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Applied Reservoir Management: Examples of Best Practices

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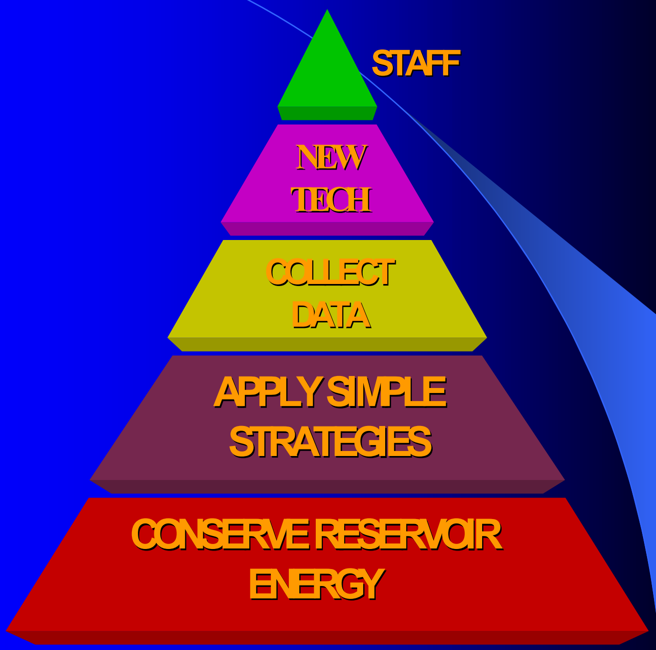
Presentation Outline

- Reservoir Management Principles
- Review Reservoir Management Principles
- 26R Reservoir Management Strategy
- Slick & Luling Reservoirs in Texas
- Mismanaged Reservoirs
  - MBB/W31S Versus North Coles Levee
  - Eugene Island Block 330, Gulf of Mexico
- Closing Remarks

Reservoir Management Principles



- Conservation of reservoir energy
- Early implementation of simple strategies
- Sustained and systematic data collection
- Continuous application of improved recovery technologies
- Long term retention of staff in multi-disciplinary teams

Conservation of Reservoir Energy

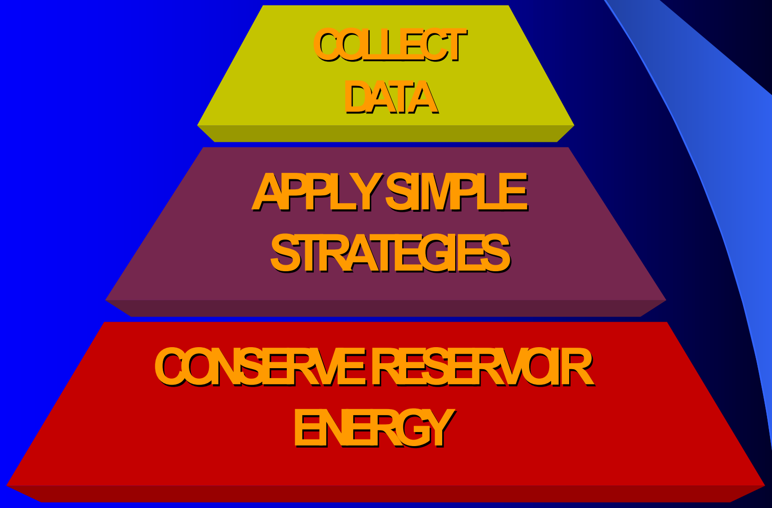
CONSERVE RESERVOIR ENERGY

- Avoid these practices:
  - Gas cap production
  - Excessive drawdown
  - Commingling large, separate reservoirs
  - Close well spacing
- Balance energy conservation and maximum economic recovery

Early Implementation of Simple Strategies

- Simple strategies conserve reservoir energy at minimum cost
- Examples of simple strategies
  - Pressure maintenance
  - Zone isolation
  - Controlled draw-down
  - Down-hole pressure gauges

Systematic and Sustained Collection of Data

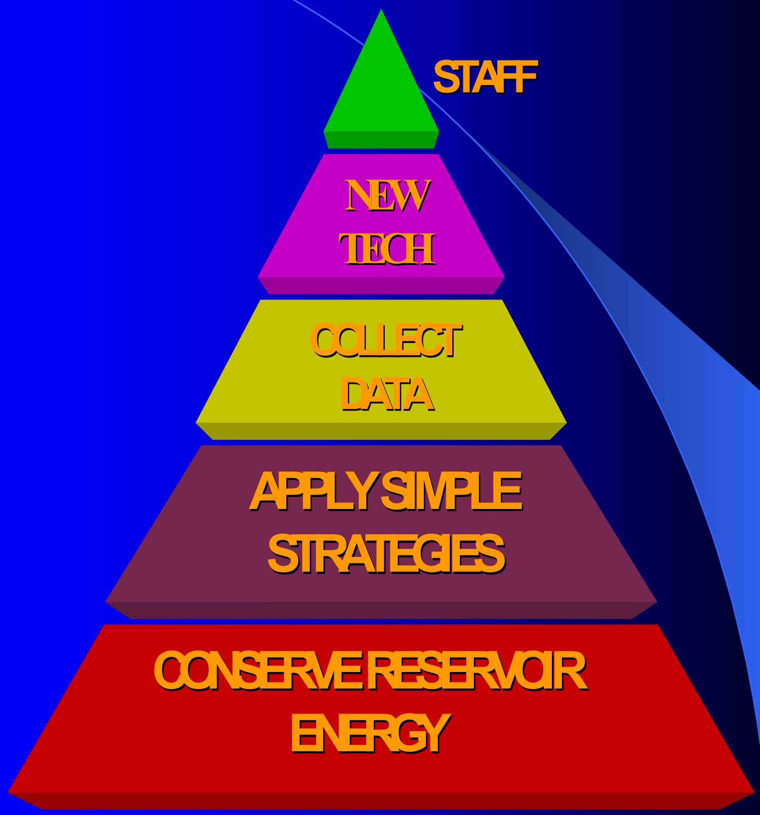


- Data to collect
  - Geologic/ seismic
  - Pressure data
  - Rock/fluid data
  - Well data
- Focus on areas of need
- Weigh costs Vs benefits

Application of Improved Recovery Technologies

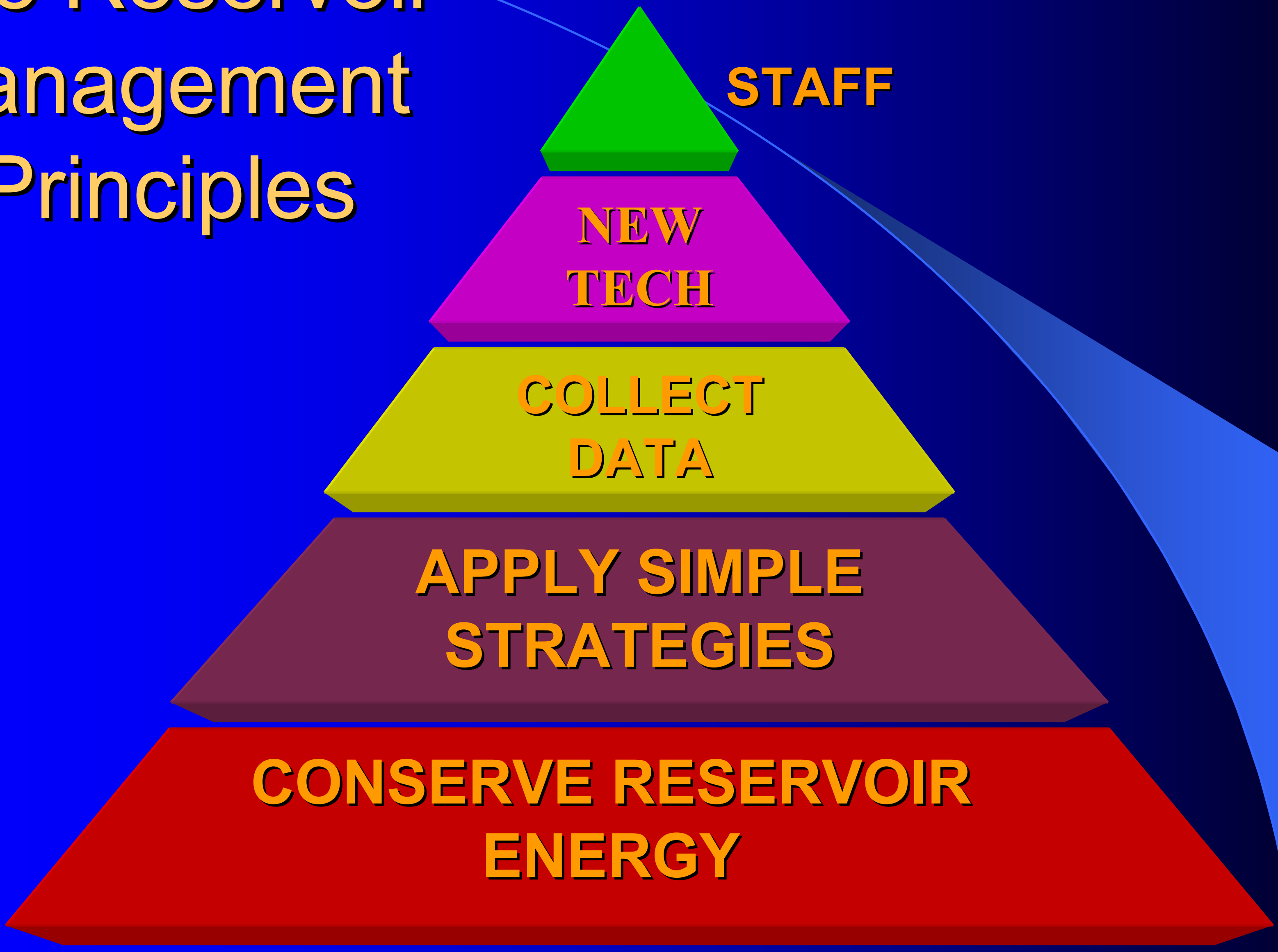
- Well-managed reservoirs benefit from improved technologies
- Improved recovery technologies are:
  - New drilling techniques
    - Multi-lateral wells
    - Geo-steering of wells
  - New completion techniques
    - Smart wells
  - New production operations
    - New/Improved Lift Systems
  - New recovery methods
    - Chemical/Polymer Flooding

