Casinghead Pressure Reduction Methane Capture Technologies

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Natural Gas STAR Workshop

Salem Unit
Casinghead Gas Project

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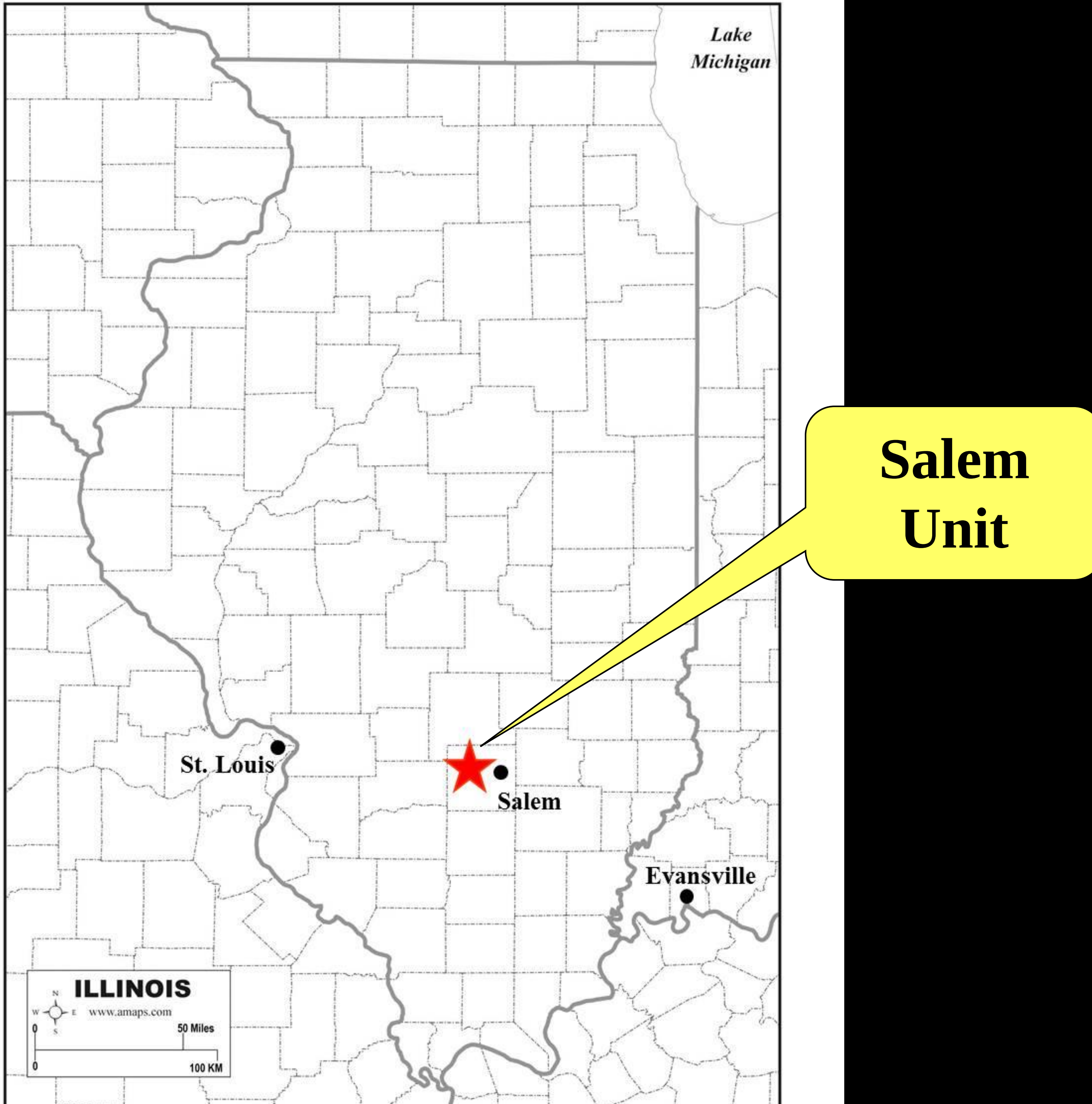
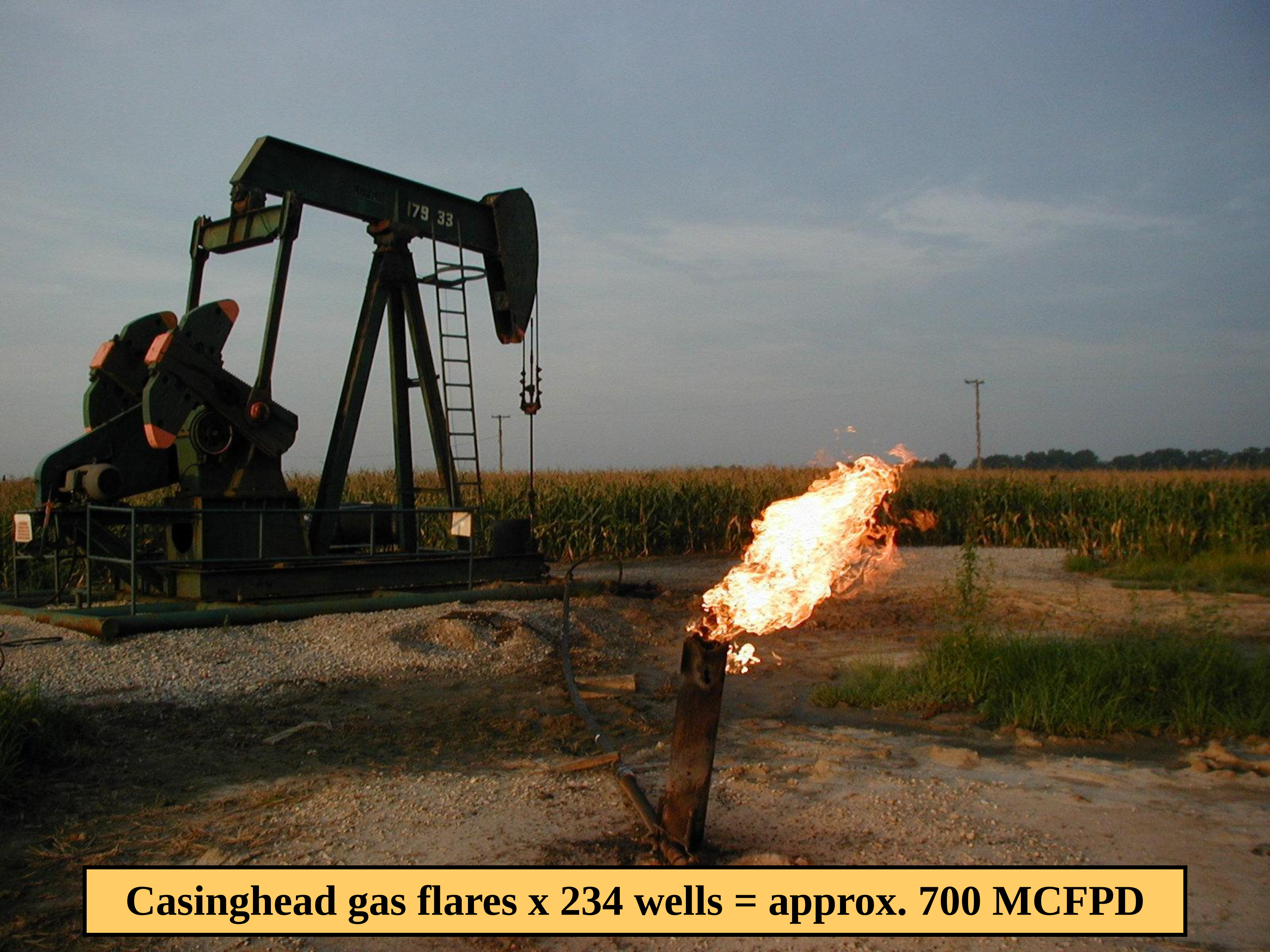
Clyde Finch

