

Innovative Multiphase Extraction Design Operating above the Upper Flammability Limit (UFL).



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SYSTEM DESIGN GROUP

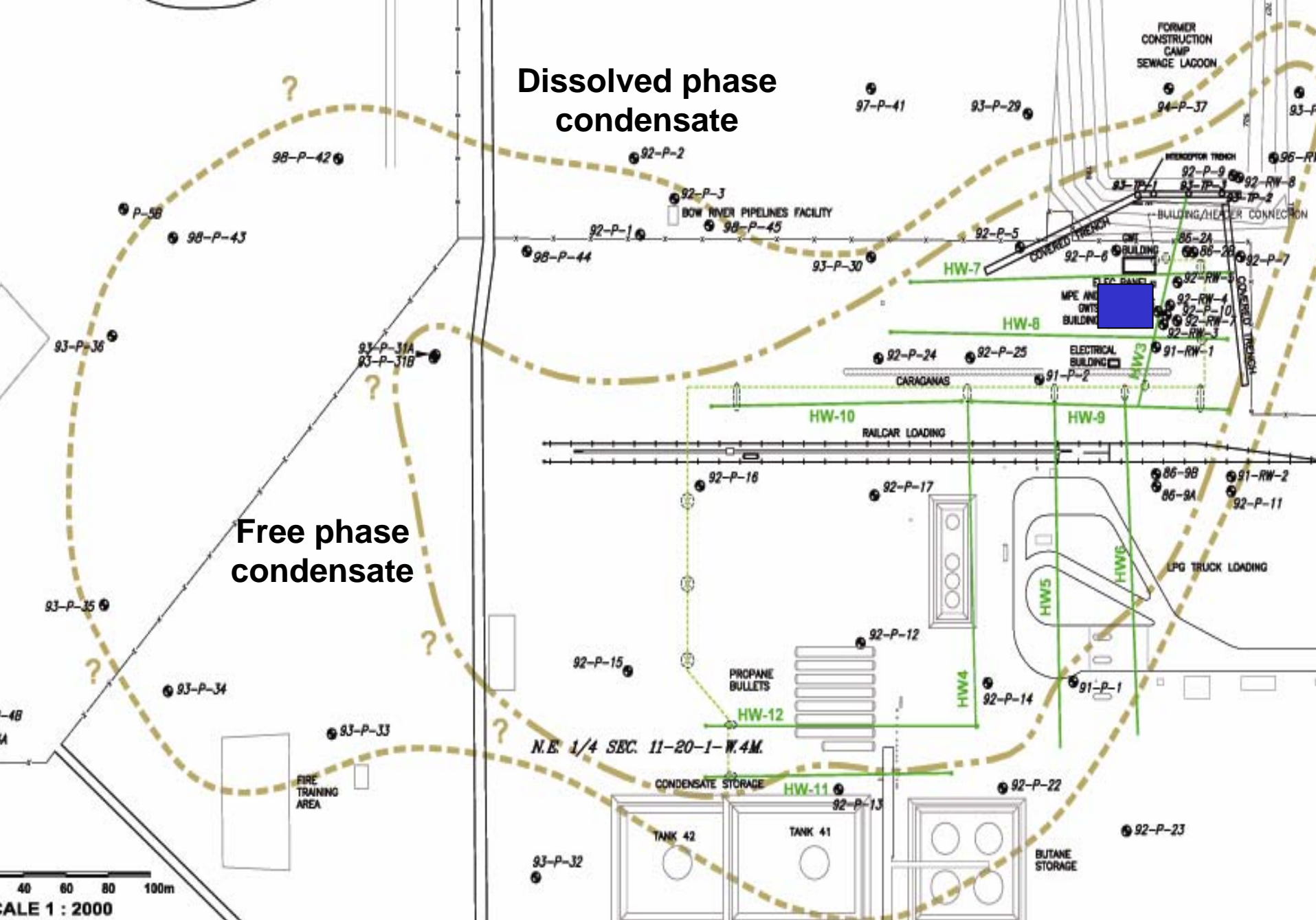
Introduction

- Background
- Design Challenges
- Objectives
- Why UFL
- Safe Operating Conditions
- Pipe & Equipment Safety
- Operation Uncertainties
- Operational Regimes
- The Design



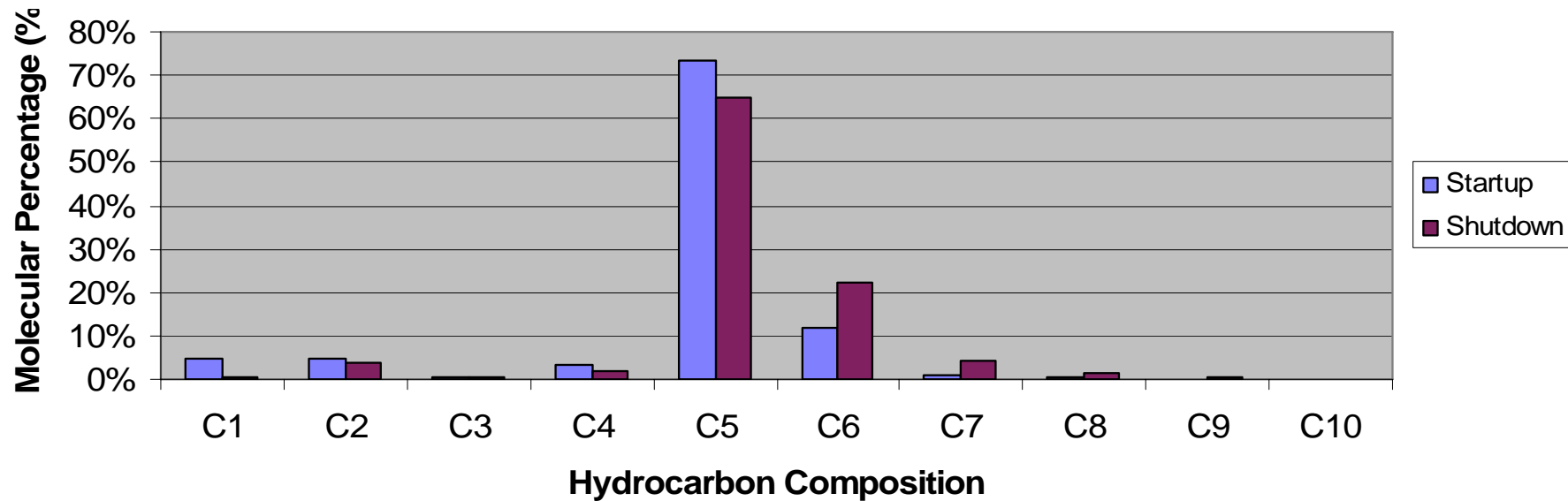
**Dissolved phase
condensate**

**Free phase
condensate**



Hydrocarbon Composition

HYDROCARBON COMPOSITION OF OFFGAS vs.TIME
Pilot Test Data



Hydrogeological Impact

- Fine silty sand, water table 4 - 5 m deep
- Condensate lens near tank farms and rail yard, covers 600 m by 400 m area
- Measured product thickness in wells varies from 0.1 to 1.5 m
- Hydrocarbon is clean cut, C_5 - C_6 , and very volatile



