

Process Safety

At the Alaska LNG Liquefaction Facility and Marine Terminal
April 12, 2018

Leslie “Fritz” Krusen



Agenda

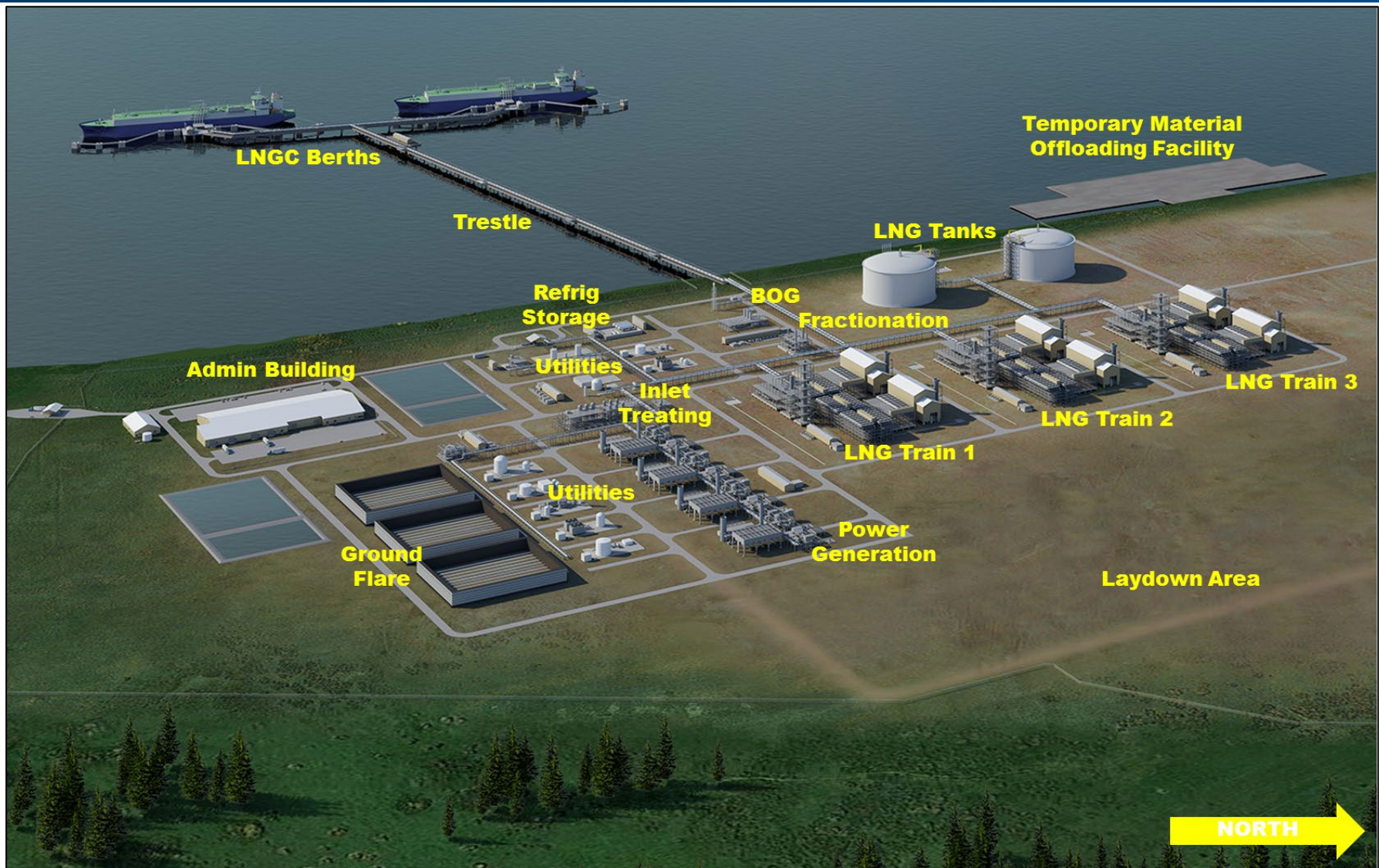
- LNG Site Overview
- Hazard Analysis Report
- Flares
- Noise
- Seismic Design
- Emergency Response Plan

- **LNG Site Overview**
- Hazard Analysis Report
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LNG Site Overview

- Summary
 - Highly modularized
 - 3 train liquefaction plant - 6.7 MTPA each
 - About 900 acres of land required
- Design Basis
 - Air Products C3MR™ process; two refrigeration cycles
 - C3 = Propane
 - MR = Mixed Refrigerant (mix of propane, ethane, & nitrogen)
 - Power plant (combined cycle), with distribution system optimized to reduce capex; Black-Start tie in to local utility
 - 2 x 240,000 m³ LNG storage tanks
 - Marine jetty with 2 loading berths, LNG loading rate 12,500 m³/hr
- Execution Basis
 - Material Offloading Facility (MOF) to support the unloading of bulk materials, modules, and construction equipment; Temporary facility

LNG Site Overview



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- **Hazard Analysis Report**
- Flares
- Noise
- Seismic Design
- Emergency Response Plan

Hazard Analysis Report - Overview

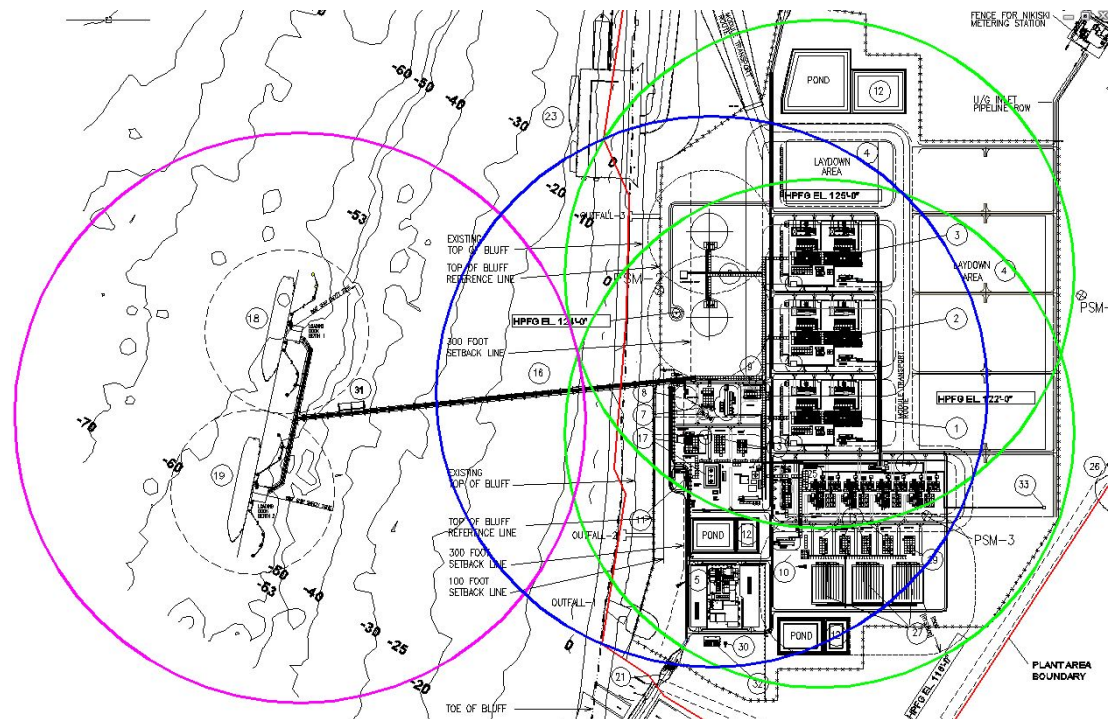
- Required by FERC and DOT PHMSA to evaluate hazards associated with:
 - Flammable Gas Dispersion (vapor dispersion exclusion zone)
 - Pool Fires (thermal radiation exclusion zone)
 - Jet Fires (hazard zone)
 - Refrigerant vapor dispersion (hazard zone)
 - Overpressure from ignition of flammable refrigerants (hazard zone)
 - Toxic vapor dispersion (hazard zone)
- All piping has a “hole size” associated with it based on DOT PHMSA FAQ website
- Piping table has been created to list every piece of pipe in the facility along with its “hole size” – over 140 release scenarios have been evaluated
- Modeling is performed on the “bounding scenarios” to ensure hazards do not impact the public – 18 bounding scenarios have been selected.