Citation Oil & Gas Corp.

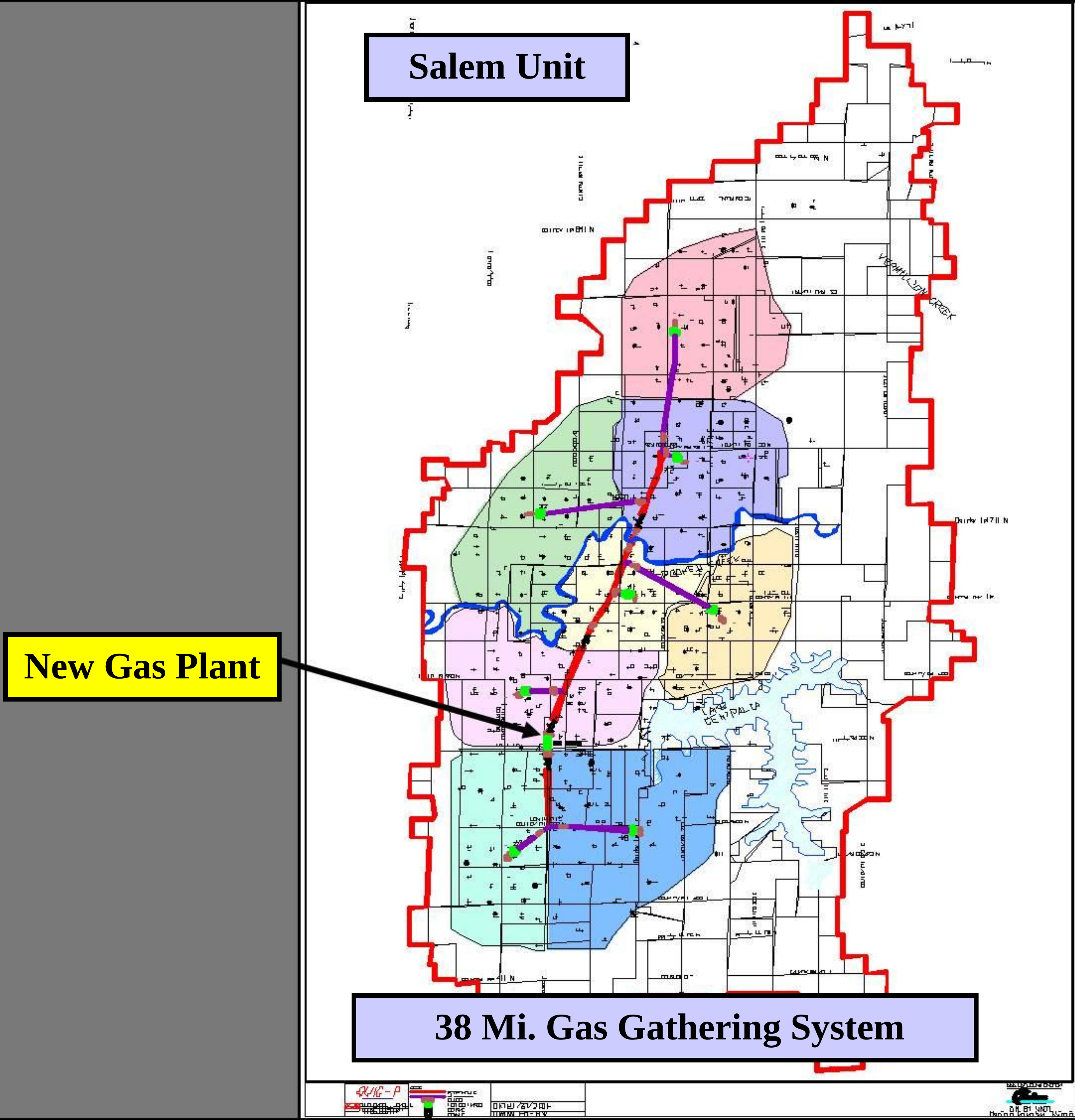

Salem Unit
Lake Michigan
St. Louis
Salem
Evansville
ILLINOIS
www.amaps.com
0
50 Miles
0
100 KM
N
S
E
W

Salem Unit History

- Field discovered 1938
- Unitized in 1950s
- Earliest large waterflood in USA
- Operated by Texaco until 1998
- Produces from 5 zones
- 1,725 BOPD & 110,000 BWPD
- All gas previously flared



