Kit Carson Electric Cooperative Hydrogen Balance of Plant Report

Project # 2512362.00

Prepared for:

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1 EXECUTIVE SUMMARY

1.1 Project Scope

The Kit Carson Hydrogen Production and Storage Project aims to integrate renewable energy with hydrogen-based backup power systems across three sites—Questa, Taos, and Penasco. ENTRUST was tasked with modeling the Balance of Plant (BOP) requirements, including water, electricity, and hydrogen usage, to bridge academic component sizing and practical engineering design.

1.2 Key Findings

- **Solar Resource Variability:** PV output fluctuates seasonally from 55% to 100% of nameplate capacity, significantly impacting electrolyzer utilization and hydrogen regeneration rates.
- **Electrolyzer Sizing:** Larger electrolyzers reduce refill time for hydrogen storage but increase capital costs. Optimal sizing should consider minimum solar production to ensure consistent operation.
- **Water Availability:** Conservative water usage estimates confirm sufficient supply at all sites, with Questa's well exceeding demand and requiring only minimal above-ground storage.
- **Compression Requirements:** Preliminary horsepower needs range from 125 HP (Penasco) to 1,878 HP (Questa) for hydrogen compression to 350 bar.
- **Backup Power Duration:** Hydrogen storage provides 3–7 days of backup power depending on site and season, meeting resilience objectives for grid outages.

1.3 Recommendations

- **Balance Capital and Performance:** Size electrolyzers to align with minimum solar output rather than peak capacity to optimize cost and utilization.
- **Leverage Existing Water Resources:** Design minimal water storage infrastructure at Questa and confirm supply for other sites.
- **Plan for Seasonal Variability:** Incorporate operational strategies to manage hydrogen regeneration during low solar periods.
- **Next Steps:** Finalize component sizing and vendor selection based on these findings, ensuring compliance with resilience and sustainability goals.

2 BACKGROUND

2.1 Scope of Work

As part of the Engineering – Fuel Cell Modeling and Balance of Plant scope, ENTRUST was tasked with calculating water, electric, and hydrogen usage through various scenarios. This report serves as an intermediary step between the initial academic sizing of components and the practical design engineering sizing of components. All calculations were completed for the three sites to recognize operational differences. These analyses can serve as the basis for a discussion on the appropriate sizing of capital equipment on the sites.

3 METHODOLOGY and INTERMEDIATE RESULTS

For optimizing the balance of plant (BOP) calculations, required inputs, outputs, and conversion processes needed to be determined. The primary system inputs were energy from solar resources and water. Constrained conversion processes were the electrolyzer and fuel cell/ linear generator. These conversion processes have a dependency on the gaseous hydrogen storage sizing.

Backup energy duration was conserved throughout all calculations to ensure sufficient electrical output to support the local community in a de-energized transmission line scenario. Water was checked to confirm sufficient availability for on-demand sourcing with a buffering water tank. Conservative water usage numbers were used throughout these calculations to ensure scenarios were plausible based on real-world experience.

3.1 PV Outputs

For optimizing the balance of plant (BOP) calculations, possible solar generation profiles were calculated using the National Renewable Energy Laboratory (NREL)'s PV Watts model. This model provides average solar output for a specified region per month of the year. Maximum and minimum solar production rates are depicted below in Table 1.

	PV Output Maximum (MW)	PV Output Minimum (MW)
Questa	52.5	28.9
Taos	17	9.4
Penasco	3.5	2.0

Table 1 shows the maximum and minimum expected solar output based on nameplate capacity at the three sites in northern New Mexico, based on PV Watts.

Using a site-specific PV Watts model, normalized solar production rates relative to nameplate capacity were calculated at each project site.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Penasco	0.58	0.72	0.81	0.89	1.00	0.98	0.85	0.89	0.88	0.75	0.63	0.55
Taos	0.59	0.70	0.81	0.88	0.99	1.00	0.86	0.84	0.85	0.74	0.64	0.55
Questa	0.64	0.69	0.82	0.89	1.00	0.98	0.87	0.85	0.82	0.76	0.65	0.57

Table 2 depicts the normalized solar output values relative to nameplate capacity based on site-specific NREL PVWatts modeling.

3.2 Possible Electrolyzer Sizes

Based upon the various solar production rates at maximum and minimum solar production, it was calculated how long it would take for the dedicated on-site solar to replenish the gaseous hydrogen storage. The on-site storage volumes were obtained from the USDA application as follows in Table 3.

	Hydrogen Storage Amount (MT)
Questa	29
Taos	8.5
Penasco	2

Table 3 shows the assumed gaseous storage volumes of hydrogen at each site.

For consistency throughout calculations, the on-site storage volume was assumed to remain fixed. Based on refilling that fixed amount using on-site solar at maximum and minimum solar production rates. For the storage refill timing several assumptions were made. It was assumed that the electrolyzer was operating with 100% conversion efficiency. It was also assumed that the solar was only producing electricity for 8 hours per day (independent of the solar calendar date). Resultant time in day calculations should be viewed as the whole number of days plus the decimal amount of days multiplied by 8 hours after assumed sunrise. Electrolyzer sizing was varied per site to demonstrate how it impacts storage filling times in Table 4.

Questa Electrolyzer Size (MW)	Elapsed Time to Fill Storage (8hrs/day) Max Solar	Elapsed Time to Fill Storage (8hrs/day) Min Solar	Elapsed Time in Days Max Solar	Elapsed Time in Days Min Solar
52.5	65	114	2.7	4.8
50	69	120	2.9	5.0
45	76	134	3.2	5.6
40	86	150	3.6	6.3
35	98	172	4.1	7.2
30	114	200	4.8	8.3
25	137	240	5.7	10.0

20	171	300	7.1	12.5
15	228	401	9.5	16.7
10	343	601	14.3	25.0
5	685	1202	28.5	50.1
Taos Electrolyzer Size (MW)	Elapsed Time to Fill Storage (8hrs/day) Max Solar	Elapsed Time to Fill Storage (8hrs/day) Min Solar	Elapsed Time in Days Max Solar	Elapsed Time in Days Min Solar
17	59	107	2.5	4.5
15	67	121	2.8	5.1
10	100	182	4.2	7.6
5	201	364	8.4	15.2
Penasco Electrolyzer Size (MW)	Elapsed Time to Fill Storage (8hrs/day) Max Solar	Elapsed Time to Fill Storage (8hrs/day) Min Solar	Elapsed Time in Days Max Solar	Elapsed Time in Days Min Solar
3.5	67	123	2.8	5.1
3	79	143	3.3	6.0
2	118	215	4.9	8.9
1	236	429	9.8	17.9

Table 4 lists replenishment durations for multiple electrolyzer sizes to fully refill the gaseous hydrogen storage at nameplate solar capacity and year-low solar production capacity.

3.3 Compressor Sizes

Preliminary compression horsepower per site was calculated for each site. It was calculated based on the energy required to compress hydrogen from 20bar (290psig) to 350bar (5076 psig). Per several DOE reports, it takes ~1.05kWh/kg H2 to compress over this range. Electrolyzer production rates were assumed based on the electrolyzer sizing, which was identical to the maximum solar output per site listed in Table 1. The resultant kWh was then converted to horsepower for easier understanding. The resultant preliminary compression sizing is shown in Table 5.

	Compression Horsepower
Questa	1878
Taos	608
Penasco	125

Table 5 shows preliminary horsepower needs for compression by site, assuming electrolyzers sized to the maximum solar production listed in Table 1.

3.4 Water Usage vs Availability

Similar to compression horsepower requirements, water usage for the electrolyzer was calculated. Water usage per kg H2 produced was calculated at both the theoretical minimum (9L H2O/ kg H2) and the conservative industry-accepted rate (30L H2O/ kg H2). All of these water usage rates were based on production rates that were assumed per electrolyzer sizing, which was identical to the maximum solar output per site listed in Table 1.

	Gallons Water/hr. (9L H2O/kg h2)	Gallons of Water/hr. (30L H2O /kg h2)
Questa	3174	10579
Taos	1028	3426
Penasco	212	705

Table 6 details the theoretical minimum and realistic water usage for the electrolyzer at all of the sites based on producing at the nameplate electrolyzer/solar capacity.

For Questa, the realistic water usage was confirmed to be at a rate less than what is accessible from the Chevron-owned well (36,000 gal/hr. > 10,579 gal/hr.). Based on the well producing at a rate which exceeds demand, a minimal above-ground water tank can be designed.

Additionally, for benchmarking, theoretical usage per year of water in Acre feet was calculated. This calculation was based on the electrolyzers running for 8-hours per day for the entire year at nameplate production capacity. Additionally, this water usage was benchmarked against a PGA Hot Dry Climate Golf Course's annual water usage (6 Acf/yr) for comparison purposes as seen in Table 7.

	Electrolyzer Acf Water/ Year	Hot Dry Climate Golf Course Equivalent Water Use
Questa	95	15.8
Taos	31	5.1
Picirus	6	1.1

Table 7 depicts the theoretical maximum water usage per year at each site, assuming 8-hours per day of operation 365 days per year, coinciding with the solar availability. This water usage is notably higher than anticipated water usage due to not running the electrolyzers every day. The equivalent amount of golf courses in a hot dry climate's water usage is provided for comparison.

3.5 Hydrogen Storage Depletion Rates

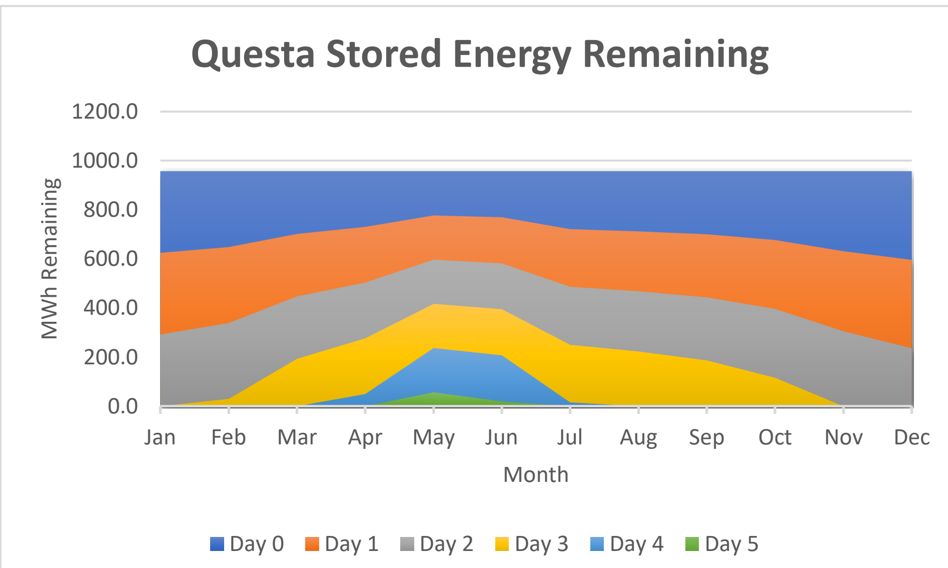
Based on on-site storage gaseous hydrogen volumes, depletion rates were calculated based on 100% efficient fuel cells/linear generators. The storage volume and regeneration rates were calculated per monthly solar availability per PV Watts on a site-basis. The amount of MWh in gaseous hydrogen storage remaining after functioning in a grid-disconnected manner was calculated for each site below. This scenario assumes that any available solar is used first to power the local grid and stored gaseous hydrogen run through a fuel cell is used to make-up any additional energy needs. Fuel cells or linear generators were assumed to be 100% efficient and have nameplate capacities listed in Table 8.

	Fuel Cell Size (MW)	Hours of Storage per 100% Fuel Cell
Questa	25	38
Taos	7.5	37
Penasco	1.5	44

Table 8 shows the anticipated fuel cell or linear generator sizing for each site and the associated timeframe to deplete gaseous hydrogen storage without any solar availability or regeneration from solar resources.

3.6 Questa Stored Energy Remaining

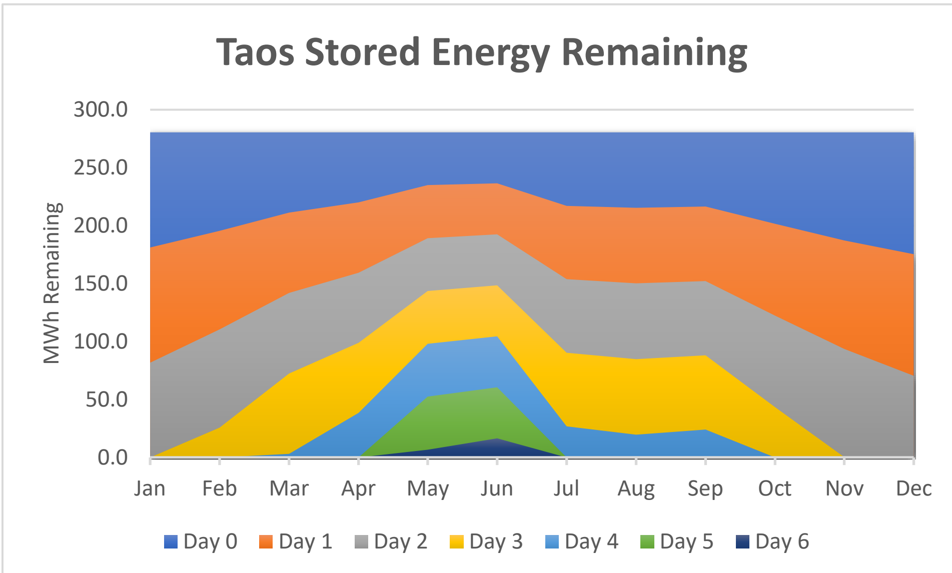
After the depletion rates per month and regeneration rates of hydrogen were calculated based on PV Watts anticipated solar availability, a monthly model showing remaining storage in gaseous hydrogen was graphed for each site. For Questa, this demonstrated that during peak solar production, over four days of backup power was available. Conversely, during periods of minimal solar production, less than three days of backup power was available.



	Questa Stored Energy Remaining											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Day 0	957.0	957.0	957.0	957.0	957.0	957.0	957.0	957.0	957.0	957.0	957.0	957.0
Day 1	624.7	647.9	702.3	730.0	777.0	769.6	721.5	712.5	700.0	676.8	631.0	596.4
Day 2	292.5	338.9	447.6	503.0	597.0	582.3	486.1	467.9	443.0	396.6	304.9	235.9
Day 3	0.0	29.8	192.8	276.1	417.0	394.9	250.6	223.4	186.1	116.4	0.0	0.0
Day 4	0.0	0.0	0.0	49.1	237.0	207.6	15.1	0.0	0.0	0.0	0.0	0.0
Day 5	0.0	0.0	0.0	0.0	57.0	20.2	0.0	0.0	0.0	0.0	0.0	0.0
Day 6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

3.7 Taos Stored Energy

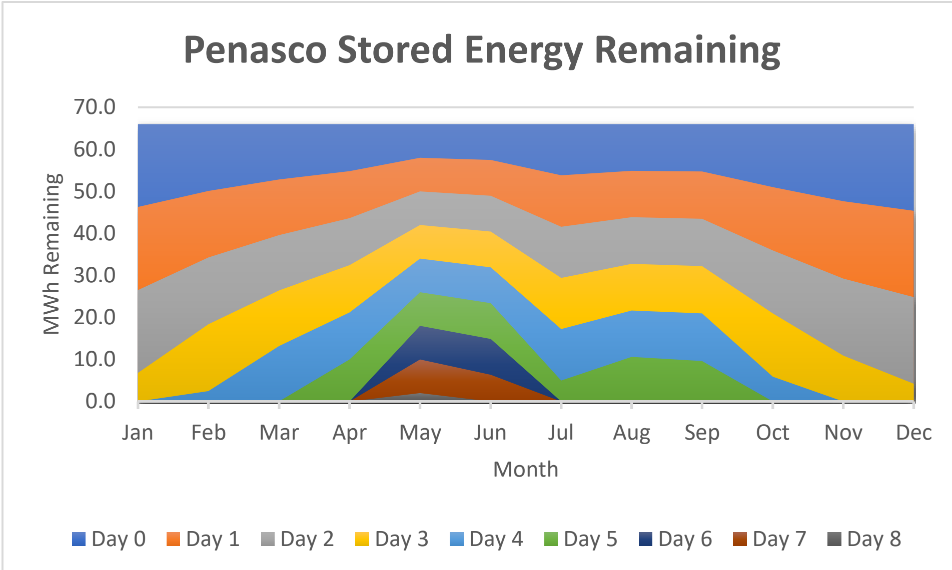
After the depletion rates per month and regeneration rates of hydrogen were calculated based on PV Watts anticipated solar availability, a monthly model showing remaining storage in gaseous hydrogen was graphed for each site. For Taos, this demonstrated that during peak solar production, over five days of backup power was available. Conversely, during periods of minimal solar production, less than three days of backup power was available.



	Taos Stored Energy Remaining											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Day 0	280.5	280.5	280.5	280.5	280.5	280.5	280.5	280.5	280.5	280.5	280.5	280.5
Day 1	181.2	195.5	211.2	220.0	234.9	236.5	217.1	215.3	216.4	201.5	187.1	175.4
Day 2	81.8	110.6	141.8	159.4	189.3	192.5	153.7	150.1	152.3	122.4	93.7	70.3
Day 3	0.0	25.6	72.5	98.9	143.6	148.5	90.3	84.9	88.1	43.4	0.3	0.0
Day 4	0.0	0.0	3.2	38.4	98.0	104.5	26.9	19.7	24.0	0.0	0.0	0.0
Day 5	0.0	0.0	0.0	0.0	52.4	60.5	0.0	0.0	0.0	0.0	0.0	0.0
Day 6	0.0	0.0	0.0	0.0	6.8	16.5	0.0	0.0	0.0	0.0	0.0	0.0
Day 7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

3.8 Penasco Stored Energy

After the depletion rates per month and regeneration rates of hydrogen were calculated based on PV Watts anticipated solar availability, a monthly model showing remaining storage in gaseous hydrogen was graphed for each site. For Penasco, this demonstrated that during peak solar production, over seven days of backup power was available. Conversely, during periods of minimal solar production, less than four days of backup power was available.



	Penasco Stored Energy Remaining											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Day 0	66.0	66.0	66.0	66.0	66.0	66.0	66.0	66.0	66.0	66.0	66.0	66.0
Day 1	46.3	50.1	52.8	54.8	58.0	57.5	53.8	54.9	54.7	51.0	47.6	45.4
Day 2	26.5	34.3	39.6	43.6	50.0	49.0	41.6	43.8	43.5	36.0	29.3	24.8
Day 3	6.8	18.4	26.4	32.4	42.0	40.4	29.4	32.8	32.2	20.9	10.9	4.2
Day 4	0.0	2.5	13.2	21.2	34.0	31.9	17.2	21.7	20.9	5.9	0.0	0.0
Day 5	0.0	0.0	0.0	10.0	26.0	23.4	5.0	10.6	9.7	0.0	0.0	0.0
Day 6	0.0	0.0	0.0	0.0	18.0	14.9	0.0	0.0	0.0	0.0	0.0	0.0
Day 7	0.0	0.0	0.0	0.0	10.0	6.4	0.0	0.0	0.0	0.0	0.0	0.0
Day 8	0.0	0.0	0.0	0.0	2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Day 9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

4 FINDINGS AND ANALYSES

4.1 Hierarchy of Considerations

The calculations focused on enabling a project which prioritized backup power generation after de-energization of electrical transmission lines. The following is ENTRUST's implemented hierarchy with #1 being the highest priority:

1. **Backup Storage Duration**
2. **Water Usage vs Availability**
3. **PV Outputs**
4. **Electrolyzer Sizing**

Throughout this report, and for consistency throughout calculations, the on-site storage volume was assumed to remain fixed. This enables all solutions to meet the first consideration of supplying the desired backup energy duration. This was validated with a go/no-go calculation on water availability for the Questa site. All other sites have assumed sufficient water supply rates will be available.

While the well at Questa's 600gpm capability exceeds demand and likely requires a minimal above-ground water storage tank. This tank's capacity could be increased to provide a local water source for the local fire department if desired.

Anticipated PV Outputs were found to be highly variable depending on the time of year. This variability of production from 55-100% of nameplate has significant impacts on available solar resources for the electrolyzers. As a result, the electrolyzers can be sized in two alternating manners depending on priorities. Electrolyzers can be sized to match the solar nameplate capacity (maximum production) or sized to match the minimum solar production. When sized to the solar nameplate capacity, other than the sunniest days of the year, there would be insufficient energy available to produce hydrogen at the maximum production rate. Conversely, sizing the electrolyzers to the minimum anticipated solar production rate helps to minimize capital spend and ensure maximal usage of the electrolyzers. The potential impact to the time to regenerate hydrogen storage from solar was explored in Table 4 at various electrolyzer sizes per site.

5 CONCLUSION AND RECOMMENDATIONS

Running calculations for the balance of plant for the various sites confirmed the viability of these projects within known boundary conditions. This study demonstrated how electrolyzer sizing could be modulated to reduce capital spend while still achieving similar storage durations. It is suggested to work to balance solar production per land available with electrolyzer sizing during minimal solar production periods to maximize the capital spend for this project.

Kit Carson Electric Cooperative Hydrogen Project 10% Design HAZID

Project # 2415733.00

Prepared for:

Kit Carson Electric Cooperative

Prepared by:

ENTRUST SOLUTIONS GROUP

Feb 3, 2026

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1.0 EXECUTIVE SUMMARY

Kit Carson Electric Cooperative (KCEC) engaged ENTRUST Solutions Group (ENTRUST) to provide technical support for the conceptual development, preliminary design, and associated risk assessment activities required for the safe and reliable implementation of the Questa Green Hydrogen Project. EN's scope of work included supporting early design decisions, evaluating safety and operability considerations, and establishing a risk-based framework to guide the development of hydrogen facilities in alignment with industry best practices and applicable standards.

Using the available conceptual (approximately 10 percent) design information, ENTRUST facilitated a structured hazard and risk assessment intended to identify credible operational, process safety, and facility related risks early in the project lifecycle. The assessment focused on identifying key hazard scenarios inherent to hydrogen production, storage, distribution, and utilization, along with potential risk drivers associated with equipment design, facility layout, operating philosophies, and external interfaces. The outcomes of this assessment were intended to support risk informed decision-making throughout subsequent stages of design and to provide an initial structure for managing hydrogen safety once the facilities are operational.

The hazard and risk assessment was completed during a two-day, onsite Hazard Identification (HAZID) workshop utilizing a What- If methodology. The workshop was facilitated by ENTRUST and conducted with a multidisciplinary team representing engineering, operations, and safety expertise. Structured What-If questions were used to systematically challenge design assumptions and identify potential deviations, failures, or abnormal operating conditions. Hazards and associated risks identified during the HAZID were documented and evaluated, and corresponding recommendations and actions were developed to support hazard mitigation and risk reduction.

This report documents the results of the HAZID, including the identified hazards, existing and proposed safeguards, and recommended actions to address operational and safety risks. The findings are intended to support the further development and refinement of KCEC's hydrogen safety plan and to inform ongoing design development. Common themes from the findings are detailed in **Appendix A** along with a consolidated list of actions and recommendations is provided in **Appendix B** and the complete, detailed HAZID record is included in **Appendix C**.

2.0 PROJECT OVERVIEW

2.1. Scope of Work

Kit Carson Electric Cooperative (KCEC) has requested ENTRUST Solutions Group (ENTRUST) to support the conceptualization, preliminary design, and risk assessment to support the safe
development and implementation of Kit Carson's Questa Green Hydrogen Project. Based on the conceptual design (10%) design, ENTRUST facilitated a hazard and risk assessment and identified mitigations of operational and safety risks throughout the design process.

The assessment was completed through an onsite two-day Hazard Identification (HAZID) analysis utilizing a What-If methodology. The following guidelines were used during facilitation of the workshop to ensure thorough hazard identification and risk mitigation.

1. Identify and evaluate the risk, threats, and hazards of processes.
2. Review and consider potential incidents or near-miss events when operating a hydrogen facility.
3. Identify and evaluate engineering and administrative controls applicable to the hazards and their interrelationships, such as detection methods to provide early warning of releases.
4. Identify the consequences of failure of engineering and administrative controls.
5. Consider facility siting.
6. Consider human factors.
7. Evaluate community or public impacts and emergency response requirements.
8. Conduct a qualitative evaluation of a range of the possible safety and health effects on employees in the workplace if there is a failure of controls.
9. Provide recommendations for mitigation or reduction of unacceptable risks identified during the analysis.

This report documents the hazards, safeguards, and actions for hazard mitigation and further development of KCEC's hydrogen safety plan. The actions and recommendations can be found in **Appendix B** with a full documented report of the HAZID in **Appendix C**.

2.2. HAZID Assessment Team

ENTRUST led the 10% design HAZID. Participating in the analysis from ENTRUST were as follows:

- John Kill: VP, Safety Management Systems; and *HAZID Facilitator*

- Jim Francis: VP, SMS Consulting and Principal Consultant
- Lindsey Schutte: Sr. Project Engineer, SMS; and *HAZID Scribe*
- Kevin Woo: Principal Engineer, Renewables; and *HAZID Scribe*
- Tim Harris: Principal Engineer, Renewables

The following personnel from KCEC participated in the HAZID:

- Richard Martinez: Chief Operating Officer
- John Ortega: Safety Manager and Mayor of Questa
- Michael Ryan: Project Manager
- Jeremy Torres: Operations Manager, Propane
- Lorenzo Rael: Supervisory Control and Data Acquisition (SCADA) Technician
- Louis Vigil: Engineer for Power, Transmission & Distribution

The following personnel from Sandia National Lab participated in the HAZID:

- Brian Erhart: H2 Safety Codes & Standards Subject Matter Expert

2.3. HAZID Assessment Dates and Logistics

The assessment was held in person on KCEC office property in Taos, New Mexico on December 2 and 3, 2025. All members of the assessment participated in person, aside from Lindsey Schutte (ENTRUST) who attended virtually.

ENTRUST used Microsoft Excel and PHAWorks to scribe and document the HAZID assessment including but not limited to attendees, sessions, systems, scenarios, consequences, risk ranking, safeguards, and actions/ recommendations.

3.0 METHODOLOGY AND PREPARATION

3.1. Assessment Methodology

For the conceptual design of the hydrogen project, the What-If HAZID assessment methodology was applied as an early phase, qualitative hazard identification tool to systematically evaluate potential safety, environmental, and operability risks associated with hydrogen generation, distribution, and use. The assessment utilized structured "What-If" questions to challenge key design concepts, operating philosophies, and design assumptions. The questions were developed with emphasis on evaluating credible loss of containment, ignition, overpressure, and abnormal operating scenarios characteristic of hydrogen service. The HAZID was facilitated by an experienced leader and conducted by a multidisciplinary team from KCEC, ENTRUST and Sandia National Lab, leveraging preliminary design information, industry experience, and lessons learned to identify major hazard drivers. Identified scenarios, existing or proposed safeguards, and recommendations were documented at a conceptual level to influence design updates, safety work plans, risk reduction strategies, and the scope of subsequent detailed safety studies.

3.2. Risk Ranking

Each What-If scenario consequence was risk ranked by the HAZID team using the scale depicted in Table 1, defining a risk level to each consequence.

Table 1: Scenario Consequence Risk Ranking		
Description	**Risk Level**	**Criteria**
Negligible	1	Could result in one or more of the following: injury or occupational illness not resulting in a lost workday, minimal environmental impact, asset damage, or reputational impact.
Low	2	Could result in one or more of the following: injury or occupational illness resulting in one or more lost workday(s), reversible minor environmental and reputation impact, minor asset damage.
Medium	3	Could result in one or more of the following: permanent partial disability, hospitalization, injuries, or occupational illness to multiple people, reversable significant environmental and reputation impact, significant asset damage and operational impacts.
High	4	Could result in one or more of the following: death, permanent total disability, irreversible significant environmental and reputational impact, irreversible catastrophic asset damage and significant operational impacts.

3.3. Assessment Preparation

The 10% conceptual design drawings of the hydrogen project were provided to the facilitator and scribe prior to the onsite HAZID. (See **Appendix D** for 10% Conceptual Design Drawings). The HAZID template and software (Excel and PHAWorks) was prepared with system and subsystem structure based on the equipment processes detailed in the conceptual design.

The systems and sub systems utilized for the HAZID were as follows:

1. Electrolyzer
2. Compressor
3. Hydrogen Storage
4. Fuel Cell / Linear Generator

5. Utilities / Miscellaneous
   5.1 Controls and Power
   5.2 Human Factors
   5.3 Water and Weather
   5.4 Facility Siting
   5.5 Environmental

What-If questions for each system and subsystem were developed by the facilitator in advance of the HAZID to serve as the initial basis for facilitating and guiding the hazard identification process.

4.0 ASSESSMENT RESULTS AND RECOMMENDATIONS

Recommendations were developed for each scenario and associated consequence identified during the assessment to mitigate or otherwise address the corresponding hazards and risks. The development of these recommendations followed the hierarchy of controls, prioritizing inherently safer design measures, engineering controls, and design modifications wherever feasible. Where engineering solutions were not practical or sufficient, administrative controls—such as operating procedures, safety plans, and personnel training—were identified to ensure risks were appropriately managed.

Each recommendation was assigned a responsible owner(s) from the following options: ENTRUST Design Team, ENTRUST Safety Management System Team, KCEC or a 3rd party owner.

The resulting list of recommendations has been compiled and will be used by the ENTRUST project manager and ENTRUST project team to manage and track action closure. Due dates and specific owners for each recommendation may be assigned by the project manager in collaboration with KCEC and the project team to ensure that each recommendation is addressed in alignment with the required project schedule and expected timeline.

4.1. Themes of Findings

Common themes identified from the recommendation list are as follows:

1. **Safety by Design and Layered Protection:** The facility must be designed with layered protection and fail-safe principles, including redundancy, automated shutdowns, pressure relief, leak/flame detection, and compliance with applicable codes and standards. Safety cannot rely on a single system or control. *(67 Associated Recommendations)*
2. **Manufacturer (Vendor) Alignment and Verification:** Successful execution depends on strict adherence to manufacturer specifications for design limits, startup/shutdown, materials, maintenance, and operating envelopes. These

requirements must be embedded early through the RFP, design reviews, and commissioning. *(34 Associated Recommendations)*

3. **Operational Discipline and Structure:** Comprehensive standard operating procedures (SOPs) are required for normal, abnormal, and emergency conditions. This includes clear guidance for loss of power, equipment failure, contamination, and seasonal impacts—supported by lockout/tagout, purging, and post-maintenance verification. *(75 Associated Recommendations)*
4. **People, Training, and Qualifications:** Safe operation depends on qualified, well-trained personnel. Role-specific training, certifications, emergency response drills, and first-responder coordination are essential. Workforce development and long-term skills planning should be treated as strategic investments. *(43 Associated Recommendations)*
5. **Detection, Instrumentation, and Monitoring:** Extensive use of instrumentation, sensors, alarms, and SCADA integration is required to detect abnormal conditions early. Critical systems should have redundancy, backup power, and defined alarm response protocols. *(42 Associated Recommendations)*
6. **Maintenance, Quality Assurance, and Asset Integrity:** Long-term safety and uptime depend on formal inspection, preventive maintenance, QA/QC, and asset integrity programs, including corrosion management, spare parts strategy, audits, and third-party reviews. *(74 Associated Recommendations)*
7. **Emergency Preparedness and Community Impact:** The design and operating model must account for fire scenarios, severe weather, site-specific hazards, and community interfaces, with clear emergency response plans, public notification protocols, and coordination with local authorities. *(26 Associated Recommendations)*

A further detailed summary of common themes identified in the findings and recommendations can be found in **Appendix A**. The consolidated list of recommendations can be found in **Appendix B** and the full assessment report can be found in **Appendix C**. An action item tracker with all recommendations, owners and associated assessment details can be found in **Appendix E**.

5.0 CLOSING

The enclosed HAZID results and associated recommendations provide KCEC with a clear foundation for advancing the Questa Green Hydrogen Project safely and responsibly through future phases of design. The insights gained from this early-stage assessment will help ensure that potential hazards are proactively addressed, that risk-reduction measures are incorporated as the design and safety plans mature, and that the project remains aligned with recognized industry practices for hydrogen safety.

6.0 APPENDICES

6.1. Appendix A: Detailed Recommendation Themes

1. Strong Emphasis on Safety-by-Design and Layered Protection

A dominant theme is designing systems with **multiple, independent layers of protection** rather than relying on a single safeguard.

- Redundancy in controls, sensors, power supplies, and protection systems
- Fail-safe design (fail-open / fail-close logic clearly defined)
- Emergency Shutdown (ESD) logic, QA/QC, and maintenance
- Pressure relief devices (PRVs, rupture disks), vent design, and verification
- Fire and flame detection (fire eyes, flame sensors, hydrogen detectors)
- Classified area studies and hazardous area compliance

Key idea: Anticipate failures and ensure the system defaults to a safe state.

---

2. Manufacturer (Vendor) Alignment and Verification

Nearly every system component (electrolyzer, compressor, storage, fuel cell/L-Gen) includes repeated calls to **confirm manufacturer requirements and recommendations.**

- Startup/shutdown protocols
- Operating envelopes (temperature, pressure, moisture, purity)
- Material compatibility (hydrogen, oxygen, moisture)
- Preventative maintenance schedules
- Design ratings of fittings and components

Key idea: Design, procedures, and maintenance must be explicitly aligned with original equipment manufacturer specifications and validated in the RFP and design reviews.

---

3. Robust Operating Procedures (SOPs) for Normal, Abnormal, and Emergency Conditions

A very strong procedural theme exists across all equipment and systems.

- SOPs for:
    - Normal operations
    - Startup and shutdown (including manual operation)
    - Abnormal conditions (loss of power, water loss, contamination, low pressure)
    - Emergency response (vent fires, hydrogen leaks, loss of automation)
    - Lockout/Tagout (LOTO), purging procedures, and post-maintenance leak checks

Key idea: Every credible scenario should have a documented, trained response.

---

4. Training, Qualifications, and Workforce Readiness

Recommendations repeatedly emphasizes **people as a critical risk control.**

- Role-specific training and qualification requirements

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- Training for:
    - Startup/shutdown
    - Emergency response
    - Abnormal operations
- Manual intervention when automation fails
- First responder and community training
- Apprenticeships, trade school partnerships, and long-term workforce planning

Key idea: Safe systems depend on competent, trained personnel at all levels.

---

5. Instrumentation, Sensors, and Monitoring

Another consistent theme is **early detection and continuous monitoring**.

- Hydrogen, oxygen, moisture, pressure, temperature, vibration, voltage sensors
- Gas quality and contaminant monitoring upstream and downstream
- Alarm thresholds integrated with SCADA
- Backup power and redundancy for critical sensors
- Calibration, testing, and maintenance included in SOPs

Key idea: Detect deviations early to prevent escalation.

---

6. Maintenance, Inspection, and Asset Integrity Management

Preventive and predictive maintenance is a major focus.

- Formal inspection and maintenance management plans
- Seasonal maintenance considerations (cold, snow, heat)
- Corrosion prevention, material selection, and thru-wall failure inspection
- Third-party maintenance oversight and verification
- Spares management and materials handling

Key idea: Reliability and safety are sustained through disciplined maintenance.

---

7. Environmental, Site, and External Hazard Considerations

The recommendations repeatedly account for **site-specific and external risks**.

- Cold weather, severe weather, wildfire exposure
- Vegetation control and site grading
- Wildlife protection and physical barriers
- Noise exposure and enclosure design
- Community impacts and public notification protocols

Key idea: Design must reflect real-world site conditions, not just equipment specifications.

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8. Emergency Preparedness and Response Integration

Emergency response planning is woven throughout the list.

- Emergency Response Plans (ERPs)
- Vent fire response guidance (including “do not spray water” scenarios)
- Coordination with fire marshal and first responders
- Mock drills, dry runs, and pre-startup safety reviews (PSSR)

- Public communication procedures

Key idea: Emergencies are expected scenarios and must be planned, trained, and rehearsed.

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9. Quality Assurance, Governance, and Compliance

There is a recurring focus on **formal process control and accountability**.

- QA/QC reviews of procedures and designs
- Third-party reviews
- Internal audits and compliance verification
- Procurement controls and material verification
- Code, standard, and regulatory alignment (Compressed Gas Association [CGA], Occupational Safety and Health Administration, local codes)

Key idea: Safety and reliability require disciplined governance, not informal practices.

---

10. System Integration and Resilience

Finally, the list consistently addresses **system-level integration and resilience**.

- Automation integration (SCADA, ESD, alarms)
- Backup power for critical systems
- Manual operability during automation failures
- Cross-ties, bypasses, and parallel paths
- Consideration of total facility loss of power or control

Key idea: The facility must remain controllable and recoverable under degraded conditions.

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6.2. Appendix B: Consolidated List of Recommendations

Electrolyzer – Design, Controls, Startup/Shutdown

1. Confirm vendor provides redundancies, shutdown controls, and layered protections for the electrolyzer — Owner(s): Design *(source IDs: 1)*
2. Develop SOPs for electrolyzer startup and shutdown (including static state vs purge sequencing) — Owner(s): SMS *(source IDs: 2)*
3. Provide personnel training specific to electrolyzer startup and shutdown — Owner(s): Design, SMS *(source IDs: 3)*
4. Confirm manufacturer-specific recommendations for electrolyzer operation and protection — Owner(s): Design, SMS *(source IDs: 4)*
5. Implement controls and automation to ensure proper startup and shutdown sequencing — Owner(s): Design, Controls *(source IDs: 5)*
6. Establish trained personnel expertise for manual startup and shutdown when required — Owner(s): Design, SMS *(source IDs: 3)*
7. Establish manual and/or automatic startup and shutdown procedures and sequencing — Owner(s): SMS *(source IDs: 7)*
8. Confirm stack health monitoring (performance, efficiency, and remaining life) — Owner(s): Design *(source IDs: 8)*
9. Define normal valve positions and methods for restoration to normal operation (manual vs signal) — Owner(s): Design *(source IDs: 9)*
10. Define operator qualifications required for electrolyzer operation — Owner(s): Design, SMS, KCEC *(source IDs: 10)*
11. Establish comprehensive electrolyzer shutdown procedures — Owner(s): SMS *(source IDs: 11)*
12. Ensure appropriate pressure detection sensors are installed on the electrolyzer — Owner(s): Design *(source IDs: 12)*
13. Ensure proper electrical grounding for electrolyzer and associated equipment — Owner(s): Design *(source IDs: 13)*
14. Provide training and qualifications for normal and abnormal electrolyzer operation — Owner(s): SMS *(source IDs: 14)*

15. Create SOPs covering normal and abnormal electrolyzer operating conditions — Owner(s): SMS *(source IDs: 15)*
16. Install power fault detection and signaling for the electrolyzer — Owner(s): Design *(source IDs: 16)*
17. Include anticipated operating temperature range and environmental conditions in the RFP — Owner(s): SMS *(source IDs: 25)*
18. Define heat tracing and insulation requirements for electrolyzer and associated equipment — Owner(s): Design *(source IDs: 18)*
19. Define hydrogen dryness requirements and manufacturer-specific moisture limits — Owner(s): Design, KCEC *(source IDs: 112)*
20. Design inlet piping considering insulation, heat tracing, routing, and temperature maintenance — Owner(s): Design *(source IDs: 20)*
21. Confirm system shuts down automatically upon loss of water supply to the electrolyzer — Owner(s): Design *(source IDs: 28)*
22. Confirm manufacturer requirements related to water quality and internal water management — Owner(s): Design *(source IDs: 24)*
23. Develop SOP for response to insufficiently dry hydrogen — Owner(s): SMS *(source IDs: 30)*
24. Install hydrogen moisture sensing to verify product gas dryness — Owner(s): Design *(source IDs: 31)*
25. Include voltage continuity sensing and associated alarms in the RFP — Owner(s): Design *(source IDs: 32)*
26. Include inline oxygen monitoring at electrolyzer outlet — Owner(s): Design *(source IDs: 33)*

Materials, Corrosion, and Water Systems (Global)

27. Establish maintenance practices per manufacturer specifications for all water-carrying systems (including corrosion monitoring) — Owner(s): SMS *(source IDs: 37)*
28. Select piping materials resistant to degradation for all water-carrying systems — Owner(s): Design *(source IDs: 38)*

29. Incorporate corrosion prevention measures into system design — Owner(s): Design *(source IDs: 39)*
30. Implement differential pressure monitoring where required for water-carrying systems — Owner(s): Design *(source IDs: 40)*
31. Develop inspection and maintenance plans to detect corrosion or through-wall failure — Owner(s): SMS *(source IDs: 36)*

Venting, Relief, and Pressure Protection

32. Include CGA G-5.5 hydrogen vent design requirements in the RFP — Owner(s): Design *(source IDs: 26)*
33. Design hydrogen vents to prevent blockage (weather, water accumulation, nesting, debris) per CGA G-5.5 — Owner(s): Design, SMS *(source IDs: 43)*
34. Establish emergency response procedures and training for hydrogen vent fire scenarios — Owner(s): SMS *(source IDs: 27)*
35. Develop a regular inspection and testing schedule for pressure relief systems (e.g., annual) — Owner(s): SMS *(source IDs: 83)*
36. Evaluate need for redundant rupture disks and define installation locations — Owner(s): Design *(source IDs: 45)*
37. Verify relief and vent system design philosophy (common header vs dedicated vents) — Owner(s): Design *(source IDs: 51)*

Compressor Systems

38. Confirm compressor automation controls, ramp rates, and SCADA integration per manufacturer guidance — Owner(s): Design *(source IDs: 46)*
39. Verify dehydration system is installed upstream of compressors — Owner(s): Design *(source IDs: 47)*
40. Confirm compressor fittings are rated appropriately for inlet and outlet pressures — Owner(s): Design *(source IDs: 48)*
41. Conduct risk modeling to define compressor impact radius — Owner(s): Design *(source IDs: 49)*

42. Confirm presence of shutoff and relief valves in compressor design — Owner(s): Design *(source IDs: 50)*
43. Confirm compressor materials (including packing) are hydrogen compatible — Owner(s): Design *(source IDs: 62)*
44. Verify installation of vibration monitoring sensors on compressors — Owner(s): Design *(source IDs: 63)*
45. Follow manufacturer preventive maintenance recommendations for compressors — Owner(s): SMS *(source IDs: 64)*
46. Evaluate alternatives to compressor enclosures (e.g., noise compliance strategies) — Owner(s): Design *(source IDs: 72)*
47. If enclosures are used, design to prevent hydrogen accumulation — Owner(s): Design *(source IDs: 73)*
48. Install leak detection within compressor enclosures — Owner(s): Design *(source IDs: 74)*
49. Ensure compressor over-pressure protection systems are included — Owner(s): Design *(source IDs: 79)*
50. Confirm manufacturer protections against improper compressor startup and shutdown — Owner(s): Design *(source IDs: 80)*
51. Evaluate battery backup needs for compressor operation — Owner(s): Design *(source IDs: 82)*
52. Confirm compressor oil temperature sensing location and suitability — Owner(s): Design *(source IDs: 85)*
53. Verify check valve configuration and pressure ratings in compressor discharge — Owner(s): Design *(source IDs: 88,89)*

Hydrogen Storage Systems

54. Include installation of valves and ports on storage tank bulkheads per RFP — Owner(s): Design *(source IDs: 90)*
55. Implement per-bank leak detection and pressure/temperature monitoring — Owner(s): Design *(source IDs: 91)*