Long Term Retention of Multi-Disciplinary Teams



- Reservoir management teams composed of multi-disciplinary staff
- Team members kept together as long as possible

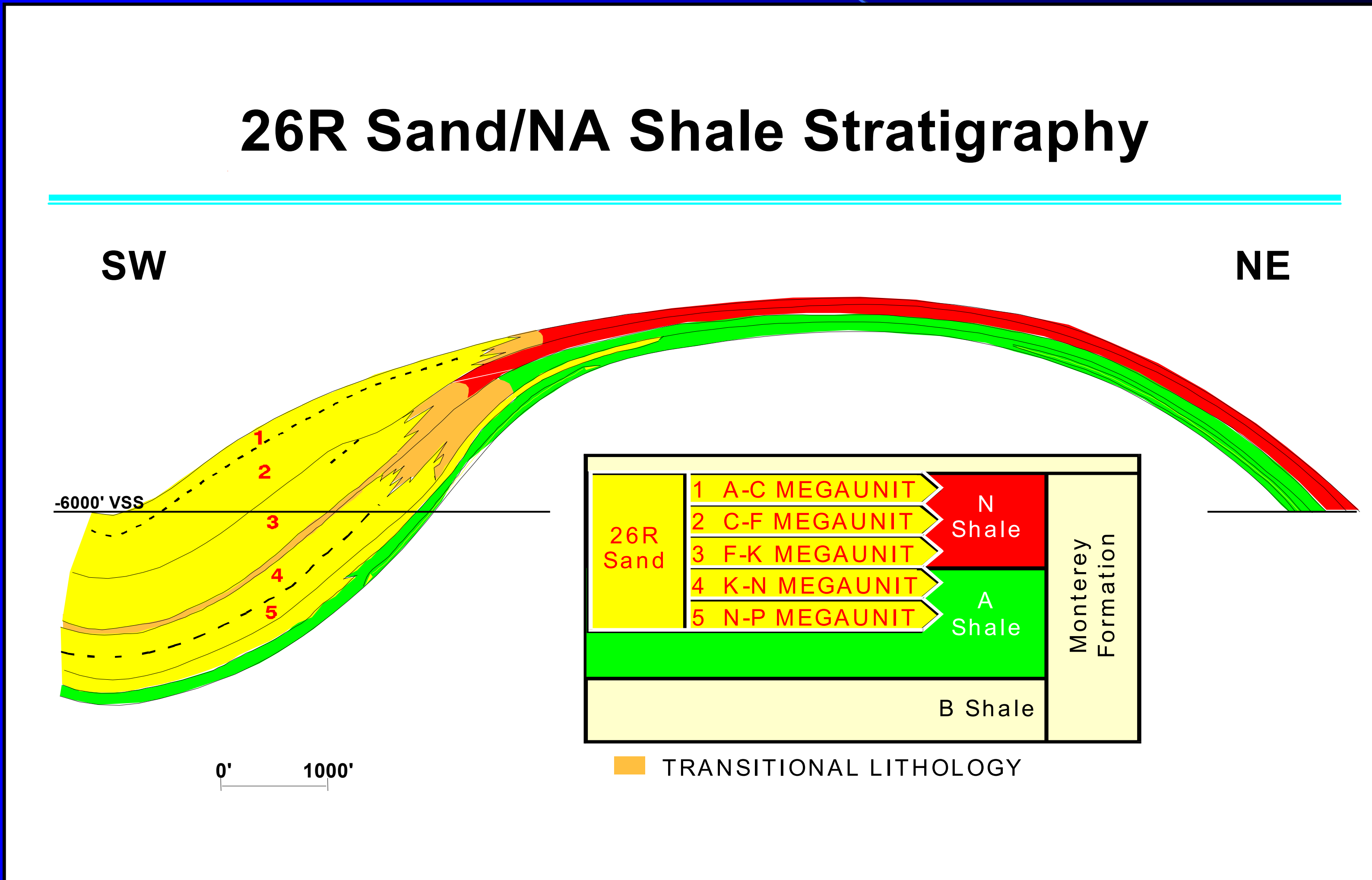
Five Reservoir Management Principles



Summary- 26R Reservoir

- Maximum net pay is 1800 feet
- OOIP is 423 MMBO
- Reservoir at bubble Point pressure
- Gravity Drainage- Main mechanism

26R Reservoir



26R Management Strategy

- Maximize Oil Recovery, 1976-1998
- Maximize Gas Recovery, 1998-2005

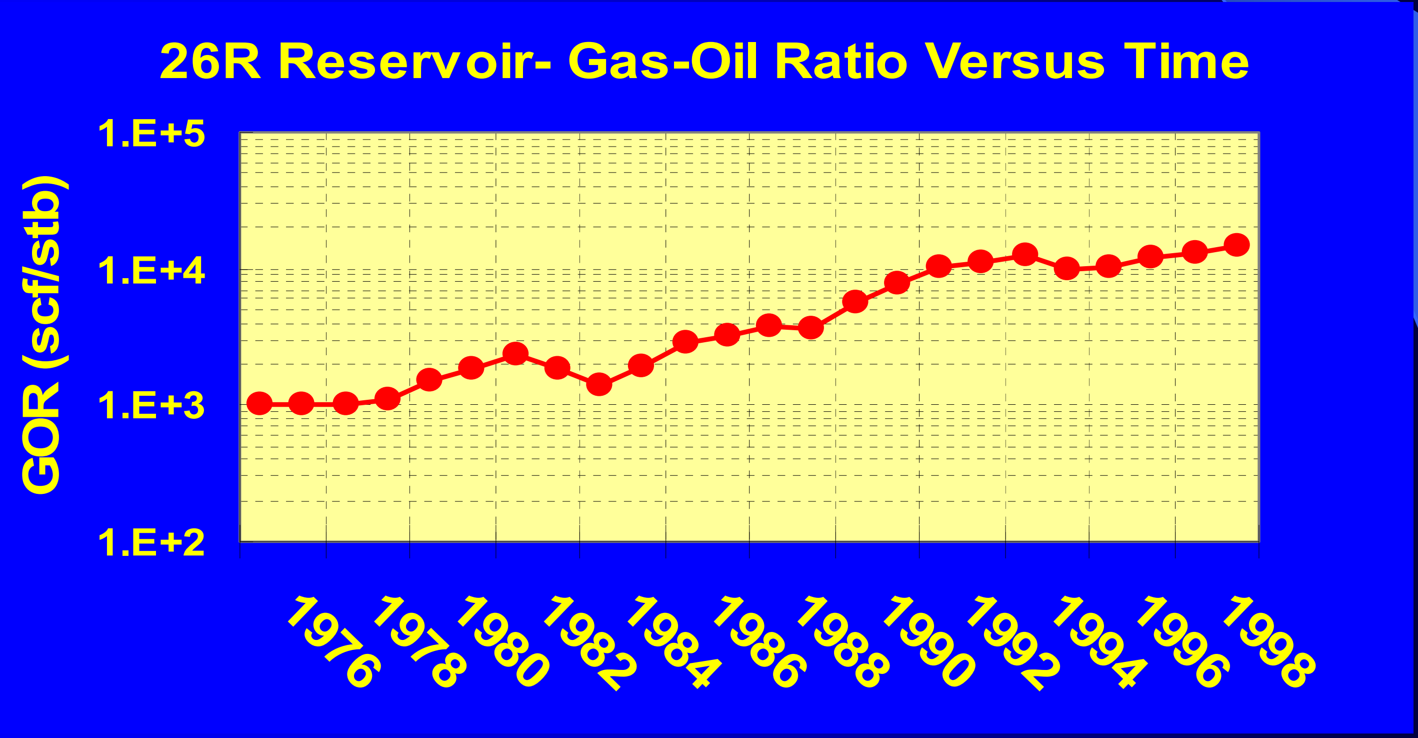
26R Management Strategy 1976-1998

- Maximize Oil Recovery
  - Gas-oil ratio controls
  - Pressure Maintenance
  - Data Collection
  - Use of Horizontal Wells