History of Remediation

- Pilot Test vertical vs. horizontal SVE wells (1993)
- Installation of 4 horizontal SVE wells, seasonal (1994-97)
- Installation of recovery trench for plume control (1994-02)
- Testing of MPE, SVE, Incinerator (2001-02)
- Design-install expanded well & header system for MPE, fluid treatment, vapour incineration (2004-05)





LEGEND

- AREA OF DISSOLVED PHASE CONDENSATE (INFERRED)
- AREA OF FREE PHASE CONDENSATE (INFERRED)
- MPE HORIZONTAL WELL LOCATION (2002 & 2003)
- HEADER CONNECTING MPE WELLHEADS (2002 & 2003)
- FUTURE WELL CONNECTION
- WELL/HEADER CONNECTIONS

NOTES:

1. 1993 PIEZOMETERS, TRENCH PIEZOMETERS AND TRENCH RECOVERY WELLS ADDED BY MIDWEST SURVEYS, NOVEMBER, 1993.
2. PIEZOMETER LOCATION PLAN ADJUSTED TO MATCH EXISTING PLANT MONUMENTS COORDINATES PER MIDWEST SURVEYS, NOVEMBER 7, 1996.
3. 1998 PIEZOMETER AND SOIL SAMPLING LOCATIONS TAKEN FROM MIDWEST SURVEYS INC. AUTOCAD FILE PCEMPL.DWG REV. 13/16 DATED 12-18-98/12-22/98.



EXISTING HORIZONTAL SVE-MPE WELLS AND HEADER SYSTEM

DRAWN BY:	EDITED BY:	DATE:
C.D.	L.P.	JUL 14/04
APPROVED:	FIGURE:	
	1	

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Design Challenges

- **Scale of Impact**
- **Volatility of product - Pentane**
- **Safety within UFL operation**
- **Design and install within an active plant**

Design Requirements

- **System constructed to client standards**
- **Minimize fuel gas usage**
- **Design for remote operation**



Design Objectives

- Multiphase system
- Horizontal wells to cover free phase
- Maintain $>120\%$ UFL
- Building safety
- Operational Safeguards in design
- Integrate the MPE and GWTS
- Remote Operation



Why Design the system for operation in the UFL?

- **To accelerate remediation of site**
- **Good solution because of the high volatility of product**
- **Prevents operation in explosive conditions that result in safety issues**
- **Required to ensure safe operational conditions in piping from wells to incinerator**



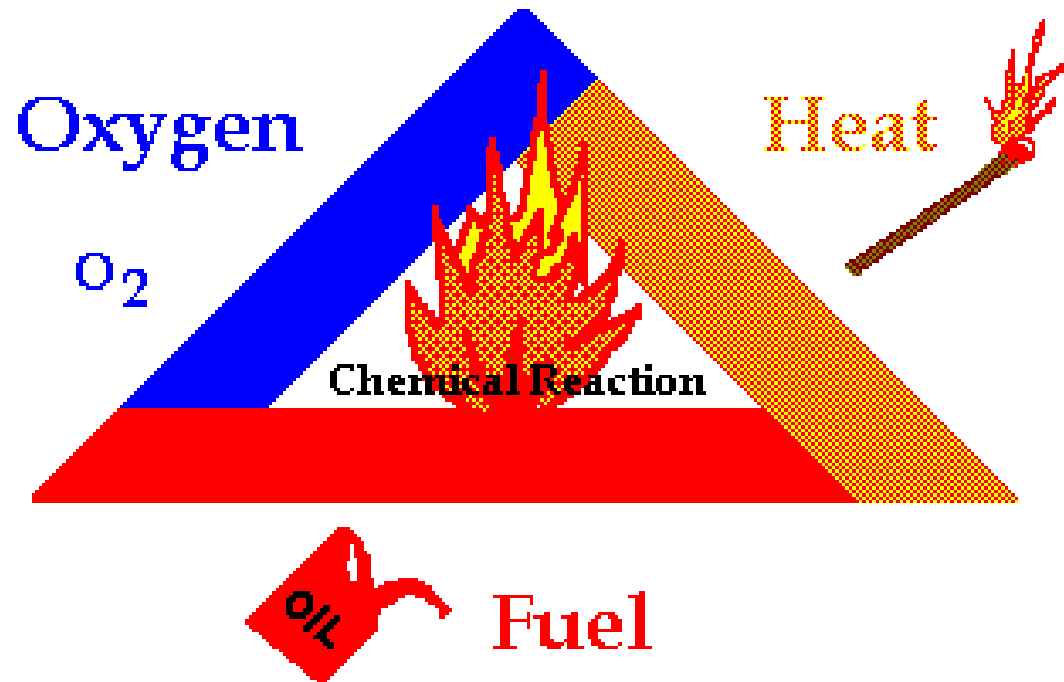
Operation Uncertainties

- O_2 values in actual soil
- Representation of O_2 values in pilot-test
- Long term trends (pilot tests only over a few months)
- Pressure required for liquid recovery
- Hydrocarbon concentrations



The Fire Triangle

Fire Triangle



Operational Regimes:

Three ways to operate safely:

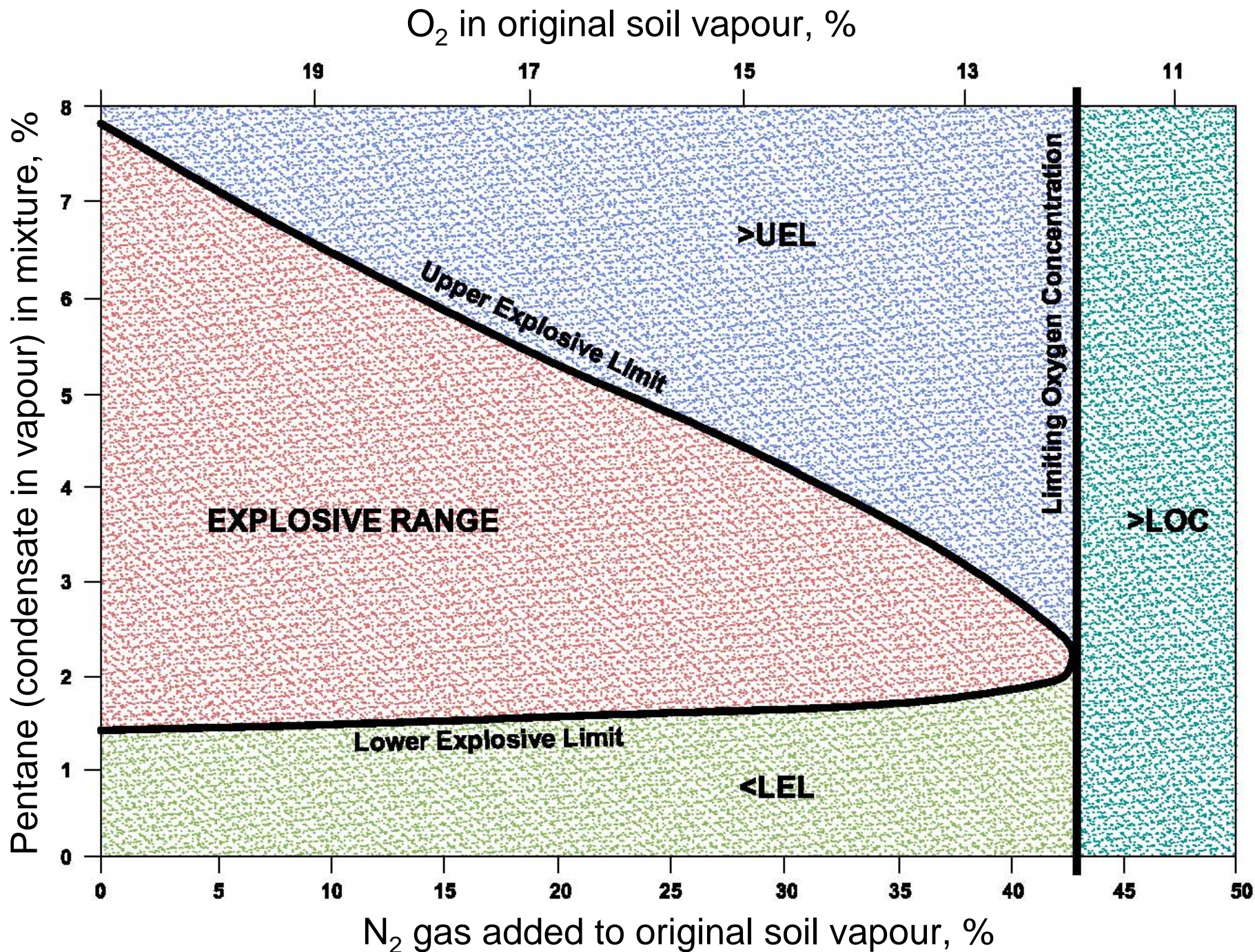
- 1. Below LFL (Lower Flammability Limit),
or**
- 2. Above UFL (Upper Flammability Limit)
and/or**
- 3. Below LOC (Limiting O₂ Concentration)**



Safe Operating Conditions UFL

- **Upper Flammability Limit (UFL)**
 - Concentration above which a fuel will not maintain combustion
 - UFL for pentane: 7.8% vol. (air @ STP)
 - UFL for methane: 15% vol. (air @ STP)
- Range can be extended by adding fuel gas at front end of piping