Casinghead gas flares x 234 wells = approx. 700 MCFPD



Salem Unit
New Gas Plant
38 Mi. Gas Gathering System

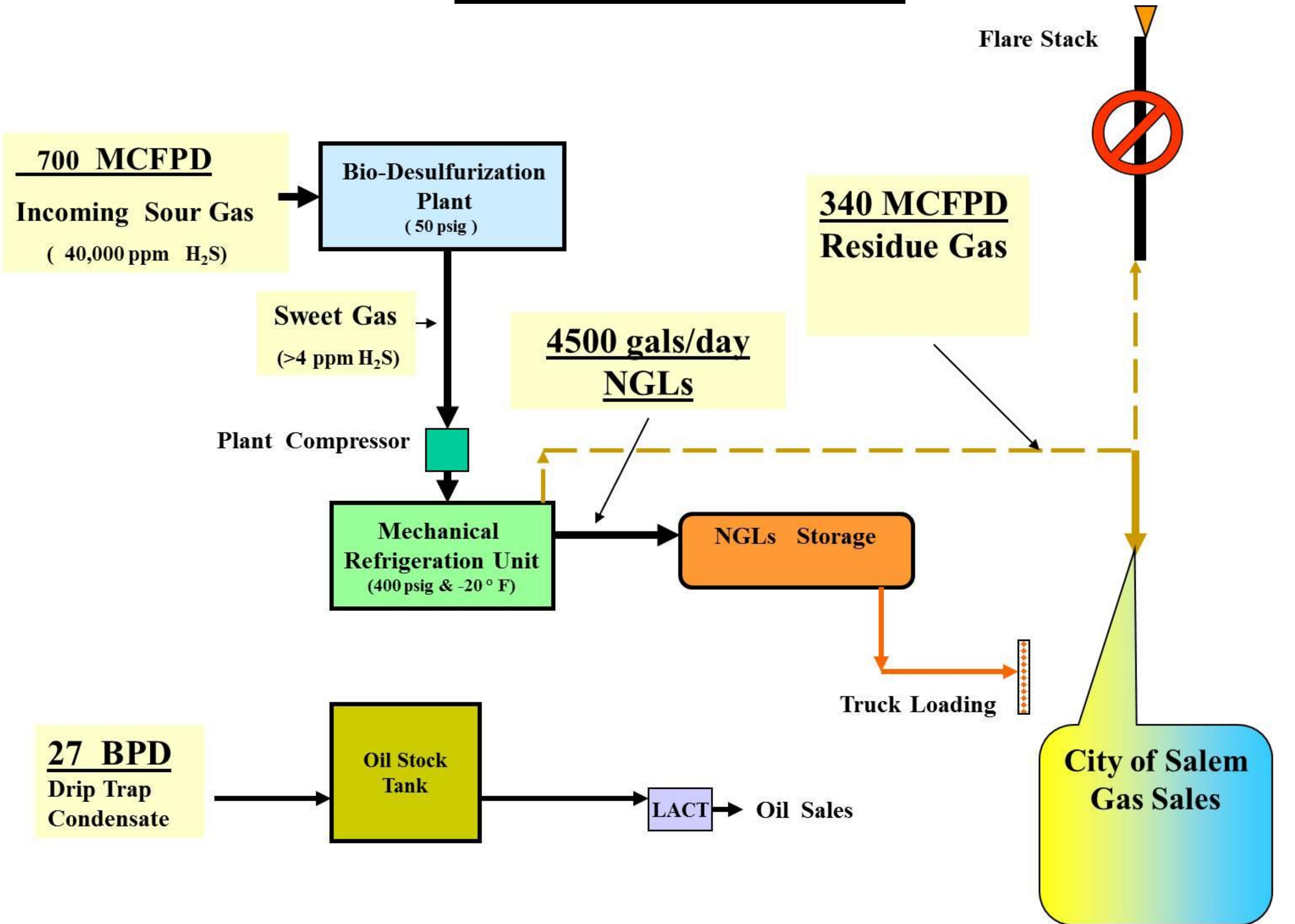