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56. Define PPE requirements for personnel working around hydrogen storage — Owner(s): SMS *(source IDs: 92)*
57. Evaluate use of detection tape on storage system flanges — Owner(s): Design *(source IDs: 93)*
58. Design hydrogen vents for storage systems per CGA G-5.5 (including drainage) — Owner(s): Design *(source IDs: 94)*
59. Develop SOPs and training for PRV installation, setting, and maintenance — Owner(s): SMS *(source IDs: 95)*
60. Confirm manufacturer storage pressure design ratings in RFP — Owner(s): Design *(source IDs: 96)*
61. Coordinate wildfire mitigation and tank cooling solutions with fire marshal — Owner(s): Design *(source IDs: 97)*
62. Evaluate need for additional upstream high-pressure relief for storage systems — Owner(s): Design *(source IDs: 98)*
63. Design impermeable barriers between storage tank bulkheads — Owner(s): Design *(source IDs: 99)*
64. Verify barrier installation during construction review — Owner(s): Design *(source IDs: 100)*
65. Confirm spacing between tank banks per codes, standards, and calculations — Owner(s): Design *(source IDs: 101)*
66. Install flame detection across storage banks — Owner(s): Design *(source IDs: 102)*
67. Analyze cost-benefit of firewalls between storage banks — Owner(s): Design *(source IDs: 104)*
68. Develop SOPs and emergency response plans and training for storage systems — Owner(s): SMS *(source IDs: 103)*
69. Establish routine inspection and maintenance SOPs for storage systems — Owner(s): SMS *(source IDs: 105)*
70. Confirm manufacturer internal inspection requirements and include in SOPs — Owner(s): Design, SMS *(source IDs: 114)*
71. Define gas quality and moisture monitoring upstream of storage — Owner(s): Design *(source IDs: 115)*

72. Incorporate operator monitoring, alarms, and relief valve configuration for storage — Owner(s): Design, SMS, KCEC *(source IDs: 117)*

Fuel Cell / Linear Generator (L-Gen)

73. Confirm hydrogen contamination detection and response requirements — Owner(s): SMS *(source IDs: 122)*
74. Install sensors for hydrogen purity, oxygen, and moisture — Owner(s): Design *(source IDs: 123)*
75. Design sediment traps upstream of FC/L-Gen equipment — Owner(s): Design *(source IDs: 124)*
76. Evaluate future FC/L-Gen capacity expansion needs — Owner(s): Design *(source IDs: 125)*
77. Develop SOPs for FC/L-Gen inspection, maintenance, and third-party work — Owner(s): SMS *(source IDs: 126,131)*
78. Confirm L-Gen operating protocol under low fuel pressure — Owner(s): Design, SMS *(source IDs: 132)*
79. Install upstream filters to capture fuel line debris — Owner(s): Design *(source IDs: 133)*
80. Develop SOPs and training for regulators and regulation stations — Owner(s): SMS *(source IDs: 134)*
81. Confirm maximum fuel line pressure for L-Gen and fuel cell — Owner(s): Design *(source IDs: 135,138)*
82. Confirm appropriate fuel line pressure relief systems for FC/L-Gen — Owner(s): Design *(source IDs: 136)*
83. Confirm manufacturer protections against improper startup and shutdown — Owner(s): Design *(source IDs: 141,144)*
84. Evaluate battery backup requirements for FC/L-Gen operation — Owner(s): Design *(source IDs: 143,146,148)*
85. Define response procedures for abnormal power and fuel loss scenarios — Owner(s): Design *(source IDs: 147)*

Electrical, ESD, Instrumentation

86. Define proper labeling and identification of valves for emergency shutdown (including fire valves) — Owner(s): Design *(source IDs: 149,155)*
87. Develop SOPs and training for loss of power response and manual operation — Owner(s): SMS *(source IDs: 150)*
88. Develop SOPs for investigation and restart after abnormal shutdown — Owner(s): SMS *(source IDs: 151,152)*
89. Evaluate backup power for lighting and low-voltage systems — Owner(s): Design *(source IDs: 153)*
90. Consider loss of automation in system design and response planning — Owner(s): Design *(source IDs: 154)*
91. Develop ESD logic and architecture — Owner(s): Design, KCEC *(source IDs: 158)*
92. Develop SOPs and training for ESD maintenance, testing, and activation — Owner(s): SMS, KCEC *(source IDs: 159,162)*
93. Define fail-open/fail-close positions for all critical valves — Owner(s): Design *(source IDs: 164)*
94. Establish QA/QC protocols for ESD and valve components — Owner(s): Design, SMS *(source IDs: 161,166)*
95. Evaluate backup power for critical sensors and flame detectors — Owner(s): Design *(source IDs: 167,170)*
96. Implement sensor alarms via control system — Owner(s): Design *(source IDs: 168,171)*
97. Include sensor maintenance, calibration, and PM schedules in SOPs — Owner(s): SMS *(source IDs: 169,172,175)*
98. Identify critical instrumentation requiring redundancy or backup — Owner(s): Design *(source IDs: 173)*
99. Perform electrical classified area study for the facility — Owner(s): Design *(source IDs: 174)*

SOPs, Training, Commissioning, and QA

100. Develop SOPs for leak detection walkdowns and verification — Owner(s): SMS, KCEC *(source IDs: 177)*

101. Train personnel to identify low-level hydrogen leaks — Owner(s): SMS, KCEC *(source IDs: 178)*

102. Develop SOPs, LOTO procedures, and purge procedures for each equipment type — Owner(s): SMS *(source IDs: 180,181,118)*

103. Define PPE requirements for specific tasks and hazards — Owner(s): Design, SMS, KCEC *(source IDs: 110,182,228)*

104. Develop a pre-commissioning checklist — Owner(s): SMS *(source IDs: 183)*

105. Formalize PSSR process — Owner(s): SMS *(source IDs: 184)*

106. Conduct procedure QA/QC reviews and approval workflows — Owner(s): SMS, Design, KCEC, 3rd party *(source IDs: 185,187,188)*

107. Develop hydrogen purge plan per manufacturer guidance — Owner(s): SMS *(source IDs: 186)*

108. Utilize third-party reviews for procedures and safety systems — Owner(s): 3rd party *(source IDs: 188)*

109. Perform pre-commissioning drills and training — Owner(s): KCEC, SMS, Design *(source IDs: 189)*

110. Include post-maintenance leak checks and material verification in SOPs — Owner(s): SMS *(source IDs: 191)*

111. Ensure materials are specified, procured, stored, and inspected properly — Owner(s): Design, KCEC, KCEC Procurement *(source IDs: 107,128,192,193)*

Site, Safety, Security, and Emergency Planning

112. Ensure compliance with codes, regulations, permitting, and commissioning requirements — Owner(s): Design, KCEC *(source IDs: 195)*

113. Include internal audits in safety plans and SOPs — Owner(s): SMS *(source IDs: 196)*

114. Assess site access control, barriers, signage, and visibility — Owner(s): Design, KCEC *(source IDs: 197,201)*

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115. Evaluate site security needs and monitoring responsibilities — Owner(s): Design, SMS, KCEC *(source IDs: 198)*

116. Include vehicle safety and training in safety programs — Owner(s): SMS, KCEC *(source IDs: 199)*

117. Incorporate signage, barriers, and high-visibility features in site design — Owner(s): Design *(source IDs: 201)*

118. Coordinate training programs with local institutions and workforce partners — Owner(s): KCEC *(source IDs: 203,207,208)*

119. Identify contract and apprenticeship resource strategies — Owner(s): KCEC *(source IDs: 204,205)*

120. Define training requirements for each operational role — Owner(s): SMS, Design, KCEC *(source IDs: 209)*

121. Address severe weather scenarios in design and emergency planning — Owner(s): Design, SMS *(source IDs: 210,211)*

122. Establish redundant water supply systems and backup well power — Owner(s): Design *(source IDs: 212,215)*

123. Develop fire water systems and hydrant supply protocols — Owner(s): Design, KCEC, SMS *(source IDs: 213,214)*

124. Integrate vegetation management into inspections and maintenance — Owner(s): KCEC, SMS *(source IDs: 220,221)*

125. Ensure pressure relief design accounts for external fire scenarios — Owner(s): Design *(source IDs: 222)*

126. Define site grading and drainage strategy — Owner(s): Design *(source IDs: 223)*

127. Provide emergency response training to local first responders — Owner(s): SMS, Design, KCEC, 3rd party *(source IDs: 225)*

128. Design facilities and safeguards to address wildlife and environmental risks — Owner(s): Design *(source IDs: 227)*

129. Implement hazard recognition training and mitigation practices — Owner(s): SMS, KCEC *(source IDs: 229)*

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6.3. Appendix C: Complete HAZID Report

See attached Appendix C for the complete hazid report from PHAWorks.

6.4. Appendix D: 10% Conceptual Design Drawings used for the HAZID

See attached PFD Drawings depicting the 10% conceptual design of the hydrogen system. These drawings were used for the HAZID to define systems and for reference during the HAZID.

6.5. Appendix E: Recommendation / Action Item Tracker

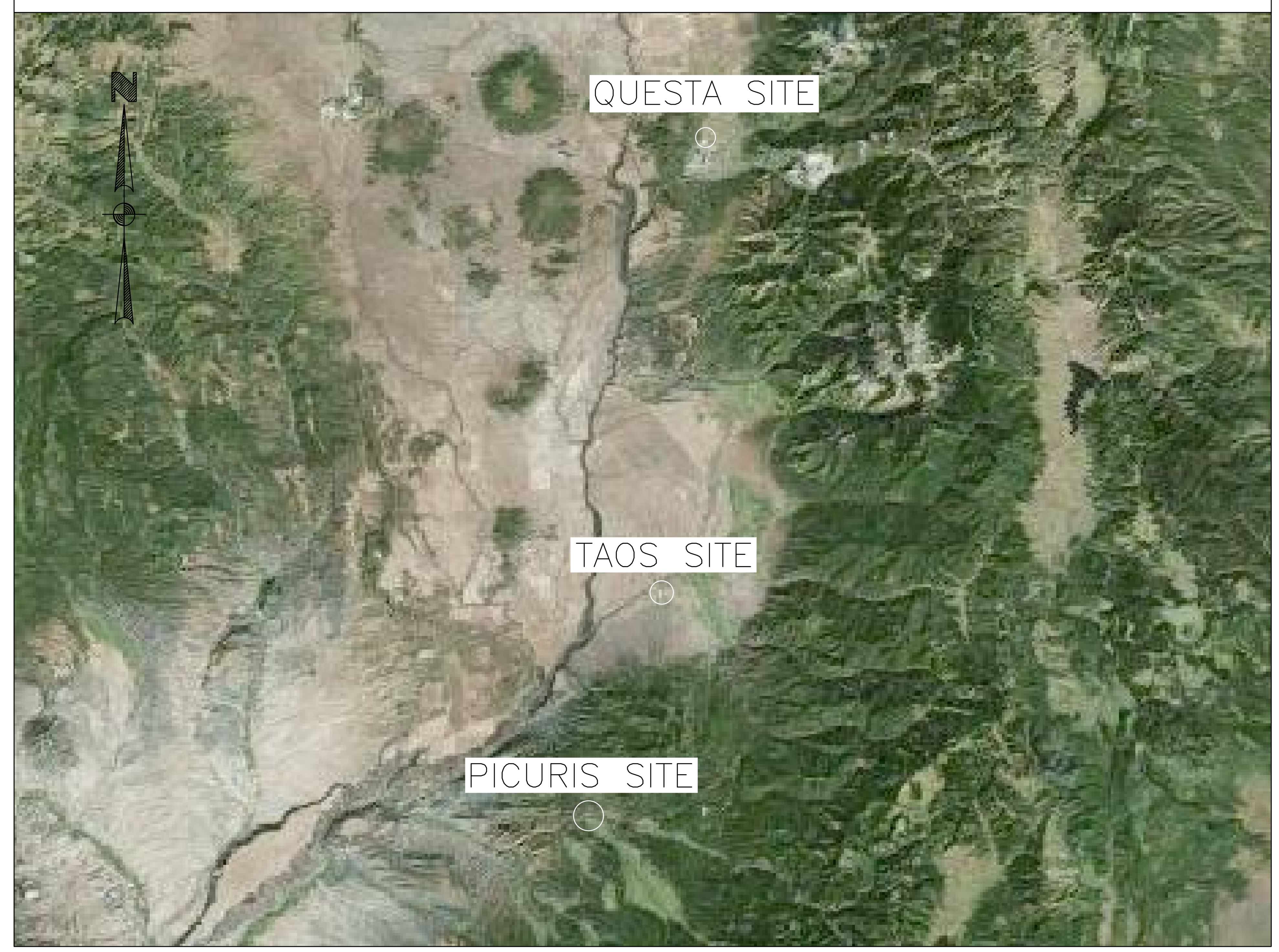
See the attached excel file used for recommendation / action tracking to ensure risk mitigation. This file may be incorporated into project planning by the ENTRUST project manager.

KIT CARSON ELECTRIC COOPERATIVE, INC.
PATHWAYS PROJECT
CONCEPTUAL ENGINEERING PACKAGE

DRAWING INDEX

No.	DESCRIPTION
H2-COVER	DRAWING INDEX AND PROJECT NOTES
Q-G-101	QUESTA PROJECT SITE
Q-G-102	QUESTA PROJECT SITE LOCATION
Q-M-103	QUESTA PROCESS FLOW DIAGRAM – SHEET 1
Q-M-104	QUESTA PROCESS FLOW DIAGRAM – SHEET 2
Q-M-105	QUESTA PROCESS FLOW DIAGRAM – SHEET 3
Q-M-106	QUESTA PROCESS FLOW DIAGRAM – SHEET 4
Q-E-107	QUESTA SINGLE LINE DIAGRAM
P-G-108	PICURIS PROJECT LOCATION
P-M-109	PICURIS PROCESS FLOW DIAGRAM – SHEET 1
P-M-110	PICURIS PROCESS FLOW DIAGRAM – SHEET 2
P-E-111	PICURIS SINGLE LINE DIAGRAM
T-G-112	TAOS PROJECT LOCATION
T-M-113	TAOS PROCESS FLOW DIAGRAM – SHEET 1
T-M-114	TAOS PROCESS FLOW DIAGRAM – SHEET 2
T-M-115	TAOS PROCESS FLOW DIAGRAM – SHEET 3
T-E-116	TAOS SINGLE LINE DIAGRAM

SITE MAP



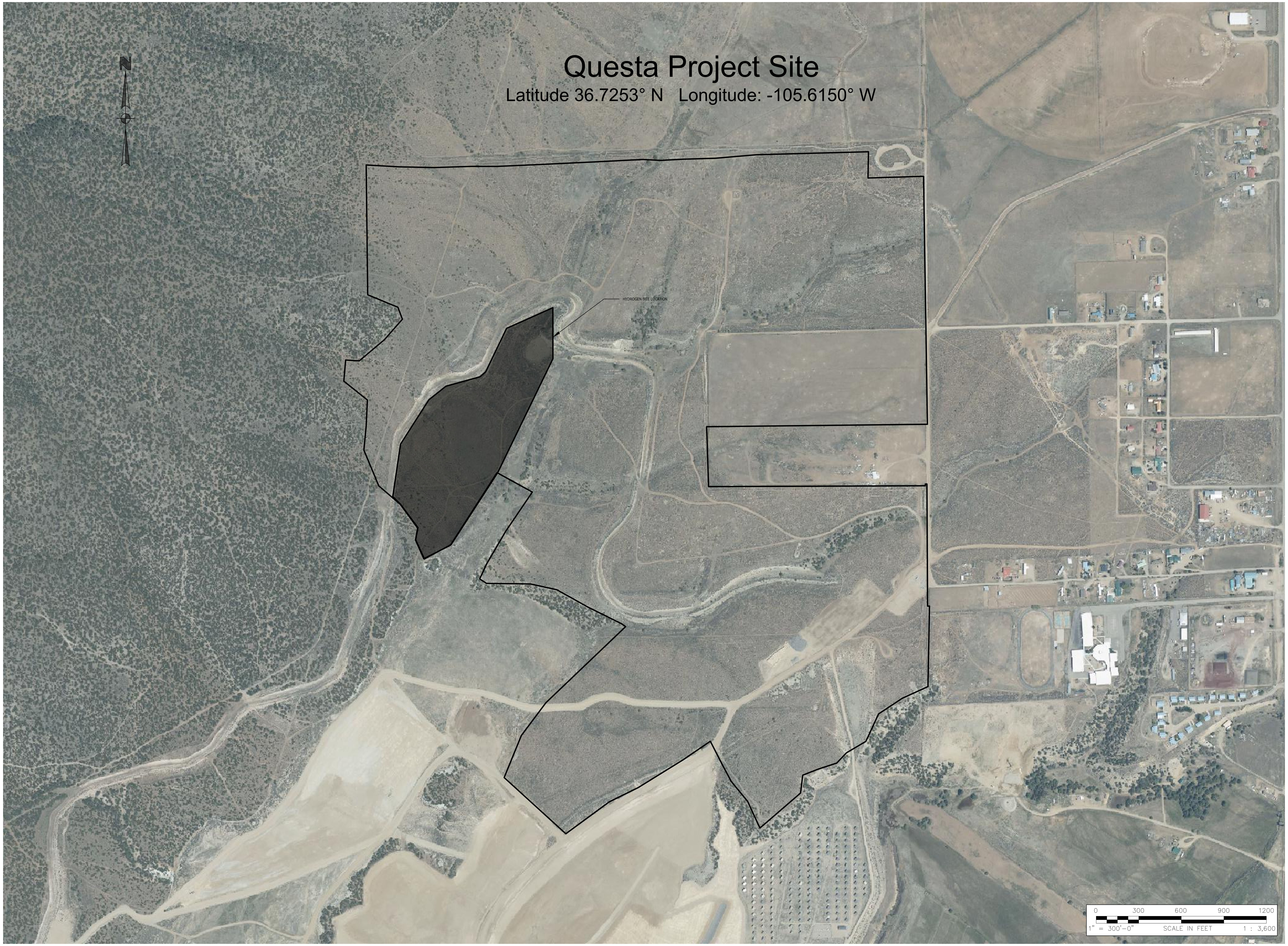
1 12/11/2025 CONCEPTUAL ENGINEERING PACKAGE

ENTRUST
SOLUTIONS GROUP
3333 WARRENVILLE RD,
SUITE 750 LISLE, IL 60532

Scale:
Date: 12/11/2025

SHEET NO.

12/11/2025 H2 – COVER.dwg



1 | 12/11/2025 | QUESTA SITE PLAN

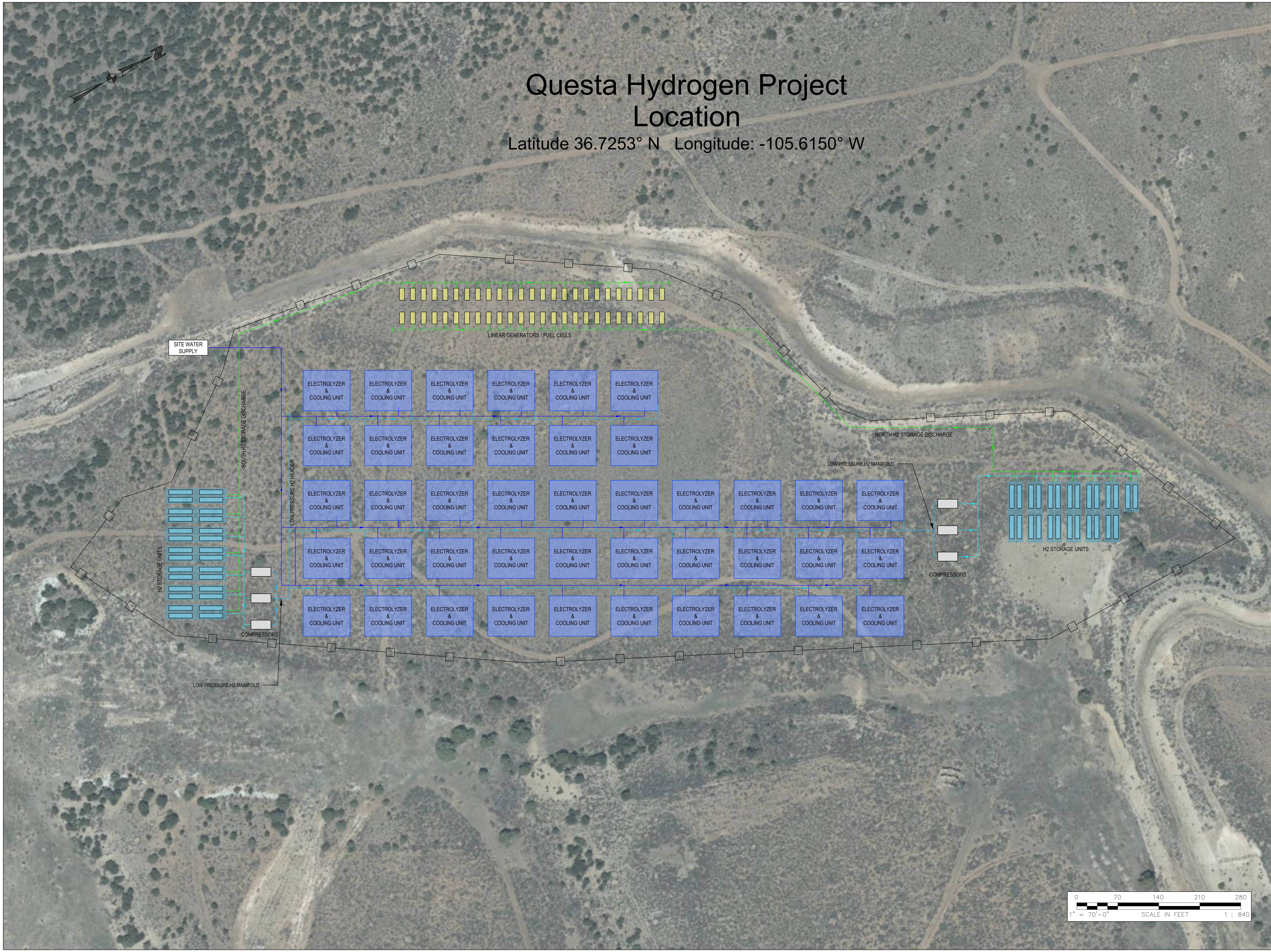
ENTRUST SOLUTIONS GROUP
3333 WARRENVILLE RD, SUITE 750 LISLE, IL 60532

QUESTA
SITE PLAN

Scale: 1" = 300'
Date: 12/11/2025

SHEET NO.
EXHIBIT Q-G-101

Q-G-101.dwg
12/11/2025



1 12/11/2025 QUESTA H2 SITE PLAN

ENTRUST SOLUTIONS GROUP
3333 WARRENVILLE RD, SUITE 750 LISLE, IL 60532

QUESTA

H2 SITE PLAN

Scale: 1" = 70'

Date: 12/11/2025

SHEET NO.

EXHIBIT Q-G-102

Q-G-102.dwg

12/11/2025

LINE IDENTIFICATION

48 – P – 001 – XY – Z

- LINE SIZE, IN.
- SERVICE CODE
- NUMERICAL SEQUENCE
- PIPING SPECIFICATION, SEE TABLE
- PRESSURE CLASS
- PIPE MATERIAL
- INSULATION CODE

SERVICE CODE

AI	AIR INTAKE	N	NITROGEN
CA	COMPRESSED AIR	NG	NATURAL GAS
D[ ]	DRAIN [NAME CHEMICAL]	P[ ]	PROCESS [M=METHONOL] PROCESS [U=UREA]
EX	ENGINE EXHAUST	PW	PRODUCED WATER
F	FLARE	R	REFRIGERATION
FG	FUEL GAS	S	STEAM
GLY	ENGINE COOLANT	SC	STEAM CONDENSATE
HC	HYDROCARBON CONDENSATE	TEG	DEHYDRATION CHEMICAL
HO, LO *	HYDRAULIC OIL & LUBE OIL	UA	UTILITY AIR
IA	INSTRUMENT AIR	V	VENT
IG	INSTRUMENT GAS		
JW,CW,W *	JACKET WATER, COOLING WATER, & WATER		

* S & R SUFFIXES MAY BE ADDED FOR SUPPLY & RETURN.

PIPING SPEC. TABLE

[X] PRESSURE CLASS	[Y] PIPE MATERIAL	[Z] INSULATION CODE
A–ANSI 150	1–CARBON STEEL	N–NONE
B–ANSI 300	2–SS304	A–ACOUSTICALLY INSULATED
C–ANSI 600	2L–SS304L	
D–ANSI 900	3–SS316	
E–ANSI 1500	3L–SS316L	
	4–LOW TEMP. C.S.	
	5–STRESS RELIEVE C.S.	
	6–316 SS TUBING	
	7–PVC	
	8–CPVC	
	9–COPPER	
	10–DUCTILE IRON	
	11–SPECIAL (E.G. PE, PLASTIC TUBING, ETC.)	

LINE SYMBOLS

- SECONDARY PROCESS PIPING & INSTRUMENT SUPPLY
- PNEUMATIC SIGNAL (SEE NOTE 1) PNEUM LTSCALE 1
- MAIN PROCESS PIPING
- ELECTRIC OR HIDDEN HIDDEN2
- CAPILLARY TUBE BLOCK: PID4
- SOFTWARE/DATA LINK FENCELINE1 LTSCALE .35
- MECHANICAL LINKAGE FENCELINE1 LTSCALE .75
- ELECTROMAGNETIC (SEE NOTE 2) BLOCK: PIPE BREAK
- HYDRAULIC SIGNAL BLOCK: PID6
- ACOUSTICALLY INSULATED PIPING
- ELECTRIC HEAT TRACED W/INSULATION
- INSULATION FOR PERSONNEL PROTECTION ONLY
- VENDOR PACKAGE SKID BOUNDARY P_LINE LTSCALE 1

NOTES:

1. THE PNEUMATIC SIGNAL SYMBOL APPLIES TO A SIGNAL USING ANY GAS AS A SIGNAL MEDIUM.
2. ELECTROMAGNETIC SIGNALS INCLUDE HEAT, RADIO WAVES, NUCLEAR RADIATION AND LIGHT.
3. ALL SYMBOLS ON THIS DRAWING ARE LAID OUT WITH AN ASSUMED PROCESS FLOW FROM LEFT TO RIGHT.
4. ALL BALL VALVES IN GAS SERVICE 2"ø AND GREATER SHALL BE FURNISHED WITH DBB PORT AND MANUAL VENT VALVE. BURIED VALVE TO HAVE VENT LINE EXTENDED ABOVE GRADE AND TERMINATED BY CONTRACTOR SUPPLIED MANUAL VALVE AND PLUG.

P&ID LINE SYMBOLS

- TEXT — LINE TERMINATION BOX
- XXXXX — OFF PAGE ARROW
- XXXXX — OFF PAGE ARROW–BI
- EQUIPMENT INSULATION
- PIPING INSULATION
- XXX / XXX — SPEC CHANGE
- AG / BG — GRADE CHANGE
- PIPE BREAK
- BLIND FLANGE
- SPECTACLE BLIND (* NO OR NC)
- CONCENTRIC REDUCER
- ECCENTRIC REDUCER
- SCREWED PIPE CAP
- PIPE WELD CAP
- PIPE PLUG
- DRAIN TO SEWER
- DRAIN TO GRADE
- VENT
- ELECTRICAL INSULATION POINT
- HOSE ADAPTER
- QUICK CONNECT
- FLEXIBLE HOSE
- EXPANSION JOINT
- CHEMICAL SEAL
- PIPING TIE IN
- VENDOR PACKAGE INTERFACE
- UNION
- SPACER RING
- THIEF HATCH OR FLAPPER
- RAIN CAP
- CHOKE NIPPLE
- MONOLITHIC INSULATING JOINT

VALVE SYMBOLS

ABBREVIATIONS

NO	NORMALLY OPEN	FL	FAIL LAST
NC	NORMALLY CLOSE	FAIL	FAIL IN DIRECTION SHOWN
LO	LOCK/WIRE OPEN	FO	FAIL OPEN
LC	LOCK/WIRE CLOSE	FC	FAIL CLOSE
EO	EMERGENCY OPEN	EC	EMERGENCY CLOSE

- GATE (NORMALLY OPEN)
- GATE (NORMALLY CLOSED)
- THREE WAY
- ANGLE
- BALL
- GLOBE
- PLUG
- CHECK
- BUTTERFLY
- NEEDLE
- BLEED VALVE
- BLOCK & BLEED
- HIGH–SELECT VALVE
- 2–VALVE MANIFOLD MV–1001
- 3–VALVE MANIFOLD MV–1002
- 5–VALVE MANIFOLD MV–1003
- EXCESS FLOW
- DIAPHRAGM, BOOT OR FLEX. PLUG TYPE VALVES
- KNIFE GATE
- RAM TYPE SAMPLE
- FLUSH BOTTOM
- CHAIN OPERATED (BUTTERFLY)
- FLOAT OPERATOR (GATE)
- EH — ELECTROHYDRAULIC (BALL VALVE)
- S — SOLENOID OPERATED (GLOBE VALVE)
- PILOT–OPERATED PRESSURE RELIEF VALVE
- GAS/HYDRAULIC OPERATOR (BALL)
- NO — PISTON OPERATOR DOUBLE ACTING (GATE)
- NO — PISTON OPERATOR W/ SPRG. RETURN (GATE)
- NO — POSITIONER (PISTON OPERATED CONTROL VALVE)
- NO — DIAPHRAGM OPERATOR (GATE)
- S — SOLENOID ACTUATED VALVE (3–WAY)
- M NO — MOTOR OPERATOR (GATE)
- PRESSURE REDUCING REGULATOR (SELF CONTAINED)
- PRESSURE REGULATOR WITH EXT.PRESSURE TAP
- BACK PRESSURE REGULATOR (SELF CONTAINED)
- MANUAL SET REGULATOR
- AIR SET WITH FILTER REGULATOR AND PI
- RUPTURE DISK
- VACUUM RUPTURE DISK
- SPRING PRESSURE RELIEF VALVE
- INSTRUMENT HANDWHEEL
- CHOKE VALVE (CHV)
- VACUUM BREAKER
- RELIEF OR SAFETY VALVE, ANGLE TYPE

COMMODITY VALVES:

"HIGHER" PRESSURE SEAL SE BALL VALVES:
- BV–1001 ½"
- BV–1002 ¾"
- BV–1003 1"
- BV–1004 1½"

"LOWER" PRESSURE SEAL SE BALL VALVES:
- BV–1005 ½"
- BV–1006 ¾"
- BV–1007 1"
- BV–1008 1½"

- CHV–1001 ½"
- CHV–1002 ¾", NEEDLE VALVE
- GV–1001–½"
- GV–1002–¾"
- BBV–1001 ½" BLOCK AND BLEED VALVE
- BBV–1002 ¾"x ½", BLOCK AND BLEED VALVE

INSTRUMENT SYMBOLS

- FIELD MOUNTED
- MULTI–FUNCTION (FIELD MTD)
- PRIMARY PANEL MOUNTED FRONT
- LOCAL PANEL, FRONT
- PRIMARY PANEL MOUNTED REAR
- LOCAL PANEL, REAR
- FUNCTION / TAG NO. — TYPICAL INSTRUMENT NUMBERING * OPTIONAL INST. SUPPLIER VENDOR NAME OR "E" FOR EXISTING INSTRUMENTATION
- INTERLOCK LOGIC (HARDWIRED)
- PI — PRESSURE INDICATOR WITH CAPPILARY SEAL
- PI — PRESSURE INDICATOR WITH DIAPHRAGM SEAL
- PI — PRESSURE INDICATOR WITH PIGTAIL
- INSERTION PROBE
- LOAD CELL (WEIGHT)
- THERMAL FLOW SWITCH
- AREA / FURN — TEMPERATURE ELEMENT IN WELL (RTD OR THERMOCPL.)
- INDUSTRIAL TYPE THERMOMETER
- CAPILLARY BULB (TI)
- THERMOWELL (PLUGGED)
- LOCAL HORN
- R — LOCAL PILOT LIGHT/STROBE * R = OFF OR CLOSED, Y = STANDBY, G = ON OR OPEN
- CCTV
- PYROMETER
- LT — INTERNAL FLOAT (LEVEL TRANSMITTER)
- LT — INTERNAL DISPLACER (LEVEL TRANSMITTER)
- LS — EXTERNAL CAGE FLOAT OR DP CELL (LEVEL SWITCH)
- LT — EXTERNAL CAGE DISPLACER (LEVEL TRANSMITTER)
- CC — CORROSION COUPON

FLOW ELEMENTS (PRIMARY METERS)

- ROTAMETER
- ROTAMETER WITH INTEGRAL VALVE
- ULTRASONIC
- MASS FLOW
- M — MAGNETIC FLOW
- POSITIVE DISPLACEMENT
- PITOT TUBE–AVERAGING
- PITOT TUBE–SINGLE
- CORIOLIS
- TURBINE
- VORTEX
- ORIFICE PLATE
- NOZZLE
- TARGET FLOW METER
- SIGHT FLOW INDICATOR
- FLOW RESTRICTOR

PROCESS CONTROL SYMBOLS

COMPUTER FUNCTION

- COMPUTER FUNCTION POINT INVISIBLE TO OPERATOR
- COMPUTER FUNCTION POINT VISIBLE TO OPERATOR
- COMPUTER FUNCTION AUXILIARY PANEL OR PANEL FURNISHED WITH EQUIPMENT
- I — COMPUTER FUNCTION SOFTWARE INTERLOCK

LOGIC AND SEQUENTIAL CONTROL SYMBOLS

- R — MANUAL RESET FOR LATCH–TYPE ACT. (NO VOLTAGE RELEASE)
- R — RESET FOR LATCH–TYPE ACT. (W/REMOTE RELEASE)

PROGRAMMABLE LOGIC CONTROLLER

- PROGRAMMABLE LOGIC CNTRL POINT INVISIBLE TO OPERATOR
- PROGRAMMABLE LOGIC CNTRL POINT VISIBLE TO OPERATOR
- PROGRAMMABLE LOGIC CNTRL AUXILIARY PANEL OR PANEL FURNISHED WITH EQUIPMENT
- PROGRAMMABLE LOGIC CNTRL SOFTWARE INTERLOCK
- SAFETY PLC SOFTWARE INTERLOCK
- HARD–WIRED SAFETY INTERLOCK

EQUIPMENT

- FLANGED NOZZLE
- HEAT EXCHANGER
- JACKETED VESSEL
- M — CENTRIFUGAL PUMP (W/ INDUCTION MOTOR)
- PNEUMATIC DIAPHRAGM PUMP
- IND * M — POSITIVE DISPLACEMENT PUMP (W/ INDUCTION MOTOR)
- M — DIAPHRAGM METERING PUMP
- BLOWER (UNDESIGNATED DRIVE)
- SYN. * M — ELECTRIC MOTOR (* SYN. OR IND.)
- VAPOR DAMPER FENCEX48 LTSCALE: .0025
- XXXXXX — FLOW DISTRIBUTION BAFFLE SCREEN (FDBS) FENCEX48 LTSCALE: .0025
- IN–LINE MIXER
- IN–LINE FILTER
- T — STEAM TRAP
- F — FLAME ARRESTOR
- D — DETONATION ARRESTOR
- IN–LINE STRAINER (STRT–TEMP., STRP–PERM.)
- "Y" STRAINER
- "Y" STRAINER WITH BLOCK
- TWIN FILTERS
- LINE SEPARATOR, FILTER, OR STRAINER
- V — VARIABLE SPEED MOTOR
- HYD — HYDRAULIC DRIVE
- INTERNAL PACKING (FOR ABSORBER)
- LIQUID VANE

Q–M–103.dwg

12/11/2025

QUESTA PFD

12/11/2025

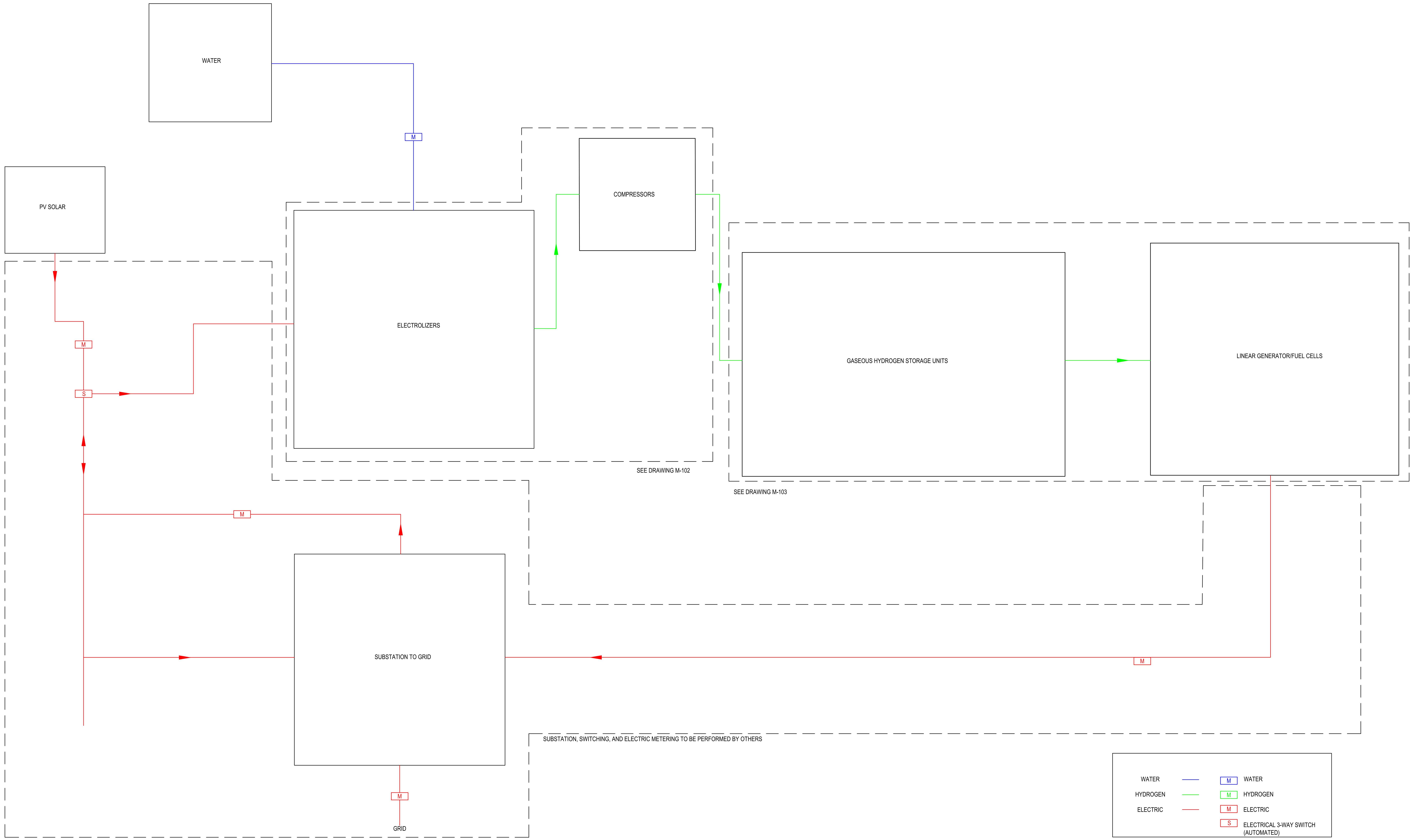
ENTRUST SOLUTIONS GROUP
3333 WARRENVILLE RD, SUITE 750 LISLE, IL 60532

STANDARD NOMENCLATURE FOR PIPING & INSTRUMENTATION DIAGRAMS

DRAWING NO. Q-M-103

Scale: 1" = 60'
Date: 12/11/2025

SHEET NO. 1



QUESTA PFD

12/11/2025

ENTRUST SOLUTIONS GROUP
3333 WARRENVILLE RD, SUITE 750 LISLE, IL 60532

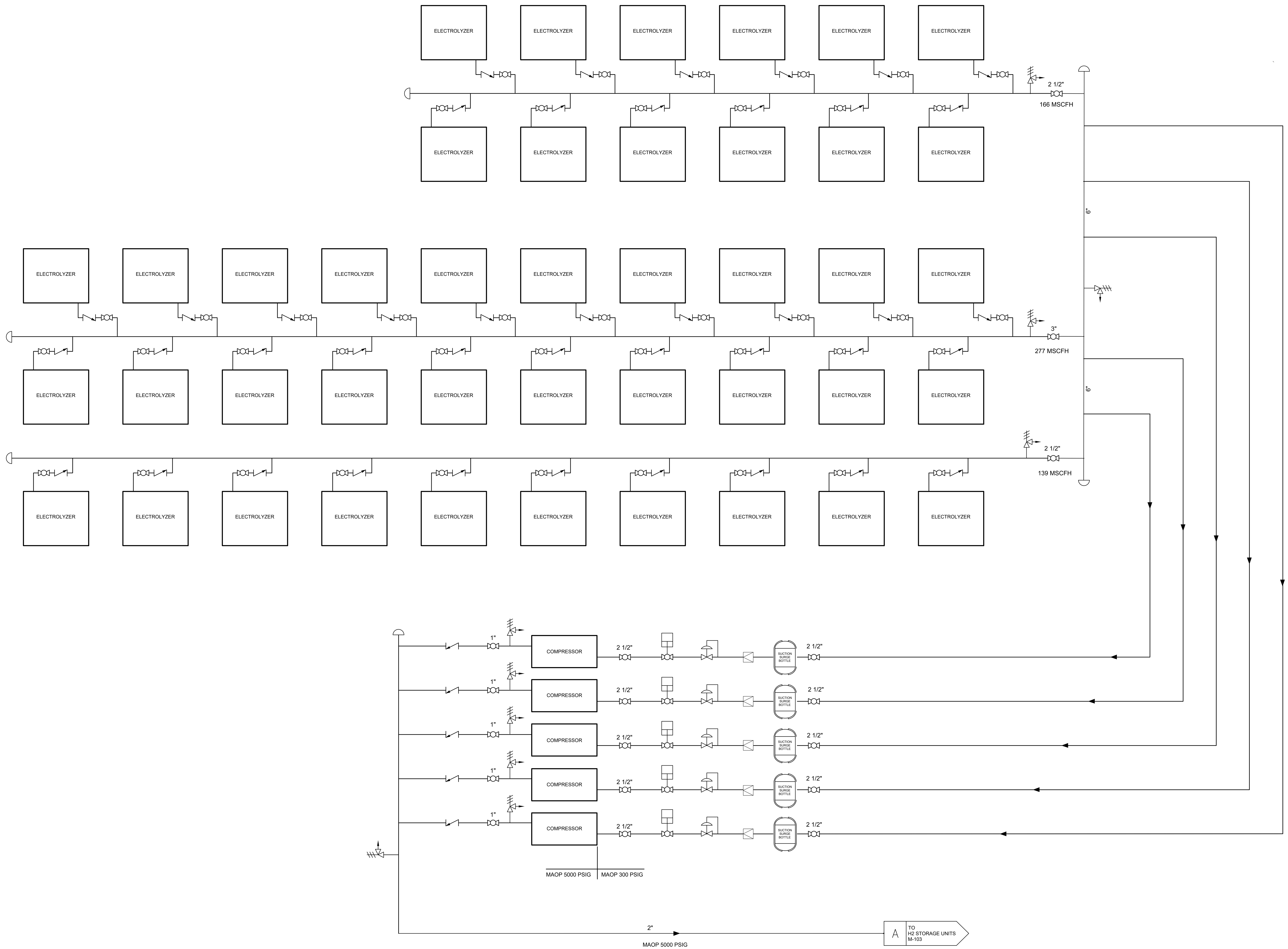
PROCESS FLOW DIAGRAM (PFD)
OVERVIEW

DRAWING NO.
Q-M-104

Scale: 1" = 60'
Date: 12/11/2025

SHEET NO.
2

Q-M-104.dwg
12/11/2025



QUESTA PFD
12/11/2025

ENTRUST SOLUTIONS GROUP
3333 WARRENVILLE RD, SUITE 750 LISLE, IL 60532

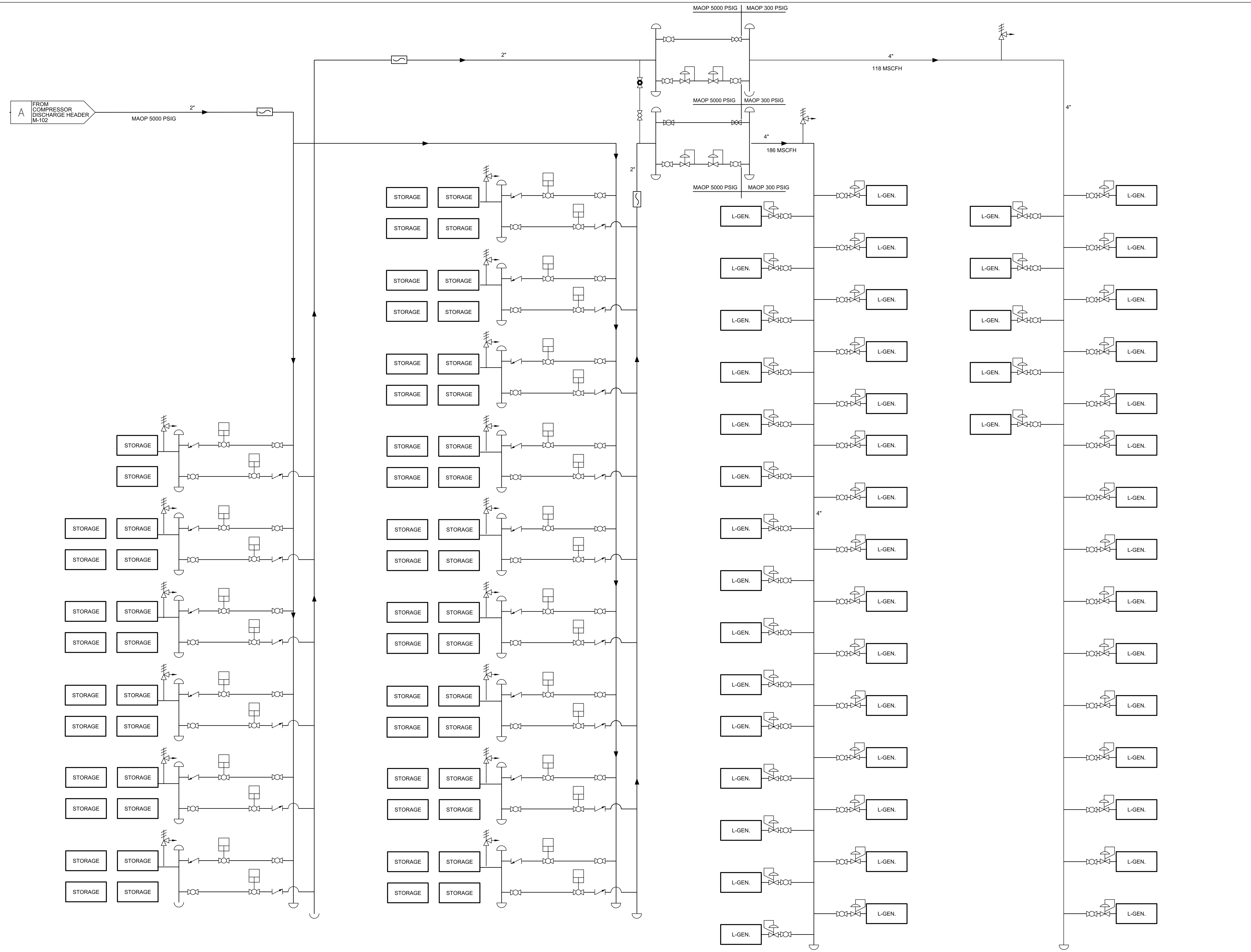
PROCESS FLOW DIAGRAM (PFD)
ELECTROLIZERS AND COMPRESSORS

DRAWING NO.
Q-M-105

Scale: 1" = 60'
Date: 12/11/2025

SHEET NO.
3

Q-M-105.dwg
12/11/2025



QUESTA PFD

12/11/2025

ENTRUST
SOLUTIONS GROUP

3333 WARRENVILLE RD,
SUITE 750 LISLE, IL 60532

PROCESS FLOW DIAGRAM (PFD)

