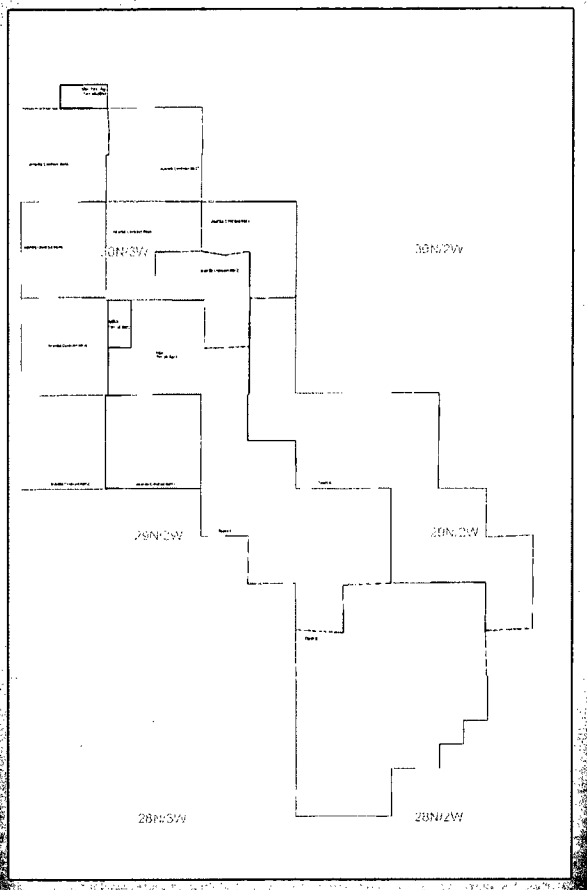
Black Hills Gas Resources

Black Hills Gas Resources
East Blanco Field
80-Acre Application

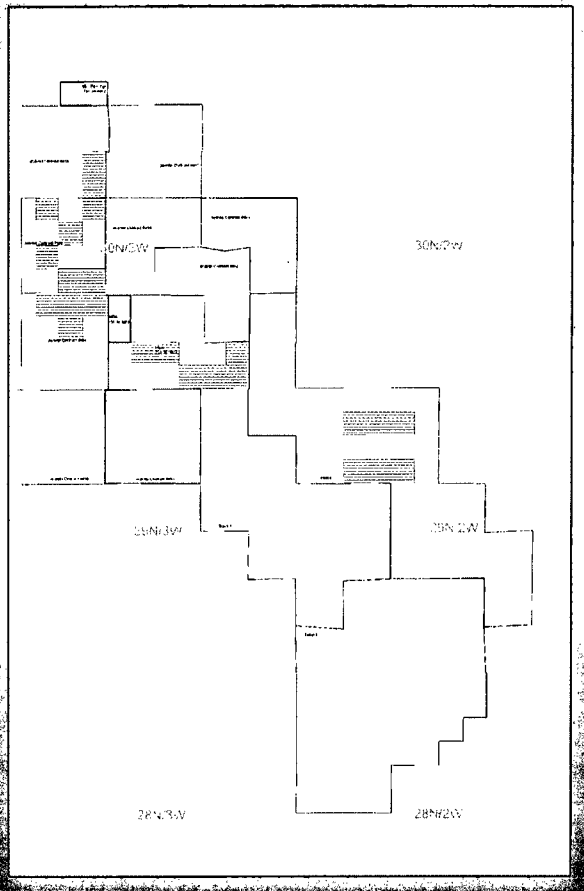
East Blanco Increased Density Application