- Goal- Maximize economic recovery

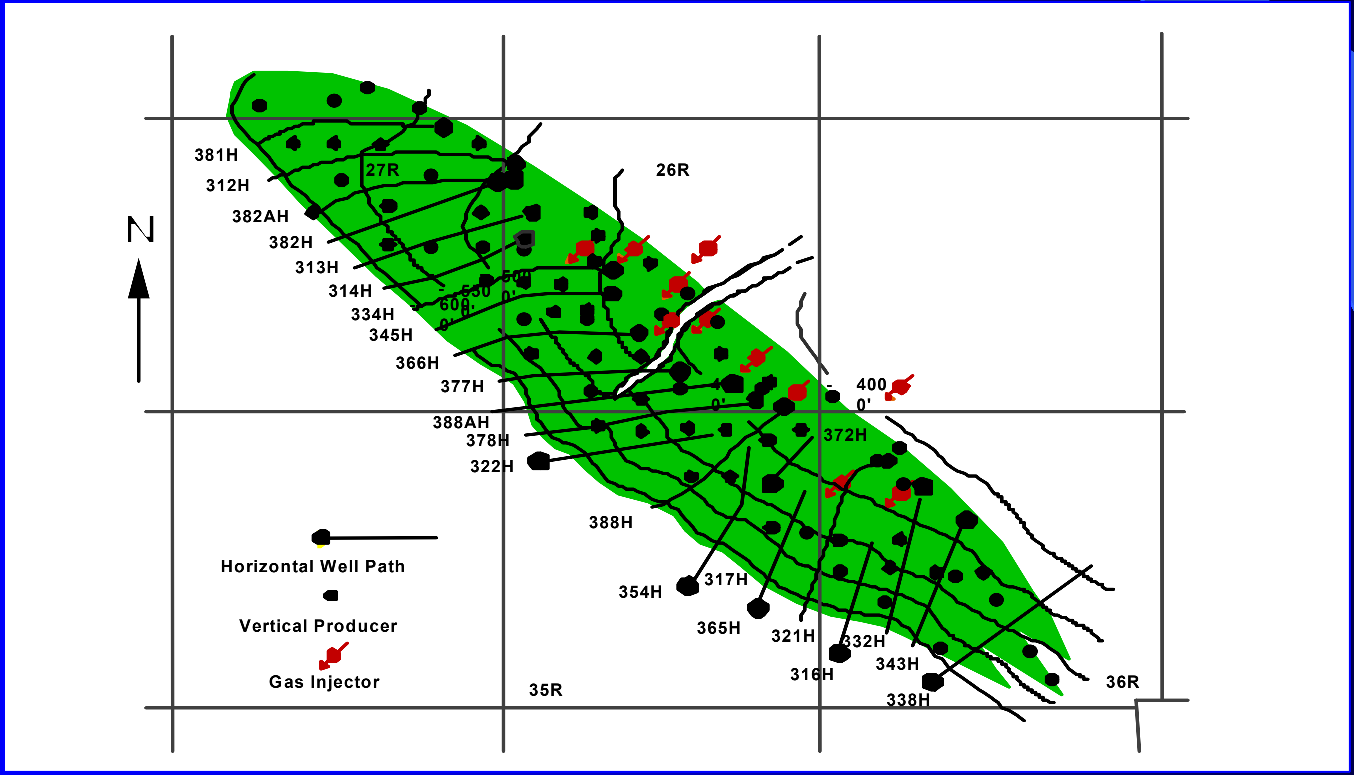
Conservation of Reservoir Energy: Gas-oil Ratio Controls

- HGOR wells shut-in to conserve reservoir energy



Early Use of Simple Strategies: Pressure Maintenance

- Crestal gas injection started 3 months from open-up in October 1976

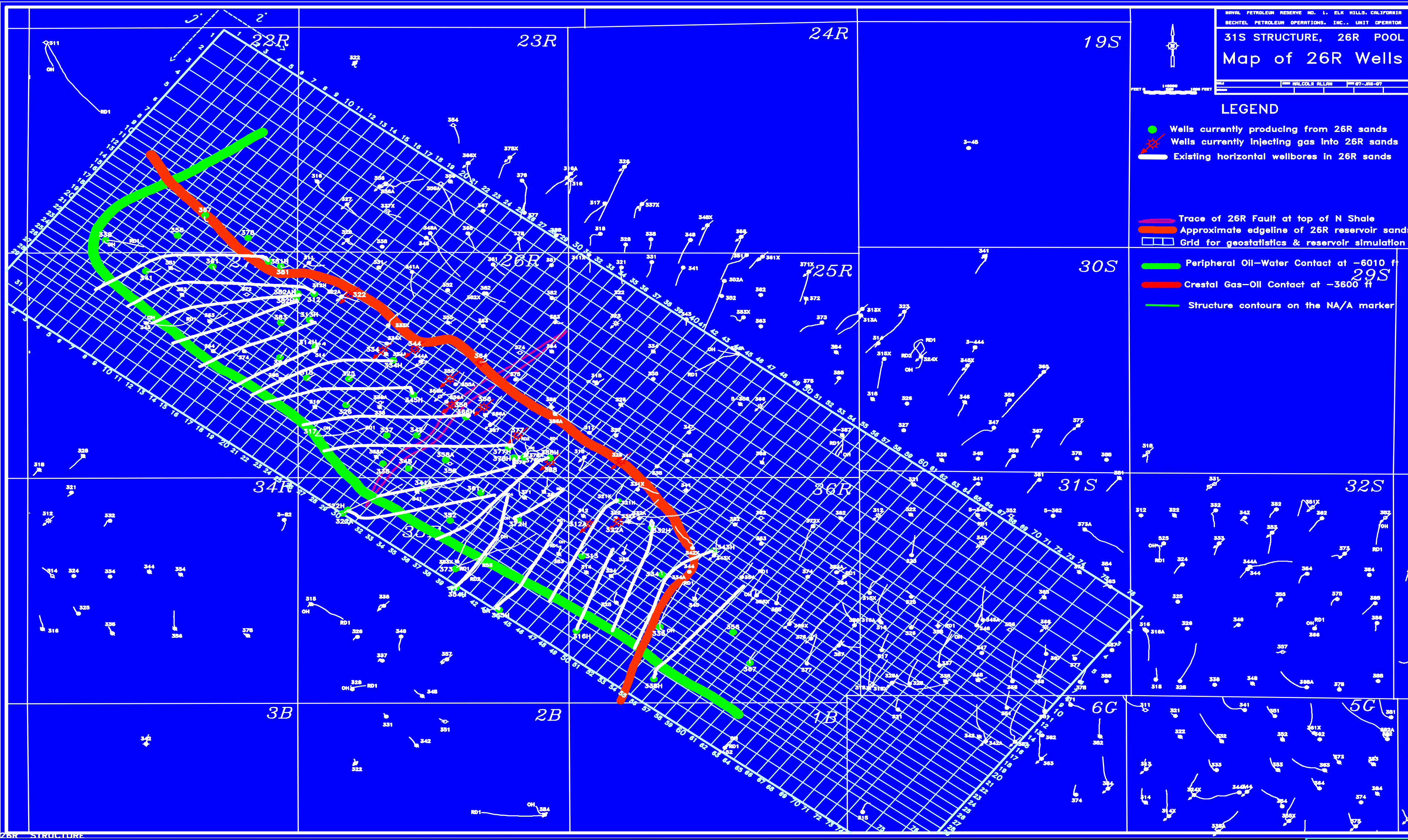


Structure map of 26R Reservoir showing gas injectors

Systematic Collection of Data

- Pressure Data
  - Key wells every month
  - Field-wide twice a year
- Core, Log and RFT data from new wells
- Improved geologic/simulation models based on new data

