table 3-8. Even when using the alternative case release scenario in RMP*COMP, there are relatively few user-selectable inputs. Two options are available for "material state;" ERM specified "unliquefied gas." Several test modeling runs were conducted using the other material state option, "liquefied gas," but there was no difference in the model results.

For an outdoor release, two different release rates were modeled:

- A "fast" rate such that the entire contents of the largest single container of gas would be released in 1 minute; and

- A "slow" rate such that the contents would be released in 10 minutes.

For an indoor release, the release rate was selected such that the entire contents would be released to the atmosphere in 30 minutes; this was done to account for gas being held up indoors before finding its way outdoors.

Two types of "surroundings" can be selected, urban or rural. "Rural" surroundings were specified because there is a mixture of terrain types in the area and selecting this input results in higher impacts than the alternative, "urban" surroundings.

The model allows for mitigation measures by selecting "enclosed space." The "enclosed space" option is designed to represent sheltered outdoor locations such as open sheds or covered storage areas. Although the "enclosed space" option does not fully account for the level of mitigation provided by the complete enclosure of a gas cabinet within a building or for the gas scrubbers used by Intel, it was employed for the indoor release scenarios. For outdoor releases, no mitigation measure was used.

Atmospheric Stability Class is a term used in atmospheric dispersion modeling to account for the stability of the air in the atmosphere. Very stable air results in relatively poor atmospheric mixing, which leads to higher pollutant concentrations and slower decay of the pollutant concentration. Choosing the "alternative case" release scenario automatically selects Atmospheric Stability Class "D." Class D is a neutral atmospheric stability class; neutral conditions are associated with relatively strong wind speeds and moderate solar radiation.

The wind speed also impacts the amount of atmospheric mixing. Choosing the "alternative case" release scenario automatically selects a wind speed of 3 meters per second, or about 7 miles per hour. This wind speed is a relatively calm wind for the Rio Rancho area and will result in relatively high predicted impacts of a given release.

*Table 3-8 Modeling Inputs for Consequence Analysis Using RMP*COMP*

Parameter	Input	
	Outdoor Release	**Indoor Release**
Type of Release	Alternative (accounts for restricted flow orifice)	
Amount of Material Released	Full contents of largest container at facility	
Material State	Unliquefied (results same as for "liquefied")	
Release Rate	100%, 10% of contents per minute	3.33% of contents per minute
Release Duration	1 minute, 10 minutes	30 minutes
Surroundings	Rural (predicts higher impacts than "urban")	
Mitigation Measures	None	Enclosed space
Atmospheric Stability Class	D (not a user-selectable input)	
Wind Speed	3 m/s (not a user-selectable input)	

The hazardous endpoints predicted by the RMP*COMP model for releases of compressed hazardous gases at the Intel Rio Rancho facility are summarized in Table 3-9 (complete outputs from the modeling runs are provided in Appendix C). RMP*COMP evaluated methane, ethane, silane, and dichlorosilane as flammable gases; the endpoints specified for releases of these gases indicate the distance to either an overpressure of 1 psi (from an explosion) or the lower flammability limit (for a vapor fire hazard).

*Table 3-9 RMP*COMP Modeling Results for Compressed Hazardous Gas Releases*

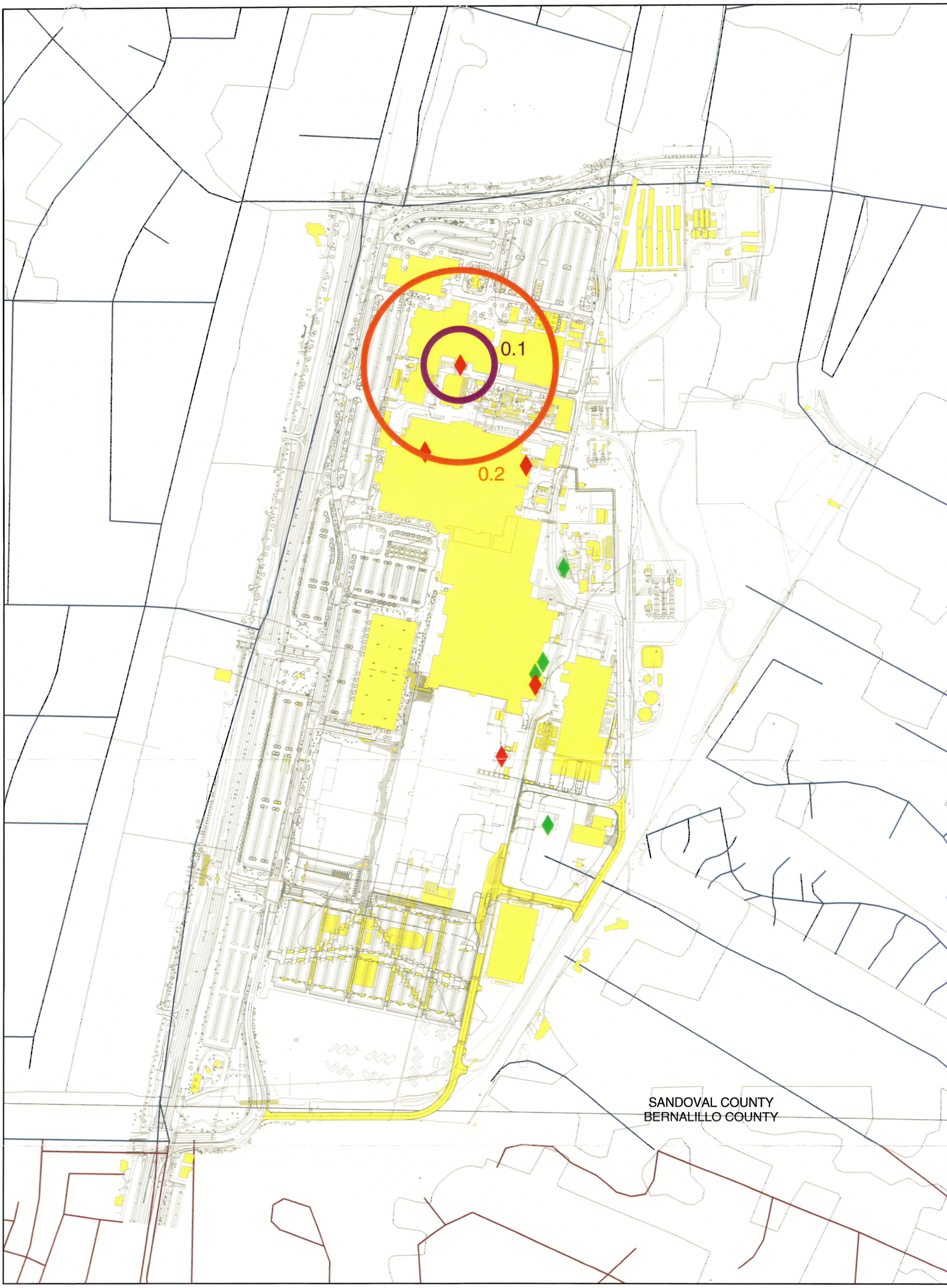
Gas	Amount of Gas in Largest Container[3] (pounds)	Hazardous Endpoint (miles)		
		Outdoor Release 1 Minute	Outdoor Release 10 Minutes	Indoor Release
Ammonia – NH_3	500	0.5	0.2	Note 1
Arsine – AsH_3	0.88	0.2	0.2	0.2
Boron Trichloride – BCl_3	42.5	0.2	0.2	0.1
Boron Trifluoride – BF_3	0.86	<0.1	<0.1	<0.1
Chlorine – Cl_2	100	0.5	0.2	0.1
Diborane – B_2H_6	0.086	0.1	0.1	0.1
Dichlorosilane – SiH_2Cl_2	50	<0.1	<0.1	Note 2
Ethane – C_2H_6	10	<0.1	<0.1	Note 2
Fluorine – F_2	0.52	0.2	0.2	0.2
Hydrogen Chloride – HCl	500	0.4	0.4	Note 1
Methane – CH_4	4	0.1	0.1	Note 2
Phosphine – PH_3	2.866	0.2	0.2	0.2
Silane – SiH_4	33.1	0.02	0.02	Note 2

1: 500-lb containers of ammonia and hydrogen chloride are not kept indoors.
2: RMP*COMP does not calculate endpoints for flammable materials stored indoors.
3: Based on 2002 Inventory.

Except for hydrogen chloride gas and ammonia, the hazardous endpoints for releases of compressed hazardous gases and the associated vulnerability zone are illustrated on Figures 3-2 and Figure 3-3. The figures only display the minimum, maximum and average hazardous endpoints for the indoor and outdoor release scenarios; an endpoint for each chemical is not illustrated. The range of hazardous endpoints for indoor releases is displayed on Figure 3-2 and the range for outdoor releases is displayed on Figure 3-3. Compressed hazardous gases can be stored at various indoor and outdoor gas pad locations which are marked on both figures. The ranges of vulnerability zones depicted on the figures assume the worst-case release points for both indoor and outdoor scenarios. In other words, Figures 3-2 and 3-3 illustrate the range of hazardous endpoints assuming the release point occurs at the indoor and outdoor gas pads that are nearest to the Intel property boundary.

The hazardous endpoints for releases of hydrogen chloride gas and ammonia are illustrated on Figure 3-4. The modeling results summarized in Table 3-9 assumed a release of the largest on-site container, which is 500 pounds for hydrogen chloride gas and ammonia. Since these containers are maintained in one location, the endpoints depicted in Figure 3-4 are based on releases from the actual locations of the 500-pound containers. The 500-pound container of hydrogen chloride gas is located at the outdoor bulk specialty gas pad east of Fab 11X. The 500-pound container of ammonia is located at the outdoor bulk specialty gas pad directly on the east side of Fab 11S.

The range of hazardous endpoints and associated vulnerability zones for releases due to on-site transportation accidents are shown in the next section on Figure 4-3. The range of endpoints on Figure 4-3 addresses on-site transportation incidents for compressed hazardous gases as well as bulk gas and liquids. The hazardous endpoints are the same as for the outdoor release scenario (summarized in Tables 3-9); the difference is in the location of the release point. Figure 4-3 illustrates the worst-case location (i.e., the on-site location with the most off-site impact) for an outdoor release associated with an on-site transportation incident instead of due to a storage incident.



F:\0021158\Intel\Task 11 Report\One Time Event\GIS\Fig 3-2

Legend

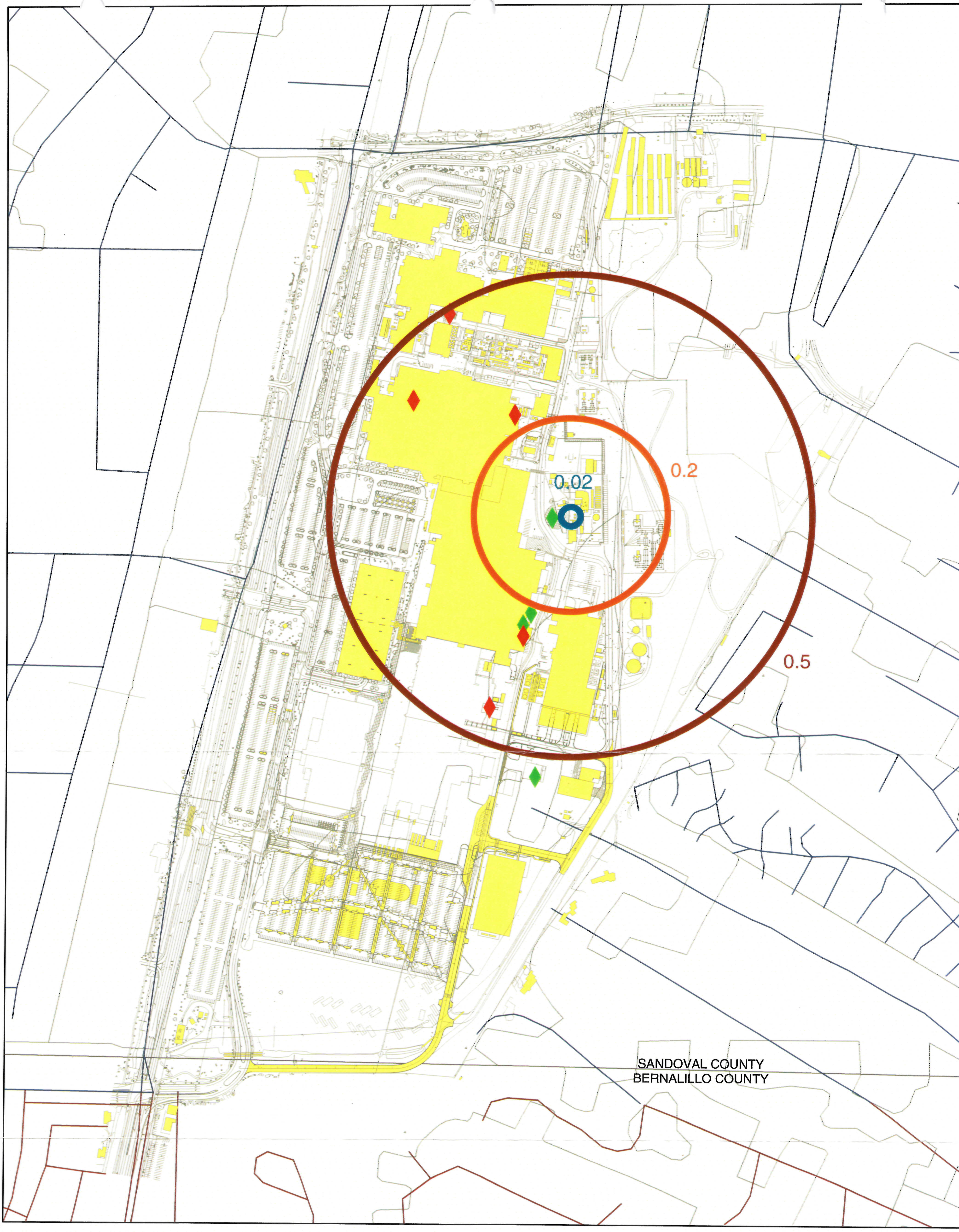
- Bulk Specialty Gas Pads
- Gas Pads
- Impact area for a compressed hazardous gas release with a hazardous endpoint of 0.2 miles
- Impact area for a compressed hazardous gas release with a hazardous endpoint of a 0.1 mile

0 125 250 500 750 1,000 Feet

N S W E

Figure 3-2
Impact Areas for Indoor Fixed Facility Releases of Compressed Hazardous Gases

ERM
Environmental Resources Management
5950 S. Willow Drive, Suite 200
Greenwood Village, CO 80111



F:\0021158\Intel\Task 11 Report\One Time Event\GIS\Fig 3-3

Legend

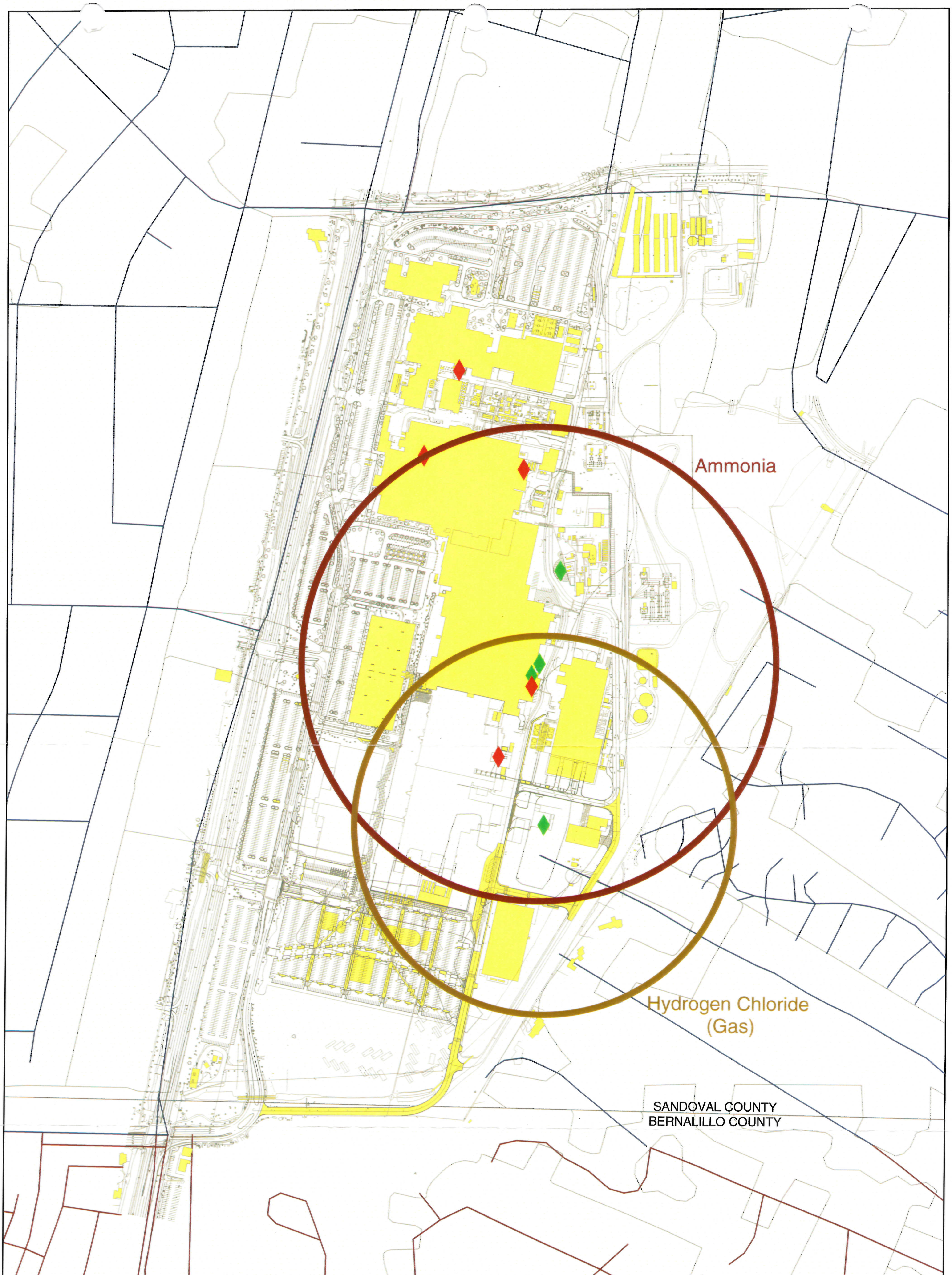
- Bulk Specialty Gas Pads
- Gas Pads
- Impact area for a compressed hazardous gas release with a hazardous endpoint of 0.02 miles
- Impact area for a compressed hazardous gas release with a hazardous endpoint of 0.2 miles
- Impact area for a compressed hazardous gas release with a hazardous endpoint of a 0.5 miles

