



August 26, 2022

Chief Luby,

Thank you for the opportunity to provide a report concerning the hazardous materials (hazmat) use and storage at Astra's facilities; 1900 Skyhawk Street and 1690 Orion Street, Alameda, CA 94501. This report is the culmination of findings derived from several resources:

- A site visit of both locations conducted with you, Chief Hearn and Astra personnel on August 23<sup>rd</sup>, 2022
- An EPA approved plume modeling program: ALOHA - Areal Locations of Hazardous Atmospheres an atmospheric dispersion model maintained by the National Oceanic and Atmospheric Administration Office of Response and Restoration's Emergency Response Division.
- Hazmat inventory information from the California Environmental Reporting System (CERS) Responder Portal accessible from Alameda Fire Department,
- Internet research
- Subject matter expertise from two 30-year veterans of Bay Area hazmat response and local environmental regulatory compliance.

Astra builds rockets and tests rocket engines at their Alameda sites. They have another site in central California, as well as a launch site in Alaska. The majority of their space in Alameda is dedicated to the manufacturing of rockets. A smaller portion of their facility space is used to test rocket engines. This smaller space is a former Navy engine testing facility that was designed to test engines much larger in scale than the engines Astra tests. The rockets created at Astra are not designed for human occupancy.

Astra's hazmat inventory reporting was evaluated during the walk through of the site. All items reported to Alameda County Environmental Health were accounted for. Alameda Fire Department's correspondence with Alameda County Environmental Health determined that there were no violations observed during the County's last environmental compliance inspection. Attached are the inventory reports from CERS. The specific hazardous materials that generated concern are liquid oxygen, liquid nitrogen, and mineral spirits (a component of rocket fuel).

Astra reports and has on site refrigerated liquid oxygen and compressed oxygen. The largest container has a capacity of 6000 gallons of liquid oxygen. This container is owned and maintained by AirProducts, a national provider of liquid oxygen. The container is industry standard with a safety vent that may display an intermittent white cloud under normal storage conditions. This material is delivered by tank truck over pre-determined City of Alameda approved traffic routes and is required to be driven by Department of Transportation (DOT) certified hazmat drivers. Oxygen itself does not burn and is non-toxic; it can enhance combustion when involved in a fire. The risk of fire is very low considering this container is located outdoors, with no combustibles in the immediate area. Two smaller containers of liquid oxygen are located in the rocket engine testing area. They are in a space that has thick concrete walls and the risk of these containers impacting the community is low. Oxygen is a natural component of the air we breathe. In the incredibly unlikely event of a loss of the entire contents of the largest container, this release would pose very little hazard to the community.

Astra reports and has on site refrigerated liquid nitrogen and compressed nitrogen. The largest container has a capacity of 6000 gallons of liquid nitrogen. This container is owned and maintained by AirProducts, a national provider of liquid nitrogen. The container is built to industry standard with a safety vent that may display an intermittent white cloud of water vapor under normal storage conditions. This material is delivered by tank truck over pre-determined City of Alameda approved traffic routes and is required to be driven by Department of Transportation (DOT) certified hazmat drivers. Liquid nitrogen is a simple asphyxiant when released which means it displaces oxygen, making it difficult for a person to breathe the oxygen we need. Liquid Nitrogen presents no fire risk as it is a DOT non-flammable gas. There are other smaller containers of liquid nitrogen located in various locations, mainly in the manufacturing areas of the facility and the risk of these containers impacting the community is low. Any release from these containers would be confined to the walls of the building. Nitrogen is a natural component of the air we breathe. In the incredibly unlikely event of a loss of the entire contents of the largest container, this release would pose very little hazard to the community as it is expected to rapidly dissipate before it would reach the community.