BHRG Leasehold on Jicarilla Lands



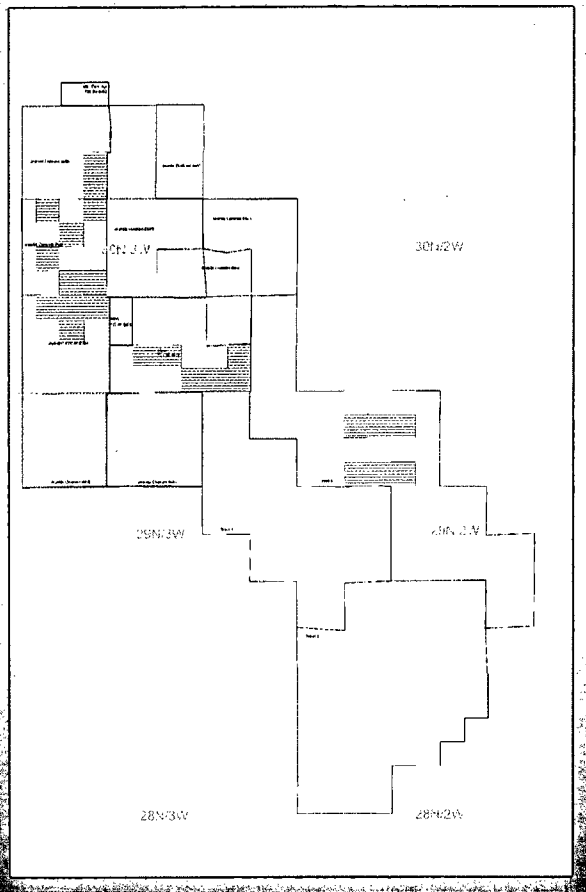
East Blanco Increased Density Application

Original Pilot Program



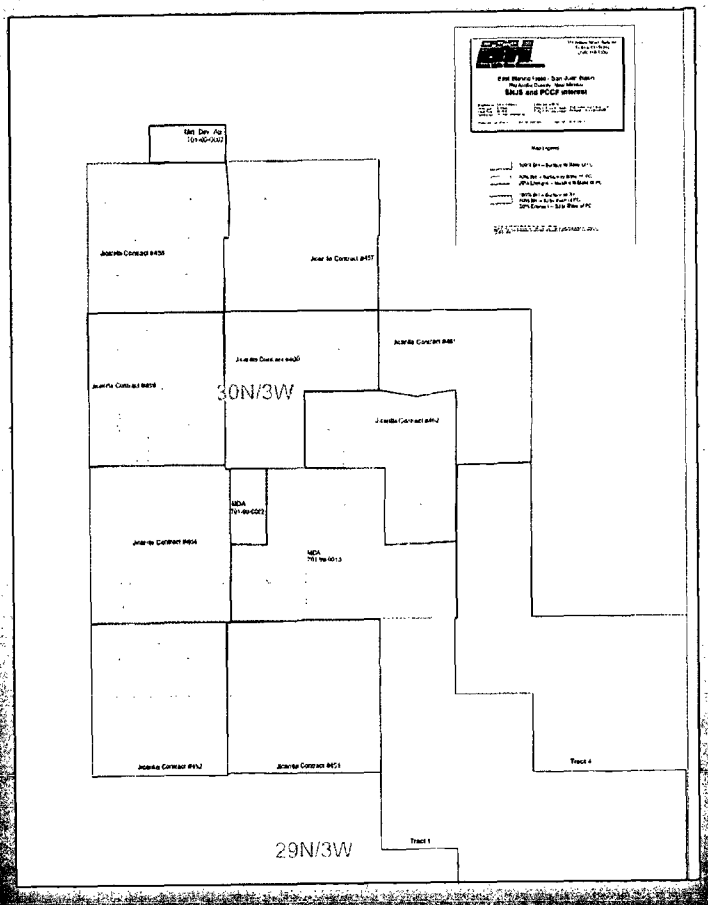
East Blanco Increased Density Application