26R Reservoir Model Grid



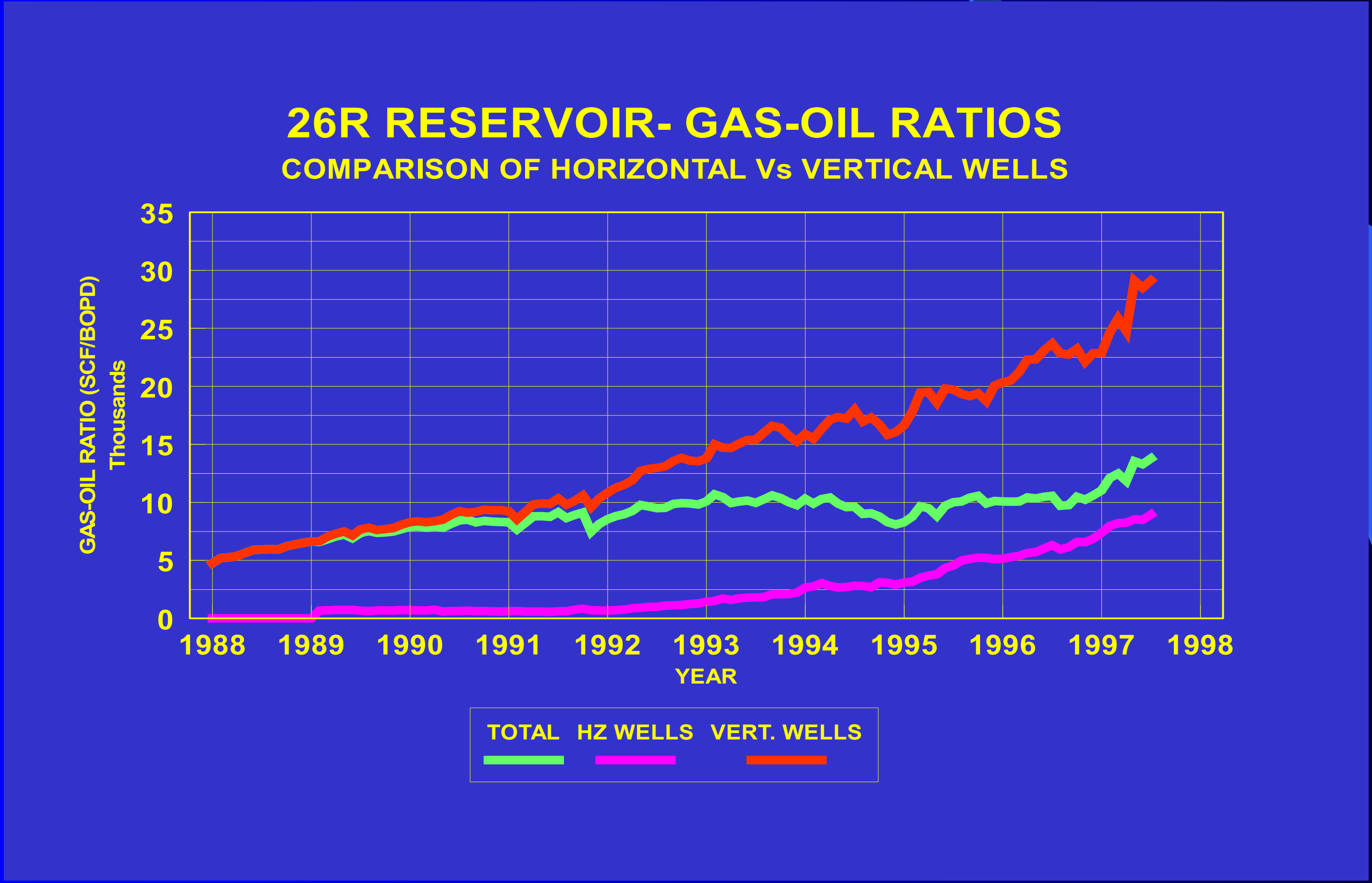
26R Model Summary

- Geologic Model: 76 X 32 X 500
  - 1.22 million cells
- Geologic model built with geostatistics
  - Used SGS for property modeling
- Reservoir model: 76 X 32 X 56
  - Upscaled to 136,000 cells
  - Simulated with Eclipse simulator
- Check SPE Paper 46231 (1998) for details

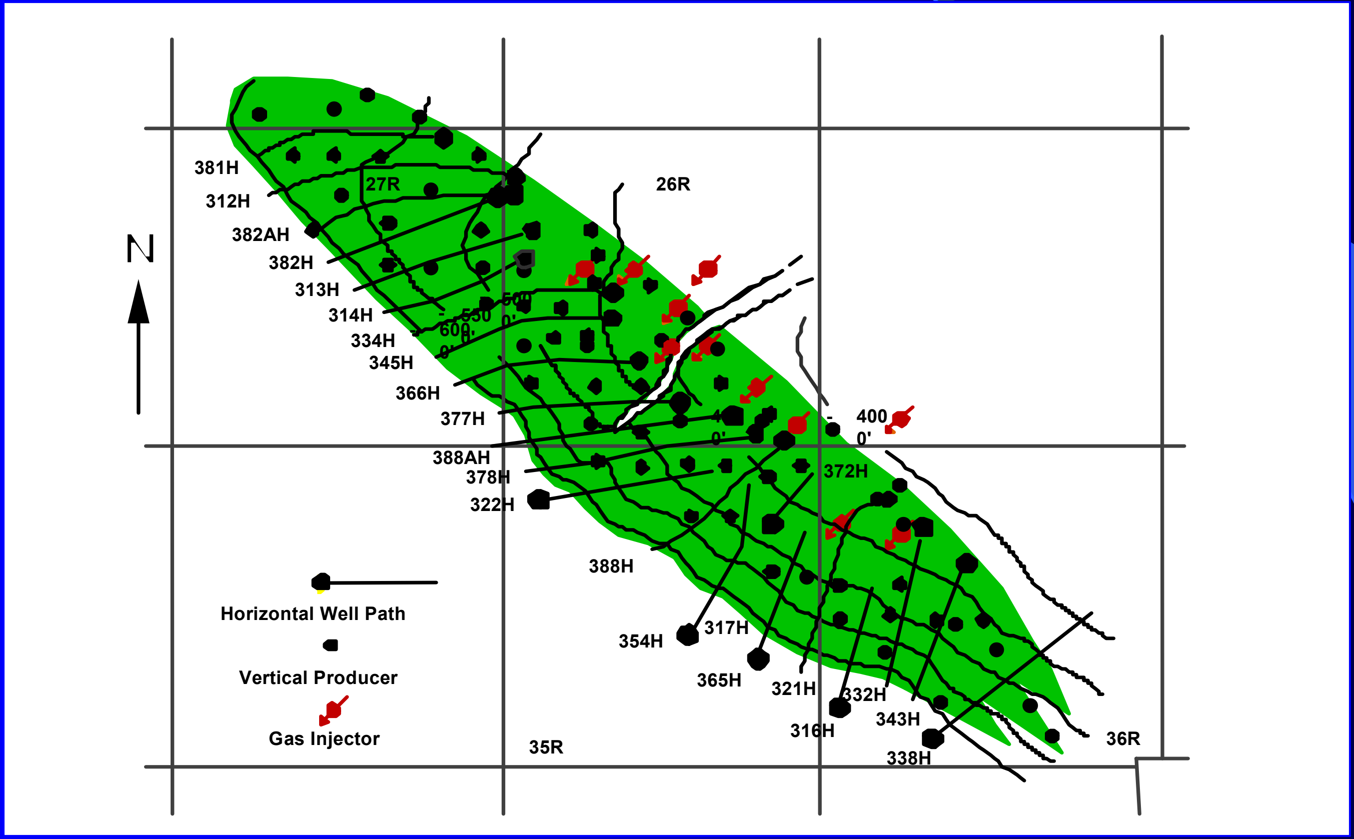
Improved Recovery Technologies: Horizontal Wells

- First horizontal (HZ) well drilled in 1988
- 22 HZ wells drilled by 1996
- In 1998, HZ wells produced 70% of oil with one-third GOR of vertical wells

Performance of HZ Vs Vertical Wells Gas-Oil Ratios in 26R Reservoir



Improved Recovery Technologies: Horizontal Wells



Horizontal (HZ) Well Locations in 26R Reservoir

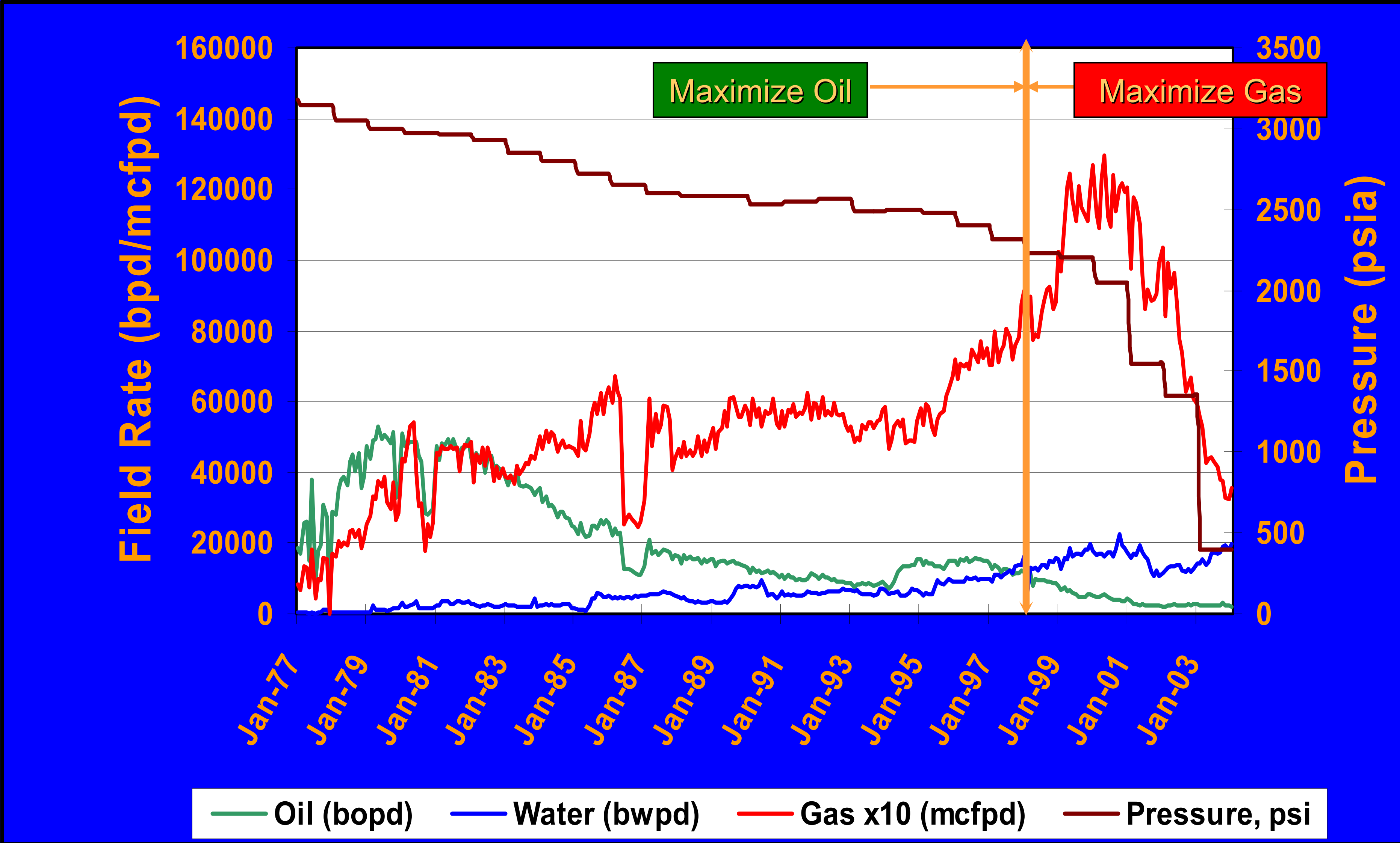
26R Management Strategy 1998-2005

- Maximize Gas Recovery
  - No Gas-oil ratio controls
  - End Pressure Maintenance
- Goal- Maximize economic recovery