0 125 250 500 750 1,000 Feet

N E S W

Figure 3-3
Impact Areas for Outdoor Fixed Facility Releases of Compressed Hazardous Gases

ERM.
Environmental Resources Management
5950 S. Willow Drive, Suite 200
Greenwood Village, CO 80111



F:\0021158\Intel\Task 11 Report\One Time Event\GIS\Fig 3-4

Legend

Bulk Specialty Gas Pads

Gas Pads

Impact area for release of Hydrogen Chloride gas with a hazardous endpoint of 0.4 miles

Impact area for release of Ammonia with a hazardous endpoint of a 0.5 miles

0 125 250 500 750 1,000 Feet

N W E S

ERM

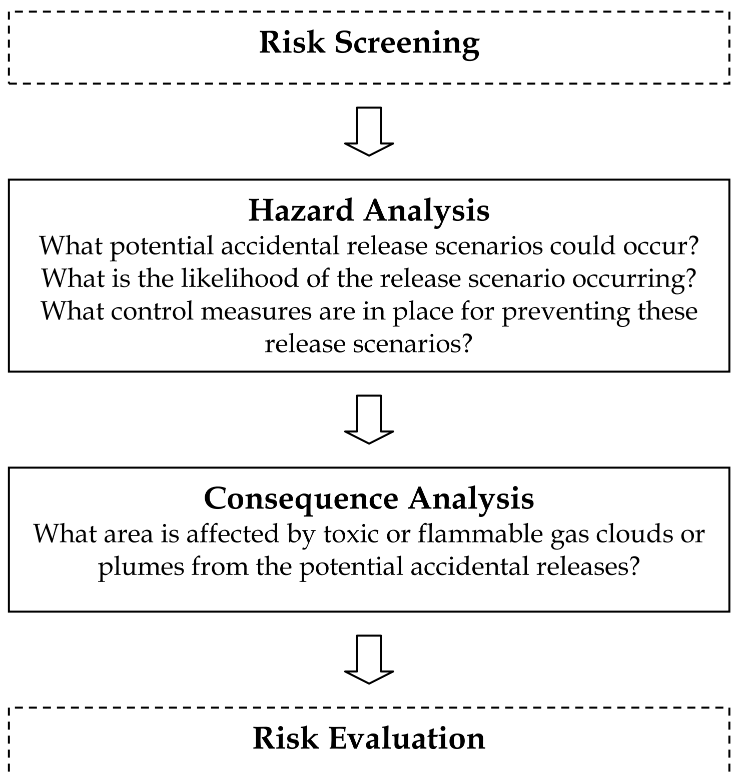
Figure 3-4
Impact Areas for Outdoor Fixed Facility Releases of Hydrogen Chloride and Ammonia Gases

Environmental Resources Management
5950 S. Willow Drive, Suite 200
Greenwood Village, CO 80111

4.0 RISKS ASSOCIATED WITH BULK GASES AND LIQUIDS

Determination of the risks to neighbors of the Intel Rio Rancho facility from operations associated with bulk gases and liquids involve the same two steps that were conducted for the compressed hazardous gases and described in Section 3 of this report: Hazard Analysis (identification and quantification of the hazards) and Consequence Analysis (evaluation of the outcome of a particular hazard). The Hazard Analysis process is summarized briefly in Sections 4.1.1 and 4.1.2. The results of the Hazard Analysis for bulk gas and liquid operations are discussed in Section 4.1.3 for fixed facility incidents and Section 4.1.4 for transportation incidents. Section 4.2 discusses the Consequence Analysis and presents the results of that analysis for bulk gases and liquids.

Figure 4-1 Risk Assessment Process – Steps 2 and 3 for Bulk Gases and Liquids



4.1 HAZARD ANALYSIS

Hazard analysis consists of two steps: hazard identification and probability analysis. These steps are addressed briefly in Sections 4.1.1 and 4.1.2, respectively. Additional information on the Hazard Analysis process is contained in Section 3.1 of this report.

Hazard Analysis identifies plausible potential accidental release scenarios and estimates the probabilities of such incidents. The hazards for both fixed facilities and transportation were examined. For fixed facility releases, the scope of hazard analysis was confined to accidental releases large enough to have potential off-site consequences; smaller release incidents that would be confined to the site were not evaluated. Both on-site transportation and off-site transportation within 5 miles of the Intel facility were considered. Only major transportation incidents were included.

4.1.1 Hazard Identification

A checklist technique was used to identify large release scenarios for bulk gases and liquids. This common risk assessment technique is described in the *Guidelines for Hazard Evaluation Procedures* (3). This technique is applicable to standardized processes and involves the use of checklists that cover maintenance, operations, and security procedures that are widely accepted in the industry, as well as known potential storage tank failure modes. Hazards associated with bulk gases already had been examined by gas suppliers through internal proprietary studies. The suppliers operate the bulk gas facilities at the Intel facility and have designed and are using safeguards to prevent accidents based on their experience and knowledge with their systems. In addition to operational accidents in the physical systems, external factors were also addressed in a qualitative sense. These factors were earthquake, fire, flood, and sabotage. A discussion of how these factors were addressed in the hazard analysis is contained in Section 3.1.1 of this report.

In this hazard analysis, the only bulk gases examined in detail were hydrogen stored in the Fab 11 bulk gas area and cryogenic nitrogen in a large storage tank in the same area. As discussed in Section 2.1.2, the other bulk gases, argon and oxygen, do not pose an off-site hazard and, thus, were not further evaluated. The only bulk liquid examined was a 37% hydrochloric acid solution that could release hydrogen chloride vapor in the event of a spill. The other bulk liquids maintained on-site have such low hazardous constituent concentrations that they do not pose an off-site hazard.

4.1.2 Probability Analysis

The probability analysis involves associating quantitative probabilities with each of the hazards identified in the hazard analysis. The hazard may involve several component failures, each having its own probability. Probability data for rare events are difficult to obtain, and some assumptions have been made to develop probabilities for some of the hazards discussed in this section. For bulk storage tanks, supplier information and generic data from the technical literature were considered. For transportation incidents, accident rate data from the *Handbook of Chemical Hazard Analysis Procedures* (5) and other information from industry sources were used in the hazard analysis. Section 3.1.2 of this report contains a more detailed general discussion of probability analysis, and various data and calculations are provided in Appendix B.

Equations describing the required conditions for various bulk gas and liquid release scenarios are summarized in Table 4-1. The results of applying calculations and failure data from the *Handbook of Chemical Hazard Analysis Procedures* (5) to scenarios in this study are presented in Table 4-2.

Table 4-1 Probability Calculation Equations for Bulk Gas and Liquid Accidental Release Events

Event	Equation
Outdoor Release of Bulk Material	$P_{event} = P_B * P_M$
Indoor Release of Bulk Material	$P_{event} = P_B * P_M$
Transportation Release of Bulk Chemical	$P_{event} = P_A * P_{BA} * P_M$

P_B = probability of bulk tank failure

P_M = probability of specified meteorological conditions

P_A = probability of transportation accident

P_{BA} = probability of tank failure during transportation accident

Table 4-2 Probability of Failure Conditions for Intel Bulk Gas and Liquid Systems

Event	Probability
Bulk Tank Failure	
- Nitrogen Tank	0.0000001 / year
- Hydrogen Tank	0.00015 / year
- HCl (liquid) Tank	0.0001 / year
Other failures	
- Nitrogen Line	0.0001 / year
- Hydrogen Hose Connection	0.00045 / year
- Hose Connections	0.01 / year
Major Transportation Accident	0.0000000072 / mile
Tank Truck Tank Failure Due To Transportation Accident	0.5 / incident

4.1.3 *Fixed Facility Incidents*

Potential failure modes for the bulk storage tanks are listed in Table 4-3. Although there may be individual differences in specific tanks, currently available probability data generally are not precise enough to distinguish between probabilities for individual component failure modes or failure modes specific to individual types of tanks.

Table 4-3 Potential Failure Modes and Corresponding Control Measures for Bulk Storage Tanks

Failure Event	Control Measure
Hose connection	Special purpose connector Operator training
Hose	Proper specifications Periodic inspection
Piping connection	Proper specifications Periodic inspection
Piping	Proper specifications Periodic inspection Proper support Vehicle barriers
Tank wall	Proper design and fabrication Periodic inspection Vehicle barriers
Tank seams	Proper design and fabrication Periodic inspection
Physical impact damage	Restricted access: fence, vehicle barrier, curbed area
Overpressure	Pressure relief device (with redundant systems)
Excessive vacuum	Vacuum breaker Low level alarms Multiple vents
External fire	No flammable or combustible materials nearby Restricted access Warning signs
Lightning strike	Lightning protection Tank grounding
Earthquake	Design for Zone 4 earthquake loading
Overfill	High level alarms
Liquid full lines	Pressure relief devices No-block design

Each tank at Intel has a number of safety features incorporated into the tank design, as discussed in Section 2. Therefore, a massive failure of these tanks is only a remote possibility. A large release from a line connected to these tanks is a more probable, but still highly unlikely occurrence. The tank systems are standard designs used by chemical suppliers in other similar installations around the country. According to gas supplier information, these installations also have been free of catastrophic incidents.

Bulk Gases

Failure data for the nitrogen and hydrogen tanks are derived from industry operating experience. The features of the nitrogen and hydrogen storage tank systems in the Fab 11 area are described below.

Cryogenic Nitrogen – Cryogenic nitrogen is a liquid; however, it is included here because at ambient temperatures and pressures, nitrogen is a gas. The 300,000-gallon cryogenic nitrogen tank, located near the east property boundary on a bluff overlooking the community below, was evaluated for the possibility of a large liquid nitrogen release. In such an event, cold liquid nitrogen could spill over the bluff into the valley below. While not toxic, a large mass of extremely cold nitrogen gas could pose an asphyxiation hazard to anyone unable to avoid the oxygen-deficient atmosphere of the temporary nitrogen cloud.

The nitrogen tank is designed in accordance with applicable codes and standards, and has other special safety features as well. A concrete wall extends around part of the perimeter of the tank area approximately 15 to 25 feet from the tank, and is designed to contain an accidental spill of the cold nitrogen on the site. The wall extends about 30 feet past each side of the tank. The wall prevents liquid spillage from migrating far from the tank and also reduces the evaporation rate, allowing the gas to boil off harmlessly. Previous dispersion modeling conducted by the gas supplier showed that reduction of oxygen concentrations in the air by the increase in nitrogen from a release would extend only about 550 feet from the point of release if there were no wall present; with the barrier wall, this distance is further reduced. Because of the tank's location near the property boundary, there is the potential for off-site impacts from a failure of this nitrogen tank.

A supplier of nitrogen systems has estimated that the failure rate of such a nitrogen tank with the current pressure control system design is about 0.0000001 per year (one failure every 10 million years). A supplier reports that they have never experienced a failure on such a tank system in their 15 years in this business.

Hydrogen – Of the several hydrogen tanks at the site, the hydrogen tank examined as a possible threat to the large cryogenic nitrogen tank is a horizontal bullet-style tank of standard design for this service. It is located on a concrete pad about 50 feet west of the cryogenic nitrogen tank. The tubing from the hydrogen tank to other parts of the plant is stainless steel, and tubing supplying air to the pneumatic fail closed valves are polypropylene which is designed to melt and cut off the hydrogen flow to the distribution system in the event of a fire. This prevents the continued flow of hydrogen into the fire. A fence surrounds the tank installation and marks the boundary of the flammability hazard. A concrete fire barrier wall is situated between the hydrogen and oxygen tanks. This firewall complies with National Fire Protection Association (NFPA) 55, Standard for Storage, Use, and Handling of Compressed Gases and Cryogenic Fluids in Portable and Stationary Containers, Cylinders, and Tanks. The firewall is eight inches thick of reinforced concrete and it is rated for six hours. Vehicle barriers in the driveway unloading area protect the unloading hose connections and valves.

Potential concerns associated with a hydrogen system are indirect community impacts. To threaten the community, a hydrogen release would have to ignite with sufficient force to damage the nearby nitrogen or oxygen tanks.

According to the supplier, there is no history of a wall or seam failure in a hydrogen tank in this service. The generic failure modes already discussed for the bulk tanks apply generally to the hydrogen tank, with some notable exceptions. The hydrogen tank is specially designed with protective features because of the high flammability hazard of hydrogen. These features are:

- Gas detection monitoring for both hydrogen (four detectors) and oxygen (two detectors) with remote indication and alarm at the bulk gas operator's building;
- Local and remote tank level indication and alarm;
- Daily observation rounds and recording of readings;
- Weld inspections upon tank installation and periodically thereafter; and
- Redundant controls and pressure relief devices.

An estimated probability of a release incident for these tanks is based on the experience of a major gas supplier that installs and operates these systems. According to the supplier, there has never been a catastrophic release of hydrogen with systems using the current technology. On the basis of past release incidents in industry in general, the probability of a release event from these tanks is about 0.00015, equating to one release every 6,670 years. This value was used as the estimated probability of a release from a tank at the Intel Rio Rancho facility. Consequences of a release are discussed in Section 4.2 of this report.

While not a direct threat, the oxygen plant and an oxygen tank are located about 25 to 30 feet north of the hydrogen tank. In the unlikely event that there were a simultaneous accidental release of both hydrogen and oxygen, this location increases the hazard potential. However, the oxygen tank sits on a fenced-in, well-protected concrete pad and has a number of other protective features, which includes a firewall (compliant with NFPA 55) located between the hydrogen tank and the oxygen tank. Additional protective measures are in place to limit the possibility of a simultaneous accidental release, including controlled vent cycles that will not allow the tanks to vent at the same time and work control procedures.

Bulk Liquids

A detailed hazard analysis was not applied to the major bulk liquid tanks (aqueous wastes, sodium hydroxide solutions, lead liquid wastes, copper liquid wastes, and spent solvents) because they pose little threat to the site or the surrounding community. Secondary containment and isolating drainage systems limit the impacts of liquid spills to the immediate vicinity of the spill. Since these storage tanks are not near the property boundary, off-site impacts are unlikely. Additionally, the constituents of concern in these wastes are present in very low concentrations and are not likely to be released to the air in the event of a spill. The only bulk liquid storage of interest is the two hydrochloric acid tanks because of the potential release of hydrogen chloride vapors to the air from a spill. The consequences of a hydrochloric acid tank failure are discussed in Section 4.2 of this report.

Hydrochloric Acid – The bulk liquid hydrochloric acid tanks selected to represent a hydrochloric acid spill scenario are vertical, cylindrical fiberglass-reinforced plastic tanks. The tanks have a secondary containment wall that could hold the entire contents of the tanks in the event of a spill. This would allow collection of the spilled acid into another tank or tanker truck, or dilution and/or neutralization of the acid to mitigate the emission of hydrogen chloride from the concentrated solution. The acid could also be routed to an acid waste neutralization system for disposal.

The probability of a failure in these tanks was assumed to be the generic industrial value for atmospheric storage tanks: 0.0001. The more likely release scenario is a spill from truck offloading caused by a hose failure. Again, containment for such a spill allows for ready response by collection, dilution, or neutralization.

Failure rates for bulk liquid tanks are based on generic failure frequency data provided in the *Handbook of Chemical Hazard Analysis Procedures* (5).

In addition to the tank data, failure rates for tank peripherals were also available from the same source.

4.1.4 *Transportation Incidents*

Transportation incidents for bulk gases and liquids were considered together because the analyses were handled similarly and use the same generic data from the technical literature (5). This study specifically examines only hydrogen gas and hydrochloric acid liquid as the largest volume and most hazardous of the bulk materials delivered by truck. The flammability hazard of hydrogen and toxicity hazard of hydrogen chloride gas release from a hydrochloric acid spill are discussed above.