Proposed Project Outline



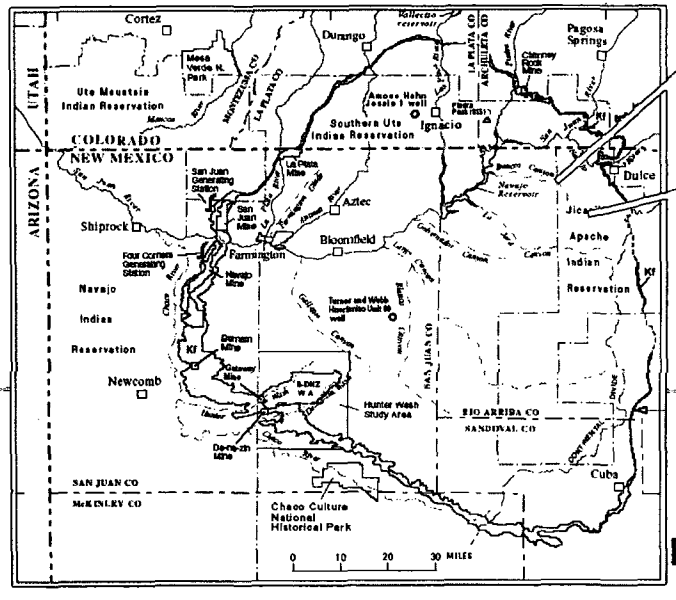
East Blanco Increased Density Application

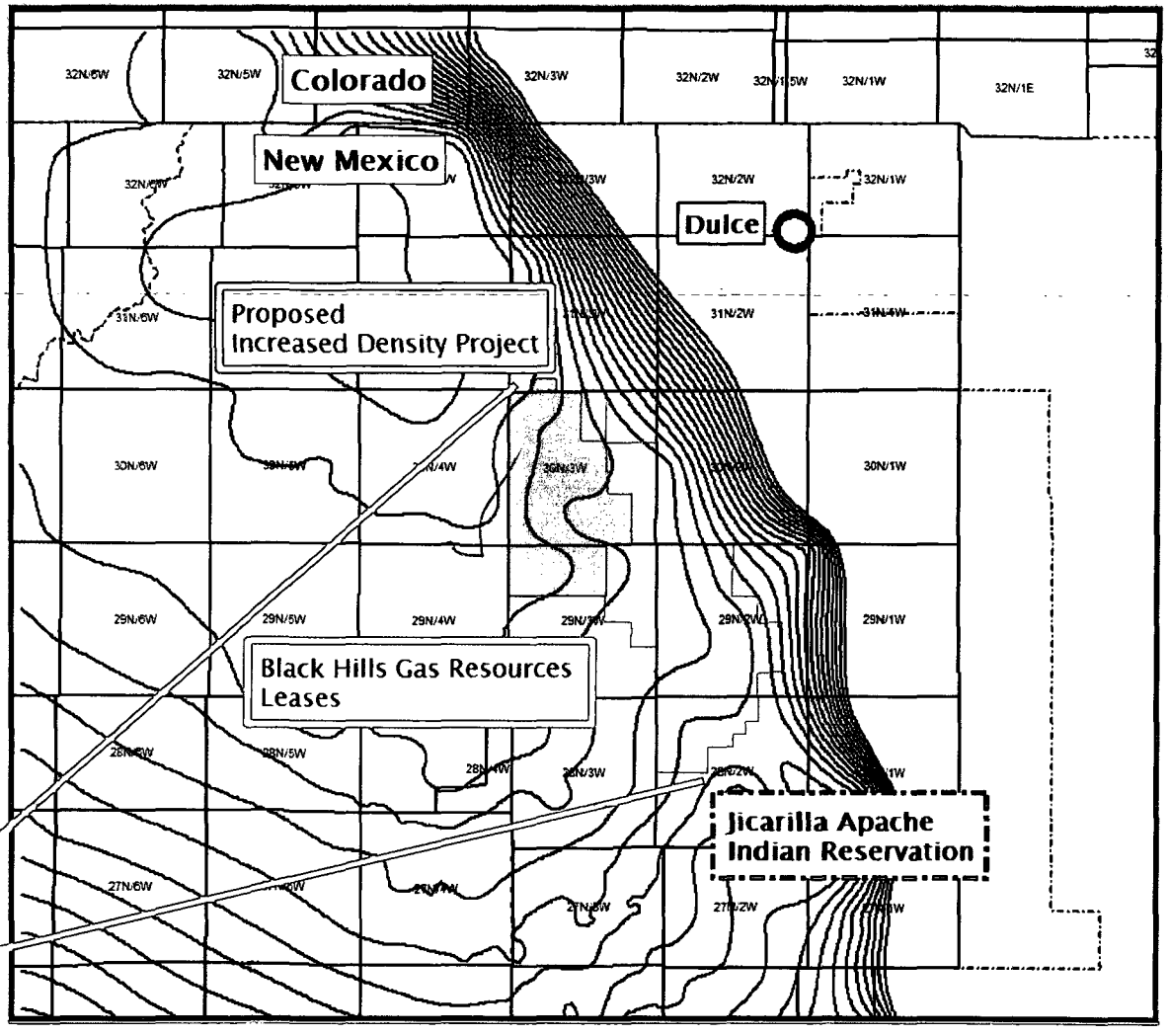
Black Hills Working Interest in Project Area



