ORMAT, DOGWOOD
GEOTHERMAL POWER GENERATION FACILITY
HEBER, CALIFORNIA

Hazard Assessment

Revision	Date	Description
0.0	April 2024	Hazard Assessment, 20,000-gallon Isopentane Storage Tanks

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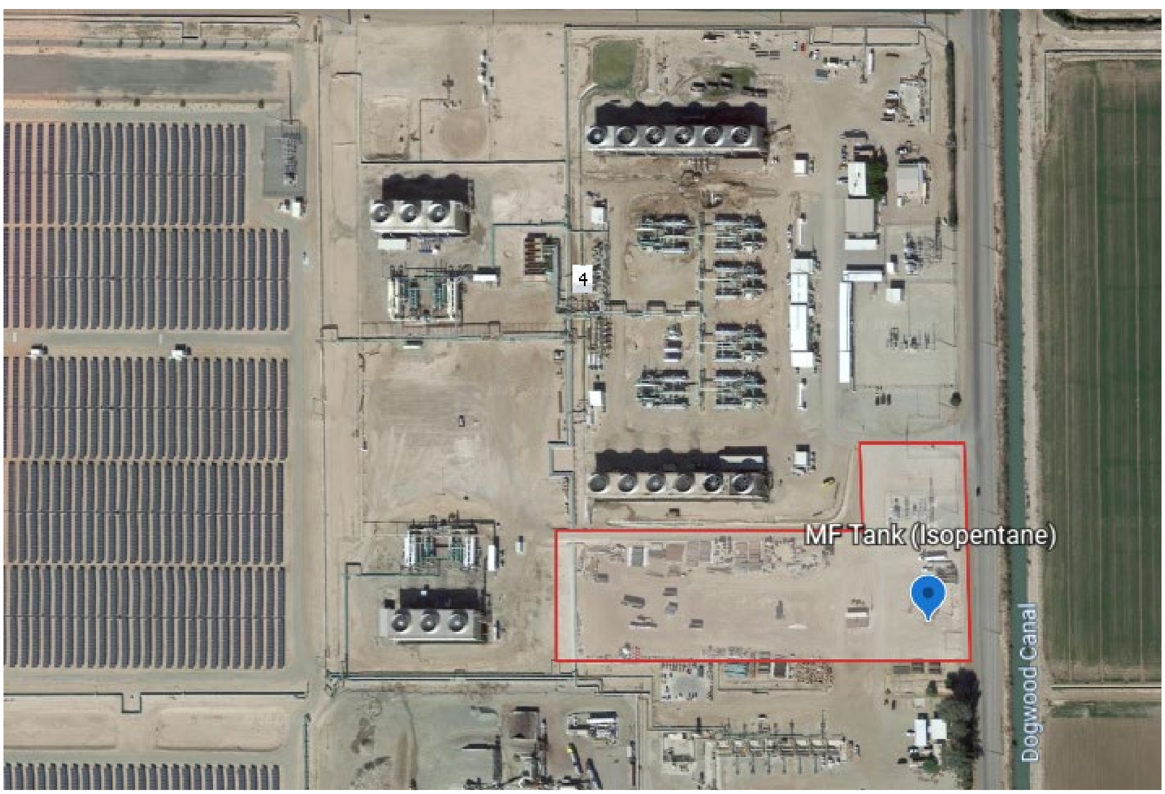
1.0 FACILITY OVERVIEW

This technical assessment was conducted to fulfill the Hazard Assessment Offsite Consequence Analysis (OCA) requirements of the following regulations:

- 40 CFR §68.65 – Environmental Protection Agency (EPA) "Risk Management Plan (RMP)"[1]
- 19 CCR 2750.1 to 2750.9 – California Code of Regulation "California Accidental Release Prevention (CalARP) Program"[2]

This assessment is completed for the **Ormat– Dogwood** Facility located in Heber, California. The facility's location at 855 Dogwood Road, Heber, CA 92249 is illustrated in Figure 1 below. The Dogwood facility is adjacent to the existing Heber, Heber 2, and Ghoulds 2 facilities; the boundaries of the Dogwood Facility are depicted by the red outline. The blue marker depicts the location of the new 10,000-gallon isopentane vessel that is being added to the facility. The coordinates for the vessel's location are presented in Table 1 on the following page.

Figure 5: Aerial View of the Facility Location



The following page presents a closer view of the facility's storage vessel location, as well as a table displaying its approximate location.

Figure 6: Aerial View of the Storage Vessel Locations

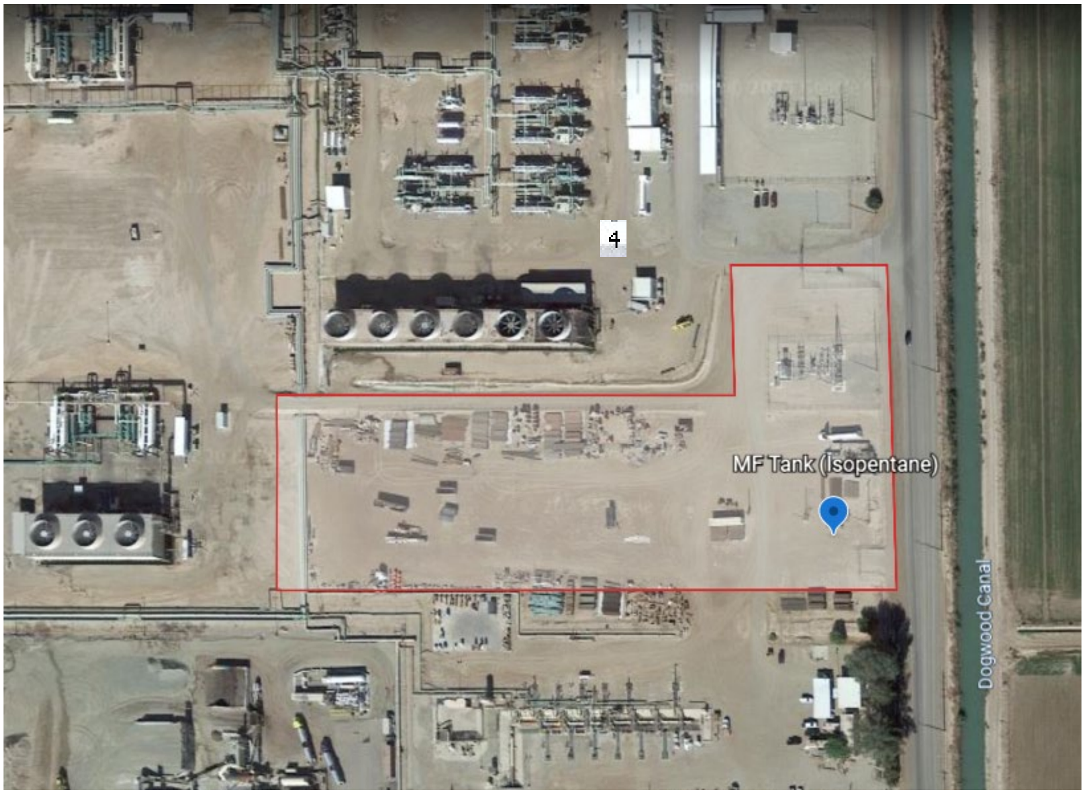


Table 2: Ormat—Dogwood New Storage Vessel Coordinates

VESSEL	FORMAT	LATITUDE	LONGITUDE
Isopentane Storage Vessel (MF Tank)	Degrees/Minutes/Seconds	32°42’46” N	115°32’04” W

2.0 COVERED PROCESS

The ***Ormat – Dogwood Project*** utilizes geothermal fluid, collected from one (1) existing and two (2) new production wells, to produce electricity via one (1) Integrated Two Level Unit (ITLU) Airer Cooled ORMAT Energy Converter (OEC) generating unit. The ITLU Airer Cooled OEC employs vaporized motive fluid to spin a turbine connected to a generator. In the Dogwood binary processes, isopentane is the motive fluid.