4.2 *CONSEQUENCE ANALYSIS*

The consequence analysis for bulk gas and liquid releases from the Intel Rio Rancho facility was used to determine the effects of accidental releases in terms of areas affected by a specified airborne concentration of a given gas. The impacts of an accidental release of hydrogen gas and a hydrochloric acid spill (resulting in a release of hydrogen chloride gas) were modeled using RMP*COMP. The results from these modeling runs are provided in Appendix C. Modeling provides the hazardous endpoint distance of the gas from the point of release. For hydrogen gas, the hazardous endpoint is a boundary at which overpressure from an explosion or hazards associated with burning gas would be experienced. From this information, the vulnerability zone can be determined. The concept of the vulnerability zone is discussed in Section 3.2. The supplier of the cryogenic air plant had previously modeled for nitrogen releases and no additional modeling was performed for the present study.

<u>Nitrogen</u>

Modeling was conducted by the gas supplier to determine the maximum distance at which the oxygen concentration in air would be reduced below 19% by excess nitrogen from a leak in the liquid nitrogen tank. The suppliers modeling indicated a maximum impact distance of 551 feet (just over 0.1 mile) from the release point. Details of this modeling are contained in the documents that are the property of the gas supplier. This impact distance results in a vulnerability zone of approximately 0.034 square miles, as shown in Figure 4-2. Note that transportation incidents for liquid nitrogen are not evaluated; liquid nitrogen is produced on site at the Intel Rio Rancho facility.

<u>Hydrogen</u>

ERM modeled the impacts of a hydrogen gas release using the worst-case release scenario option in RMP*COMP. Modeling inputs included unliquefied gas and rural surroundings.

The hazardous endpoint predicted by the RMP*COMP model for release of hydrogen from the 6,000-gallon tank at the Intel Rio Rancho facility is 0.2 mile; this endpoint applied to the 1 psi overpressure from a vapor explosion. An endpoint of 0.2 mile results in a vulnerability zone of approximately 0.126 square miles. Figure 4-2 illustrates the extent of this vulnerability zone.

Hydrochloric Acid

ERM modeled the impacts of a hydrochloric acid spill using the worst-case release scenario option in RMP*COMP. Modeling inputs included release of 20,000 gallons of 37% hydrochloric acid solution at 70° F into a containment area with a surface area of 2,000 square feet. The hazardous endpoint for the resulting hydrogen chloride plume released from the building is 0.3 mile; this gives a vulnerability zone of approximately 0.283 square miles, as shown in Figure 4-2.

Impacts from releases of bulk gases and liquids are summarized in Table 4-4.

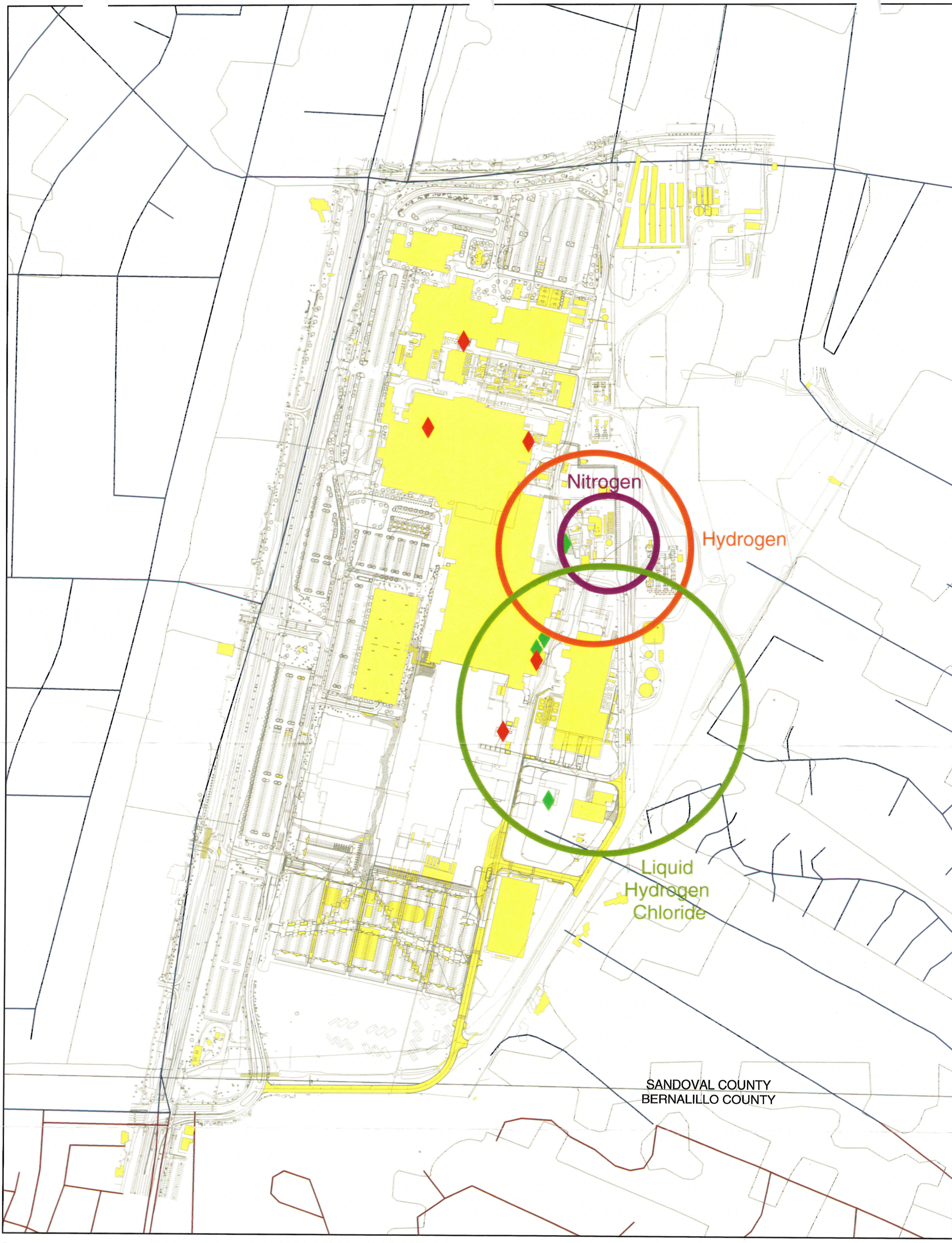
*Table 4-4 RMP*COMP Modeling Results for Bulk Gas and Liquid Releases*

Gas	Amount of Material in Largest Container[2] (pounds)	Hazardous Endpoint (miles)
Nitrogen – N_2	2,420,885	0.1[1]
Hydrogen – H_2	3,480	0.2
Hydrochloric acid – HCl	58,080	0.3

1: Endpoint calculated by material vendor, not using RMP*COMP.
2: Based on 2002 Inventory.

The hazardous endpoints summarized in Table 4-4 are illustrated on Figure 4-2. Figure 4-2 indicates the vulnerability zone based on the actual locations for each of the bulk liquid containers.

The range of hazardous endpoints and associated vulnerability zones for releases due to on-site transportation accidents are shown on Figure 4-3. This range of endpoints addresses on-site transportation incidents for compressed hazardous gases as well as bulk gas and liquids. The hazardous endpoints are the same as for the outdoor release scenarios (summarized in Tables 3-9 and 4-4); the difference is in the location of the release point. The only exception is for liquid nitrogen which is produced on site and not transported to the facility. Figure 4-3 illustrates the worst-case location (i.e., the on-site location with the most off-site impact) for an outdoor release associated with an on-site transportation incident instead of due to a storage incident.



F:\0021158\Intel\Task 11 Report\One Time Event\GIS\Fig 4-2

Legend

- Bulk Specialty Gas Pads
- Gas Pads
- Impact area for release of bulk Nitrogen with a hazardous endpoint of 0.1 mile
- Impact area for Hydrogen with a hazardous endpoint of 0.2 miles
- Impact area for Liquid Hydrogen Chloride with a hazardous endpoint of a 0.3 miles

0 125 250 500 750 1,000 Feet

N E S W

Figure 4-2
Impact Areas for Outdoor Fixed Facility Releases of Bulk Gas and Liquids

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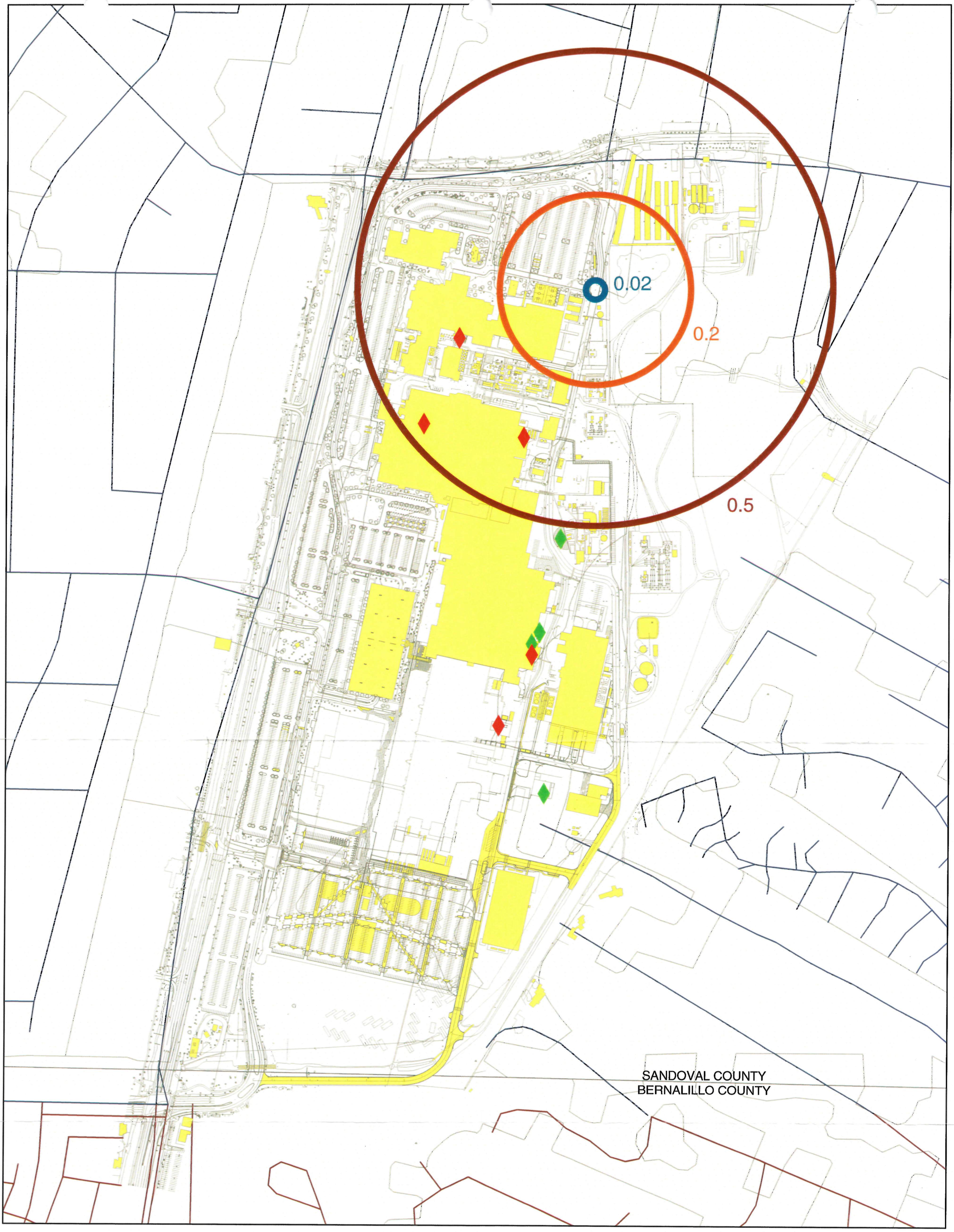
Greenwood Village, CO 80111



F:\0021158\Intel\Task 11 Report\One Time Event\GIS\Fig 4-3

Legend

- Bulk Specialty Gas Pads
- Gas Pads
- Impact area if the hazardous endpoint is 0.02 miles
- Impact area if the hazardous endpoint is 0.2 miles
- Impact area if the hazardous endpoint is 0.5 miles

0 125 250 500 750 1,000 Feet

N W E S

ERM

Figure 4-3
Impact Areas for Releases of Compressed Hazardous Gases & Bulk Gases Due to On-Site Transportation Accidents

Environmental Resources Management
5950 S. Willow Drive, Suite 200
Greenwood Village, CO 80111

5.0 RISK EVALUATION

This section summarizes the hazards identified in Sections 3 and 4 and evaluates them primarily within the two following contexts:

- How do these hazards contribute to the overall risk faced by residents near the Intel facility, and

- How do the Intel facility hazards compare to those of other industrial activities, regardless of location.

Figure 5-1 Risk Assessment Process – Step 4

Risk Screening

⇩

Hazard Analysis

⇩

Consequence Analysis

⇩

Risk Evaluation
What are the probabilities and consequences from the releases in context with other risks?

5.1 OFF-SITE RISKS FROM INTEL RIO RANCHO FACILITY

Risk is the product of the probability of an event and the consequences resulting from that event. Since the consequences evaluated in this assessment are only semi-quantitative (the off-site area affected by an incident can be quantified, but the actual consequences are in terms of health or safety hazards which cannot be quantified), calculating meaningful risks for these incidents can be difficult. Rather than calculating risks, ERM has elected to leave the risk evaluation in the form of probabilities and consequences, with consequences expressed in terms of vulnerability zones and qualitative impacts possible within those zones. Leaving the probabilities (i.e., the likelihood of an event occurring) expressed in their pure form allows for more direct comparability with hazards from other causes.

Tables 5-1 and 5-2 summarize the results of the probability analysis and the consequence analysis for the various release scenarios evaluated in this study. These results show that:

- Probabilities of catastrophic releases are very low.

- Off-site vulnerability zones are very limited in size, indicating that only the very closest neighbors of the Intel facility are exposed to any quantifiable risk associated with chemical releases.

- Probabilities of off-site transportation accidents are very low, but off-site impacts associated with such incidents are higher than for on-site releases because the release occurs within the community.

Tables 5-1 and 5-2 also indicate the primary consequence resulting from the incidents evaluated. However, the consequences shown in the tables are extremely limited because this study does not include a toxicity assessment. Thus, Tables 5-1 and 5-2 merely indicate what a person would be exposed to as a result of the incident (i.e., hazardous gas or fire).

Other factors that could not be accounted for in the modeling but that could reduce the off-site impact from the Intel facility include:

- The storage and use of compressed gases indoors, combined with a scrubber and elevated vent stack, are expected to substantially reduce the potential for off-site impacts.

- RMP*COMP Modeling does not account for barrier effects of buildings. These effects could confine much of the initial release to the Intel property, slowing dispersion and transport of gases away from the release site and possibly resulting in reduced off-site impacts.