San Juan Basin

Location Maps





Structural Datum – Huerfanito Bentonite

East Blanco Increased Density Application

San Jose

Nacimiento

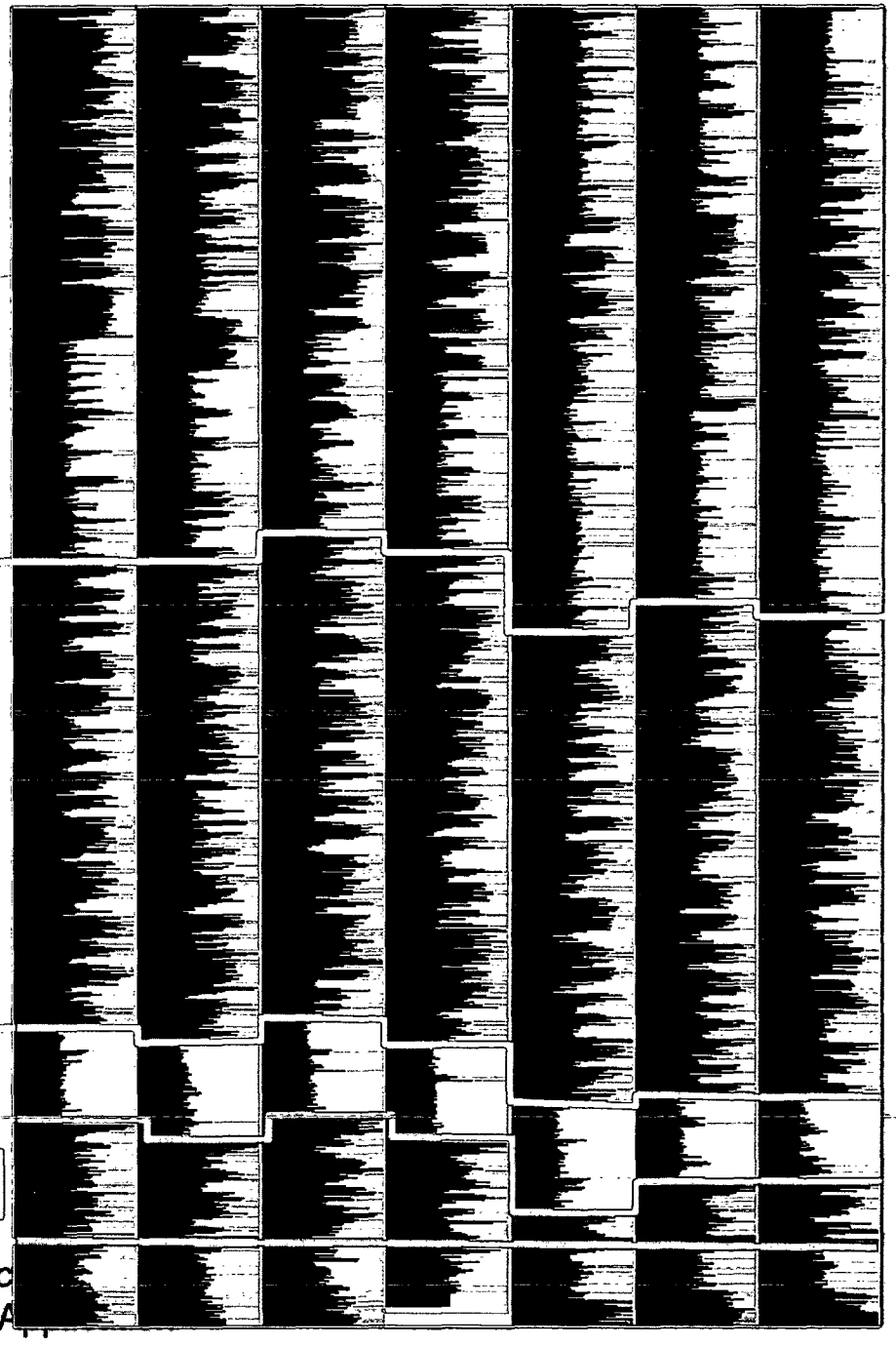