Astra reports and has on site a mineral spirits-based rocket fuel component. The largest container has a capacity of 2500 gallons and has secondary containment built into the construction of the tank as well as a cinder block berm approximately 24 inches tall to contain any unlikely leaks past this secondary containment. The container is built to industry standard. This material is delivered by tank truck over pre-determined City of Alameda approved traffic routes and is required to be driven by Department of Transportation (DOT) certified hazmat drivers. This product is a DOT flammable liquid that is less flammable than automobile gasoline and more flammable than diesel fuel. The risk of fire is very low as the largest container is located outdoors, with no combustibles in the immediate area. There are other smaller containers of mineral spirits, mainly in the rocket engine testing areas of the facility and the risk of these containers impacting the community is low. Any release from these containers would be confined to the extra thick walls of the testing area. This mineral spirit material becomes rocket fuel when combined with liquid oxygen. Only when it is precisely sprayed (aerosolized) in the correct fuel/oxygen ratio, mixing with the liquid oxygen, does it become what we think of as a "rocket fuel". As it is stored, there is no oxygenated component stored within it. The oxygen is introduced during testing of the rocket engine, so the risk of fire/explosion is low. In the incredibly unlikely event of a loss of the entire contents of the largest container, this release would pose very little hazard to the community. The plume modeling shows that radiant heat would be the biggest hazard to anyone within 50 yards without firefighting protective gear. The plume model also does not indicate any risk of an explosion during a release. Along with the plume modeling, this is a non-pressurized liquid in an industrial standard container with venting, so the potential for an explosion is non-existent. The tank's secondary containment is designed to contain any leaks and there is little possibility from external factors of physical impact to the tank, it is in a secured lot with no forklifts or other equipment near the vicinity to potentially damage it.

For this report, plume modeling using EPA's ALOHA software is used instead of the DOT Emergency Response Guidebook (DOT ERG). The DOT ERG provides initial isolation distances for transportation accidents involving failure of a container due to some sort of impact, as a conservative measure with no other context. The intent then is for a hazmat response team to use plume modeling and handheld atmospheric monitoring to better determine the area impacted by the transportation accident. Astra is a fixed facility where the possibility of impact to any of their tanks described earlier is very small. The plume modeling attached shows a more realistic model than the use of the DOT ERG.

We can draw comparisons with other facilities in the City of Alameda that have flammable liquids or cryogenics such as liquid oxygen and liquid nitrogen. Gasoline tankers are fueling gas stations all over the city. They typically carry around 10,000 gallons of gasoline on the roads using approved transportation routes. The hospital has the second largest liquid oxygen tank, over 3000 gallons. The WETA Facility mentioned in other correspondence has over 48,000 gallons diesel fuel. There are multiple oxygen cylinders used in the small number of permitted rehabilitation, convalescence, and wellness facilities. The beverage plant has 14 tons of carbon dioxide, another simple asphyxiant. There are no organophosphates observed during the site walk through of the facility, nor should one expect to see any, as the business operations do not warrant the use of them.



Feel free to reach out with further questions of follow up from this report.

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[hazmatgal@yahoo.com](mailto:hazmatgal@yahoo.com)  
510-773-2507

Attachments:

Plume Model Report for Mineral Spirits

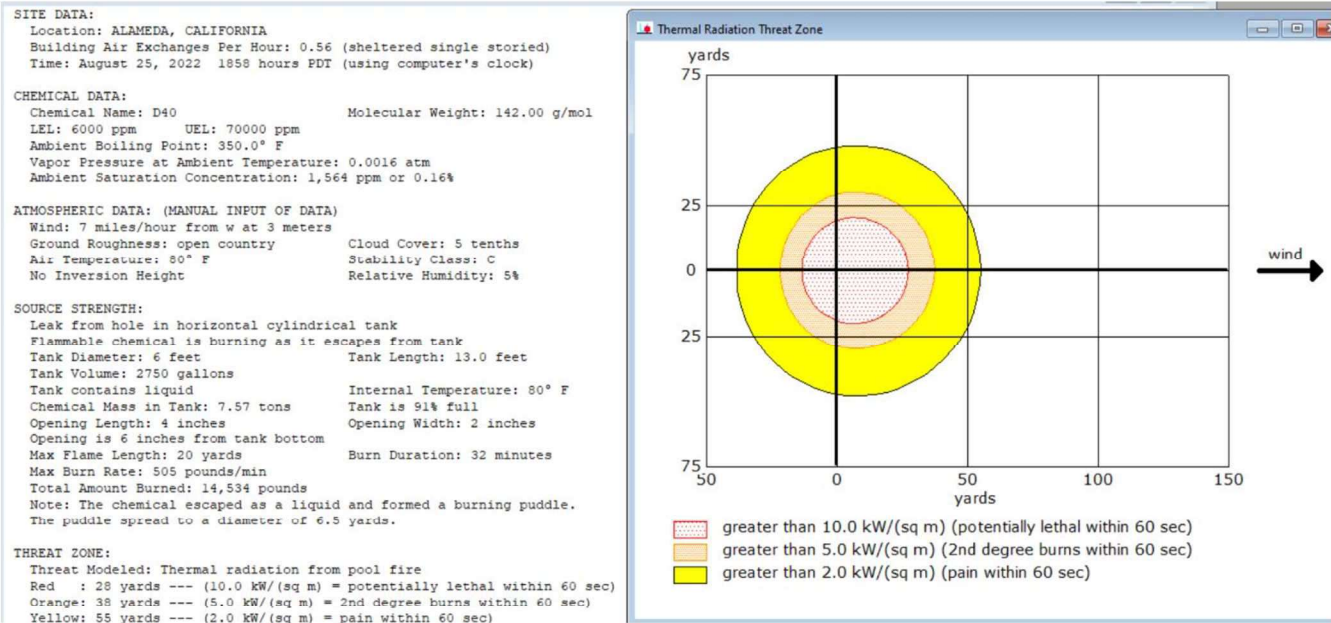
Inventory from Astra as reported in the CERS Responder Portal

