

## **APPENDIX G - BLAST HAZARD ANALYSIS**

**To:** QK, Inc.  
**From:** Trinity Consultants, Inc.  
**Date:** January 31, 2025 (Revised May 15, 2026)  
**RE:** Tortuga Bay Water Park Project – Blast Hazard Analysis

## Purpose

This analysis assesses the potential impact of a catastrophic failure and explosion of a liquid propane gas (LPG) vessel at the adjacent Kiva United Energy LPG Facility on the proposed Tortuga Bay Water Park Project (Project) site. The analysis determines the potential radius of an over-pressurized area or impact zone that could cause injury to people or property on the Project site.

## Background

The Project would be located in the incorporated City of Bakersfield, Kern County, California, southeast of the intersection of Hageman Road and Mohawk Street. The proposed Project encompasses approximately 117.55 net acres and includes a water park, golf driving range, medical offices, hotels, general commercial uses, and light and service industrial uses. During the planning process, concern was expressed regarding the close proximity of an LPG storage facility located southeast of the Project site and the potential hazard it might present to the fully developed Project. It was determined that an analysis should be conducted to determine if an LPG vessel failure and subsequent explosion at the LPG storage facility would impact the Project site and, if so, to what extent.

As shown in Figure 1 below, the Kiva United Energy LPG Facility, located southeast of the Project site, contains 35 horizontal LPG storage vessels. These vessels are filled via railcar from the rail spur along the northern side of the facility. LPG is transferred from the railcars to the vessels through transfer valves located at the north end of each vessel. The stored LPG is then transferred to LPG trucks for local delivery via similar valve assemblies at the south end of the tanks. LPG trucks depart the facility via a public roadway located at the southeast corner of the site. Neither the transfer rates nor the railcar/truck offloading frequency were known or considered in this analysis.

## Assumptions

Each LPG vessel measures 60 feet long and 12 feet in diameter.<sup>1</sup> Each tank is placed on at least two 3-foot-high stands, making the top of each vessel approximately 15 feet above the ground. Each vessel stores LPG at 85% of its full 40,000-gallon capacity, or 34,000 gallons (at standard conditions). Without further knowing whether propane is liquefied by decreasing the storage temperature or increasing the storage pressure or both, Trinity assumed that LPG (propane) has a specific gravity of 0.59 (at -50 °C), resulting in a total quantity of 167,410 pounds (lbs) of propane by weight in each vessel.<sup>2</sup> This assumption is conservative, as a higher storage temperature would lower the LPG's specific gravity, thus reducing the mass quantity of propane.

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<sup>1</sup> LPG tank measurements were estimated using Google Earth imagery.

<sup>2</sup> <https://cameochemicals.noaa.gov/chris/PRP.pdf>

**Figure 1 – Coast Energy LPG Storage Tanks Location**

## Methodology

### Vapor Cloud Explosion

Trinity used The Netherlands Organisation for Applied Scientific Research (TNO) Multi-Energy method to model the endpoint distance to 1 pound per square inch (psi) (g) overpressure for a potential vapor cloud explosion (VCE) involving the nearest Kiva United Energy LPG storage tank.<sup>3</sup> The TNO Multi-Energy method is a well-established approach specifically developed to estimate VCE overpressure effects and endpoint distances and accounts for the influence of congestion and confinement within the vapor cloud, which are key factors at LPG storage and transfer facilities, such as the source modeled for the proposed Project. This methodology was applied in conjunction with U.S. Environmental Protection Agency Risk Management Program worst-case release assumptions, discussed below, to conservatively assess the maximum potential offsite impact to the proposed Project site.

### RMP Worst-Case Modeling

In applying the TNO Multi-Energy method, an initial blast strength of 4 was specified. Predicted impact distances are sensitive to the selected initial blast strength, which reflects conditions related to ignition strength, congestion, and confinement within the release area.<sup>4</sup> Based on review of the surrounding tank farm layout, the area is generally unconfined with only low congestion associated with the tank array and related piping, and a low-energy ignition source (such as a spark, flame, or hot surface) is considered more representative than a high-energy ignition source such as a confined or vented explosion within a structure.

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<sup>3</sup> van den Berg, A. C. (1985). "The multi-energy method: A framework for vapour cloud explosion blast prediction." *Journal of Hazardous Materials* 12(1): 1-10.