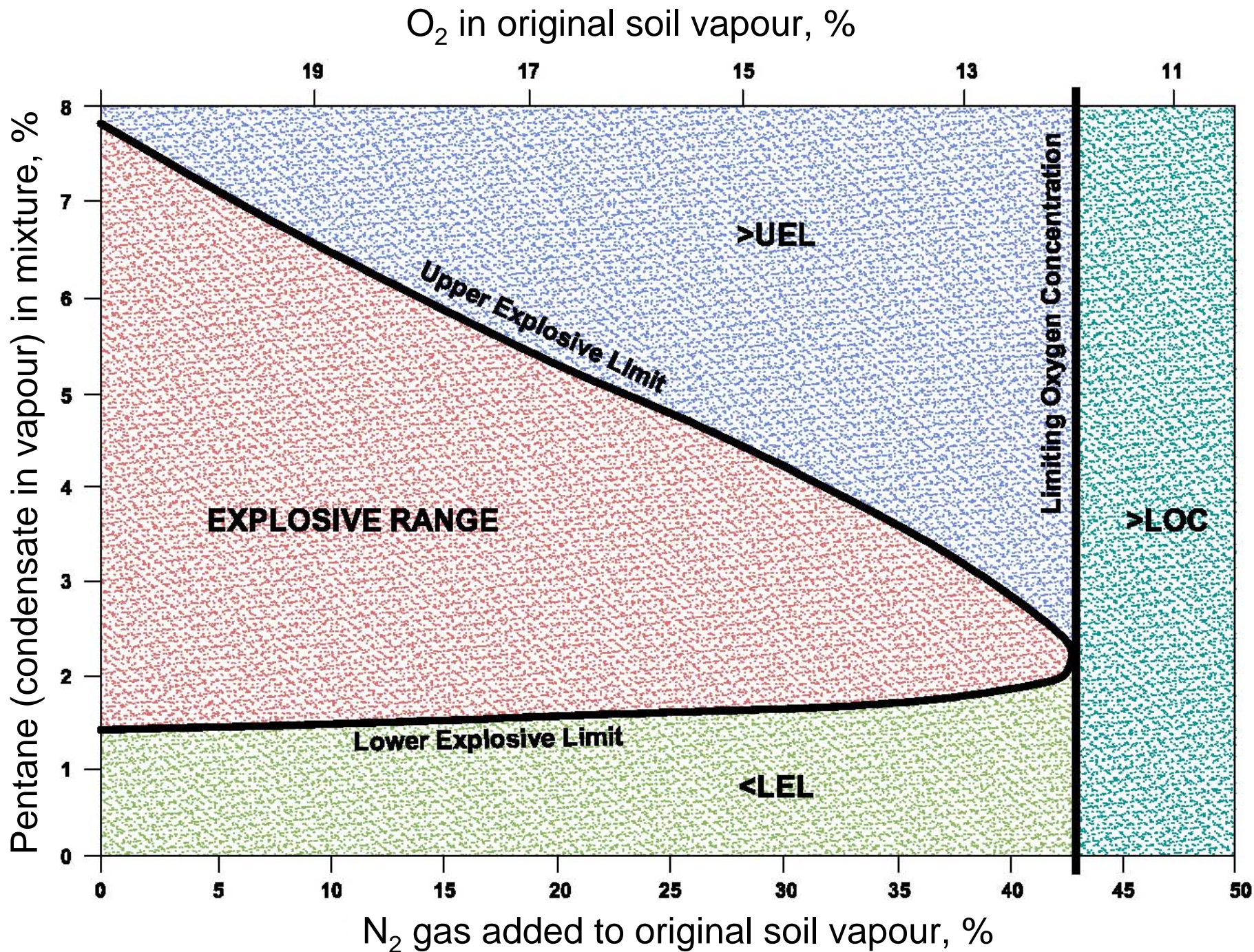




Safe Operating Conditions LFL

- **Lower Explosive Limit (LFL)**
 - Concentration below which a fuel will not maintain combustion
 - LFL for pentane: 1.5% vol. (air @ STP)
- Range can be extended by adding air as diluting agent at front end of piping

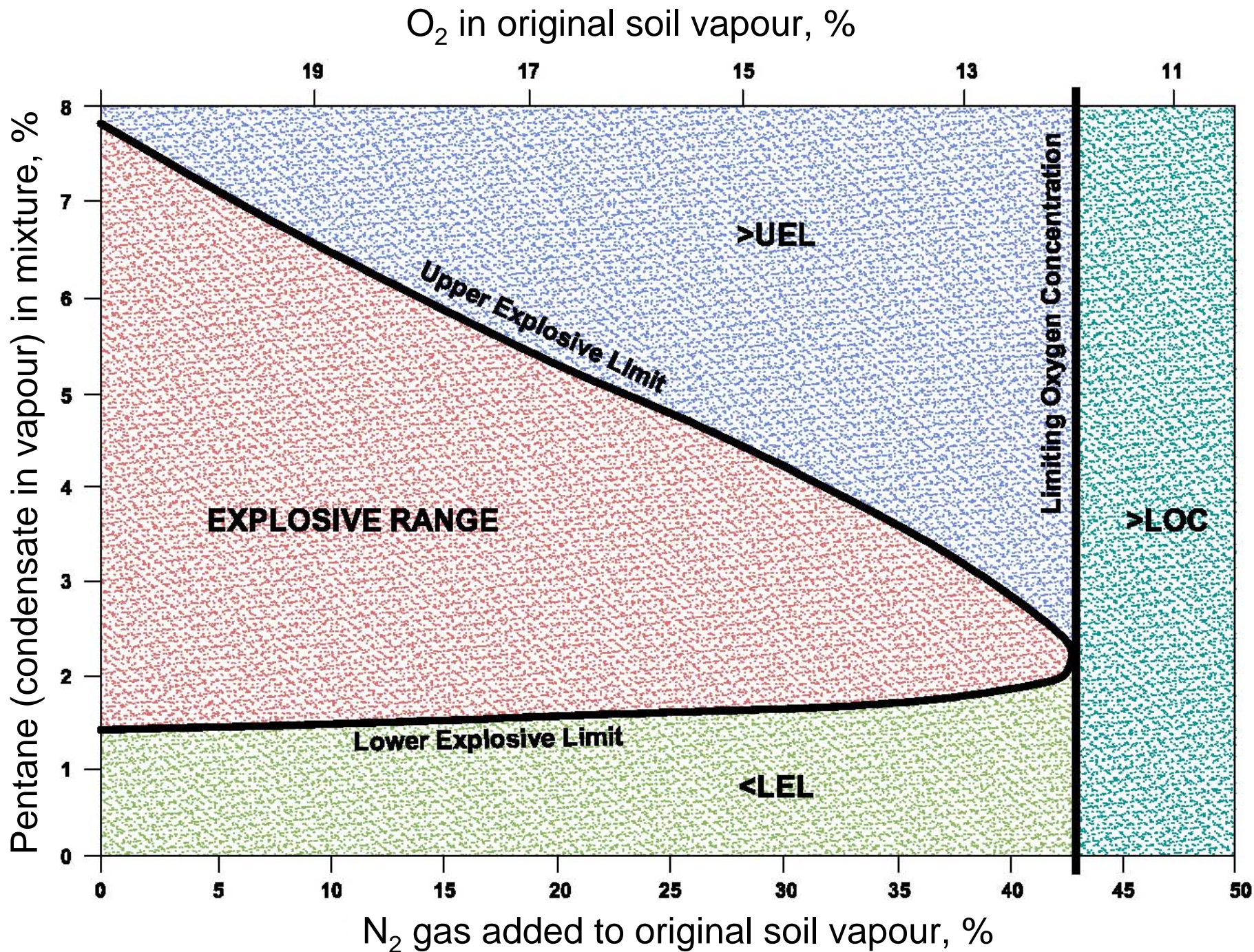




Safe Operating Conditions LOC

- **Limiting O₂ Concentration (LOC)**
 - Concentration of O₂ below which combustion cannot occur
 - Minimum O₂ concentration for methane and pentane: 12%
- Range can be extended by adding N₂ as diluting agent at front end of piping





Pipe & Equipment Safety

- **Design controls:**
 - Prevent flammable conditions within piping header
 - Use grounded stainless steel piping to dissipate static
 - Use rupture plates to mitigate any detonation
 - Use flame arrestor at Incinerator to contain flame