Diagram of Approved Hazmat Transportations Routes in the City of Alameda

## D40 Rocket Fuel Modeled for Radiant Heat Exposure from the contents of the tank leaking and burning.

In short, if the entire tank's contents were on fire (would take ~30 minutes to burn) and you walked up to it (25 yards away from tank) while it was burning (without firefighting gear) the radiant heat could be lethal in one minute. If you were 50 yards away from it while it was burning you would feel some pain. Similar to the effects you would suffer if a medium size diesel fuel tank truck leaked it's contents and caught fire.

### ALOHA Plume Model:



The above plume model was based on the highly un-probable scenario that something like a forklift tine pierced the double walled tank and the cinder block secondary containment berm was also damaged; such that the leaking fuel could form a puddle around the tank – and then somehow the pool of fuel found an ignition source and caught fire.



## D40 Rocket Fuel Modeled for Radiant Heat Exposure from the contents of the tank leaking and burning.

In short; if the entire tank's contents leaked out onto the ground, the flammable area of the vapor cloud produced (the area where you would be concerned about the cloud finding an ignition source) extends out to about 26 yards

away from the tank. Looking at the picture on the previous page taken during the site visit – no obvious ignition sources were observed anywhere near the tank.

## D40 Rocket Fuel Modeled for the potential to cause an explosion from a vapor cloud formed as a result of the tanks contents leaking out.

In short, if the entire tank's contents leaked out and the vapor cloud did find an ignition source could it produce an explosion? Answer was no vapor cloud explosion would occur.

The screenshot displays a software interface with two main windows. The background window shows detailed input data for a hazard analysis of D40 rocket fuel. The 'Flammable Threat Zone' window is overlaid on the right side, showing the results of a Gaussian model run. The threat zone is modeled as a flammable area of vapor cloud, with a red zone extending 26 yards (60% LEL) and a yellow zone extending 26 yards (10% LEL). Notes indicate that the threat zone was not drawn due to near-field patchiness effects.

**SITE DATA:**  
Location: ALAMEDA, CALIFORNIA  
Building Air Exchanges Per Hour: 0.56 (sheltered single storied)  
Time: August 25, 2022 1858 hours PDT (using computer's clock)

**CHEMICAL DATA:**  
Chemical Name: D40 Molecular Weight: 142.00 g/mol  
LEL: 6000 ppm UEL: 70000 ppm  
Ambient Boiling Point: 350.0° F  
Vapor Pressure at Ambient Temperature: 0.0016 atm  
Ambient Saturation Concentration: 1,564 ppm or 0.16%

**ATMOSPHERIC DATA: (MANUAL INPUT OF DATA)**  
Wind: 7 miles/hour from w at 3 meters  
Ground Roughness: open country Cloud Cover: 5 tenths  
Air Temperature: 80° F Stability Class: C  
No Inversion Height Relative Humidity: 5%