- Flammable Gas Dispersion for LNG (1/2 LFL)

Purple = release
from loading line at
jetty

Blue = release from
loading line on
shore

Green = release
from LNG rundown
lines



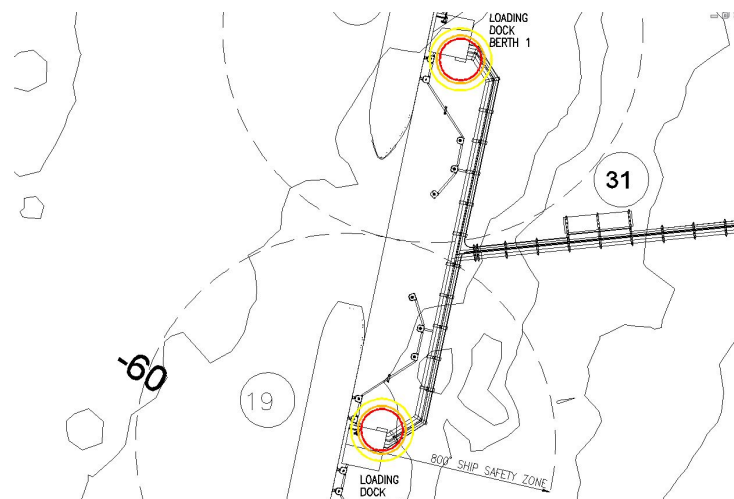
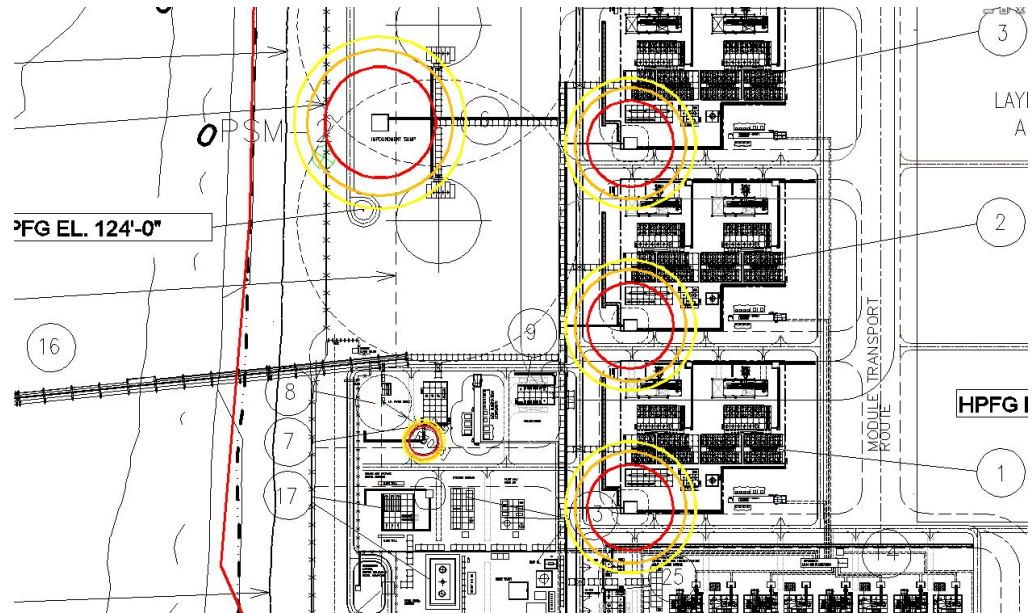
Hazard Analysis Report – Pool Fire

- Pool Fires for Process Areas

Yellow = low flux
(1,600 Btu/ft²-hr)

Orange = medium
flux (3,000
Btu/ft²-hr)

Red = high flux
(10,00 Btu/ft²-hr)



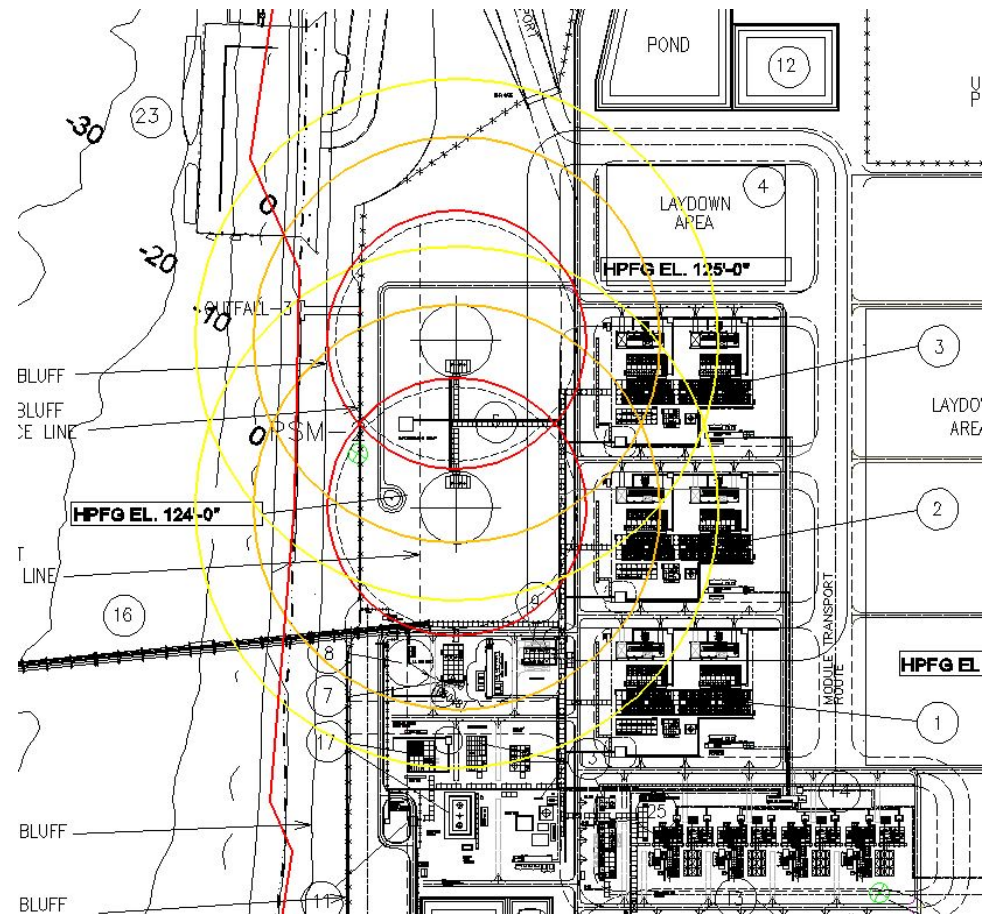
Hazard Analysis Report – Pool Fire

- Pool Fires for LNG Tanks

Yellow = low flux
(1,600 Btu/ft²-hr)