STORAGE AND GENERATORS

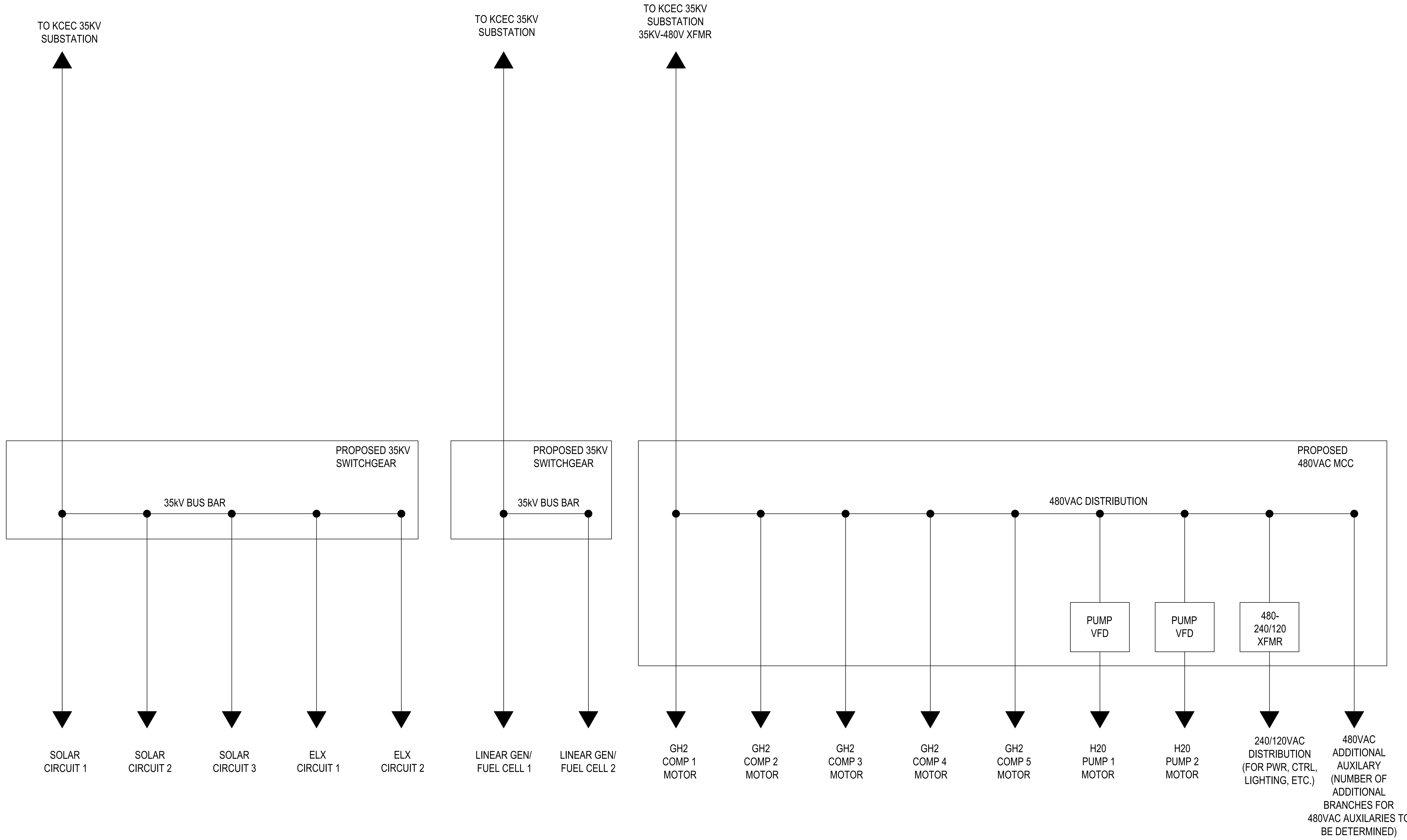
DRAWING NO.
Q-M-106

Scale: 1" = 60'
Date: 12/11/2025

SHEET NO.
4

Q-M-106.dwg

12/11/2025



QUESTA SINGLE LINE DIAGRAM 12/11/2025

ENTRUST
SOLUTIONS GROUP
3333 WARRENVILLE RD,
SUITE 750 LISLE, IL 60532

KIT CARSON HYDROGEN STORAGE
AND POWER GENERATION -
QUESTA SITE

SINGLE LINE DIAGRAM

DRAWING NO.
Q-E-107

Scale: 1" = 60'
Date: 12/11/2025

SHEET NO.
Q-E-107

Q-E-107.dwg
12/11/2025

P-G-108.dwg

12/11/2025

PICURIS H2 SITE PLAN

1 12/11/2025

ENTRUST
SOLUTIONS GROUP
3333 WARRENVILLE RD,
SUITE 750 LISLE, IL 60532

PICURIS

SITE PLAN

Scale: 1" = 50'

Date: 12/11/2025

SHEET NO.

EXHIBIT
P-G-108

LINE IDENTIFICATION

48 – P – 001 – XY – Z

- LINE SIZE, IN.
- SERVICE CODE
- NUMERICAL SEQUENCE
- PIPING SPECIFICATION, SEE TABLE
- INSULATION CODE
- PRESSURE CLASS
- PIPE MATERIAL

SERVICE CODE

AI	AIR INTAKE	N	NITROGEN
CA	COMPRESSED AIR	NG	NATURAL GAS
D[ ]	DRAIN [NAME CHEMICAL]	P[ ]	PROCESS [M=METHONOL] PROCESS [U=UREA]
EX	ENGINE EXHAUST		
F	FLARE	PW	PRODUCED WATER
FG	FUEL GAS	R	REFRIGERATION
GLY	ENGINE COOLANT	S	STEAM
HC	HYDROCARBON CONDENSATE	SC	STEAM CONDENSATE
HO, LO *	HYDRAULIC OIL & LUBE OIL	TEG	DEHYDRATION CHEMICAL
IA	INSTRUMENT AIR	UA	UTILITY AIR
IG	INSTRUMENT GAS	V	VENT
JW,CW,W *	JACKET WATER, COOLING WATER, & WATER		

* S & R SUFFIXES MAY BE ADDED FOR SUPPLY & RETURN.

PIPING SPEC. TABLE

[X] PRESSURE CLASS	[Y] PIPE MATERIAL	[Z] INSULATION CODE
A–ANSI 150	1–CARBON STEEL	N–NONE
B–ANSI 300	2–SS304	A–ACOUSTICALLY INSULATED
C–ANSI 600	2L–SS304L	
D–ANSI 900	3–SS316	
E–ANSI 1500	3L–SS316L	
	4–LOW TEMP. C.S.	
	5–STRESS RELIEVE C.S.	
	6–316 SS TUBING	
	7–PVC	
	8–CPVC	
	9–COPPER	
	10–DUCTILE IRON	
	11–SPECIAL (E.G. PE, PLASTIC TUBING, ETC.)	

LINE SYMBOLS

- SECONDARY PROCESS PIPING & INSTRUMENT SUPPLY
- PNEUMATIC SIGNAL (SEE NOTE 1) PNEUM LTSCALE 1
- MAIN PROCESS PIPING
- ELECTRIC OR HIDDEN HIDDEN2
- CAPILLARY TUBE BLOCK: PID4
- SOFTWARE/DATA LINK FENCELINE1 LTSCALE .35
- MECHANICAL LINKAGE FENCELINE1 LTSCALE .75
- ELECTROMAGNETIC (SEE NOTE 2) BLOCK: PIPE BREAK
- HYDRAULIC SIGNAL BLOCK: PID6
- ACOUSTICALLY INSULATED PIPING
- ELECTRIC HEAT TRACED W/INSULATION (E)
- INSULATION FOR PERSONNEL PROTECTION ONLY (PPO)
- VENDOR PACKAGE SKID BOUNDARY P_LINE LTSCALE 1

NOTES:

1. THE PNEUMATIC SIGNAL SYMBOL APPLIES TO A SIGNAL USING ANY GAS AS A SIGNAL MEDIUM.
2. ELECTROMAGNETIC SIGNALS INCLUDE HEAT, RADIO WAVES, NUCLEAR RADIATION AND LIGHT.
3. ALL SYMBOLS ON THIS DRAWING ARE LAID OUT WITH AN ASSUMED PROCESS FLOW FROM LEFT TO RIGHT.
4. ALL BALL VALVES IN GAS SERVICE 2"ø AND GREATER SHALL BE FURNISHED WITH DBB PORT AND MANUAL VENT VALVE. BURIED VALVE TO HAVE VENT LINE EXTENDED ABOVE GRADE AND TERMINATED BY CONTRACTOR SUPPLIED MANUAL VALVE AND PLUG.

P&ID LINE SYMBOLS

- TEXT — LINE TERMINATION BOX
- XXXXX — OFF PAGE ARROW
- XXXXX — OFF PAGE ARROW–BI
- EQUIPMENT INSULATION
- PIPING INSULATION
- XXX / XXX — SPEC CHANGE
- AG / BG — GRADE CHANGE
- PIPE BREAK
- BLIND FLANGE
- SPECTACLE BLIND (* NO OR NC)
- CONCENTRIC REDUCER
- ECCENTRIC REDUCER
- SCREWED PIPE CAP
- PIPE WELD CAP
- PIPE PLUG
- DRAIN TO SEWER
- DRAIN TO GRADE
- VENT
- ELECTRICAL INSULATION POINT
- HOSE ADAPTER
- QUICK CONNECT
- FLEXIBLE HOSE
- EXPANSION JOINT
- CHEMICAL SEAL
- PIPING TIE IN
- VENDOR PACKAGE INTERFACE
- UNION
- SPACER RING (SP XX)
- THIEF HATCH OR FLAPPER
- RAIN CAP
- CHOKE NIPPLE
- MONOLITHIC INSULATING JOINT

VALVE SYMBOLS

✳ ABBREVIATIONS

NO	NORMALLY OPEN	FL	FAIL LAST
NC	NORMALLY CLOSE	FAIL	FAIL IN DIRECTION SHOWN
LO	LOCK/WIRE OPEN	FO	FAIL OPEN
LC	LOCK/WIRE CLOSE	FC	FAIL CLOSE
EO	EMERGENCY OPEN	EC	EMERGENCY CLOSE

- GATE (NORMALLY OPEN)
- GATE (NORMALLY CLOSED)
- THREE WAY
- ANGLE
- BALL
- GLOBE
- PLUG
- CHECK
- BUTTERFLY
- NEEDLE
- BLEED VALVE
- BLOCK & BLEED
- HIGH–SELECT VALVE
- 2–VALVE MANIFOLD MV–1001
- 3–VALVE MANIFOLD MV–1002
- 5–VALVE MANIFOLD MV–1003
- EXCESS FLOW
- DIAPHRAGM, BOOT OR FLEX. PLUG TYPE VALVES
- KNIFE GATE
- RAM TYPE SAMPLE
- FLUSH BOTTOM
- CHAIN OPERATED (BUTTERFLY)
- FLOAT OPERATOR (GATE)
- ELECTROHYDRAULIC (BALL VALVE) (EH)
- SOLENOID OPERATED (GLOBE VALVE) (S)
- PILOT–OPERATED PRESSURE RELIEF VALVE
- GAS/HYDRAULIC OPERATOR (BALL)
- PISTON OPERATOR DOUBLE ACTING (GATE) (NO)
- PISTON OPERATOR W/ SPRG. RETURN (GATE) (NO)
- POSITIONER (PISTON OPERATED CONTROL VALVE) (NO)
- DIAPHRAGM OPERATOR (GATE) (NO)
- SOLENOID ACTUATED VALVE (3–WAY) (S)
- MOTOR OPERATOR (GATE) (M, NO)
- PRESSURE REDUCING REGULATOR (SELF CONTAINED)
- PRESSURE REGULATOR WITH EXT.PRESSURE TAP
- BACK PRESSURE REGULATOR (SELF CONTAINED)
- MANUAL SET REGULATOR
- AIR SET WITH FILTER REGULATOR AND PI
- RUPTURE DISK
- VACUUM RUPTURE DISK
- SPRING PRESSURE RELIEF VALVE
- INSTRUMENT HANDWHEEL
- CHOKE VALVE (CHV)
- VACUUM BREAKER
- RELIEF OR SAFETY VALVE, ANGLE TYPE

COMMODITY VALVES:

"HIGHER" PRESSURE SEAL SE BALL VALVES { BV–1001 ½", BV–1002 ¾", BV–1003 1", BV–1004 1½"

"LOWER" PRESSURE SEAL SE BALL VALVES { BV–1005 ½", BV–1006 ¾", BV–1007 1", BV–1008 1½"

CHV–1001 ½"
CHV–1002 ¾", NEEDLE VALVE
GV–1001–½"
GV–1002–¾"
BBV–1001 ½" BLOCK AND BLEED VALVE
BBV–1002 ¾"x ½", BLOCK AND BLEED VALVE

INSTRUMENT SYMBOLS

- FIELD MOUNTED
- MULTI–FUNCTION (FIELD MTD)
- PRIMARY PANEL MOUNTED FRONT
- LOCAL PANEL, FRONT
- PRIMARY PANEL MOUNTED REAR
- LOCAL PANEL, REAR
- FUNCTION / TAG NO. — TYPICAL INSTRUMENT NUMBERING ✳ OPTIONAL INST. SUPPLIER VENDOR NAME OR "E" FOR EXISTING INSTRUMENTATION
- INTERLOCK LOGIC (HARDWIRED)
- PRESSURE INDICATOR WITH CAPPILARY SEAL (PI)
- PRESSURE INDICATOR WITH DIAPHRAGM SEAL (PI)
- PRESSURE INDICATOR WITH PIGTAIL (PI)
- INSERTION PROBE
- LOAD CELL (WEIGHT)
- THERMAL FLOW SWITCH
- AREA / FURN — TEMPERATURE ELEMENT IN WELL (RTD OR THERMOCPL.)
- INDUSTRIAL TYPE THERMOMETER
- CAPILLARY BULB (TI)
- THERMOWELL (PLUGGED)
- LOCAL HORN
- LOCAL PILOT LIGHT/STROBE ✳ R = OFF OR CLOSED, Y = STANDBY, G = ON OR OPEN
- CCTV
- PYROMETER
- INTERNAL FLOAT (LEVEL TRANSMITTER) (LT)
- INTERNAL DISPLACER (LEVEL TRANSMITTER) (LT)
- EXTERNAL CAGE FLOAT OR DP CELL (LEVEL SWITCH) (LS)
- EXTERNAL CAGE DISPLACER (LEVEL TRANSMITTER) (LT)
- CORROSION COUPON (CC)

FLOW ELEMENTS (PRIMARY METERS)

- ROTAMETER
- ROTAMETER WITH INTEGRAL VALVE
- ULTRASONIC
- MASS FLOW
- MAGNETIC FLOW (M)
- POSITIVE DISPLACEMENT
- PITOT TUBE–AVERAGING
- PITOT TUBE–SINGLE
- CORIOLIS
- TURBINE
- VORTEX
- ORIFICE PLATE
- NOZZLE
- TARGET FLOW METER
- SIGHT FLOW INDICATOR
- FLOW RESTRICTOR

PROCESS CONTROL SYMBOLS

COMPUTER FUNCTION

- COMPUTER FUNCTION POINT INVISIBLE TO OPERATOR
- COMPUTER FUNCTION POINT VISIBLE TO OPERATOR
- COMPUTER FUNCTION AUXILIARY PANEL OR PANEL FURNISHED WITH EQUIPMENT
- COMPUTER FUNCTION SOFTWARE INTERLOCK

LOGIC AND SEQUENTIAL CONTROL SYMBOLS

- MANUAL RESET FOR LATCH–TYPE ACT. (NO VOLTAGE RELEASE)
- RESET FOR LATCH–TYPE ACT. (W/REMOTE RELEASE)

PROGRAMMABLE LOGIC CONTROLLER

- PROGRAMMABLE LOGIC CNTRL POINT INVISIBLE TO OPERATOR
- PROGRAMMABLE LOGIC CNTRL POINT VISIBLE TO OPERATOR
- PROGRAMMABLE LOGIC CNTRL AUXILIARY PANEL OR PANEL FURNISHED WITH EQUIPMENT
- PROGRAMMABLE LOGIC CNTRL SOFTWARE INTERLOCK
- SAFETY PLC SOFTWARE INTERLOCK
- HARD–WIRED SAFETY INTERLOCK

EQUIPMENT

- FLANGED NOZZLE
- HEAT EXCHANGER
- JACKETED VESSEL
- CENTRIFUGAL PUMP (W/ INDUCTION MOTOR)
- PNEUMATIC DIAPHRAGM PUMP
- IND * — POSITIVE DISPLACEMENT PUMP (W/ INDUCTION MOTOR)
- DIAPHRAGM METERING PUMP
- BLOWER (UNDESIGNATED DRIVE)
- SYN. * — ELECTRIC MOTOR (* SYN. OR IND.)
- VAPOR DAMPER FENCEX48 LTSCALE: .0025
- XXXXXX — FLOW DISTRIBUTION BAFFLE SCREEN (FDBS) FENCEX48 LTSCALE: .0025
- IN–LINE MIXER
- IN–LINE FILTER
- STEAM TRAP (T)
- FLAME ARRESTOR (F)
- DETONATION ARRESTOR (D)
- IN–LINE STRAINER (STRT–TEMP., STRP–PERM.)
- "Y" STRAINER
- "Y" STRAINER WITH BLOCK
- TWIN FILTERS
- LINE SEPARATOR, FILTER, OR STRAINER
- VARIABLE SPEED MOTOR (V)
- HYDRAULIC DRIVE (HYD)
- INTERNAL PACKING (FOR ABSORBER)
- LIQUID VANE

PICURIS PFD — 12/11/2025

ENTRUST SOLUTIONS GROUP
3333 WARRENVILLE RD, SUITE 750 LISLE, IL 60532

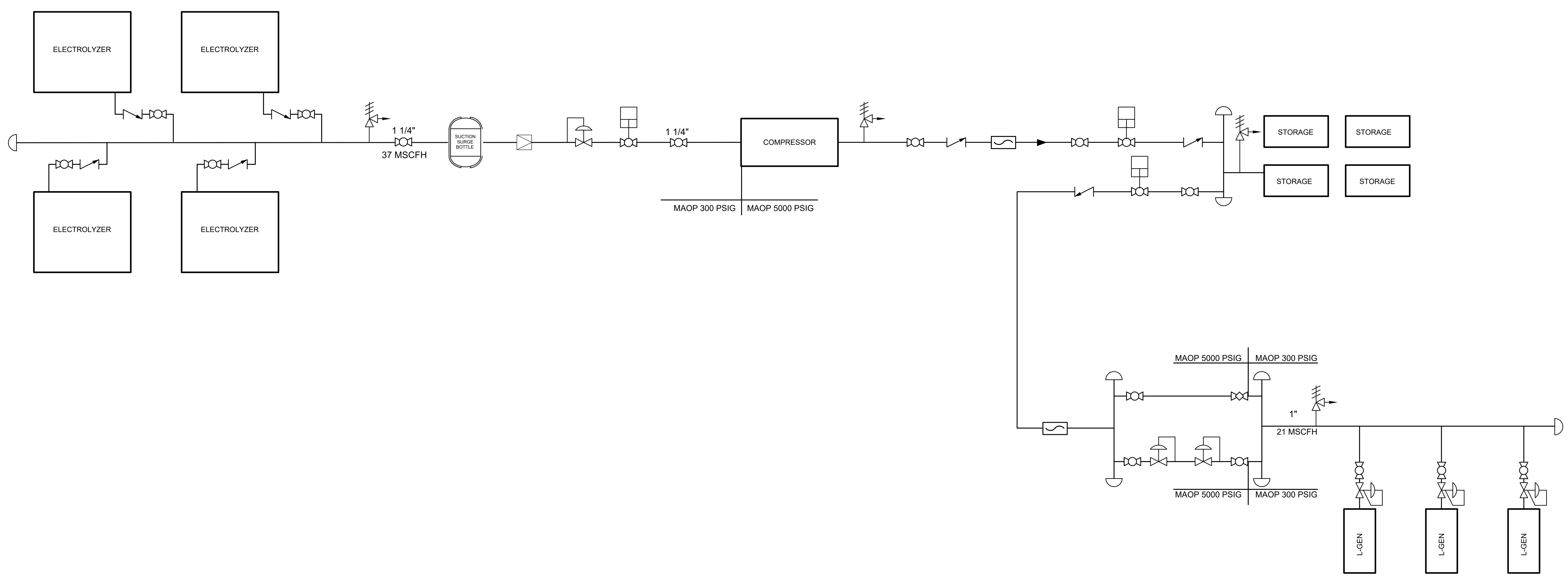
STANDARD NOMENCLATURE FOR PIPING & INSTRUMENTATION DIAGRAMS

DRAWING NO. P-M-109

Scale: 1" = 60'
Date: 12/11/2025

SHEET NO. 1

P–M–109.dwg
12/11/2025



PICURIS PFD
12/11/2025

ENTRUST SOLUTIONS GROUP
3333 WARRENVILLE RD, SUITE 750 LISLE, IL 60532

KIT CARSON HYDROGEN STORAGE AND POWER GENERATION - PICURIS SITE

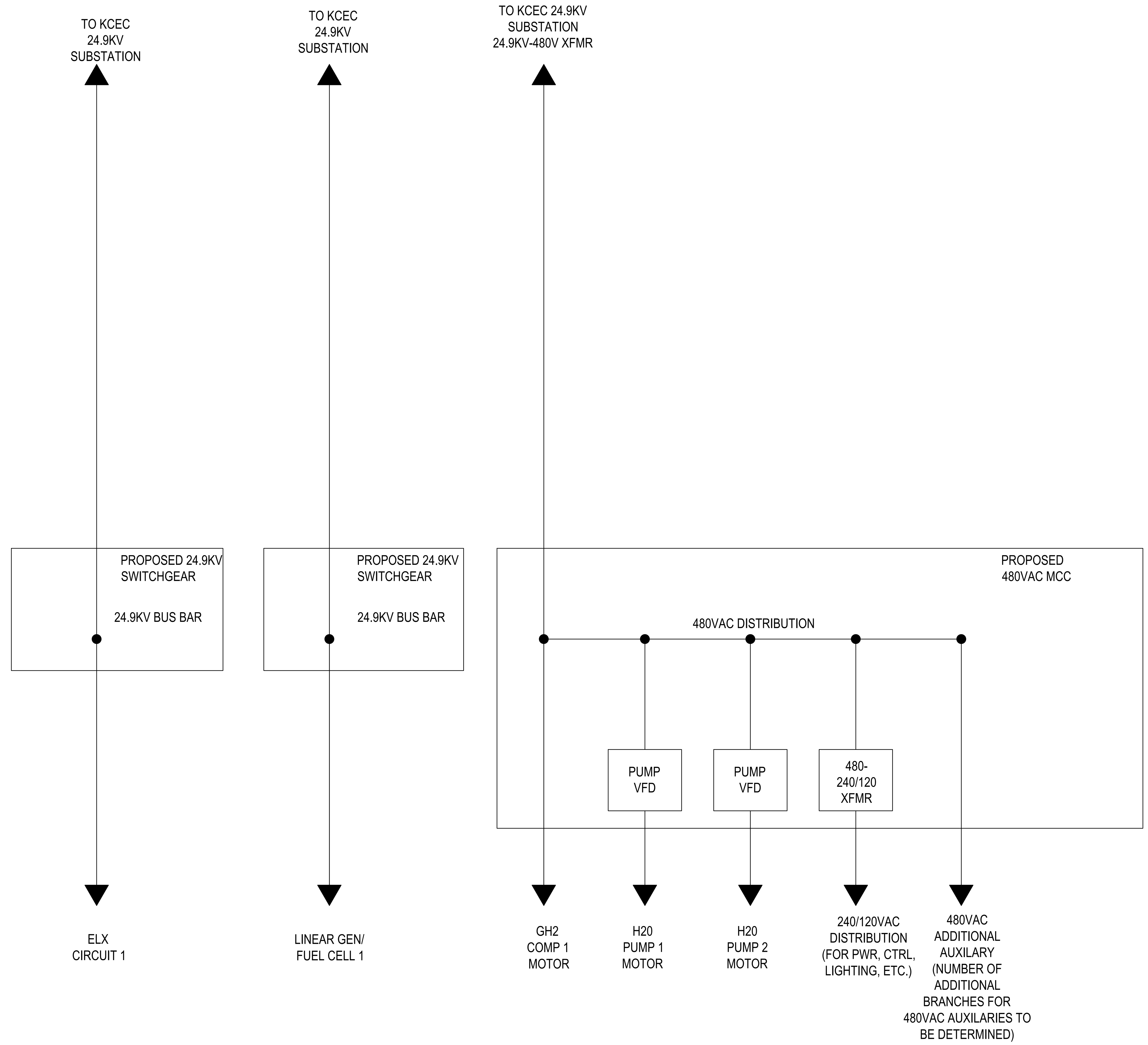
PROCESS FLOW DIAGRAM (PFD)

DRAWING NO.
P-M-110

Scale: 1" = 60'
Date: 12/11/2025

SHEET NO.
2

12/11/2025 P-M-110.dwg



12/11/2025 PICURIS SINGLE LINE DIAGRAM

ENTRUST
SOLUTIONS GROUP
3333 WARRENVILLE RD,
SUITE 750 LISLE, IL 60532

KIT CARSON HYDROGEN STORAGE
AND POWER GENERATION -
PICURIS SITE

SINGLE LINE DIAGRAM

DRAWING NO.
P-E-111

Scale: 1" = 60'
Date: 12/11/2025

SHEET NO.
P-E-111

P-E-111.dwg

12/11/2025

T-G-112.dwg

12/11/2025

1 | 12/11/2025 | TAOS H2 SITE PLAN

ENTRUST SOLUTIONS GROUP
3333 WARRENVILLE RD, SUITE 750 LISLE, IL 60532

TAOS
SITE PLAN

Scale: 1" = 60'
Date: 12/11/2025

SHEET NO.
EXHIBIT T-G-112

LINE IDENTIFICATION

48 – P – 001 – XY – Z

- 48: LINE SIZE, IN.
- P: SERVICE CODE
- 001: NUMERICAL SEQUENCE
- XY: PIPING SPECIFICATION, SEE TABLE (X: PRESSURE CLASS; Y: PIPE MATERIAL)
- Z: INSULATION CODE

SERVICE CODE

AI	AIR INTAKE
CA	COMPRESSED AIR
D[ ]	DRAIN [NAME CHEMICAL]
EX	ENGINE EXHAUST
F	FLARE
FG	FUEL GAS
GLY	ENGINE COOLANT
HC	HYDROCARBON CONDENSATE
HO, LO *	HYDRAULIC OIL & LUBE OIL
IA	INSTRUMENT AIR
IG	INSTRUMENT GAS
JW,CW,W *	JACKET WATER, COOLING WATER, & WATER
N	NITROGEN
NG	NATURAL GAS
P[ ]	PROCESS [M=METHONOL] PROCESS [U=UREA]
PW	PRODUCED WATER
R	REFRIGERATION
S	STEAM
SC	STEAM CONDENSATE
TEG	DEHYDRATION CHEMICAL
UA	UTILITY AIR
V	VENT

* S & R SUFFIXES MAY BE ADDED FOR SUPPLY & RETURN.

PIPING SPEC. TABLE

[X] PRESSURE CLASS	[Y] PIPE MATERIAL	[Z] INSULATION CODE
A–ANSI 150	1–CARBON STEEL	N–NONE
B–ANSI 300	2–SS304	A–ACOUSTICALLY INSULATED
C–ANSI 600	2L–SS304L	
D–ANSI 900	3–SS316	
E–ANSI 1500	3L–SS316L	
	4–LOW TEMP. C.S.	
	5–STRESS RELIEVE C.S.	
	6–316 SS TUBING	
	7–PVC	
	8–CPVC	
	9–COPPER	
	10–DUCTILE IRON	
	11–SPECIAL (E.G. PE, PLASTIC TUBING, ETC.)	

LINE SYMBOLS

- SECONDARY PROCESS PIPING & INSTRUMENT SUPPLY
- PNEUMATIC SIGNAL (SEE NOTE 1) PNEUM LTSCALE 1
- MAIN PROCESS PIPING
- ELECTRIC OR HIDDEN HIDDEN2
- CAPILLARY TUBE BLOCK: PID4
- SOFTWARE/DATA LINK FENCELINE1 LTSCALE .35
- MECHANICAL LINKAGE FENCELINE1 LTSCALE .75
- ELECTROMAGNETIC (SEE NOTE 2) BLOCK: PIPE BREAK
- HYDRAULIC SIGNAL BLOCK: PID6
- ACOUSTICALLY INSULATED PIPING
- E: ELECTRIC HEAT TRACED W/INSULATION
- PPO: INSULATION FOR PERSONNEL PROTECTION ONLY
- VENDOR PACKAGE SKID BOUNDARY P_LINE LTSCALE 1

NOTES:

1. THE PNEUMATIC SIGNAL SYMBOL APPLIES TO A SIGNAL USING ANY GAS AS A SIGNAL MEDIUM.
2. ELECTROMAGNETIC SIGNALS INCLUDE HEAT, RADIO WAVES, NUCLEAR RADIATION AND LIGHT.
3. ALL SYMBOLS ON THIS DRAWING ARE LAID OUT WITH AN ASSUMED PROCESS FLOW FROM LEFT TO RIGHT.
4. ALL BALL VALVES IN GAS SERVICE 2"ø AND GREATER SHALL BE FURNISHED WITH DBB PORT AND MANUAL VENT VALVE. BURIED VALVE TO HAVE VENT LINE EXTENDED ABOVE GRADE AND TERMINATED BY CONTRACTOR SUPPLIED MANUAL VALVE AND PLUG.

P&ID LINE SYMBOLS

- TEXT: LINE TERMINATION BOX
- XXXXX: OFF PAGE ARROW
- XXXXX: OFF PAGE ARROW–BI
- EQUIPMENT INSULATION
- X: PIPING INSULATION
- XXX / XXX: SPEC CHANGE
- AG / BG: GRADE CHANGE
- PIPE BREAK
- BLIND FLANGE
- SPECTACLE BLIND (* NO OR NC) — *, NC
- CONCENTRIC REDUCER
- ECCENTRIC REDUCER
- SCREWED PIPE CAP
- PIPE WELD CAP
- PIPE PLUG
- DRAIN TO SEWER
- DRAIN TO GRADE
- VENT
- ELECTRICAL INSULATION POINT
- HOSE ADAPTER
- QUICK CONNECT
- FLEXIBLE HOSE
- EXPANSION JOINT
- CHEMICAL SEAL
- X / X: PIPING TIE IN
- X: VENDOR PACKAGE INTERFACE
- UNION
- SP XX: SPACER RING
- THIEF HATCH OR FLAPPER
- RAIN CAP
- CHOKE NIPPLE
- MONOLITHIC INSULATING JOINT

VALVE SYMBOLS

✳ ABBREVIATIONS

NO	NORMALLY OPEN	FL	FAIL LAST
NC	NORMALLY CLOSE	FAIL↷	FAIL IN DIRECTION SHOWN
LO	LOCK/WIRE OPEN	FO	FAIL OPEN
LC	LOCK/WIRE CLOSE	FC	FAIL CLOSE
EO	EMERGENCY OPEN	EC	EMERGENCY CLOSE

- GATE (NORMALLY OPEN)
- GATE (NORMALLY CLOSED)
- THREE WAY
- ANGLE
- BALL
- GLOBE
- PLUG
- CHECK
- BUTTERFLY
- NEEDLE
- BLEED VALVE
- BLOCK & BLEED
- HIGH–SELECT VALVE
- 2–VALVE MANIFOLD MV–1001
- 3–VALVE MANIFOLD MV–1002
- 5–VALVE MANIFOLD MV–1003
- EXCESS FLOW
- DIAPHRAGM, BOOT OR FLEX. PLUG TYPE VALVES
- KNIFE GATE
- RAM TYPE SAMPLE
- FLUSH BOTTOM
- CHAIN OPERATED (BUTTERFLY)
- FLOAT OPERATOR (GATE)
- EH: ELECTROHYDRAULIC (BALL VALVE)
- S: SOLENOID OPERATED (GLOBE VALVE)
- PILOT–OPERATED PRESSURE RELIEF VALVE
- GAS/HYDRAULIC OPERATOR (BALL)
- NO: PISTON OPERATOR DOUBLE ACTING (GATE)
- NO: PISTON OPERATOR W/ SPRG. RETURN (GATE)
- NO: POSITIONER (PISTON OPERATED CONTROL VALVE)
- NO: DIAPHRAGM OPERATOR (GATE)
- S: SOLENOID ACTUATED VALVE (3–WAY)
- M, NO: MOTOR OPERATOR (GATE)
- PRESSURE REDUCING REGULATOR (SELF CONTAINED)
- PRESSURE REGULATOR WITH EXT.PRESSURE TAP
- BACK PRESSURE REGULATOR (SELF CONTAINED)
- MANUAL SET REGULATOR
- AIR SET WITH FILTER REGULATOR AND PI
- RUPTURE DISK
- VACUUM RUPTURE DISK
- SPRING PRESSURE RELIEF VALVE
- INSTRUMENT HANDWHEEL
- CHOKE VALVE (CHV)
- VACUUM BREAKER
- RELIEF OR SAFETY VALVE, ANGLE TYPE

COMMODITY VALVES:

"HIGHER" PRESSURE SEAL SE BALL VALVES:
- BV–1001 ½"
- BV–1002 ¾"
- BV–1003 1"
- BV–1004 1½"

"LOWER" PRESSURE SEAL SE BALL VALVES:
- BV–1005 ½"
- BV–1006 ¾"
- BV–1007 1"
- BV–1008 1½"

- CHV–1001 ½"
- CHV–1002 ¾", NEEDLE VALVE
- GV–1001–½"
- GV–1002–¾"
- BBV–1001 ½" BLOCK AND BLEED VALVE
- BBV–1002 ¾"x ½", BLOCK AND BLEED VALVE

INSTRUMENT SYMBOLS

- FIELD MOUNTED
- MULTI–FUNCTION (FIELD MTD)
- PRIMARY PANEL MOUNTED FRONT
- LOCAL PANEL, FRONT
- PRIMARY PANEL MOUNTED REAR
- LOCAL PANEL, REAR
- FUNCTION / TAG NO.: TYPICAL INSTRUMENT NUMBERING — * OPTIONAL INST. SUPPLIER VENDOR NAME OR "E" FOR EXISTING INSTRUMENTATION
- I: INTERLOCK LOGIC (HARDWIRED)
- PI: PRESSURE INDICATOR WITH CAPPILARY SEAL
- PI: PRESSURE INDICATOR WITH DIAPHRAGM SEAL
- PI: PRESSURE INDICATOR WITH PIGTAIL
- INSERTION PROBE
- LOAD CELL (WEIGHT)
- THERMAL FLOW SWITCH
- AREA / FURN: TEMPERATURE ELEMENT IN WELL (RTD OR THERMOCPL.)
- INDUSTRIAL TYPE THERMOMETER
- CAPILLARY BULB (TI)
- THERMOWELL (PLUGGED)
- LOCAL HORN
- R: LOCAL PILOT LIGHT/STROBE — * R = OFF OR CLOSED, Y = STANDBY, G = ON OR OPEN
- CCTV
- PYROMETER
- LT: INTERNAL FLOAT (LEVEL TRANSMITTER)
- LT: INTERNAL DISPLACER (LEVEL TRANSMITTER)
- LS: EXTERNAL CAGE FLOAT OR DP CELL (LEVEL SWITCH)
- LT: EXTERNAL CAGE DISPLACER (LEVEL TRANSMITTER)
- CC: CORROSION COUPON

FLOW ELEMENTS (PRIMARY METERS)

- ROTAMETER
- ROTAMETER WITH INTEGRAL VALVE
- ULTRASONIC
- MASS FLOW
- M: MAGNETIC FLOW
- POSITIVE DISPLACEMENT
- PITOT TUBE–AVERAGING
- PITOT TUBE–SINGLE
- CORIOLIS
- TURBINE
- VORTEX
- ORIFICE PLATE
- NOZZLE
- TARGET FLOW METER
- SIGHT FLOW INDICATOR
- FLOW RESTRICTOR

PROCESS CONTROL SYMBOLS

COMPUTER FUNCTION

- COMPUTER FUNCTION POINT INVISIBLE TO OPERATOR
- COMPUTER FUNCTION POINT VISIBLE TO OPERATOR
- COMPUTER FUNCTION AUXILIARY PANEL OR PANEL FURNISHED WITH EQUIPMENT
- I: COMPUTER FUNCTION SOFTWARE INTERLOCK

LOGIC AND SEQUENTIAL CONTROL SYMBOLS

- H: MANUAL RESET FOR LATCH–TYPE ACT. (NO VOLTAGE RELEASE)
- R: RESET FOR LATCH–TYPE ACT. (W/REMOTE RELEASE)

PROGRAMMABLE LOGIC CONTROLLER

- PROGRAMMABLE LOGIC CNTRL POINT INVISIBLE TO OPERATOR
- PROGRAMMABLE LOGIC CNTRL POINT VISIBLE TO OPERATOR
- PROGRAMMABLE LOGIC CNTRL AUXILIARY PANEL OR PANEL FURNISHED WITH EQUIPMENT
- I: PROGRAMMABLE LOGIC CNTRL SOFTWARE INTERLOCK
- SI: SAFETY PLC SOFTWARE INTERLOCK
- I: HARD–WIRED SAFETY INTERLOCK

EQUIPMENT

- FLANGED NOZZLE
- HEAT EXCHANGER
- JACKETED VESSEL
- M: CENTRIFUGAL PUMP (W/ INDUCTION MOTOR)
- PNEUMATIC DIAPHRAGM PUMP
- IND *, M: POSITIVE DISPLACEMENT PUMP (W/ INDUCTION MOTOR)
- M: DIAPHRAGM METERING PUMP
- BLOWER (UNDESIGNATED DRIVE)
- SYN. *, M: ELECTRIC MOTOR (* SYN. OR IND.)
- VAPOR DAMPER FENCEX48 LTSCALE: .0025
- FLOW DISTRIBUTION BAFFLE SCREEN (FDBS) FENCEX48 LTSCALE: .0025
- IN–LINE MIXER
- IN–LINE FILTER
- T: STEAM TRAP
- F: FLAME ARRESTOR
- D: DETONATION ARRESTOR
- IN–LINE STRAINER (STRT–TEMP., STRP–PERM.)
- "Y" STRAINER
- "Y" STRAINER WITH BLOCK
- TWIN FILTERS
- LINE SEPARATOR, FILTER, OR STRAINER
- V: VARIABLE SPEED MOTOR
- HYD: HYDRAULIC DRIVE
- INTERNAL PACKING (FOR ABSORBER)
- LIQUID VANE