26R Management Strategy 1998-2005

- Factors behind strategy change
  - High market value for gas
  - Reservoir was near depletion
  - NPV of gas reserves 5 times greater than NPV of remaining oil reserves

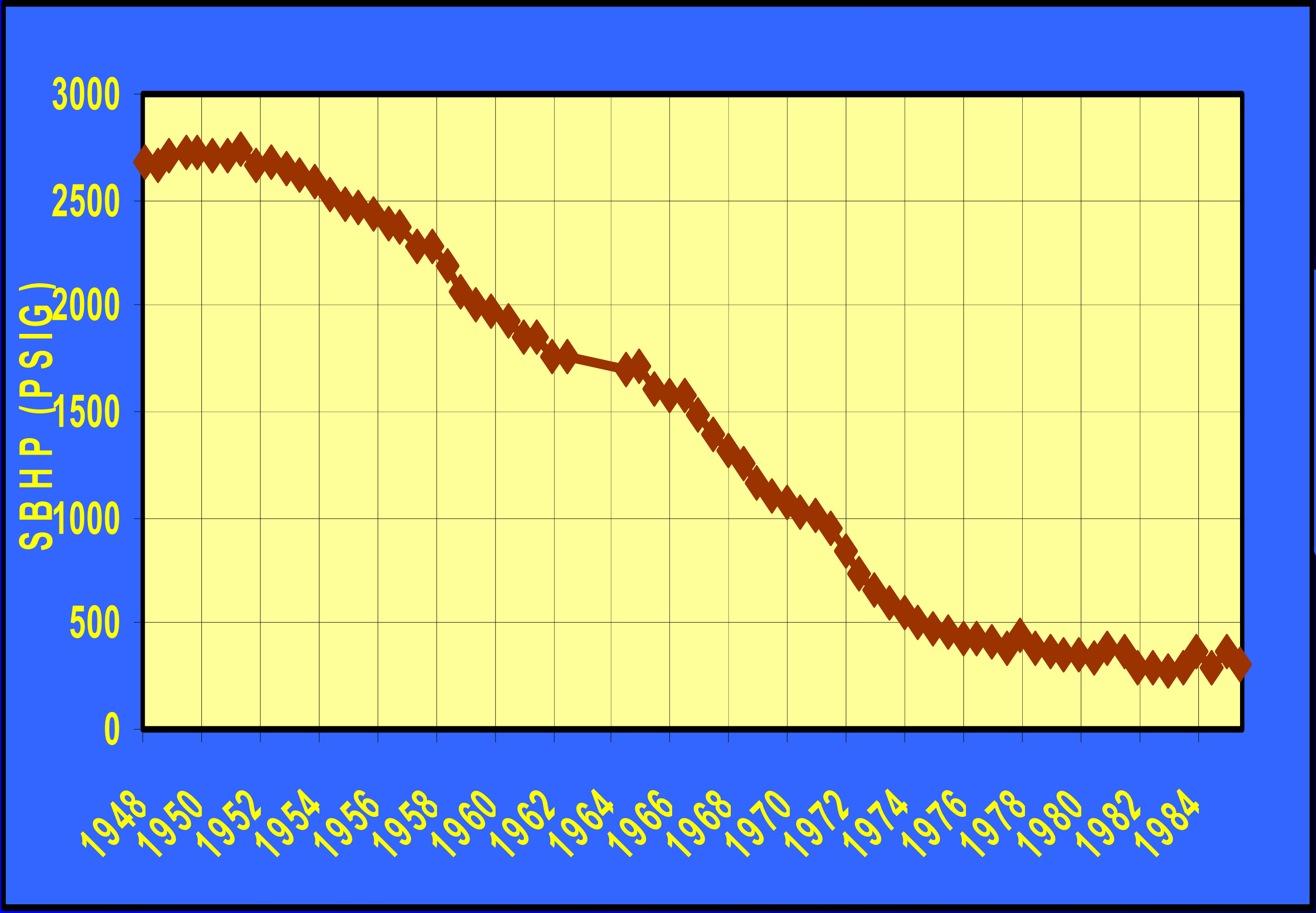
26R FIELD PRODUCTION



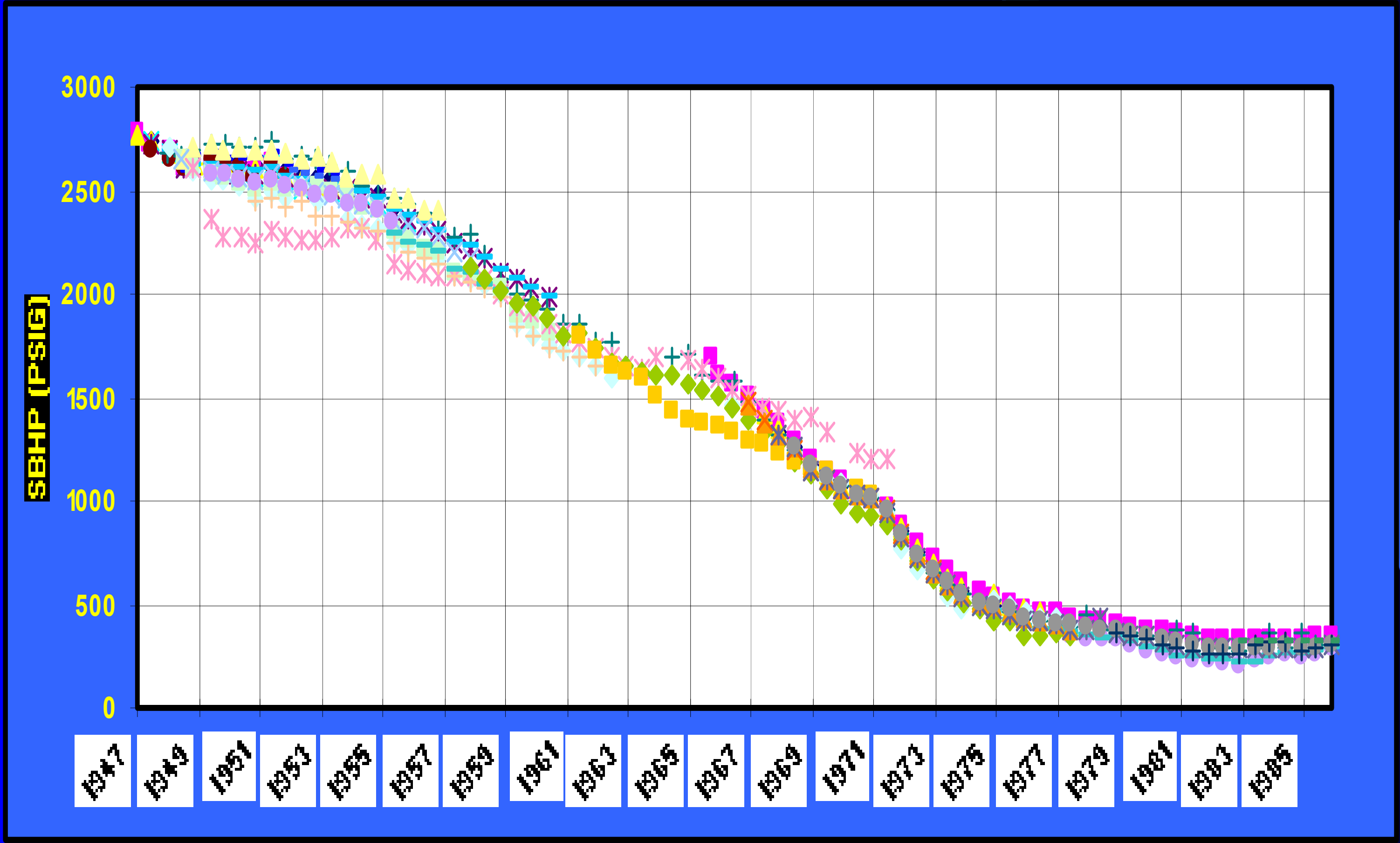
Example of Sustained & Systematic Data Collection

- Slick & Luling Reservoirs in Texas, U.S.A.
- Collected SBHP data 2 times per year over forty years
- Historical pressure and production data documented in well files over 40 years