Field Compressor Site

Electric drive used to minimize downtime.

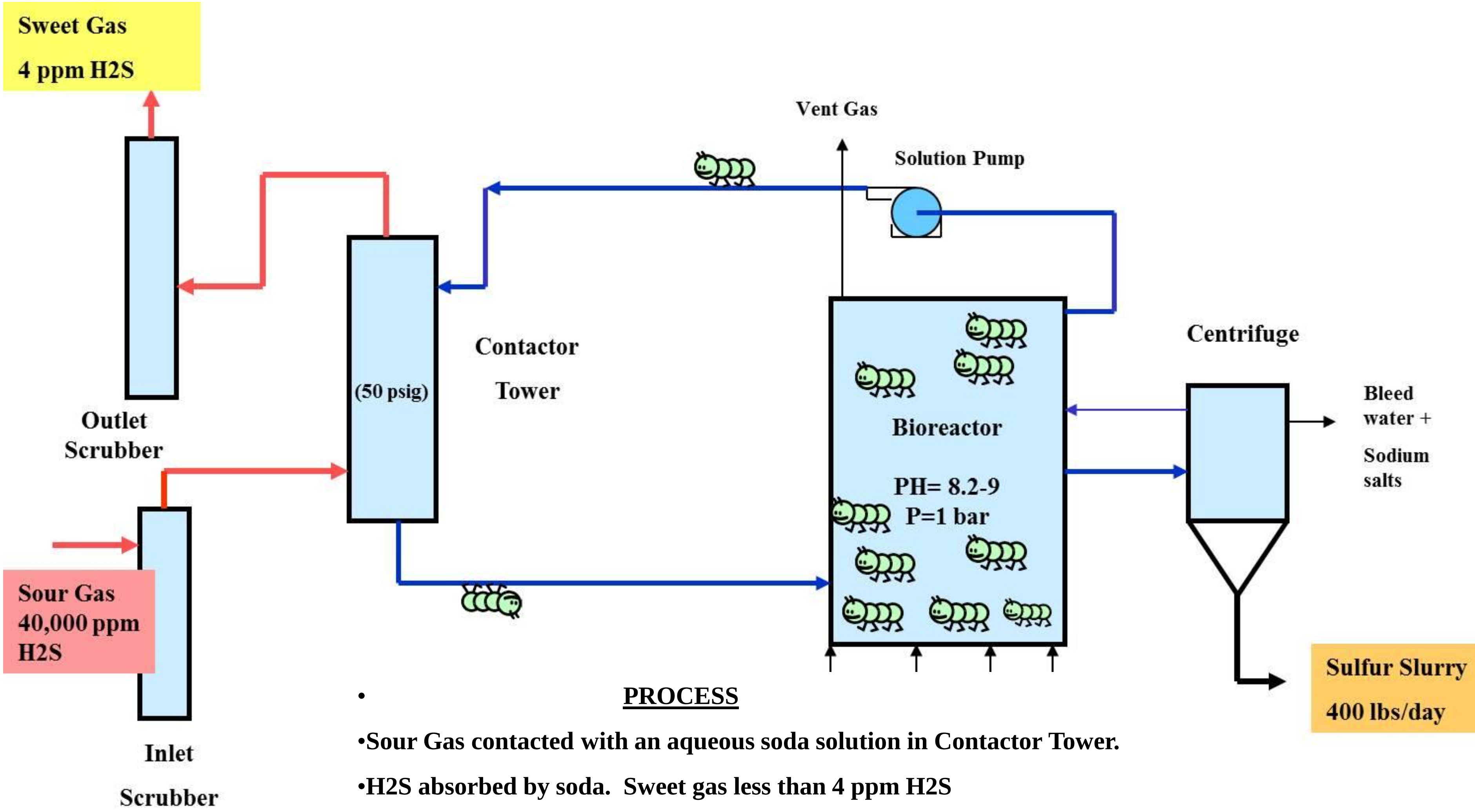
PLC monitoring used to maintain a constant vacuum on the wells..