Orange = medium
flux (3,000
Btu/ft²-hr)

Red = high flux
(10,00 Btu/ft²-hr)



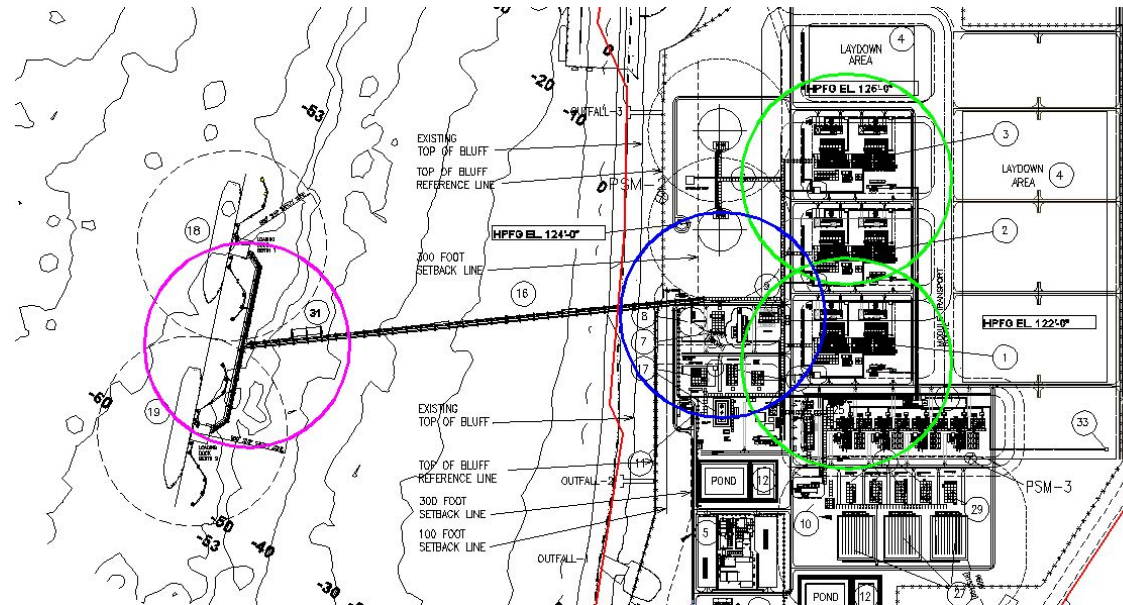
Hazard Analysis Report – Jet Fire

- Jet Fires for LNG, low flux (1,600 Btu/ft²-hr)

Purple = release from unloading line at jetty

Blue = release from unloading line on shore

Green = release from LNG rundown lines

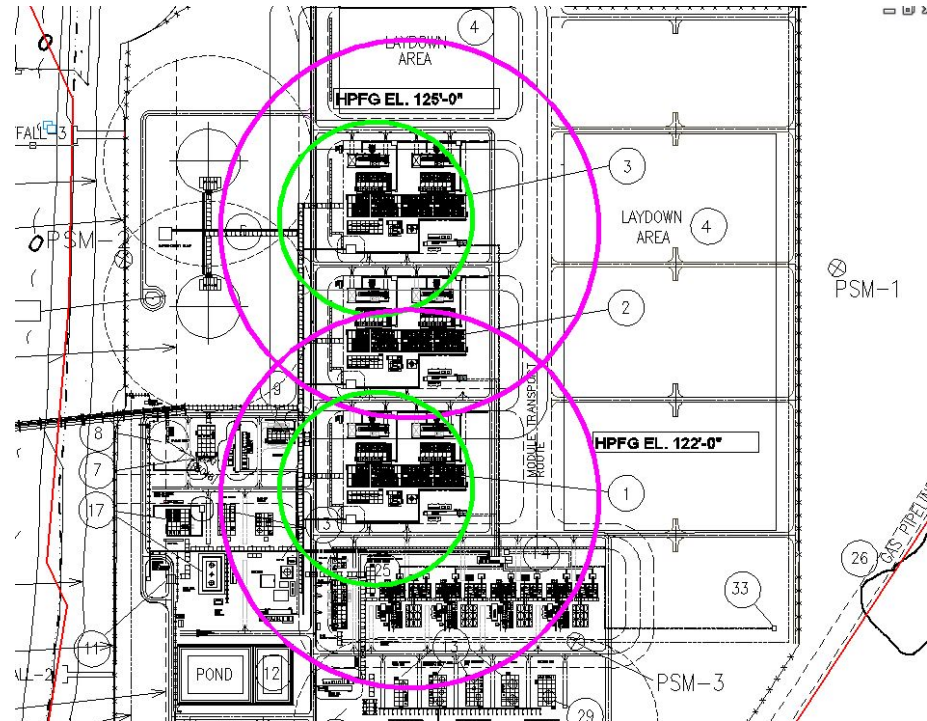


Hazard Analysis Report – Jet Fire

- Jet Fires for Mixed Refrigerant, low flux (1,600 Btu/ft²-hr)

Purple = MCHE release

Green = HP MR Compressor outlet release



Hazard Analysis Report – Jet Fire

- Jet Fires for Propane Refrigerant, low flux ($1,600 \text{ Btu/ft}^2\text{-hr}$)