SBHP- Well Ruhman B-1
Slick Reservoir



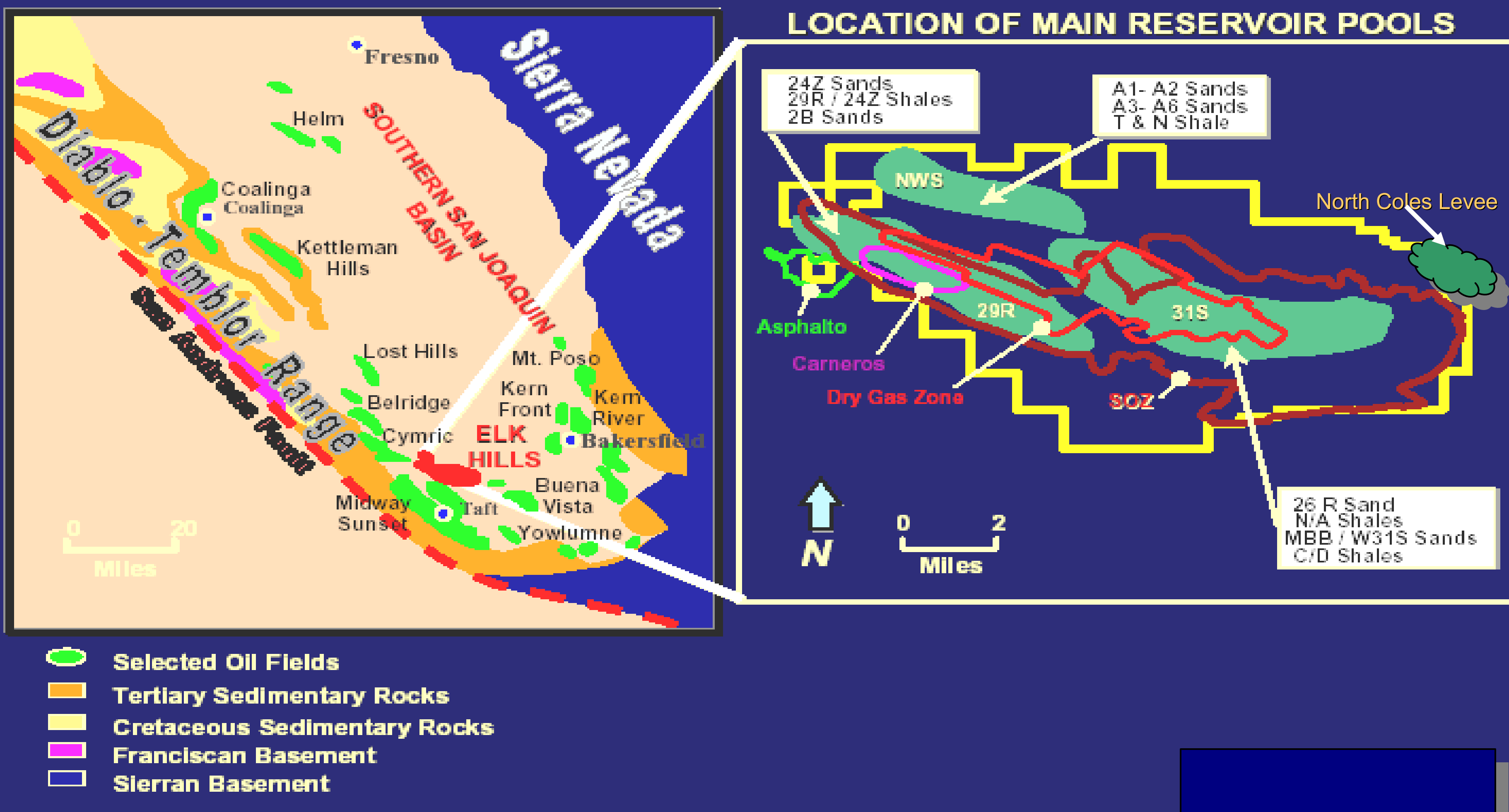
SBHP- Slick Reservoir (26 Wells)



Mismanaged Reservoirs

- Numerous examples exist in our industry
- Reservoirs in this category include
  - Absence of clearly stated or defined strategies
  - Management strategies not based on data
  - Low pressured reservoirs with depleted gas caps
  - Poorly planned pressure maintenance programs
  - Extended excessive production to meet targets

MBB/W31S Vs North Coles Levee



MBB/W31S Vs North Coles Levee

Properties	MBB/W31S	North Coles Levee
Initial Press, psi	3150	3960
Avg Porosity, %	15	20
Avg Wat Sat, %	33	43
Perm range, mD	0-4570	0-7500
Bubble Pt, psi	2950	3260
GOR, scf/bbl	800	800
Oil Gravity, API	33.5	36.1
Oil Viscosity, cp	0.4	0.45

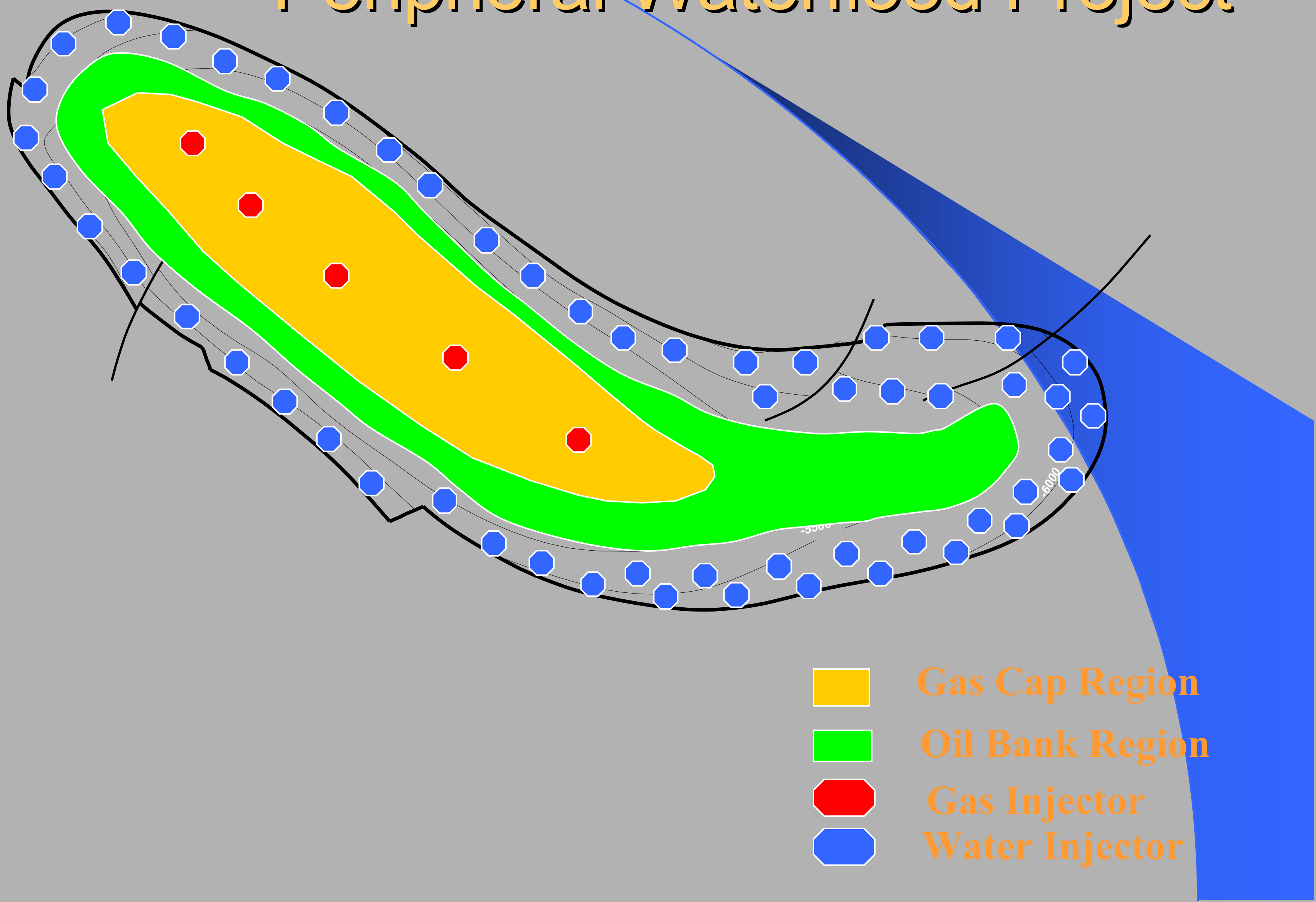
MBB/W31S Vs North Coles Levee

- Same geologic age-Miocene era
- Turbidite sand deposits
- Identical type logs
- Similar reservoir fluids

Reservoir Management strategies MBB/W31S Vs North Coles Levee

- Both reservoirs had:
  - Early production by depletion drive
  - Gas injection for pressure maintenance
  - Waterfloods installed in both reservoirs
- Major difference:
  - Gas cap in North Coles Levee blown down **BEFORE** waterflood was installed
- Main consequence:
  - Injected water FLOODED the gas cap in North Coles Levee