TAGS PFD

12/11/2025

ENTRUST SOLUTIONS GROUP
28100 TORCH PKWY
WARRENVILLE, IL 60555

STANDARD NOMENCLATURE FOR PIPING & INSTRUMENTATION DIAGRAMS

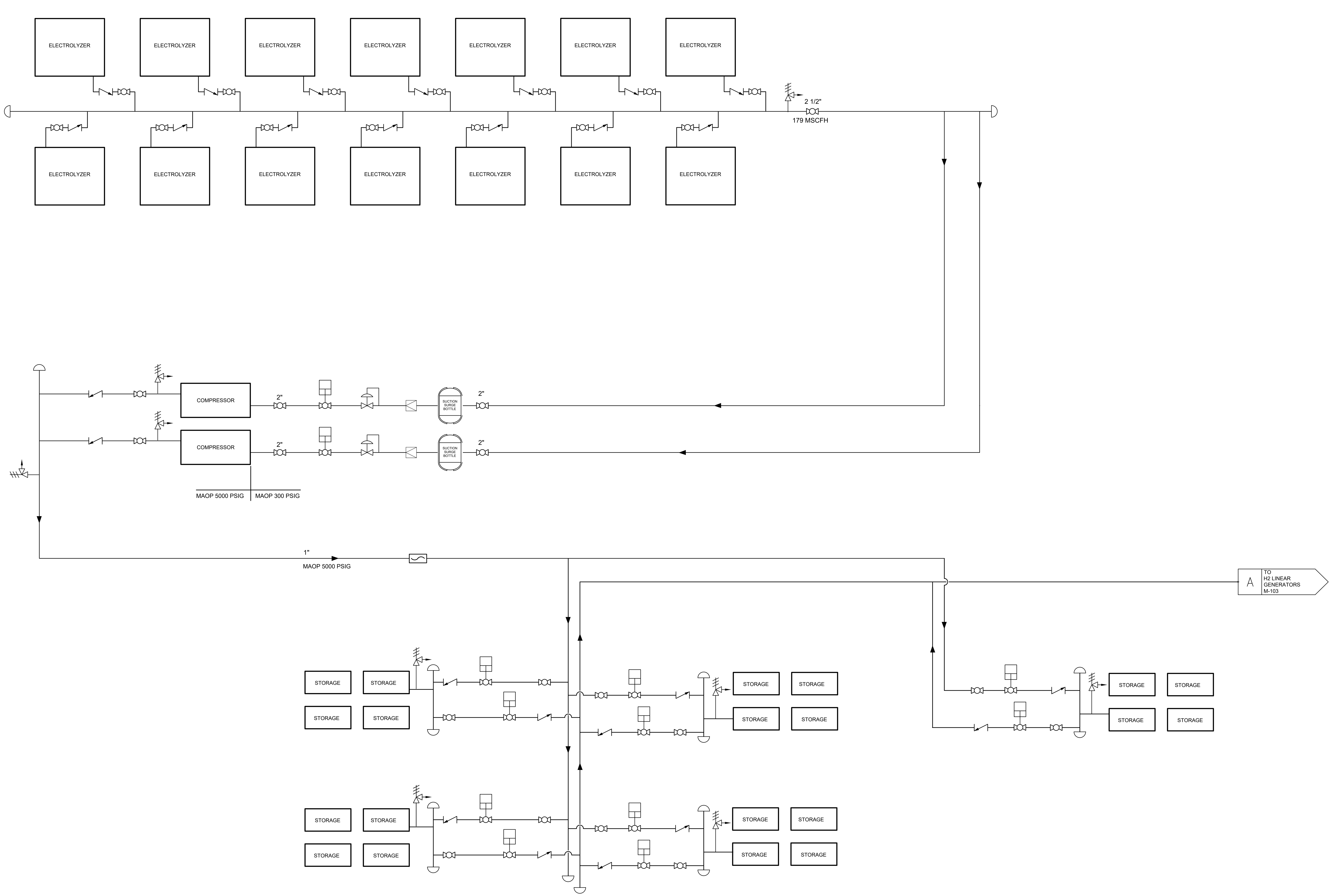
DRAWING NO. T-M-113

Scale: 1" = 60'
Date: 12/11/2025

SHEET NO. 1

T–M–113.dwg

12/11/2025



12/11/2025 TAOS PFD

ENTRUST SOLUTIONS GROUP
28100 TORCH PKWY
WARRENVILLE, IL 60555

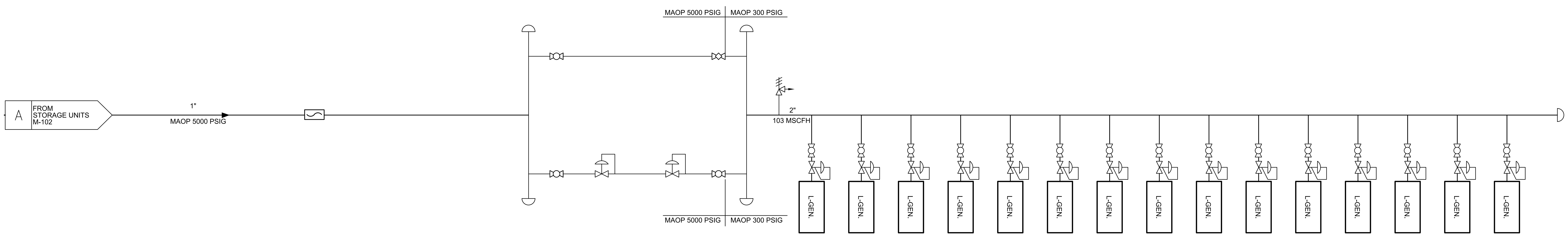
KIT CARSON HYDROGEN STORAGE AND POWER GENERATION - TAOS SITE
PROCESS FLOW DIAGRAM (PFD)
ELECTROLIZERS, COMPRESSORS, AND STORAGE

DRAWING NO.
T-M-114

Scale: 1" = 60'
Date: 12/11/2025

SHEET NO.
2

T-M-114.dwg
12/11/2025



TAOS PFD

12/11/2025

ENTRUST
SOLUTIONS GROUP

28100 TORCH PKWY
WARRENVILLE, IL 60555

KIT CARSON HYDROGEN
STORAGE AND POWER
GENERATION - TAOS SITE

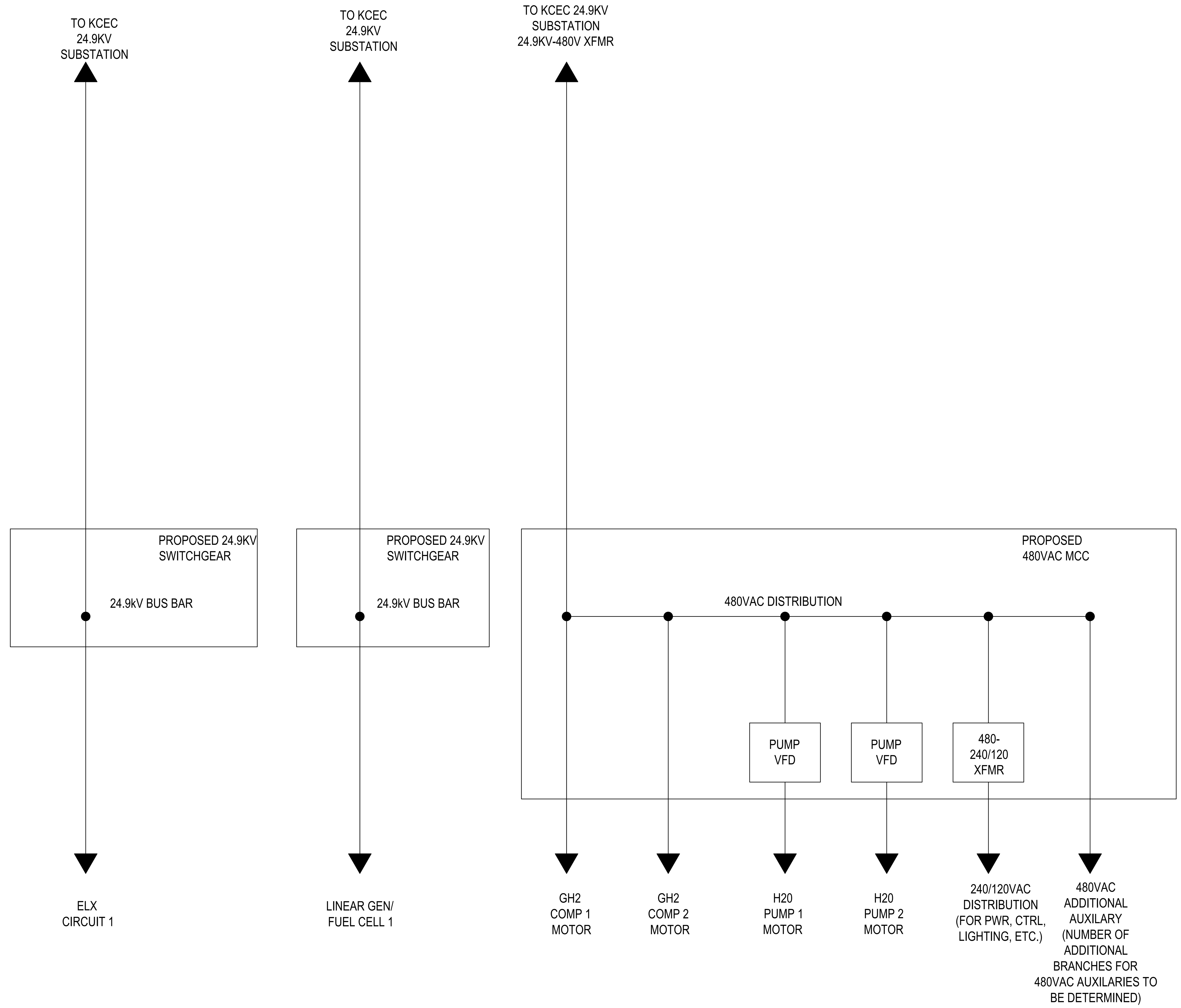
PROCESS FLOW DIAGRAM (PFD)
LINER GENERATORS

DRAWING NO.
T-M-115

Scale: 1" = 60'
Date: 12/11/2025

SHEET NO.
3

T-M-115.dwg
12/11/2025



12/11/2025 TAOS SINGLE LINE DIAGRAM

ENTRUST
SOLUTIONS GROUP
3333 WARRENVILLE RD,
SUITE 750 LISLE, IL 60532

KIT CARSON HYDROGEN STORAGE
AND POWER GENERATION -
TAOS SITE

SINGLE LINE DIAGRAM

DRAWING NO.
T-E-116

Scale: 1" = 60'
Date: 12/11/2025

SHEET NO.
T-E-116

T-E-116.dwg
12/11/2025

Worksheet

Method Name: What-If

Project Name: KCEC - Hydrogen 10% HAZID

Type of Study: Initial

Study Dates: 12/2/25, 12/3/25

Company: Kit Carson

Location: KCEC - Taos, NM

Facility: Hydrogen Power Facilities

Chemicals: Hydrogen

Worksheet

Company: Kit Carson

Location: KCEC - Taos, NM

Facility: Hydrogen Power Facilities

System: 1. Electrolyzer

Subsystem: 1.1. N/A

What If...	Hazard/Cause	Consequences	Consequence Level	Safeguards	Recommendations		Notes
			S		Recommendations	Responsible Owner	
1. What if the electrolyzer cooling system fails?	1.1. Loss of power; mechanical failure - pump, bearing, direct drive motored fans; wiring failure; heat exchanger (specifics depends on manufacturer); fouling of tubes	1.1.1. Overheating (can damage electrolyzer. Temp sense should protect, but that can also fail); oil burn up; auto-ignition of H2 or O2(?)	1	1.1.1.1. Q: What alerts to failures? A: depends on manufacturer (e.g. temp sensors); Q: will temp sensor shut off equipment? A: depends on vendor	1.1.1.1. Confirm vendor has redundancies and shutdown controls, other layers of protection for the Electrolyzer	Design	Primarily air driven; assigned 1 - safeguards should be in place
	1.2. Loss of containment	1.2.1. Ignition source		1.2.1.1. Steel materials to withstand temp			Not considered credible scenario
2. What if electrolyzer is started/stopped incorrectly?	2.1. Preparation of personnel (human error) Issues in control logic Accidental loss of power	2.1.1. Damage to electrolyzer stack - degradation to catalyst Potential for pressure spikes	2	2.1.1.1. Briding backup power system to help shutdown (for stack damage)	2.1.1.1. Standard operating procedures for startup and shutdown (static state vs purge sequence)	SMS	Need to consider normal vs abnormal circumstances
				2.1.1.2. Integrated vents (for pressure spikes)	2.1.1.2. Training for personnel (specific to startup and shutdown)	• SMS • Design	
				2.1.1.3. Overpressure H2 vents (mfr specific)	2.1.1.3. Check with vendor for mfr specific recommendations (for Electrolyzer)	• SMS • Design	
				2.1.1.4. Automated processes where feasible	2.1.1.4. Consider controls/ automation in place to ensure proper startup/shutdown sequencing (for Electrolyzer)	• Design • Controls	
				2.1.1.5. Equipment red tagging procedures	2.1.1.5. Establish expertise for startup/shutdown specifics (trained to be able to do manually)	• Design • SMS • KCEC	
					2.1.1.6. Establish manual and/	SMS	

Worksheet

Company: Kit Carson
Location: KCEC - Taos, NM
Facility: Hydrogen Power Facilities
System: 1. Electrolyzer
Subsystem: 1.1. N/A

What If...	Hazard/Cause	Consequences	Consequence Level S	Safeguards	Recommendations	Responsible Owner	Notes
					or automatic procedures/ sequencing (for Electrolyzer		
					2.1.1.7. Confirm stack health sensor (measures performance, efficiency and life of stack)	Design	
					2.1.1.8. Confirm normal conditions for valving (open/ close) and how valves will be reinstated when back to normal operating conditions (manual vs signal)	Design	
					2.1.1.9. Operator Qualifications possibly needed (for Electrolyzer operation).	• Design • SMS • KCEC	
3. Variability of electrolyzer pressure output	3.1. Variability of compressed water pressure on front end. Low water pressure on inlet or no water available.	3.1.1. Less than header pressure = check valve closed (need to confirm mfr specifics) H2 vent stack for each unit = H2 to atmosphere If no water, no gas can be produced	2	3.1.1.1. Overpressure protection - relief valve No gas produced = safe condition	3.1.1.1. Establish shutdown procedures	SMS	H2 vent stack = metal pipe that reaches above personnel height (auto ignition plausible at vent stack), when H2 burns the flame is nearly invisible to human eye
					3.1.1.2. Ensure Appropriate detection sensors installed (Electolyzer pressure)	Design	
4. Unintentional loss of power to electrolyzer?	4.1. Weather (lightning, snow accummulation) Equipment failure (transformer) Electrical flash, arc flash (harm to on-site personnel)	4.1.1. Doesn't work Not creating H2 Incorrect stop		4.1.1.1. Proper grounding	4.1.1.1. Ensure design has proper grounding (for the elctrolyzer and other applicable equipment)	Design	
				4.1.1.2. Qualifying personnel	4.1.1.2. Provide training and qualifications specific to	SMS	

Worksheet

Company: Kit Carson

Location: KCEC - Taos, NM

Facility: Hydrogen Power Facilities

System: 1. Electrolyzer

Subsystem: 1.1. N/A

What If...	Hazard/Cause	Consequences	Consequence Level	Safeguards	Recommendations		Notes
			S		Recommendations	Responsible Owner	
	Wildlife (birds, squirrels, raccoons) Faulty craftsmanship on connections Theft, unauthorized access				electrolyzer normal and abnormal operating conditions		
				4.1.1.3. Proper QA/ QC on terminations/ craftsmanship	4.1.1.3. Create appropriate SOPs for normal and abnormal operating conditions	SMS	
				4.1.1.4. SOP on abnormal operating conditions specific to electrolyzer loss of power	4.1.1.4. Consider installing fault detectors / signals (power for electrolyzer)	Design	
				4.1.1.5. Cleaning solar panels			
5. Adverse weather conditions (freezing temps, lightning, wind)	5.1. Freezing conditions = water freeze Wind/dust storm = clogged/contaminated equipment (cooling systems) Accumulated snow (see loss of power)	5.1.1. Freezing = inadverdent electrolyzer shutdown	2	5.1.1.1. Buried water lines, insulated/heat traced inlet	5.1.1.1. Confirm RFP addresses mfr having sufficiently wide temperature range and other anticipated operating conditions (e.g. -15 deg F in Questa)	Design	
				5.1.1.2. Preemptive shutoff of electrolyzers to avoid causing wildfire (relying on stored H2)	5.1.1.2. Determine what needs to be heat traced and/or insulated and include in design (Electrolyzer and other applicable equipment)	Design	
					5.1.1.3. Ensure produced H2 is sufficiently dry (avoid consequences to header system - traps or moisture detection system) and determine mfr specific requirements	Design	
6. Stagnant water in	6.1. Abnormal startup	6.1.1. Frozen water in	3	6.1.1.1. Buried water	6.1.1.1. Ensure design	Design	Unlikely scenario:

Worksheet

Company: Kit Carson

Location: KCEC - Taos, NM

Facility: Hydrogen Power Facilities

System: 1. Electrolyzer

Subsystem: 1.1. N/A

What If...	Hazard/Cause	Consequences	Consequence Level	Safeguards	Recommendations		Notes
			S		Recommendations	Responsible Owner	
inlet line in freezing weather conditions?	condition	exposed piping sections Failed compression fittings		line	considers insulation, heat tracing, header location, how to maintain temperature, keep underground as much as possible (Electrolyzer inlet line)		freezing water while in operation (consideration under abnormal shutdown conditions)
				6.1.1.2. Insulation/ heat tracing	6.1.1.2. Develop complete materials requisition list and ensure adequate spares are procured prior to start-up	KCEC Procurement	
				6.1.1.3. Design header system accordingly	6.1.1.3. Establish maintenance check procedures/protocols to inspect potential component failures	• SMS • KCEC	
				6.1.1.4. Pressure relief valves	6.1.1.4. Ensure shutdown procedures include full range of seasonal conditions to ensure proper restart	SMS	
				6.1.1.5. Recirculation loop			
				6.1.1.6. Routine maintenance checks			
7. Stagnant water in water inside electrolyzer in freezing conditions	7.1. Abnormal startup conditions Improper maintenance	7.1.1. Equipment damage Water onto electrical components	4	7.1.1.1. Space conditioning to maintain pressure differential. Mfr specific mechanisms/controls	7.1.1.1. Confirm with mfr on specific recommendations/ protocols (for water in Electrolyzer)	Design	
					7.1.1.2. Include anticipated operating temperature/ conditions in RFP (For Electrolyzer)	SMS	
8. What if vent stack ignites?	8.1. Auto ignition	8.1.1. H2 fire at vent stack Noise	1	8.1.1.1. Vent stack design per CGA G-5.5	8.1.1.1. Include Compressed Gas Association (CGA) G-5.5 H2 vent design std in RFP	Design	Consider how to address scenario with community

Worksheet

Company: Kit Carson

Location: KCEC - Taos, NM

Facility: Hydrogen Power Facilities

System: 1. Electrolyzer

Subsystem: 1.1. N/A

What If...	Hazard/Cause	Consequences	Consequence Level	Safeguards	Recommendations		Notes
			S		Recommendations	Responsible Owner	
		Attendance		8.1.1.2. flame detection (fire eyes)	8.1.1.2. Develop appropriate SOP and emergency response/ first responder training for when vent fire occurs	SMS	(public awareness)
				8.1.1.3. Standard operating procedure for vent fire occurrence			
9. Loss of water to electrolyzer	9.1. Freezing conditions Shutdown of purification system Pipe failure Loss of source (well)	9.1.1. System shutdown, no H2 produced	1	9.1.1.1. System shutdown on loss of water	9.1.1.1. Confirm with mfr that system shuts down with loss of water to electorlyzer	Design	
10. What if produced H2 is not sufficiently dry?	10.1. Water crossing membrane	10.1.1. Freezing water drop out Plugging up/corroding sensors and meters (e.g. corriolis) with water	1	10.1.1.1. Appropriate material selection (stainless steel)	10.1.1.1. Specify appropriate welding procedure under wet and dry conditions	SMS	
				10.1.1.2. Appropriate weld procedure	10.1.1.2. Develp SOP for when water is not sufficiently dry	SMS	
					10.1.1.3. Install water moisture sensor (for Electrolyzer to ensure H2 is dry).	Design	
11. What if the electrolyzer produces oxygen and hydrogen and a cross-leak occurs between the product streams?	11.1. Membrane issue/ failure	11.1.1. Combustible mixture (stoichiometric) in electrolyzer and potentially pushed further downstream (compressor to storage)	4	11.1.1.1. Voltage continuity sensor in electrolyzer to shutdown electrolyzer	11.1.1.1. Include in RFP voltage continuity sensor, determine if specific alarm/ response can be associated	Design	
					11.1.1.2. Include inline oxygen sensor on Electrolyzer Outlet	Design	
					11.1.1.3. Verify mfr specific requirements/ recommendations for integrity of components (Global)	Design	
					11.1.1.4. Implement work	• SMS	

Worksheet

Company: Kit Carson

Location: KCEC - Taos, NM

Facility: Hydrogen Power Facilities

System: 1. Electrolyzer

Subsystem: 1.1. N/A

What If...	Hazard/Cause	Consequences	Consequence Level	Safeguards	Recommendations		Notes
			S		Recommendations	Responsible Owner	
					safety management system at Kit Carson (Global)	• KCEC	
					11.1.1.5. Develop inspection & maintenance management plans to inspect for corrosion/ thru-wall failure (for Electrolyzer)	SMS	
12. What if water feed to the electrolyzer is contaminated (salts, particulates) or insufficient?	12.1. Failure of conditioning/purification system (filter break, inadvertent bypass) Plugging/clogging	12.1.1. Water rejected by electrolyzer Electrolyzer shutdown	1	12.1.1.1. Confirm acceptable water purity (measurement/ reading)	12.1.1.1. Establish appropriate maintenance practices per mfr specs (incuding corrosion checks) (for all water carrying systems and components)	SMS	Potential global consideration in all water carrying systems and components to each of the recommendation s in this What If #12.
				12.1.1.2. Automated system shutdown	12.1.1.2. Design piping with appropriate materials to prevent degradation (include in RFP) (for all water carrying systems and components)	Design	
				12.1.1.3. Differential pressure monitoring	12.1.1.3. Design to include for corrosion prevention (for all water carrying systems and components)	Design	
				12.1.1.4. Routine cleaning per mfr specifications	12.1.1.4. Design for differential pressure monitoring (if needed) (for all water carrying systems and components)	Design	
13. What if vents are blocked?	13.1. Weather (e.g. snow, dirt) Poor design Wildlife (birds nest) Water accumulation	13.1.1. Pressure buildup leading to loss of containment (failure of components, systems, seals, etc.)	4	13.1.1.1. Regular maintenance schedules to check for blocks	13.1.1.1. Incorporate regular maintenance schedule including seasonal-specific conditions (e.g. snow) (Global)	SMS	
				13.1.1.2. Design vent stacks to prevent	13.1.1.2. Develop Emergency Response Plan to address	SMS	

Worksheet

Company: Kit Carson

Location: KCEC - Taos, NM

Facility: Hydrogen Power Facilities

System: 1. Electrolyzer

Subsystem: 1.1. N/A

What If...	Hazard/Cause	Consequences	Consequence Level	Safeguards	Recommendations		Notes
			S		Recommendations	Responsible Owner	
				blocks (CGA G-5.5)	appropriate vent fire measure (i.e. don't spray water)		
				13.1.1.3. Water capture at bottom of vent pipe	13.1.1.3. Follow vent design standard guidance for preventing blockage from various conditions (water accumulation, weather, birds nest, etc.) - CGA G-5.5	• Design • SMS	
14. What if pressure relief system fails?	14.1. Mechanical failure Incorrect setpoints Corrosion (depending on material)	14.1.1. Pressure buildup leading to loss of containment (failure of components, systems, seals, etc.)	4	14.1.1.1. Regular maintenace/ inspection schedule	14.1.1.1. Regular maintenance schedule to check pressure relief system is working properly (e.g. annually)	SMS	Rupture discs cannot be tested
				14.1.1.2. Redundant rupture disc	14.1.1.2. Consider if redundant rupture disc should be installed and where on system	Design	

Worksheet

Company: Kit Carson

Location: KCEC - Taos, NM

Facility: Hydrogen Power Facilities

System: 2. Compressor

Subsystem: 2.1. N/A

What If...	Hazard/Cause	Consequences	Consequence Level	Safeguards	Recommendations		Notes
			S		Recommendations	Responsible Owner	
1. What if electrolyzers unexpectedly shutdown (all)?	1.1. Reduction in overall suction pressure Compressor ramp rate out of sync	1.1.1. Damage to compressor Repurge segment	3	1.1.1.1. Automation of number of operating compressors optimized (number of units vs level)	1.1.1.1. Confirm multiple compressor automation controls, ramp rates, integration to SCADA; confirm with mfr optimized control schema	Design	
2. What if hydrogen is insufficiently dry?	2.1. Moisture into compressor	2.1.1. Component and mechanical failure	3	2.1.1.1. Dehydration system	2.1.1.1. Verify that design includes dehydration system upstream of compressors	Design	
3. Loss of containment (inlet)	3.1. Valve failure Leaking flange Instrumentation failure (including at port) Overpressure	3.1.1. Jet fire/explosion On-site personnel injury Environmental impact Community impact Asset Damage	4	3.1.1.1. Routine walk downs/ inspections	3.1.1.1. Confirm with mfr design ratings of fittings (designed to inlet pressure vs outlet) For Compressor	Design	
				3.1.1.2. Prevenative Maintenance	3.1.1.2. Conduct risk modeling to determine potential impact radius For Compressor	Design	
				3.1.1.3. Relieve / Over pressure protection	3.1.1.3. Confirm presence of shutoff and relief valves in design For Compressor	Design	
				3.1.1.4. Leak detection sensors	3.1.1.4. Verification of design philosophy for relief and vent systems (common header vs separate vent lines)	Design	
				3.1.1.5. Automatic shutoff valves	3.1.1.5. Develop routine maintenance and inspection procedures	SMS	
					3.1.1.6. Develop public notification procedures/ protocols to address community impacts	SMS	
					3.1.1.7. Develop emergency	SMS	

Worksheet

Company: Kit Carson

Location: KCEC - Taos, NM

Facility: Hydrogen Power Facilities

System: 2. Compressor

Subsystem: 2.1. N/A

What If...	Hazard/Cause	Consequences	Consequence Level S	Safeguards	Recommendations	Responsible Owner	Notes
					response procedures and first responder training for appropriate response measures		
4. Loss of containment (outlet)	4.1. Valve failure Leaking flange Instrumentation failure (including at port) Overpressure	4.1.1. Jet fire/explosion On-site personnel injury Environmental impact Community impact Asset Damage	4	4.1.1.1. Routine walk downs/ inspections	4.1.1.1. Confirm with mfr design ratings of fittings (designed to inlet pressure vs outlet)	Design	Further jet fire Additional spacing/less structure congestion on 5000 psi system (vs inlet pressure)
				4.1.1.2. Prevenative Maintenance	4.1.1.2. Conduct risk modeling to determine potential impact radius	Design	
				4.1.1.3. Relieve / Over pressure protection	4.1.1.3. Confirm presence of shutoff and relief valves in design	Design	
				4.1.1.4. Leak detection sensors	4.1.1.4. Verification of design philosophy for relief and vent systems (common header vs separate vent lines)	Design	
				4.1.1.5. Automatic shutoff valves	4.1.1.5. Develop routine maintenance and inspection procedures	SMS	
					4.1.1.6. Develop public notification procedures/ protocols to address community impacts	SMS	
					4.1.1.7. Develop emergency response procedures and first responder training for appropriate response measures	SMS	
5. Loss of containment in compressor	5.1. Valve failure Leaking flange Instrumentation failure	5.1.1. Jet fire/explosion On-site personnel injury Environmental impact		5.1.1.1. Vibration sensors	5.1.1.1. Confirm H2 compatibility (material, packing material) for compressor	Design	

Worksheet

Company: Kit Carson
Location: KCEC - Taos, NM
Facility: Hydrogen Power Facilities
System: 2. Compressor
Subsystem: 2.1. N/A

What If...	Hazard/Cause	Consequences	Consequence Level	Safeguards	Recommendations		Notes
			S		Recommendations	Responsible Owner	
	(including at port) Overpressure	Community impact Asset Damage		5.1.1.2. Routine walk downs/ inspections	5.1.1.2. Confirm mfr includes/ incorporates vibration sensors	Design	
				5.1.1.3. Prevenative Maintenance	5.1.1.3. Follow mfr recommendations for preventative maintenance	SMS	
				5.1.1.4. Relieve / Over pressure protection	5.1.1.4. Confirm with mfr design ratings of fittings (designed to inlet pressure vs outlet) For Compressor	Design	
				5.1.1.5. Leak detection sensors	5.1.1.5. Conduct risk modeling to determine potential impact radius	Design	
				5.1.1.6. Automatic shutoff valves	5.1.1.6. Confirm presence of shutoff and relief valves in design	Design	
					5.1.1.7. Verification of design philosophy for relief and vent systems (common header vs separate vent lines)	Design	
					5.1.1.8. Develop routine maintenance and inspection procedures	SMS	
					5.1.1.9. Develop public notification procedures/ protocols to address community impacts	SMS	
					5.1.1.10. Develop emergency response procedures and first responder training for appropriate response measures	SMS	

Worksheet

Company: Kit Carson

Location: KCEC - Taos, NM

Facility: Hydrogen Power Facilities

System: 2. Compressor

Subsystem: 2.1. N/A

What If...	Hazard/Cause	Consequences	Consequence Level	Safeguards	Recommendations		Notes
			S		Recommendations	Responsible Owner	
6. Enclosure considerations for compressors	6.1. Enclosure worsens conditions for H2 confinement and/or explosion during loss of containment	6.1.1. Explosion On-site personnel injury Environmental impact Community impact Asset Damage	4	6.1.1.1. Explosion venting	6.1.1.1. Ask design team to look at alternative solutions to enclosures (e.g. compliance with sound ordances) for compressor	Design	Consider other environmental impacts due to noise (e.g. wildlife)
				6.1.1.2. Enclosure venting	6.1.1.2. If enclosures are required, design appropriately to prevent accumulation of H2 for compressors	Design	
				6.1.1.3. Proper enclosure design to facilitate venting	6.1.1.3. Incorporate proper leak detection technologies within enclosure	Design	
				6.1.1.4. Appropriately located leak detection			
	6.2. higher noise impact on personnel when inside confinement	6.2.1. Long-term hearing damage	3	6.2.1.1. Enclosure venting	6.2.1.1. Provide list of proper PPE and admin controls (sound exposure, H2 exposure)	SMS	
				6.2.1.2. Proper enclosure design to facilitate venting	6.2.1.2. Consult OSHA requirements for dB and time thresholds (sound exposure)	• Design • SMS	
				6.2.1.3. Appropriately located leak detection	6.2.1.3. Signage for hazard exposure	• Design • KCEC	
					6.2.1.4. Incorporate proper leak detection technologies within enclosure	Design	
7. Overpressure on discharge side	7.1. Inadverdent closing of discharge valve	7.1.1. Damage to compressor, piping	2	7.1.1.1. Overpressure protection	7.1.1.1. Ensure design incorporates proper overprotection system/ equipment for compressor	design	
8. Inappropriate	8.1. Loss of power	8.1.1. Damage to	3	8.1.1.1. Standard	8.1.1.1. Confirm mfr controls/	Design	

Worksheet

Company: Kit Carson

Location: KCEC - Taos, NM

Facility: Hydrogen Power Facilities

System: 2. Compressor

Subsystem: 2.1. N/A

What If...	Hazard/Cause	Consequences	Consequence Level	Safeguards	Recommendations		Notes
			S		Recommendations	Responsible Owner	
startup/shutdown of compressors	(electric driven) Improper personnel training Not following management of change (MOC) Automation failure	rotating equipment (bending, overheating)		operating procedures	mechanisms for protecting against improper startup/ shutdown for compressor		
				8.1.1.2. Lock out tag out (LOTO)	8.1.1.2. Develop proper SOPs, LOTO, P&M, etc. and provide training to personnel	SMS	
				8.1.1.3. Automation/ mfr controls	8.1.1.3. Design team to confirm if battery backup is appropriate for compressor	Design	
				8.1.1.4. Preventative maintenance			
				8.1.1.5. Battery backup?			
9. Pressure relief system failure	9.1. Multi-component failure (see overpressure on discharge side)	9.1.1. Pressure buildup leading to loss of containment (failure of components, systems, seals, etc.)	4	9.1.1.1. Regular maintenace/ inspection schedule	9.1.1.1. Develop Regular maintenance schedule to check pressure relief system is working properly (e.g. annually)	SMS	
				9.1.1.2. Redundant rupture disc	9.1.1.2. Consider if redundant rupture disc should be installed and where on system	Design	
10. Compressor lacks oil/lube	10.1. Lack of prevention/maintenance	10.1.1. Asset damage Loss of containment - jet fire/explosion	4	10.1.1.1. SOP, walkdown checklists	10.1.1.1. Confirm temperature sensor is appropriately placed on unit for compressor oil	Design	
				10.1.1.2. Preventative maintenance	10.1.1.2. Confirm mfr guidance for preventative maintenance procedures for compressor	• Design • SMS	
					10.1.1.3. Develop SOP, walkdown checklists	SMS	
11. Reversed flow from storage back into compressor	11.1. Check valve failure	11.1.1. Ovepressure 1 or 2 compressor stages upstream	3	11.1.1.1. Stage-to-stage checks within compressor	11.1.1.1. Check with design team if double check valve on outlet is appropriate (for	Design	

Worksheet

Company: Kit Carson

Location: KCEC - Taos, NM

Facility: Hydrogen Power Facilities

System: 2. Compressor

Subsystem: 2.1. N/A

What If...	Hazard/Cause	Consequences	Consequence Level	Safeguards	Recommendations		Notes
			S		Recommendations	Responsible Owner	
					compressor)		
				11.1.1.2. Double check valve on outlet?	11.1.1.2. Ensure prior stage check valves rated for max pressure (for compressor)	Design	

Worksheet

Company: Kit Carson

Location: KCEC - Taos, NM

Facility: Hydrogen Power Facilities

System: 3. Hydrogen Storage

Subsystem: 3.1. N/A

What If...	Hazard/Cause	Consequences	Consequence Level	Safeguards	Recommendations		Notes
			S		Recommendations	Responsible Owner	
1. What if a hydrogen storage vessel develops a leak at a flange/ valve?	1.1. Component failure Faulty gasket Material degradation Improper torque on flange Ground shift/land movement Lightning strike	1.1.1. Jet fire/explosion Congestion causing containment of H2	4	1.1.1.1. Separation of banks to reduce congestion	1.1.1.1. Include in RFP required installation of valves/ports on bulkhead of hydrogen storage tanks	Design	Fire risks to facility; accumulation of H2 can lead to asphyxiation
				1.1.1.2. Ports/valves installed on bulkhead of tanks to minimize potential congestion	1.1.1.2. Incorporate proper leak detection technologies and pressure and temperature sensing/monitoring (per bank) for hydrogen storage	Design	
				1.1.1.3. Applicable leak detection installed	1.1.1.3. Define Personal PPE list and protocols for personnel working in and around storage (e.g. personal monitors, fire resistant clothing, etc.)	SMS	
					1.1.1.4. Consider applicability of detection tape for flanges on H2 storage system	Design	
2. What if storage vessel pressure relief valve (PRV) fails to lift and pressure exceeds maximum allowable operating pressure (MAOP) during charging? Note: not exceeding design pressure, i.e. not failing	2.1. Mechanical failure of PRV Dirt, debris, ice, etc. Water entrainment Operational error Improper setting of PRV Operational temperature range exceeded	2.1.1. Non-catastrophic overpressure of storage system	1	2.1.1.1. Procedural cleaning of H2 vent drain with spring closure/ball valve	2.1.1.1. Design H2 vent in accordance with CGA G-5.5 (proper drain location) for storage system	Design	Need to define MAOP, MOP, Design Pressure and how to apply concepts (e.g. following PHMSA regulations?)
				2.1.1.2. SOP for testing and proper setting of PRV	2.1.1.2. Develop proper SOPs, training, and personnel qualifications for installing, setting, and maintaining PRV systems	SMS	
				2.1.1.3. Training and qualifications for personnel	2.1.1.3. Confirm in RFP with mfr design pressures	Design	
				2.1.1.4. Pre startup safety review (PSSR)	2.1.1.4. Work with fire marshal on wildfire mitigation and	Design	

Worksheet

Company: Kit Carson

Location: KCEC - Taos, NM

Facility: Hydrogen Power Facilities

System: 3. Hydrogen Storage

Subsystem: 3.1. N/A

What If...	Hazard/Cause	Consequences	Consequence Level	Safeguards	Recommendations		Notes
			S		Recommendations	Responsible Owner	
				of installation	solution for tank cooling		
				2.1.1.5. Proper pressure sensing/ monitoring	2.1.1.5. Determine (Design team) if additional high pressure relief upstream of reg station for the hydrogen storage system is warranted	Design	
				2.1.1.6. Tank cooling mechanism			
				2.1.1.7. Additional high pressure relief upstream of reg station(?)			
3. What if hydrogen accumulates around equipment (ventilation failure)?	3.1. Leak on tank/vessel (less than valve/flange failure, e.g. pinhole)	3.1.1. Accumulation of H2 to explosive level	4	3.1.1.1. Gas impermeable barrier between bulkheads to prevent accumulation	3.1.1.1. Incorporate into the design impermeable barrier between storage tank bulkheads	Design	
					3.1.1.2. Confirm presence of barrier solution in construction review of H2 storage tank bulkheads.	Design	
4. What if a jet fire impinges on adjacent vessels (domino effect)?	4.1. Horizontal jet fire	4.1.1. Cause secondary leak on adjacent tank (valve) Heat adjacent tank raising pressure	4	4.1.1.1. Establish design criteria/ engineer solution	4.1.1.1. Consult with existing design codes and standards + engineering calculations to determine appropriate distance between tank banks	Design	
				4.1.1.2. Thermal protective coating on tanks	4.1.1.2. Install fire eyes for flame detection and monitoring across storage banks	Design	
				4.1.1.3. Fire eyes for flame detection	4.1.1.3. Develop SOPs and emergency response plans and training for personnel and first responders	SMS	

Worksheet

Company: Kit Carson

Location: KCEC - Taos, NM

Facility: Hydrogen Power Facilities

System: 3. Hydrogen Storage

Subsystem: 3.1. N/A

What If...	Hazard/Cause	Consequences	Consequence Level	Safeguards	Recommendations		Notes
			S		Recommendations	Responsible Owner	
				4.1.1.4. Pressure relief system on each bank	4.1.1.4. Analyze cost benefit of firewalls between storage tank banks	Design	
				4.1.1.5. Automation to lock in tank bank			
				4.1.1.6. Consider firewalls in design			
				4.1.1.7. SOP, emergency response plan			
5. What if hydrogen embrittlement causes a pipeline or fitting to fracture?	5.1. Wrong/incompatible material Flaw in material Wrong design specification or design calc Undisclosed 3rd party damage to external structure Land slip/movement (buried storage/assets)	5.1.1. Loss of containment Jet fire/explosion	4	5.1.1.1. Use of compatible material	5.1.1.1. Develop SOP for routine inspection/maintenance including for 3rd party work	SMS	
				5.1.1.2. Periodic inspections	5.1.1.2. Establish design criteria for appropriate material selection	Design	
				5.1.1.3. Design calcs for material selection	5.1.1.3. Inspection and verification of material upon receipt	• Design • KCEC	
					5.1.1.4. Training for on site personnel (internal + 3rd party)	• Design • SMS • KCEC	
6. What if a small persistent leak produces an invisible hydrogen flame that goes undetected?	6.1. Failure in detection system or inability to capture flame (i.e. fire eyes)	6.1.1. Prolonged damage from heat or flame impingement on nearby/adjacent equipment/structure	2	6.1.1.1. Regular maintenance schedule of flame detection equipment	6.1.1.1. Develop SOP for routine maintenance of detection equipment	SMS	Confirm status of compatible odorant for project application
				6.1.1.2. Use of H2 monitors/detection devices for H2 leaks	6.1.1.2. Establish appropriate PPE for responding to H2 leak and potential flame	• Design • SMS	
				6.1.1.3. SOP and	6.1.1.3. Develop SOP and	• SMS	

Worksheet

Company: Kit Carson
Location: KCEC - Taos, NM
Facility: Hydrogen Power Facilities
System: 3. Hydrogen Storage
Subsystem: 3.1. N/A

What If...	Hazard/Cause	Consequences	Consequence Level	Safeguards	Recommendations		Notes
			S		Recommendations	Responsible Owner	
				training for confirming H2 flame (hazard recogniztion, abnormal operating condition response)	training for confirming H2 flame (hazard recognition, abnormal operating condition response)	• Design	
7. Water entrainment into storage	7.1. Water in H2 transported from upstream equipment (electrolyzer --> compressor) Startup before water sufficiently removed from H2	7.1.1. Corrosion possible depending on material	3	7.1.1.1. Follow code/ standard/BSP for installation dryness requirements	7.1.1.1. Confirm hydrogen dryness requirements prior to startup	• Design • KCEC	
				7.1.1.2. Moisture sensors installed upstream	7.1.1.2. Confirm if oxygen cleaning is required	Design	
				7.1.1.3. SOP for internal inspection	7.1.1.3. Confirm mfr recommendation for internal inspection schedule (for hydrogen storage) and include in SOP	• Design • SMS	
					7.1.1.4. Design to include appropriate gas quality and moisture monitoring/sensors upstream of storage	Design	
8. What if the regulating station fails?	8.1. Improper inspection/maintenance Open bypass, bleed by Regulators do not fail close Improper regulator type selection	8.1.1. Overpressure downstream relief system	3	8.1.1.1. Design operator monitor and relief valve	8.1.1.1. Incorporate into design operator-monitor configuration, relief valve for hydrogen storage	Design	
				8.1.1.2. SCADA system w/alarms + alarm mgmt and dispatch protocol	8.1.1.2. Incorporate appropriately set alarm thresholds tied to SCADA system for alerting abnormal operating condition and appropriate response/dispatch procedures	• Design • SMS • KCEC	

Worksheet

Company: Kit Carson
Location: KCEC - Taos, NM
Facility: Hydrogen Power Facilities
System: 3. Hydrogen Storage
Subsystem: 3.1. N/A

What If...	Hazard/Cause	Consequences	Consequence Level	Safeguards	Recommendations		Notes
			S		Recommendations	Responsible Owner	
				8.1.1.3. Inspection & maintenance procedures	8.1.1.3. Develop appropriate Lock out tag out procedure	SMS	
				8.1.1.4. LOTO procedure	8.1.1.4. Develop inspection and maintenance SOP for confirming regulating system pressures	SMS	
				8.1.1.5. Double valve on bypass	8.1.1.5. Develop calibration and maintenance procedures for applicable measurement equipment	SMS	
				8.1.1.6. Visual indicator for open/close status of relief system (H2 Storage)	8.1.1.6. Consider regulated bypass/3rd parallel run with FC/L-Gen header cross tie	Design	

Worksheet

Company: Kit Carson

Location: KCEC - Taos, NM

Facility: Hydrogen Power Facilities

System: 4. Fuel Cell / Linear Generator

Subsystem: 4.1. N/A

What If...	Hazard/Cause	Consequences	Consequence Level	Safeguards	Recommendations		Notes
			S		Recommendations	Responsible Owner	
1. What if fuel cell stack is contaminated/ poisoned due to impurities in hydrogen?	1.1. Compressor oil Improper maintenance (O2?) Water entrainment Particulates from degradation	1.1.1. For fuel cell: catalyst poisoned Particulates can lead to degradation of seals leading to leaks	4	1.1.1.1. Sediment trap for particulates	1.1.1.1. Develop SOP for contaminant detection and clearing contaminants (L-Gen = keeps running; Fuel Cell = shutdown)	SMS	Applicable to fuel cells and L-Gens
				1.1.1.2. Hydrogen purity measurement/ confirmation (post electrolyzer)	1.1.1.2. Confirm appropriate sensors for detecting/ measuring contaminants (H2 purity, O2, moisture)in hydrogen	Design	
				1.1.1.3. Moisture sensor and filter	1.1.1.3. Design for sediment traps upstream of FC/L-Gen	Design	
2. What if a supply line to the fuel cell ruptures during high flow demand?	2.1. Welding failure Embrittlement/material failure Vibration, land movement Wrong/incompatible material Flaw in material Wrong design specification or design calc Undisclosed 3rd party damage to external structure	2.1.1. Loss of containment Jet fire/explosion	4	2.1.1.1. Use of compatible material	2.1.1.1. Design consideration for additional FC/L-Gen capacity	Design	
				2.1.1.2. Periodic inspections	2.1.1.2. Develop SOP for routine inspection/ maintenance including for 3rd party work (for fuel cell / linear generator)	SMS	
				2.1.1.3. Design calcs for material selection	2.1.1.3. Establish design criteria for appropriate material selection	Design	
					2.1.1.4. Ensure inspection and verification of material upon receipt	• Design • KCEC	
					2.1.1.5. Implement training for on site personnel (internal + 3rd party)	• Design • SMS • KCEC	
3. What if backflow from fuel cell into storage or electrolyzer occurs?	3.1.	3.1.1.					Not a credible scenario

Worksheet

Company: Kit Carson

Location: KCEC - Taos, NM

Facility: Hydrogen Power Facilities

System: 4. Fuel Cell / Linear Generator

Subsystem: 4.1. N/A

What If...	Hazard/Cause	Consequences	Consequence Level	Safeguards	Recommendations		Notes
			S		Recommendations	Responsible Owner	
4. Rotating/ mechanical equipment failure with linear generators?	4.1. Out of balance piston Seal failure Maintenance issues Spring failure improper software update/settings input	4.1.1. Leak in enclosure from seal failure --> loss of containment Piston degradation --> asset loss	4	4.1.1.1. Establish routine maintenance and inspection	4.1.1.1. Work closely with mfr on detailed SOPs, protocols, guidelines, etc. for maintenance, inspection, updates/overhauls	SMS	
					4.1.1.2. Develop SOP for routine inspection/maintenance including for 3rd party work	SMS	
5. Water entrainment to fuel cell/L-Gen	5.1.	5.1.1.					Team did not evaluate because hazard/ cause/concern requires more research
6. What if L-Gen runs fuel line dry?	6.1. Loss of fuel supply (plugged line/regulator, improper maintenance/ operation of upstream reg station, inadvertent lifting of pressure relief)	6.1.1. Sudden stop		6.1.1.1. Low pressure gas switch	6.1.1.1. Confirm with mfr L-Gen operation protocol under low fuel pressure situation	• Design • SMS	Team did not determine consequence level - need more info from mfr
				6.1.1.2. Debris filter	6.1.1.2. Design for upstream filter of L-Gen to catch fuel line debris	Design	
				6.1.1.3. SOP for operation and maintenance of reg station and regulators	6.1.1.3. Develop SOPs and training for proper operations, maintenance, and inspection of reg station components and regulators (for Fuel Cell / L-Gen)	SMS	
7. What if L-Gen is overpressured from supply line upstream of appliance reg?	7.1. Full reg station failure Appliance regulator failure Improper maintenance of regulators	7.1.1. Failure of fuel line components leading to internal leakage --> loss of containment Mechanical failure	4	7.1.1.1. Proper appliance reg design (compatible with upstream pressure ~300 psi)	7.1.1.1. Confirm with mfr on the maximum fuel line pressure of the L-Gen	Design	Confirm with mfr pressure ratings of fittings and componenets of fuel line

Worksheet

Company: Kit Carson

Location: KCEC - Taos, NM

Facility: Hydrogen Power Facilities

System: 4. Fuel Cell / Linear Generator

Subsystem: 4.1. N/A

What If...	Hazard/Cause	Consequences	Consequence Level S	Safeguards	Recommendations	Responsible Owner	Notes
				7.1.1.2. SOP for appliance reg maintenance and inspection	7.1.1.2. Confirm with design appropriate fuel line pressure and relief systems	Design	
				7.1.1.3. Internal & external regulator relief	7.1.1.3. Develop SOP for proper maintenance & inspection of external and internal regulators	SMS	
8. What if fuel cell is overpressured from supply line upstream of appliance reg?	8.1. Full reg station failure Appliance regulator failure Improper maintenance of regulators	8.1.1. Failure of fuel line components leading to internal leakage --> loss of containment Membrane failure	4	8.1.1.1. Proper appliance reg design (compatible with upstream pressure ~300 psi)	8.1.1.1. Confirm with mfr maximum fuel line pressure of fuel cell	Design	Confirm with mfr pressure ratings of fittings and componenets of fuel line
				8.1.1.2. SOP for appliance reg maintenance and inspection	8.1.1.2. Confirm for design the appropriate fuel line pressure and relief systems (for fuel cell / L-gen)	Design	
				8.1.1.3. Internal & external regulator relief	8.1.1.3. Develop SOP for proper maintenance & inspection of external and internal regulators	SMS	
9. Incorrect startup or shutdown	9.1. LGEN: Loss of power Improper operations/ personnel training Not following management of change (MOC) Automation/logic failure Purge failure prior to initial start up	9.1.1. Mechanical failure (L-Gen)	2	9.1.1.1. Standard operating procedures	9.1.1.1. Confirm mfr controls/ mechanisms for protecting against improper startup/ shutdown (for Fuel Cell / L - Gen)	Design	
				9.1.1.2. Lock out tag out (LOTO)	9.1.1.2. Develop proper SOPs, LOTO, P&M, etc. and provide training to personnel	SMS	
				9.1.1.3. Automation/ mfr controls	9.1.1.3. Confirm if battery back up is appropriate for fuel cell /	Design	

Worksheet

Company: Kit Carson

Location: KCEC - Taos, NM

Facility: Hydrogen Power Facilities

System: 4. Fuel Cell / Linear Generator

Subsystem: 4.1. N/A

What If...	Hazard/Cause	Consequences	Consequence Level	Safeguards	Recommendations		Notes
			S		Recommendations	Responsible Owner	
				9.1.1.4. Preventative maintenance	L- Gen.		
				9.1.1.5. Battery backup?			
	9.2. Fuel Cell: Loss of power Improper operations/ personnel training Not following management of change (MOC) Automation/logic failure Purge failure prior to initial start up	9.2.1. Component damage (poisoning of fuel cell)	4	9.2.1.1. Standard operating procedures	9.2.1.1. Confirm mfr controls/ mechanisms for protecting against improper startup/ shutdown of Fuel Cell / L - Gen.	Design	
				9.2.1.2. Lock out tag out (LOTO)	9.2.1.2. Develop proper SOPs, LOTO, P&M, etc. and provide training to personnel	SMS	
				9.2.1.3. Automation/ mfr controls	9.2.1.3. Confirm if battery back up is appropriate for fuel cell / L -Gen.	Design	
				9.2.1.4. Preventative maintenance			
				9.2.1.5. Battery backup?			