Green = Propane Storage Bullet

Blue = Propane subcooler outlet

Purple = connection on propane cooler

Orange = release from reflux drum

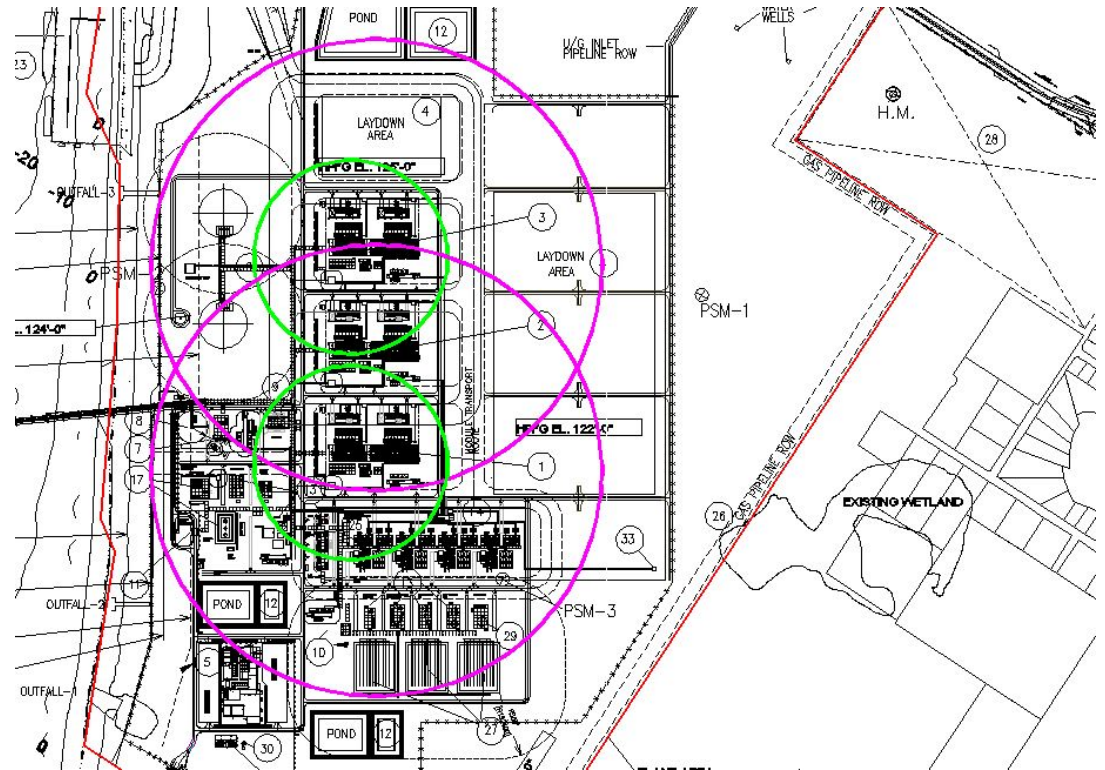


Hazard Analysis Report – Gas Release

- Refrigerant vapor dispersion for mixed refrigerant (1/2 LFL)

Purple = MCHE release

Green = HP MR Compressor outlet release



Hazard Analysis Report – Gas Release

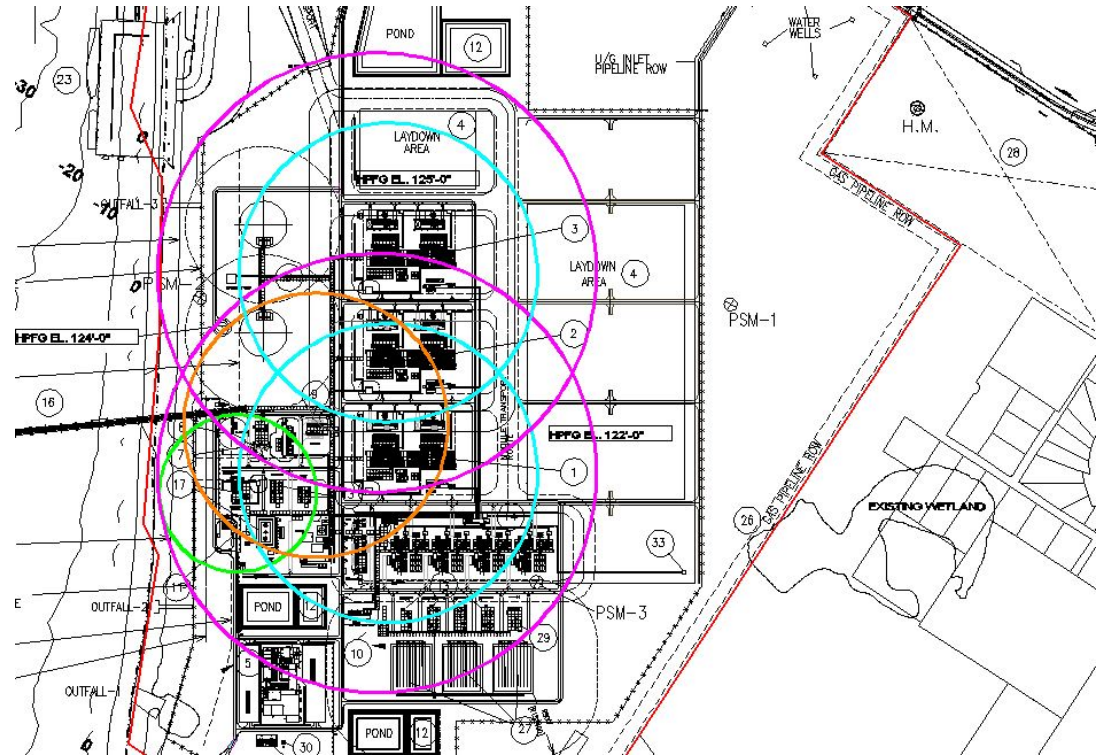
- Refrigerant vapor dispersion for propane refrigerant (1/2 LFL)

Green = Propane Storage Bullet

Blue = Propane subcooler outlet

Purple = connection on propane cooler

Orange = release from reflux drum



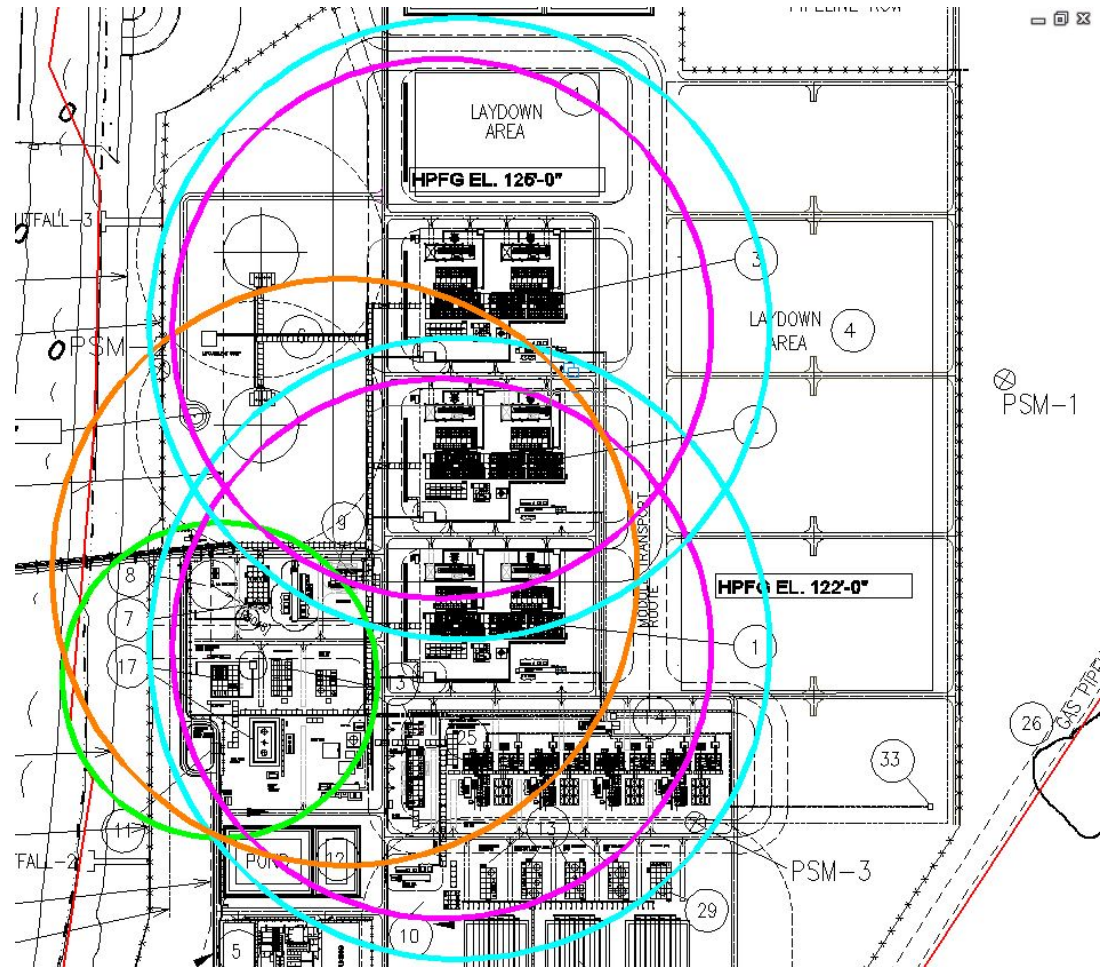
Hazard Analysis Report - Overpressure

- Overpressure from mixed refrigerant ignition (1 psi)
 - Purple = MCHE release
 - Green = HP MR Compressor outlet release