Rotary Screw compressors were used due to the wet nature of this gas stream. Filters are used before the skid to remove iron sulfide, then a scrubber vessel and automated liquid transfer system on skid to handle the liquids which are common in this application.

Salem Gas Plant



Bio-Desulfurization Process



- <u>PROCESS</u>

•Sour Gas contacted with an aqueous soda solution in Contactor Tower.

•H2S absorbed by soda. Sweet gas less than 4 ppm H2S

•H2S removed from soda by biological conversion to elemental sulfur, using air in Bioreactor

•Regenerated soda returned to Contactor Tower

•Sulfur disposal required

Thiobacillus excreting sulfur crystals

<u>Optimum</u>

<u>Conditions</u>

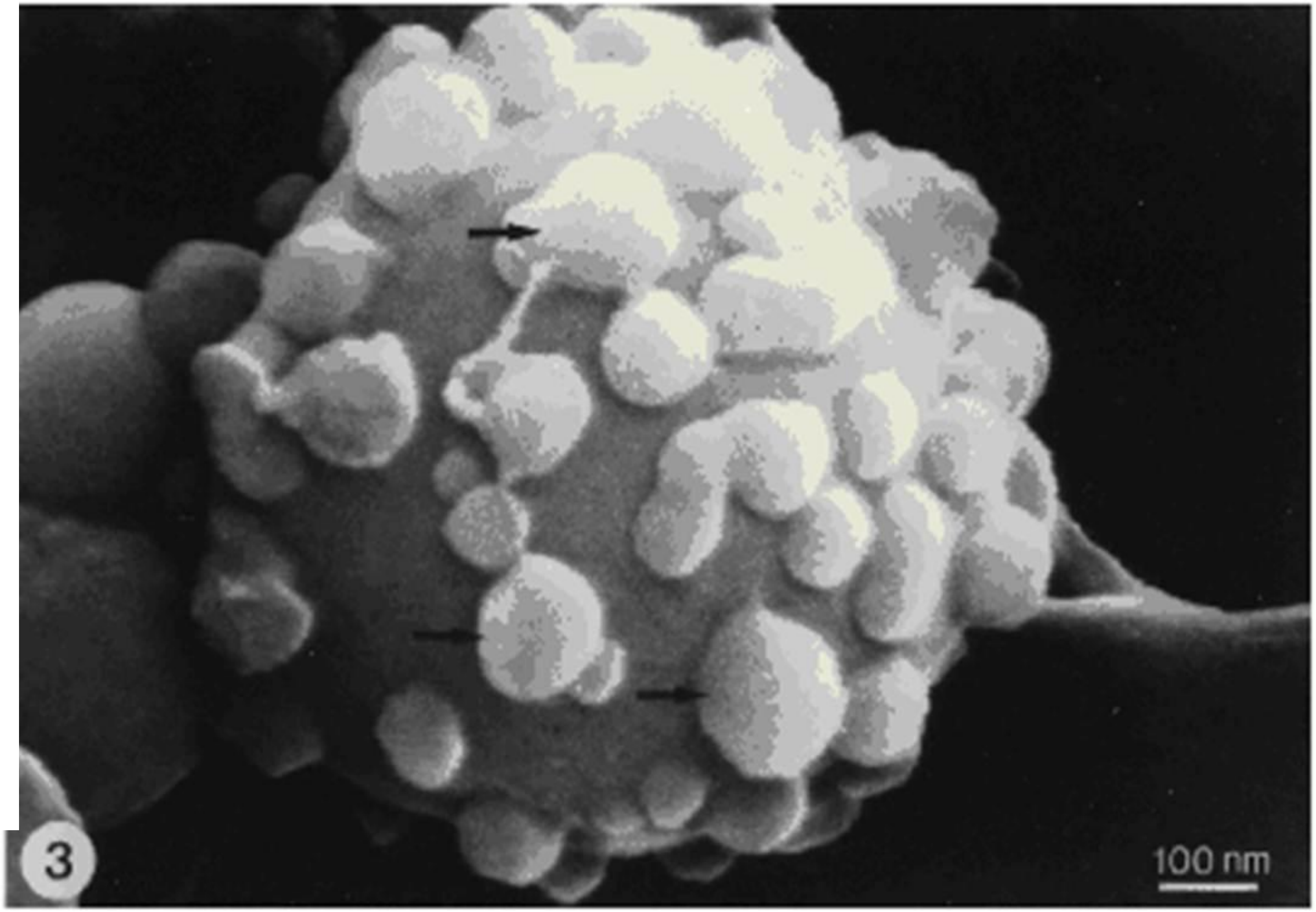
PH : 8

Cond.: 55 mS/cm

Redox: - 365 mV

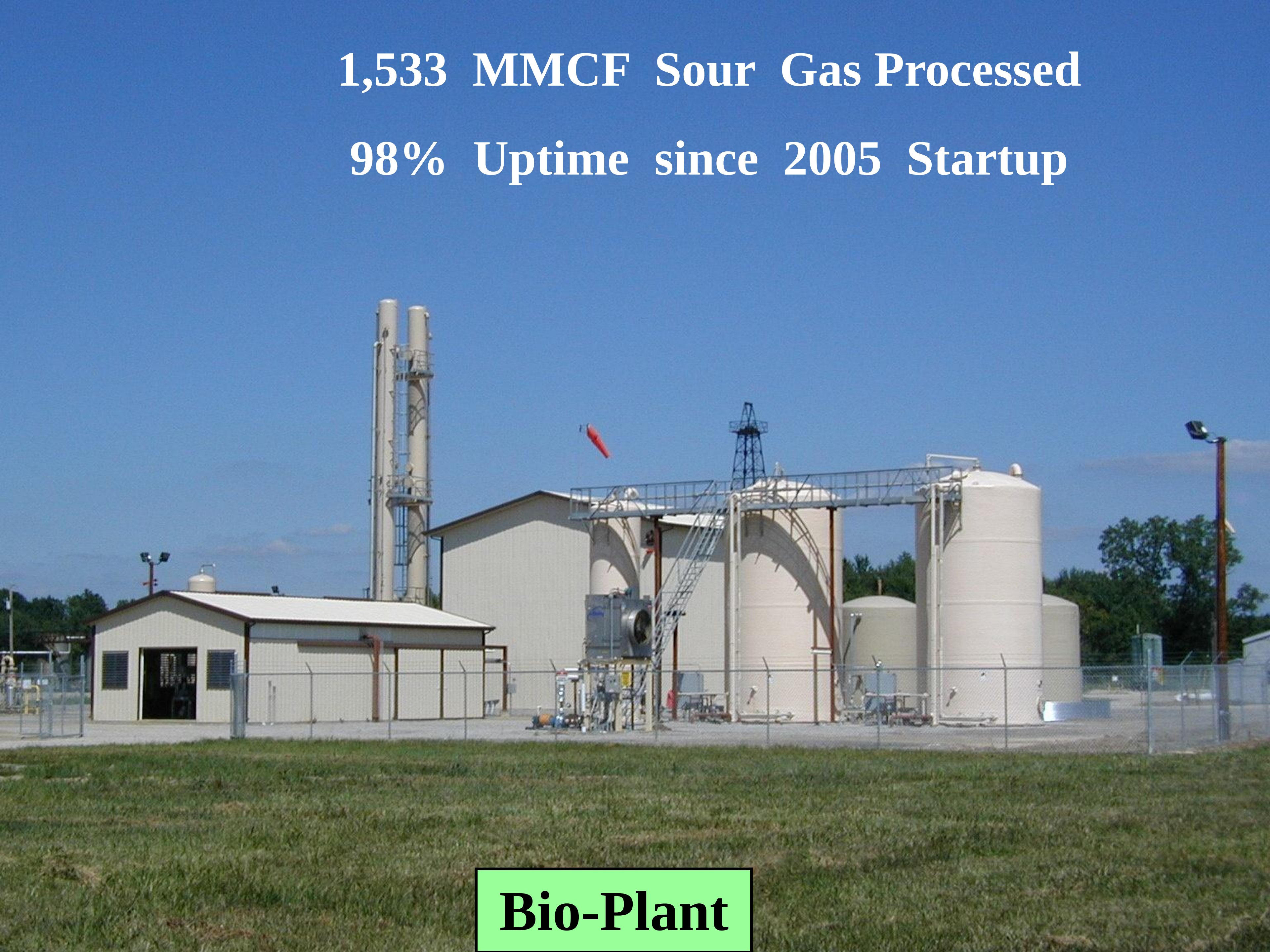
Temp: 95 deg F

Solids: 5 g/l



1,533 MMCF Sour Gas Processed

98% Uptime since 2005 Startup



Bio-Plant

Sulfur

Plant Compressor

(Boosting gas to Salem)