Worksheet

Company: Kit Carson

Location: KCEC - Taos, NM

Facility: Hydrogen Power Facilities

System: 5. Utilities / Misc

Subsystem: 5.1. Controls and Power

What If...	Hazard/Cause	Consequences	Consequence Level	Safeguards	Recommendations		Notes
			S		Recommendations	Responsible Owner	
1. What if there is a loss of power?	1.1. Adverse weather event Wildlife Unexpected external forces/events/conditions	1.1.1. equipment specific loss of power consequences Abnormal shutdown inspection/investigation Loss of facility lighting	4	1.1.1.1. Valves to fail position	1.1.1.1. Consider operation of abnormal conditions due to loss of power	Design	
				1.1.1.2. Relief protection	1.1.1.2. Consider battery backup for fuel cell/L-Gen startup without primary power	Design	
				1.1.1.3. SOP for post-abnormal shutdown inspection/ maintenance/ investigation/startup	1.1.1.3. Design to determine proper labeling/identification of valves for proper shutdown (including potential of fire valves for first responders)	Design	
					1.1.1.4. Develop SOP and training for responding to facility loss of power (e.g. manual operation of valves and equipment)	SMS	
					1.1.1.5. Develop SOP and training for investigating abnormal facility shutdown	SMS	
					1.1.1.6. Develop SOP for startup after abnormal shutdown	SMS	
					1.1.1.7. Evaluate backup power design for lighting and other low voltage power needs	Design	
2. What if Distributive Control System/ Programmable Logic Controller loses communication with	2.1. Network failure Loss of power Manufacturing defects Human error (misconfiguration) Software issues (bad	2.1.1. Uncontrolled operations (loss of containment, explosion, loss of life and property)	4	2.1.1.1. Go to fail safe mode/position	2.1.1.1. Consider system wide loss of automation systems in the design	Design	Consider potential of fire control valves for first responders
				2.1.1.2. SOP for personnel intervention to shutdown/correct	2.1.1.2. Determine proper labeling/identification of valves for proper shutdown (including	Design	

Worksheet

Company: Kit Carson
Location: KCEC - Taos, NM
Facility: Hydrogen Power Facilities
System: 5. Utilities / Misc
Subsystem: 5.1. Controls and Power

What If...	Hazard/Cause	Consequences	Consequence Level	Safeguards	Recommendations		Notes
			S		Recommendations	Responsible Owner	
field instruments?	update) 3rd party infrastructure damage			(controlled shutdown)	potential of fire valves for first responders)		
					2.1.1.3. Develop SOPs, training, qualifications and emergency response plan for personnel intervention to shutdown/correct	• SMS • KCEC	
					2.1.1.4. Consider availability/ installation of local gauges/ sensors	Design	
3. What if the emergency shutdown (ESD) logic fails to isolate a leaking hydrogen source?	3.1. Bad actuator Loss of power Manufacturing defects Human error (misconfiguration) Software issues (bad update) Leak location not captured by ESD system	3.1.1. Loss of containment Jet fire/explosion	4	3.1.1.1. Determine proper ESD logic	3.1.1.1. Develop ESD logic	• Design • KCEC	
				3.1.1.2. Maintenance of actuators	3.1.1.2. Develop SOP and training for ESD system maintenance and inspection	SMS	
				3.1.1.3. Backup power for ESD	3.1.1.3. Consider backup power solution for loss of power	Design	
				3.1.1.4. Material QA/ QC for ESD system components	3.1.1.4. Establish QA/QC protocol for ESD system components	Design	
					3.1.1.5. Develop SOP, training, emergency response plan for appropriate circumstance to activate ESD	• Design • KCEC	
4. What if a valve actuator fails in the open position during a leak?	4.1. Bad actuator Loss of power Manufacturing defects Human error (misconfiguration) Software issues (bad update)	4.1.1. Loss of containment Jet fire/explosion	4	4.1.1.1. Proper maintenance of actuators	4.1.1.1. Develop SOP and training for valve maintenance and inspection	SMS	
				4.1.1.2. Material QA/ QC of valve components	4.1.1.2. Establish fail close/fail open for each applicable valve on system	Design	

Worksheet

Company: Kit Carson

Location: KCEC - Taos, NM

Facility: Hydrogen Power Facilities

System: 5. Utilities / Misc

Subsystem: 5.1. Controls and Power

What If...	Hazard/Cause	Consequences	Consequence Level	Safeguards	Recommendations		Notes
			S		Recommendations	Responsible Owner	
	Mechanical failure				4.1.1.3. Consider back up power solution for loss of power	Design	
					4.1.1.4. Establish QA/QC protocol for valve components	• Design • SMS	
5. What if hydrogen point sensors fail?	5.1. Loss of power Sensor fault	5.1.1. Loss of containment Jet fire/explosion	4	5.1.1.1. Back up power	5.1.1.1. Consider back up power for critical systems (sensors)	Design	
				5.1.1.2. SOP for maintenance / calibration / PM	5.1.1.2. Consider setting up sensor detection alarm	Design	
				5.1.1.3. Detector for sensor (depending on type) in controls	5.1.1.3. Include sensor maintenance in SOP development and maintenance PM schedules	SMS	
6. What if hydrogen flame detectors fail?	6.1. Loss of power Sensor fault	6.1.1. Loss of containment Jet fire/explosion	4	6.1.1.1. Back up power	6.1.1.1. Consider back up power for critical systems (flame detectors)	Design	
				6.1.1.2. SOP for maintenance / calibration / PM	6.1.1.2. Consider setting up sensor detection alarm	Design	
				6.1.1.3. Detector for sensor (depending on type) in controls	6.1.1.3. Include sensor maintenance in SOP development and maintenance PM schedules	SMS	
7. What instrumentation is critical and needs back up and/or redundancy?	7.1.	7.1.1.			7.1.1.1. Review instrumentation and sensors to determine which are critical and determine which require back up and/or redundancy	Design	question is to detailed for this stage of review. Added recommendation to make sure the concern is

Worksheet

Company: Kit Carson

Location: KCEC - Taos, NM

Facility: Hydrogen Power Facilities

System: 5. Utilities / Misc

Subsystem: 5.1. Controls and Power

What If...	Hazard/Cause	Consequences	Consequence Level	Safeguards	Recommendations		Notes
			S		Recommendations	Responsible Owner	
							captured for appropriate action and design consideration.
8. Electrical classification	8.1. Improper electrical classification of equipment	8.1.1. Arch / electrical ignition	4	8.1.1.1. Follow NEC code and AGA XL 1001	8.1.1.1. Perform electrical classified area study for entire facility	Design	
9. What if an ignition source is present in an area with low-concentration hydrogen (e.g., transient spark from equipment)?	9.1. Used the wrong tools Incorrect grounding Smoking Weather event Hot Work performed incorrectly Fireworks Technology use	9.1.1. Fire Explosion Asset Damange Potential injury	4	9.1.1.1. Flame detectors	9.1.1.1. Develop SOPs for detectors PM, maintenance and calibration.	SMS	Worst case : explosion.
				9.1.1.2. Leak Detectors	9.1.1.2. Consider PPE hydrogen detectors	• Design • KCEC	
				9.1.1.3. PM and maintenance plans, calibration	9.1.1.3. Implement routine leak walk downs and include in SOPs	• SMS • KCEC	
				9.1.1.4. SOPs	9.1.1.4. Ensure training personnel accurately conduct walk downs and checking for low level leaks	• SMS • KCEC	

Worksheet

Company: Kit Carson

Location: KCEC - Taos, NM

Facility: Hydrogen Power Facilities

System: 5. Utilities / Misc

Subsystem: 5.2. Human Factors

What If...	Hazard/Cause	Consequences	Consequence Level S	Safeguards	Recommendations	Responsible Owner	Notes
1. What if operators misconfigure valve sequencing during maintenance?	1.1. Not following SOP Improper training	1.1.1. Loss of containment Jet fire/explosion Asset damage Personnel injury	4	1.1.1.1. SOP and routine training specific to equipment	1.1.1.1. Develop SOPs and training for each equipment	SMS	
				1.1.1.2. LOTO procedure for specific equipment	1.1.1.2. Develop LOTO for each equipment	SMS	
				1.1.1.3. Purging procedures	1.1.1.3. Develop purging procedures for each equipment	SMS	
				1.1.1.4. List of PPE	1.1.1.4. Establish PPE needed for specific procedures	SMS	
2. What if incorrect procedures are used during commissioning (e.g., incorrect purge sequence)?	2.1. Lack of understanding or specialists for vendor requirements, technology, sequencing, document oversight.	2.1.1. Loss of containment Jet fire/explosion Asset damage Personnel injury	4	2.1.1.1. QA/QC process for procedure development	2.1.1.1. Develop a Pre-commisioning checklist	SMS	
				2.1.1.2. Mock drills - pre start up	2.1.1.2. Formalize a PSSR	SMS	
				2.1.1.3. Training	2.1.1.3. Conduct procedure reviews - QA/QC with all approvers	• 3rd Party • SMS • Design • KCEC	
				2.1.1.4. 3rd party review	2.1.1.4. Formalize a hydrogen purge plan based on mfr recommendations	SMS	
					2.1.1.5. Determine appropriate review and approval process for procedures	• KCEC • Design • SMS	
					2.1.1.6. Utilize 3rd party review and QA/QC	3rd Party	
					2.1.1.7. Perform pre-commisioning mock drill / dry run and training	• KCEC • Design • SMS	

Worksheet

Company: Kit Carson

Location: KCEC - Taos, NM

Facility: Hydrogen Power Facilities

System: 5. Utilities / Misc

Subsystem: 5.2. Human Factors

What If...	Hazard/Cause	Consequences	Consequence Level	Safeguards	Recommendations		Notes
			S		Recommendations	Responsible Owner	
3. What if routine maintenance introduces a leak (e.g., gasket replaced incorrectly)?	3.1. Improper implementation of SOP Faulty equipment and materials Used wrong materials	3.1.1. Loss of containment Jet fire/explosion Asset damage Personnel injury	4	3.1.1.1. SOPs	3.1.1.1. Review and address proper torque practices and mfr maintenance practices	Design	
				3.1.1.2. Training	3.1.1.2. Ensure SOPs should include post maintenance leak checks, proper material verification	SMS	
					3.1.1.3. Ensure materials are specified for procurement	• Design • KCEC	
					3.1.1.4. Ensure procurement maintains appropriate storage of readily needed materials.	KCEC	
4. What if an operator overrides safety interlocks to maintain power during high demand?	4.1. Inadequate safety culture and decipline, balancing demand requirements.	4.1.1. Loss of containment Jet fire/explosion Asset damage Personnel injury	4	4.1.1.1. Leadership oversight for safety culture - admin controls	4.1.1.1. Include approval, consequence and discipline expectations in the safety plan and/or SOPs	• SMS • KCEC	
				4.1.1.2. Pressure relief protection			
5. What if emergency response plan is not adequate for H_2 incidents or responders are not trained?	5.1.	5.1.1.					Determined to be not an adequate question at this time.
6. What if a regulatory inspection finds non-conformance with local codes (e.g., siting/spacing)?	6.1. Inadequate access to equipment and operation for maintenance tasks	6.1.1. potential forced shutdown potential for fines (regulatory)	2	6.1.1.1. Internal audits for compliance	6.1.1.1. Ensure local codes and regulations are considered during design, permitting and commissioning	• Design • KCEC	
				6.1.1.2. Permitting	6.1.1.2. Include internal audits for compliance within the SOPs	SMS	

Worksheet

Company: Kit Carson

Location: KCEC - Taos, NM

Facility: Hydrogen Power Facilities

System: 5. Utilities / Misc

Subsystem: 5.2. Human Factors

What If...	Hazard/Cause	Consequences	Consequence Level	Safeguards	Recommendations		Notes
			S		Recommendations	Responsible Owner	
				6.1.1.3. Code review during design	/ Safety Plans		
7. What if a vehicle strikes the H2 facilities/equipment (mechanical impact)?	7.1. EXTERNAL: Impaired driver Weather lack of fencing Proximaty to public roads	7.1.1. Loss of containment Jet fire/explosion Asset damage Personnel injury	4	7.1.1.1. fencing / vehicle barrier cable	7.1.1.1. Consider and assess site access controls, removable ballards, signs/ high vis, and security with design.	• Design • KCEC	
				7.1.1.2. signs / high vis tape	7.1.1.2. Consider physical security needs and additions for sites and monitoring responsibilities.	• Design • KCEC • SMS	
				7.1.1.3. adequate distance			
				7.1.1.4. controlled access solutions			
				7.1.1.5. physical security (possibily)			
				7.1.1.6. ballards within facility			
	7.2. INTERNAL: Impaired driver weather lack of driver training not following training or SOPs	7.2.1. Loss of containment Jet fire/explosion Asset damage Personnel injury	4	7.2.1.1. signs/ high vis tape	7.2.1.1. Include vehicle safety and training within SOP and safety plan.	• SMS • KCEC	
				7.2.1.2. vehicle barrier cables	7.2.1.2. Consider updating company vehicle technology / review compnay vehicle maintenance program.	KCEC	
				7.2.1.3. admin controls	7.2.1.3. Include signs / high vis and barriers in design	Design	
				7.2.1.4. Company vehicle SOPs and Training			
				7.2.1.5. Company			

Worksheet

Company: Kit Carson

Location: KCEC - Taos, NM

Facility: Hydrogen Power Facilities

System: 5. Utilities / Misc

Subsystem: 5.2. Human Factors

What If...	Hazard/Cause	Consequences	Consequence Level	Safeguards	Recommendations		Notes
			S		Recommendations	Responsible Owner	
				vehicle technology / back up cameras			
8. What if routine maintenance introduces debris/ contaminant?	8.1. Not following SOPs and training No inspection, pre start up process	8.1.1. Contamination of hydrogen Fouling, corrosion and damage of downstream equipment Damage to regulators, sensors and/or instrumentation	3	8.1.1.1. SOPs and Training	8.1.1.1. Provide SOPs and adequate training for maintenance and start up	SMS	
				8.1.1.2. QA/QC processes			
9. What if we can't recruit anyone for workforce development (specific to H2 facilities/equipment)?	9.1. Lack of interest No local training & development program	9.1.1. No available local workforce to operate and maintain facilities	4	9.1.1.1. Work with local college/university to implement training and development program	9.1.1.1. Work with local groups (schools) to develop training programs for potential workforce	KCEC	
				9.1.1.2. Utilize contract resources	9.1.1.2. Identify contract resources	KCEC	
				9.1.1.3. Apprenticeship program	9.1.1.3. Consider the possibility of utilizing apprenticeship program for operating and maintenance crafts.	KCEC	
10. What is the workforce requirement to fully operate the facility?	10.1. Lack of understanding workforce requirements/support needed for each component of the facility	10.1.1. Inability to staff prior to commissioning	4	10.1.1.1. Cite existing similar facilities (e.g. Plug Power Peachtree)	10.1.1.1. Include in RFP mfr guidance for PM program to establish man hour/FTE requirements per unit	• Design • KCEC • SMS	
				10.1.1.2. Understanding PM programs for selected mfr/vendors	10.1.1.2. Consider funding for training (trade schools, universities)	KCEC	
					10.1.1.3. Develop conceptual resource plan	KCEC	
					10.1.1.4. Establish training	• SMS	

Worksheet

Company: Kit Carson

Location: KCEC - Taos, NM

Facility: Hydrogen Power Facilities

System: 5. Utilities / Misc

Subsystem: 5.2. Human Factors

What If...	Hazard/Cause	Consequences	Consequence Level	Safeguards	Recommendations		Notes
			S		Recommendations	Responsible Owner	
					requirements for each expected role	• Design • KCEC	

Worksheet

Company: Kit Carson

Location: KCEC - Taos, NM

Facility: Hydrogen Power Facilities

System: 5. Utilities / Misc

Subsystem: 5.3. Water and Weather

What If...	Hazard/Cause	Consequences	Consequence Level	Safeguards	Recommendations		Notes
			S		Recommendations	Responsible Owner	
1. What if a severe weather event (flooding/seismic) damages piping or electrical systems?	1.1. Weather	1.1.1. Loss of power Loss of containment and operability Damage to assets	4	1.1.1.1. Design, material selection	1.1.1.1. Consider severe weather events in Emergency Response / Safety Plan. Include in training and mock drills.	SMS	
				1.1.1.2. Local codes and regulations	1.1.1.2. Consider severe weather events in design and material selection.	Design	
				1.1.1.3. Emergency Response			
2. What if the facility firewater system or deluge fails during a fire involving hydrogen?	2.1. Well pump failure	2.1.1. Total loss of facility	4	2.1.1.1. Parallel/ redundant well pump	2.1.1.1. Design to include redundant/parallel well pump	Design	
3. What if there is not enough water supply onsite for emergency response?	3.1. Well pump failure	3.1.1.		3.1.1.1. Conduct firewater calculations	3.1.1.1. Conduct fire water calculations and develop required fire water systems	Design	Team currently lacks understanding of fire water requirements
				3.1.1.2. Perform safety fire analysis	3.1.1.2. Establish system and protocol for procuring and transferring water from neighboring/nearby hydrants	• Design • KCEC • SMS	
				3.1.1.3. Nearby hydrant transfer system	3.1.1.3. Design backup power source for well pump	Design	
				3.1.1.4. Backup power source for well pump			
4. What if water purification system fails?	4.1. Improper maintenance, not following SOPs or PMs Plugging/clogging	4.1.1. Water rejected by electrolyzer Electrolyzer shutdown	1	4.1.1.1. Confirm acceptable water purity (measurement/	4.1.1.1. Establish appropriate maintenance practices per mfr specs (incuding corrosion checks) (for all water carrying	SMS	Potential global consideration (all water carrying systems and

Worksheet

Company: Kit Carson

Location: KCEC - Taos, NM

Facility: Hydrogen Power Facilities

System: 5. Utilities / Misc

Subsystem: 5.3. Water and Weather

What If...	Hazard/Cause	Consequences	Consequence Level	Safeguards	Recommendations		Notes
			S		Recommendations	Responsible Owner	
				reading)	systems and components)		components)
				4.1.1.2. Automated system shutdown	4.1.1.2. Design piping with appropriate materials to prevent degradation (include in RFP) (for all water carrying systems and components)	Design	
				4.1.1.3. Differential pressure monitoring	4.1.1.3. Design to include for corrosion prevention (for all water carrying systems and components)	Design	
				4.1.1.4. Routine cleaning per mfr specifications	4.1.1.4. Design for differential pressure monitoring (if needed) (for all water carrying systems and components)	Design	
5. Wildfire threat	5.1. Uncleared vegetation	5.1.1. Fire Heating storage over pressure Personnel injury Asset damage	3	5.1.1.1. Confirm clearing of nearby vegetation	5.1.1.1. Confirm with local leadership that local vegetation will be cleared	KCEC	
				5.1.1.2. Confirm clearing distances required to avoid wildfire threats	5.1.1.2. Incorporate vegetation clearance requirements into on-site personnel's inspection and maintenance program.	SMS	
				5.1.1.3. Over pressure protection	5.1.1.3. Ensure proper pressure relief for external fire scenarios, consider burst disks.	Design	
6. What is the environmental impact from fire water use and will there be an adequate drainage system?	6.1.	6.1.1.			6.1.1.1. Grade Questa site toward channel	Design	Design to include water runoff system that includes fire water

Worksheet

Company: Kit Carson

Location: KCEC - Taos, NM

Facility: Hydrogen Power Facilities

System: 5. Utilities / Misc

Subsystem: 5.3. Water and Weather

What If...	Hazard/Cause	Consequences	Consequence Level	Safeguards	Recommendations		Notes
			S		Recommendations	Responsible Owner	
7. Weather conditions or other external forces cause temporary equipment outage or preemptive temporary shutdown (protecting equipment)	7.1.	7.1.1.					Covered in #1

Worksheet

Company: Kit Carson

Location: KCEC - Taos, NM

Facility: Hydrogen Power Facilities

System: 5. Utilities / Misc

Subsystem: 5.4. Facility Siting

What If...	Hazard/Cause	Consequences	Consequence Level	Safeguards	Recommendations		Notes
			S		Recommendations	Responsible Owner	
1. Emergency response for external occupied structures	1.1. Catastrophic event	1.1.1. Potential public impact	4	1.1.1.1. Recognize ERG response per guide 115	1.1.1.1. Incorporate applicable parts of guide 115 into emergency response plan	SMS	Look at Kit Carson process for propane system
					1.1.1.2. Provide awareness/ training to local first responders (fire, sheriff)	• SMS • Design • KCEC • 3rd Party	
2. Do temporary and permanent occupied buildings provide adequate safety	2.1. Catastrophic event	2.1.1. Potential loss of life	4	2.1.1.1. API RP 752 and 753	2.1.1.1. Build and locate occupancy buildings according to regulations and codes	Design	

Worksheet

Company: Kit Carson

Location: KCEC - Taos, NM

Facility: Hydrogen Power Facilities

System: 5. Utilities / Misc

Subsystem: 5.5. Environmental

What If...	Hazard/Cause	Consequences	Consequence Level	Safeguards	Recommendations		Notes
			S		Recommendations	Responsible Owner	
1. Surface runoff	1.1.	1.1.1.					Need to confirm with EPA on rules/regulations/ requirements (next scheduled meeting planned for early 2026)
2. Applicability of OSHA 1910	2.1.	2.1.1.					Confirmed if this was addressed in Phase 1 EA
3. Applicability of EPA Risk Management Plan	3.1.	3.1.1.					Confirmed if this was addressed in Phase 1 EA
4. Wildlife threats	4.1. Rodents Snakes Deer Elk Squirrels Coyotes Mountain Lions Bears Birds	4.1.1. Damage to equipment Injury to on site personnel	2	4.1.1.1. Bird guards	4.1.1.1. Identify and design appropriate safeguards, barriers, etc. for wildlife threats.	Design	
				4.1.1.2. Perimeter barriers	4.1.1.2. Identify and implement appropriate PPE	• SMS • Design • KCEC	
				4.1.1.3. PPE 4.1.1.4. Hazard recognition training	4.1.1.3. Develop and implement training for hazard recognition and appropriate mitigation measures/actions	• SMS • KCEC	

Kit Carson Electric Cooperative
Hydrogen Technology Vendor Report

Project # 2512362.00

Prepared for:

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Prepared by:

November 7, 2025
Final Report
CONFIDENTIAL REPORT – Do not redistribute

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TABLE OF CONTENTS

1 EXECUTIVE SUMMARY

1.1 Kit Carson Hydrogen Production and Storage Project

Kit Carson Electric Cooperative (Kit Carson) has requested ENTRUST Solutions Group (ENTRUST) to research and compile hydrogen technology manufacturer information to support the development of a hydrogen technology procurement strategy for Kit Carson's hydrogen production and storage project as detailed in USDA Rural Utilities Service (RUS) New ERA Program loan application (borrower ID#NM0011).

1.2 Project Scope

This document provides the key details and findings of the various hydrogen technology manufacturers that ENTRUST directly engaged with along with ENTRUST's recommended considerations for developing a formal procurement and competitive bid strategy subject to RUS regulations pertaining to equipment sourcing and Buy American compliance.

1.3 Summary of Results and Recommendations

Available manufacturers with technologies applicable to the project's scope vary depending on the technology category, although each has a viable pathway. Within the production category, the most recognizable electrolyzer manufacturers continue to be engaged and eager to offer their product lines to Kit Carson with reasonable timelines for manufacturing and shipping.

The hydrogen-fueled power generation category presents some challenges with vendor product availability being dynamic throughout the engagement period. Both the compression and storage categories have well-established manufacturers and applicable technologies that present virtually equal weighting of pros and cons.

A future competitive bid will need to place heavy emphasis on Buy American compliance and manufacturer's ability to meet Kit Carson's procurement and construction timelines based on its New ERA project schedule. Additionally, long-term support services should be a significant consideration for scoring manufacturers' responses to a competitive bid.

2 BACKGROUND

2.1 Scope of Work

ENTRUST was tasked with reviewing ongoing or previous Kit Carson discussions with hydrogen technology and equipment manufacturers and leveraging ENTRUST's hydrogen technology expertise to establish a list of hydrogen technologies and associated manufacturers that are Buy American compliant. ENTRUST also initiated direct engagement with hydrogen technology manufacturers and vendors to better understand detailed specifications and procurement lead times.

3 METHODOLOGY

3.1 Hydrogen Equipment Categories

ENTRUST's first task was to establish the core categories of hydrogen technology and equipment manufacturers relevant to the Kit Carson New ERA project for proper side-by-side comparisons and analyses. The following are the categories established:

1. Hydrogen Production
2. Hydrogen-Fueled Power Generation
3. Hydrogen Compression
4. Hydrogen Storage

3.2 Manufacturer Research

ENTRUST's next task was to conduct research into the available manufacturers of technologies within each of the established categories to begin narrowing down the list of manufacturers to directly engage with. ENTRUST considered several factors including (in no particular order):

1. North American presence/footprint
2. Buy American compliance
3. Technology Readiness Level (TRL) of offered technology (International Energy Agency framework: https://www.iea.org/reports/innovation-gaps)
4. Recommendations from ENTRUST's hydrogen-industry network
5. Prior engagement between Kit Carson and manufacturer
6. ENTRUST's prior knowledge or familiarity with manufacturer

3.3 Direct Engagement

After narrowing the list of potentially applicable manufacturers, ENTRUST began direct engagement primarily through email requesting virtual meetings and follow-ups. Amongst the manufacturers that responded to ENTRUST's initial communication request, the majority required mutual nondisclosure agreements (NDA) in place prior to conducting any detailed conversations of their respective technology. In cases where an executed NDA does not include Kit Carson as a party or bilateral agreements established, ENTRUST is unable to share proprietary and explicit details provided by the respective manufacturer – this fact has been considered when compiling and presenting the data and information contained within this document.

3.4 Hierarchy of Considerations

To consistently assess the manufacturers across technologies, ENTRUST developed a hierarchy of considerations beginning with the most objective information on top, and down to subjective interpretation and posture. The following is ENTRUST's implemented hierarchy with #1 being the highest priority:

1. **Technical specifications** – ability to meet project scope and application.

2. **TRL and Buy American Compliance** – compliance with RUS requirements for minimum Technology Readiness Level (TRL) and the Buy American domestic sourcing thresholds.
3. **Prior experience and testimonies** – ENTRUST's existing knowledge and any previous interactions with manufacturer, including anecdotes from industry peers.
4. **External issues and indirect risks** – factors that may manifest at later project stages, including manufacturer packager partnerships, pending changes to domestic presence/footprint, or company financial health.

4 FINDINGS AND ANALYSES

Key findings, specifications, and analyses for each technology category are presented in this section.

4.1 Production

	Electrolyzer #1	Electrolyzer #2	Electrolyzer #3	Electrolyzer #4
TRL	9	9	9	9
Max Pressure (bar/psi gauge)	30 / 435	40 / 580	30 / 435	32 / 464
Per Unit Capacity (MW)	1.25, 2.5, 10	5	1.25, 2.5, 10	10
Fully Integrated Package?	Yes (smaller units only)	Yes	No	Yes
Buy America?	No	Yes	Yes	Likely
Lead Time	15 months (2 units/month)	16 months (2 units/month)	11-12 months (modules only)	18-24 months

4.1.1 Electrolyzer Subtype Discussion

ENTRUST focused on proton exchange membrane (PEM) type electrolyzer manufacturers after analyzing the specific needs and application of the project. ENTRUST's findings primarily came down to market availability and the need for quick startup operations. The table below shows a side-by-side comparison of the three most widely available electrolyzer technologies on the market today:

	Alkaline	PEM	Solid Oxide
IEA TRL	9	9	8
H2 Purity	Fuel cell grade	Fuel cell grade	Below fuel cell grade
Durability	60,000 hrs	40,000 hrs	20,000 hrs
CAPEX (DOE 2020)	$1500 / kW	$2200 / kW	$5000 / kW
OPEX (DOE 2020)	$75 / kW / yr	$110 / kW / yr	$250 / kW / yr
Cold Start up Time	< 1 hr	< 5 mins	4 to 24 hr
Output Pressure	30 bar	30-40 bar	< 1 bar
Water Purity Need	Low	High	High

4.2 Hydrogen-Fueled Power Generation

	Power Gen #1	Power Gen #2	Power Gen #3	Power Gen #4
TRL	9	9	8	9
Per Unit Capacity (MW)	0.25	1	0.30	0.80
H2 Purity (%)	Any	99.95	99.90	Unknown (likely 99.9+)
Buy America?	No	Yes	Unknown	No
Start Up Time	< 1 min	< 5 min	> 1 hr	< 5 min

4.3 Compression

	Compressor #1	Compressor #2
Type	Reciprocating	Reciprocating
TRL	11	11
Location	Assembly in USA	Assembly in USA
Max Pressure	550 bar	500 bar
Buy America?	Yes	Yes
Sales Availability	Available	Available

4.4 Storage

	Storage #1	Storage #2
Type	Composite Wrap	Steel
Subtype	Type 3 (aluminum seamless, fully wrapped carbon fiber)	Seamless
TRL	11	11
Sales Availability	Available	Available
Max pressure	345 bar (5003 psi)	250 bar (3625 psi)
Location	HQ and manufacturing in USA	HQ and manufacturing in USA
Buy America?	Yes	Yes

Manufacturer Notes:

5 CONCLUSION AND RECOMMENDATIONS

Available manufacturers with technologies applicable to the project's scope vary depending on the technology category, although each has a viable pathway. Within the production category, the most recognizable electrolyzer manufacturers continue to be engaged and eager to offer their product lines to Kit Carson with reasonable timelines for manufacturing. The hydrogen-fueled power generation category presents some challenges with vendor product availability being dynamic throughout the engagement period. Both the compression and storage categories have well-established manufacturers and applicable technologies that present virtually equal weighting of pros and cons.

A future competitive bid will need to make Buy American compliance and manufacturer's ability to meet Kit Carson's procurement and construction timelines the highest priority in the vendor selection process. Additionally, long-term support services should be a significant consideration for scoring manufacturers' responses to a competitive bid.

ENTRUST will ensure that the competitive bid will be listed in a public-facing portal on the Kit Carson website. Note that the actual list of vendors invited may be subject to change based on several unpredictable factors, including changes in vendor's manufacturing capabilities, market availability, financial health, or willingness to participate in a bid process. Additionally, vendors not previously engaged may be invited to the competitive bid based on similar changes in market conditions.

6 ADDITIONAL DISCUSSION

The content within this report is a combination of publicly available information and both non-confidential and confidential data as well as conversations with each of the unnamed manufacturers. ENTRUST's analyses and recommendations are for Kit Carson's consideration only and should not be used to inform external entities and projects outside of the current scope of work. The hydrogen technology space is very dynamic and continues to be impacted by various external factors such as manufacturer packager partnerships, pending changes to domestic presence/footprint, or company financial health, that have the potential to create unexpected changes in product availability or technology viability. Although ENTRUST will continue to assess market conditions and technology manufacturers with applicable products, ENTRUST cannot guarantee that the information, analyses, and recommendations in this report will remain accurate at the time of competitive bid solicitation.

KCEC H_2 Project Consequence Screening Studies - FINAL

ENTrust, Northern New Mexico

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BakerRisk Project No. 01-09679-001-25
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Agenda

1 Introductions and Objective

2 Project Milestones

3 Consequence Screening Workflow Process

4 Consequence Analysis Results

5 Conclusion and Next Steps

Consequence Analysis Objectives, Timeline, and Workflow

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Scope of Work

- ENTrust contracted BakerRisk to perform initial consequence screening studies for three greenfield sites for the KCEC Hydrogen Project located in northern New Mexico.
    - Picuris
    - Taos
    - Questa
- The purpose of this screening is to identify potential consequence contours and building damage level (BDL) contours for loss of containment H_2 scenarios defined by ENTrust.
- Note that a full facility siting study (FSS) is not currently in scope but can be developed as a follow-on activity as project conditions are finalized.

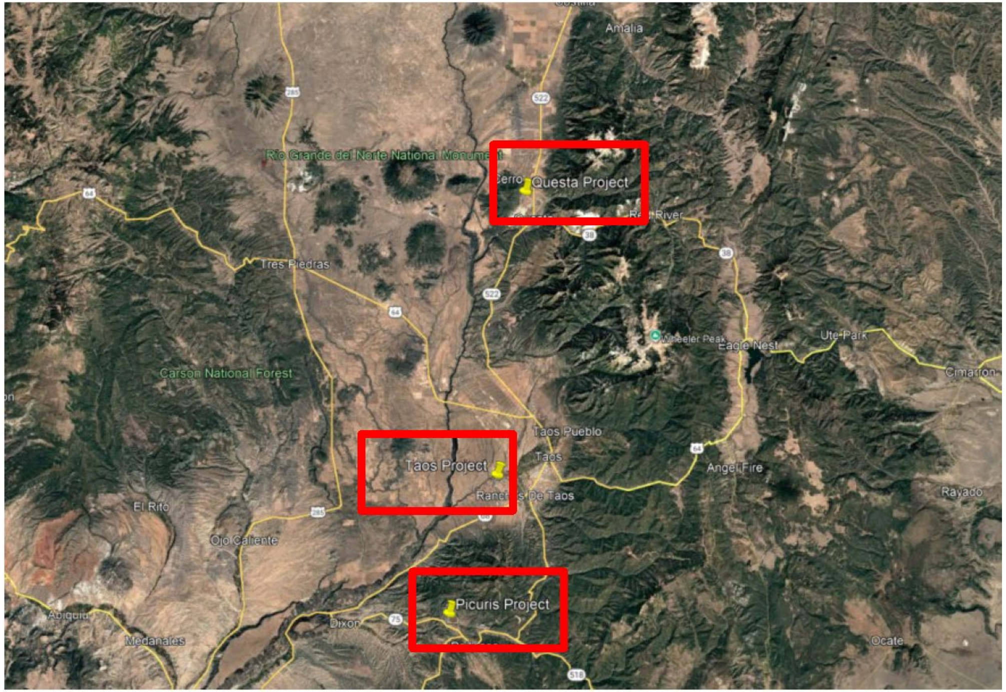


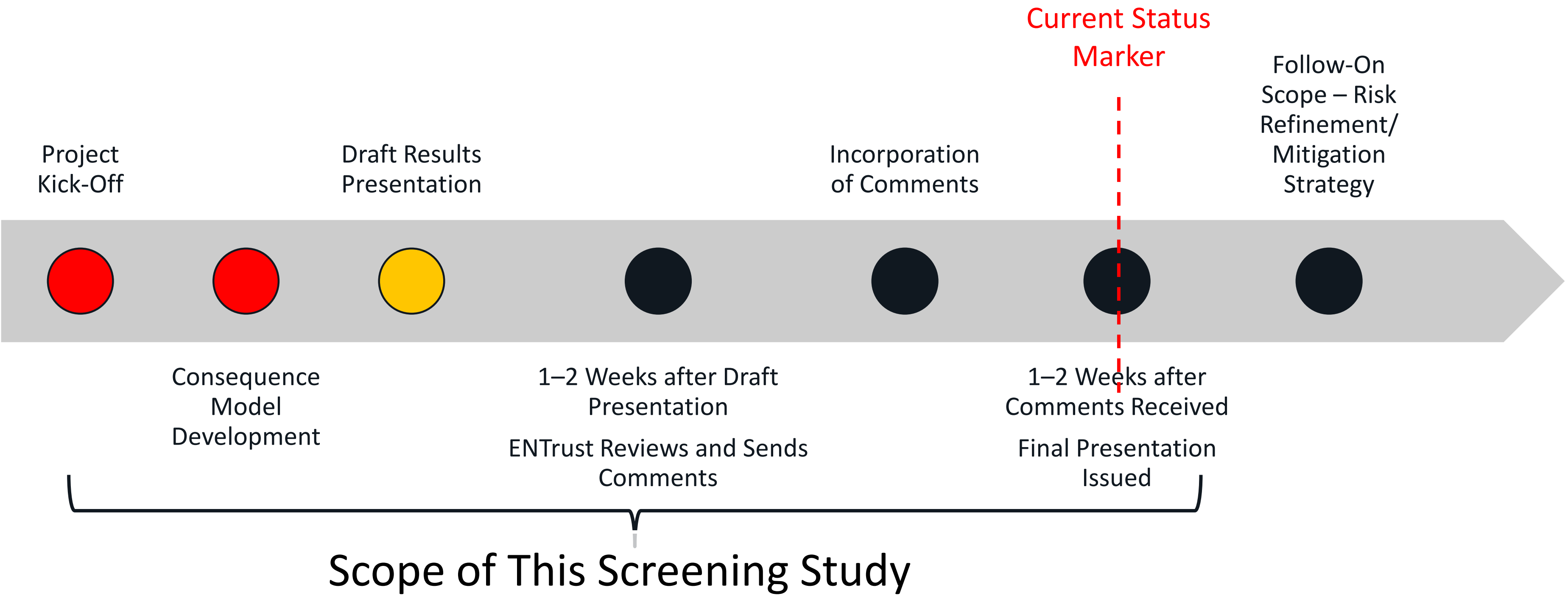
Image obtained from Google Earth™ mapping service.

Scope of Work – Building Construction Selections

- Modeled five total construction types for BDLs based on structures observed via Google Earth™ and through discussions with ENTrust:

    1. Light Wood Trailer – BEAST Type 18.
    2. Wood Residential – 2015 ERC Study #4.
    3. PEMB – Generic SDOF model based on conventional loads.
    4. LB Masonry – Generic SDOF model based on load-bearing capacity of typical 8-inch block walls spanning 8 feet tall (walls will control response).
        - Steel-framed with masonry infill – LB masonry model will be a conservative representation of this structure's response.
    5. ISO Container – BEAST Type 19.