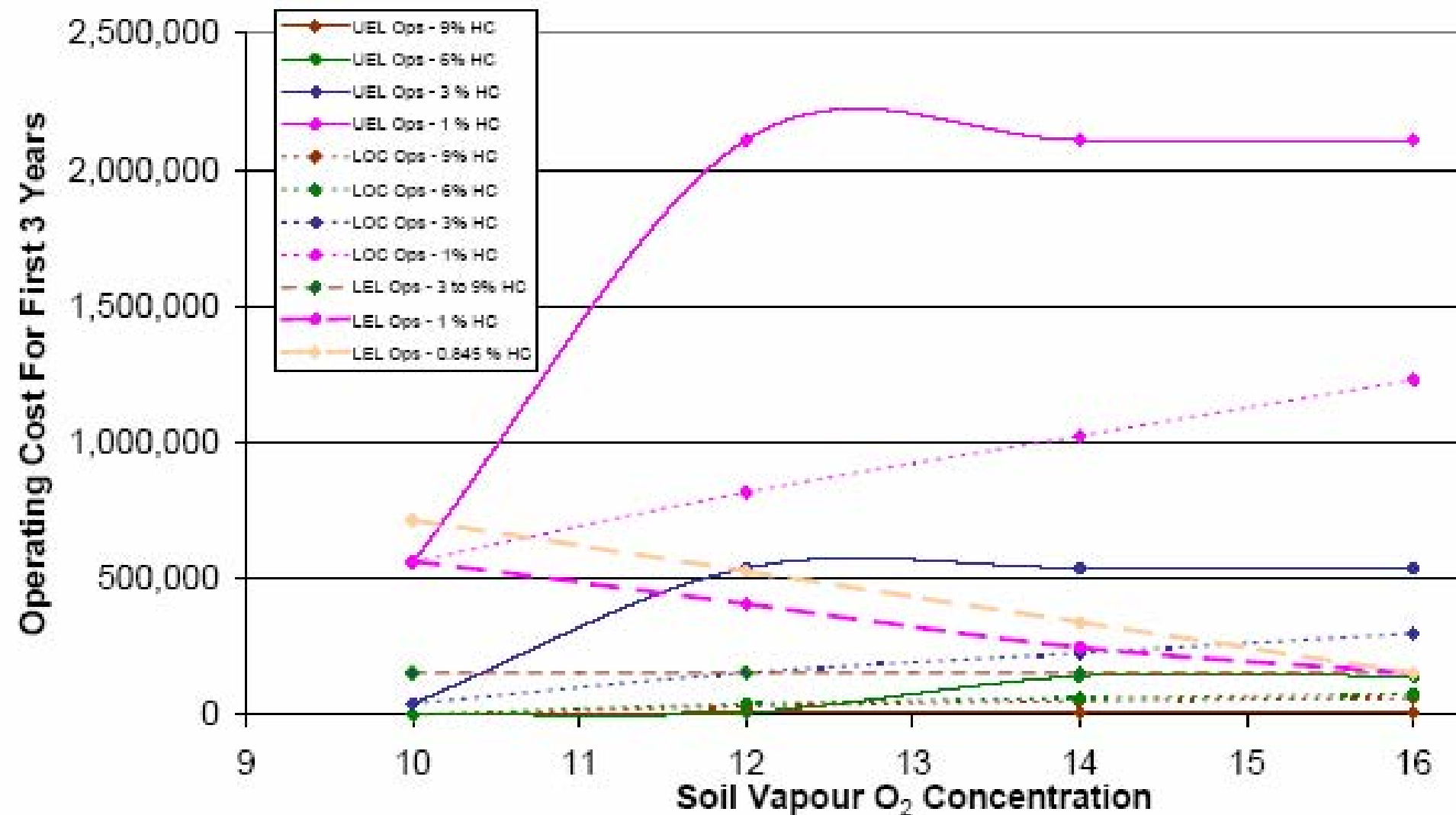


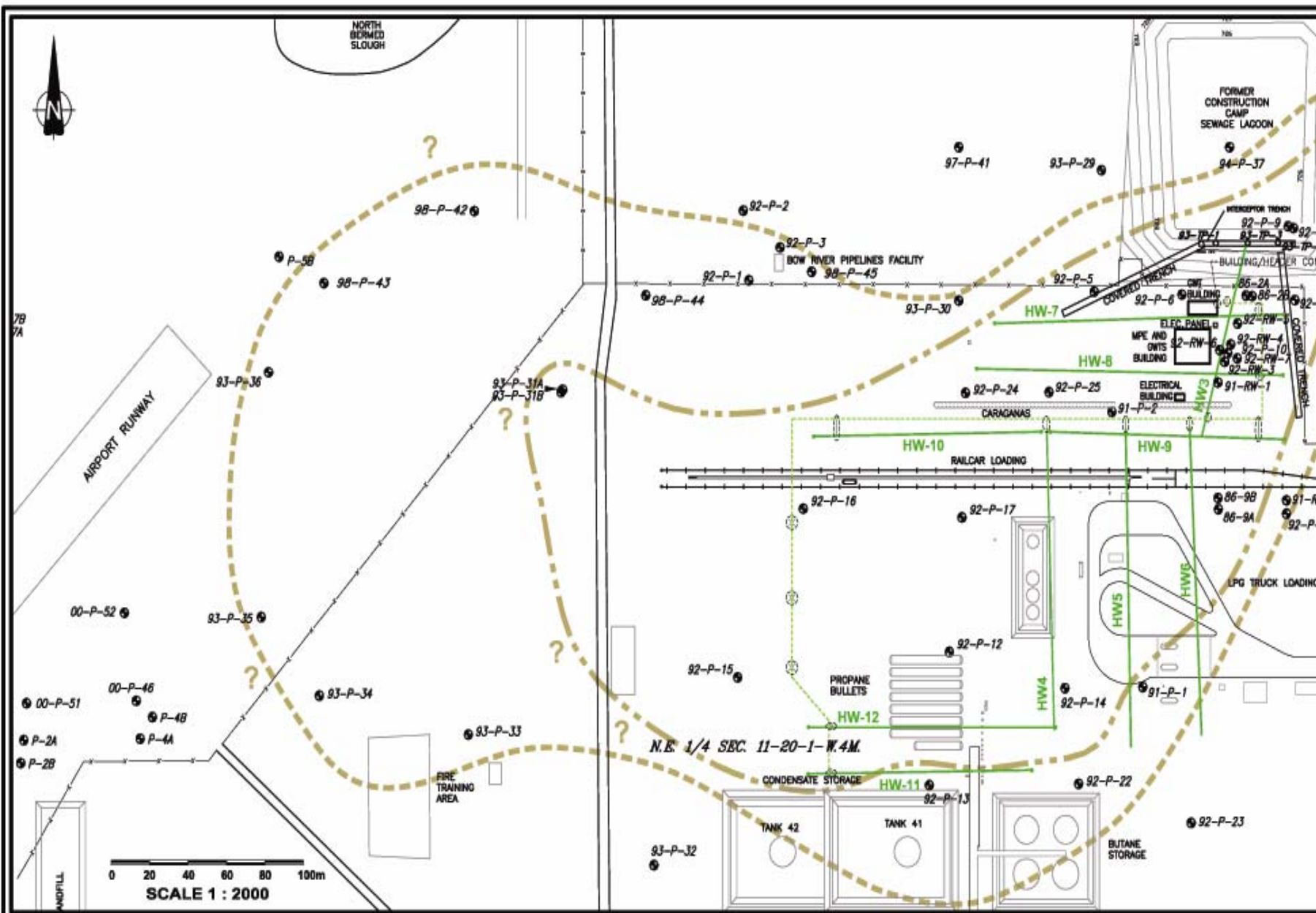
Operational Regimes

- Stepwise progression through operational regimes with changing soil conditions
 1. UFL or LOC operation with incineration
 2. LFL operation with incineration
 3. LFL operation with venting
- High concentrations in soil vapour: above UFL is most economical
- Low concentrations in soil vapour: below LFL is most economical