MBB/W31S Reservoirs Peripheral Waterflood Project



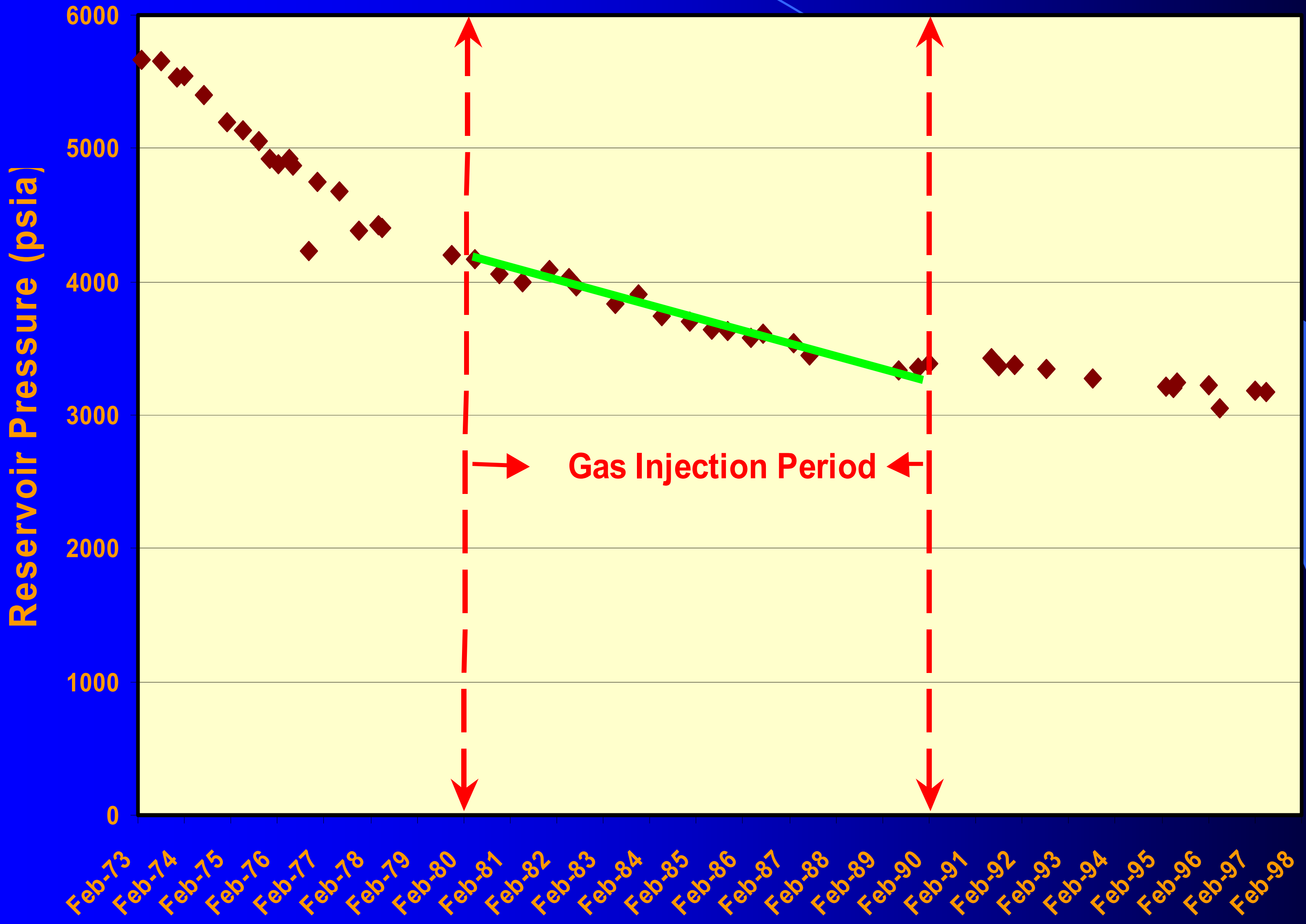
MBB/W31S Vs North Coles Levee Current Status

- North Coles Levee is Shut-in
  - SPE 9934 & SPE 15499
- Expansion of Pattern waterflood in MBB/W31S Reservoirs
  - SPE 68879 & SPE 76723

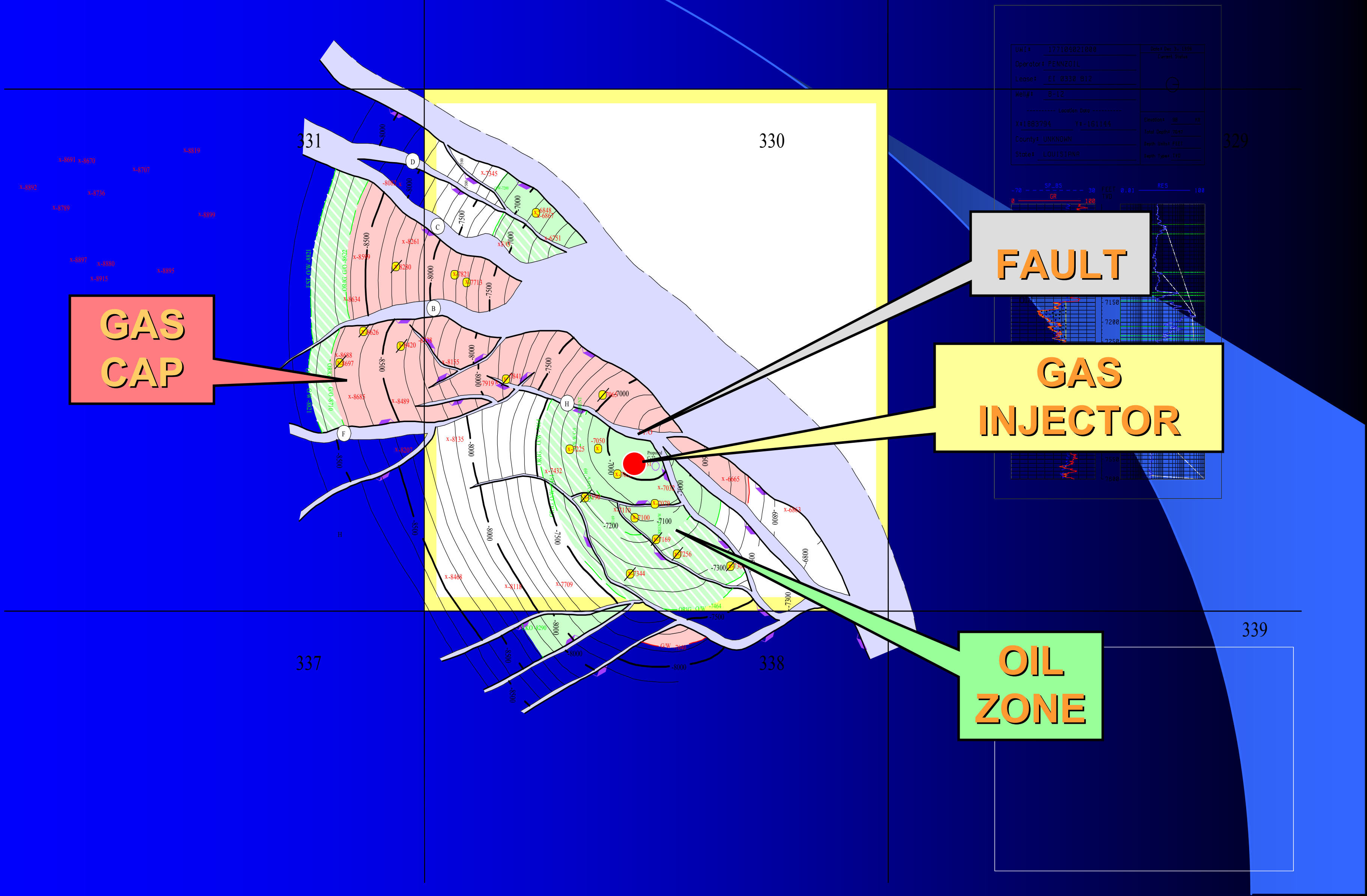
Eugene Island Block 330 Reservoir-Gulf of Mexico: Another Example

- Production began in 1973
- Rapid pressure decline from 1973 to 1980
- Gas injection for pressure maintenance began in 1980

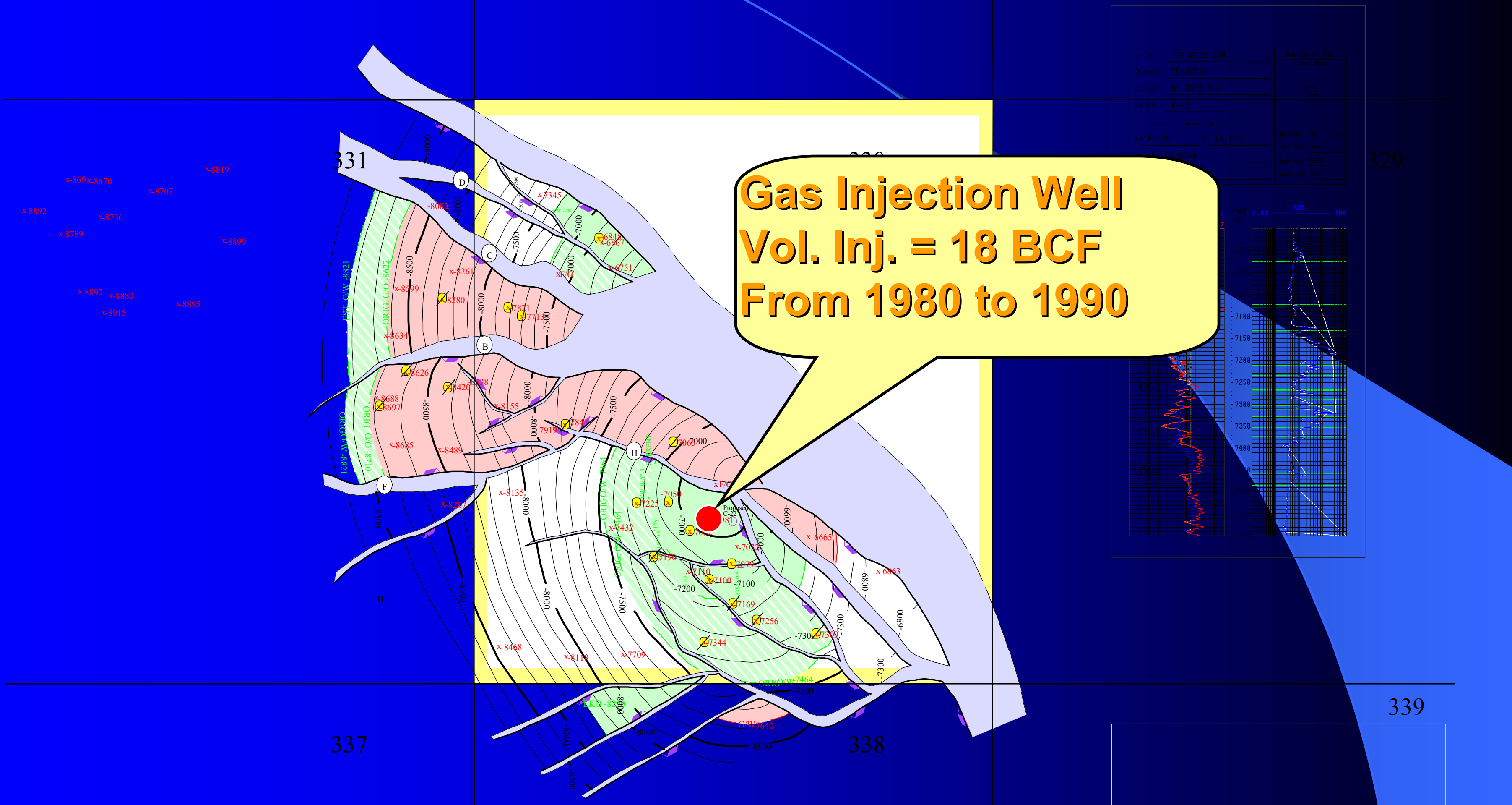
Gulf of Mexico: EI 330
Reservoir Pressures Vs Time