Key Milestones



Consequence Analysis Inputs - Picuris

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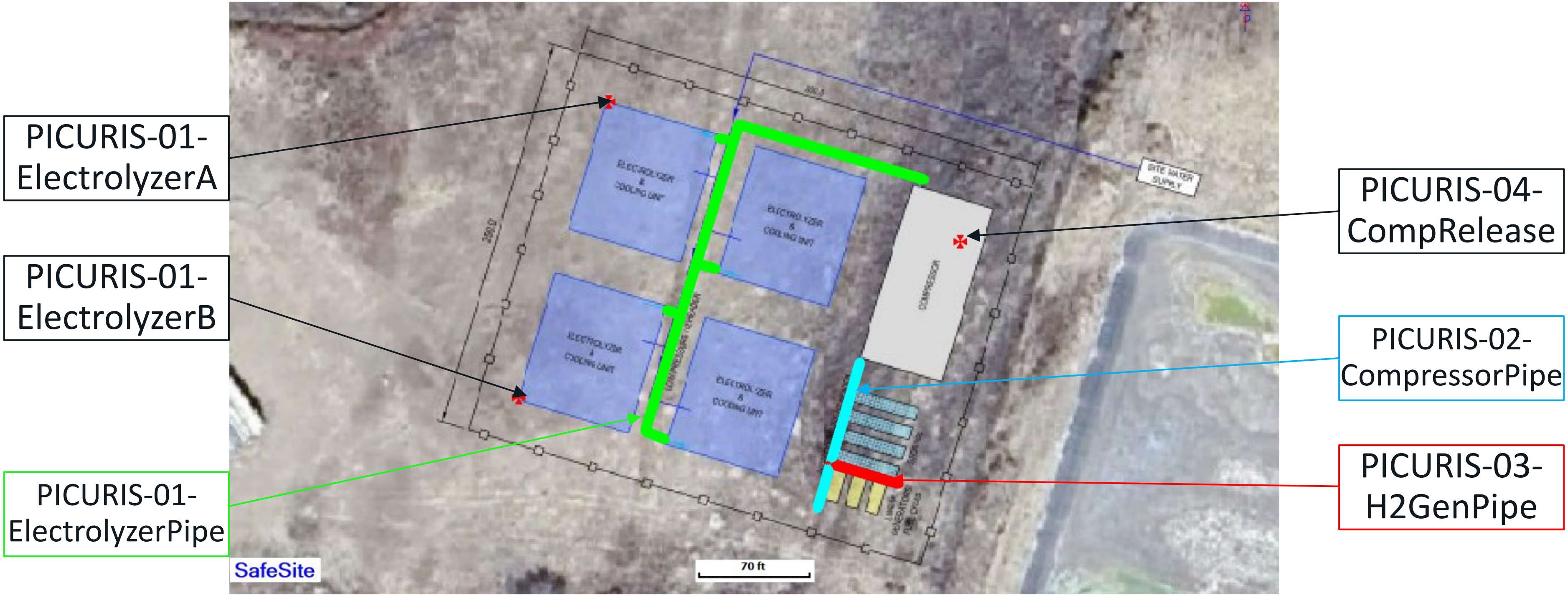
Source Definitions - Picuris



Release Case Definitions - Picuris

Source	Description	Material	Temperature (F)	Pressure (psig)	State	Max Size (in dia)	Internal Source
PICURIS-01-ElectrolyzerPipe	Picuris: Hydrogen from Electrolyzers to Compressor	HYDROGEN	70	400	Gas	1.25	
PICURIS-02-CompressorPipe	Picuris: Hydrogen Compressor Discharge to Storage and L-Gen	HYDROGEN	70	5,000	Gas	1	
PICURIS-03-H2GenPipe	Picuris: Hydrogen Header to Generators	HYDROGEN	70	300	Gas	1	
PICURIS-04-CompRelease	Picuris: Internal Compressor Release	HYDROGEN	70	5,000	Gas	1	✓
PICURIS-06-ElectrolyzerA	Picuris: Hydrogen Release from Electrolyzer	HYDROGEN	70	400	Gas	1.25	
PICURIS-06-ElectrolyzerB	Picuris: Hydrogen Release from Electrolyzer	HYDROGEN	70	400	Gas	1.25	

- Release sizes of 0.5-inch and full bore up to 1.25 inches in diameter were assessed for each release.
- Releases were dispersed in 16 wind directions for four weather conditions based on meteorological data for Taos Regional Airport in El Prado, New Mexico, for the years 2020–2024.
- Process conditions were provided by ENTrust.

Additional Fill Cases - Picuris

<table>
<tr><th>Scenario Name</th><th>Scenario</th><th>Fill %</th><th>#FuelCell01</th><th>#FuelCell02</th><th>#FuelCell03</th><th>*CompEncl_001</th><th>*CompEncl_002</th><th>*CompEncl_003</th><th>*CompEncl_004</th><th>*CompEncl_005</th><th>*CompEncl_006</th><th>Volume (ft^3)</th><th>Material</th><th>Material Reactivity</th><th>Total Energy (in-lb)</th></tr>
<tr><td>PICURIS-05-FuelCell01-Fill90</td><td>Fuel Cell 1</td><td>90</td><td>X</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>1,344</td><td>HYDROGEN</td><td>High</td><td>9.0E+8</td></tr>
<tr><td>PICURIS-05-FuelCell02-Fill90</td><td>Fuel Cell 2</td><td>90</td><td></td><td>X</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>1,344</td><td>HYDROGEN</td><td>High</td><td>9.0E+8</td></tr>
<tr><td>PICURIS-05-FuelCell03-Fill90</td><td>Fuel Cell 3</td><td>90</td><td></td><td></td><td>X</td><td></td><td></td><td></td><td></td><td></td><td></td><td>1,441</td><td>HYDROGEN</td><td>High</td><td>9.6E+8</td></tr>
<tr><td>Indoor Dispersion: PICURIS-04-CompRelease-1</td><td>CompEnclosure, 90% Fill</td><td>90</td><td rowspan="6"></td><td rowspan="6"></td><td rowspan="6"></td><td rowspan="6">X</td><td rowspan="6">X</td><td rowspan="6">X</td><td rowspan="6">X</td><td rowspan="6">X</td><td rowspan="6">X</td><td rowspan="6">155,254</td><td rowspan="6">HYDROGEN</td><td rowspan="6">High</td><td>1.0E+11</td></tr>
<tr><td>Indoor Dispersion: PICURIS-04-CompRelease-1</td><td>CompEnclosure, 50% Fill</td><td>50</td><td>5.8E+10</td></tr>
<tr><td>Indoor Dispersion: PICURIS-04-CompRelease-1</td><td>CompEnclosure, 25% Fill</td><td>25</td><td>2.9E+10</td></tr>
<tr><td>Indoor Dispersion: PICURIS-04-CompRelease-0.5</td><td>CompEnclosure, 90% Fill</td><td>90</td><td>1.0E+11</td></tr>
<tr><td>Indoor Dispersion: PICURIS-04-CompRelease-0.5</td><td>CompEnclosure, 50% Fill</td><td>50</td><td>5.8E+10</td></tr>
<tr><td>Indoor Dispersion: PICURIS-04-CompRelease-0.5</td><td>CompEnclosure, 25% Fill</td><td>25</td><td>2.9E+10</td></tr>
</table>

- BakerRisk also included scenarios assuming a fuel cell fill of 90% and a compressor enclosure that would fill with flammable concentration based on release size and result in an indoor dispersion.
  - Compressor enclosure was assumed to have an HVAC of 1 ACH and building air change of 3 ACH at 5 mph.

Define Zones of Congestion/Confinement - Picuris

- Document levels of congestion and confinement by reviewing plot plans and aerial views of each site.
- Define potential explosion sites (PES).
- Distinguish between zones internal to buildings and zones susceptible to gas infiltration.

Overall Model - Picuris

Consequence Analysis Inputs - Questa

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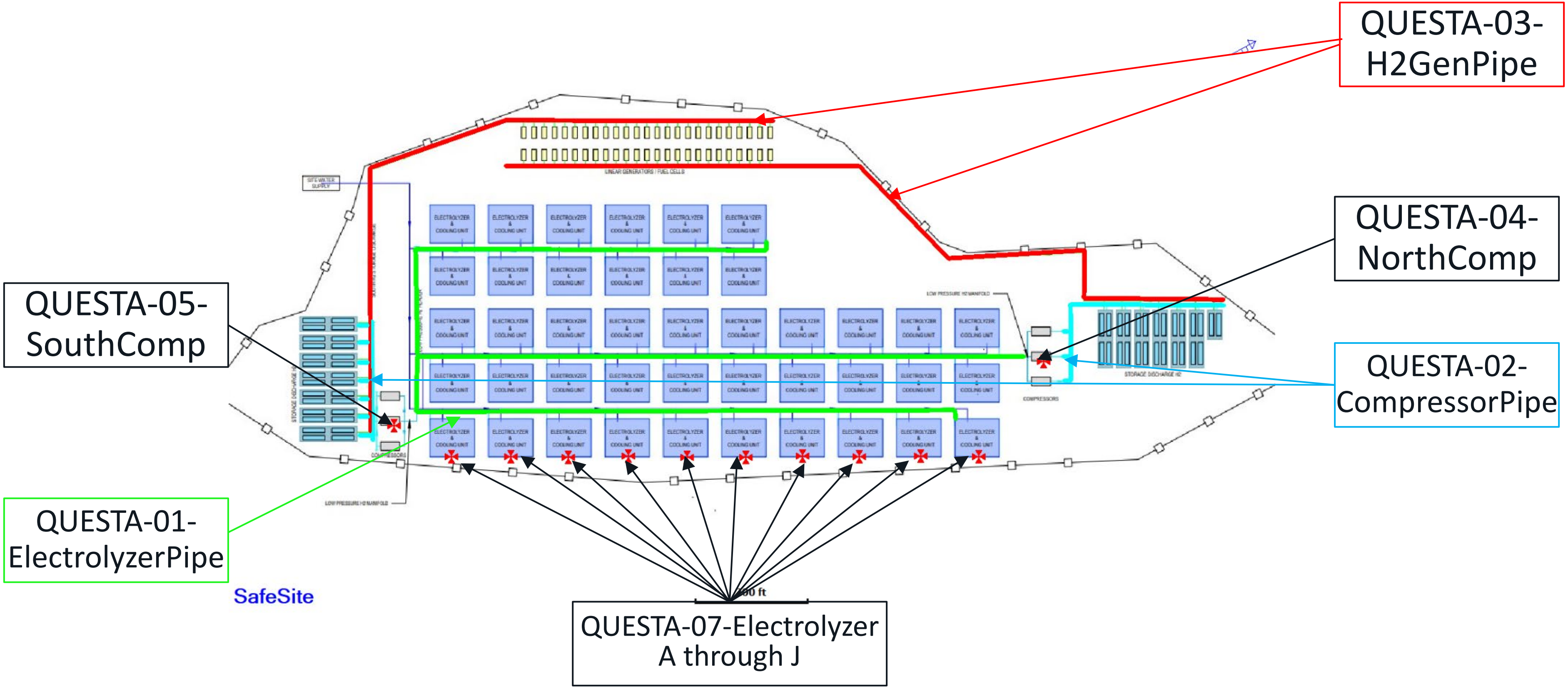
Source Definitions - Questa



Release Case Definitions - Questa

Source	Description	Material	Temperature (F)	Pressure (psig)	State	Max Size (in dia)	Internal Source
QUESTA-01-ElectrolyzerPipe	Questa: Hydrogen from Electrolyzers to Compressor	HYDROGEN	70	400	Gas	6	
QUESTA-02-CompressorPipe	Questa: Hydrogen Compressor Discharge to Storage and L-Gen	HYDROGEN	70	5,000	Gas	2	
QUESTA-03-H2GenPipe	Questa: Hydrogen Header to Generators	HYDROGEN	70	300	Gas	4	
QUESTA-04-NorthComp	Questa: North Compressor Fill Case	HYDROGEN	70	5,000	Gas	2	✓
QUESTA-05-SouthComp	Questa: South Compressor Fill Case	HYDROGEN	70	5,000	Gas	2	✓
QUESTA-07-ElectrolyzerA	Questa: Hydrogen Release from Electrolyzer	HYDROGEN	70	400	Gas	6	
QUESTA-07-ElectrolyzerB	Questa: Hydrogen Release from Electrolyzer	HYDROGEN	70	400	Gas	6	
QUESTA-07-ElectrolyzerC	Questa: Hydrogen Release from Electrolyzer	HYDROGEN	70	400	Gas	6	
QUESTA-07-ElectrolyzerD	Questa: Hydrogen Release from Electrolyzer	HYDROGEN	70	400	Gas	6	
QUESTA-07-ElectrolyzerE	Questa: Hydrogen Release from Electrolyzer	HYDROGEN	70	400	Gas	6	
QUESTA-07-ElectrolyzerF	Questa: Hydrogen Release from Electrolyzer	HYDROGEN	70	400	Gas	6	
QUESTA-07-ElectrolyzerG	Questa: Hydrogen Release from Electrolyzer	HYDROGEN	70	400	Gas	6	
QUESTA-07-ElectrolyzerH	Questa: Hydrogen Release from Electrolyzer	HYDROGEN	70	400	Gas	6	
QUESTA-07-ElectrolyzerI	Questa: Hydrogen Release from Electrolyzer	HYDROGEN	70	400	Gas	6	
QUESTA-07-ElectrolyzerJ	Questa: Hydrogen Release from Electrolyzer	HYDROGEN	70	400	Gas	6	

- Release sizes of 0.5-inch, 2-inch, and full bore up to 6 inches in diameter were assessed for each release.
- Releases were dispersed in 16 wind directions for four weather conditions based on meteorological data for Taos Regional Airport in El Prado, New Mexico, for the years 2020–2024.
- Process conditions were provided by ENTrust.

Additional Fill Cases - Questa

Scenario Name	Scenario	Fill %	#FuelCell_01	#FuelCell_02	#FuelCell_03	*NorthComp_001	*NorthComp_002	*NorthComp_003	*NorthComp_004	*NorthComp_005	*NorthComp_006	*NorthComp_007	*NorthComp_008	*NorthComp_009	*NorthComp_010	*NorthComp_011	*NorthComp_012	*NorthComp_013	*NorthComp_014	*SouthComp_001	*SouthComp_002	*SouthComp_003	*SouthComp_004	*SouthComp_005	*SouthComp_006	*SouthComp_007	*SouthComp_008	*SouthComp_009	*SouthComp_010	*SouthComp_011	*SouthComp_012	*SouthComp_013	*SouthComp_014	Volume (ft^3)	Material	Material Reactivity	Total Energy (in-lb)
QUESTA-06-FuelCell01-Fill90	Fuel Cell 1	90	X																															1,680	HYDROGEN	High	1.1E+9
QUESTA-06-FuelCell02-Fill90	Fuel Cell 2	90		X																														1,680	HYDROGEN	High	1.1E+9
QUESTA-06-FuelCell03-Fill90	Fuel Cell 3	90			X																													1,680	HYDROGEN	High	1.1E+9
Indoor Dispersion: QUESTA-05-SouthComp-2	SouthComp, 90% Fill	90																		X	X	X	X	X	X	X	X	X	X	X	X	X	X	199,327	HYDROGEN	High	1.3E+11
Indoor Dispersion: QUESTA-05-SouthComp-2	SouthComp, 50% Fill	50																																			7.4E+10
Indoor Dispersion: QUESTA-05-SouthComp-2	SouthComp, 25% Fill	25																																			3.7E+10
Indoor Dispersion: QUESTA-05-SouthComp-0.5	SouthComp, 90% Fill	90																																			1.3E+11
Indoor Dispersion: QUESTA-05-SouthComp-0.5	SouthComp, 50% Fill	50																																			7.4E+10
Indoor Dispersion: QUESTA-05-SouthComp-0.5	SouthComp, 25% Fill	25																																			3.7E+10
Indoor Dispersion: QUESTA-04-NorthComp-2	NorthComp, 90% Fill	90				X	X	X	X	X	X	X	X	X	X	X	X	X	X															199,329	HYDROGEN	High	1.3E+11
Indoor Dispersion: QUESTA-04-NorthComp-2	NorthComp, 50% Fill	50																																			7.4E+10
Indoor Dispersion: QUESTA-04-NorthComp-2	NorthComp, 25% Fill	25																																			3.7E+10
Indoor Dispersion: QUESTA-04-NorthComp-0.5	NorthComp, 90% Fill	90																																			1.3E+11
Indoor Dispersion: QUESTA-04-NorthComp-0.5	NorthComp, 50% Fill	50																																			7.4E+10
Indoor Dispersion: QUESTA-04-NorthComp-0.5	NorthComp, 25% Fill	25																																			3.7E+10

- BakerRisk also included scenarios assuming a fuel cell fill of 90% and a compressor enclosure that would fill with flammable concentration based on release size and result in an indoor dispersion.
  - Compressor enclosure was assumed to have an HVAC of 1 ACH and building air change of 3 ACH at 5 mph.
- See results spreadsheet, ***Fill*** tab, for full list of scenarios.

Define Zones of Congestion/Confinement - Questa

- Document levels of congestion and confinement by reviewing plot plans and aerial views of each site.
- Define PES.
- Distinguish between zones internal to buildings and zones susceptible to gas infiltration.

Overall Model - Questa

Consequence Analysis Inputs - Taos

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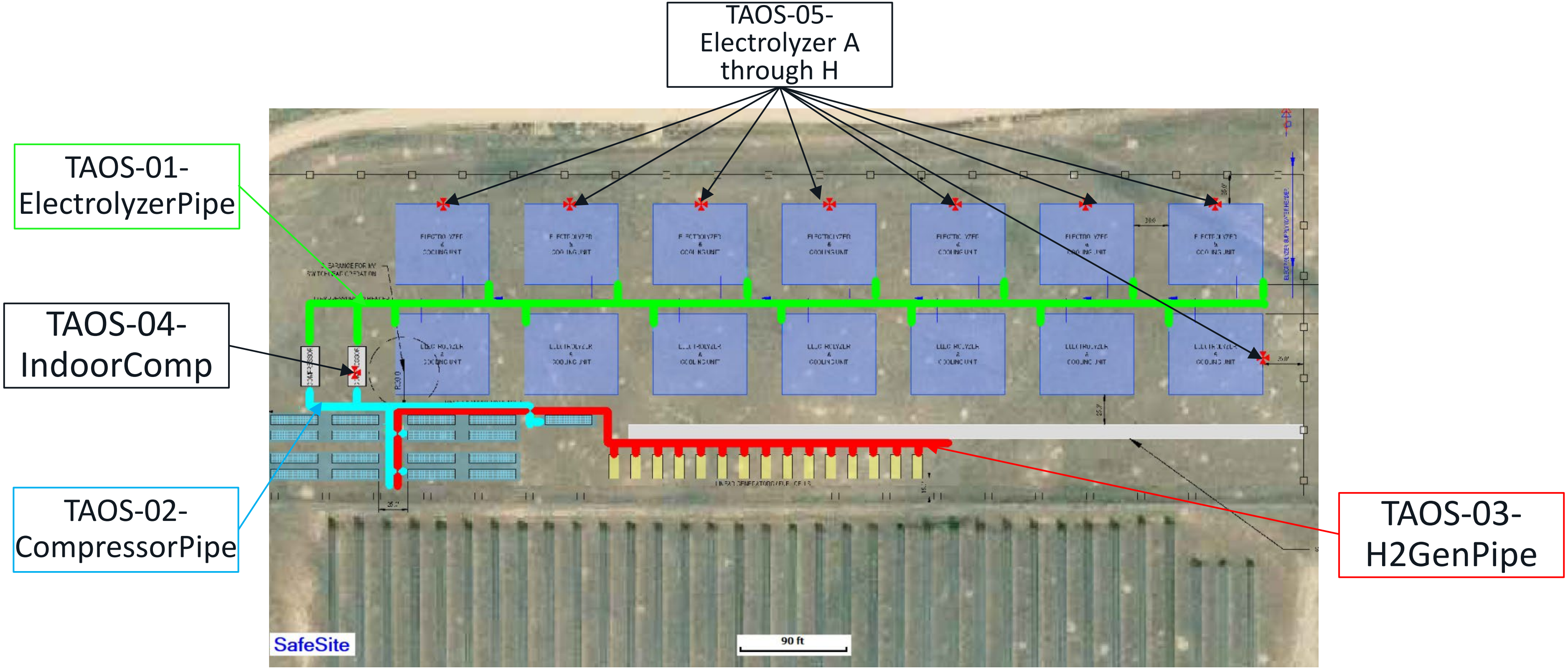
Source Definitions - Taos



Release Case Definitions - Taos

Source	Description	Material	Temperature (F)	Pressure (psig)	State	Max Size (in dia)	Internal Source
TAOS-01-ElectrolyzerPipe	Taos: Hydrogen from Electrolyzers to Compressor	HYDROGEN	70	400	Gas	2.5	
TAOS-02-CompressorPipe	Taos: Hydrogen Compressor Discharge to Storage and L-Gen	HYDROGEN	70	5,000	Gas	1	
TAOS-03-H2GenPipe	Taos: Hydrogen Header to Generators	HYDROGEN	70	300	Gas	2	
TAOS-04-Indoor_Comp_Release	Taos: Indoor Compressor Release	HYDROGEN	70	5,000	Gas	1	✓
TAOS-05-ElectrolyzerA	Taos: Hydrogen Release from Electrolyzer	HYDROGEN	70	400	Gas	2.5	
TAOS-05-ElectrolyzerB	Taos: Hydrogen Release from Electrolyzer	HYDROGEN	70	400	Gas	2.5	
TAOS-05-ElectrolyzerC	Taos: Hydrogen Release from Electrolyzer	HYDROGEN	70	400	Gas	2.5	
TAOS-05-ElectrolyzerD	Taos: Hydrogen Release from Electrolyzer	HYDROGEN	70	400	Gas	2.5	
TAOS-05-ElectrolyzerE	Taos: Hydrogen Release from Electrolyzer	HYDROGEN	70	400	Gas	2.5	
TAOS-05-ElectrolyzerF	Taos: Hydrogen Release from Electrolyzer	HYDROGEN	70	400	Gas	2.5	
TAOS-05-ElectrolyzerG	Taos: Hydrogen Release from Electrolyzer	HYDROGEN	70	400	Gas	2.5	
TAOS-05-ElectrolyzerH	Taos: Hydrogen Release from Electrolyzer	HYDROGEN	70	400	Gas	2.5	

- Release sizes of 0.5-inch, 2-inch, and full bore up to 2.5 inches in diameter were assessed for each release.
- Releases were dispersed in 16 wind directions for four weather conditions based on meteorological data for Taos Regional Airport in El Prado, New Mexico, for the years 2020–2024.
- Process conditions were provided by ENTrust.

Additional Fill Cases - Taos

Scenario Name	Scenario	Fill %	*CompEnclosure_001	*CompEnclosure_002	*CompEnclosure_003	*CompEnclosure_004	*CompEnclosure_005	*CompEnclosure_006	*CompEnclosure_007	Zone_066	Zone_067	Zone_068	Volume (ft^3)	Material	Material Reactivity	Total Energy (in-lb)
TAOS-05-Fuel_Cell01-Fill90	Fuel Cell 1	90								X			1,344	HYDROGEN	High	9.0E+8
TAOS-05-Fuel_Cell02-Fill90	Fuel Cell 2	90									X		1,344	HYDROGEN	High	9.0E+8
TAOS-05-Fuel_Cell03-Fill90	Fuel Cell 3	90										X	1,344	HYDROGEN	High	9.0E+8
Indoor Dispersion: TAOS-04-Indoor_Comp_Release-1	CompEnclosure, 90% Fill	90	X	X	X	X	X	X	X				58,625	HYDROGEN	High	3.9E+10
Indoor Dispersion: TAOS-04-Indoor_Comp_Release-1	CompEnclosure, 50% Fill	50														2.2E+10
Indoor Dispersion: TAOS-04-Indoor_Comp_Release-1	CompEnclosure, 25% Fill	25														1.1E+10
Indoor Dispersion: TAOS-04-Indoor_Comp_Release-0.5	CompEnclosure, 90% Fill	90														3.9E+10
Indoor Dispersion: TAOS-04-Indoor_Comp_Release-0.5	CompEnclosure, 50% Fill	50														2.2E+10
Indoor Dispersion: TAOS-04-Indoor_Comp_Release-0.5	CompEnclosure, 25% Fill	25														1.1E+10

- BakerRisk also included scenarios assuming a fuel cell fill of 90% and a compressor enclosure that would fill with flammable concentration based on release size and result in an indoor dispersion.
  - Compressor enclosure was assumed to have an HVAC of 1 ACH and building air change of 3 ACH at 5 mph.
- Full list of fill cases in spreadsheet, ***Fill*** tab.

Define Zones of Congestion/Confinement - Taos

- Document levels of congestion and confinement by reviewing plot plans and aerial views of each site.
- Define PES.
- Distinguish between zones internal to buildings and zones susceptible to gas infiltration.

Overall Model - Taos

Consequence Analysis Methodology

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Thermal Radiation Thresholds

Thermal Flux (kW/m²)	Observed Effect (CCPS)*
37.5	Sufficient to cause damage to process equipment
12.5	Minimum energy required piloted ignition of wood, melting of plastic tubing
4	Sufficient to cause pain to personnel if unable to reach cover within 20 sec, however blistering of the skin (second degree burns) is likely; 0% lethality

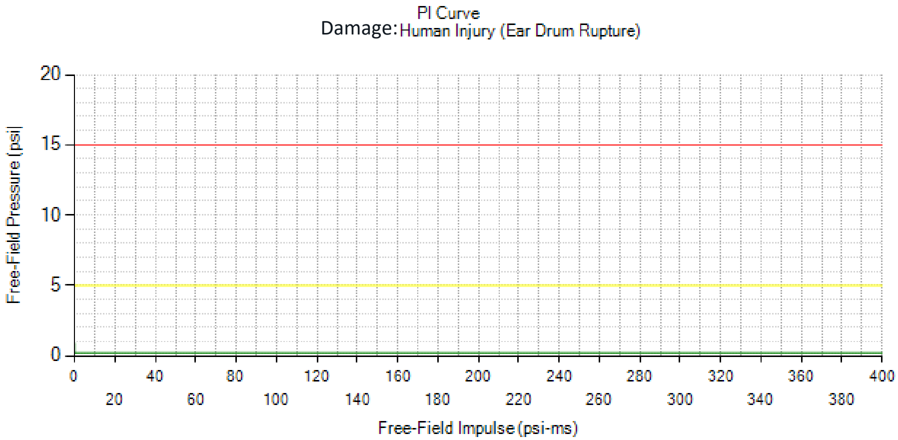
* Guideline for Consequence Analysis of Chemical Releases (CCPS 1999)

Building Damage Levels

- Qualitative categories of damage that represent different levels of vulnerability to building occupants

BDL	Damage Description
1	Walls sustain the onset of visible damage. The building can be reused, and repairs are necessary for cosmetic reasons only.
2	Localized damage. Walls facing the blast sustain moderate damage, while other walls and the roof sustain minor to moderate damage. Building can be repaired and reused.
2.5	Widespread building damage. Walls facing the blast sustain major damage, while other walls and the roof sustain moderate damage. Building repair may not be practical.
3	Walls facing the blast fail, while other walls have compromised structural integrity. This may cause eventual collapse of the building. Building repair is not practical.
4	Primary and secondary structural members fail or sustain major damage resulting in building collapse.

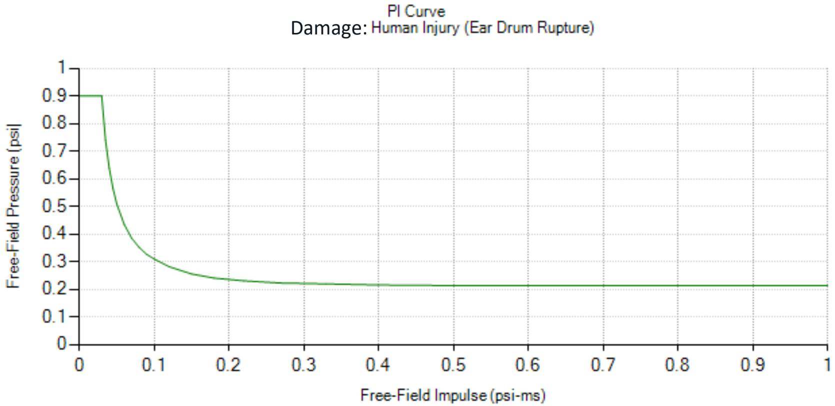
Ear Damage Thresholds



Temporary Threshold Shift

Rupture Threshold

50% Rupture

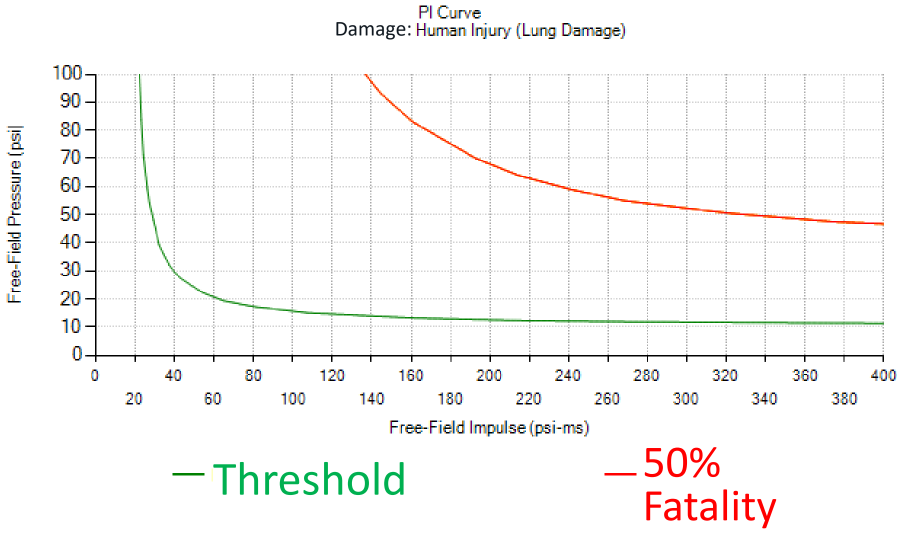


Temporary Threshold Shift

Ear drum ruptures are not scaled and apply to all human targets.

UFC 3-340-02 on Human Injury, Change 2, September 1, 2014.

Lung Damage Thresholds



Both lung curves are based on a 154-lb male, which is the recommended weight per UFC.

UFC 3-340-02 on Human Injury, Change 2, September 1, 2014.

Consequence Results: Contours - Picuris

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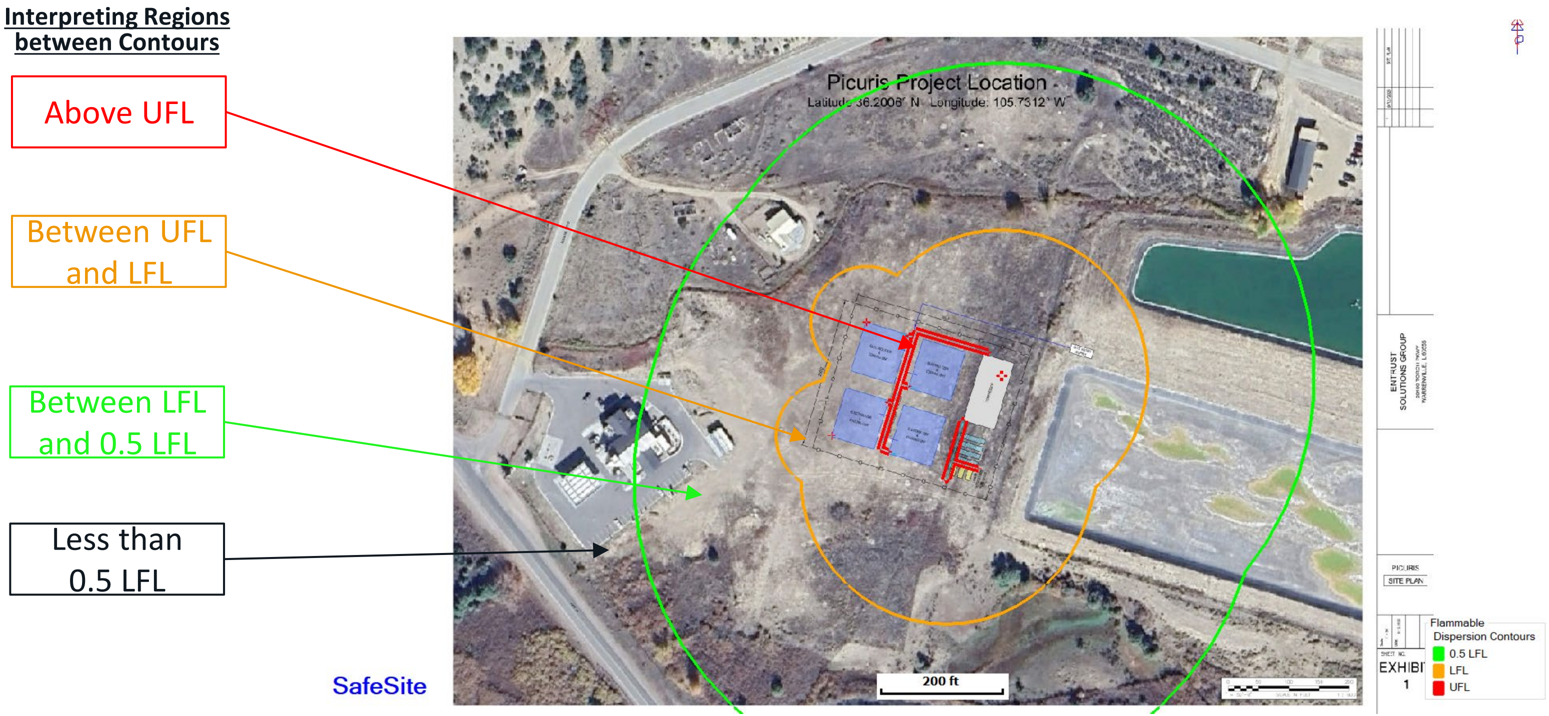
Consequence Analysis Results – Flammable Dispersion Contours



Flammable Dispersion Contours for All Release Scenarios Assessed

Consequence Analysis Results – Thermal Radiation Flux Contours

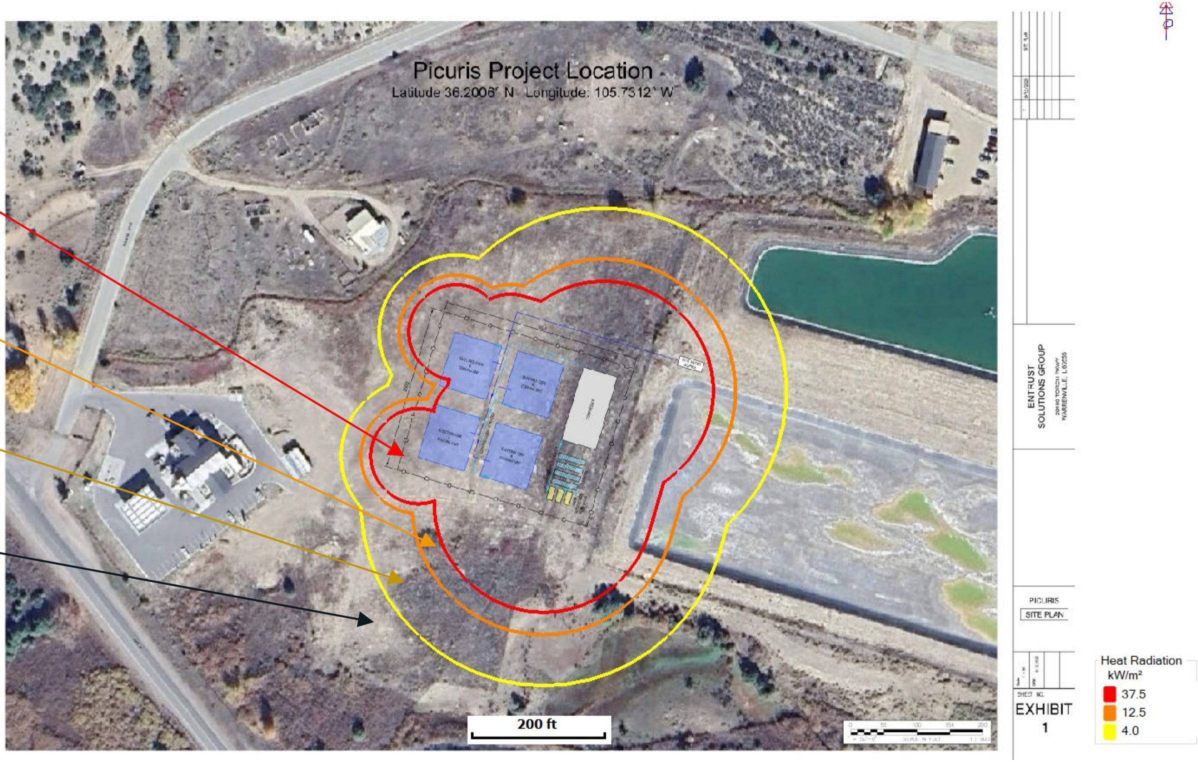
Interpreting Regions between Contours

Above 37.5 kW/m²

Between 12.5 and 37.5 kW/m²

Between 4.0 and 12.5 kW/m²

Below 4.0 kW/m²



SafeSite

Thermal Radiation Contours for All Release Scenarios Assessed

Consequence Analysis Results – Overpressure Contours

Interpreting Regions between Contours

Above 10 psig

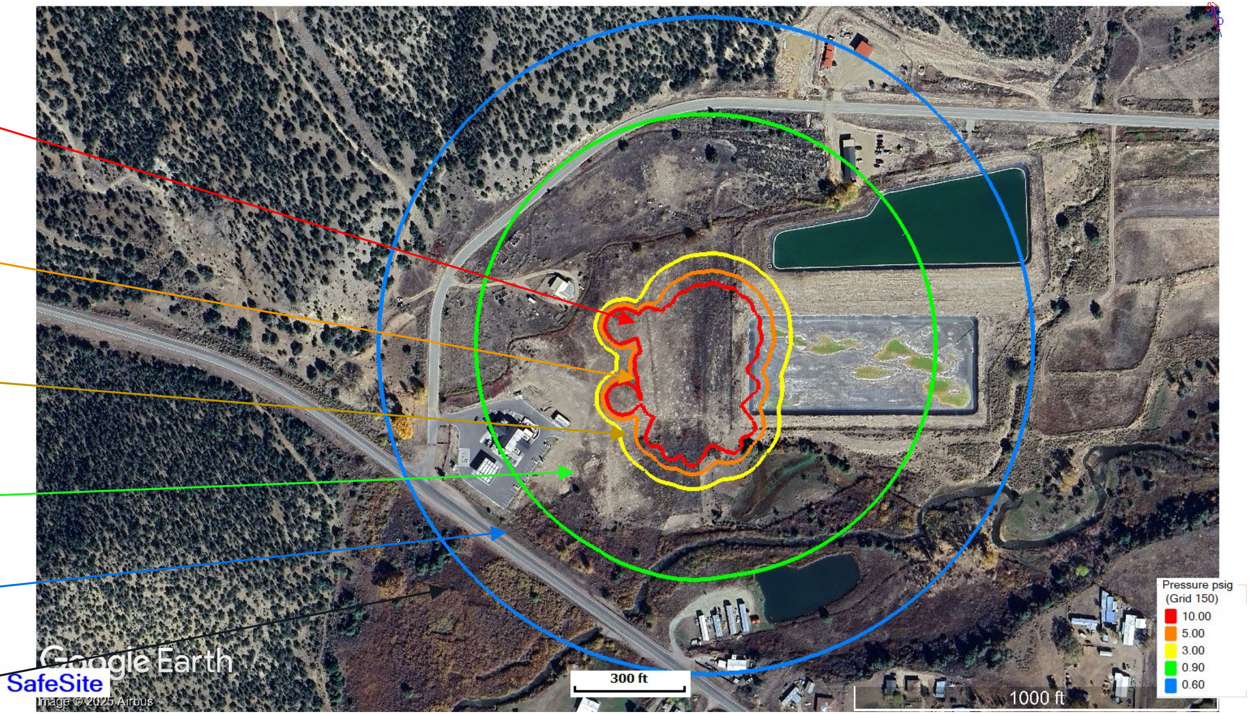
Between 5 and 10 psig

Between 3 and 5 psig

Between 0.9 and 3 psig

Between 0.6 and 0.9 psig

Below 0.6 psig



Side-On Overpressure Contours for All Release Scenarios Assessed, DDT-Out Excluded