Table 5-1 Risk Evaluation for Various One-Time Compressed Hazardous Gas Release Incidents

Incident	Probability	Total Area of Vulnerability Zone (square miles)	Off-Site Portion of Vulnerability Zone (square miles)	Primary Consequence Evaluated
Outdoor Fixed Facility Release				
Compressed Hazardous Gas Cylinder Major Release[1]				
Ammonia	0.0000040	0.785	0.001	Person in vulnerability zone exposed to levels of gas that can be hazardous to safety or health in relatively short time (several minutes)
Arsine	0.0000087	0.126	0	
Boron Trichloride	0.0000475	0.126	0	
Boron Trifluoride	0.0000177	<0.031	0	
Chlorine	0.0000264	0.785	0.003	
Diborane	0.0000008	0.031	0	
Dichlorosilane	0.0000114	<0.031	0	
Ethane	0.0000002	<0.031	0	
Fluorine	0.0000042	0.126	0	
Hydrogen Chloride	0.0000029	0.503	0.003	
Methane	0.0000002	0.031	0	
Phosphine	0.0000211	0.126	0	
Silane	0.0000239	0.001	0	
Off-Site Transportation Accidents				
Major Off-Site Accident - No Release	0.0000094	0	0	None
Major Off-Site Accident With Compressed Hazardous Gas Release[2]				
Ammonia	0.000000125	0.785	0.785	Person in vulnerability zone exposed to levels of gas that can be hazardous to safety or health in relatively short time (several minutes)
Arsine	0.000000273	0.126	0.126	
Boron Trichloride	0.000001486	0.126	0.126	
Boron Trifluoride	0.000000553	<0.031	<0.031	
Chlorine	0.000000826	0.785	0.785	
Diborane	0.000000024	0.031	0.031	
Dichlorosilane	0.000000357	<0.031	<0.031	
Ethane	0.000000006	<0.031	<0.031	
Fluorine	0.000000131	0.126	0.126	
Hydrogen Chloride	0.000000089	0.503	0.503	
Methane	0.000000006	0.031	0.031	
Phosphine	0.000000660	0.126	0.126	
Silane	0.000000749	0.001	0.001	
On-Site Transportation Accidents				
Major On-Site Accident - No Release	0.0000014	0	0	None

Incident	Probability	Total Area of Vulnerability Zone (square miles)	Off-Site Portion of Vulnerability Zone (square miles)	Primary Consequence Evaluated
Major On-Site Accident With Compressed Hazardous Gas Release[3]				
Ammonia	0.0000000062	0.785	0.009	Person in vulnerability zone exposed to levels of gas that can be hazardous to safety or health in relatively short time (several minutes)
Arsine	0.0000000137	0.126	0.001	
Boron Trichloride	0.0000000743	0.126	0.001	
Boron Trifluoride	0.0000000276	<0.031	0.001	
Chlorine	0.0000000413	0.785	0.009	
Diborane	0.0000000012	0.031	0.001	
Dichlorosilane	0.0000000178	<0.031	0.001	
Ethane	0.0000000003	<0.031	0.001	
Fluorine	0.0000000065	0.126	0.001	
Hydrogen Chloride	0.0000000045	0.503	0.007	
Methane	0.0000000003	0.031	0.001	
Phosphine	0.0000000330	0.126	0.001	
Silane	0.0000000374	0.001	0	

1: Probability of Outdoor Release = Probability of major leak * Total number of cylinders handled per year * 50% Probability Cylinder is Outside

2: Probability of Major Off-Site Accident With Release = Probability of major transportation accident * 5 Miles per delivery * 520 Deliveries per year * 50% Probability of cylinder failure in major accident * Probability the specific gas is on-board

3: Probability of Major On-Site Accident With Release = Probability of major transportation accident * 0.5 Miles per delivery * 520 Deliveries per year * 25% Probability of cylinder failure in major accident * Probability the specific gas is on-board

Table 5-2 Risk Evaluation for One-Time Bulk Gas and Liquid Release Incidents

Incident	Probability	Total Area of Vulnerability Zone (square miles)	Off-Site Portion of Vulnerability Zone (square miles)	Primary Consequence Evaluated
Outdoor Fixed Facility Release[1]				
Cryogenic Nitrogen Tank Spill	0.0000001	0.031	0	Person in vulnerability zone exposed to reduced levels of oxygen, possibly leading to asphyxiation
Hydrogen Tank Failure	0.00015	0.126	0	Person in vulnerability zone exposed to potential explosion or serious fire
Hydrochloric acid tank failure	0.0001	0.283	0.001	Person in vulnerability zone exposed to levels of gas that can be hazardous to safety or health in relatively short time (several minutes)
Off-Site Transportation Accidents[2]				
Major Off-Site Accident - No Release	0.00000043	0	0	None
Major Off-Site Accident With Bulk Gas Release (Hydrogen)[3]	0.00000022	0.126	0.126	Person in vulnerability zone exposed to potential explosion or serious fire
Major Off-Site Accident With Bulk Liquid Release (Hydrochloric Acid)[3]	0.00000022	0.283	0.283	Person in vulnerability zone exposed to levels of gas that can be hazardous to safety or health in relatively short time (several minutes)
On-Site Transportation Accidents				
Major On-Site Accident - No Release	0.000000043	0	0	None
Major On-Site Accident With Bulk Gas Release (Hydrogen)[4]	0.000000022	0.126	0.001	Person in vulnerability zone exposed to potential explosion or serious fire
Major On-Site Accident With Bulk Liquid Release (Hydrochloric Acid)[4]	0.000000022	0.283	0.002	Person in vulnerability zone exposed to levels of gas that can be hazardous to safety or health in relatively short time (several minutes)

1: Probability of an Outdoor Fixed Facility Release = Supplier/Industry estimate
2: Transportation incidents involving liquid nitrogen were not evaluated because liquid nitrogen is produced on site at the Intel Rio Rancho facility.
3: Probability of a Major Off-Site Accident with Bulk Gas/Liquid Release = Probability of major transportation accident * 5 Miles per delivery * 12 deliveries per year * 50% Probability of tank failure in accident
4: Probability of Major On-Site Accident With Bulk Gas/Liquid Release = Probability of major transportation accident * 0.5 Miles per delivery * 12 deliveries per year * 50% Probability of tank failure in accident

5.2 COMPARISON TO OTHER RISKS

Individuals encounter risks in all aspects of their lives. Essentially every action has an associated risk, and data have been created in order to quantitatively evaluate the risks associated with certain actions. These published risk data are based on the historical experience of a large population base. The purpose of this section is to compare risks – or at least probabilities of an undesired event – routinely encountered by an individual to those risks associated with the Intel facility.

5.2.1 Societal Risks

The one-time event release incidents from the Intel Rio Rancho facility evaluated in this study have relatively low probabilities of impacting very limited off-site areas. However, the consequences of these incidents could be serious. The probabilities of Intel releases are compared in Table 5-3 with other risks that may affect the general population. This table shows that one-time event releases from the Intel facility have probabilities in the same range as many events that generally are considered unlikely. Additionally, the Intel one-time event releases would affect people only within the vulnerability zones, which range from 0.02 mile (106 feet) to 0.5 mile (2,640 feet) from the release point. There are two ways to make use of this information: 1) to evaluate additional prevention measures to further reduce the probability of a release, and 2) to evaluate responses that focus on those areas that are at most risk if a release occurs.

Table 5-3 Probability of Intel One-Time Event Releases Compared with Other Events

Event	Probability per year	Reference
Motor vehicle accident (NM average - 2000)	0.0264	9
Motor vehicle accident (U.S. average)	0.0233	10
Injury - Motor vehicle accident (NM average - 2000)	0.0151	9
Injury - Motor vehicle accident (U.S. average)	0.0116	10
Intel Possible Off-Site Impacts - Fixed facility incident resulting in compressed hazardous gas release with possible off-site impacts	0.0006	This study
Death - Motor vehicle accident (NM average - 2000)	0.000239	9
Death - Influenza (U.S. average)	0.0002	11
Intel Possible Off-Site Impacts - Hydrogen tank failure resulting in bulk hydrogen leak with possible off-site impacts	0.00015	This study
Intel Possible Off-Site Impacts - Hydrochloric acid hose connection failure resulting in bulk hydrochloric acid spill with possible off-site impacts	0.0001	This study
Death - Leukemia (U.S. average)	0.00008	11
Disease - Pertussis (NM average - 1998)	0.0000566	12
Death - Struck by automobile (U.S. average)	0.00005	11
Death - Motor vehicle accident - driving without seat belts fastened (U.S. average)	0.000049	13
Death - Motor vehicle accident - pedestrian or other driver struck by drunk driver (U.S. average)	0.000018	13
Death - Motor vehicle accident - driving while using cell phone (U.S. average)	0.000013	13
Death - Heart disease (U.S. average)	0.0000117	14
Intel Possible Off-Site Impacts - Off-site transportation accident resulting in compressed hazardous gas release	0.0000094	This study
Death - Cancer (U.S. average)	0.00000552	14
Disease - Plague (NM average - 1998)	0.00000509	12
Death - Motor vehicle accident - pedestrian or other driver struck by driver using cell phone (U.S. average)	0.000004	14
Disease - Hantavirus (NM average - 1998)	0.00000339	12
Death - Flood (U.S. average)	0.0000022	11
Death - Motor vehicle accidents (U.S. average)	0.000000724	14
Disease - Rubella (NM average – 1998)	0.000000566	12
Death - Work accidents (U.S. average)	0.000000517	14
Intel Possible Off-Site Impacts - On-site transportation accident resulting in compressed hazardous gas release with possible off-site impacts	0.000000468	This study
Intel Possible Off-Site Impacts - Off-site transportation accident resulting in bulk hydrochloric acid or bulk hydrogen release	0.00000044	This study
Death - Homicides (U.S. average)	0.000000321	14
Death - Falls (U.S. average)	0.000000255	14
Death - Drowning (U.S. average)	0.000000128	14
Death - Fires/burns (U.S. average)	0.000000103	14

Event	Probability per year	Reference
Death - Falling aircraft (U.S. average)	0.0000001	11
Intel Possible Off-Site Impacts - Nitrogen tank failure resulting in cryogenic nitrogen spill with possible off-site impacts	0.0000001	This study
Intel Possible Off-Site Impacts - On-site transportation accident resulting in bulk hydrochloric acid or hydrogen release with possible off-site impacts	0.000000044	This study
Death - Civil aviation (U.S. average)	0.0000000276	14
Death - Lightning (U.S. average)	0.00000000172	14
Death - Meteorite (U.S. average)	0.00000000001	11

5.2.2 *Industrial Risks*

ERM compared the vulnerability zones developed in this study with other industrial data to evaluate the general risk of the Intel Rio Rancho facility in the context of industrial activities. Most of the comparison data were taken from *Chemical Accident Risks in U.S. Industry – A Preliminary Analysis of Accident Risk Data from U.S. Hazardous Chemical Facilities* (8), which is a compilation of data from facilities subject to U.S. EPA's Chemical Accident Prevention Provisions rule. Because these data were developed using RMP*COMP, the results should be directly comparable to the RMP*COMP modeling data generated by ERM during the present study.

Table 5-4 compares the mean and median endpoint distances for alternative release scenarios reported by all of the facilities regulated under the Chemical Accident Prevention Provisions rule (2) with the endpoint distances generated in the present study. The Intel facility endpoint distances are lower than the mean reported endpoint distances for the regulated facilities, and comparable to or less than the median reported endpoint distances.

Table 5-4 Comparison of Intel Endpoint Distances with Other Industrial Facilities

	Endpoint Distance (miles)	
	Toxic – Alternative Release	**Flammable – Alternative Release**
Industry Mean [1]	0.45	0.14
Industry Median [2]	0.22	0.1
Intel Rio Rancho Facility Mean	0.27	0.08
Intel Rio Rancho Facility Median	0.3	0.1

1: Mean is defined as a value that is computed by dividing the sum of a set of terms by the number of terms.

2: Median is defined as a value in an ordered set of values below and above which there is an equal number of values or which is the arithmetic mean of the two middle values if there is no one middle number.

6.0 ULTIMATE ONE-TIME EVENT

Sections 2 through 5 of this report focused on chemical releases that could take place through the occurrence of one or more low-probability, but conceivable, incidents. For the 1997 Risk Assessment, Intel's Community Advisory Panel requested the evaluation of a more significant release without regard to the probability that such an event might occur. ERM has updated this request and evaluated the impacts associated with the total simultaneous release of the gases kept at the Intel facility.

6.1 SELECTION OF RELEASE CONDITIONS

RMP*COMP is set up to handle only one material at a time. For this worst-case scenario, ERM determined the total amount of each gas kept at the Intel facility, and then modeled the instantaneous release of that total amount. This was done for the thirteen compressed hazardous gases identified in Section 3, hydrogen gas, and hydrochloric acid. When multiple gases are released simultaneously, it is possible that there may be additive or interactive effects between the gases; because RMP*COMP is not capable of addressing such impacts, the model predicts the impact of only the worst single component of a gas mixture.

Modeling was done using the worst-case option in RMP*COMP. Using this option automatically selected the material release rate (full contents of container released in 10 minutes) and the meteorology (stability class F – stable, and low wind speed – 1.5 m/s). All gases were considered to be unliquefied (though that input option did not affect the results), and the rural landscape option was selected since that option produces higher endpoints. For outdoor releases, no mitigation measure was included. For indoor releases, the "enclosed space" option was selected, though this option does not account for the level of mitigation afforded by release into a gas cabinet within a sealed gas pad, vented through a gas scrubber.

6.2 WORST-CASE MODELING RESULTS

Table 6-1 summarizes the results of the worst-case modeling. The endpoint distances are greater than for the alternative release scenarios (summarized previously in Table 3-8), especially for arsine, boron trichloride, and phosphine, all of which have worst-case endpoints between 1 and 2 miles. If a sabotage event or terrorist act occurred, the impacts are not likely to exceed those summarized in Table 6-1.

Table 6-2 compares the Intel worst-case endpoints with data for facilities subject to U.S. EPA's Chemical Accident Prevention Provisions rule (2). Comparison with the industry mean indicates that the worst-case release from the Intel Rio Rancho facility would be less extensive than an "average" industrial facility. Comparison with the industry median indicates that the worst-case release from the Intel facility would be less extensive than more than half the regulated industrial facilities.

*Table 6-1 RMP*COMP Worst-Case Modeling Results for Intel Facility*

Gas	Inventory[4] (pounds)	Hazardous Endpoint (miles)	
		Outdoor Release	Indoor Release
Compressed Hazardous Gas Cylinders			
Ammonia – NH_3	2,430	0.8	Note 1
Arsine – AsH_3	5	1.1	1.1
Boron Trichloride – BCl_3	1,193	4.2	3.0
Boron Trifluoride – BF_3	5	0.2	0.2
Chlorine – Cl_2	6,000	5.2	3.7
Diborane – B_2H_6	1	0.2	0.2
Dichlorosilane – SiH_2Cl_2	1,650	0.05	Note 2
Ethane – C_2H_6	10	0.02	Note 2
Fluorine – F_2	5	0.8	0.8
Hydrogen Chloride – HCl	1,780	2.7	2.2
Methane – CH_4	4	0.01	Note 2
Phosphine – PH_3	19	1.1	0.8
Silane – SiH_4	1,287	0.09	Note 2
Bulk Storage Tanks			
Hydrogen – H_2	11,188	0.2	Note 2
Hydrochloric Acid – HCl	49,336	1.3	Note 3

1: Large cylinders of ammonia are not kept indoors.
2: RMP*COMP does not distinguish between indoor and outdoor scenarios for flammable materials.
3: The bulk liquid hydrochloric acid tanks are outdoors.
4: Based on 2002 Inventory.

Table 6-2 Comparison of Intel Worst-Case Endpoint Distances with Other Industrial Facilities

	Endpoint Distance (miles)	
	Toxic – Worst-case	**Flammable – Worst-case**
Industry Mean	2.9	0.44
Industry Median	1.6	0.40
Intel Rio Rancho Facility Mean	1.76	0.074
Intel Rio Rancho Facility Median	1.1	0.05

6.3 LIMITATIONS OF THE WORST-CASE SCENARIO

The probability of this worst-case scenario occurring has not been quantified due to lack of available data on such incidents, but the probability would be orders of magnitude lower than any of the plausible accident scenarios discussed in Sections 3 through 5.

7.0 MANAGEMENT SYSTEMS EVALUATION

Intel practices continue to be consistent with OSHA and USEPA process and safety risk management programs. Intel also continues to utilize procedures to control the handling and use of hazardous chemicals that were reviewed during the initial risk assessment. ERM conducted a site visit to review Intel's overall systems for process safety and risk management of hazardous chemicals. The site visit included the following three process areas, which were added to the site since the initial risk assessment:

- C4 Process,
- Bulk storage area, and
- Fab 11X Process.

During the site visit as well as document review, ERM evaluated Intel's systems and compared them to OSHA PSM and U.S. EPA RMP requirements, as discussed in Section 1.0. These two rules reflect the industry consensus on key features of hazardous chemical accident risk management programs. Even though Intel does not store or use sufficient quantities of chemicals at the facility to require compliance with each of these standards, the regulations provide guidelines that were used to compare Intel's practices for controlling risk to general industry practice.

The federal rules apply to any process handling more than specified threshold quantities of hazardous chemicals as defined by the regulations. A process is defined as an inventory of a chemical that exceeds the threshold quantity in interconnected or separate vessels that could be released by a single incident. At the time of the analysis by ERM, Intel did not exceed threshold quantities of listed chemicals in a process.

ERM reviewed Intel's chemical release risk management activities and the following table outlines Intel's practices that meet the OSHA PSM and RMP standards. ERM determined that Intel has numerous systems in place to manage and minimize the risks associated with a chemical release and that Intel practices are generally consistent with OSHA and U.S. EPA process safety and risk management programs.

Table 7-1 Current Management Systems at the Intel Rio Rancho Facility

Intel Practice	**Equivalent OSHA PSM and U.S. EPA RMP Requirement**
Employees participate in all phases of the process safety management system including developing and certifying operating specifications, completing design reviews, developing job hazard analyses, participating in safety teams, health and safety surveys, and open forums. Employees appear to be intimately involved in all aspects of the process safety management program.	Written action plan to ensure employee participation in the development and implementation of the process safety management plan and the performance of hazard assessments.
Process safety information covering chemicals, processes, and equipment are comprehensive and detailed. Master specifications assure that design and operation relating to identical or similar processes are consistent, uniform, and benefit from "lessons learned." Safety is integrated into the Comprehensive Master Design Specifications. An abundance of existing documentation relates to specific consensus codes, regulatory requirements, and industry guides that are followed to assure the safe design and operation of facilities and equipment.	Completion of written process safety information to assist employees in identifying and understanding the hazards posed by the process(es), including information on the chemical hazards, process technology, and process equipment.
Design reviews are performed for all new installations at various stages of design (i.e. 30, 60, and 90% complete) to assure conformance with internal quality standards, consensus and regulatory requirements, and proprietary design specifications and guidelines.	The performance of an initial process hazard analysis (PHA) that identifies, evaluates, and controls process risk.
Written operating procedures exist that describe how to perform each required task and to help assure that each is performed safely, efficiently, and properly. The procedures are reviewed for accuracy and currency on a periodic basis. The operating procedures are used as a resource to support operator training.	Preparation, communication, and periodic re-certification of appropriate, clear, and consistent operating procedures that provide instructions for safely and efficiently performing all tasks and activities required by the process.
A combination of well-documented instructor based, computer based, and on-the-job training is in place. This includes various levels of training that requires operators to demonstrate competency before performing certain tasks. The facility has various levels of authorization that includes completion of Level 0 training before an employee is allowed access to gas pads, completion of Level 1 training before an employee can transport gas cylinders, and completion of Level 2 training before an employee can change gas cylinders and perform work involving live process gas systems.	Existence of a formal training program that includes an overview of the process and instruction in the operating procedures/safe work practices; safety and health hazards and controls; and emergency operation (including shutdown). Periodically, refresher training must be provided to assure that employees understand and adhere to current procedures.
The contractor program includes pre-qualification, safety orientation, and periodic evaluation of contractor performance. The program is well documented. Additionally, before contractors enter selected process areas they are required to have completed training that is equivalent in content to that required for Intel employees working in the same area.	Contractors must be competent and have job skills, knowledge, and training to safely perform their work. Requirements include specific contractor selection criteria; communicating known fire, explosion, or toxic release hazards; describing provisions on the facility's emergency action plan; controlling the presence, entrance, and exit of contract employees for hazardous process areas; and periodic performance evaluations.