T

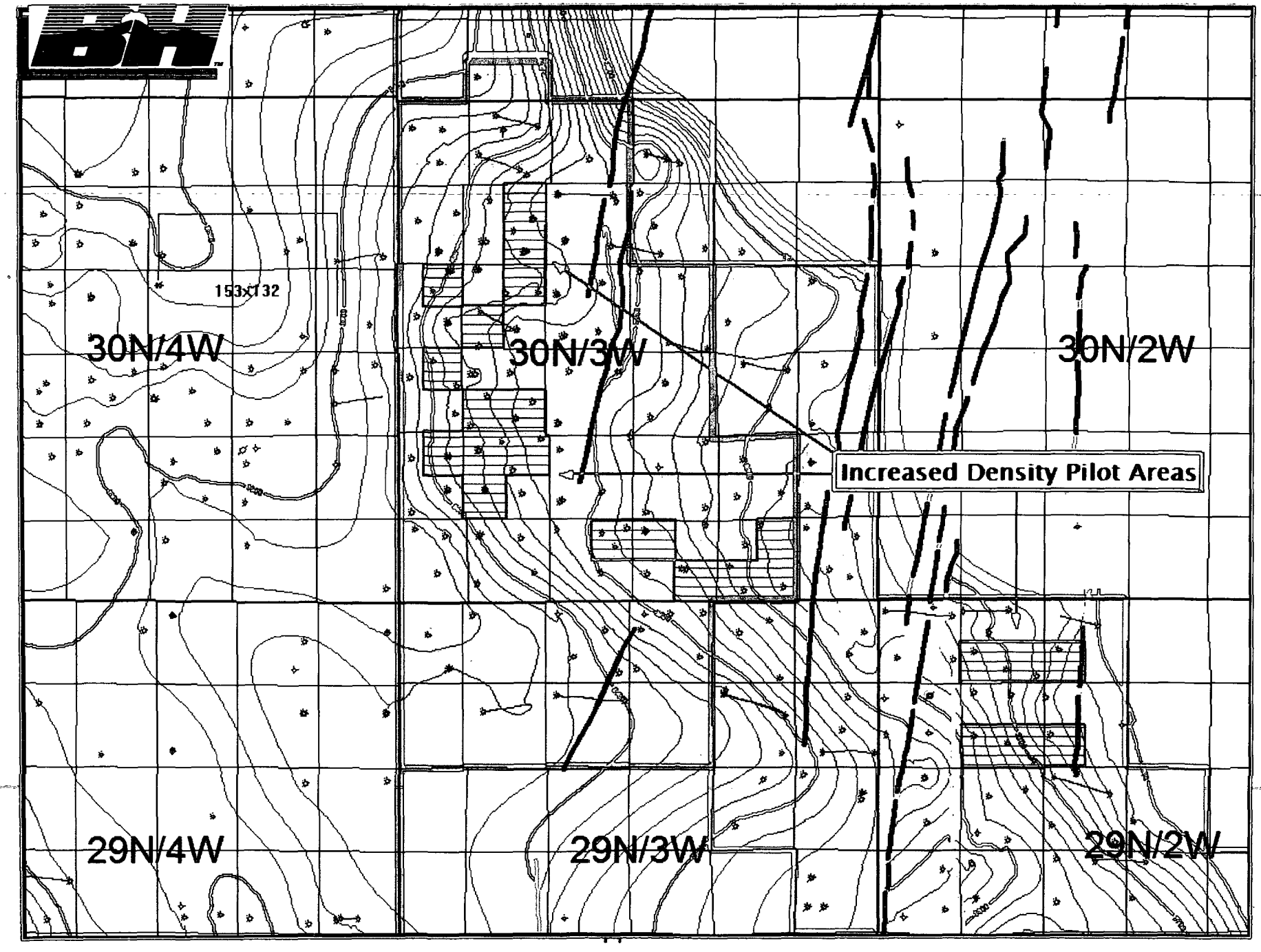
Ojo Alamo

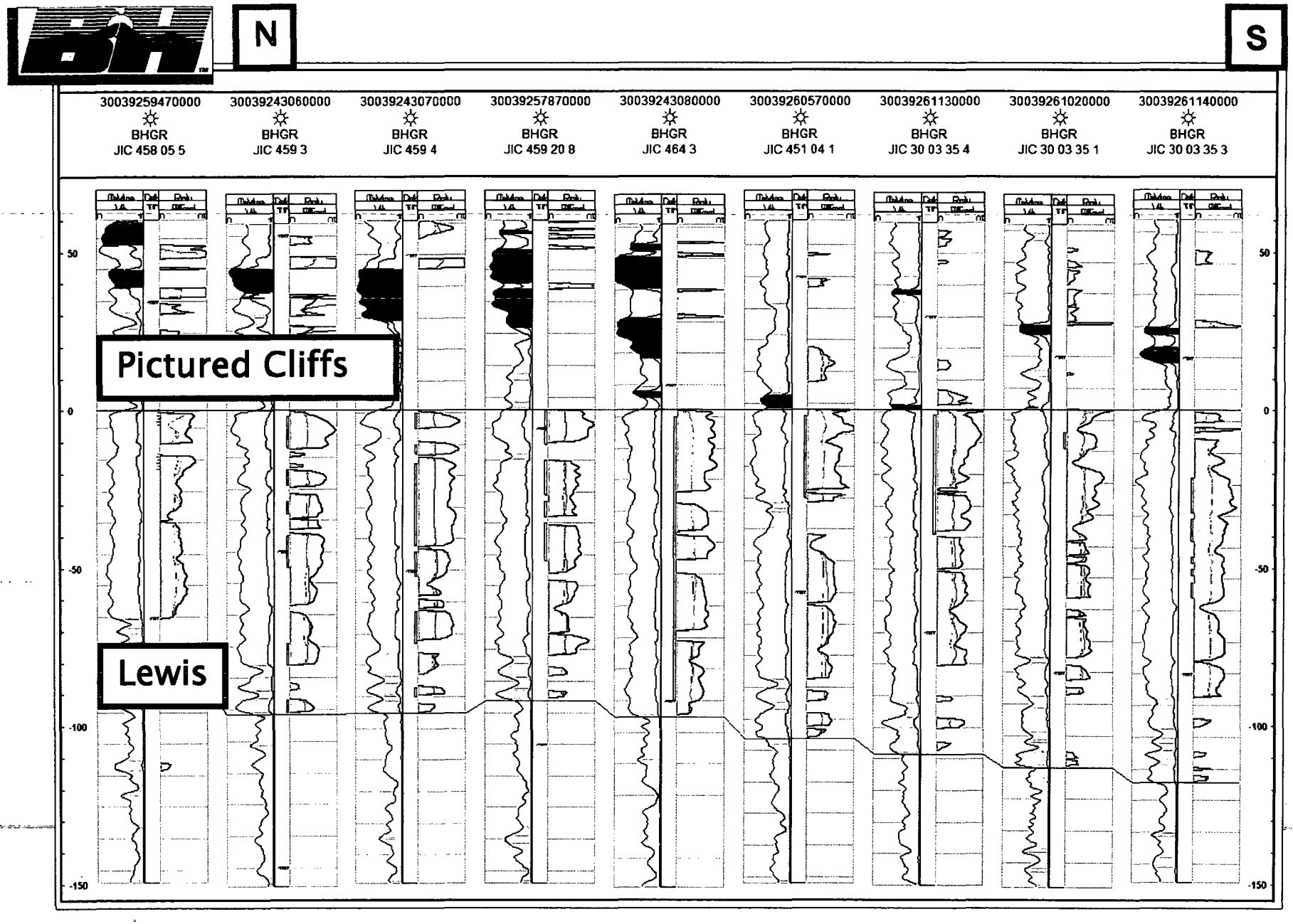