Consequence Analysis Results – Impulse Contours

Interpreting Regions between Contours

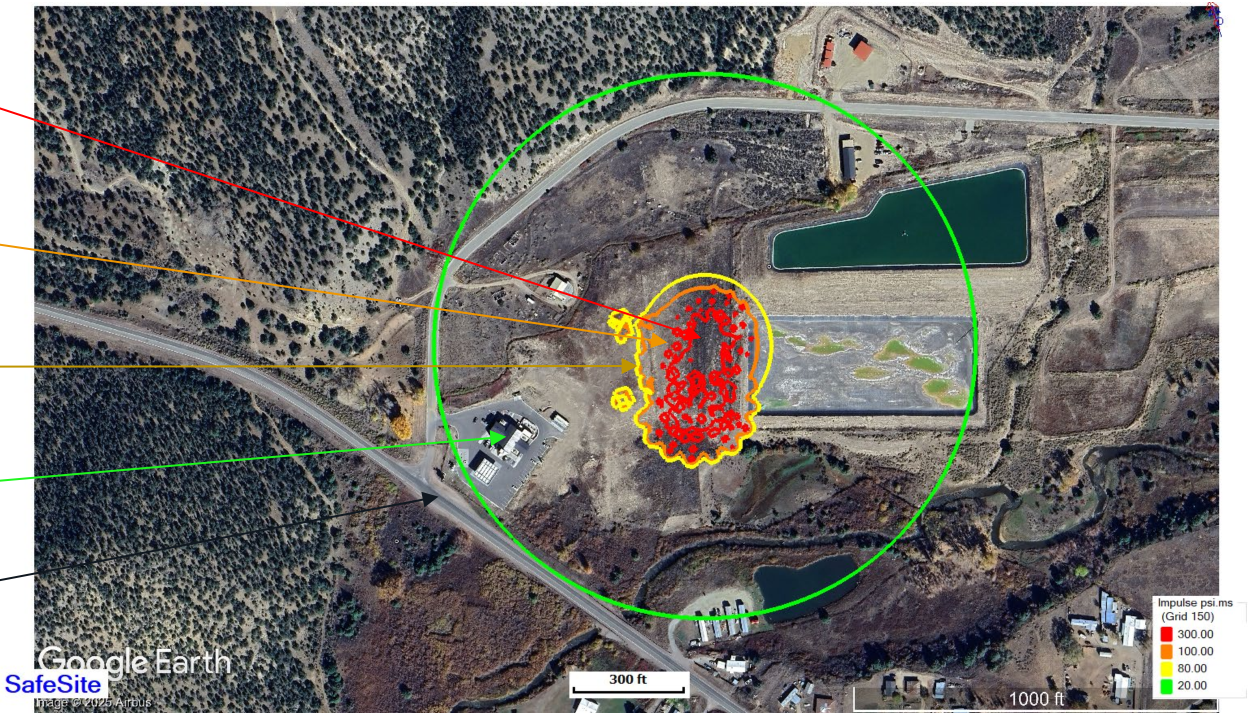
Above 300 psig.ms

Between 100 and 300 psig.ms

Between 80 and 100 psig.ms

Between 20 and 80 psig.ms

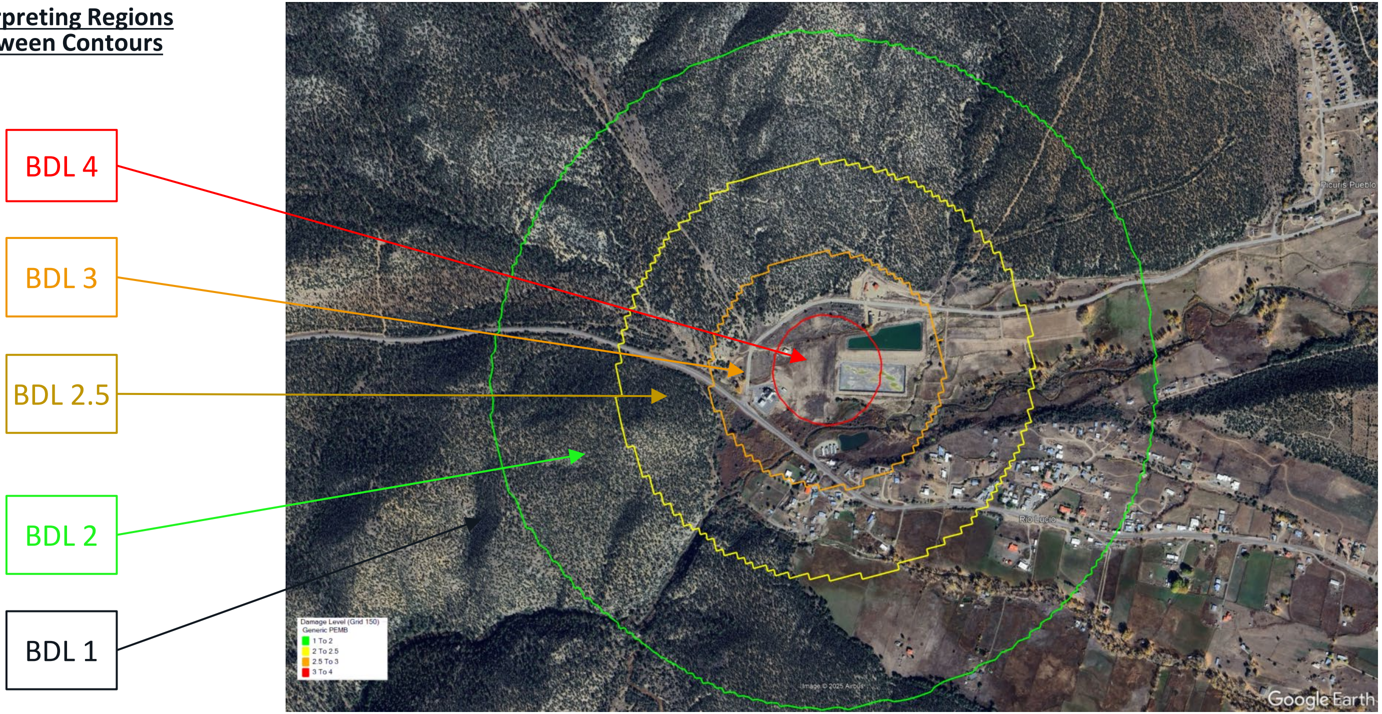
Below 20 psig.ms



Side-On Impulse Contours for All Release Scenarios Assessed

Consequence Analysis Results – BDL Contours: Generic PEMB

Interpreting Regions between Contours



BDL Contours for All Release Scenarios Assessed

Consequence Analysis Results – BDL Contours: ISO Container

Interpreting Regions between Contours

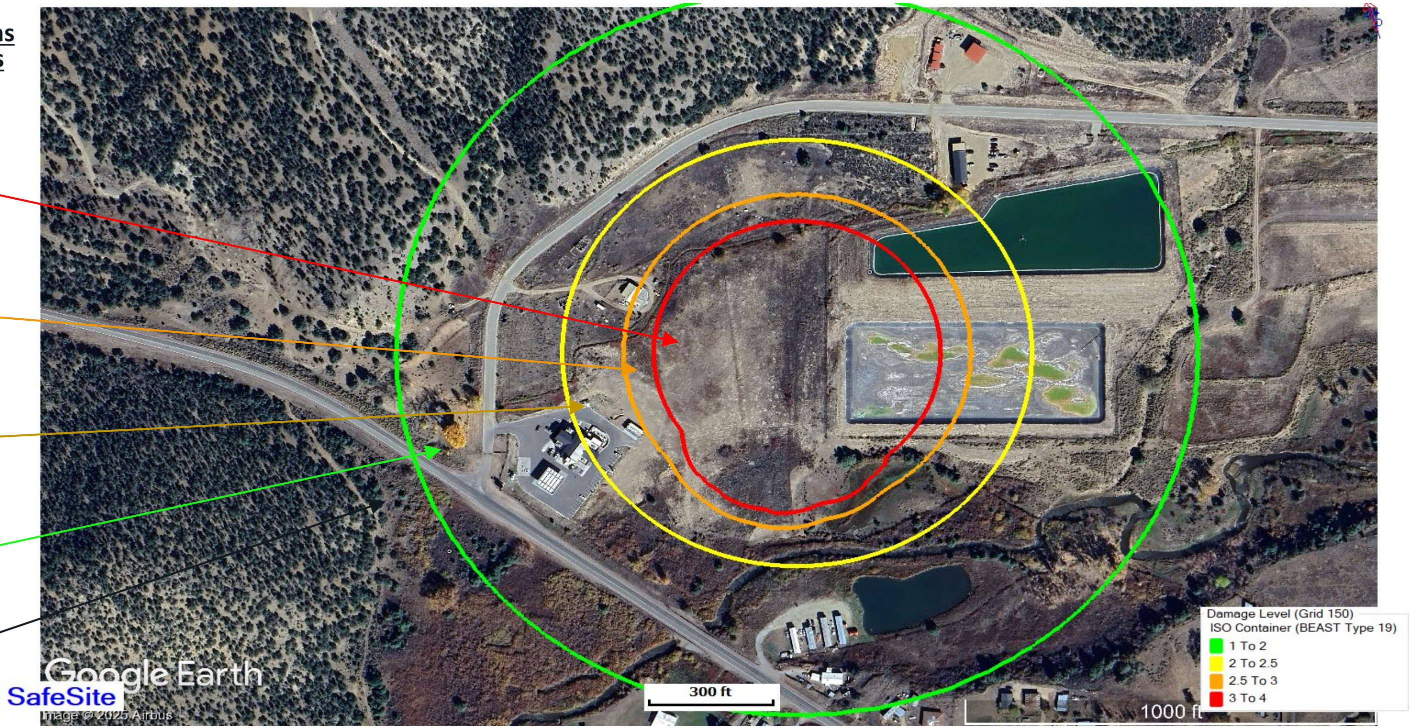
BDL 4

BDL 3

BDL 2.5

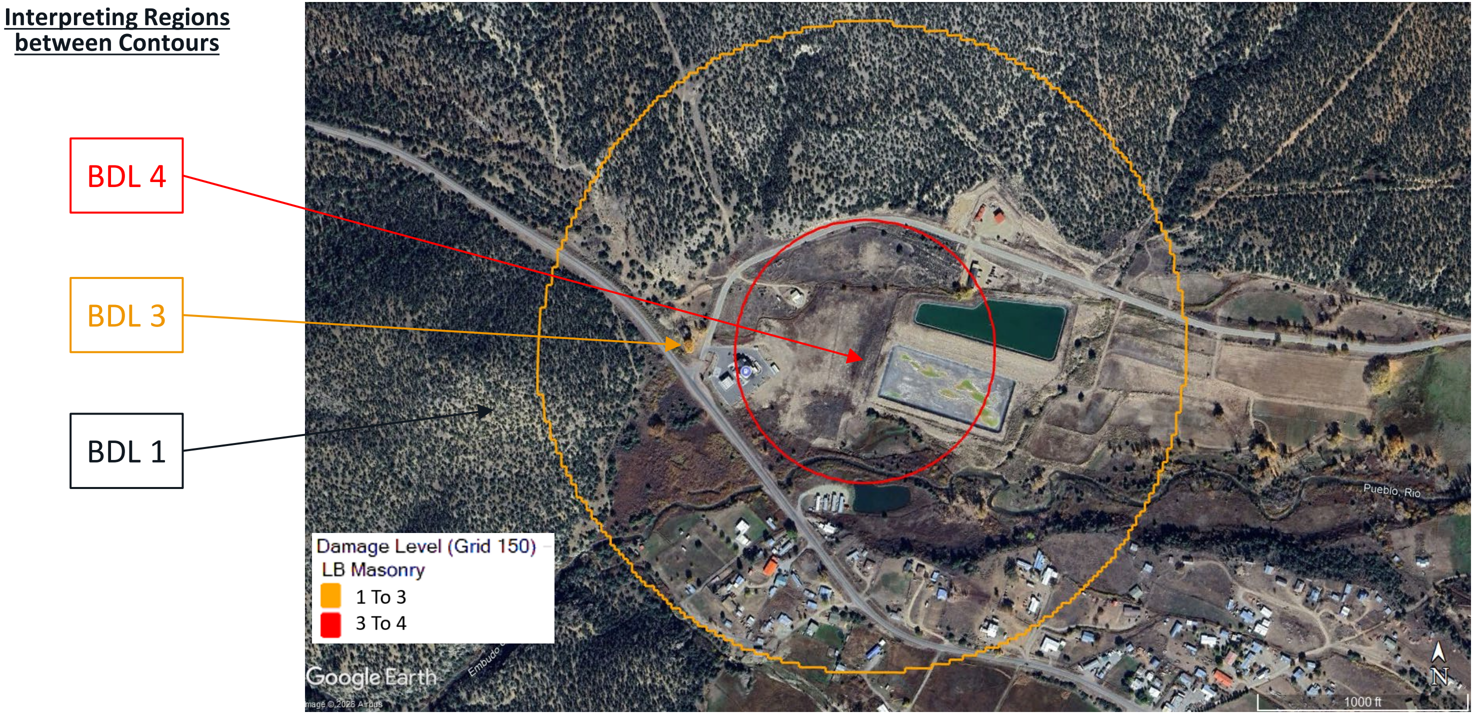
BDL 2

BDL 1



BDL Contours for All Release Scenarios Assessed

Consequence Analysis Results – BDL Contours: LB Masonry



BDL Contours for All Release Scenarios Assessed

Consequence Analysis Results – BDL Contours: Wood Residential

Interpreting Regions between Contours

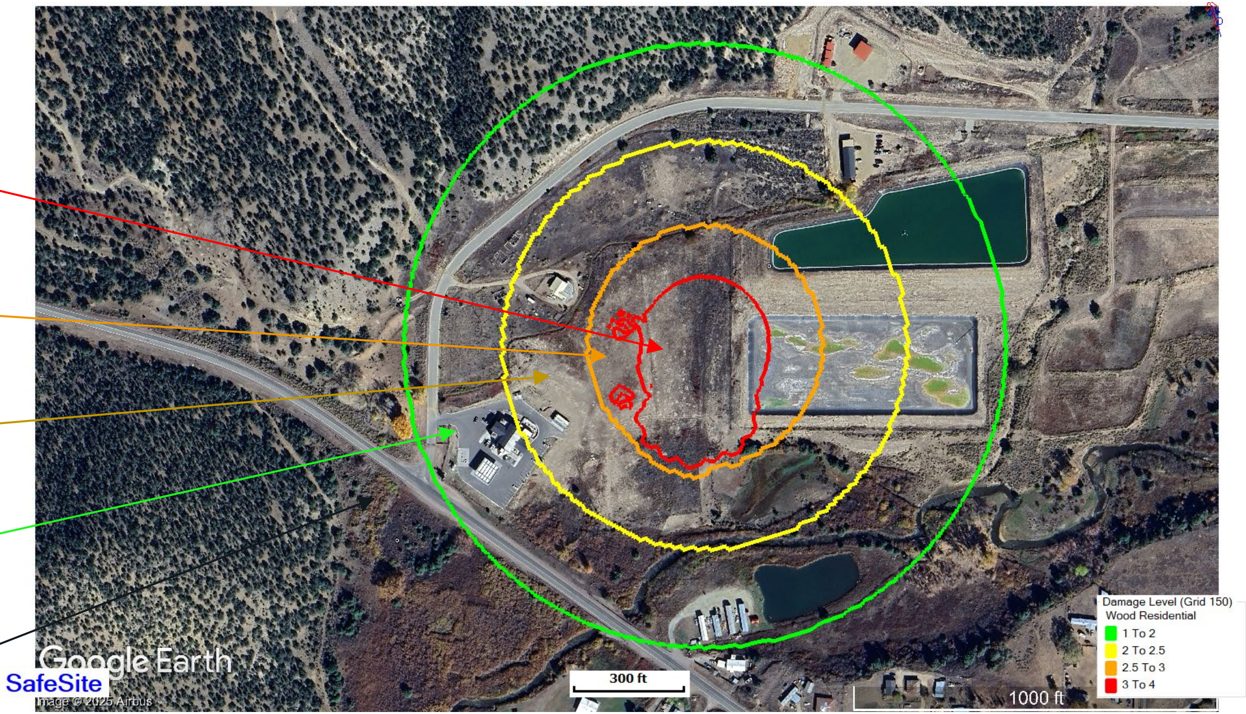
BDL 4

BDL 3

BDL 2.5

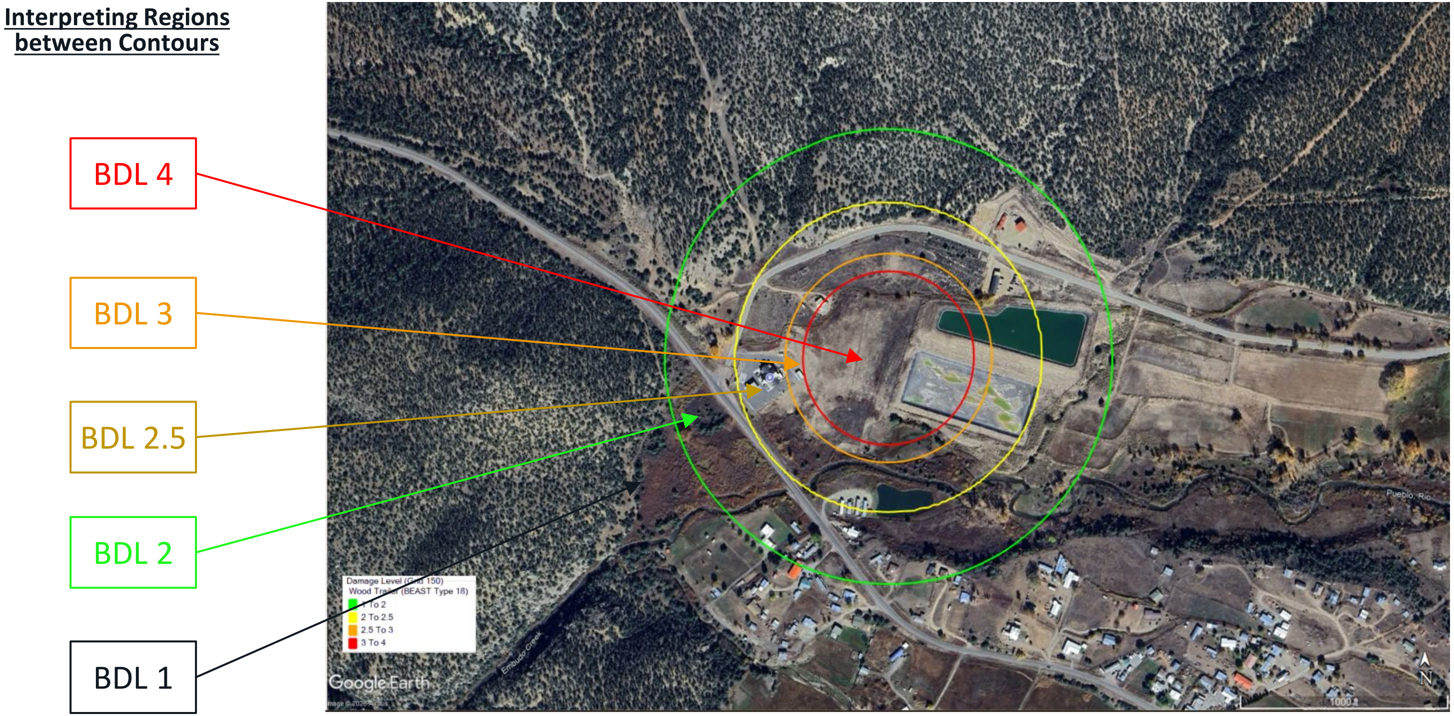
BDL 2

BDL 1



BDL Contours for All Release Scenarios Assessed

Consequence Analysis Results – BDL Contours: Light Wood Trailer



BDL Contours for All Release Scenarios Assessed

Consequence Analysis Results – Human Tolerance Contour: Ear Drum Rupture

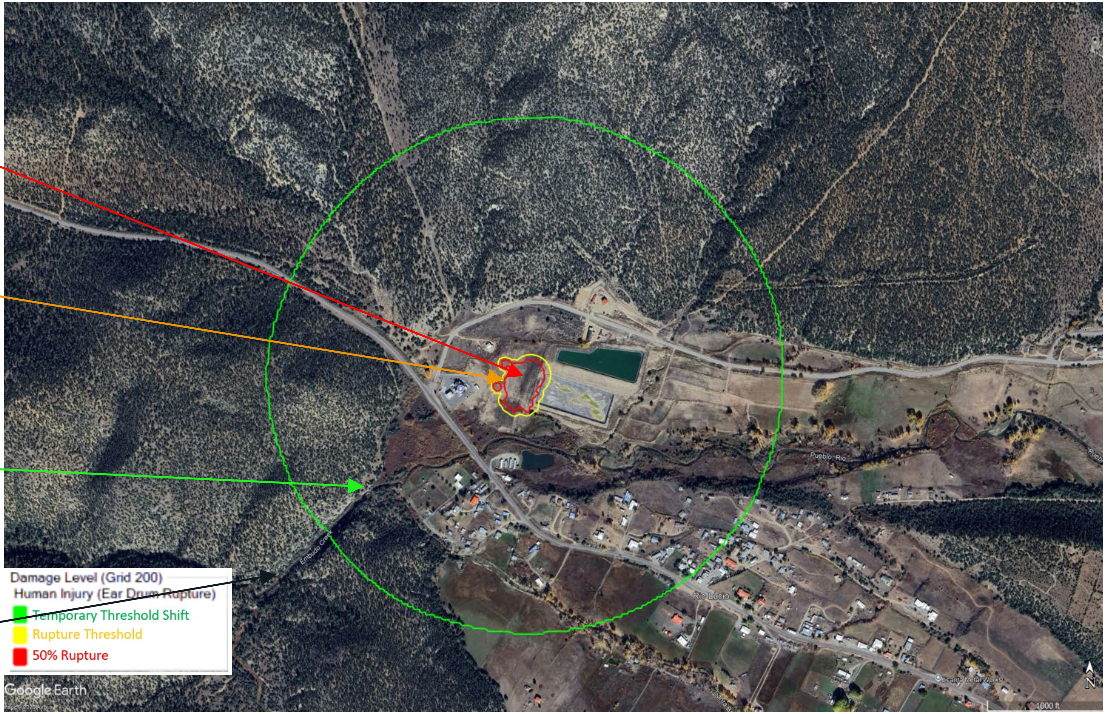
Interpreting Regions between Contours

Potential to exceed 50% Rupture

Potential to exceed rupture threshold but remain below 50% Rupture

Potential to exceed temporary threshold shift but remain below rupture threshold

Not expected to experience any effects



Human Tolerance Contours for All Release Scenarios Assessed, DDT-Out Excluded

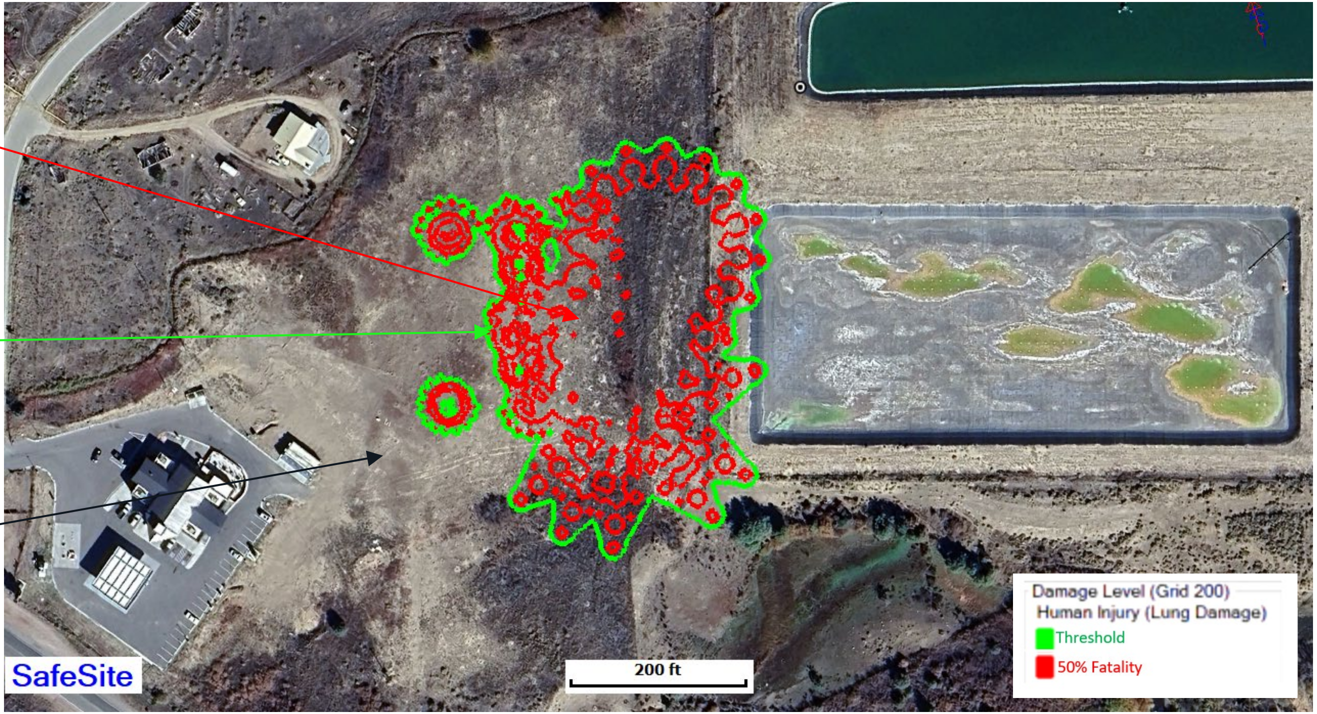
Consequence Analysis Results – Human Tolerance Contour: Lung Damage

Interpreting Regions between Contours

Potential to exceed 50% Fatality

Potential to exceed threshold shift but remain below 50% Fatality

Not expected to experience any effects



Human Tolerance Contours for All Release Scenarios Assessed, DDT-Out Excluded

Consequence Results: Contours - Questa

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Consequence Analysis Results – Flammable Dispersion Contours

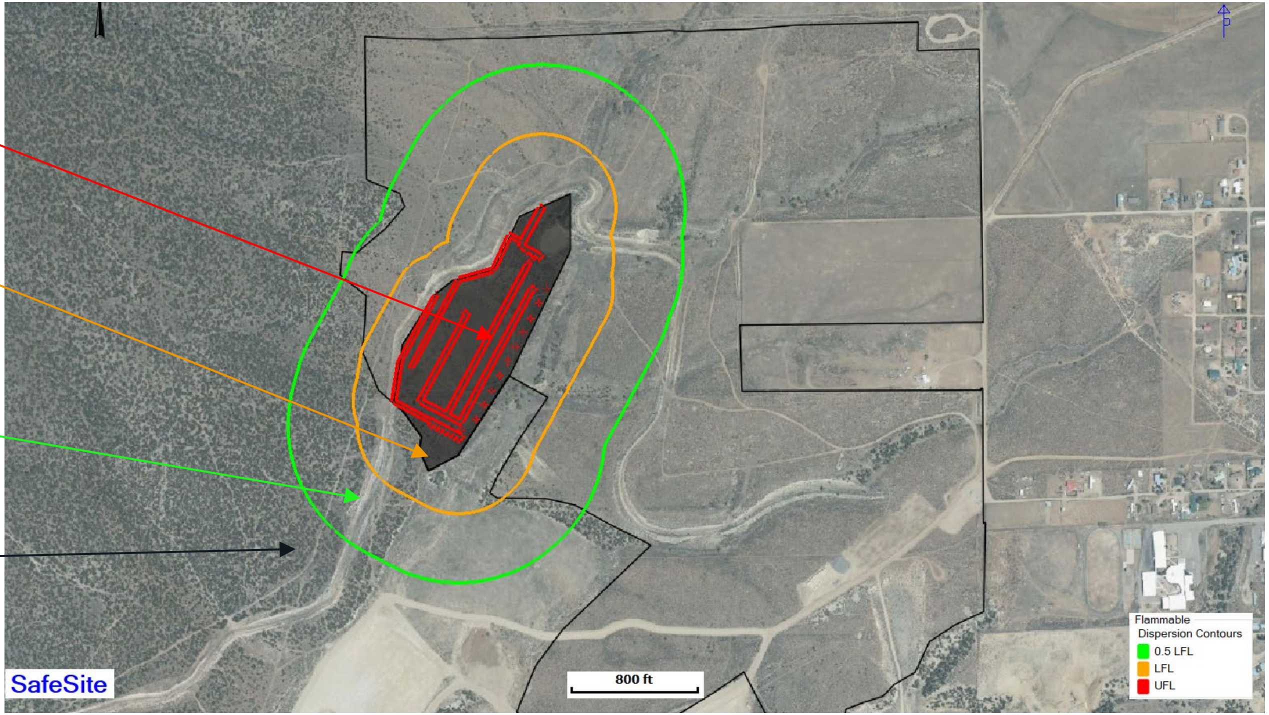
Interpreting Regions between Contours

Above UFL

Between UFL and LFL

Between LFL and 0.5 LFL

Less than 0.5 LFL



Flammable Dispersion Contours for All Release Scenarios Assessed

Consequence Analysis Results – Thermal Radiation Flux Contours

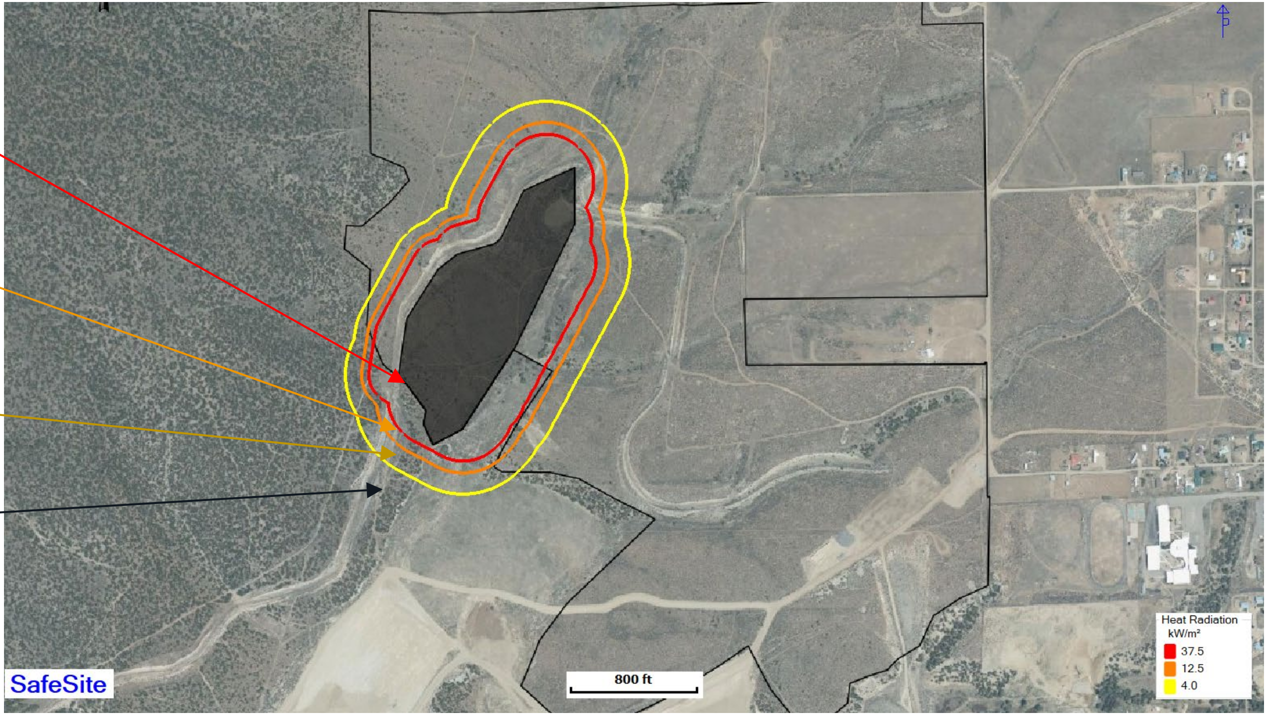
Interpreting Regions between Contours

Above 37.5 kW/m²

Between 12.5 and 37.5 kW/m²

Between 4.0 and 12.5 kW/m²

Below 4.0 kW/m²



Thermal Radiation Contours for All Release Scenarios Assessed

Consequence Analysis Results – Overpressure Contours

Interpreting Regions between Contours

Above 10 psig

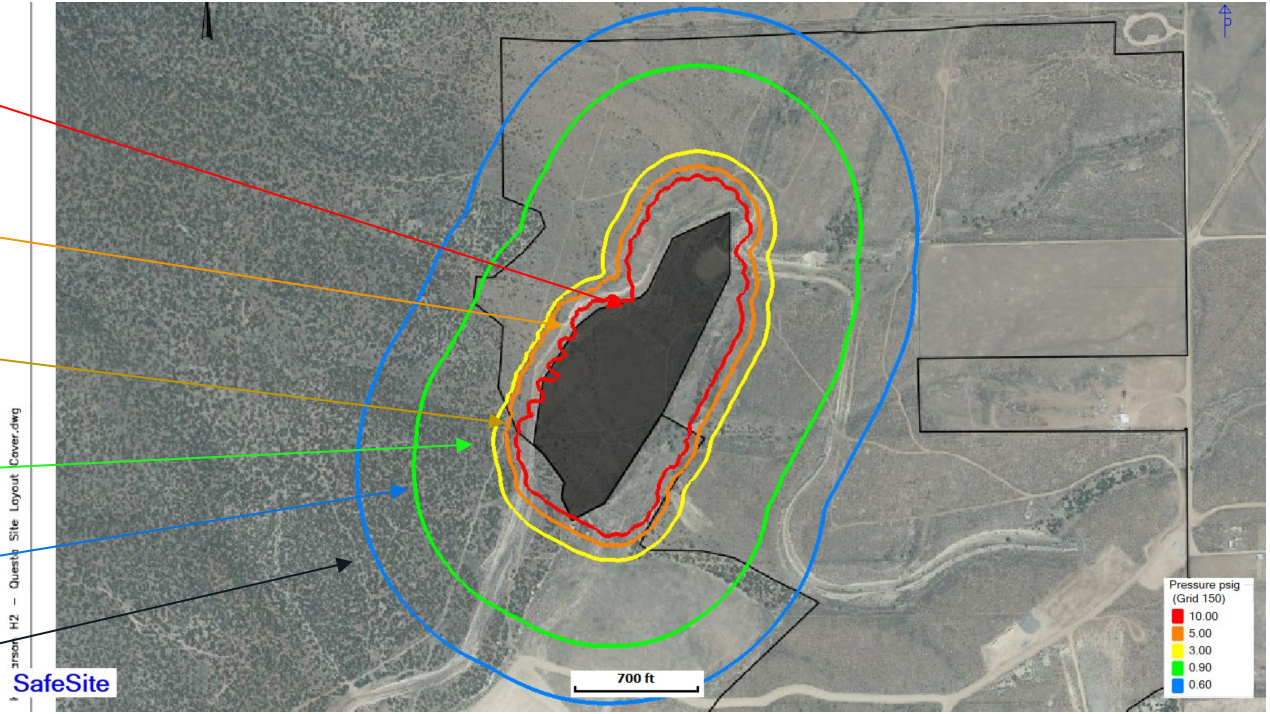
Between 5 and 10 psig

Between 3 and 5 psig

Between 0.9 and 3 psig

Between 0.6 and 0.9 psig

Below 0.6 psig



Side-On Overpressure Contours for All Release Scenarios Assessed, DDT-Out Excluded

Consequence Analysis Results – Impulse Contours

Interpreting Regions between Contours

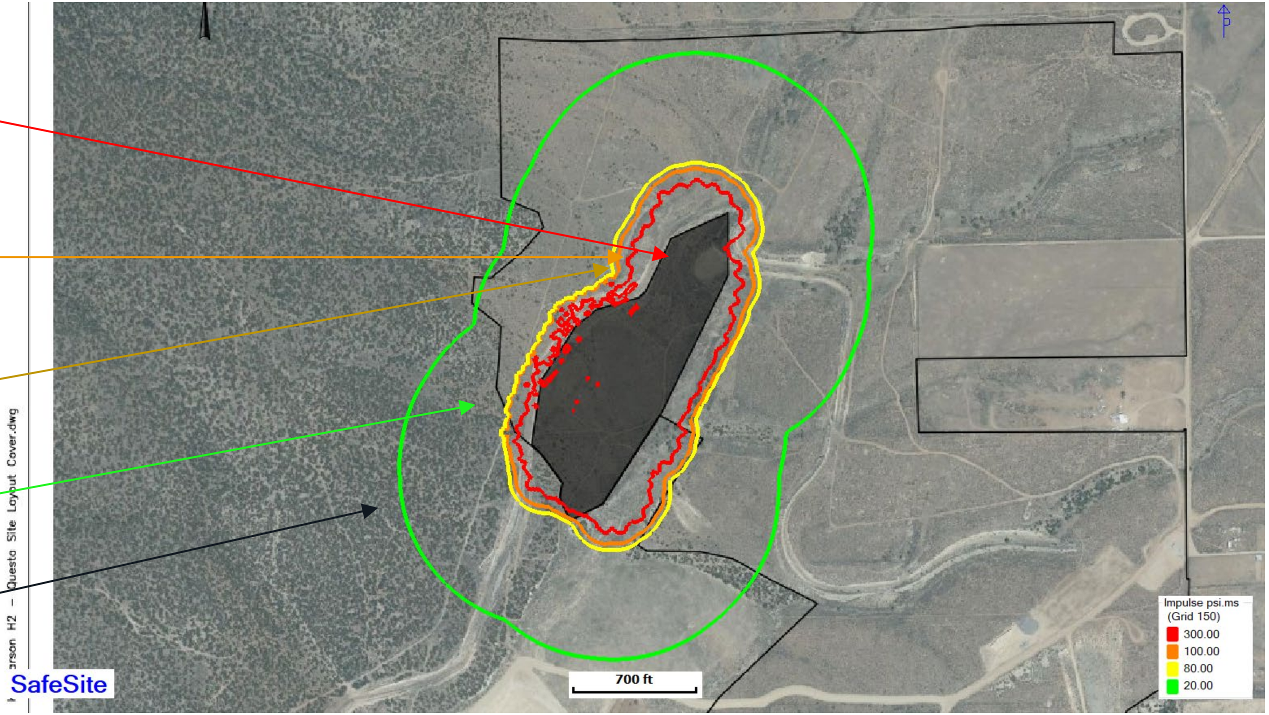
Above 300 psig.ms

Between 100 and 300 psig.ms

Between 80 and 100 psig.ms

Between 20 and 80 psig.ms

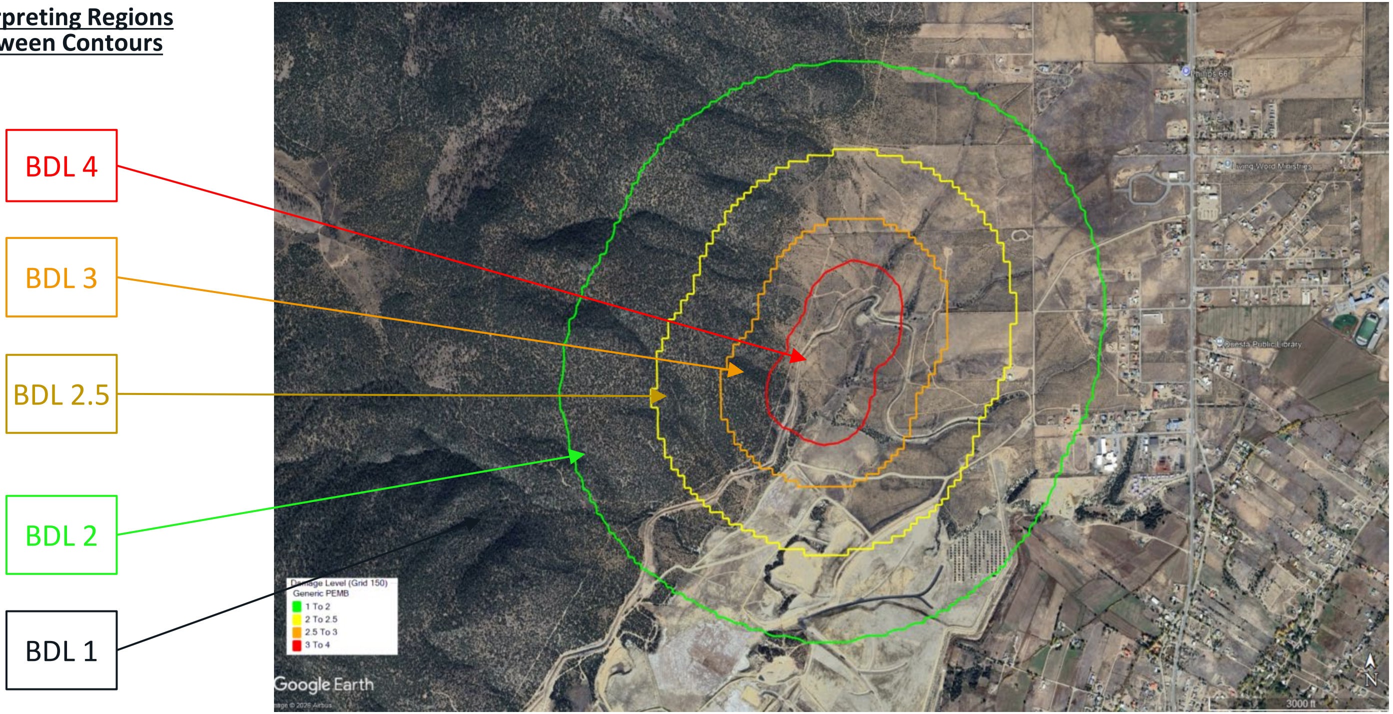
Below 20 psig.ms



Side-On Impulse Contours for All Release Scenarios Assessed

Consequence Analysis Results – BDL Contours: Generic PEMB

Interpreting Regions between Contours
between Contours



BDL Contours for All Release Scenarios Assessed

Consequence Analysis Results – BDL Contours: ISO Container

Interpreting Regions between Contours

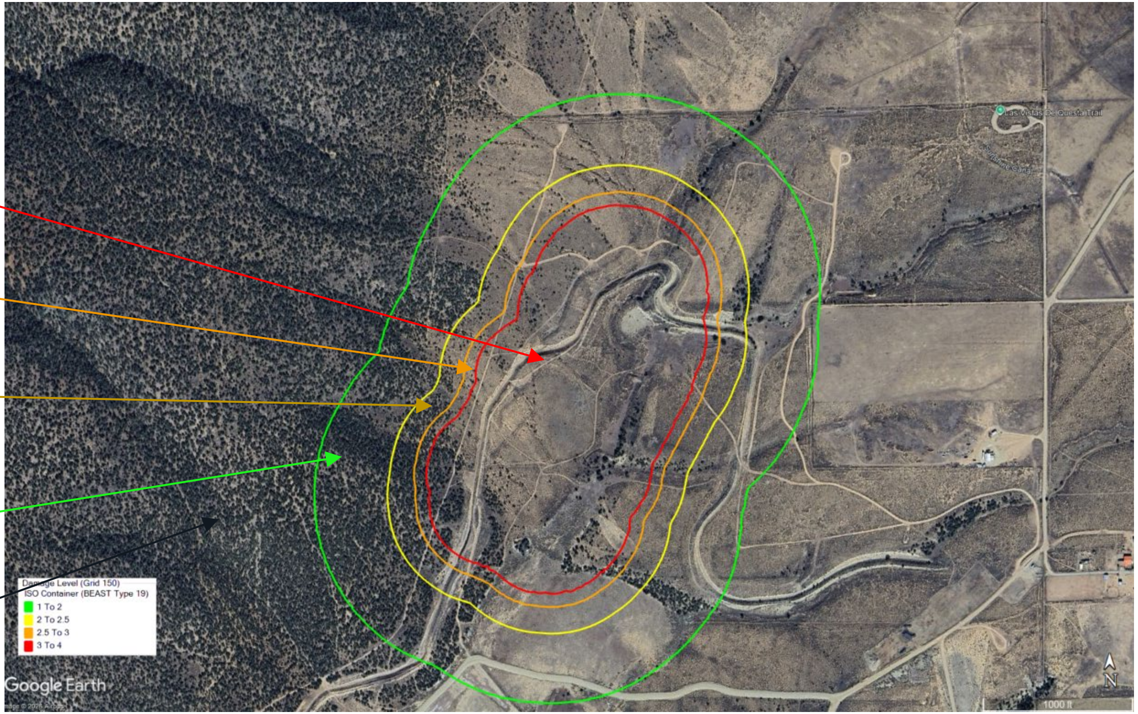
BDL 4

BDL 3

BDL 2.5

BDL 2

BDL 1



BDL Contours for All Release Scenarios Assessed

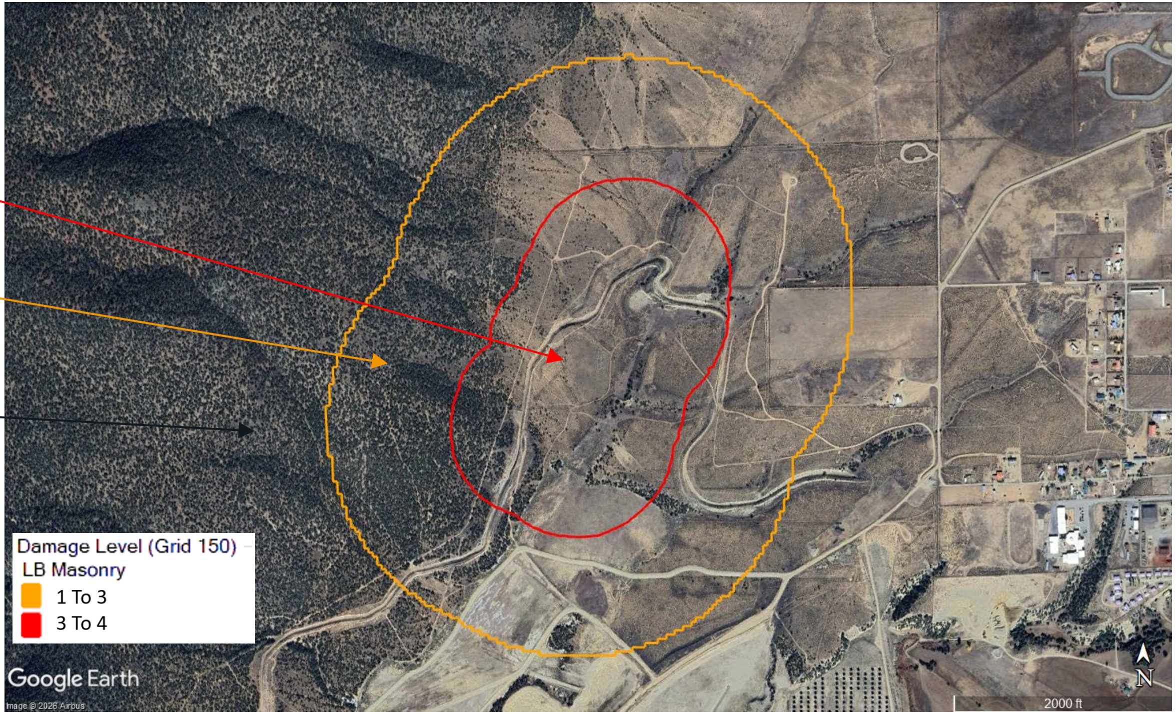
Consequence Analysis Results – BDL Contours: LB Masonry