Hazard Analysis Report - Overpressure

- Overpressure from propane refrigerant ignition (1 psi)
 - Green = Propane Storage Bullet
 - Blue = Propane subcooler outlet
 - Purple = connection on propane cooler
 - Orange = release from reflux drum



Hazard Analysis Report - Toxics

- AEGL = Acute Exposure Guideline Level, 3 levels
 - AEGL 3: Lethal (Life threatening health effects or death)
 - AEGL 2: Disabling (Irreversible health effects, impairs escape)
 - AEGL 1: Non-Disabling (Notable discomfort, reversible)
- Exposure Durations from 10 minutes to 8 hours
- PHMSA analysis: AEGL Levels 1, 2, & 3 @1 hour
- Different hazard from asphyxiant, flammable, or explosive
- Website reference: WWW.EPA.GOV/AEGL

Hazard Analysis Report - Toxics

AEGL Info from EPA; exposure = 1 hour, concentration in parts per million

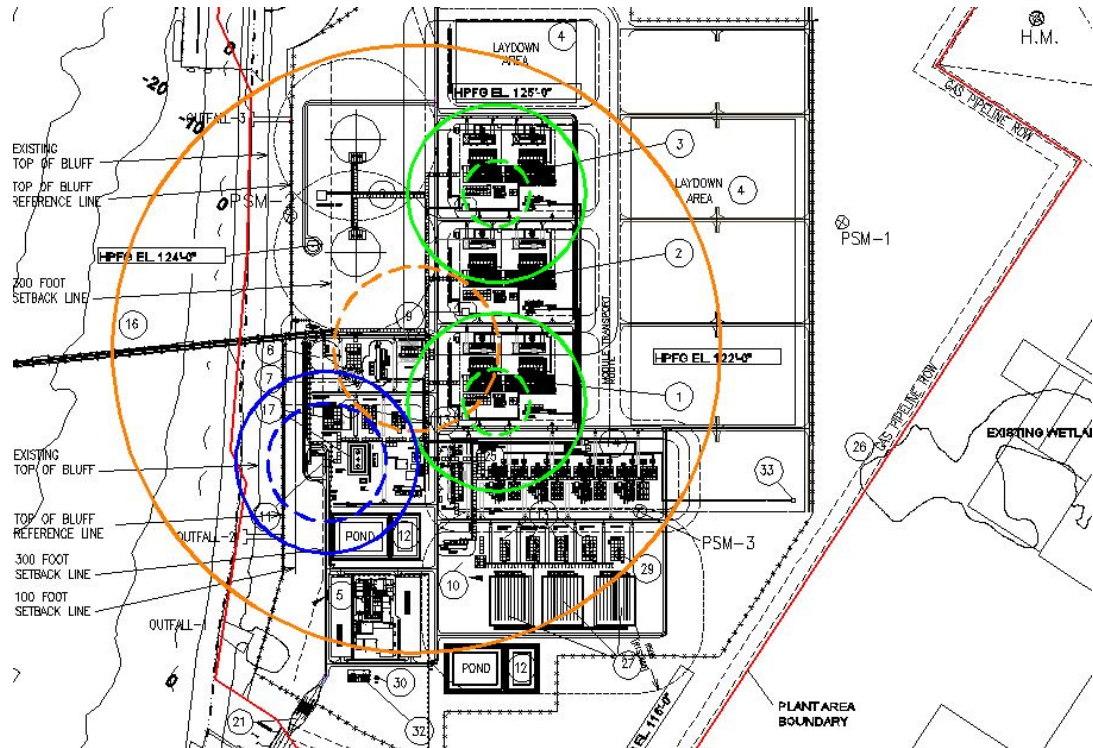
COMPOUND	AEGL1	AEGL2	AEGL3
Aromatics (Benzene)	52	800	4,000
C6+ (Hexane)	Not Recorded	2,900	8,600
C5's (Pentane)	No Information	N.I.	N.I.
C4 (Butanes)	5,500	17,000(1)	33,000(1)
C3 (Propane)	5,500	17,000(1)	33,000(1)
C2 (Ethane)(2)	Not Listed	N.L.	N.L.
C1 (Methane)(2)	Not Listed	N.L.	N.L.

Notes:

- (1) Flammability hazard is at a lower concentration
- (2) Alaska LNG gas at plant entrance is about 97% methane and ethane

Hazard Analysis Report - Toxics

- Toxic vapor dispersion from heavy hydrocarbons (1/2 AEGL)
- (solid line – AEGL-2)
- (dotted line – AEGL-3)



Hazard Analysis Report - Toxics

AEGL Info from EPA; exposure = 1 hour, concentration in parts per million

COMPOUND	AEGL-1	AEGL-2	AEGL-3
Aromatics (Benzene)	52	800	4,000
C6+ (Hexane)	Not Recorded	2,900	8,600
C5's (Pentane)	No Information	N.I.	N.I.
C4 (Butanes)	5,500	17,000	33,000
C3 (Propane)	5,500	17,000	33,000
C2 (Ethane)	Not Listed	N.L.	N.L.
C1 (Methane)	Not Listed	N.L.	N.L.
Methyl Mercaptan*	Not Recorded	23	68
Chlorine*	.050	2	28

*Note: Methyl mercaptan and chlorine are not present at the LNG facility and are listed for reference only.