The covered processes at the facility are listed below.

Table 2: Ormat—Heber 2 Geothermal Complex Facility Covered Process

PLANT	REGULATED SUBSTANCE	MAXIMUM INVENTORY IN SINGLE VESSEL (GAL)[A]	TANK TYPE	VESSEL STORAGE INVENTORY
Dogwood	Isopentane	18,000	Storage	20,000-gallon tank

[A] This value represents the maximum amount stored in a single vessel, taking into account administrative controls, which are in place to limit the quantity stored.

This hazard assessment will focus on the regulated substance, isopentane, in Dogwood. The facility is classified as Prevention Program 3 and is regulated by the Environmental Protection Agency's Risk Management Program (EPA RMP) for Chemical Accidental Release Prevention in accordance with the Code of Federal Regulations, Title 40, Chapter I, Subchapter C, Part 68, Subpart B Sections 68.20 to 68.42 (40 CFR §68.20 - 68.42)[1] for isopentane, because it is held on site in excess of 10,000 lbs. The geothermal power plant utilizes isopentane as the motive fluid in the generation of electricity.

3.0 LEVEL OF CONCERN

To address potential health effects for the worst-case release scenario, the following are the key endpoints of concern for the EPA RMP as defined in Title 40 CFR Section 68.22(2):

(i) *Explosion. An overpressure of 1 psi.*

(ii) *Radiant heat/exposure time. A radiant heat of 5 kW/m^2 for 40 seconds.*

(iii) *Lower flammability limit. A lower flammability limit as provided in NFPA documents or other generally recognized sources.*

The distance from the point of release to the endpoint identified above defines a radius circle of concern for which consequences are reported in the Risk Management Plan.

4.0 WORST-CASE SCENARIO

The US EPA RMP determines the worst-case release quantity in Title 40 CFR Part 68.25(b) as follows:

The worst-case release quantity shall be the greater of the following:

> *(1) For substances in a vessel, the greatest amount held in a single vessel, taking into account administrative controls that limit the maximum quantity;*
>
> *(2) For substances in pipes, the greatest amount in a pipe, taking into account administrative controls that limit the maximum quantity.*

Given the substance released is a flammable, the US EPA RMP gives further guidelines in 68.25 (f):

> *Worst-Case scenario-flammable liquids. The owner or operator shall assume that the quantity of the substance, as determined under paragraph (b) of this section and the provisions below, vaporizes resulting in a vapor cloud explosion. A yield factor of 10 percent of the available energy released in the explosion shall be used to determine the distance to the explosion endpoint if the model used is based on TNT equivalent methods.*
>
> *(1) For regulated flammable substances that are normally liquids at ambient temperature, the owner or operator shall assume that the entire quantity in the vessel or pipe as determined under paragraph (b) of this section, is spilled instantaneously to form a liquid pool. For liquids at temperatures below their atmospheric boiling point, the volatilization rate shall be calculated at the condition specified in paragraph (d) of this section.*
>
> *(2) The owner or operator shall assume that the quantity which becomes vapor in the first 10 minutes is involved in the vapor cloud explosion.*

Furthermore, vapor cloud explosions are considered a conservative analysis as Chapter 4: OCA of the General Risk Management Program Guidance states:

> *As in the case of the worst-case release analysis for toxic substances, the worst-case distance to the endpoint for flammable substances is based on a number of very conservative assumptions. Release of the total quantity of a flammable substance in a vessel or pipe into a vapor cloud generally would be highly unlikely. Vapor cloud explosions are also unlikely events; in an actual release, the flammable gas or vapor released to air might disperse without ignition, or it might burn instead of exploding, with more limited consequences. The endpoint of 1 psi is intended to be conservative and protective; it does not define a level at which severe injuries or death would be commonly expected. An overpressure of 1 psi is unlikely to have serious direct effects on people; this overpressure may cause property damage such as partial demolition*

of houses, which can result in injuries to people, and shattering of glass windows, which may cause skin laceration from flying glass.

To develop the worst-case scenario, the largest storage vessel was selected. As stated in 19°CCR §2750.3, the worst-case release quantity is the greatest amount held in a single vessel, taking into account inventory procedures and limits.

The Areal Locations of Hazardous Atmospheres (ALOHA)[3] modeling software was used to determine the distance to the endpoint for the worst-case release scenario analysis. The vulnerability zone resulting from this analysis was then reviewed. A vulnerability zone is defined as a circle whose center is the point of release and its radius is the length of the endpoint, which is predicted by the dispersion model (e.g., ALOHA).

4.1 Worst-Case Scenario Selection Process

The process of worst-case release scenario identification is summarized as follows. Figure 3 on the following page depicts the steps in this process.

- **Inventory Calculation**: The first step was to perform the inventory calculations for the 20,000-gallon storage vessels in the covered units and systems.
- **Screening Analysis**: The 20,000-gallon isopentane storage vessels' location was screened. ALOHA modeling software was used to model the scenario and determine the dispersion endpoints for the worst-case release scenario. This was performed to determine the vulnerability zone associated with the worst-case release scenario.
- **Review of the Vulnerability Zone**: The vulnerability zone resulting from the previous step was reviewed and is representative for the plant's worst-case scenario.
- **Worst-Case Analysis**: To document the worst-case scenario, the potential public receptors within the vulnerability zone were identified. All modeling inputs, calculations and assumptions are documented.

Figure 7: Worst-Case Scenario Selection Process

Inventory Calculation

1. Calculate Inventory of the 20,000 gallon isopentane storage vessels in the Heber 2 Repower project.

Screening Analysis

2. Select one of the isopentane storage vessels with the greatest potential to impact the community for analysis.

3. Model potential release disperion of the vessel using the selected software.

Review of Hazard Zone

4. Overlay results onto a map illustrating the circle of concern.

This shall represent the worst-case scenario that impacts all potential receptors.

Worst-Case Scenario Analysis

5. Determine and document all public and sensitive receptors.

Present final results and modeling assumptions.

4.2 Flammable Release Potential Consequences

Several possible consequences of releases of flammable substances are discussed below. It should be noted that the following possible consequences apply to not only worst-case release analysis.

- **Flash Fire**. This event may result from dispersion of a flammable vapor cloud and ignition of the cloud following dispersion. Such a fire could flash back and could represent a severe heat radiation hazard to anyone in the area of the cloud. The lower flammability limit (LFL) endpoint, specified in the rule, would be appropriate for flash fires (vapor cloud fires).
- **Pool Fire**. Spill of a liquid whose boiling point is above ambient temperature may form a liquid pool, which could ignite and form a pool fire. The applicable endpoint specified in the rule is the heat radiation level of 5 kW/m^2.