Table 7-1 Current Management Systems at the Intel Rio Rancho Facility

Intel Practice	Equivalent OSHA PSM and U.S. EPA RMP Requirement
Pre-startup safety review is addressed with the SL1, SL2, and SL3 equipment sign-off procedures for tools and bulk chemical systems prior to start-up. For facility modifications, commissioning procedures and specifications are followed that include a series of operational and functional acceptance tests before start-up of a new or modified process occurs.	For new or modified processes, the engineering design, start-up procedures, and normal operating procedures are to be fully evaluated as part of the pre-startup review to ensure a safe transfer into the normal operating mode. This could apply, for example, when a new tool is added, operating procedures are modified, there is a change in chemical(s) used, or the gas discharge pressure is modified.
The facility has a hot work program for operations so that all welding, cutting, brazing, and other operations involving flames, heat, and sparks is performed safely. Authorization is granted before work actually commences.	A hot work permit system is to be used when operations involving hot work (i.e. creates a flame, or sparks) are performed near processes involving hazardous materials.
The change management process is comprehensive and highly systemized. Change Control Boards (CCBs) function to evaluate and approve process changes (PCCB) and facility changes (FCCB). Formal "White Papers" are also prepared to justify and support changes based on safety, quality, and operability. In addition, the EHS New Facility Equipment Procurement Process procedure requires that a code review and PHA be performed for any change that introduces a new hazard.	Contemplated process changes (except "replacement-in-kind") must be evaluated before-the-fact to fully assess their impact on employee and community risk. Change management procedures include formal authorization prior to implementation.
Information and lessons learned are shared between the various Intel facilities. The facility has a formal system which documents and communicates incidents causing injury or illness or that results in a chemical release and the corrective action that was applied.	Investigation of each incident that results in, or could have resulted in, a catastrophic release; identification of root cause(s); and implementation of corrective action to prevent recurrence.
The facility has an emergency response plan that describes the specific procedures for handling releases and other emergencies related to the handling of hazardous substances. Over 300 employees have been trained as emergency response technicians and they receive the appropriate annual and refresher training. The facility investigates releases to determine the cause and to prevent future releases from occurring.	Development of an emergency action plan that describes specific actions that employees are expected to execute following an unplanned release of a highly hazardous chemical.

8.0 CONCLUSIONS

Intel and its chemical suppliers employ state of the art processes and systems to minimize potential impacts from accidental chemical releases. This conclusion is supported both by the risk identification and calculations (documented in Sections 3 through 5) and the management systems review (documented in Section 7). Risks are confined to those residing within, at most, one-half mile from the Rio Rancho facility, and even those residents are exposed to risks that are comparable to or lower than many common societal and industrial risks.

Most hazardous chemicals at the Intel facility are handled in small individual gas cylinders that are kept indoors except for a short time after delivery. The engineering controls provided by the indoor environment include containment within gas cabinets that are themselves contained within isolated gas pads, and venting of both the cabinets and pads through rooftop scrubbers. The mitigating effect that these controls would have on a potential chemical release was not accounted for in this risk assessment because of limitations with the U.S. EPA recommended computer model that was used.

Bulk gases used at the Intel facility are stored in outdoor containers that are appropriately designed for their applications and are inspected and maintained in accordance with standard industry practice. Off-site risks associated with bulk gas storage are comparable to the risks from compressed hazardous gas cylinders.

Bulk liquids used or produced at the Intel facility are mostly too dilute to represent a risk to nearby residents; two tanks of liquid hydrochloric acid are stored outside and do represent a quantifiable risk in the event of a release. The tanks are appropriately designed for their use and are inspected and maintained in accordance with industry practice. Adequate spill prevention and mitigation measures are employed; these measures decrease the off-site risk from the hydrochloric acid tanks.

Intel is not subject to the OSHA PSM and U.S. EPA RMP requirements for maintaining safe operations. However, Intel complies with the majority of these guidelines for assuring safe operations, and adherence to these guidelines plays an important role in maintaining a low hazard probability.

9.0 REFERENCES

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Appendix A
Chemical Inventory and Usage Data

Table A-1. Gases Used at Intel Rio Rancho Facility

Gas	Type of Container
Ammonia (NH_3)	Cylinder/Bulk Container
Argon (Ar)	Cylinder/Bulk Container
Arsine (AsH_3)	Cylinder
Boron Trichloride (BCl_3)	Cylinder
Boron Trifluoride (BF_3)	Cylinder
Carbon Monoxide (CO)	Cylinder
Chlorine (Cl_2)	Cylinder
1% Diborane (B_2H_6) in Hydrogen (H_2)	Cylinder
Dichlorosilane (SiH_2Cl_2)	Cylinder
Difluoromethane (CH_2F_2)	Cylinder
Ethane (C_2H_6)	Cylinder
1% Fluorine (F_2) in Argon/Neon	Cylinder
1% Fluorine (F_2) in Krypton/Neon	Cylinder
Fluoromethane (CH_3F)	Cylinder
1% Germane (GeH_4) in Hydrogen (H_2)	Cylinder
Germanium Tetrafluoride (GeF_4)	Cylinder
20% Helium (He2) in Argon	Cylinder
Helium	Cylinder/Bulk Container
Hexafluorobutadiene (C_4F_6)	Cylinder
Hexafluoroethane (C_2F_6)	Cylinder/Bulk Container
Hydrogen (H_2)	Bulk Container
5% Hydrogen (H_2) in Nitrogen	Cylinder
Hydrogen Bromide (HBr)	Cylinder
Hydrogen Chloride (HCl)	Cylinder/Bulk Container
Methane (CH_4)	Cylinder
Nitrogen	Bulk Container
Nitrogen Trifluoride (NF_3)	Cylinder/Bulk Container
Nitrous Oxide (N_2O)	Cylinder/Bulk Container
Octafluorocyclobutane (C_4F_8)	Cylinder
Octafluorocyclopentene (C_5F_8)	Cylinder
Oxygen	Bulk Container
Phosphine (PH_3)	Cylinder
Silane (SiH_4)	Cylinder
Silicon Tetrafluoride (SiF_4)	Cylinder
Sulfur Hexafluoride (SF_6)	Cylinder/Bulk Container
Tetrafluoromethane (CF_4)	Cylinder/Bulk Container
Trifluoromethane (CHF_3)	Cylinder/Bulk Container
Tungsten Hexafluoride (WF_6)	Cylinder

Table A-2. Immediately Dangerous to Life and Health (IDLH) Data for Intel Gases

Gas	IDLH (ppm)	Source for IDLH Data
Ammonia (NH_3)	300	NIOSH IDLH
Arsine (AsH_3)	3	NIOSH IDLH
Boron Trichloride (BCl_3)	5	TLV or TWA from MSDS
Boron Trifluoride (BF_3)	25	NIOSH IDLH
Carbon Monoxide (CO)	1,200	NIOSH IDLH
Chlorine (Cl_2)	10	NIOSH IDLH
Diborane (B_2H_6)	15	NIOSH IDLH
Dichlorosilane (SiH_2Cl_2)	5	TLV or TWA from MSDS
Difluoromethane (CH_2F_2)	1,000	TLV or TWA from MSDS
Ethane (C_2H_6)	1,000	TLV for simple asphyxiant
Fluorine (F_2)	25	NIOSH IDLH
Fluoromethane (CH_3F)	1,000	TLV for simple asphyxiant
Germane (GeH_4)	0.2	TLV or TWA from MSDS
Germanium Tetrafluoride (GeF_4)	3	TLV or TWA from MSDS
Hexafluorobutadiene (C_4F_6)	667	LC_{50} / 4 hours, rat
Hexafluoroethane (C_2F_6)	1,000	TLV for simple asphyxiant
Hydrogen Bromide (HBr)	30	NIOSH IDLH
Hydrogen Chloride (HCl)	50	NIOSH IDLH
Methane (CH_4)	1,000	TLV for simple asphyxiant
Nitrogen Trifluoride (NF_3)	1,000	NIOSH IDLH
Nitrous Oxide (N_2O)	50	TLV or TWA from MSDS
Octafluorocyclobutane (C_4F_8)	1,000	TLV for simple asphyxiant
Octafluorocyclopentene (C_5F_8)	2	TLV or TWA from MSDS
Phosphine (PH_3)	50	NIOSH IDLH
Silane (SiH_4)	5	TLV or TWA from MSDS
Silicon Tetrafluoride (SiF_4)	6	TLV or TWA from MSDS
Sulfur Hexafluoride (SF_6)	1,000	TLV or TWA from MSDS
Tetrafluoromethane (CF_4)	1,000	TLV for simple asphyxiant
Trifluoromethane (CHF_3)	1,000	TLV for simple asphyxiant
Tungsten Hexafluoride (WF_6)	4	TLV or TWA from MSDS

Appendix B
One-Time Event Risk Assessment Calculations

Compressed Hazardous Gas Release Probability - Fixed Incident

Gas	Cylinder Size (lbs)	Number of Cylinders Handled per Year	Probability of Minor Leak Outdoors	Probability of Major Leak Outdoors
Ammonia – NH_3	55.00	17	3.825E-05	3.230E-06
	500.00	4	9.000E-06	7.600E-07
Arsine – AsH_3	0.88	46	1.035E-04	8.740E-06
Boron Trichloride – BCl_3	42.50	18	4.050E-05	3.420E-06
	35.00	232	5.220E-04	4.408E-05
Boron Trifluoride – BF_3	0.86	31	6.975E-05	5.890E-06
	0.57	9	2.025E-05	1.710E-06
	0.29	53	1.193E-04	1.007E-05
Carbon Monoxide - CO	15.50	20	4.500E-05	3.800E-06
Chlorine – Cl_2	100.00	139	3.128E-04	2.641E-05
Diborane – B_2H_6	0.09	4	9.000E-06	7.600E-07
Dichlorosilane – SiH_2Cl_2	50.00	60	1.350E-04	1.140E-05
Difluoromethane – CH_2F_2	9.00	15	3.375E-05	2.850E-06
Ethane – C_2H_6	10.00	1	2.250E-06	1.900E-07
Fluorine – F_2	0.52	6	1.350E-05	1.140E-06
	0.10	16	3.600E-05	3.040E-06
Fluoromethane – CH_3F	6.00	12	2.700E-05	2.280E-06
Germane – GeH_4	0.37	4	9.000E-06	7.600E-07
Germanium Tetrafluoride – GeF_4	0.40	13	2.925E-05	2.470E-06
	1.37	10	2.250E-05	1.900E-06
Hexafluoroethane - C_2F_6	23,540.00	1	2.250E-06	1.900E-07
	1,125.00	1	2.250E-06	1.900E-07
Tetrafluoromethane - CF_4	575.00	4	9.000E-06	7.600E-07
Trifluoromethane - CHF_3	1,500.00	2	4.500E-06	3.800E-07
Hexafluorobutadiene – C_4F_6	30.00	8	1.800E-05	1.520E-06
Hydrogen Bromide – HBr	140.00	44	9.900E-05	8.360E-06
Hydrogen Chloride – HCl	65.00	13	2.925E-05	2.470E-06
	500.00	2	4.500E-06	3.800E-07
Methane – CH_4	4.00	1	2.250E-06	1.900E-07
Nitrogen Trifluoride – NF_3	4,379.00	12	2.700E-05	2.280E-06
	432.00	16	3.600E-05	3.040E-06
	50.00	36	8.100E-05	6.840E-06
Nitrous Oxide – N_2O	600.00	14	3.150E-05	2.660E-06
	70.00	214	4.815E-04	4.066E-05
Octafluorocyclobutane – C_4F_8	140.00	29	6.525E-05	5.510E-06
Octafluorocyclopentane – C_5F_8	4.41	41	9.225E-05	7.790E-06
	19.00	3	6.750E-06	5.700E-07
Phosphine – PH_3	2.87	4	9.000E-06	7.600E-07
	0.19	62	1.395E-04	1.178E-05
	0.06	37	8.325E-05	7.030E-06
	0.37	8	1.800E-05	1.520E-06
Silane – SiH_4	33.10	126	2.835E-04	2.394E-05
Silicon Tetrafluoride – SiF_4	55.00	50	1.125E-04	9.500E-06
	1.85	7	1.575E-05	1.330E-06
	0.51	23	5.175E-05	4.370E-06
Sulfur Hexafluoride - SF_6	1,150.00	2	4.500E-06	3.800E-07
Tungsten Hexafluoride – WF_6	130.00	105	2.363E-04	1.995E-05
Cumulative Probability		1,575	3.544E-03	2.993E-04

Incident	Probability	Endpoint	Total Area	Off-Site Area	Data	Units
Off-Site Transportation Accidents						
Major Accident - no release	9.360E-06		0	0		
Major Accident - compressed gas release						
Ammonia	1.248E-07	0.5	0.785	0.785	0.0133	probability gas on board (cyl/yr / total cyl/yr)
Arsine	2.734E-07	0.2	0.126	0.126	0.0292	probability gas on board (cyl/yr / total cyl/yr)
Boron Trichloride	1.486E-06	0.2	0.126	0.126	0.1587	probability gas on board (cyl/yr / total cyl/yr)
Boron Trifluoride	5.527E-07	0.1	0.031	0.031	0.0590	probability gas on board (cyl/yr / total cyl/yr)
Chlorine	8.261E-07	0.5	0.785	0.785	0.0883	probability gas on board (cyl/yr / total cyl/yr)
Diborane	2.377E-08	0.1	0.031	0.031	0.0025	probability gas on board (cyl/yr / total cyl/yr)
Dichlorosilane	3.566E-07	0.1	0.031	0.031	0.0381	probability gas on board (cyl/yr / total cyl/yr)
Ethane	5.943E-09	0.1	0.031	0.031	0.0006	probability gas on board (cyl/yr / total cyl/yr)
Fluorine	1.307E-07	0.2	0.126	0.126	0.0140	probability gas on board (cyl/yr / total cyl/yr)
Hydrogen Chloride	8.914E-08	0.4	0.503	0.503	0.0095	probability gas on board (cyl/yr / total cyl/yr)
Methane	5.943E-09	0.1	0.031	0.031	0.0006	probability gas on board (cyl/yr / total cyl/yr)
Phosphine	6.597E-07	0.2	0.126	0.126	0.0705	probability gas on board (cyl/yr / total cyl/yr)
Silane	7.488E-07	0.02	0.001	0.001	0.0800	probability gas on board (cyl/yr / total cyl/yr)
On-Site Transportation Accidents						
Major Accident - no release	1.404E-06		0	0		
Major Accident - compressed gas release						
Ammonia	6.240E-09	0.5	0.785	0.009		
Arsine	1.367E-08	0.2	0.126	0.001		
Boron Trichloride	7.429E-08	0.2	0.126	0.001		
Boron Trifluoride	2.763E-08	0.1	0.031	0.001		
Chlorine	4.130E-08	0.5	0.785	0.009		
Diborane	1.189E-09	0.1	0.031	0.001		
Dichlorosilane	1.783E-08	0.1	0.031	0.001		
Ethane	2.971E-10	0.1	0.031	0.001		
Fluorine	6.537E-09	0.2	0.126	0.001		
Hydrogen Chloride	4.457E-09	0.4	0.503	0.007	7.200E-09	probability of major off-site vehicle accident /mile
Methane	2.971E-10	0.1	0.031	0.001	520	deliveries/year [2 per day, 5 days/wk, 52 wks/yr]
Phosphine	3.298E-08	0.2	0.126	0.001	5	off-site miles/delivery
Silane	3.744E-08	0.02	0.001	0	0.5	cylinder failures/major accident off-site
Outdoor Fixed Facility Release					0.5	on-site miles/delivery
Compressed gas cylinder major release					0.25	cylinder failures/major accident on-site
Ammonia	3.990E-06	0.5	0.785	0.0014		
Arsine	8.740E-06	0.2	0.126	0		
Boron Trichloride	4.750E-05	0.2	0.126	0		
Boron Trifluoride	1.767E-05	0.1	0.031	0		
Chlorine	2.641E-05	0.5	0.785	0.0031		
Diborane	7.600E-07	0.1	0.031	0		
Dichlorosilane	1.140E-05	0.1	0.031	0		
Ethane	1.900E-07	0.1	0.031	0		
Fluorine	4.180E-06	0.2	0.126	0		
Hydrogen Chloride	2.850E-06	0.4	0.503	0.0026		
Methane	1.900E-07	0.1	0.031	0	0.27	mean of toxic endpoints
Phosphine	2.109E-05	0.2	0.126	0	0.08	mean of flammable endpoints
Silane	2.394E-05	0.02	0.001	0		
Indoor Fixed Facility Release						
Compressed gas cylinder major release						
Ammonia	3.990E-06	Note 1	Note 1	Note 1	Note 1	
Arsine	8.740E-06	0.2	0.126	0	0	
Boron Trichloride	4.750E-05	0.1	0.031	0	0	
Boron Trifluoride	1.767E-05	0.1	0.031	0	0	
Chlorine	2.641E-05	0.1	0.031	0	0	
Diborane	7.600E-07	0.1	0.031	0	0	
Dichlorosilane	1.140E-05	Note 2	Note 2	Note 2	Note 2	
Ethane	1.900E-07	Note 2	Note 2	Note 2	Note 2	
Fluorine	4.180E-06	0.2	0.126	0	0	
Hydrogen Chloride	2.850E-06	Note 1	Note 1	Note 1	Note 1	
Methane	1.900E-07	Note 2	Note 2	Note 2	Note 2	
Phosphine	2.109E-05	0.2	0.126	0	0	
Silane	2.394E-05	Note 2	Note 2	Note 2	Note 2	
Note 1: 500 lb containers of ammonia and hydrogen chloride are not kept indoors.				NORTH	SOUTH	
Note 2: RMP*COMP does not calculate endpoints for flammable materials stored indoors.						