<sup>4</sup> Kiinsella, K. G. (1993). "A rapid assessment methodology for the prediction of vapour cloud explosion overpressure." *Proceedings of the International Conference and Exhibition on Health, Safety and Loss Prevention in the Oil, Chemical and Process Industries*. Singapore 15-19. February: 200-211

According to TNO blast strength selection guidance, these conditions correspond approximately to blast category 10, or an initial blast strength of 2 to 3. Trinity conservatively applied an initial blast strength of 4, which is expected to yield a more conservative impact distance than would be predicted using a lower blast strength more closely aligned with observed open tank farm conditions. The U.S. Environmental Protection Agency Risk Management Program (RMP) Guidance for Offsite Consequence Analysis worst-case meteorological conditions were used in the VCE modeling, including a 1.5 meter per second (m/s) wind speed, 77 °F ambient temperature, 50 percent humidity, and F atmospheric stability.<sup>5</sup> In addition, RMP defines the worst-case scenario as the release of the largest quantity of a regulated substance from a single vessel or process line failure that results in the greatest distance to an endpoint; therefore, one LPG storage tank containing 167,410 pounds of propane among the 35 onsite tanks was modeled.

## Thermal Radiation

The analysis was performed using the Acceptable Separation Distance (ASD) Electronic Assessment Tool, an electronic application developed by the U.S. Department of Housing and Urban Development (HUD) Office of Environment and Energy to automate the calculation procedures contained in 24 CFR Part 51, Subpart C, and its associated guidebook. This regulation establishes safety standards for evaluating potential risks to people and structures associated with stationary hazardous facilities, including above-ground storage tanks (ASTs) containing flammable or explosive substances.

The ASD Electronic Assessment Tool applies mathematical equations derived from HUD nomographs to determine the distance beyond which a hazard is unlikely to expose people or structures to blast overpressure or thermal radiation levels exceeding HUD safety standards. These standards include blast overpressure of 0.5 psi for buildings and thermal radiation exposure thresholds of 450 British Thermal Units (BTU) per square foot per hour for people and 10,000 BTU per square foot per hour for buildings.<sup>6</sup>

The following inputs were used in the ASD assessment:

- ▶ Is the container above ground: Yes
- ▶ Is the container under pressure: Yes
- ▶ Does the container hold a cryogenic liquified gas: No
- ▶ Is the container diked: N/A
- ▶ What is the volume (gal) of the container: 34,000

## Results

### Vapor Cloud Explosion

The RMP worst-case modeling results indicate that the endpoint distance to 1 psi (g) due to a VCE of 167,410 lbs LPG is 321.4 meters (0.2 mile). No overpressure above 3.5 psi (g) and 8 psi (g) is detected. The modeled output results are presented in Figure 2.

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<sup>5</sup> U.S. EPA (2009). Risk Management Program Guidance for Offsite Consequence Analysis. EPA 550-B-99-009

<sup>6</sup> 24 CFR 51.203.

**Figure 2 – TNO Model Output Results**

| MULTI-ENERGY EXPLOSION MODEL                    |                |         |
|-------------------------------------------------|----------------|---------|
| INPUT DATA                                      |                |         |
| Modeled Chemical                                | Propane        |         |
| Heat Combustion                                 | 46333          |         |
| Results data                                    |                |         |
| Subcloud1:                                      |                |         |
| Absolute Coordinates(meters)                    | 313251.7       | 3919162 |
| Explosive Mass(pounds)                          | 167410         |         |
| Charge Strength                                 | 4              |         |
| Energy(Btu)                                     | 3334740739.251 |         |
| CALCULATED DISTANCES AT SPECIFIED OVERPRESSURES |                |         |
| Overpressure                                    | Distance       |         |
| psi (g)                                         | meters         |         |
| 1.000                                           | 321.369        |         |
| 3.500                                           | 0.000          |         |
| 8.000                                           | 0.000          |         |

## Thermal Radiation

Based on HUD guidance, the governing ASD is 366.29 meters (0.23 miles) for Thermal Radiation for People (ASDPPU). The calculated ASD values for Blast Over Pressure (ASDBOP) and Thermal Radiation for Buildings (ASDBPU) are 214.20 meters (0.13 miles) and 78.24 meters (0.05 miles), respectively.

## Conclusion

The projected VCE and thermal radiation impact areas associated with the Kiva United Energy LPG Facility are illustrated in Figures 3 and 4, overlaid on the conceptual site plan. Figure 3 depicts the 321.4-meter radius corresponding to a 1 psi (g) blast overpressure, while Figure 4 shows the 366.3-meter radius of the ASDPPU, which corresponds to a thermal radiation exposure threshold of 450 BTU per square foot per hour.

This analysis was conducted for informational and planning purposes only and did not contemplate or assume the incorporation of any design features, site modifications, or mitigation measures that could potentially reduce or alter the projected impacts of a VCE or thermal radiation event. The distances shown represent conservative screening values based on HUD guidance and standard modeling assumptions.