Fuel Gas Cost Evaluation





LEGEND

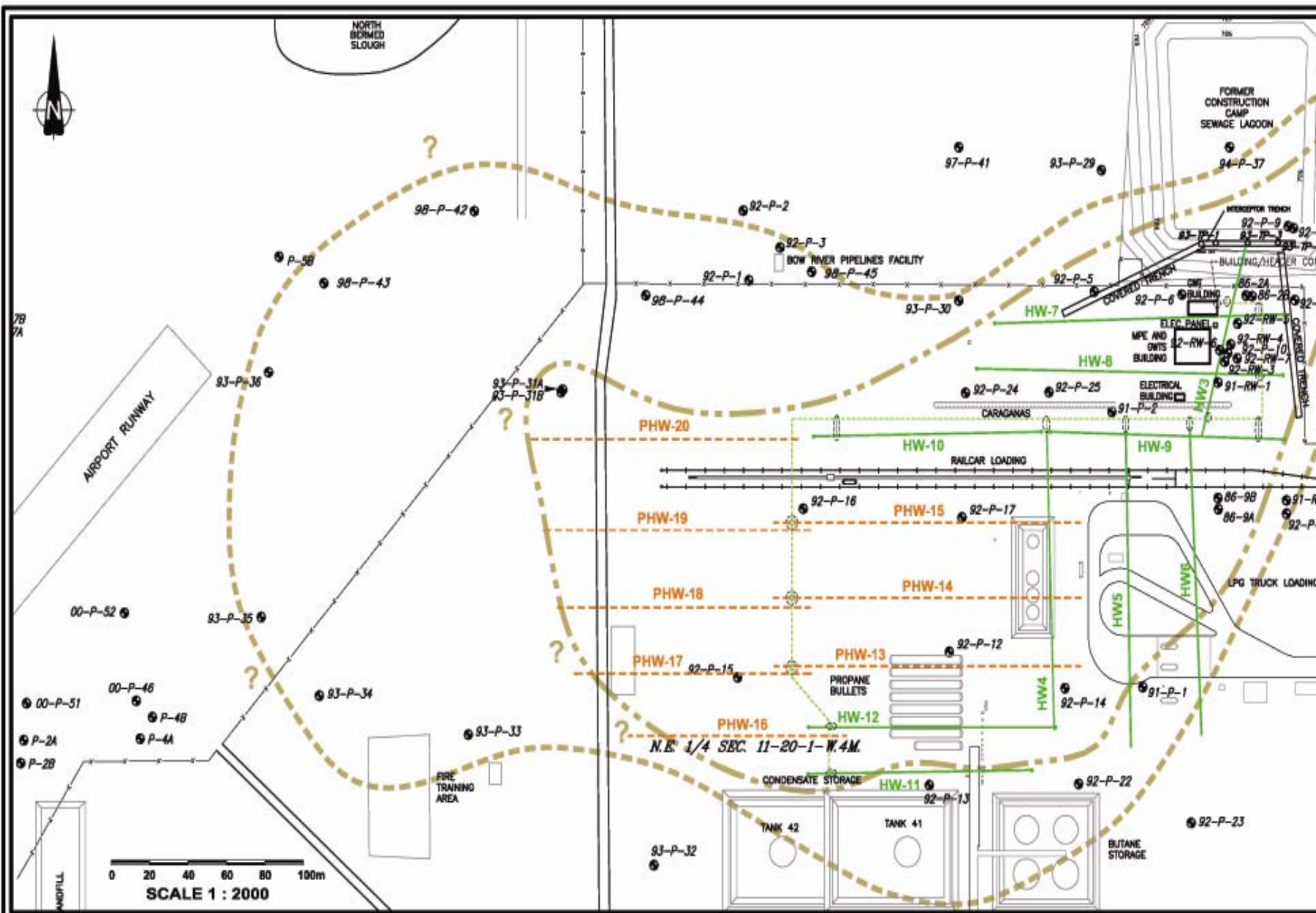
— AREA OF DISSOLVED PHASE CONDENSATE (INFERRED)

○ FUTURE WELL CONNECTION

— AREA OF FREE PHASE CONDENSATE (INFERRED)

CONOCOPHILLIPS CANADA
EMPRESS STRADDLE PLANT

KOMEX INT
ENVIRONMENT AND



LEGEND

AREA OF DISSOLVED PHASE CONDENSATE (INFERRED)



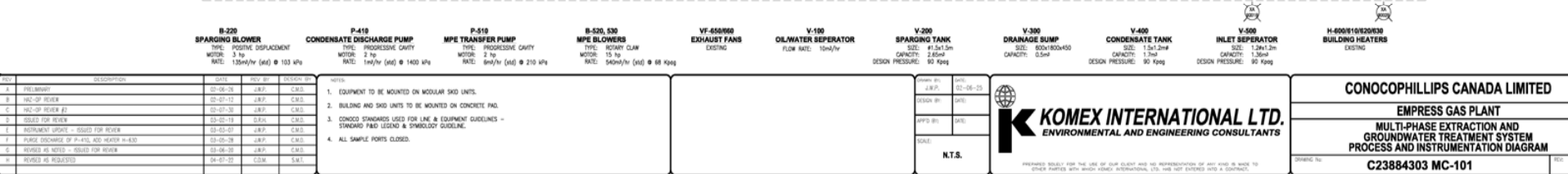
FUTURE WELL CONNECTION

AREA OF FREE PHASE CONDENSATE (INFERRED)