- **BLEVE.** A BLEVE (Boiling Liquid Expanding Vapor Explosion) is a potential release scenario associated with a large quantity of flammable materials kept at below their boiling points. A BLEVE that may lead to a fireball could produce intense heat. This event may occur if a vessel containing flammable material ruptures as a result of exposure to fire. Heat radiation from the fireball is the primary hazard and vessel fragments and overpressure from the explosion are generally considered unlikely. To estimate the distance to a radiant heat level that can cause second degree burns (a heat "dose" equivalent to the specified radiant heat endpoint of 5 kW/m^2 for 40 seconds). Consistent with the EPA's "Risk Management Program Guidance for Offsite Consequence Analysis" published guidance, BLEVEs are generally considered unlikely events and were therefore not considered a probable event for the Offsite Consequence Analysis.
- **Vapor Cloud Explosion.** For a vapor cloud explosion to occur, rapid release of a large quantity, turbulent conditions (caused by a turbulent release or congested conditions in the area of the release, or both), and other factors are generally necessary. The endpoint for vapor cloud explosions is 1 psi.
- **Jet Fire.** This may result from the puncture or rupture of a tank or pipeline containing a compressed or liquefied gas under pressure. The gas discharging from the hole can form a jet that "blows" into the air in the direction away from the hole; the jet then may ignite. Jet fires could contribute to BLEVEs and fireballs if they impinge on tanks of flammable substances. A large horizontal jet fire may have the potential to pose an offsite hazard.

For the flammable worst-case release scenario, a vapor cloud explosion was the most appropriate consequence, as defined by the EPA RMP rule.

4.3 Endpoints

As mentioned previously, for flammable materials, the endpoints specified by the EPA RMP are:

- Overpressure of 1 pound per square inch (psi) for vapor cloud explosions
- Radiant heat of 5 kilowatts per square meter (kW/m^2) for jet fires
- Lower flammability limit (LFL) for flash fires

The rule specifies endpoints for fires based on the heat radiation level that may cause second degree burns from a 40-second exposure and the LFL, which is the lowest concentration in air at which a substance will burn. For a vapor cloud explosion, the endpoint is 1 psi, which is the force to cause partial demolition of houses with potential serious injuries to people, or shattering glass windows with potential skin laceration from flying glass.

4.4 Modeling Assumptions

The EPA RMP regulation imposes several assumptions that were adhered to when performing the offsite consequence analysis of the worst-case release scenario. These are conservative assumptions for weather and release conditions. The distance to the endpoint estimated under worst-case conditions provides an estimate for the maximum possible area that might be affected by these unlikely conditions. It should be noted that EPA's intention for the vulnerability zone representing a worst-case release scenario is to provide a basis for discussion among the regulated industry, emergency responders, and the public, rather than a basis for any specific actions. The EPA RMP regulations, in conjunction with the RMP Guidance for Offsite Consequence Analysis[4], were used to model the worst-case release scenario and prescribe these atmospheric parameters.

- **Meteorological Parameters:** For the worst-case release analysis, the following assumptions were entered into ALOHA, as specific by the EPA RMP regulations / RMP Guidance for Offsite Consequence Analysis.
  - *Atmospheric stability*: F stability (very stable conditions)
  - *Wind speed:* 1.5 meters/second
  - *Ambient Temperature:* 77 °F
  - *Relative Humidity*: The typical relative humidity at the stationary source, which is 50%
- **Dispersion & Impact Modeling Parameters:**
  - *Height of Release:* Ground level, per EPA Rule requirement
  - *Surface Roughness:* Open Country, meaning there are no obstacles in the immediate area; obstacles including buildings or trees, as defined by the EPA RMP regulations
  - *Vapor Cloud Explosion Impact:* A Vapor Cloud Explosion has been modeled with an endpoint of 1 psi

- **Mitigation Systems:** Once a release has occurred, mitigation systems are means (structures, equipment, or activities) that help minimize the transport of material to the atmosphere. Mitigation systems can be characterized as passive or active systems.
    - *Passive mitigation systems do not require activation, an energy source, or movement of components to perform their intended function*
    - *Active mitigation systems do require activation, an energy source, and/or movement of components to perform their intended function*

It should be emphasized that the effectiveness of mitigation systems was taken into account when these systems were considered in the offsite consequence analysis. The effectiveness is determined based on how well the systems are designed and their abilities to respond reliably upon demand. The rule permits consideration of only passive mitigation systems for the worst-case release analysis provided that the systems are capable of withstanding the event triggering the release scenario and would still function as intended. For the worst-case release scenario, the secondary containment area built with concrete around the isopentane vessel was considered as a passive mitigation measure in the offsite consequence analysis.

4.5 Worst-Case Release Scenario

One worst-case scenario (WCS) was developed for the facility. For the worst-case release scenario, the 20,000-gallon storage vessel containing isopentane at the Ormat – Dogwood facility was considered. The storage vessel is capable of storing a maximum of 18,000 gallons of isopentane, taking into account administrative controls. According to the Chevron Philips Chemical Company safety data sheet, the density of isopentane is 5.14 lbs./gal, which yields a total mass of 92,520 pounds of isopentane held in the storage vessel. The worst-case scenario considers the catastrophic failure of the 20,000-gallon isopentane storage vessel, which would result in a release of the entire contents of the vessel, into the secondary containment area. All dispersion modeling parameters utilized in the worst-case release scenario modeling is listed in Table 4 below. A summary of the scenario is presented in Table 5. Appendix A of this report provides a detailed description of the worst-case release scenario, ALOHA modeling output, MARPLOT 5.1.1[5] output with population estimates, and maps displaying the vulnerability zone for a release from each tank, denoted by a circle superimposed on the map.

Table 3: Worst Case Release Scenario Dispersion Modeling Parameters

PARAMETER	INPUT VALUE	NOTES
Isopentane Input Parameters		
Quantity Released	18,000 gallons	Entire contents of isopentane storage vessel assumed to be released and from an evaporating puddle in secondary containment area, which is involved in a vapor cloud explosion.
Meteorological Parameters		
Atmospheric Stability	F stability	As per 40 CFR §68.22 (b), "For the worst-case release analysis, the owner or operator shall use a wind speed of 1.5 meters per second and F atmospheric stability class"
Wind Speed	1.5 m/s	
Wind Direction	W	Wind Direction from the west based on the Wind Rose plot for Imperial, CA (closest city with wind rose plot available). Since the endpoint distance and circle of interest is presented in this report, the wind direction does not impact the analysis/distance to endpoint and instead is a generic input that ALOHA modeling software requires.
Measurement Height above Ground	10 m	Wind speed is assumed to be measured at this elevation, as this is the standard height at which the National Weather Service usually reports wind speed.
Ambient Temperature	77ºF (25°C)	As per 40 CFR §68.22 (c), "An owner or operator using the RMP Offsite

PARAMETER	INPUT VALUE	NOTES
Relative Humidity	50%	Consequence Analysis Guidance may use 25 °C and 50 percent humidity as values for these variables”
Ground temperature	122ºF	As per 40 CFR §68.22 (g), “for worst case, [it] shall be considered to be released at the highest daily maximum temperature, based on data for the previous three years appropriate for the stationary source.” Temperature data was sourced from Weather Underground [6] for Imperial, CA (closest available city with temperature history) and the highest daily maximum temperature from the previous 3 years was identified.
Dispersion and Impact Modeling Parameters		
Height of Release	Ground level	As per 40 CFR §68.22(d), “you must assume a ground level release” and as per the RMP Offsite Consequence Analysis Guidance Document, “this guidance assumes a ground-level release”
Topography/Surface Roughness	Open Country	Open Country, meaning there are no obstacles in the immediate area; obstacles including buildings or trees, as defined by the EPA RMP regulations.