Hazard Analysis Report - Summary

- All exclusion zones (thermal radiation and vapor dispersion) meet DOT PHMSA requirements and do not impact the public
- All hazard zones (jet fires, refrigerant vapor dispersion, refrigerant overpressure, and toxicity) meet DOT PHMSA requirements and do not impact the public
- Alaska LNG Hazard Analysis Report is publically-available; see AGDC's Alaska LNG website WWW.Alaska-LNG.com, then
 - Upper Tab Regulatory Process – FERC Application Exhibits (Resource Reports)
 - Resource Report 13 (LNG Plant), Appendix Part 1, page 279

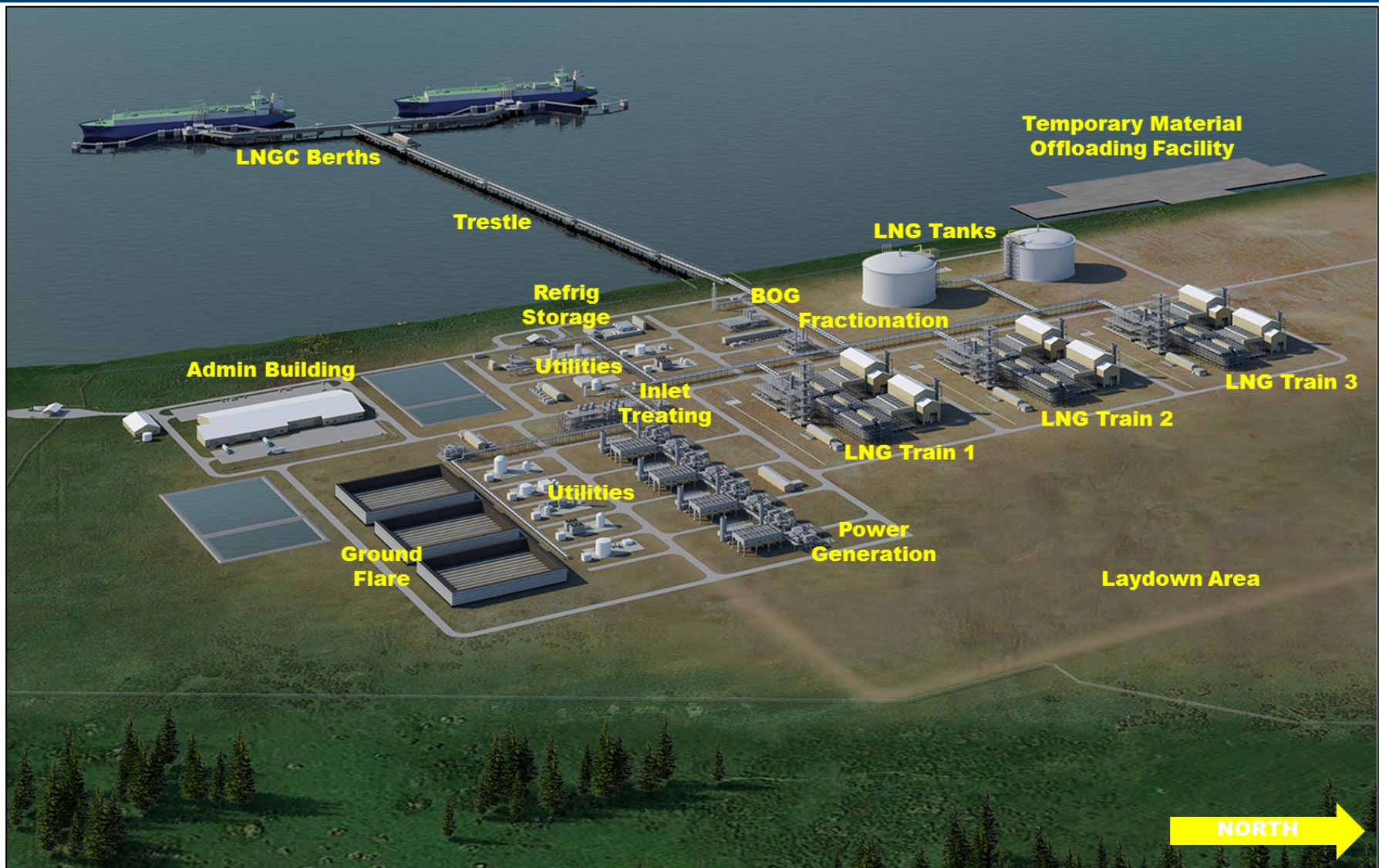
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- Noise
- Seismic Design
- Emergency Response Plan

- There are two flares at Alaska LNG
 - High-Pressure Ground Flare
 - Low-Pressure Elevated Flare
- High-Pressure Ground Flare
 - Located at south end of plant
 - Handles inlet gas (“wet”), LNG process (“dry”), and refrigerant compressor overpressure situations
 - Three 50% units, each 260 ft X 350 ft
 - Each enclosed by 50 ft tall radiation fence, no “sterile zone” required (to get to 500 BTU/ft²-hr radius)
 - Flare area surrounded by 500 ft “no hydrocarbon-handling equipment” radius (equipment-spacing insurance guideline)
- 500 BTU/ft²-hr: Allows continuous exposure with appropriate clothing

- Low-Pressure Elevated Flare
 - Located near bluff at middle of plant
 - Handles LNG Carrier (ship) and LNG tank overpressure situations, plus ship cool-down
 - One 24" tower, currently 200 ft tall
 - Tower surrounded by fence with 120 ft radius for "sterile zone" (to get to 500 BTU/ft²-hr)
 - Ship cool-down could occur 4-5 times per year and could last about 17 hours (depends on ship size)

LNG Site - Flares



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Noise - Introduction

- Two Operations-phase noise criteria for the Alaska LNG Plant
 - 85 dBA: Within-plant, at 3 ft from noise-generating equipment
 - 55 dBA, Off-site at “Noise Sensitive Areas” (NSA’s) as per FERC 18 CFR 157.206
- Operations phase analysis does not include upsets such as flares
- Four NSA’s identified and measured on 10-11 March, 2015 for pre-construction background, 2015; see map
 - LT-1: 10,500 ft NW of center Train 2, about 6160 ft from plant fence
 - LT-2: 3,700 ft E of center of Train 2, about 300 ft from plant fence
 - LT-3: 6,600 ft S of center of Train 2, about 300 ft from plant fence
 - ST-4: 5,700 ft SE of center of Train 2, about 300 ft from plant fence
- LT station measurements were made for about 48 hours, ST measurements for about 40 minutes

Noise – Pre-Construction Background



Description of NSA Locations			
Location (NSA)	Description	Approximate Distance from Train #2 Center (feet)	Direction
LT-1 (NSA_01215)	Located on the northwest corner of Malaitna Road and Tarawa Street, and approximately 6,160 feet north of the proposed LNG liquefaction facility footprint boundary	10,500	Northwest
LT-2 (NSA_01533)	Located on the north side of Ray Court east of Top Gun Street (Jody Street on Google Maps), and less than 300 feet east of the proposed LNG liquefaction facility footprint boundary	3700	East
LT-3 (NSA_01555)	Located on the north side of Spruce Place north of South Miller Loop Road, and approximately 300 feet southeast of the proposed LNG liquefaction facility footprint boundary	6600	South
ST-4 (NSA_01486)	Located at the northern terminus of Redoubt Drive off of Birch Lane, and less than 300 feet east of the proposed LNG liquefaction facility footprint boundary	5700	Southeast

Noise - Operational

- Numerous design optimizations were made to reduce operational noise:
 - Low-noise blades on the airfin coolers
 - Low-noise inlet air ducts and exhaust stacks on the gas turbines
 - Noise-abatement insulation on compressor discharge piping
 - Enclosures and buildings around noise-generating equipment
 - Etc
- The four NSA's currently look to be under the 55 dBA Operational noise limit during steady-state operations, see map

Noise - Operational



Estimated Sound Levels Noise Sensitive Areas	
Location	Estimated Sound Level, L_{dn} , dBA
LT-1 (NSA_01215)	39.0
LT-2 (NSA_01533)	54.8
LT-3 (NSA_01555)	47.6
ST-4 (NSA_01486)	53.5