**SOURCE STRENGTH:**  
Leak from hole in horizontal cylindrical tank  
Flammable chemical escaping from tank (not burning)  
Tank Diameter: 6 feet Tank Length: 13.0 feet  
Tank Volume: 2750 gallons  
Tank contains liquid Internal Temperature: 80° F  
Chemical Mass in Tank: 7.57 tons Tank is 91% full  
Opening Length: 4 inches Opening Width: 2 inches  
Opening is 6 inches from tank bottom  
Ground Type: Concrete  
Ground Temperature: equal to ambient  
Max Puddle Diameter: Unknown  
Release Duration: ALOHA limited the duration to 1 hour  
Max Average Sustained Release Rate: 9.66 pounds/min (averaged over a minute or more)  
Total Amount Released: 447 pounds  
Note: The chemical escaped as a liquid and formed an evaporating puddle. The puddle spread to a diameter of 52 yards.

**THREAT ZONE:**  
Threat Modeled: Flammable Area of Vapor Cloud  
Model Run: Gaussian  
Red : 26 yards --- (3600 ppm = 60% LEL = Flame Pockets)  
Note: Threat zone was not drawn because effects of near-field patchiness make dispersion predictions less reliable for short distances.  
Yellow: 26 yards --- (600 ppm = 10% LEL)  
Note: Threat zone was not drawn because effects of near-field patchiness make dispersion predictions less reliable for short distances.

The screenshot displays a software interface with a background window showing site and chemical data for D40 rocket fuel, and a 'Hazard To Analyze' dialog box overlaid on the right side. The dialog box has three radio button options: 'Toxic Area of', 'Flammable Area of', and 'Blast Area of'. The 'Flammable Area of' option is selected. A 'Note!' dialog box is also overlaid on top of the 'Hazard To Analyze' dialog, stating that the chemical's ambient saturation concentration is below its lower explosive limit, making a vapor cloud explosion unlikely.

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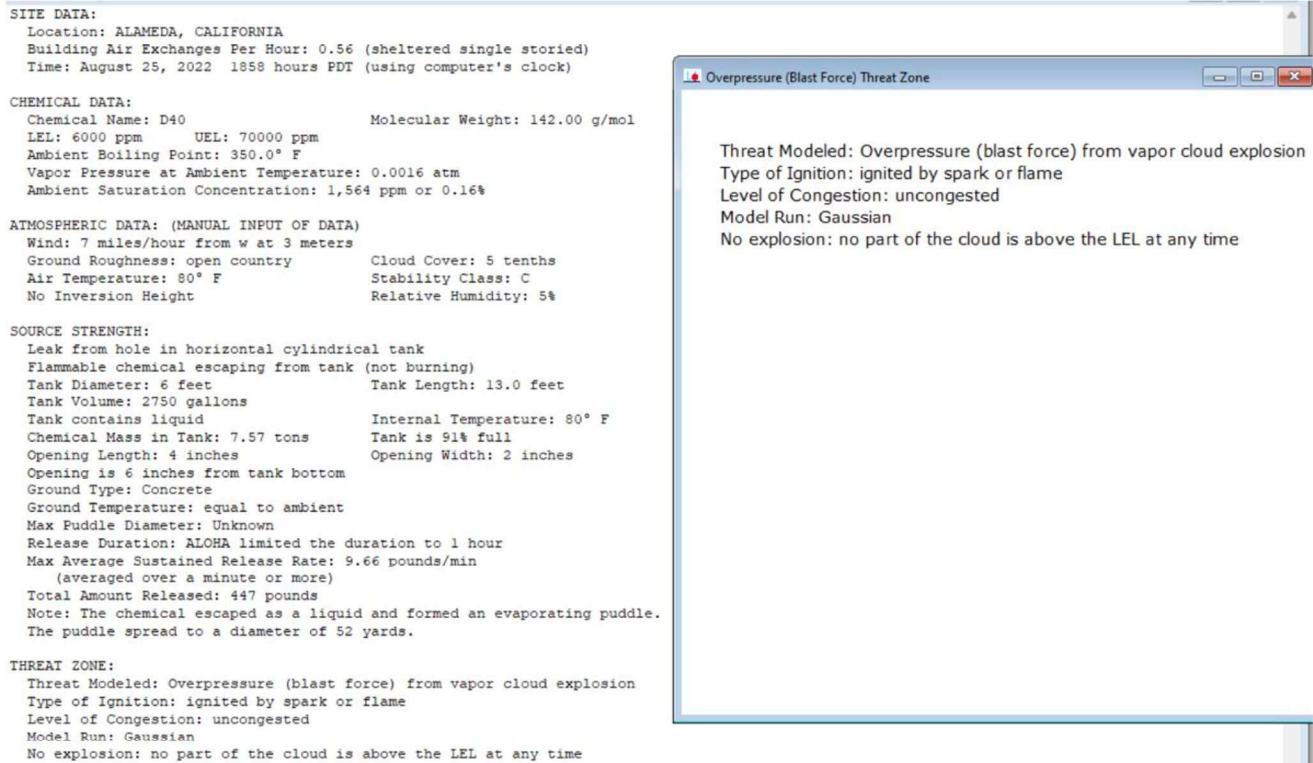
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When the ALOHA program was prompted to run the vapor cloud explosion model the result was that such an explosion was not a possibility:



The image shows a screenshot of the ALOHA program's output window on the left and a smaller summary window titled "Overpressure (Blast Force) Threat Zone" on the right. The output window contains detailed data for site, chemical, atmospheric, and source strength parameters, along with a threat zone analysis. The summary window provides a concise overview of the modeled threat, ignition type, congestion level, model used, and the final conclusion that no explosion occurred.

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**THREAT ZONE:**  
Threat Modeled: Overpressure (blast force) from vapor cloud explosion  
Type of Ignition: ignited by spark or flame  
Level of Congestion: uncongested  
Model Run: Gaussian  
No explosion: no part of the cloud is above the LEL at any time

**Overpressure (Blast Force) Threat Zone**  
Threat Modeled: Overpressure (blast force) from vapor cloud explosion  
Type of Ignition: ignited by spark or flame  
Level of Congestion: uncongested  
Model Run: Gaussian  
No explosion: no part of the cloud is above the LEL at any time

## Facility: Astra (CERSID: 10811254)

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[Inventory Detail](#)

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### Inventory Detail for CERS ID: 10811254

**Facility Name:** Astra  
**Business Name:** Astra Space, Inc. (Alameda, CA)  
**CUPA:** Alameda County Environmental Health

#### Inventory Summary

DOT Hazard Class	Common Name	Max Daily Amount	Units
No DOT Hazard Class Provided			
	Acetone	75	gallons
	Air	284	cubic feet
	Argon	1488	cubic feet
	B-Cool 755 (Blaser)	595	gallons
	Helium	2619	cubic feet
	Hydraulic Oil	130	gallons
	Isopropyl Alcohol	100	gallons
	Lithium-ion Polymer Batteries	1450	pounds
	Nitrogen	3439	cubic feet
	Nitrogen, Refrigerated Liquid	51	gallons
	Propane, ethane, propylene	2000	gallons
	Propylene Glycol 50%	110	gallons
	Deionized water	220	gallons

## Facility: Astra (CERSID: 10781188)

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[Summary](#)

[Inventory Detail](#)

[Site Map](#)