PARAMETER	INPUT VALUE	NOTES
Level of Congestion	Congested	The level of congestion was assumed to be congested, which is a conservative assumption since greater turbulence (greater congestion) allows the flame front to accelerate, thereby generating a more powerful blast wave (i.e., greater overpressure). The immediate area within the facility is also considered to be congested with piping and equipment.
Isopentane Mitigation System		
Passive Mitigation	Secondary Containment Area	The amount released from the alternative release scenario is assumed to release into a concrete secondary containment area, which is contained around each storage vessel.

Table 4: Worst-Case Scenario Results Summary

RELEASE SCENARIO	REGULATED SUBSTANCE	ENDPOINT	ENDPOINT DISTANCE
WCS: 20,000-gallon Isopentane Storage Vessel Rupture/Release	Isopentane	Overpressure of 1 psi	119 yd / 357 ft / 0.068 mi

4.6 Worst-Case Analysis Considerations

The worst-case distances to the flammable endpoints are based on a number of very conservative assumptions. The following summarizes the assumptions:

- The likelihood of a vessel rupture is extremely low. As a result, the release of entire inventory of a vessel is an unrealistic assumption.

- An overpressure of 1 psi is unlikely to have serious direct effects on people. This overpressure may cause property damage such as partial demolition of houses, which can result in injuries to people, and shattering of glass windows, which may cause skin laceration from flying glass.

5.0 ALTERNATIVE RELEASE SCENARIO

Alternative scenarios are potential releases that may result in consequences whose footprints represented by the endpoints could extend beyond the plant boundary. For a release case to be considered an alternative scenario, two conditions must be met:

1. The likelihood of the alternative release scenarios should be higher than that of the worst-case release scenarios.
2. The distance to endpoint from an alternative release scenario must go beyond the plant fence line.

As put forth in Title 40 CFR Section 68.28(a):

> *The owner or operator shall identify and analyze…at least one alternative release scenario to represent all flammable substances held in a covered process*

Title 40 CFR Section 68.28 (b)(2) defines the scenarios typically considered, but not limited to, the following:

> *(i) Transfer hose releases due to splits or sudden hose uncoupling;*
>
> *(ii) Process piping releases from failures at flanges, joints, welds, valves and valve seals, and drains or bleeds*
>
> *(iii) Process vessel or pump release due to cracks, seal failure, or drain, bleed, or plug failure; and*
>
> *(iv) Vessel overfilling and spill, or over pressurization and venting through relief valves or rupture disks.*
>
> *(v) Shipping container mishandling and breakage or puncturing leading to a spill.*

For alternative release scenarios, active mitigation systems, such as interlocks, shutdown systems, pressure relieving devices, flares, emergency isolation systems, and fire water and deluge systems, as well as passive mitigation systems are considered, if they were applicable. In order to be credited, the mitigation systems considered must be capable of withstanding the event that triggers the release while remaining functional.

5.1 Alternative Release Scenario Selection Process

The process of alternative release scenario identification is summarized as follows and depicted in Figure 4.

- **Selection of Candidate Alternative Release Scenario:** The process of alternative release scenario identification was initiated with the review of the worst-case release case. Additional vessels, containing various quantities of regulated substances, which considered having a higher likelihood of release, were then reviewed. In this process, all covered processes were reviewed and the candidate case for the alternative release scenario analysis was subsequently selected. The following criteria was utilized to identify the potential scenario:
    - Corrosion history and corrosive services
    - Past incidents and near misses
    - Potential equipment failure
    - Operating conditions
    - Potential for human error
    - Consequences considered in the unit Process Hazard Analysis
- **Analysis of the Selected Alternative Release Scenario:** Once the candidate scenario was selected, ALOHA was utilized to model the selected scenario. The vulnerability zone resulting from the analysis of the alternative release scenario was then reviewed. The release duration was limited by the length of time to release the entire contents of the single Isopentane Storage Vessel.
- **Alternative Release Scenario**: The alternative release scenario for the flammable substance was selected and modeled to evaluate potential offsite impacts. Documentation of this scenario included modeling calculations, parameters and assumptions.

Figure 8: Alternative Release Scenario Selection Process

Criteria

Corrosion History and Corrosive Surfaces, Past Incidents and Near Misses, Potential Equipment Failure, Operating Conditions, Potential Human Error, Scenarios Considered in the Process Hazard Analysis.

Select Alternative Release Scenario

Review process and facility characteristics to develop the candidate for an Alternative Release Scenario.

Modeling of Alternative Release Scenario

Model potential release dispersion for the selected Alternative Release Scenario.

Alternative Release Scenario Analysis

Present final results and modeling assumptions.

5.2 Modeling Assumptions

The EPA RMP regulation does not impose any mandatory assumptions for the OCA of the alternative release scenario. All dispersion modeling parameters utilized in the alternative release scenario modeling are listed in Table 6. For the alternative release scenario, a release due to a break in the product transfer hose connection during truck loading has been considered. Appendix B of this report provides a detailed description of the worst-case release scenario, ALOHA modeling output, MARPLOT 5.1.1 output with population estimates, and a map with the vulnerability zone denoted by a circle superimposed on the map.

Table 5: Alternative Release Scenario Dispersion Modeling Parameters

Parameter	Input Value	Notes
Isopentane Input Parameters		
Quantity Released	46,260 lbs.	The most likely alternative release scenario involves the uncoupling of a transfer hose during truck loading operations. Calculations shown in Appendix B.
Release Rate	19,468 lbs./min	Calculations shown in Appendix B.
Release Duration	2.4 mins	The release duration is limited by the quantity stored in a single Isopentane Storage Vessel (18,000 gallons).
Meteorological Parameters		
Atmospheric Stability	D stability	As per EPA RMP Offsite Consequence Analysis Guidance, for an alternative scenario, “this guidance assumes wind speed of 3 meters per second and D stability”
Wind Speed	3.0 m/s	
Wind Direction	W	Wind Direction from the west based on the Wind Rose plot for Imperial, CA (closest city with wind rose plot available). Since the endpoint distance and circle of interest is presented in this report, the wind direction does not impact the analysis/distance to endpoint and instead is a generic input that ALOHA modeling software requires.

Parameter	Input Value	Notes
Measurement Height above Ground	10 m	Wind speed is assumed to be measured at this elevation, as this is the standard height at which the National Weather Service usually reports wind speed.
Ambient Temperature	77ºF (25°C)	As per EPA RMP Offsite Consequence Analysis Guidance, for an alternative scenario, "this guidance assumes 25ºC and 50 percent humidity"
Relative Humidity	50%	
Dispersion and Impact Modeling Parameters		
Height of Release	Ground Level	As per EPA RMP Offsite Consequence Analysis Guidance, for an alternative scenario, "this guidance assumes a ground-level release"
Topography/Surface Roughness	Open Country	Open Country, meaning there are no obstacles in the immediate area; obstacles including buildings or trees, as defined by the EPA RMP regulations.
Level of Congestion	Congested	The level of congestion was assumed to be congested, which is a conservative assumption since greater turbulence (greater congestion) allows the flame front to accelerate, thereby generating a more powerful blast wave (i.e., greater overpressure). The immediate area within the facility is also considered to be congested with piping and equipment.