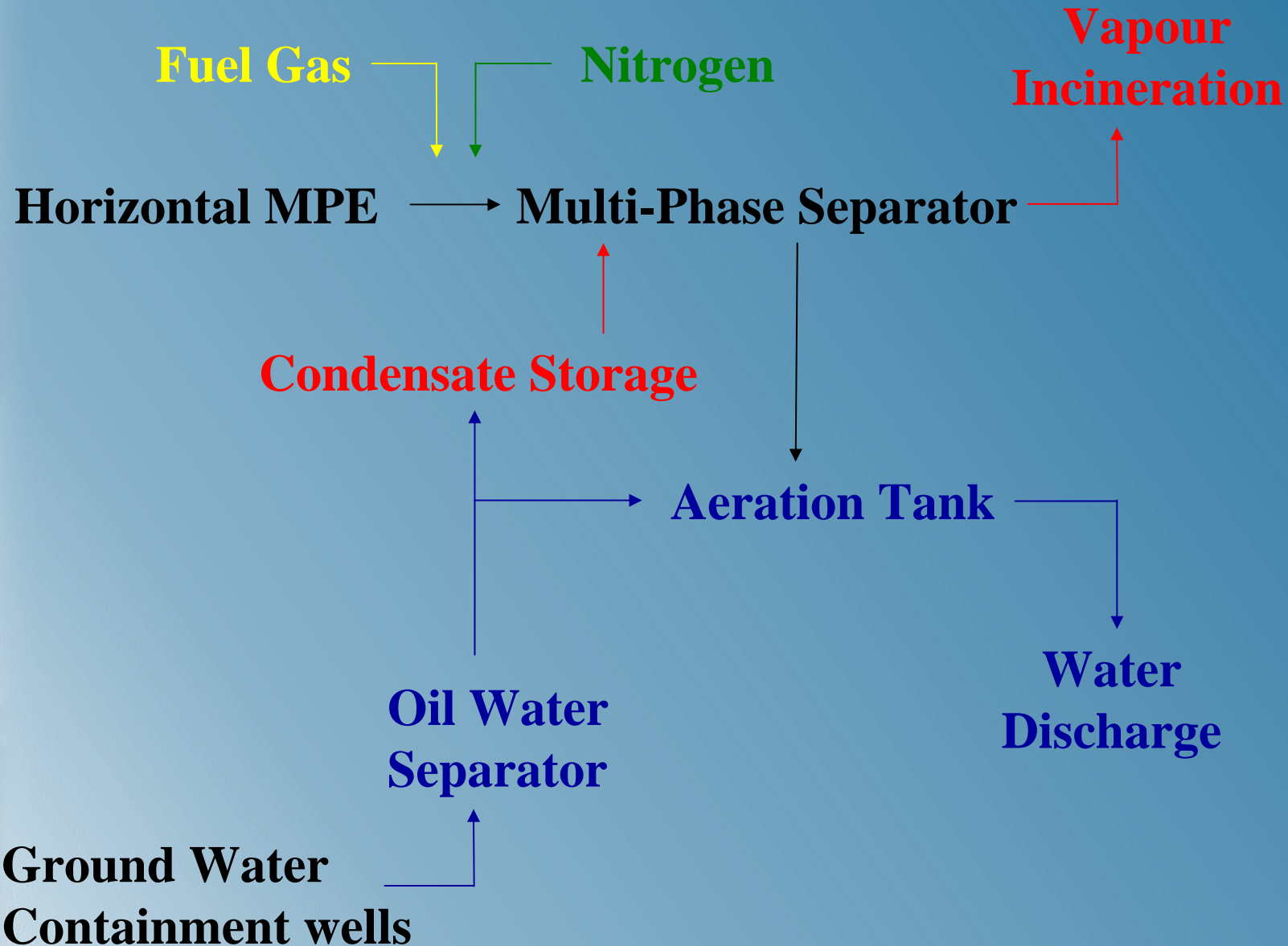
CONOCOPHILLIPS CANADA
EMPRESS STRADDLE PLANT



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Process Flow



Design Summary

MPE System

- Flowrate capability of two blowers:
- 1020 m³/hr (600 acfm)
- Vacuum: -68 kPag (32 kPaa)
- 12 Horizontal Wells existing
- System designed to handle 8 wells additional for future expansion

Groundwater Containment

- 5 wells installed to prevent offsite migration (6m x 200m Trench)
- 25 l/m design flowrate