Evaluation of Risks from Bulk Material Release

Incident	Probability	Endpoint	Total Area	Off-Site Area	Data	Units
Off-Site Transportation Accidents					7.200E-09	probability of major off-site vehicle accident /mile
Major Accident - no release	4.320E-07	0.0	0.000	0	12	deliveries/year of hydrogen
Major Accident - bulk gas release (hydrogen)	2.160E-07	0.2	0.126	0.126	12	deliveries/year of HCl
Major Accident - bulk liquid release (HCl)	2.160E-07	0.3	0.283	0.283	5	off-site miles/delivery
On-Site Transportation Accidents					0.5	on-site miles/delivery
Major Accident - no release	4.320E-08	0.0	0.000	0	0.5	tank failures/major accident
Major Accident - bulk gas release (hydrogen)	2.160E-08	0.2	0.126	0.001		
Major Accident - bulk liquid release (HCl)	2.160E-08	0.3	0.283	0.002	1.000E-07	N2 line break
Outdoor Fixed Facility Release					1.500E-04	H2 tank failure
Cryogenic nitrogen tank spill	1.000E-07	0.1	0.031	0	1.000E-04	HCl liquid tank failure
Hydrogen tank release	1.500E-04	0.2	0.126	0		
Hydrochloric acid tank failure	1.000E-04	0.3	0.283	0.0009		

Appendix C
Modeling Data

General Information on RMP*COMP

RMP*Comp Ver. 1.07

Welcome to RMP*Comp! Use RMP*Comp to perform the offsite consequence analyses required under the EPA's Risk Management Planning (RMP) rule, which implements Section 112(r) of the 1990 Clean Air Act. To begin an analysis, click Next.

Some Background Information

If you own or operate a facility, you are subject to the RMP rule if you have more than a threshold quantity of a "regulated substance" in any process at your facility. These regulated substances include 77 acutely toxic substances and 63 flammable gases and volatile liquids.

If you are subject to the rule, you will need to perform an offsite consequence analysis to check whether your process puts nearby populations at risk (if you find that it does, you will need to take some steps to manage that risk; these steps are described in the rule). You can use RMP*Comp to make this analysis. It implements the RMP consequence analysis procedures recommended by the EPA. Because these procedures may change in the future, please check the following web page to be sure that you are using the latest version of RMP*Comp:

http://www.epa.gov/ceppo/tools/rmp-comp/rmp-comp.html

On this page, you'll also find a collection of links to online resources to help you complete your analyses.

RMP*Comp was developed by the CAMEO Team at the Hazardous Materials Response and Assessment Division, NOAA, and the Chemical Emergency Prevention and Preparedness Office of the EPA.

Direct comments or questions about RMP*Comp by email to:
rmpmail@hazmat.noaa.gov

To report a bug in the program, please first refer to the web page listed above.

Direct comments or questions about the RMP Program by telephone to the RCRA, Superfund, & EPCRA Hotline:
(800) 424-9346 or
DC Area Local (703) 412-9810 or
TDD (800) 553-7672 or
TDD DC Area Local (703) 412-3323

Results of Consequence Analysis: Single Container / Alternative Scenarios

Chemical: Ammonia (anhydrous) [Outdoor; 500-lb container; "fast" release]
CAS #: 7664-41-7
Category: Toxic Gas
Scenario: Alternative
Release Duration: 1 minutes
Release Rate: 500 pounds per min
Mitigation Measures: NONE
Topography: Rural surroundings (terrain generally flat and unobstructed)
Toxic Endpoint: 0.14 mg/L; basis: ERPG-2
Estimated Distance to Toxic Endpoint: 0.5 miles (0.8 kilometers)

--------Assumptions About This Scenario---------
Wind Speed: 3 meters/second (6.7 miles/hour)
Stability Class: D
Air Temperature: 77 degrees F (25 degrees C)

Chemical: Ammonia (anhydrous) [Outdoor; 500-lb container; "slow" release]
CAS #: 7664-41-7
Category: Toxic Gas
Scenario: Alternative
Release Duration: 10 minutes
Release Rate: 50 pounds per min
Mitigation Measures: NONE
Topography: Rural surroundings (terrain generally flat and unobstructed)
Toxic Endpoint: 0.14 mg/L; basis: ERPG-2
Estimated Distance to Toxic Endpoint: 0.2 miles (0.3 kilometers)

--------Assumptions About This Scenario---------
Wind Speed: 3 meters/second (6.7 miles/hour)
Stability Class: D
Air Temperature: 77 degrees F (25 degrees C)

Chemical: Arsine [Indoor; 0.879-lb container]
CAS #: 7784-42-1
Category: Toxic Gas
Scenario: Alternative
Release Duration: 30 minutes
Release Rate: 0.0293 pounds per min
Mitigation Measures: Release in enclosed space, in direct contact with outside air
Topography: Rural surroundings (terrain generally flat and unobstructed)
Toxic Endpoint: 0.0019 mg/L; basis: EHS-LOC (IDLH)
Estimated Distance to Toxic Endpoint: 0.2 miles (0.3 kilometers)

--------Assumptions About This Scenario---------
Wind Speed: 3 meters/second (6.7 miles/hour)
Stability Class: D
Air Temperature: 77 degrees F (25 degrees C)

Chemical: Arsine [Outdoor; 0.879-lb container; "fast" release]
CAS #: 7784-42-1
Category: Toxic Gas
Scenario: Alternative
Release Duration: 1 minutes
Release Rate: 0.88 pounds per min
Mitigation Measures: NONE
Topography: Rural surroundings (terrain generally flat and unobstructed)
Toxic Endpoint: 0.0019 mg/L; basis: EHS-LOC (IDLH)
Estimated Distance to Toxic Endpoint: 0.2 miles (0.3 kilometers)

--------Assumptions About This Scenario---------
Wind Speed: 3 meters/second (6.7 miles/hour)
Stability Class: D
Air Temperature: 77 degrees F (25 degrees C)

Chemical: Arsine [Outdoor; 0.879-lb container; "slow" release]
CAS #: 7784-42-1
Category: Toxic Gas
Scenario: Alternative
Release Duration: 10 minutes
Release Rate: 0.088 pounds per min
Mitigation Measures: NONE
Topography: Rural surroundings (terrain generally flat and unobstructed)
Toxic Endpoint: 0.0019 mg/L; basis: EHS-LOC (IDLH)
Estimated Distance to Toxic Endpoint: 0.2 miles (0.3 kilometers)

--------Assumptions About This Scenario---------
Wind Speed: 3 meters/second (6.7 miles/hour)
Stability Class: D
Air Temperature: 77 degrees F (25 degrees C)

Chemical: Boron trichloride [Indoor; 42.5-lb container]
CAS #: 10294-34-5
Category: Toxic Gas
Scenario: Alternative
Release Duration: 30 minutes
Release Rate: 1.4167 pounds per min
Mitigation Measures: Release in enclosed space, in direct contact with outside air
Topography: Rural surroundings (terrain generally flat and unobstructed)
Toxic Endpoint: 0.010 mg/L; basis: EHS-LOC; LOC is based on IDLH-equivalent level estimated from toxicity data.
Estimated Distance to Toxic Endpoint: 0.1 miles (0.2 kilometers)

--------Assumptions About This Scenario---------
Wind Speed: 3 meters/second (6.7 miles/hour)
Stability Class: D
Air Temperature: 77 degrees F (25 degrees C)

Chemical: Boron trichloride [Outdoor; 42.5-lb container; "fast" release]
CAS #: 10294-34-5
Category: Toxic Gas
Scenario: Alternative
Release Duration: 1 minutes
Release Rate: 42.5 pounds per min
Mitigation Measures: NONE
Topography: Rural surroundings (terrain generally flat and unobstructed)
Toxic Endpoint: 0.010 mg/L; basis: EHS-LOC; LOC is based on IDLH-equivalent level estimated from toxicity data.
Estimated Distance to Toxic Endpoint: 0.2 miles (0.3 kilometers)

--------Assumptions About This Scenario---------
Wind Speed: 3 meters/second (6.7 miles/hour)
Stability Class: D
Air Temperature: 77 degrees F (25 degrees C)

Chemical: Boron trichloride [Outdoor; 42.5-lb container; "slow" release]
CAS #: 10294-34-5
Category: Toxic Gas
Scenario: Alternative
Release Duration: 10 minutes
Release Rate: 4.25 pounds per min
Mitigation Measures: NONE
Topography: Rural surroundings (terrain generally flat and unobstructed)
Toxic Endpoint: 0.010 mg/L; basis: EHS-LOC; LOC is based on IDLH-equivalent level estimated from toxicity data.
Estimated Distance to Toxic Endpoint: 0.2 miles (0.3 kilometers)

--------Assumptions About This Scenario---------
Wind Speed: 3 meters/second (6.7 miles/hour)
Stability Class: D
Air Temperature: 77 degrees F (25 degrees C)

Chemical: Boron trifluoride [Indoor; 0.86-lb container]
CAS #: 7637-07-2
Category: Toxic Gas
Scenario: Alternative
Release Duration: 30 minutes
Release Rate: 0.02867 pounds per min
Mitigation Measures: Release in enclosed space, in direct contact with outside air
Topography: Rural surroundings (terrain generally flat and unobstructed)
Toxic Endpoint: 0.028 mg/L; basis: EHS-LOC (IDLH)
Estimated Distance to Toxic Endpoint: <0.1 miles (<0.16 kilometers); report as 0.1 mile

--------Assumptions About This Scenario---------
Wind Speed: 3 meters/second (6.7 miles/hour)
Stability Class: D
Air Temperature: 77 degrees F (25 degrees C)

Chemical: Boron trifluoride [Outdoor; 0.86-lb container; "fast" release]
CAS #: 7637-07-2
Category: Toxic Gas
Scenario: Alternative
Release Duration: 1 minutes
Release Rate: 0.86 pounds per min
Mitigation Measures: NONE
Topography: Rural surroundings (terrain generally flat and unobstructed)
Toxic Endpoint: 0.028 mg/L; basis: EHS-LOC (IDLH)
Estimated Distance to Toxic Endpoint: <0.1 miles (<0.16 kilometers); report as 0.1 mile

--------Assumptions About This Scenario---------
Wind Speed: 3 meters/second (6.7 miles/hour)
Stability Class: D
Air Temperature: 77 degrees F (25 degrees C)

Chemical: Boron trifluoride [Outdoor; 0.86-lb container; "slow" release]
CAS #: 7637-07-2
Category: Toxic Gas
Scenario: Alternative
Release Duration: 10 minutes
Release Rate: 0.086 pounds per min
Mitigation Measures: NONE
Topography: Rural surroundings (terrain generally flat and unobstructed)
Toxic Endpoint: 0.028 mg/L; basis: EHS-LOC (IDLH)
Estimated Distance to Toxic Endpoint: <0.1 miles (<0.16 kilometers); report as 0.1 mile

--------Assumptions About This Scenario---------
Wind Speed: 3 meters/second (6.7 miles/hour)
Stability Class: D
Air Temperature: 77 degrees F (25 degrees C)

Chemical: Chlorine [Indoor; 100-lb container]
CAS #: 7782-50-5
Category: Toxic Gas
Scenario: Alternative
Release Duration: 30 minutes
Release Rate: 3.33 pounds per min
Mitigation Measures: Release in enclosed space, in direct contact with outside air
Topography: Rural surroundings (terrain generally flat and unobstructed)
Toxic Endpoint: 0.0087 mg/L; basis: ERPG-2
Estimated Distance to Toxic Endpoint: 0.1 miles (0.2 kilometers)

--------Assumptions About This Scenario---------
Wind Speed: 3 meters/second (6.7 miles/hour)
Stability Class: D
Air Temperature: 77 degrees F (25 degrees C)

Chemical: Chlorine [Outdoor; 100-lb container; "fast" release]
CAS #: 7782-50-5
Category: Toxic Gas
Scenario: Alternative
Release Duration: 1 minutes
Release Rate: 100 pounds per min
Mitigation Measures: NONE
Topography: Rural surroundings (terrain generally flat and unobstructed)
Toxic Endpoint: 0.0087 mg/L; basis: ERPG-2
Estimated Distance to Toxic Endpoint: 0.5 miles (0.8 kilometers)

--------Assumptions About This Scenario---------
Wind Speed: 3 meters/second (6.7 miles/hour)
Stability Class: D
Air Temperature: 77 degrees F (25 degrees C)

Chemical: Chlorine [Outdoor; 100-lb container; "slow" release]
CAS #: 7782-50-5
Category: Toxic Gas
Scenario: Alternative
Release Duration: 10 minutes
Release Rate: 10 pounds per min
Mitigation Measures: NONE
Topography: Rural surroundings (terrain generally flat and unobstructed)
Toxic Endpoint: 0.0087 mg/L; basis: ERPG-2
Estimated Distance to Toxic Endpoint: 0.2 miles (0.3 kilometers)

--------Assumptions About This Scenario---------
Wind Speed: 3 meters/second (6.7 miles/hour)
Stability Class: D
Air Temperature: 77 degrees F (25 degrees C)

Chemical: Diborane [Indoor; 0.086-lb container]
CAS #: 19287-45-7
Category: Toxic Gas
Scenario: Alternative
Release Duration: 30 minutes
Release Rate: 0.002867 pounds per min
Mitigation Measures: Release in enclosed space, in direct contact with outside air
Topography: Rural surroundings (terrain generally flat and unobstructed)
Toxic Endpoint: 0.0011 mg/L; basis: ERPG-2
Estimated Distance to Toxic Endpoint: 0.1 miles (0.2 kilometers)

--------Assumptions About This Scenario---------
Wind Speed: 3 meters/second (6.7 miles/hour)
Stability Class: D
Air Temperature: 77 degrees F (25 degrees C)

Chemical: Diborane [Outdoor; 0.086-lb container; "fast" release]
CAS #: 19287-45-7
Category: Toxic Gas
Scenario: Alternative
Release Duration: 1 minutes
Release Rate: 0.086 pounds per min
Mitigation Measures: NONE
Topography: Rural surroundings (terrain generally flat and unobstructed)
Toxic Endpoint: 0.0011 mg/L; basis: ERPG-2
Estimated Distance to Toxic Endpoint: 0.1 miles (0.2 kilometers)

--------Assumptions About This Scenario---------
Wind Speed: 3 meters/second (6.7 miles/hour)
Stability Class: D
Air Temperature: 77 degrees F (25 degrees C)

Chemical: Diborane [Outdoor; 0.086-lb container; "slow" release]
CAS #: 19287-45-7
Category: Toxic Gas
Scenario: Alternative
Release Duration: 10 minutes
Release Rate: 0.0086 pounds per min
Mitigation Measures: NONE
Topography: Rural surroundings (terrain generally flat and unobstructed)
Toxic Endpoint: 0.0011 mg/L; basis: ERPG-2
Estimated Distance to Toxic Endpoint: 0.1 miles (0.2 kilometers)

--------Assumptions About This Scenario---------
Wind Speed: 3 meters/second (6.7 miles/hour)
Stability Class: D
Air Temperature: 77 degrees F (25 degrees C)