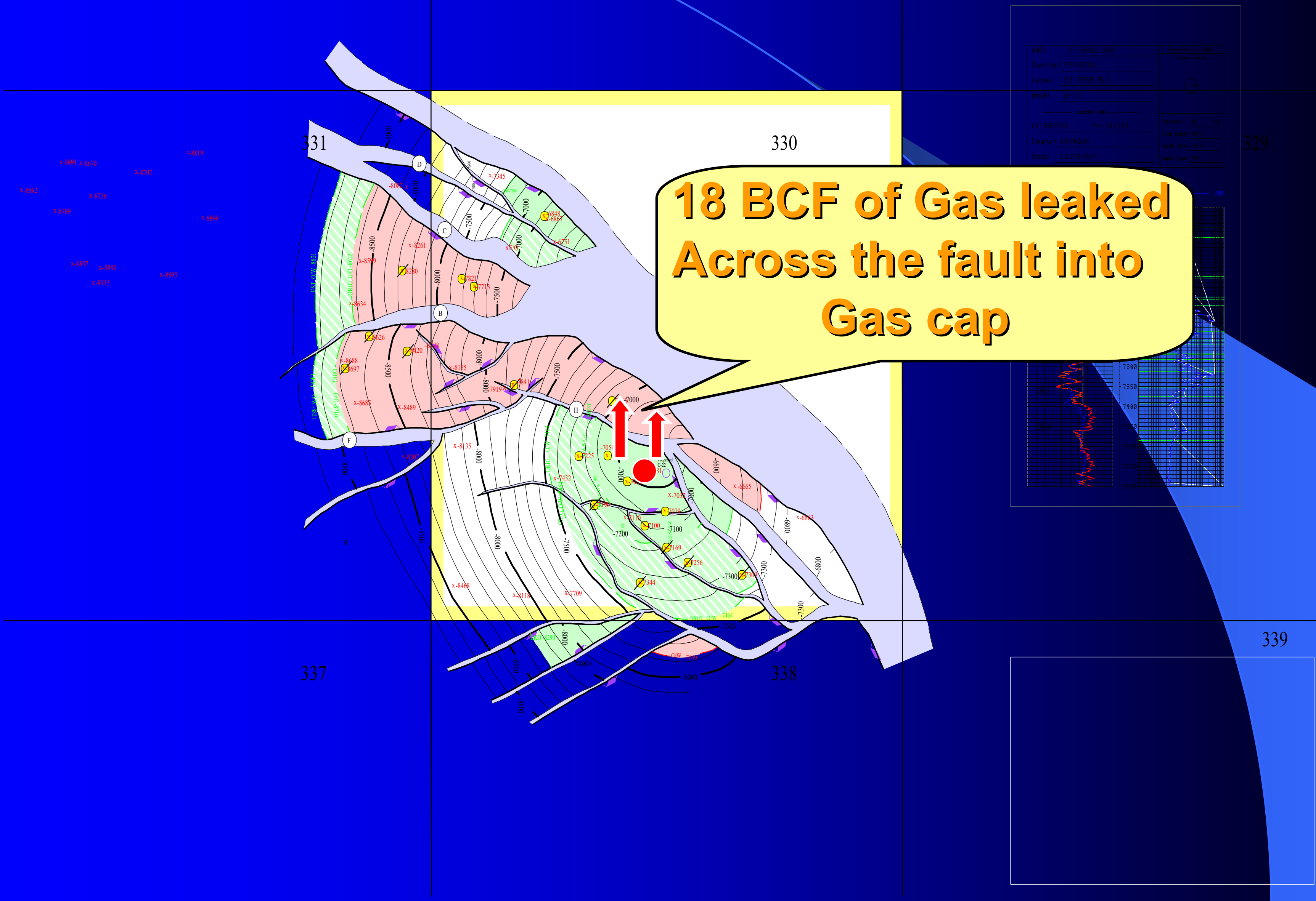
Gulf of Mexico: EI 330 Reservoir



Gulf of Mexico: EI 330 Reservoir



Gulf of Mexico: EI 330 Reservoir



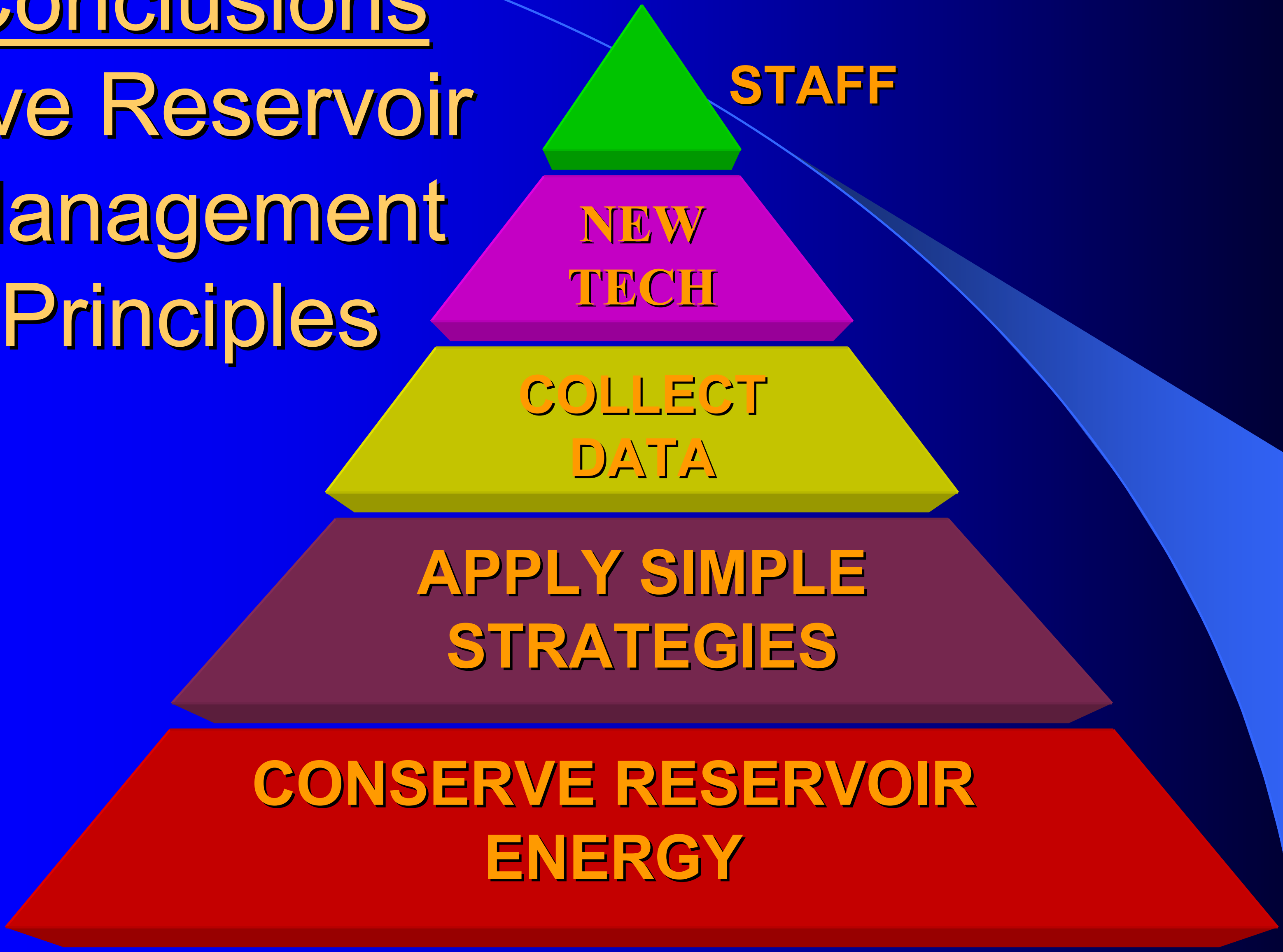
EI 330: Pressure Maintenance Failure

- Reasons:
  1. Poor Geologic work
  2. Poor monitoring of reservoir pressures

– Costs of Failure:
  1. Injection facilities
  2. Operating costs over 10 years
  3. Lost value of 18 BCF of injected gas

Conclusions

Five Reservoir Management Principles



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