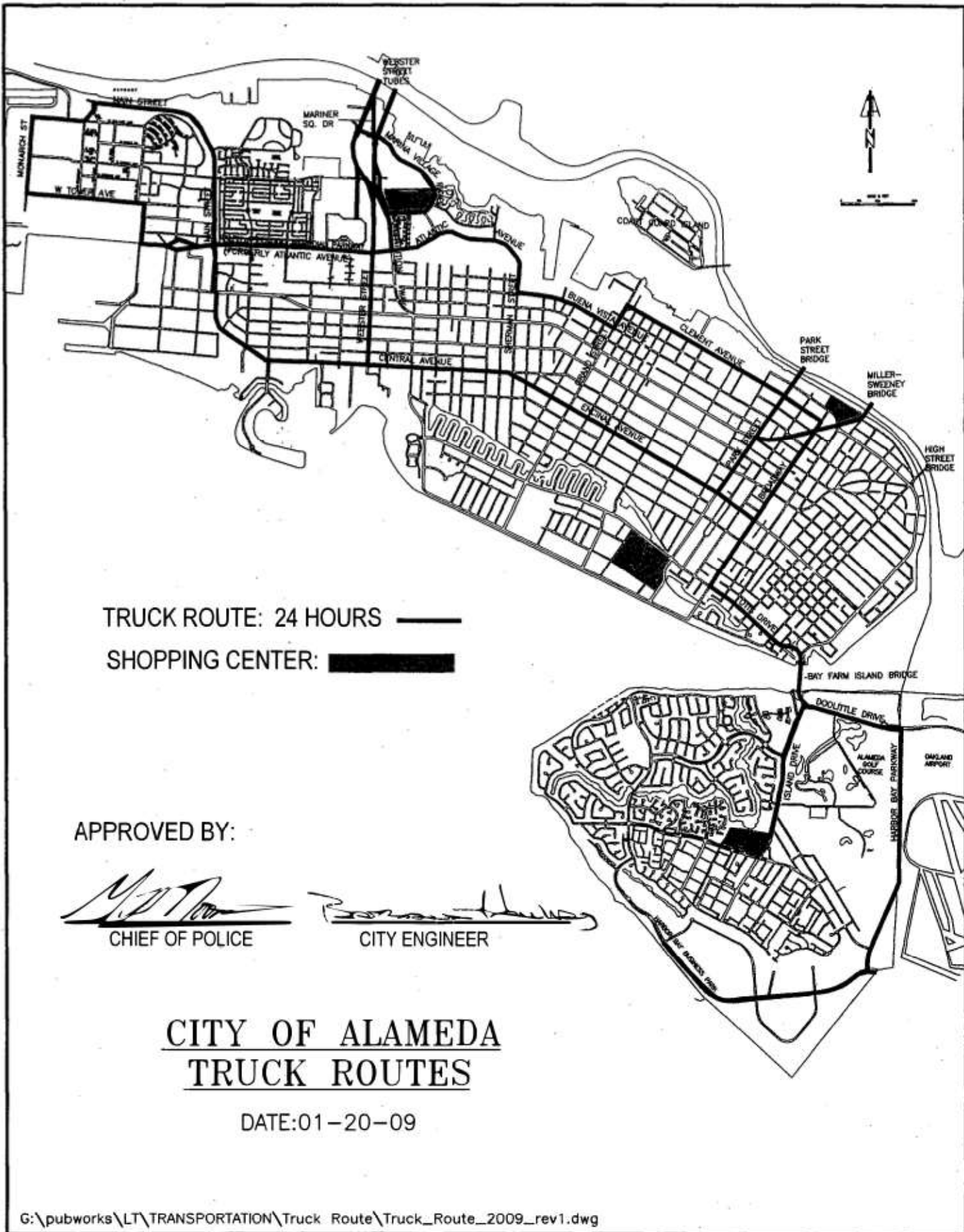
### Inventory Detail for CERS ID: 10781188

**Facility Name:** Astra  
**Business Name:** Astra Space, Inc. (Alameda, CA)  
**CUPA:** Alameda County Environmental Health

#### Inventory Summary

DOT Hazard Class	Common Name	Max Daily Amount	Units
No DOT Hazard Class Provided			
	Acetylene	260	cubic feet
	Argon	10912	cubic feet
	StarGold C8	843	cubic feet
	Argon Balance Hydrogen	527	cubic feet
	Carbon Dioxide	2508	cubic feet
	Carbon Dioxide, Refrigerated Liquid	71	gallons
	Helium	37346	cubic feet
	Hydrogen	588	cubic feet
	Methane	1320	cubic feet
	Nitrogen	9576	cubic feet
	Nitrogen, Refrigerated Liquid	13512	gallons
	Oxygen	1019	cubic feet
	Oxygen, Refrigerated Liquid	8112	gallons
	Mineral spirits	4659	gallons
	Propane	50	gallons
	Propylene Glycol 50%	60	gallons
	Simple Green	60	gallons





TRUCK ROUTE: 24 HOURS ———

SHOPPING CENTER: ■■■■■

APPROVED BY:

CHIEF OF POLICE

CITY ENGINEER

**CITY OF ALAMEDA**  
**TRUCK ROUTES**

DATE:01-20-09