Parameter	Input Value	Notes
Isopentane Mitigation System		
Passive Mitigation	Secondary Containment Area	The amount released from the alternative release scenario is assumed to release into a concrete secondary containment area, which is contained around each storage vessel.
Active Mitigation	None	

5.3 Alternative Release Scenario

A summary of the alternative release scenario is presented in Table 7. Appendix B of this report provides a detailed description of the alternative release scenario, ALOHA modeling outputs, MARPLOT 5.1.1 outputs with population estimates, and a map with circles representing the vulnerability zones.

Table 6: Alternative Release Scenario Result Summary

RELEASE SCENARIO	REGULATED SUBSTANCE	ENDPOINT	ENDPOINT DISTANCE
ARS: Transfer Hose uncoupling from 10,000-gallon Isopentane Storage Vessel during Truck Loading Operations	Isopentane	Overpressure of 1 psi	84 yd / 252 ft / 0.048 mi

5.4 Alternative Release Analysis Considerations

Typically, the same conservative assumptions apply for the alternative release analysis as for the worst-case release analysis. Although the alternative release scenario is intended to be more likely than the worst-case release scenario, the analysis of the alternative release scenario should not be expected to provide a realistic estimate of an area in which off-site impact may occur. The same conservative endpoints have been used for both the worst-case and the alternative release analysis. These endpoints are intended to represent exposure levels below which most members of the public will not experience serious long-term health effects.

6.0 OFFSITE IMPACTS

A summary of the off-site impacts from an accidental release, including population and sensitive receptors, is discussed in the following sub-sections.

6.1 Impacted Population

In order to determine the impacted population around the facility, the potential for exposure within the endpoint was determined. The furthest endpoint distances reached by the worst-case scenario and alternative release scenario along with the estimated impacted population are summarized in Table 8:

Table 7: Impacted Population for OCA Scenarios

SCENARIO	ENDPOINT DISTANCE	ESTIMATED IMPACTED POPULATION
WCS: 20,000-gallon Isopentane Storage Vessel Rupture/Release	119 yd / 357 ft / 0.068 mi	0
ARS: Transfer Hose uncoupling from 20,000-gallon Isopentane Storage Vessel during Truck Loading Operations	84 yd / 252 ft / 0.048 mi	0

The population was estimated using 2010 census tract data with the MARPLOT 5.1.1 software. When calculating population densities for large areas that encompass many tracts, the accuracy is rated as good; however, for small areas that encompass only two or three partial tracts, the population data may be skewed due to the unequal distribution within the tract. The use of MARPLOT 5.1.1 is pursuant to guidance endorsed by the US EPA. MARPLOT 5.1.1 requires the latitude and longitude of the facility in order to calculate the population. The latitude and longitude were estimated using Google Earth GPS[7] software and an aerial photo. In consideration of the unique case of bystanders along facility boarders during a vapor cloud explosion, vessels are placed far enough within company fencing that surrounding walkways and streets are free of severe impacts.

6.2 Offsite Sensitive Receptor Data Sources

Table 9 includes a list of websites and software used to locate offsite sensitive receptors. A few sites will perform a distance search in order to determine the eligibility of a possible receptor. For all other sites, a map interpolation determines whether the receptor falls within the circle of concern.

Table 8: Websites and Software Used

SOURCE	RECEPTORS THIS SOURCE IS USED TO IDENTIFY	METHOD OF DETERMINING ELIGIBILITY
Google Maps[8]	Used to identify all receptors	Distance search in conjunction with a map interpolation
Google Earth	This mapping software is used to locate all receptors. It also incorporates an internet search with the map to locate businesses.	Software will map the location of the receptor.

6.3 Offsite Sensitive Receptors

RMP requirements state that sensitive populations such as schools, hospitals, day-care centers, long-term health care facilities, prisons, residential areas, public use parks/recreational areas, and major commercial facilities, located within the "at risk" area must be identified. These sensitive populations include individuals who could not remove themselves from the exposure area without assistance. The sensitive populations also include industrial installations which may have a hazardous process that cannot be immediately left unattended. According to the EPA's General Risk Management Plan Guidance [9], "The basic test for identifying a public receptor is thus whether an area is a place where it is reasonable to expect that members of the public will routinely gather at least some of the time. Roads and parking lots are not included as such in the definition of ‘public receptor.’ Neither are places where people typically gather; instead, they are used to travel from one place to another or to park a vehicle while attending an activity elsewhere.” Table 10 shows a summary of offsite population receptors and offsite environmental receptors for isopentane, within the circle of concern as determined by the worst-case and alternative release scenarios.

Table 9: Summary of Sensitive and Environmental Receptors

RECEPTOR	WCS (0.068 MI)	ARS (0.032 MI)
Population Receptors		
Schools	No	No
Residences	No	No
Hospitals	No	No
Prisons/Correction Facilities	No	No
Recreation Areas	No	No
Major Commercial, Office, or Industrial Areas	No	No
Child Daycare	No	No
Long-term Health Care (e.g., convalescent homes)	No	No
Other (Government Buildings)	No	No
Environmental Receptors		
National or State Parks, Forests, or Monuments	No	No
Officially Designated Wildlife Sanctuaries, Preserves, or Refuges	No	No
Federal Wilderness Areas	No	No

RECEPTOR	WCS (0.068 MI)	ARS (0.032 MI)
Other (Landmark & Indian Reservations)	No	No

7.0 WORST-CASE RELEASE AND ALTERNATIVE RELEASE SCENARIO SUMMARY

The following sections outlines a summary of the parameters used for the one worst case release scenario and the one alternative release scenario analyzed for the Heber 2 Repower project.

7.1 Worst-Case Scenario

The worst-case scenario evaluated the release of the entire contents of one of the two 20,000-gallon isopentane storage vessels, containing 18,000 gallons of isopentane. The following table provides a summary of the parameters used for the worst-case scenario and the corresponding inputs.

Table 10: Worst-Case Scenario Parameter/Input Summary

Worst-Case Scenario	
Chemical	Isopentane
Model Used	ALOHA
Scenario	Vapor Cloud Explosion
Quantity Released (gal)	18,000 gallons
Endpoint Used	Overpressure of 1 psi
Distance to Endpoint	119 yd / 357 ft / 0.068 mi
Estimated Residential Population within Distance to Endpoint (numbers)	0
Public Receptors within Distance to Endpoint	
Schools	No
Residences	No

Worst-Case Scenario	
Hospitals	No
Prison/Correctional Facilities	No
Recreational Areas	No
Major Commercial, Office, or Industrial Areas	No
Other	None
Environmental Receptors within Distance to Endpoint	
National or State Parks, Forests, or Monuments	No
Officially Designated Wildlife Sanctuaries, Preserves or Refuges	No
Federal Wilderness Area	No
Other	No
Passive Mitigation Considered	
Secondary Containment Area	Yes
Other	No

7.2 Alternative Release Scenario

It was determined that a release due to a break in the isopentane transfer hose connection during truck loading, was the most likely release scenario due to human factors associated with manned transfer operations, as well as reliability issues in industry related to hose degradation and coupling failures. The following table provides a summary of the parameters that were used for alternative release scenario and the corresponding inputs.