Interpreting Regions between Contours

BDL 4

BDL 3

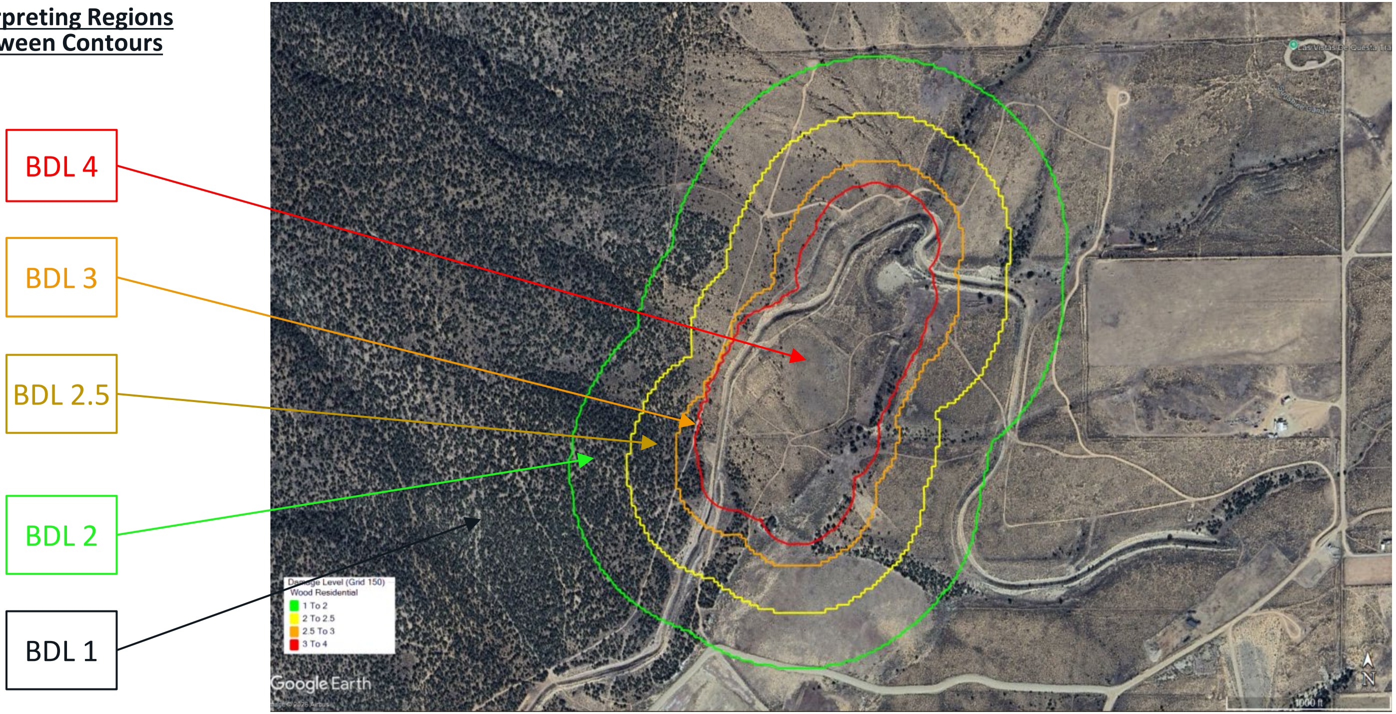
BDL 1



BDL Contours for All Release Scenarios Assessed

Consequence Analysis Results – BDL Contours: Wood Residential

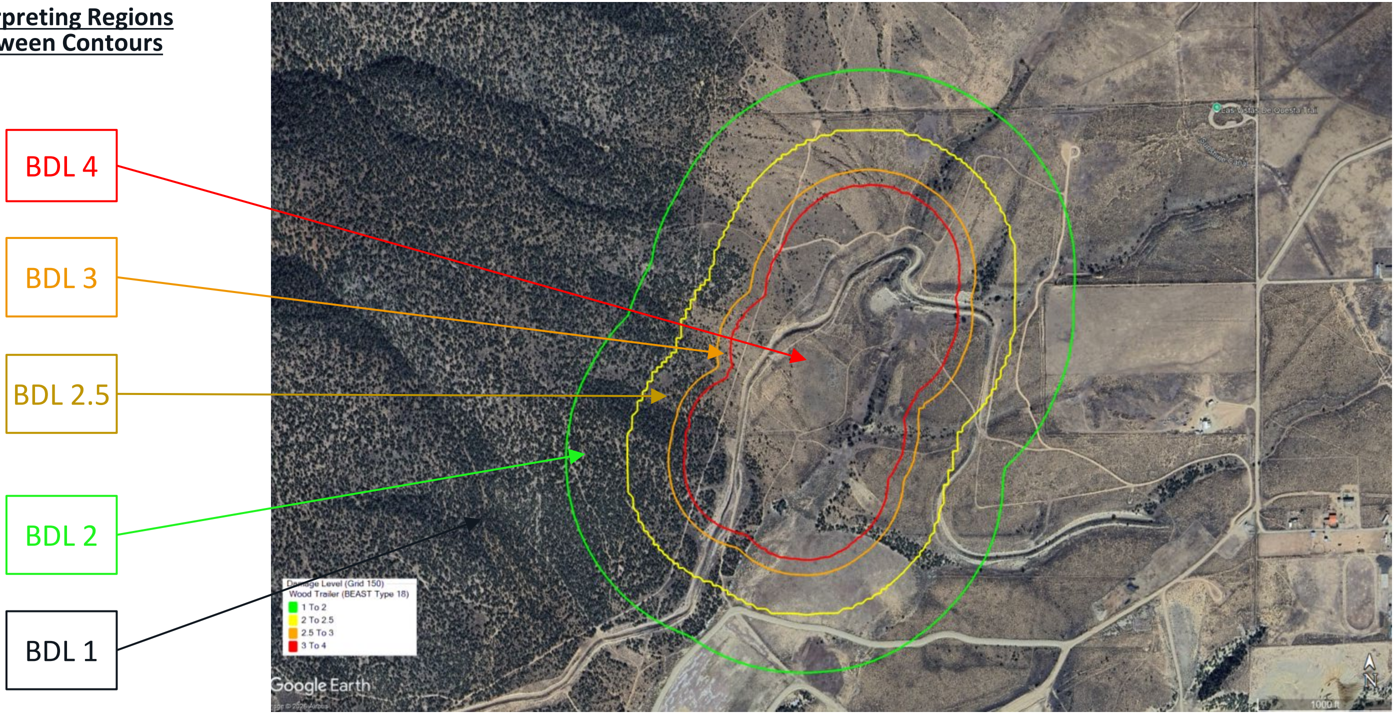
Interpreting Regions between Contours



BDL Contours for All Release Scenarios Assessed

Consequence Analysis Results – BDL Contours: Light Wood Trailer

Interpreting Regions between Contours



BDL Contours for All Release Scenarios Assessed

Consequence Analysis Results – Human Tolerance Contour: Ear Drum Rupture

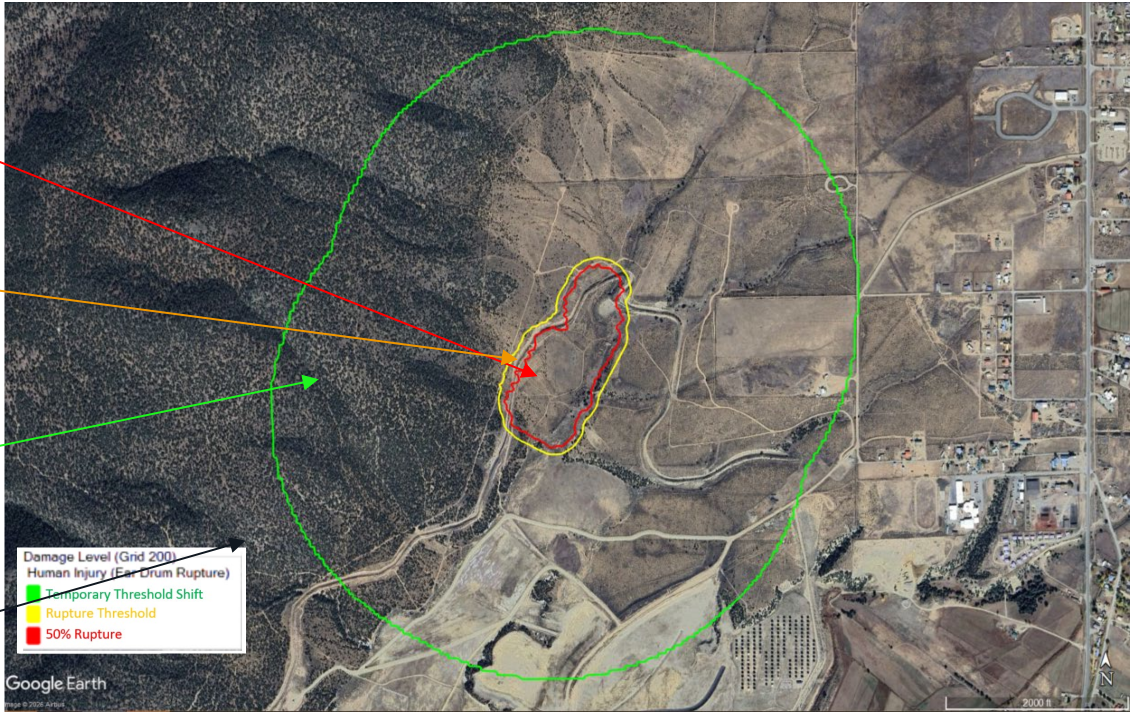
Interpreting Regions between Contours

Potential to exceed 50% Rupture

Potential to exceed rupture threshold but remain below 50% Rupture

Potential to exceed temporary threshold shift but remain below rupture threshold

Not expected to experience any effects



Human Tolerance Contours for All Release Scenarios Assessed, DDT-Out Excluded

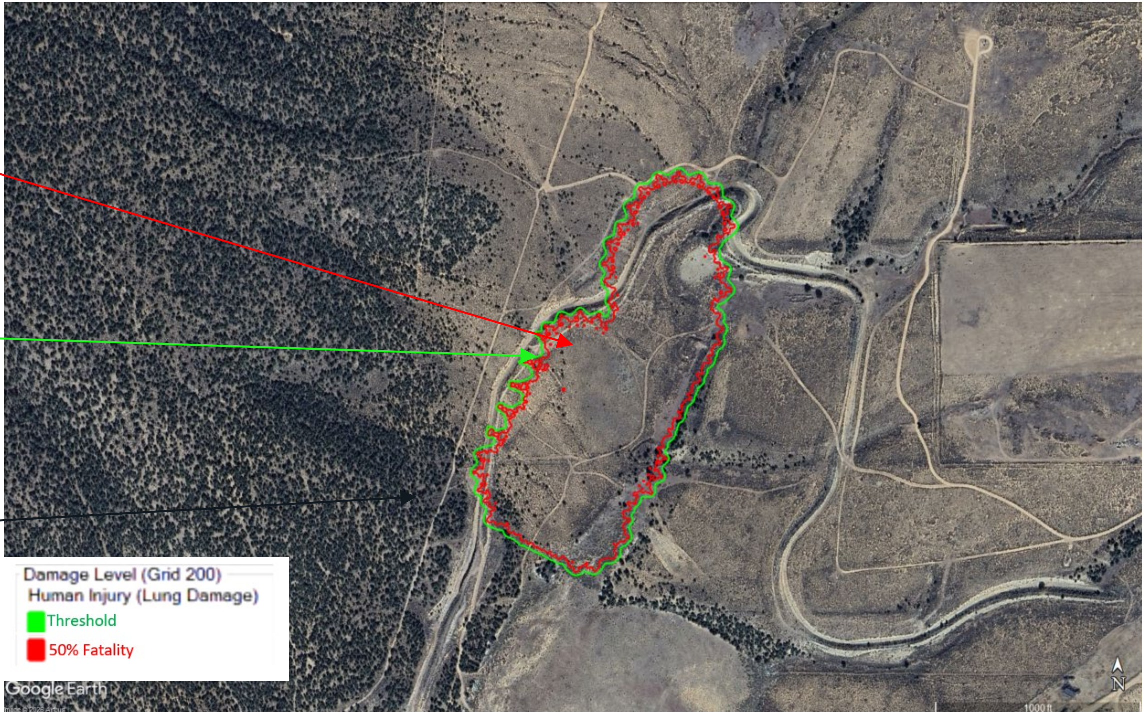
Consequence Analysis Results – Human Tolerance Contour: Lung Damage

Interpreting Regions between Contours

Potential to exceed 50% Fatality

Potential to exceed threshold shift but remain below 50% Fatality

Not expected to experience any effects



Human Tolerance Contours for All Release Scenarios Assessed, DDT-Out Excluded

Consequence Results: Contours - Taos

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Consequence Analysis Results – Flammable Dispersion Contours

Interpreting Regions between Contours

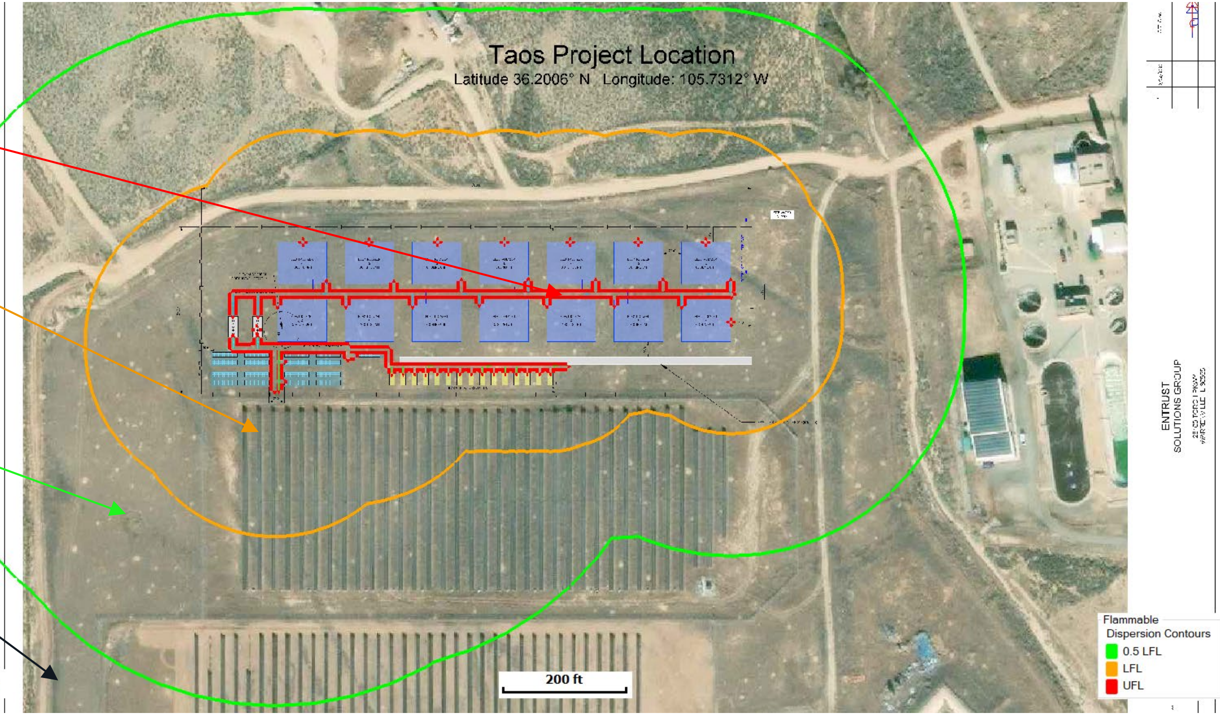
Above UFL

Between UFL and LFL

Between LFL and 0.5 LFL

Less than 0.5 LFL

SafeSite



Flammable Dispersion Contours for All Release Scenarios Assessed

Consequence Analysis Results – Thermal Radiation Flux Contours

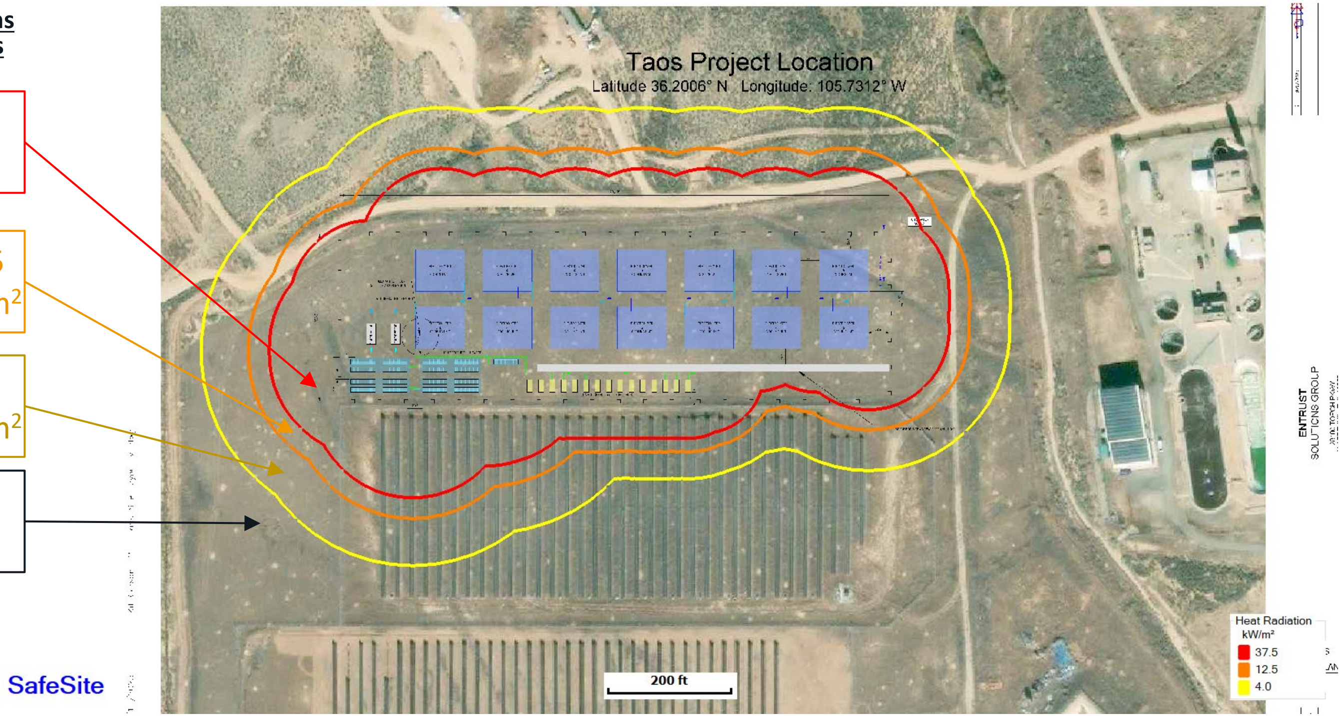
Interpreting Regions between Contours

Above 37.5 kW/m²

Between 12.5 and 37.5 kW/m²

Between 4.0 and 12.5 kW/m²

Below 4.0 kW/m²



Thermal Radiation Contours for All Release Scenarios Assessed

Consequence Analysis Results – Overpressure Contours

Interpreting Regions between Contours

Above 10 psig

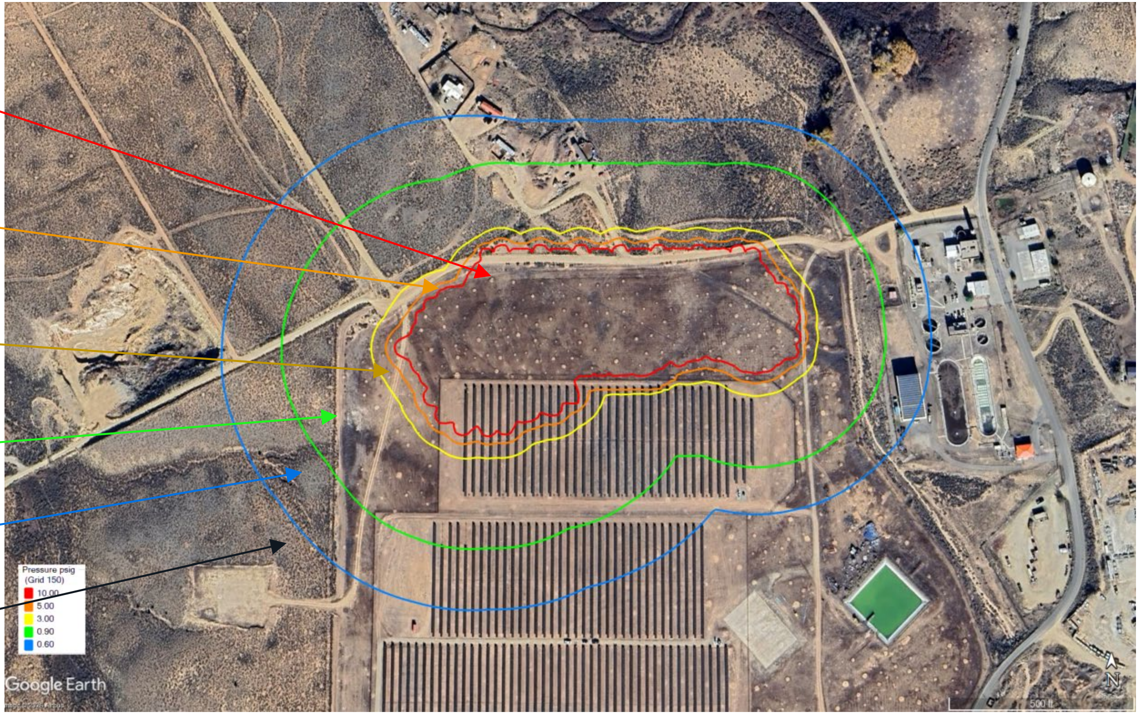
Between 5 and 10 psig

Between 3 and 5 psig

Between 0.9 and 3 psig

Between 0.6 and 0.9 psig

Below 0.6 psig



Side-On Overpressure Contours for All Release Scenarios Assessed, DDT-Out Excluded

Consequence Analysis Results – Impulse Contours

Interpreting Regions between Contours

Above 300 psig.ms

Between 100 and 300 psig.ms

Between 80 and 100 psig.ms

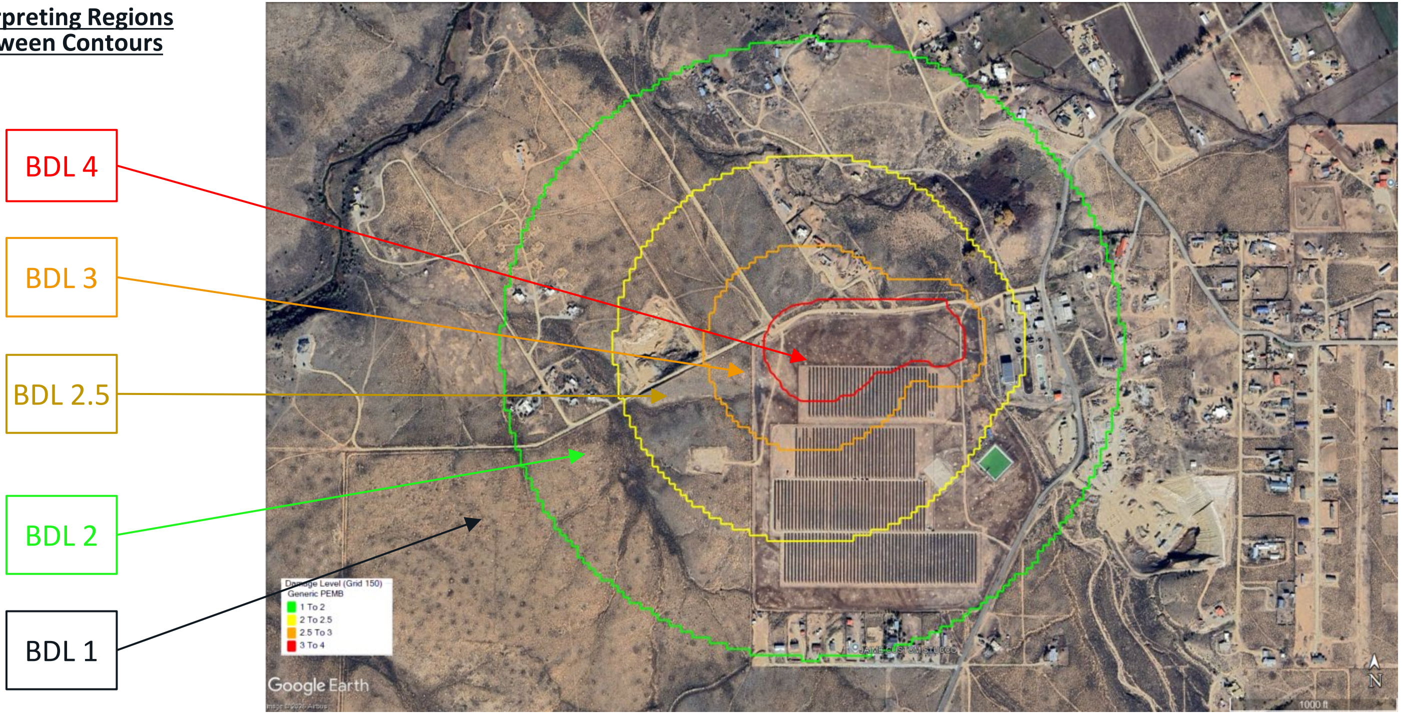
Between 20 and 80 psig.ms

Below 20 psig.ms

Side-On Impulse Contours for All Release Scenarios Assessed

Consequence Analysis Results – BDL Contours: Generic PEMB

Interpreting Regions between Contours



BDL Contours for All Release Scenarios Assessed

Consequence Analysis Results – BDL Contours: ISO Container

Interpreting Regions between Contours

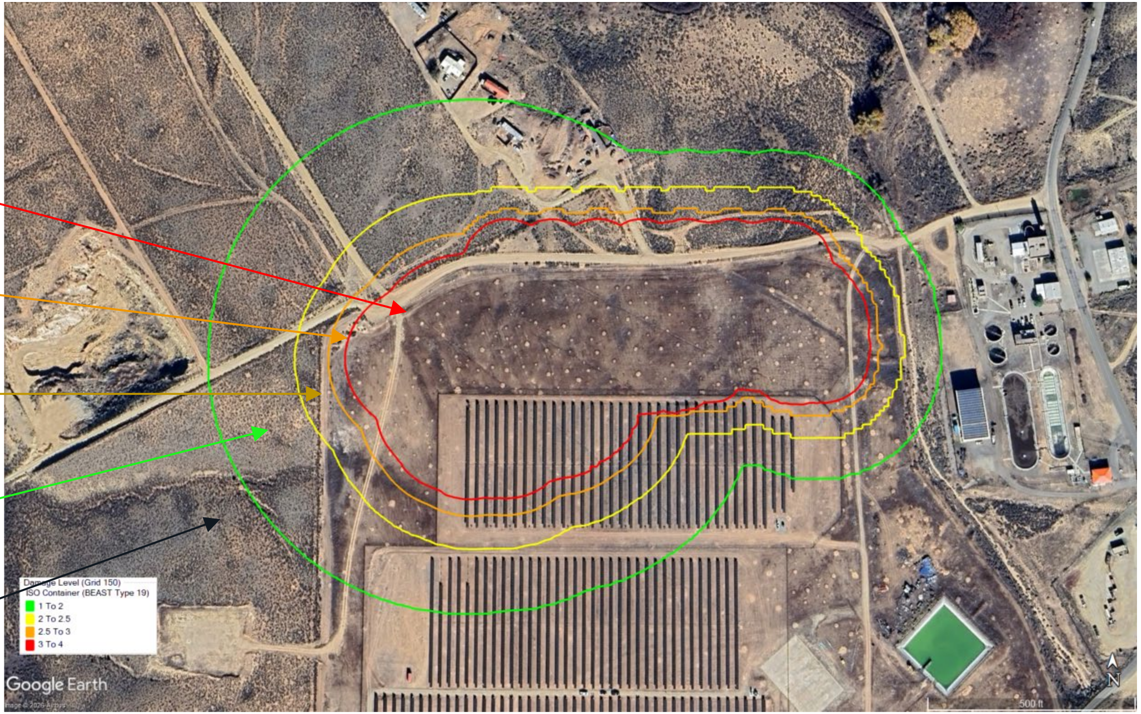
BDL 4

BDL 3

BDL 2.5

BDL 2

BDL 1



BDL Contours for All Release Scenarios Assessed

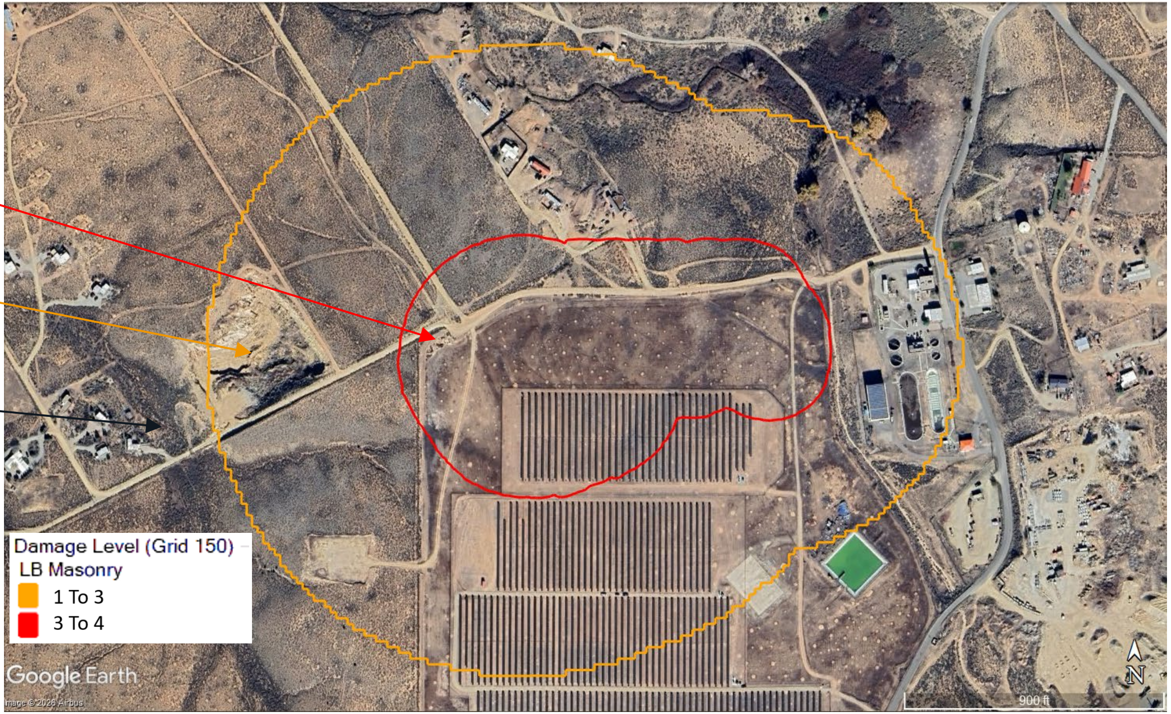
Consequence Analysis Results – BDL Contours: LB Masonry

Interpreting Regions between Contours

BDL 4

BDL 3

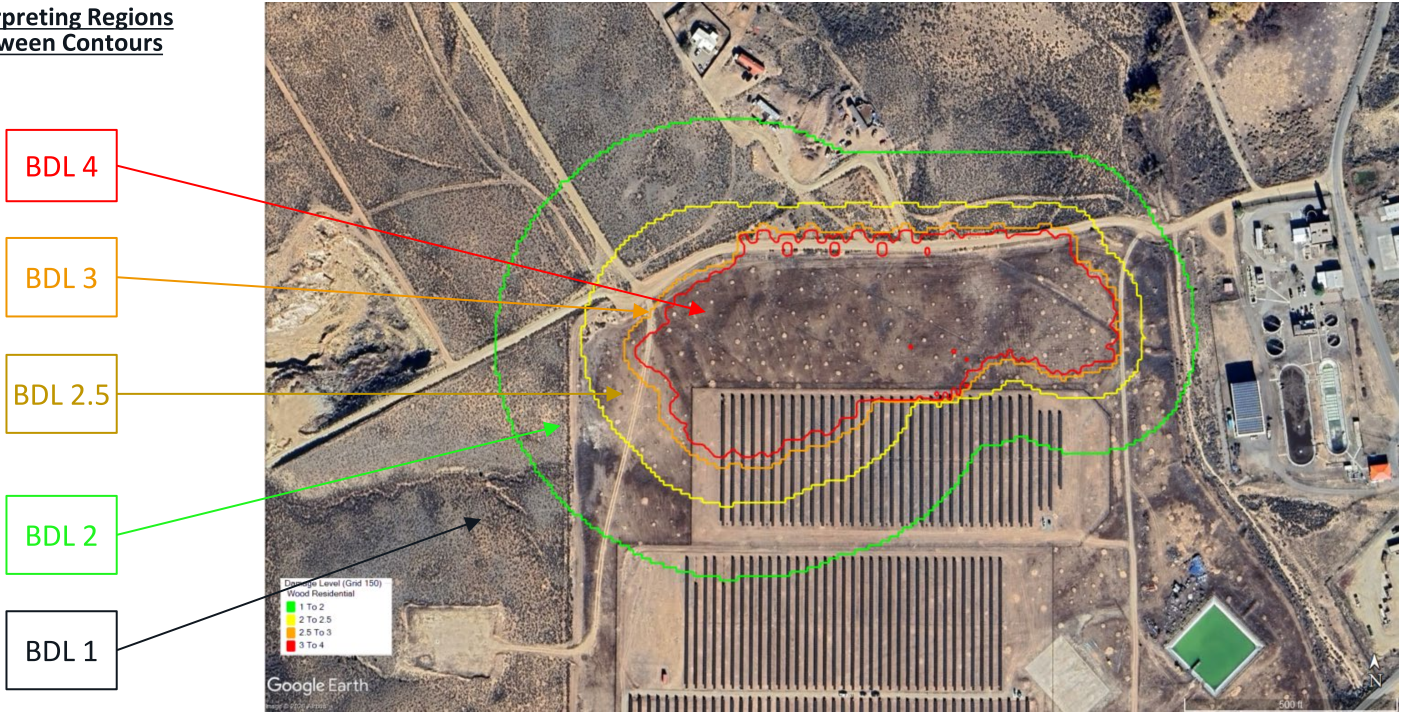
BDL 1



BDL Contours for All Release Scenarios Assessed

Consequence Analysis Results – BDL Contours: Wood Residential

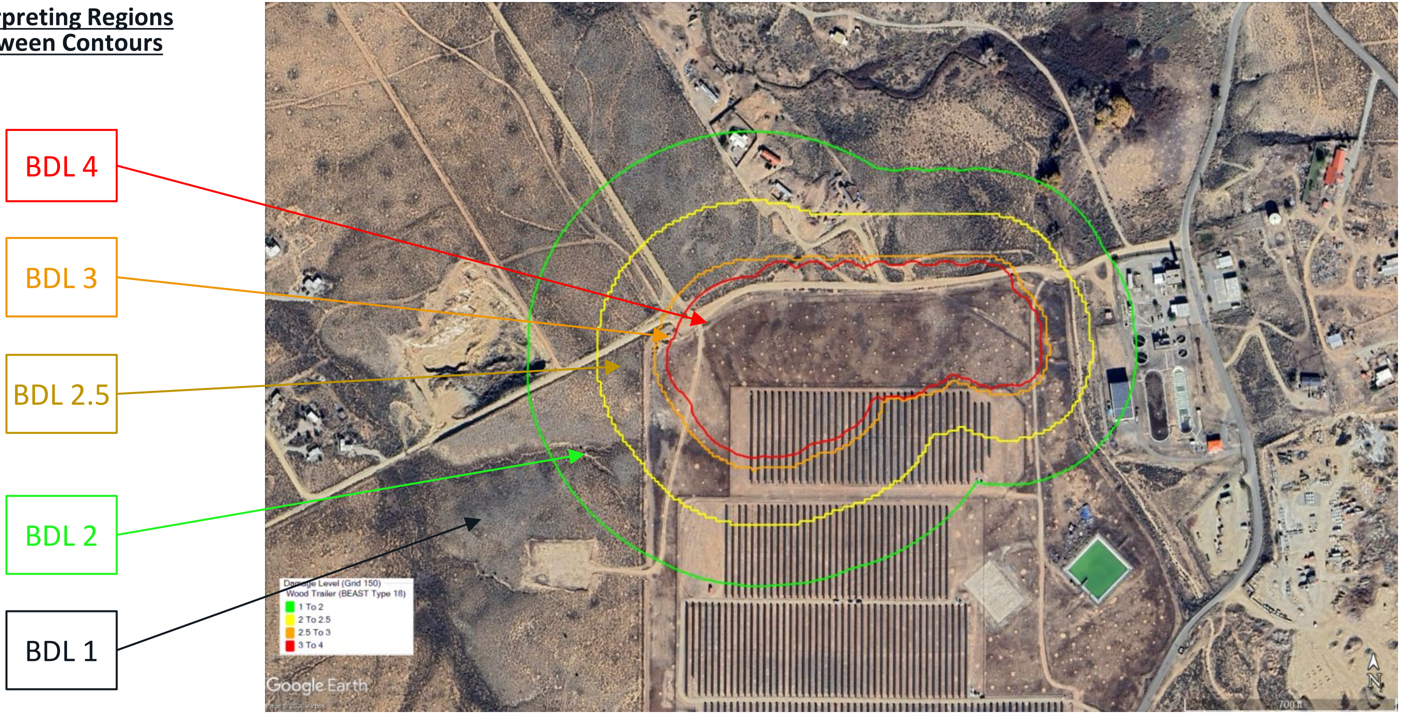
Interpreting Regions between Contours



BDL Contours for All Release Scenarios Assessed

Consequence Analysis Results – BDL Contours: Light Wood Trailer

Interpreting Regions between Contours



BDL Contours for All Release Scenarios Assessed

Consequence Analysis Results – Human Tolerance Contour: Ear Drum Rupture

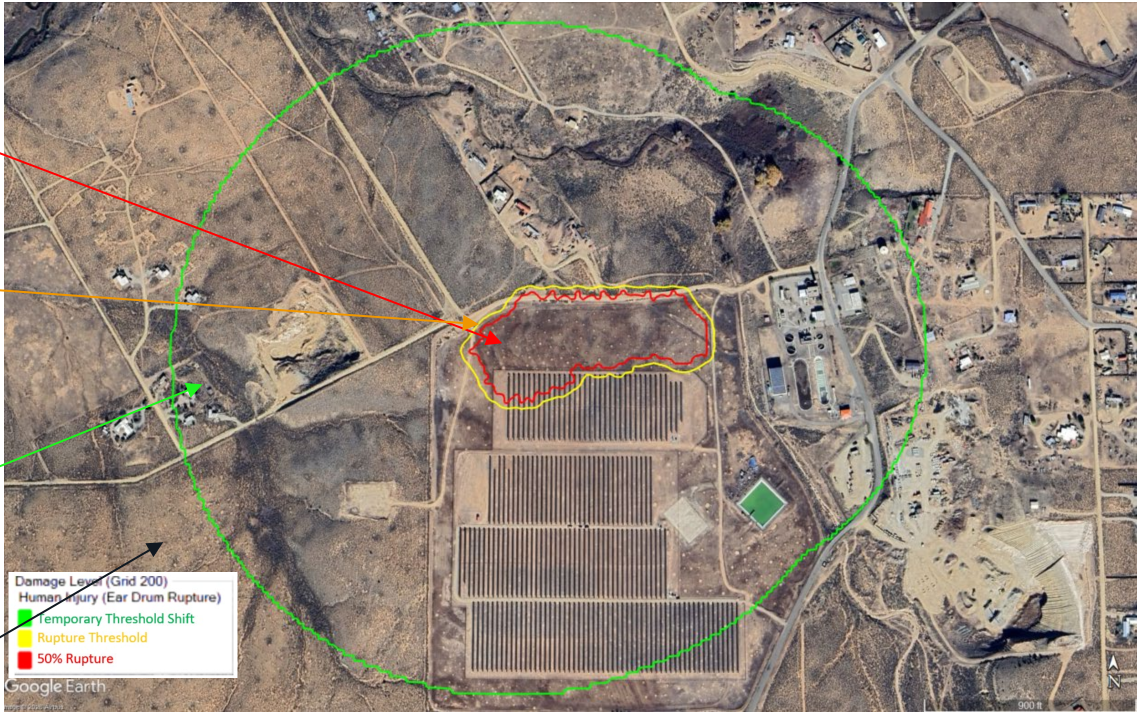
Interpreting Regions between Contours

Potential to exceed 50% Rupture

Potential to exceed rupture threshold but remain below 50% Rupture

Potential to exceed temporary threshold shift but remain below rupture threshold

Not expected to experience any effects



Human Tolerance Contours for All Release Scenarios Assessed, DDT-Out Excluded

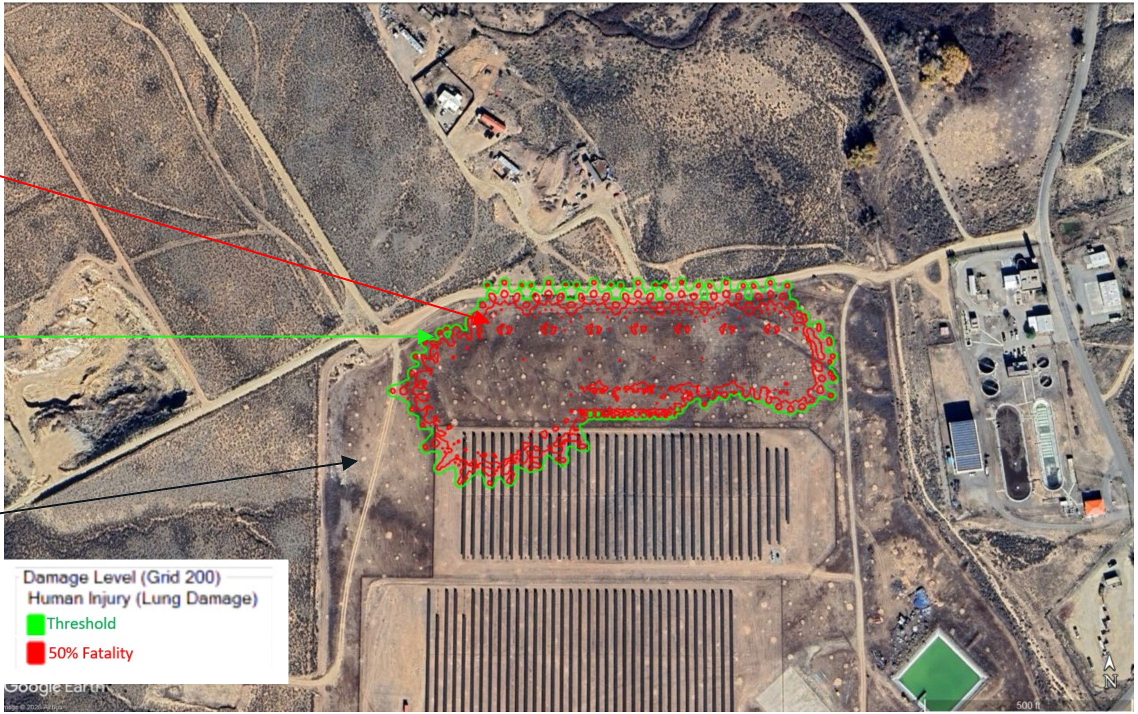
Consequence Analysis Results – Human Tolerance Contour: Lung Damage

Interpreting Regions between Contours

Potential to exceed 50% Fatality

Potential to exceed threshold shift but remain below 50% Fatality

Not expected to experience any effects



Human Tolerance Contours for All Release Scenarios Assessed, DDT-Out Excluded

Conclusions and Next Steps

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Conclusions and Next Steps

- Thermal radiation/fire consequences largely expected within or near site boundary.
  - Develop a site fire protection plan by evaluating necessary fire water supply to handle worst-case scenarios at each location.
- Blast overpressure and impulse contours can be utilized as a preliminary design basis if developing any buildings onsite for personnel usage.
- BDL contours developed for each of the construction types can provide some insight into potential offsite/other building impacts. Construction types were estimated based on aerial images and street views in Google Earth™ surrounding the three locations.
- Human impact thresholds provided confirmed lung damage localized to each site, with potential for temporary threshold shift in ear drum to occur past site boundaries.
- BakerRisk will evaluate and provide recommendations on potential follow-on analyses that could benefit the project based on screening results (emergency response planning, blast mitigation, F&G detection, action plan development, etc.).
- Review results spreadsheets in detail and provide comments and edits where necessary.
- Implement technical corrections to study.
  - Minor scenario refinements.

QUESTIONS?

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