Chemical: Dichlorosilane [Outdoor; 50-lb container; vapor cloud fire; "fast" release]
CAS #: 4109-96-0
Category: Flammable Gas
Scenario: Alternative
Release Type: Vapor Cloud Fire
Release Rate: 50 pounds per min
Mitigation Measures: NONE
Topography: Rural surroundings (terrain generally flat and unobstructed)
Lower Flammability Limit: 160 mg/L
Estimated Distance to Lower Flammability Limit: <0.1 miles (<0.16 kilometers)

--------Assumptions About This Scenario---------
Wind Speed: 3 meters/second (6.7 miles/hour)
Stability Class: D
Air Temperature: 77 degrees F (25 degrees C)

Chemical: Dichlorosilane [Outdoor; 50-lb container; vapor cloud fire; "slow" release]
CAS #: 4109-96-0
Category: Flammable Gas
Scenario: Alternative
Release Type: Vapor Cloud Fire
Release Rate: 5 pounds per min
Mitigation Measures: NONE
Topography: Rural surroundings (terrain generally flat and unobstructed)
Lower Flammability Limit: 160 mg/L
Estimated Distance to Lower Flammability Limit: <0.1 miles (<0.16 kilometers)

--------Assumptions About This Scenario---------
Wind Speed: 3 meters/second (6.7 miles/hour)
Stability Class: D
Air Temperature: 77 degrees F (25 degrees C)

Chemical: Dichlorosilane [Outdoor; 50-lb container; vapor cloud explosion; "fast" release]
CAS #: 4109-96-0
Category: Flammable Gas
Scenario: Alternative
Release Duration: 1 minutes
Release Type: Vapor Cloud Explosion
Release Rate: 50 pounds per min
Mitigation Measures: NONE
Estimated Distance to 1 psi overpressure: .01 miles (.02 kilometers)

--------Assumptions About This Scenario---------
Wind Speed: 3 meters/second (6.7 miles/hour)
Stability Class: D
Air Temperature: 77 degrees F (25 degrees C)

Chemical: Dichlorosilane [Outdoor; 50-lb container; vapor cloud explosion; "slow" release]
CAS #: 4109-96-0
Category: Flammable Gas
Scenario: Alternative
Release Duration: 10 minutes
Release Type: Vapor Cloud Explosion
Release Rate: 5 pounds per min
Mitigation Measures: NONE
Estimated Distance to 1 psi overpressure: .01 miles (.02 kilometers)

--------Assumptions About This Scenario---------
Wind Speed: 3 meters/second (6.7 miles/hour)
Stability Class: D
Air Temperature: 77 degrees F (25 degrees C)

Chemical: Dichlorosilane [Outdoor; 50-lb container; BLEVE]
CAS #: 4109-96-0
Category: Flammable Gas
Scenario: Alternative
Release Type: BLEVE
Quantity in Fireball: 50 pounds
Estimated Distance at which exposure may cause second-degree burns: .005 miles (.008 kilometers)

--------Assumptions About This Scenario---------
Wind Speed: 3 meters/second (6.7 miles/hour)
Stability Class: D
Air Temperature: 77 degrees F (25 degrees C)

Chemical: Ethane [Outdoor; 10-lb container; vapor cloud fire; "fast" release]
CAS #: 74-84-0
Category: Flammable Gas
Scenario: Alternative
Release Type: Vapor Cloud Fire
Release Rate: 10 pounds per min
Mitigation Measures: NONE
Topography: Rural surroundings (terrain generally flat and unobstructed)
Lower Flammability Limit: 36 mg/L
Estimated Distance to Lower Flammability Limit: <0.1 miles (<0.16 kilometers)

--------Assumptions About This Scenario---------
Wind Speed: 3 meters/second (6.7 miles/hour)
Stability Class: D
Air Temperature: 77 degrees F (25 degrees C)

Chemical: Ethane [Outdoor; 10-lb container; vapor cloud fire; "slow" release]
CAS #: 74-84-0
Category: Flammable Gas
Scenario: Alternative
Release Type: Vapor Cloud Fire
Release Rate: 1 pounds per min
Mitigation Measures: NONE
Topography: Rural surroundings (terrain generally flat and unobstructed)
Lower Flammability Limit: 36 mg/L
Estimated Distance to Lower Flammability Limit: <0.1 miles (<0.16 kilometers)

--------Assumptions About This Scenario---------
Wind Speed: 3 meters/second (6.7 miles/hour)
Stability Class: D
Air Temperature: 77 degrees F (25 degrees C)

Chemical: Ethane [Outdoor; 10-lb container; vapor cloud explosion; "fast" release]
CAS #: 74-84-0
Category: Flammable Gas
Scenario: Alternative
Release Duration: 1 minutes
Release Type: Vapor Cloud Explosion
Release Rate: 10 pounds per min
Mitigation Measures: NONE
Estimated Distance to 1 psi overpressure: .01 miles (.02 kilometers)

--------Assumptions About This Scenario---------
Wind Speed: 3 meters/second (6.7 miles/hour)
Stability Class: D
Air Temperature: 77 degrees F (25 degrees C)

Chemical: Ethane [Outdoor; 10-lb container; vapor cloud explosion; "slow" release]
CAS #: 74-84-0
Category: Flammable Gas
Scenario: Alternative
Release Duration: 10 minutes
Release Type: Vapor Cloud Explosion
Release Rate: 1 pounds per min
Mitigation Measures: NONE
Estimated Distance to 1 psi overpressure: .01 miles (.02 kilometers)

--------Assumptions About This Scenario---------
Wind Speed: 3 meters/second (6.7 miles/hour)
Stability Class: D
Air Temperature: 77 degrees F (25 degrees C)

Chemical: Ethane [Outdoor; 10-lb container; BLEVE]
CAS #: 74-84-0
Category: Flammable Gas
Scenario: Alternative
Release Type: BLEVE
Quantity in Fireball: 10 pounds
Estimated Distance at which exposure may cause second-degree burns: .006 miles (.010 kilometers)

--------Assumptions About This Scenario---------
Wind Speed: 3 meters/second (6.7 miles/hour)
Stability Class: D
Air Temperature: 77 degrees F (25 degrees C)

Chemical: Fluorine [Indoor; 0.52-lb container]
CAS #: 7782-41-4
Category: Toxic Gas
Scenario: Alternative
Release Duration: 30 minutes
Release Rate: 0.0173 pounds per min
Mitigation Measures: Release in enclosed space, in direct contact with outside air
Topography: Rural surroundings (terrain generally flat and unobstructed)
Toxic Endpoint: 0.0039 mg/L; basis: EHS-LOC (IDLH)
Estimated Distance to Toxic Endpoint: 0.2 miles (0.3 kilometers)

--------Assumptions About This Scenario---------
Wind Speed: 3 meters/second (6.7 miles/hour)
Stability Class: D
Air Temperature: 77 degrees F (25 degrees C)

Chemical: Fluorine [Outdoor; 0.52-lb container; "fast" release]
CAS #: 7782-41-4
Category: Toxic Gas
Scenario: Alternative
Release Duration: 1 minutes
Release Rate: 0.52 pounds per min
Mitigation Measures: NONE
Topography: Rural surroundings (terrain generally flat and unobstructed)
Toxic Endpoint: 0.0039 mg/L; basis: EHS-LOC (IDLH)
Estimated Distance to Toxic Endpoint: 0.2 miles (0.3 kilometers)

--------Assumptions About This Scenario---------
Wind Speed: 3 meters/second (6.7 miles/hour)
Stability Class: D
Air Temperature: 77 degrees F (25 degrees C)

Chemical: Fluorine [Outdoor; 0.52-lb container; "slow" release]
CAS #: 7782-41-4
Category: Toxic Gas
Scenario: Alternative
Release Duration: 10 minutes
Release Rate: 0.052 pounds per min
Mitigation Measures: NONE
Topography: Rural surroundings (terrain generally flat and unobstructed)
Toxic Endpoint: 0.0039 mg/L; basis: EHS-LOC (IDLH)
Estimated Distance to Toxic Endpoint: 0.2 miles (0.3 kilometers)

--------Assumptions About This Scenario---------
Wind Speed: 3 meters/second (6.7 miles/hour)
Stability Class: D
Air Temperature: 77 degrees F (25 degrees C)

Chemical: Hydrogen [Outdoor; 3480-lb container; vapor cloud fire; "fast" release]
CAS #: 1333-74-0
Category: Flammable Gas
Scenario: Worst-case
Quantity Released: 3480 pounds
Release Type: Vapor Cloud Explosion
Estimated Distance to 1 psi overpressure: .2 miles (.3 kilometers)

--------Assumptions About This Scenario---------
Wind Speed: 1.5 meters/second (3.4 miles/hour)
Stability Class: F
Air Temperature: 77 degrees F (25 degrees C)

Chemical: Hydrogen chloride (anhydrous) [Indoor; 500-lb container]
CAS #: 7647-01-0
Category: Toxic Gas
Scenario: Alternative
Release Duration: 30 minutes
Release Rate: 2.167 pounds per min
Mitigation Measures: Release in enclosed space, in direct contact with outside air
Topography: Rural surroundings (terrain generally flat and unobstructed)
Toxic Endpoint: 0.030 mg/L; basis: ERPG-2
Estimated Distance to Toxic Endpoint: <0.1 miles (<0.16 kilometers); report as 0.1 mile

--------Assumptions About This Scenario---------
Wind Speed: 3 meters/second (6.7 miles/hour)
Stability Class: D
Air Temperature: 77 degrees F (25 degrees C)

Chemical: Hydrogen chloride (anhydrous) [Outdoor; 500-lb container; "fast" release]
CAS #: 7647-01-0
Category: Toxic Gas
Scenario: Alternative
Release Duration: 1 minutes
Release Rate: 500 pounds per min
Mitigation Measures: NONE
Topography: Rural surroundings (terrain generally flat and unobstructed)
Toxic Endpoint: 0.030 mg/L; basis: ERPG-2
Estimated Distance to Toxic Endpoint: 0.4 miles (0.6 kilometers)

--------Assumptions About This Scenario---------
Wind Speed: 3 meters/second (6.7 miles/hour)
Stability Class: D
Air Temperature: 77 degrees F (25 degrees C)

Chemical: Hydrogen chloride (anhydrous) [Outdoor; 500-lb container; "slow" release]
CAS #: 7647-01-0
Category: Toxic Gas
Scenario: Alternative
Release Duration: 10 minutes
Release Rate: 50 pounds per min
Mitigation Measures: NONE
Topography: Rural surroundings (terrain generally flat and unobstructed)
Toxic Endpoint: 0.030 mg/L; basis: ERPG-2
Estimated Distance to Toxic Endpoint: 0.4 miles (0.6 kilometers)

--------Assumptions About This Scenario---------
Wind Speed: 3 meters/second (6.7 miles/hour)
Stability Class: D
Air Temperature: 77 degrees F (25 degrees C)

Chemical: Methane [Outdoor; 4-lb container; vapor cloud fire; "fast" release]
CAS #: 74-82-8
Category: Flammable Gas
Scenario: Alternative
Release Type: Vapor Cloud Fire
Release Rate: 4 pounds per min
Mitigation Measures: NONE
Topography: Rural surroundings (terrain generally flat and unobstructed)
Lower Flammability Limit: 33 mg/L
Estimated Distance to Lower Flammability Limit: .1 miles (.2 kilometers)

--------Assumptions About This Scenario---------
Wind Speed: 3 meters/second (6.7 miles/hour)
Stability Class: D
Air Temperature: 77 degrees F (25 degrees C)

Chemical: Methane [Outdoor; 4-lb container; vapor cloud fire; "slow" release]
CAS #: 74-82-8
Category: Flammable Gas
Scenario: Alternative
Release Type: Vapor Cloud Fire
Release Rate: 0.4 pounds per min
Mitigation Measures: NONE
Topography: Rural surroundings (terrain generally flat and unobstructed)
Lower Flammability Limit: 33 mg/L
Estimated Distance to Lower Flammability Limit: .1 miles (.2 kilometers)

--------Assumptions About This Scenario---------
Wind Speed: 3 meters/second (6.7 miles/hour)
Stability Class: D
Air Temperature: 77 degrees F (25 degrees C)

Chemical: Methane [Outdoor; 4-lb container; vapor cloud explosion; "fast" release]
CAS #: 74-82-8
Category: Flammable Gas
Scenario: Alternative
Release Duration: 1 minutes
Release Type: Vapor Cloud Explosion
Release Rate: 4 pounds per min
Mitigation Measures: NONE
Estimated Distance to 1 psi overpressure: .009 miles (.014 kilometers)

--------Assumptions About This Scenario---------
Wind Speed: 3 meters/second (6.7 miles/hour)
Stability Class: D
Air Temperature: 77 degrees F (25 degrees C)

Chemical: Methane [Outdoor; 4-lb container; vapor cloud explosion; "slow" release]
CAS #: 74-82-8
Category: Flammable Gas
Scenario: Alternative
Release Duration: 10 minutes
Release Type: Vapor Cloud Explosion
Release Rate: 0.4 pounds per min
Mitigation Measures: NONE
Estimated Distance to 1 psi overpressure: .009 miles (.014 kilometers)

--------Assumptions About This Scenario---------
Wind Speed: 3 meters/second (6.7 miles/hour)
Stability Class: D
Air Temperature: 77 degrees F (25 degrees C)

Chemical: Methane [Outdoor; 4-lb container; BLEVE]
CAS #: 74-82-8
Category: Flammable Gas
Scenario: Alternative
Release Type: BLEVE
Quantity in Fireball: 4 pounds
Estimated Distance at which exposure may cause second-degree burns: .004 miles (.006 kilometers)

--------Assumptions About This Scenario---------
Wind Speed: 3 meters/second (6.7 miles/hour)
Stability Class: D
Air Temperature: 77 degrees F (25 degrees C)

Chemical: Phosphine [Indoor; 2.866-lb container]
CAS #: 7803-51-2
Category: Toxic Gas
Scenario: Alternative
Release Duration: 30 minutes
Release Rate: 0.0955 pounds per min
Mitigation Measures: Release in enclosed space, in direct contact with outside air
Topography: Rural surroundings (terrain generally flat and unobstructed)
Toxic Endpoint: 0.0035 mg/L; basis: ERPG-2
Estimated Distance to Toxic Endpoint: 0.2 miles (0.3 kilometers)

--------Assumptions About This Scenario---------
Wind Speed: 3 meters/second (6.7 miles/hour)
Stability Class: D
Air Temperature: 77 degrees F (25 degrees C)

Chemical: Phosphine [Outdoor; 2.866-lb container; "fast" release]
CAS #: 7803-51-2
Category: Toxic Gas
Scenario: Alternative
Release Duration: 1 minutes
Release Rate: 2.866 pounds per min
Mitigation Measures: NONE
Topography: Rural surroundings (terrain generally flat and unobstructed)
Toxic Endpoint: 0.0035 mg/L; basis: ERPG-2
Estimated Distance to Toxic Endpoint: 0.2 miles (0.3 kilometers)

--------Assumptions About This Scenario---------
Wind Speed: 3 meters/second (6.7 miles/hour)
Stability Class: D
Air Temperature: 77 degrees F (25 degrees C)

Chemical: Phosphine [Outdoor; 2.866-lb container; "slow" release]
CAS #: 7803-51-2
Category: Toxic Gas
Scenario: Alternative
Release Duration: 10 minutes
Release Rate: 0.2866 pounds per min
Mitigation Measures: NONE
Topography: Rural surroundings (terrain generally flat and unobstructed)
Toxic Endpoint: 0.0035 mg/L; basis: ERPG-2
Estimated Distance to Toxic Endpoint: 0.2 miles (0.3 kilometers)

--------Assumptions About This Scenario---------
Wind Speed: 3 meters/second (6.7 miles/hour)
Stability Class: D
Air Temperature: 77 degrees F (25 degrees C)

Chemical: Silane [Outdoor; 33.1-lb container; vapor cloud explosion; "fast" release]
CAS #: 7803-62-5
Category: Flammable Gas
Scenario: Alternative
Release Duration: 1 minutes
Release Type: Vapor Cloud Explosion
Release Rate: 33.1 pounds per min
Mitigation Measures: NONE
Estimated Distance to 1 psi overpressure: .02 miles (.03 kilometers)

--------Assumptions About This Scenario---------
Wind Speed: 3 meters/second (6.7 miles/hour)
Stability Class: D
Air Temperature: 77 degrees F (25 degrees C)

Chemical: Silane [Outdoor; 33.1-lb container; vapor cloud explosion; "fast" release]
CAS #: 7803-62-5
Category: Flammable Gas
Scenario: Alternative
Release Duration: 10 minutes
Release Type: Vapor Cloud Explosion
Release Rate: 3.31 pounds per min
Mitigation Measures: NONE
Estimated Distance to 1 psi overpressure: .02 miles (.03 kilometers)

--------Assumptions About This Scenario---------
Wind Speed: 3 meters/second (6.7 miles/hour)
Stability Class: D
Air Temperature: 77 degrees F (25 degrees C)

Chemical: Silane [Outdoor; 33.1-lb container; BLEVE]
CAS #: 7803-62-5
Category: Flammable Gas
Scenario: Alternative
Release Type: BLEVE
Quantity in Fireball: 33.1 pounds
Estimated Distance at which exposure may cause second-degree burns: .01 miles (.02 kilometers)