Noise - Construction

- Construction phase uses Federal Highway Administration (FHWA) protocols to address intermittent nature of activities such; average noise may exceed 55 dBA at NSA's (see map)
- Pile-Driving is likely the loudest construction activity
 - Probably will be limited to 12 hours per day
 - Plant permits will include piled foundations
 - But good Nikiski soils may allow some spread-footing foundations instead of piles
- Pile-Driving will occur for the offshore structures
- Kenai Spur Highway Re-Route is not currently included in the LNG Plant construction (or operational) noise assessment

Noise - Construction



Estimated Sound Levels at NSAs Construction	
Location	L_{dn} dBA
LT-1 (NSA_01215)	53.5
LT-2 (NSA_01533)	67.1
LT-3 (NSA_01555)	63.6
ST-4 (NSA_01486)	65.5

Noise - Comparisons

- 90 dBA: Power mower at 25 ft
- 80 dBA: Garbage disposal
- 70 dBA: Vacuum cleaner
- 60 dBA: Conversation at restaurant
- 50 dBA: Conversation at home

Noise - Conclusion

- With design mitigations, the Alaska LNG Plant will meet the steady-state Operational offsite criteria of 55 dBA
- Construction could be noisier than 55dBA at offsite receptors, but impact will be intermittent
- Alaska LNG Liquefaction Facility Environmental Sound Level Assessment Report is publically-available; see AGDC's Alaska LNG website WWW.Alaska-LNG.com, then
 - Upper Tab Regulatory Process – FERC Application Exhibits (Resource Reports)
 - Resource Report 9, Appendix P

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Seismic Design Considerations I

- Nikiski is known to be a high-seismic area
 - 1964 Great Alaska Earthquake (magnitude 9.2)
 - Recent (Jan, 2016) magnitude 7.1 earthquake felt on Kenai Peninsula
- Several design code give guidance to ensure robustness
 - Overall: DOT Title 49 CFR 193, FERC Draft 2007 Seismic Design Guidelines
 - LNG-Containing/Controlling Equipment: NFPA-59A
 - Buildings and Structures: ASCE 7-05 and 7-10
 - Marine Facilities:
 - USCG Title 33 CFR 127.103
 - California MOTEMS (Marine Oil Terminal Engineering & Maintenance Standard)

Seismic Design Considerations II

- Facilities must be designed for:
 - Operating Basis Earthquake (OBE): Equipment remains functional
 - Safe Shutdown Earthquake (SSE): Equipment may be damaged and require repair, but containment is maintained
- Seismic design details are confidential, but Alaska LNG (LNG plant) Facilities Seismic Engineering Report is publically-available; see AGDC's Alaska LNG website WWW.Alaska-LNG.com, then
 - Upper Tab Regulatory Process – FERC Application Exhibits (Resource Reports)
 - Resource Report 13 (LNG Plant), Appendix Part 4

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- **Emergency Response Plan**

Emergency Response Plan - Overview

- A combined Emergency Response Plan (ERP) will be developed to incorporate not just the Liquefaction Facility, but also the GTP and Pipeline that are part of the overall Alaska LNG Project
- Within this combined plan will be individual ERPs that will meet all regulatory requirements and address the site-specific nature of the covered facilities.
 - Individual ERPs will be site-specific and identify the types of emergencies that will require notification to appropriate agencies.
 - The individual ERPs will contain the response organization and resources (e.g., diagrams, maps, plans, and procedures) necessary to respond adequately.
- The combined ERP will be developed using the nationally recognized Federal Emergency Management Agency (FEMA) guidelines and use the National Incident Management System (NIMS) as the methodology with the Incident Command System (ICS) organizational structure.
 - The ICS is the common emergency response tool used by industry and local emergency response agencies.
 - The Project's ICS will link to plans maintained by other affected response agencies or third parties and thus help to ensure appropriate communications, understanding, and cooperation are in place.
- The combined and individual plans will be prepared in consultation with stakeholders to ensure that all actions to emergencies are coordinated and understood by emergency responders, local community leaders, the government, and the general public.

Emergency Response Plan – Possible TOC

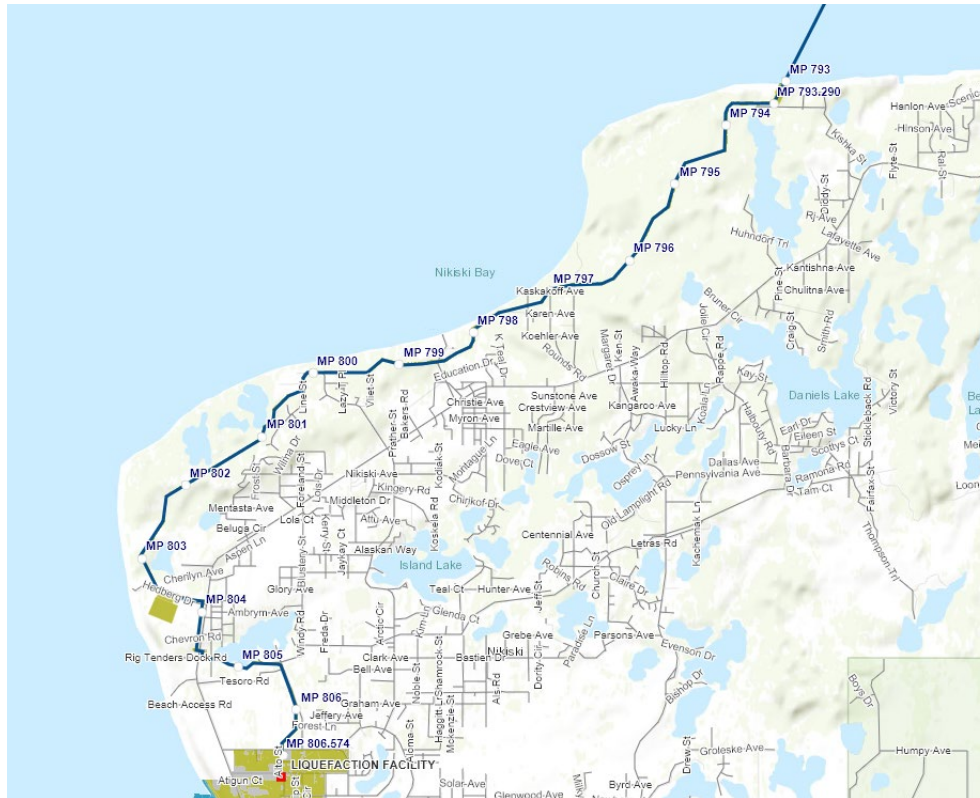
- Background on LNG
- Facility, Process Descriptions, and Safety System Descriptions
- Incident Command System: Description, Organization Chart, Roles, and Responsibilities; Onsite Emergency Response Personnel
- Emergency Response Contacts/Proximity and Mutual Aid Arrangements
- Description of Onsite Emergency Response Equipment
- Definition of Emergency Events
- Response Plans for the Emergency Events
- Emergency Access & Egress Routes within/adjacent to Facilities, including LNG Vessels
- Onsite and Public Emergency Notification Plan
- Emergency/Security Drill Plan
- Incident Reporting Requirements
- Post-Incident Investigations