Table 11: Alternative Release Scenario Parameter/Input Summary

Alternative Release Scenario	
Chemical	Isopentane
Model Used	ALOHA

Alternative Release Scenario	
Scenario	Vapor Cloud Explosion
Quantity Released	46,260 lbs.
Endpoint Used	Overpressure of 1 psi
Distance to Endpoint	84 yd / 252 ft / 0.048 mi
Estimated Residential Population within Distance to Endpoint (numbers)	0
Public Receptors within Distance to Endpoint	
Schools	No
Residences	No
Hospitals	No
Prison/Correctional Facilities	No
Recreational Areas	No
Major Commercial, Office, or Industrial Areas	No
Other	None
Environmental Receptors within Distance to Endpoint	
National or State Parks, Forests, or Monuments	No
Officially Designated Wildlife Sanctuaries, Preserves or Refuges	No
Federal Wilderness Area	No
Other	No
Passive Mitigation Considered	
Secondary Containment Area	Yes
Other	No
Active Mitigation Considered	
Sprinkler Systems	No

Alternative Release Scenario	
Deluge Systems	No
Water Curtain	No
Excess Flow Valve	No
Other	No

8.0 FIVE YEAR ACCIDENT HISTORY

There have been no applicable CalARP/RMP/PSM releases of isopentane at the facility within the last five years, therefore, this section is not applicable.

9.0 REFERENCES

1. Code of Federal Regulations (CFR), Title 40, Chapter I, Subchapter C, Part 68, Subpart B, Sections 68.20 to 68.42, "Hazard Assessment"; 2015, January 1.
2. California Code of Regulations (CCR), Title 19, Division 2, Chapter 4.5, Article 4, Sections 2750.1 to 2750.9, "Hazard Assessment"; 2015, January 1.
3. Areal Locations of Hazardous Atmospheres - ALOHA Version 5.4.7, U.S. Environmental Protection Agency, September 2016. http://www2.epa.gov/cameo/aloha-software
4. Risk Management Program Guidance for Offsite Consequence Analysis, U.S. Environmental Protection Agency, March 2009.
5. MARPLOT® 5.1.1 Mapping Software (internet download), National Oceanic and Atmospheric Administration and U.S. Environmental Protection Agency. http://www.epa.gov/osweroe1/content/cameo/marplot.htm. December 2017.
6. Weather History for KIPL (Imperial County Station), Weather Underground, May 11, 2020, https://www.wunderground.com/history/monthly/us/ca/imperial/KIPL
7. Google ™ Earth, version 7.3.2.5776, Google, Inc. (2019)
8. Google ™ Maps, Google, Inc. (2019)
9. General Risk Management Program Guidance – Chapter 2: Applicability of Program Levels, U.S. Environmental Protection Agency, April 2004.

APPENDIX A
WORST-CASE SCENARIO CALCULATIONS

WORST-CASE SCENARIO (WCS)

The selected worst-case release scenario analyzes the hypothetical rupture of any one of the 20,000-gallon isopentane vessels, new or existing. Any one vessel can store up to 18,000 gallons of isopentane, taking into account administrative controls, which are in place to limit the quantity stored in each tank. Per requirement of the EPA rule for flammable substances, it was assumed that the whole quantity is released. The entire quantity is released into the secondary containment area, which is credited as a passive mitigation measure, to form an evaporating puddle, for which the vapors form a vapor cloud. If this vapor cloud ignited, the resultant blast could generate overpressure damage. The secondary containment area dimensions are 60 ft length, 16 ft width, 3.5 ft depth (surface area = 960 ft^2), and it assumed the secondary containment area ground type is concrete.

The ALOHA modeling calculation predicts that the area impacted by the endpoint, which is an overpressure of 1 psi, is a circle with approximately a 119-yard radius (357 ft / 0.0676 mi). According to MARPLOT 5.1.1, there are 0 residents and 0 housing units within this vulnerability zone for both vessels. The table and figures on the following pages illustrate the scenario modeling parameter summary, scenario circle for the release, the ALOHA modeling output, as well as the MARPLOT results. These figures demonstrate Ormat's strategic placement of new storage vessels, showing that one explosion and release of all isopentane contents would not affect the other as demonstrated in the following figures. Each of the new vessels are at least 184 yards (twice the radius of concern) from one another and do not reach any of the three existing vessels.

```
SITE DATA:
  Location: HEBER, CALIFORNIA
  Building Air Exchanges Per Hour: 0.20 (unsheltered double storied)
  Time: April 12, 2023  1113 hours PDT (using computer's clock)

CHEMICAL DATA:
  Chemical Name: ISOPENTANE
  CAS Number: 78-78-4                    Molecular Weight: 72.15 g/mol
  PAC-1: 3000 ppm    PAC-2: 33000 ppm    PAC-3: 200000 ppm
  LEL: 14000 ppm     UEL: 76000 ppm
  Ambient Boiling Point: 82.1° F
  Vapor Pressure at Ambient Temperature: 0.91 atm
  Ambient Saturation Concentration: 904,926 ppm or 90.5%

ATMOSPHERIC DATA: (MANUAL INPUT OF DATA)
  Wind: 1.5 meters/second from W at 10 meters
  Ground Roughness: open country         Cloud Cover: 5 tenths
  Air Temperature: 77° F
  Stability Class: F (user override)
  No Inversion Height                    Relative Humidity: 50%

SOURCE STRENGTH:
  Evaporating Puddle (Note: chemical is flammable)
  Puddle Area: 960 square feet           Puddle Volume: 18000 gallons
  Ground Type: Concrete                  Ground Temperature: 77° F
  Initial Puddle Temperature: Air temperature
  Release Duration: ALOHA limited the duration to 1 hour
  Max Average Sustained Release Rate: 198 pounds/min
     (averaged over a minute or more)
  Total Amount Released: 8,199 pounds

THREAT ZONE:
  Threat Modeled: Overpressure (blast force) from vapor cloud explosion
  Type of Ignition: ignited by spark or flame
  Level of Congestion: congested
  Model Run: Heavy Gas
  Red   : LOC was never exceeded --- (8.0 psi = destruction of buildings)
  Orange: 69 yards --- (3.5 psi = serious injury likely)
  Yellow: 119 yards --- (1.0 psi = shatters glass)
```