The following items identify potential mitigation approaches that are commonly referenced in HUD guidance for situations where acceptable separation distances cannot be fully achieved. These measures are presented solely as illustrative options and are not recommended, proposed, or evaluated for feasibility as part of this analysis:

- ▶ Site plan reconfiguration to increase separation distance between the hazardous facility and proposed development, including rearrangement of building placement or modification of building footprints.
- ▶ Building design modifications, such as the use of heat-resistant or high-tensile-strength materials on facades oriented toward the hazardous facility, which may provide limited protection from thermal radiation or blast effects.
- ▶ Construction of protective barriers designed to attenuate blast overpressure and thermal radiation.

In summary, the mitigation approaches described above are provided for contextual awareness only and do not represent recommended actions or project commitments. If proposed structures were ultimately located outside the projected impact areas, depending on building design, construction materials, and intended use, some degree of reduction in potential VCE-related impacts could occur. However, no such assumptions are incorporated into this analysis. Any consideration of structural mitigation measures, including barriers or enhanced building materials, would require detailed engineering analysis and design. Only a licensed professional should evaluate, design, and oversee the implementation of such measures.

**Figure 3 – Modeled VCE Impact Area**

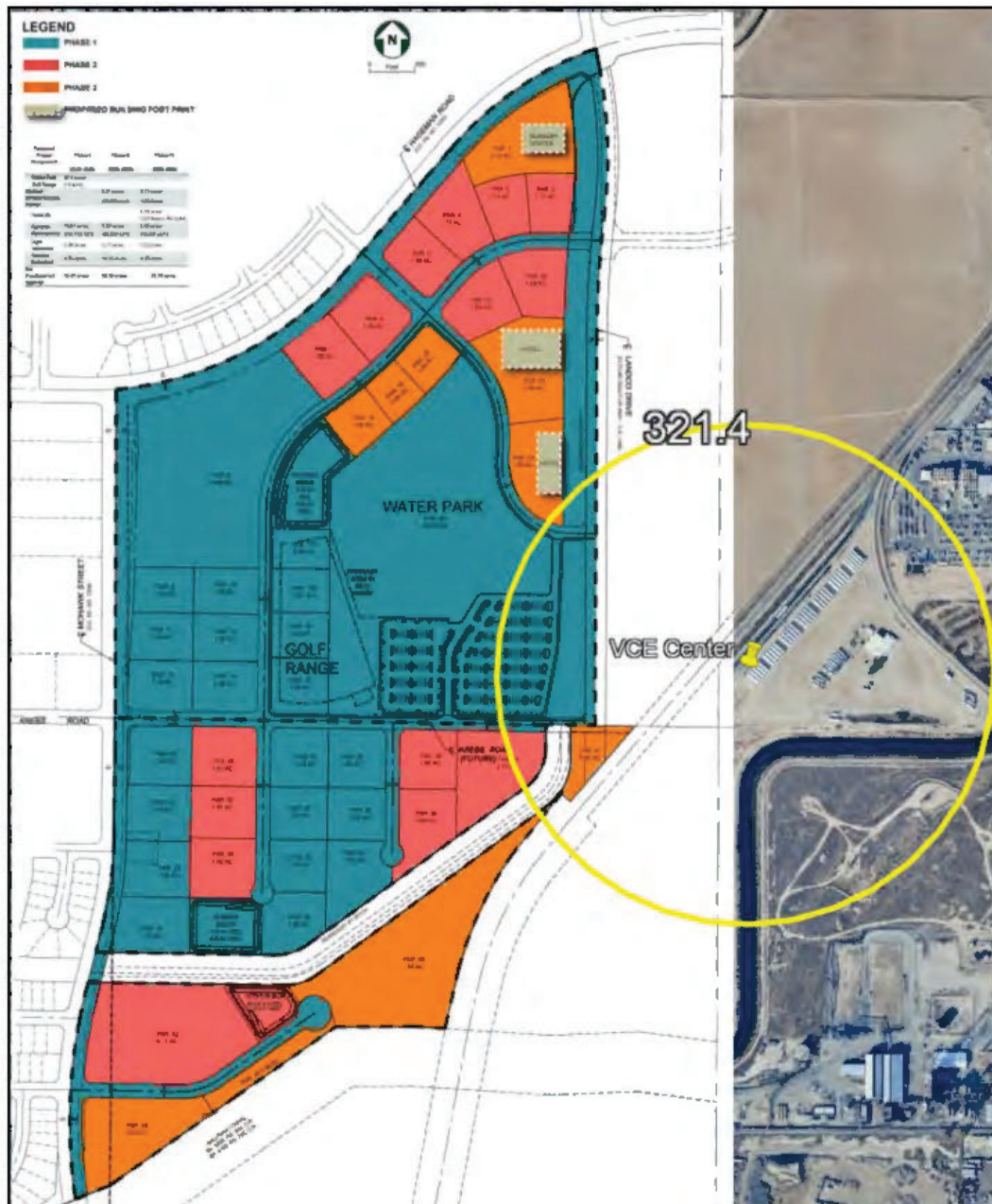
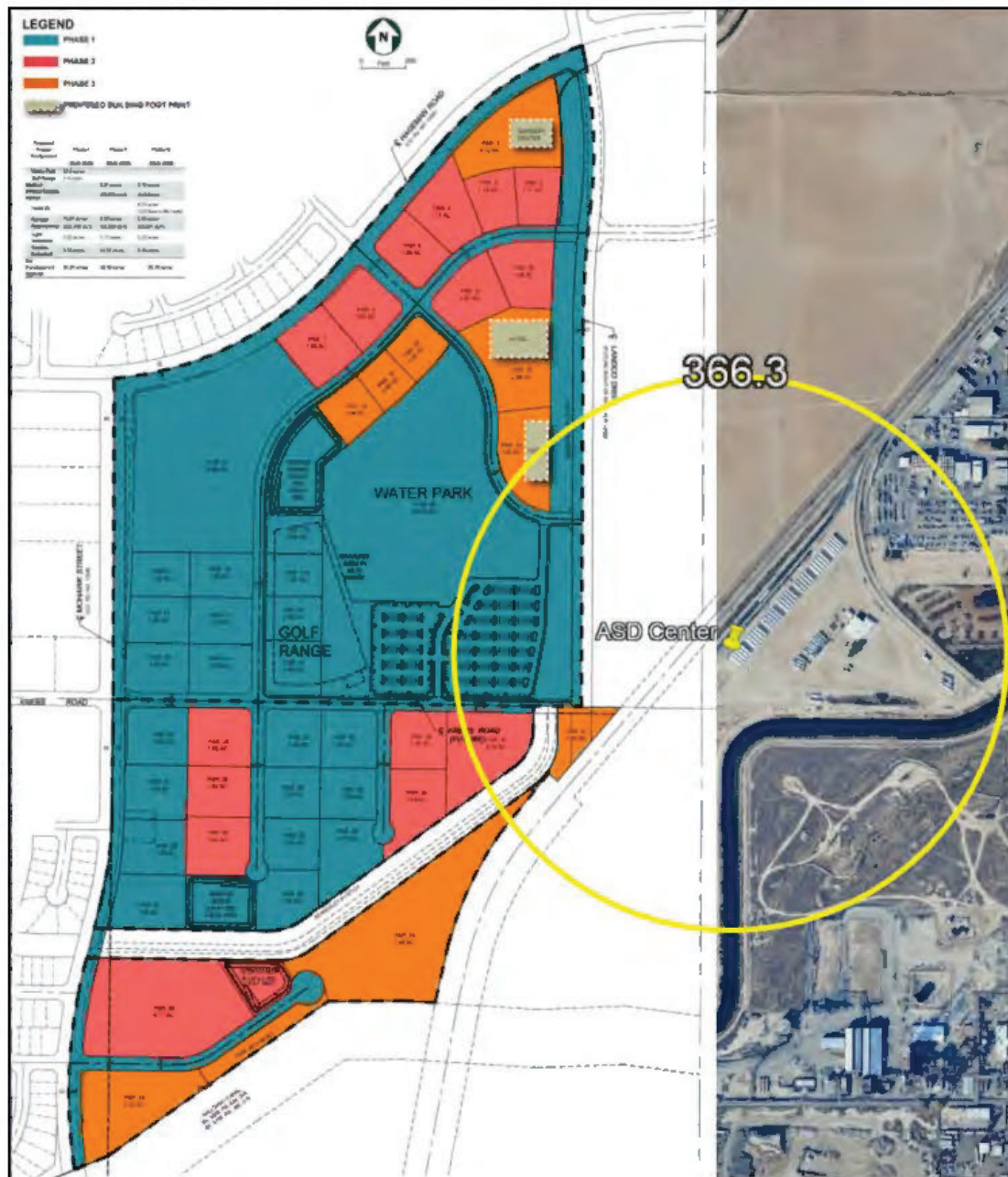


**Figure 4 – Modeled Thermal Radiation Impact Area**

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Trinity Consultants does not warrant that the results presented herein represent impacts beyond those specifically projected by the modeling program used in this analysis. Furthermore, Trinity Consultants accepts no liability for any errors in these results arising from limitations inherent to the modeling program.