--------Assumptions About This Scenario---------
Wind Speed: 3 meters/second (6.7 miles/hour)
Stability Class: D
Air Temperature: 77 degrees F (25 degrees C)

Chemical: Hydrochloric acid 37% [Outdoor; 2x10000-gallon tank; fast release]
CAS #: 7647-01-0
Category: Toxic Liquid
Scenario: Alternative
Quantity Released: 193000 pounds
Release Duration: 1 minutes
Release Rate: 20000 gallons per min
Liquid Temperature: 70 F
Mitigation Measures: Diked area: 2000 square feet Dike height: 6 feet

Release Rate to Outside Air: 29.8 pounds per minute
Topography: Rural surroundings (terrain generally flat and unobstructed)
Toxic Endpoint: 0.030 mg/L; basis: ERPG-2
Estimated Distance to Toxic Endpoint: 0.3 miles (0.5 kilometers)

--------Assumptions About This Scenario---------
Wind Speed: 3 meters/second (6.7 miles/hour)
Stability Class: D
Air Temperature: 77 degrees F (25 degrees C)

Chemical: Hydrochloric acid 37% [Outdoor; 2x10000-gallon tank; slow release]
CAS #: 7647-01-0
Category: Toxic Liquid
Scenario: Alternative
Quantity Released: 193000 pounds
Release Duration: 10 minutes
Release Rate: 2000 gallons per min
Liquid Temperature: 70 F
Mitigation Measures: Diked area: 2000 square feet Dike height: 6 feet

Release Rate to Outside Air: 29.8 pounds per minute
Topography: Rural surroundings (terrain generally flat and unobstructed)
Toxic Endpoint: 0.030 mg/L; basis: ERPG-2
Estimated Distance to Toxic Endpoint: 0.3 miles (0.5 kilometers)

--------Assumptions About This Scenario---------
Wind Speed: 3 meters/second (6.7 miles/hour)
Stability Class: D
Air Temperature: 77 degrees F (25 degrees C)

Results of Consequence Analysis: Full Inventory / Worst-Case

Chemical: Ammonia (anhydrous) [Outdoor]
CAS #: 7664-41-7
Category: Toxic Gas
Scenario: Worst-case
Quantity Released: 2430 pounds
Release Duration: 10 min
Release Rate: 243 pounds per min
Mitigation Measures: NONE
Topography: Rural surroundings (terrain generally flat and unobstructed)
Toxic Endpoint: 0.14 mg/L; basis: ERPG-2
Estimated Distance to Toxic Endpoint: 0.8 miles (1.3 kilometers)

--------Assumptions About This Scenario---------
Wind Speed: 1.5 meters/second (3.4 miles/hour)
Stability Class: F
Air Temperature: 77 degrees F (25 degrees C)

Chemical: Arsine [Indoor]
CAS #: 7784-42-1
Category: Toxic Gas
Scenario: Worst-case
Quantity Released: 5.29 pounds
Release Duration: 10 min
Release Rate: .291 pounds per min
Mitigation Measures: Release in enclosed space, in direct contact with outside air
Topography: Rural surroundings (terrain generally flat and unobstructed)
Toxic Endpoint: 0.0019 mg/L; basis: EHS-LOC (IDLH)
Estimated Distance to Toxic Endpoint: 1.1 miles (1.8 kilometers)

--------Assumptions About This Scenario---------
Wind Speed: 1.5 meters/second (3.4 miles/hour)
Stability Class: F
Air Temperature: 77 degrees F (25 degrees C)

Chemical: Arsine [Outdoor]
CAS #: 7784-42-1
Category: Toxic Gas
Scenario: Worst-case
Quantity Released: 5.29 pounds
Release Duration: 10 min
Release Rate: .529 pounds per min
Mitigation Measures: NONE
Topography: Rural surroundings (terrain generally flat and unobstructed)
Toxic Endpoint: 0.0019 mg/L; basis: EHS-LOC (IDLH)
Estimated Distance to Toxic Endpoint: 1.1 miles (1.8 kilometers)

--------Assumptions About This Scenario---------
Wind Speed: 1.5 meters/second (3.4 miles/hour)
Stability Class: F
Air Temperature: 77 degrees F (25 degrees C)

Chemical: Boron trichloride [Indoor]
CAS #: 10294-34-5
Category: Toxic Gas
Scenario: Worst-case
Quantity Released: 1192.5 pounds
Release Duration: 10 min
Release Rate: 65.6 pounds per min
Mitigation Measures: Release in enclosed space, in direct contact with outside air
Topography: Rural surroundings (terrain generally flat and unobstructed)
Toxic Endpoint: 0.010 mg/L; basis: EHS-LOC; LOC is based on IDLH-equivalent level estimated from toxicity data.
Estimated Distance to Toxic Endpoint: 3.0 miles (4.8 kilometers)

--------Assumptions About This Scenario---------
Wind Speed: 1.5 meters/second (3.4 miles/hour)
Stability Class: F
Air Temperature: 77 degrees F (25 degrees C)

Chemical: Boron trichloride [Outdoor]
CAS #: 10294-34-5
Category: Toxic Gas
Scenario: Worst-case
Quantity Released: 1192.5 pounds
Release Duration: 10 min
Release Rate: 119 pounds per min
Mitigation Measures: NONE
Topography: Rural surroundings (terrain generally flat and unobstructed)
Toxic Endpoint: 0.010 mg/L; basis: EHS-LOC; LOC is based on IDLH-equivalent level estimated from toxicity data.
Estimated Distance to Toxic Endpoint: 4.2 miles (6.8 kilometers)

--------Assumptions About This Scenario---------
Wind Speed: 1.5 meters/second (3.4 miles/hour)
Stability Class: F
Air Temperature: 77 degrees F (25 degrees C)

Chemical: Boron trifluoride [Indoor]
CAS #: 7637-07-2
Category: Toxic Gas
Scenario: Worst-case
Quantity Released: 4.87 pounds
Release Duration: 10 min
Release Rate: .268 pounds per min
Mitigation Measures: Release in enclosed space, in direct contact with outside air
Topography: Rural surroundings (terrain generally flat and unobstructed)
Toxic Endpoint: 0.028 mg/L; basis: EHS-LOC (IDLH)
Estimated Distance to Toxic Endpoint: 0.2 miles (0.3 kilometers)

--------Assumptions About This Scenario---------
Wind Speed: 1.5 meters/second (3.4 miles/hour)
Stability Class: F
Air Temperature: 77 degrees F (25 degrees C)

Chemical: Boron trifluoride [Outdoor]
CAS #: 7637-07-2
Category: Toxic Gas
Scenario: Worst-case
Quantity Released: 4.87 pounds
Release Duration: 10 min
Release Rate: .487 pounds per min
Mitigation Measures: NONE
Topography: Rural surroundings (terrain generally flat and unobstructed)
Toxic Endpoint: 0.028 mg/L; basis: EHS-LOC (IDLH)
Estimated Distance to Toxic Endpoint: 0.2 miles (0.3 kilometers)

--------Assumptions About This Scenario---------
Wind Speed: 1.5 meters/second (3.4 miles/hour)
Stability Class: F
Air Temperature: 77 degrees F (25 degrees C)

Chemical: Chlorine [Indoor]
CAS #: 7782-50-5
Category: Toxic Gas
Scenario: Worst-case
Quantity Released: 6000 pounds
Release Duration: 10 min
Release Rate: 330 pounds per min
Mitigation Measures: Release in enclosed space, in direct contact with outside air
Topography: Rural surroundings (terrain generally flat and unobstructed)
Toxic Endpoint: 0.0087 mg/L; basis: ERPG-2
Estimated Distance to Toxic Endpoint: 3.7 miles (6.0 kilometers)

--------Assumptions About This Scenario---------
Wind Speed: 1.5 meters/second (3.4 miles/hour)
Stability Class: F
Air Temperature: 77 degrees F (25 degrees C)

Chemical: Chlorine [Outdoor]
CAS #: 7782-50-5
Category: Toxic Gas
Scenario: Worst-case
Quantity Released: 6000 pounds
Release Duration: 10 min
Release Rate: 600 pounds per min
Mitigation Measures: NONE
Topography: Rural surroundings (terrain generally flat and unobstructed)
Toxic Endpoint: 0.0087 mg/L; basis: ERPG-2
Estimated Distance to Toxic Endpoint: 5.2 miles (8.4 kilometers)

--------Assumptions About This Scenario---------
Wind Speed: 1.5 meters/second (3.4 miles/hour)
Stability Class: F
Air Temperature: 77 degrees F (25 degrees C)

Chemical: Diborane [Indoor]
CAS #: 19287-45-7
Category: Toxic Gas
Scenario: Worst-case
Quantity Released: 0.34 pounds
Release Duration: 10 min
Release Rate: .0187 pounds per min
Mitigation Measures: Release in enclosed space, in direct contact with outside air
Topography: Rural surroundings (terrain generally flat and unobstructed)
Toxic Endpoint: 0.0011 mg/L; basis: ERPG-2
Estimated Distance to Toxic Endpoint: 0.2 miles (0.3 kilometers)

--------Assumptions About This Scenario---------
Wind Speed: 1.5 meters/second (3.4 miles/hour)
Stability Class: F
Air Temperature: 77 degrees F (25 degrees C)

Chemical: Diborane [Outdoor]
CAS #: 19287-45-7
Category: Toxic Gas
Scenario: Worst-case
Quantity Released: 0.34 pounds
Release Duration: 10 min
Release Rate: .0340 pounds per min
Mitigation Measures: NONE
Topography: Rural surroundings (terrain generally flat and unobstructed)
Toxic Endpoint: 0.0011 mg/L; basis: ERPG-2
Estimated Distance to Toxic Endpoint: 0.2 miles (0.3 kilometers)

--------Assumptions About This Scenario---------
Wind Speed: 1.5 meters/second (3.4 miles/hour)
Stability Class: F
Air Temperature: 77 degrees F (25 degrees C)

Chemical: Dichlorosilane
CAS #: 4109-96-0
Category: Flammable Gas
Scenario: Worst-case
Quantity Released: 1650 pounds
Release Type: Vapor Cloud Explosion
Estimated Distance to 1 psi overpressure: .05 miles (.09 kilometers)

--------Assumptions About This Scenario---------
Wind Speed: 1.5 meters/second (3.4 miles/hour)
Stability Class: F
Air Temperature: 77 degrees F (25 degrees C)

Chemical: Ethane
CAS #: 74-84-0
Category: Flammable Gas
Scenario: Worst-case
Quantity Released: 10 pounds
Release Type: Vapor Cloud Explosion
Estimated Distance to 1 psi overpressure: .02 miles (.03 kilometers)

--------Assumptions About This Scenario---------
Wind Speed: 1.5 meters/second (3.4 miles/hour)
Stability Class: F
Air Temperature: 77 degrees F (25 degrees C)

Chemical: Fluorine [Indoor]
CAS #: 7782-41-4
Category: Toxic Gas
Scenario: Worst-case
Quantity Released: 4.66 pounds
Release Duration: 10 min
Release Rate: .256 pounds per min
Mitigation Measures: Release in enclosed space, in direct contact with outside air
Topography: Rural surroundings (terrain generally flat and unobstructed)
Toxic Endpoint: 0.0039 mg/L; basis: EHS-LOC (IDLH)
Estimated Distance to Toxic Endpoint: 0.8 miles (1.3 kilometers)

--------Assumptions About This Scenario---------
Wind Speed: 1.5 meters/second (3.4 miles/hour)
Stability Class: F
Air Temperature: 77 degrees F (25 degrees C)

Chemical: Fluorine [Outdoor]
CAS #: 7782-41-4
Category: Toxic Gas
Scenario: Worst-case
Quantity Released: 4.66 pounds
Release Duration: 10 min
Release Rate: .466 pounds per min
Mitigation Measures: NONE
Topography: Rural surroundings (terrain generally flat and unobstructed)
Toxic Endpoint: 0.0039 mg/L; basis: EHS-LOC (IDLH)
Estimated Distance to Toxic Endpoint: 0.8 miles (1.3 kilometers)

--------Assumptions About This Scenario---------
Wind Speed: 1.5 meters/second (3.4 miles/hour)
Stability Class: F
Air Temperature: 77 degrees F (25 degrees C)

Chemical: Hydrogen
CAS #: 1333-74-0
Category: Flammable Gas
Scenario: Worst-case
Quantity Released: 11188 pounds
Release Type: Vapor Cloud Explosion
Estimated Distance to 1 psi overpressure: .2 miles (.4 kilometers)

--------Assumptions About This Scenario---------
Wind Speed: 1.5 meters/second (3.4 miles/hour)
Stability Class: F
Air Temperature: 77 degrees F (25 degrees C)

Chemical: Hydrogen chloride (anhydrous) [Indoor]
CAS #: 7647-01-0
Category: Toxic Gas
Scenario: Worst-case
Quantity Released: 1780 pounds
Release Duration: 10 min
Release Rate: 97.9 pounds per min
Mitigation Measures: Release in enclosed space, in direct contact with outside air
Topography: Rural surroundings (terrain generally flat and unobstructed)
Toxic Endpoint: 0.030 mg/L; basis: ERPG-2
Estimated Distance to Toxic Endpoint: 2.2 miles (3.5 kilometers)

--------Assumptions About This Scenario---------
Wind Speed: 1.5 meters/second (3.4 miles/hour)
Stability Class: F
Air Temperature: 77 degrees F (25 degrees C)

Chemical: Hydrogen chloride (anhydrous) [Outdoor]
CAS #: 7647-01-0
Category: Toxic Gas
Scenario: Worst-case
Quantity Released: 1780 pounds
Release Duration: 10 min
Release Rate: 178 pounds per min
Mitigation Measures: NONE
Topography: Rural surroundings (terrain generally flat and unobstructed)
Toxic Endpoint: 0.030 mg/L; basis: ERPG-2
Estimated Distance to Toxic Endpoint: 2.7 miles (4.3 kilometers)

--------Assumptions About This Scenario---------
Wind Speed: 1.5 meters/second (3.4 miles/hour)
Stability Class: F
Air Temperature: 77 degrees F (25 degrees C)

Chemical: Methane
CAS #: 74-82-8
Category: Flammable Gas
Scenario: Worst-case
Quantity Released: 4 pounds
Release Type: Vapor Cloud Explosion
Estimated Distance to 1 psi overpressure: .01 miles (.02 kilometers)

--------Assumptions About This Scenario---------
Wind Speed: 1.5 meters/second (3.4 miles/hour)
Stability Class: F
Air Temperature: 77 degrees F (25 degrees C)

Chemical: Phosphine [Indoor]
CAS #: 7803-51-2
Category: Toxic Gas
Scenario: Worst-case
Quantity Released: 18.7 pounds
Release Duration: 10 min
Release Rate: 1.03 pounds per min
Mitigation Measures: Release in enclosed space, in direct contact with outside air
Topography: Rural surroundings (terrain generally flat and unobstructed)
Toxic Endpoint: 0.0035 mg/L; basis: ERPG-2
Estimated Distance to Toxic Endpoint: 0.8 miles (1.3 kilometers)

--------Assumptions About This Scenario---------
Wind Speed: 1.5 meters/second (3.4 miles/hour)
Stability Class: F
Air Temperature: 77 degrees F (25 degrees C)

Chemical: Phosphine [Outdoor]
CAS #: 7803-51-2
Category: Toxic Gas
Scenario: Worst-case
Quantity Released: 18.7 pounds
Release Duration: 10 min
Release Rate: 1.87 pounds per min
Mitigation Measures: NONE

Topography: Rural surroundings (terrain generally flat and unobstructed)
Toxic Endpoint: 0.0035 mg/L; basis: ERPG-2
Estimated Distance to Toxic Endpoint: 1.1 miles (1.8 kilometers)

--------Assumptions About This Scenario---------
Wind Speed: 1.5 meters/second (3.4 miles/hour)
Stability Class: F
Air Temperature: 77 degrees F (25 degrees C)

Chemical: Silane
CAS #: 7803-62-5
Category: Flammable Gas
Scenario: Worst-case
Quantity Released: 1287 pounds
Release Type: Vapor Cloud Explosion
Estimated Distance to 1 psi overpressure: .09 miles (.14 kilometers)

--------Assumptions About This Scenario---------
Wind Speed: 1.5 meters/second (3.4 miles/hour)
Stability Class: F
Air Temperature: 77 degrees F (25 degrees C)

Chemical: Hydrochloric acid 37% [Outdoor]
CAS #: 7647-01-0
Category: Toxic Liquid
Scenario: Worst-case
Quantity Released: 49336 pounds
Liquid Temperature: 77 F
Mitigation Measures: Diked area: 2000 square feet Dike height: 4 feet
Release Rate to Outside Air: 23.8 pounds per minute
Topography: Rural surroundings (terrain generally flat and unobstructed)
Toxic Endpoint: 0.030 mg/L; basis: ERPG-2
Estimated Distance to Toxic Endpoint: 1.3 miles (2.1 kilometers)

--------Assumptions About This Scenario---------
Wind Speed: 1.5 meters/second (3.4 miles/hour)
Stability Class: F
Air Temperature: 77 degrees F (25 degrees C)