Figure 5: WCS ALOHA Modeling Results

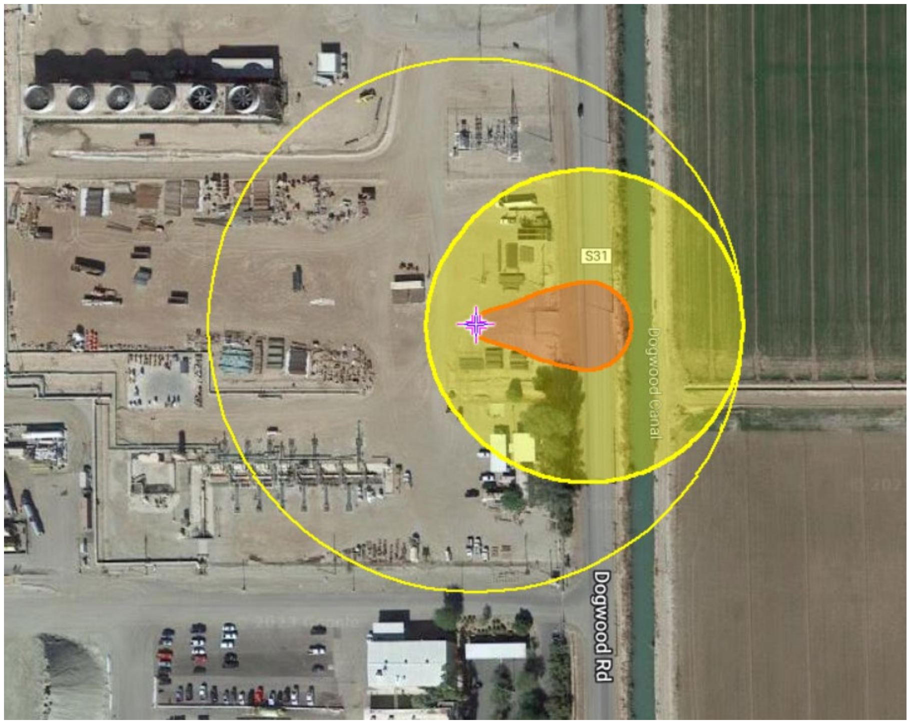


Figure 6: WCS MARPLOT 5.1.1 Map for Isopentane Storage Vessel

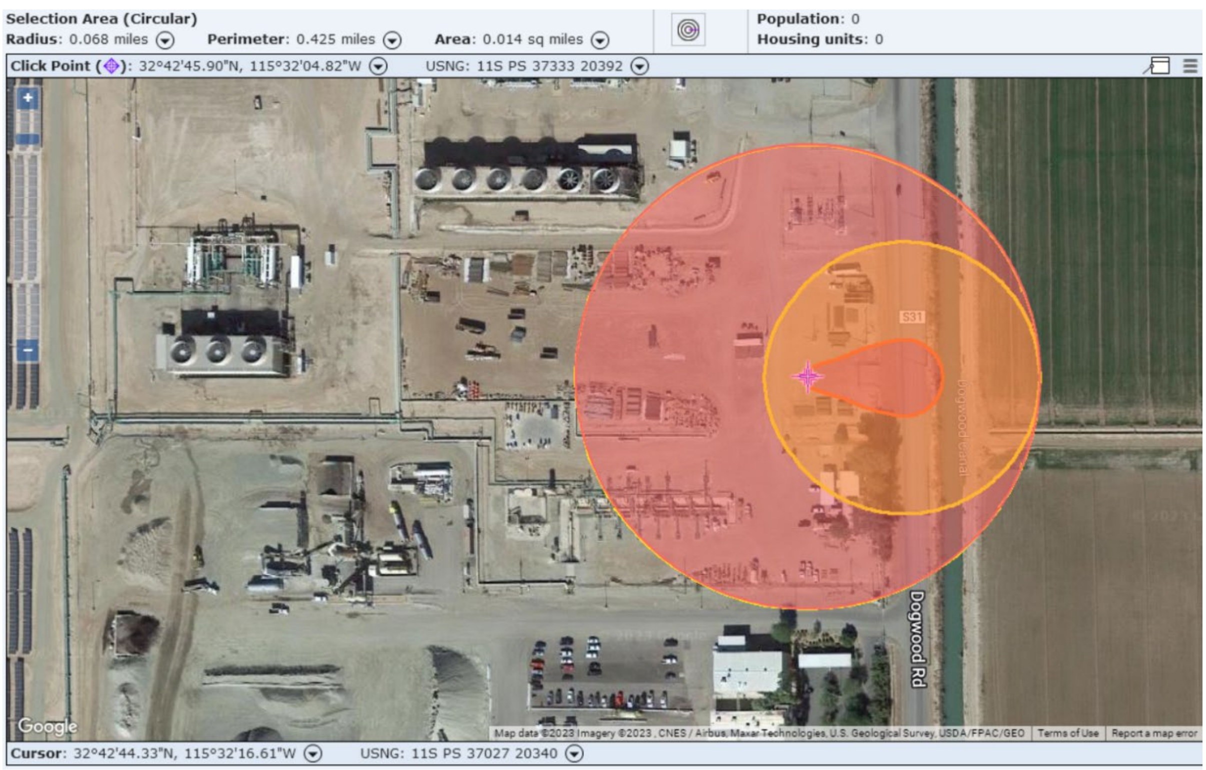


Figure 7: Receptors Within the Threat Zone

APPENDIX B
ALTERNATIVE SCENARIO CALCULATIONS

ALTERNATIVE RELEASE SCENARIO (ARS)

The selected alternative release scenario is a release due to a break in the product (isopentane) transfer hose connection during truck loading. This was considered the most likely release scenario due to human factors associated with manned transfer operations, as well as reliability issues in industry related to hose degradation and coupling failures. It is assumed that the transfer hose uncouples during isopentane transfer operations and that it is released through an area of 12.6 square inches based on the transfer hose size. The release duration is limited by the volume in the Isopentane Storage Vessel (18,000 gallons), which is 2.4 minutes. In the evaluations of this alternative release scenario, the concrete secondary containment area composed was credited as a mitigation measure.

In order to calculate the release quantity for a transfer hose rupture, the release rate through the transfer hose must be calculated. The following equation, obtained from the EPA Risk Management Plan Guidance for Offsite Consequence Analysis, illustrates the calculation of the release rate for flammable liquids under pressure through a transfer hose:

$$QR = A_h \times 6.82\sqrt{\frac{11.7}{DF^2} \times LH + \frac{669}{DF} \times P_g}$$

Where:

- QR = Release rate (lbs./min)
- A_h= Hole or puncture area (square inches)
- DF = Density Factor, dimensionless, obtained from the EPA Risk Management Plan Guidance for Offsite Consequence Analysis
- LH = Height of liquid level above hole (inches)
- P_g = Gauge pressure of the vessel (psig)

To calculate the release rate utilizing the above equation, the values for each of the following variables were calculated for isopentane:

Hole Area

The transfer hose used in isopentane filling operations at both plants is 4 inches in diameter. Thus, the hole area is based upon the transfer hose rupturing and calculated using the following:

$$HA = \pi r^2 = 12.6 \text{ in}^2$$

Density Factor

The Density Factors are obtained from Appendix C of the EPA Risk Management Plan Guidance for Offsite Consequence Analysis. The Density Factor value for isopentane is 0.79.

Liquid Height

The height of the liquid level above the hole is determined by the nominal liquid level in the vessel. The isopentane transfer point is taken to be at the bottom of the tank. Assuming that the isopentane storage vessel is 33% full of isopentane, this equates to 5, 940 gallons being stored in the vessel (794 ft^3). This is a conservative assumption as the storage tanks are normally empty and are only used for temporary storage of isopentane. According to the available tank data provided by the facility, the diameter of the Isopentane Storage Vessel is approximately 10.5 feet and length is 31 feet (tangent to tangent length). It should be noted that the Isopentane Storage Vessel is a horizontal vessel. In calculating the height of the liquid column within the tank, the Isopentane Storage Vessel was modeled as a cylinder, and thus the equation for volume of liquid within the tank is that of a horizontal cylinder. The equations below were used to find the height of the liquid column within the Isopentane Storage Vessel:

$$V_L = A_L \times L$$

$$A_L = R^2 \cos^{-1}\left(\frac{R - LH}{R}\right) - (R - LH)\sqrt{2R \cdot LH - LH^2}, \qquad \therefore$$

$$V_L = L \times \left[R^2 \cos^{-1}\left(\frac{R - LH}{R}\right) - (R - LH)\sqrt{2R \cdot LH - LH^2}\right]$$

Where:

V_L = Volume of liquid within the Tank (ft^3)

A_L = Area of liquid (ft^2)

R = Radius of the Tank (ft.)