Mechanical Refrigeration Unit

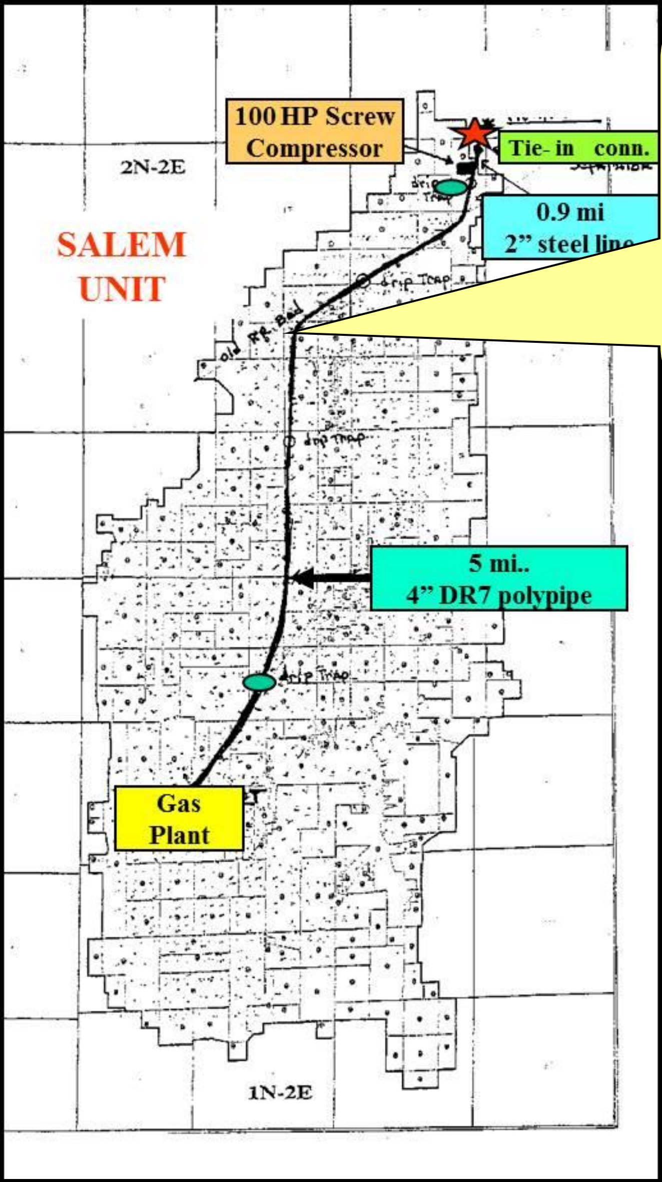
<u>To Date</u>

879 Truck Loads

Or

7.9 million gals

(188,000 bbls)



Pipeline provides 25% of Salem's Annual Gas Use

Gas Sales = 468 MMCF since 2007 startup

SALES GAS PIPELINE to CITY of SALEM

Conclusions

- **Capturing this stranded gas is good business. Over 700 mcf per day captured since project began**
- **188,000 barrels of liquid condensate captured and sold from this wet gas stream since project inception**
- **Bio-desulfurization works very well (< 4ppm H_2S).**
- **Sales gas deal is win/win for Citation & Salem.**
- **Infrastructure now available for more gas and profit (Additional Trenton Zone wells drilled).**
- **1,200 tons/year SO_2 eliminated from air @ Salem Unit.**

CASINGHEAD GAS CAPTURE

STRATEGIES

AND

CASE STUDIES

CASINGHEAD GAS

- Approximately 18 Bcf/yr of Methane is estimated to be lost from well venting and flaring in the U.S.   In many oil producing countries these numbers could be measured in the Bcf per DAY.

  2 Primary Sources Include:
  - Separator gas vented or flared during oil processing
    - occurs at each stage of separation process (typically 3) as water and gas are separated from the oil for collection
  - Casinghead gas
    - Most mature formations produce more oil if the gas pressure on the casing (or annulus) is reduced.
    - This is often accomplished by venting this casinghead gas at or near the wellhead

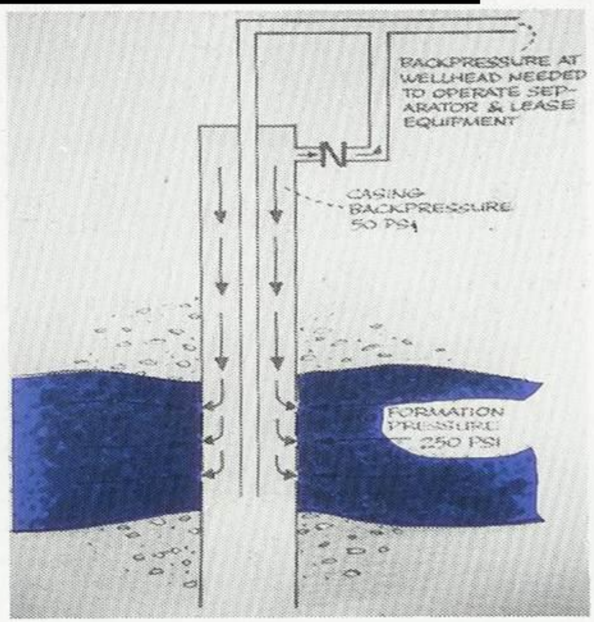
CASINGHEAD GAS REDUCTION
The Concept

- Casinghead gas relatively wet (.85 spec gravity / 16gpm)
- Weight of this column of wet gas sitting on the formation has an incremental effect on bottom hole pressure
  - Dictated by oil specific gravity and the well depth
- When you add wellhead pressure (i.e. flowline or 1st stage separator), this pressure on the formation is significantly impacted
  - Further complicated by fluctuating wellhead pressure from the pipeline
- Concept is simple – relieving this pressure in the casinghead reduces the weight (pressure) on the formation, allowing oil or gas to more easily flow from the formation into the well bore.