Horizontal Well Install

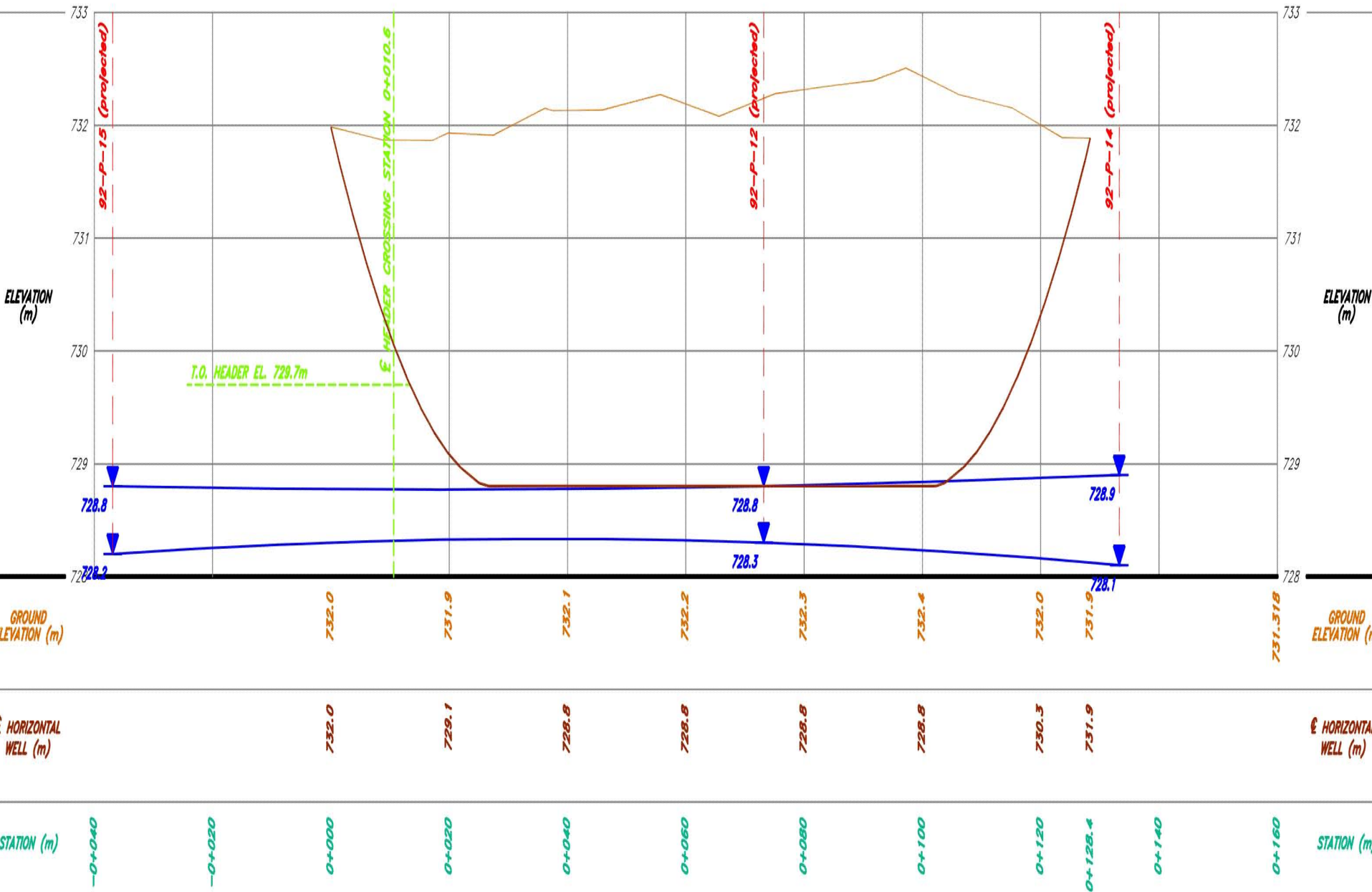


- Screen: 304SS wire wrap (0.010" slot size)
- Casing: 304SS



WEST

EAST



PHW-12 HORIZONTAL WELL





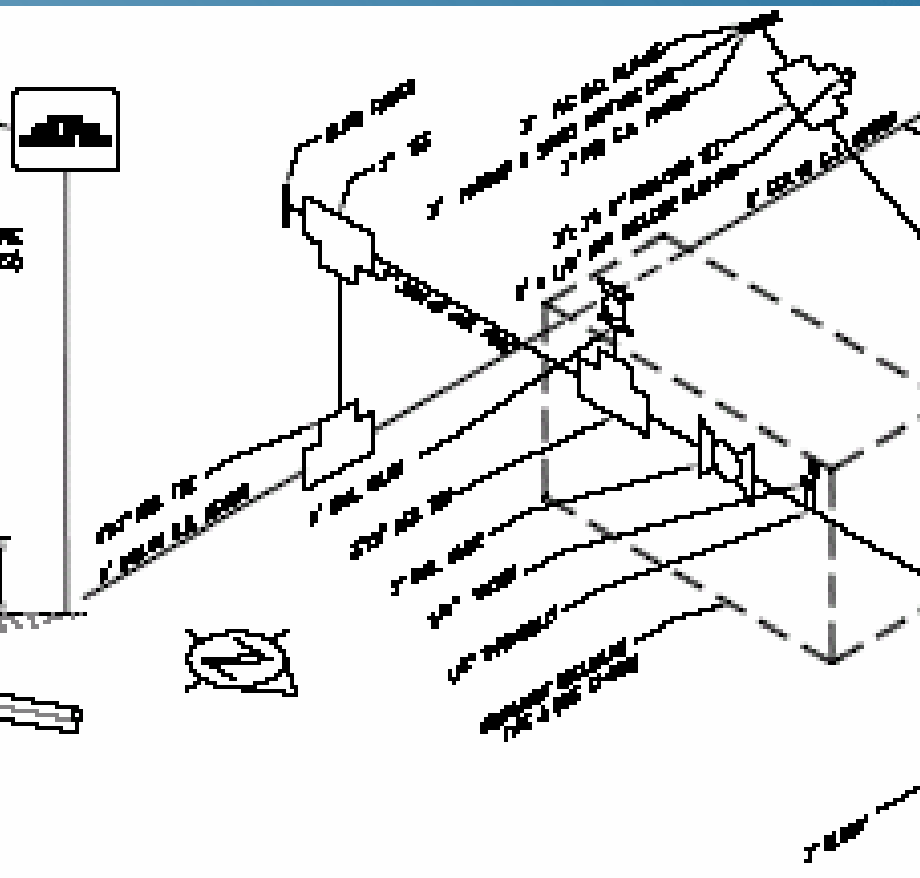








Horizontal Wellhead



ISOMETRIC

TWO

Well Number	Well Name	Formation
1H-3	J ¹ FMO	TM
1H-4	J ¹ FMO	TM
1H-5	J ¹ FMO	TM
1H-6	J ¹ FMO	TM

System Installation



The image shows a complex industrial piping system within a room with yellow corrugated metal walls. A central vertical metal frame supports various components. At the top, there are two red-handled control valves. Below them, a horizontal white pipe runs across the frame, featuring a large blue-handled manual valve on the left and a smaller black-handled valve on the right. To the right of the main frame, a large white cylindrical tank is visible. In the lower right foreground, another large valve with a blue handle is partially shown. The floor is concrete, and some boxes are visible in the background.

**Fuel Gas / Flow
Control Valves**

System Inlet

**Air Water
Separator**

**Fuel Gas /
Nitrogen
Control Valves**

The image shows a complex industrial setup. In the foreground, there are white pipes and valves, some with handwritten labels like '34-7002'. A large, vertical, cylindrical air-water separator with a metal mesh screen is the central feature. To its right, a large white horizontal tank is visible. In the background, there are more pipes, valves, and a fire extinguisher. The scene is lit with warm, yellowish light.

**Air Water
Separator**

Blowers

The image shows an industrial interior with two large white cylindrical tanks. The tank in the foreground is partially visible, showing a circular access hatch with a handle and a series of bolts. The tank in the background is more fully visible and has several pipes and valves connected to its top. A metal walkway with railings runs between the tanks. The walls are made of vertical corrugated metal panels. The lighting is warm and comes from overhead fixtures.

**Air Water
Separator**

**Condensate
Storage Tank**

A photograph of an industrial facility, likely a wastewater treatment plant. The scene shows a complex network of white PVC pipes, black valves, and mechanical equipment. In the foreground, there are two large black blower units. To the right, there are in-line gas analyzers mounted on a metal frame. In the background, a blue metal storage box and a white ladder are visible against a wall of vertical wooden planks.

**Discharge to
Incinerator**

**In-line Gas
Analyzers**

Blowers

A large, vertical, cylindrical industrial tank with a rounded top and bottom. It is surrounded by a complex network of white pipes, valves, and mechanical components. The tank is supported by a metal frame. The background shows a wooden wall and some structural elements of the facility.

Sparging Tank

Sparging Blower

PD Pump

MCC Building



Incinerator



Oil Water Separator



MPE Building



Groundwater Extraction Trench



Summary

- **UFL Operation ideal for light product**
- **Large impact and light product required to maintain UFL cost effectively**
- **Horizontal wells a better solution for capture of large plume**
- **System likely in operation in UFL for 2-5 yrs, LFL for longer period**



Thank you



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