L = Length of the Tank (ft.)

LH = Height of the liquid within the Tank (ft.)

Values for each variable listed in the equations above are provided below, with the exception of LH, as this is the variable to be calculated:

V_L = 5,940 gallons = 794 ft^3

R = 5.25 ft.

L = 31 ft.

By using the above values within the equation, the height of the liquid column within the Isopentane Storage Vessel can be calculated, which is approximately 2.3 ft (2.2857 ft) or 27.6 inches.

Pressure

The normal operating pressure of the isopentane motive fluid storage tank was identified to be 60 psig.

Modeling

Using these values, the release rate of isopentane can be determined. Please see the calculations below for determining the isopentane release rate:

$$QR = 12.6\ in^2 \times 6.82\sqrt{\frac{11.7}{(0.79^2)} \times 27.6\ in + \frac{669}{0.79} \times 60\ psig}$$

$$QR = 19{,}468.3955\ \frac{lbs.}{min} \approx 19{,}468\ \frac{lbs.}{min}$$

Over the 2.4 minute release period, this results in a total of 46,260 lbs. released to the secondary containment area to form an evaporating puddle, for which the vapors form a vapor cloud. If this vapor cloud ignited, the resultant blast could generate overpressure damage.

The ALOHA modeling calculation predicts that the area impacted by the endpoint, which is overpressure of 1 psi, is a circle with approximately a 57-yard radius (171 ft / 0.032 mi). According to MARPLOT 5.1.1, there are 0 residents and 0 housing units within this vulnerability zone for all six vessels. The table and figures on the following pages illustrate the scenario modeling parameter summary, scenario circle for the release, the ALOHA modeling output, as well as the MARPLOT results.

```
SITE DATA:
  Location: HEBER, CALIFORNIA
  Building Air Exchanges Per Hour: 0.23 (unsheltered double storied)
  Time: April 28, 2024  1949 hours PDT (using computer's clock)

CHEMICAL DATA:
  Chemical Name: ISOPENTANE
  CAS Number: 78-78-4                  Molecular Weight: 72.15 g/mol
  PAC-1: 3000 ppm    PAC-2: 33000 ppm    PAC-3: 200000 ppm
  LEL: 14000 ppm     UEL: 76000 ppm
  Ambient Boiling Point: 82.1° F
  Vapor Pressure at Ambient Temperature: 0.91 atm
  Ambient Saturation Concentration: 904,926 ppm or 90.5%

ATMOSPHERIC DATA: (MANUAL INPUT OF DATA)
  Wind: 3 miles/hour from W at 3 meters
  Ground Roughness: open country        Cloud Cover: 5 tenths
  Air Temperature: 77° F
  Stability Class: D (user override)
  No Inversion Height                   Relative Humidity: 50%

SOURCE STRENGTH:
  Evaporating Puddle (Note: chemical is flammable)
  Puddle Area: 960 square feet          Puddle Mass: 46260 pounds
  Ground Type: Concrete                 Ground Temperature: 77° F
  Initial Puddle Temperature: Air temperature
  Release Duration: ALOHA limited the duration to 1 hour
  Max Average Sustained Release Rate: 193 pounds/min
     (averaged over a minute or more)
  Total Amount Released: 6,646 pounds

THREAT ZONE:
  Threat Modeled: Overpressure (blast force) from vapor cloud explosion
  Type of Ignition: ignited by spark or flame
  Level of Congestion: congested
  Model Run: Heavy Gas
  Red   : LOC was never exceeded --- (8.0 psi = destruction of buildings)
  Orange: 43 yards --- (3.5 psi = serious injury likely)
  Yellow: 84 yards --- (1.0 psi = shatters glass)
```

Figure 8: ARS ALOHA Modeling Results

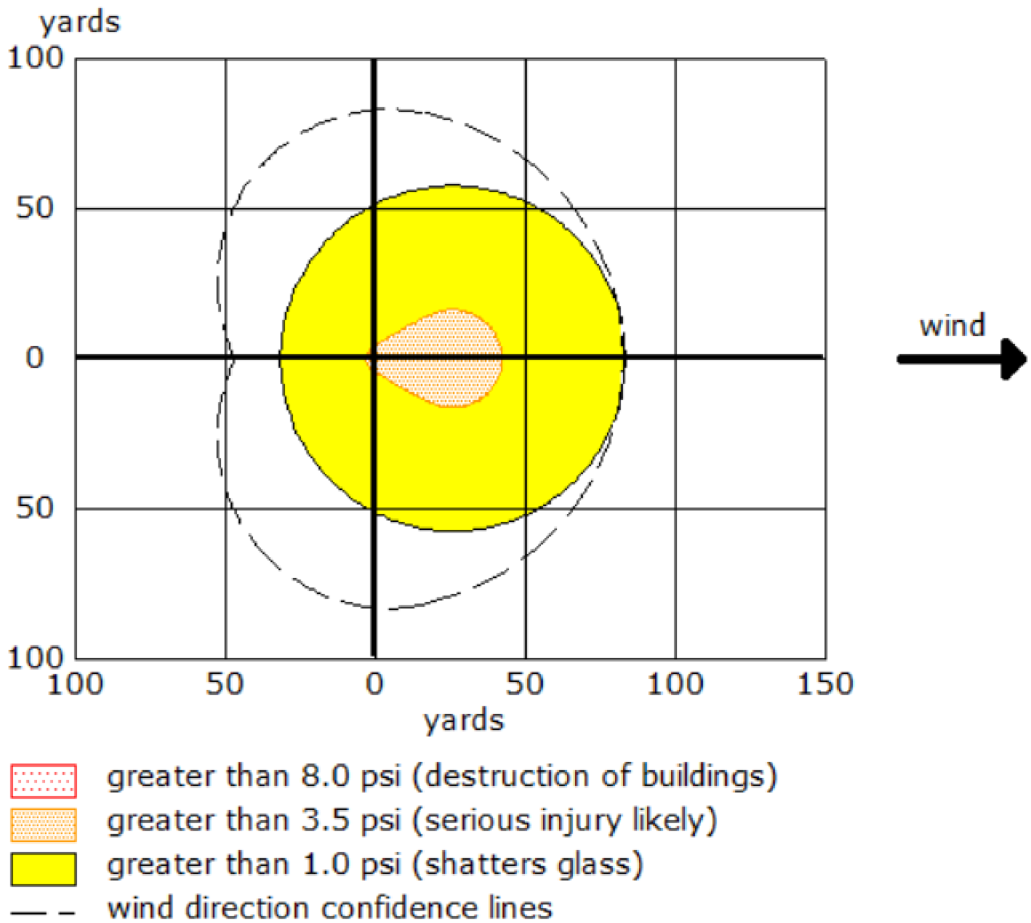


Figure 9: ARS Threat Zone