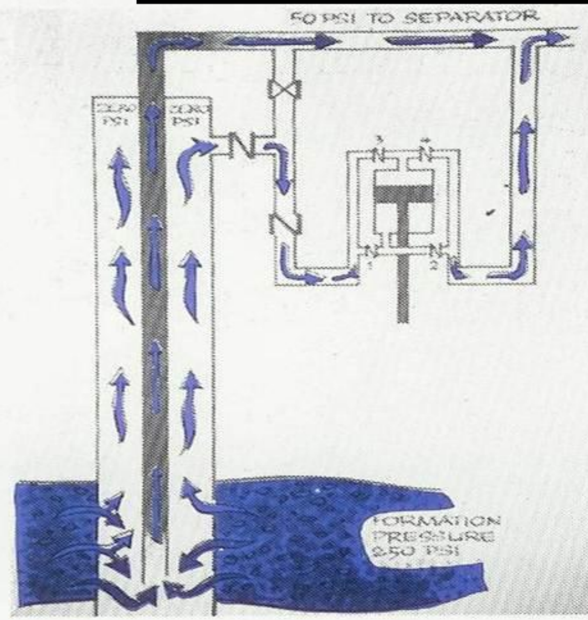
Relieving Back Pressure

BEFORE COMPRESSION

Restricting Back pressure holds back the flow of Hydrocarbons into the well bore.



AFTER COMPRESSION



Back pressure is relieved from the face of the formation allowing more hydrocarbons to flow into the well bore.

Diagram courtesy of Beam Gas Compressor Company

CASINGHEAD GAS REDUCTION
How It Works

Goal is to maintain a casinghead pressure as close to zero as possible without pulling a vacuum

- Low horsepower compressor units utilized
  - Can be rotary vane, rotary screw or small recip based on gas stream
- Pressures as low as ½" water column are maintained using a bypass system with a recycle/ throttling valve
  - Bypass pilot control maintains this pressure / gas recycled below set point
- Steady pressure is maintained on the well bore, and produced gas is sent down the flowline or gas line

CASINGHEAD GAS REDUCTION
Benefits

- The majority of wells tested in older, mature basins tend to respond favorably to a reduction in casinghead pressure

- Many wells respond with dramatic increases in oil and or gas production – particularly in water flood or CO2 flood projects

- Often allows subsurface pumps to operate more efficiently, and often eliminates “gas locking” problems

- Eliminates the impact of fluctuating or rising pipeline pressures on your production

- On wells that respond favorably, the payback economics are extremely compelling

CASINGHEAD GAS REDUCTION
Weaknesses

- Not all formations respond favorably; even individual, adjacent wells in the same formation often respond differently
- While we know some entire formations that do not respond, within areas that do respond it requires well-by-well testing
- Some formations respond with increased produced water
- In some cases, wells respond incredibly for 7 to 10 days, and then drop to previous levels
- While oil production gains after 30 days generally remain constant, gains in gas production may drop to previous levels.

CASE STUDY - LEA CO., N.M.
Hobbs Area

	BEFORE COMPRESSION	AFTER COMPRESSION	GROSS MONTHLY INCOME INCREASE
CASINGHEAD PRESSURE	50 PSIG	2 PSIG	
GAS PRODUCTION	200 MSCFD	250 MSCFD	50 X \$3.00 X 30 = \$4500.00
OIL PRODUCTION	30 BBLD	35 BBLD	5 X \$20.00 X 30 = \$3000.00
DISCHARGE PRESSURE	-	50 PSIG	**Total = \$7,500 per Month**

Case Study – Ector County
4 Separate Compressors / Multiple Wells
Cowden Area

	BEFORE COMPRESSION	AFTER COMPRESSION	GROSS MONTHLY INCOME INCREASE
CASINGHEAD PRESSURE	45 PSIG	2 PSIG	
GAS PRODUCTION	Incremental Gas Produced	18 MSCFD 12 MSCFD 7 MSCFD 8 MSCFD	45 X $3 X 30 = $4,050
OIL PRODUCTION	160 BBLD 50 BBLD 46 BBLD 17 BBLD	180 BBLD 115 BBLD 58 BBLD 27 BBLD	107 X $20.00 X 30 = $64,200.00
DISCHARGE PRESSURE	-	45 PSIG	**$68,250 per Month**

RECOMMENDED PROCESS

1. Determine which fields may respond most favorably, and then prioritize well locations.

Picture Courtesy of Hy-Bon Engineering

RECOMMENDED PROCESS

2. Following well selection, a mobile, trailer mounted unit (natural gas engine driven) is moved to location for a 45 day test.

Picture Courtesy of Hy-Bon Engineering

RECOMMENDED PROCESS

3. Following 30 days of sustained production increase, an electric drive, skid mounted unit is moved to location, and the trailer is released to test the next candidate well.

Picture Courtesy of Hy-Bon Engineering

RECOMMENDED PROCESS

4. Based on the proximity of the wells and line pressure, evaluate linking opportunities for multiple well gathering systems

Picture Courtesy of Hy-Bon Engineering

CASINGHEAD GAS REDUCTION
Lessons Learned

- Ask the questions – you may be venting this gas and not know it
  - Especially when contract pumpers are being used
- Make your decisions based on fact
  - Like tank testing, the key is accurately quantifying the gas stream, so true payback economics can be evaluated
- Look at the opportunities across the entire field, not simply well by well
  - Linking multiple wellsites can dramatically improve the economics of gas capture
- Align field incentives to your gas capture goals
  - If field personnel incentives are strictly tied to increased oil production and cost containment, the field solution will always be to vent this gas – a ball valve is much cheaper than a compressor package.

Hy-bon Engineering Company