Other Emergency Response Documents

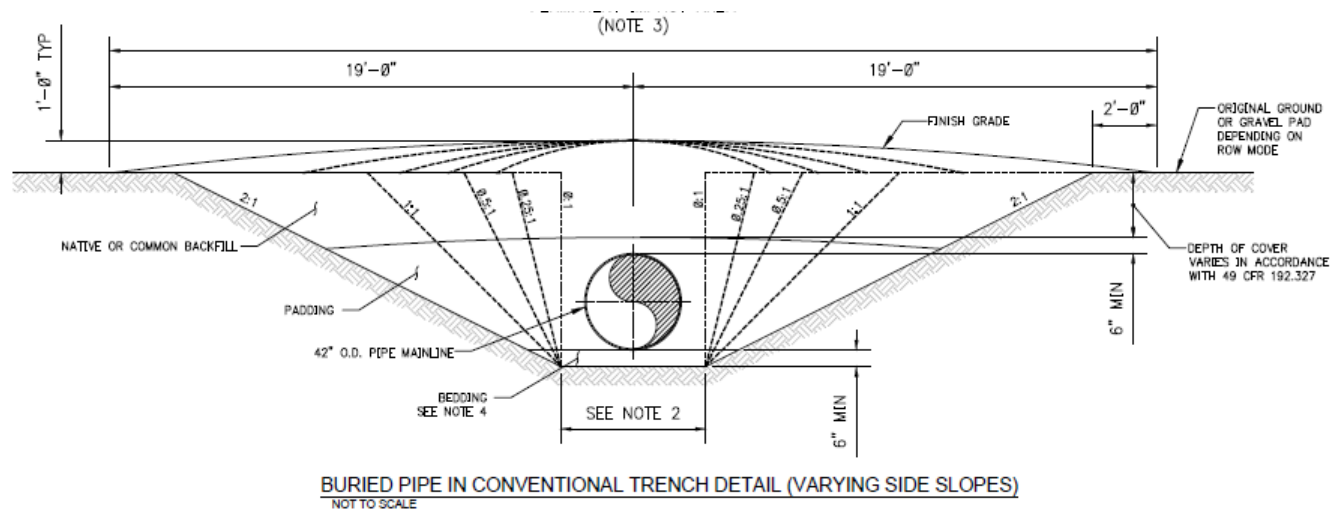
- LNG Transfer Manual (USCG)
- Spill Prevention Control & Countermeasure (SPCC) Plan
- Material Safety Data Sheets (MSDS's)
 - Methane
 - Ethane
 - Propane
 - N-Butane
 - Nitrogen
 - Diesel
- Alaska LNG Hazard Analysis Report is publically-available; see AGDC's Alaska LNG website WWW.Alaska-LNG.com, then
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- 800-mile, 42" buried pipe
 - ~55 miles within KPB
- 49 CFR Part 192
- Construction Right-of-Way
 - Nominal 120'

Route Map



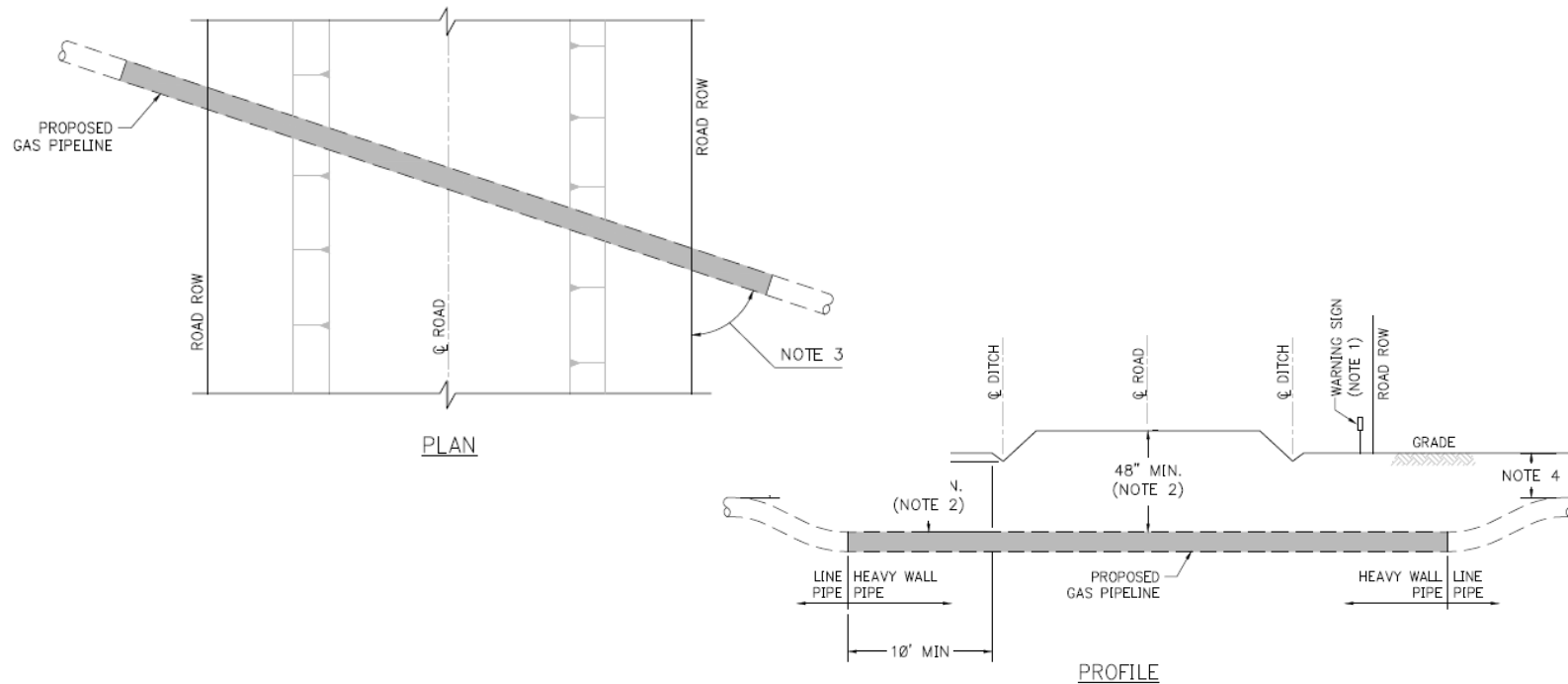
Buried Pipe



Pipeline Construction



Road Crossing



Integrity Management during Operations

(Required by 49 CFR 192.605 *Procedural Manual for Operations, Maintenance and Emergencies*)

Key items addressed:

- Worker qualification
- Periodic contact with stakeholders
- Public Education & Awareness
- Right-of-Way Patrols
- Pipeline markers
- Participation in Alaska's "One-Call" system (811 Dispatch)
- Cathodic Protection inspection and monitoring
- Pipeline In-Line-Inspection (ILI) - "smart pigs"
- Training Programs
- Procedures for ensuring public safety during planned maintenance and corrective action procedures

Integrates:

- Technology
- Operating Procedures
- Management protocols



AGDC Committed to Maximize Local Hire

The project is expected to generate thousands of jobs, including constructions support facilities:

- Project offices, personnel housing and support, and logistics support sites
- Construction work pads (gravel/ice or snow/grade)
- Laydown yards and storage facilities
- Port facilities
- Access roads
- Airports and airstrips



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