K

Kirtland / Fruitland

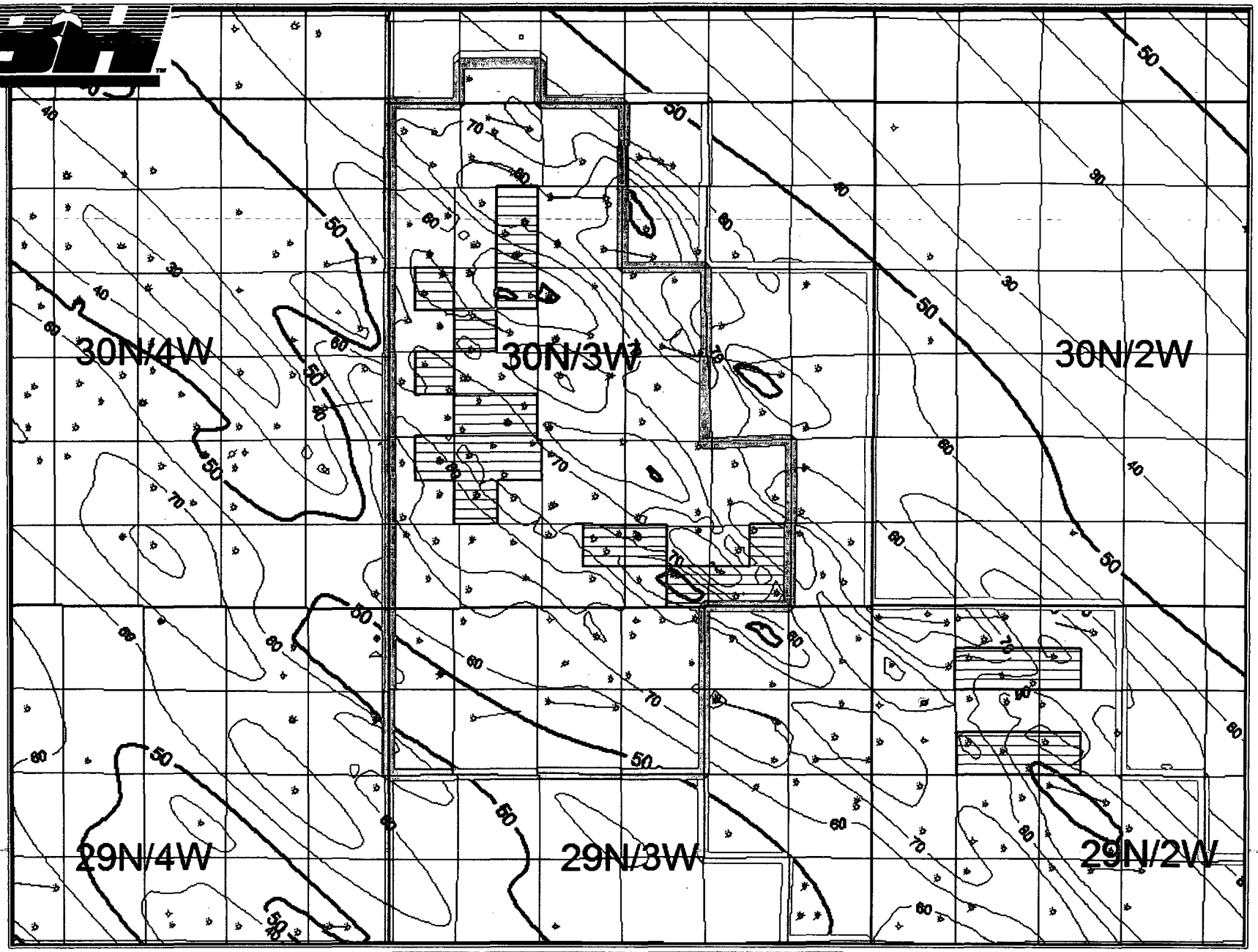
Pictured Cliffs



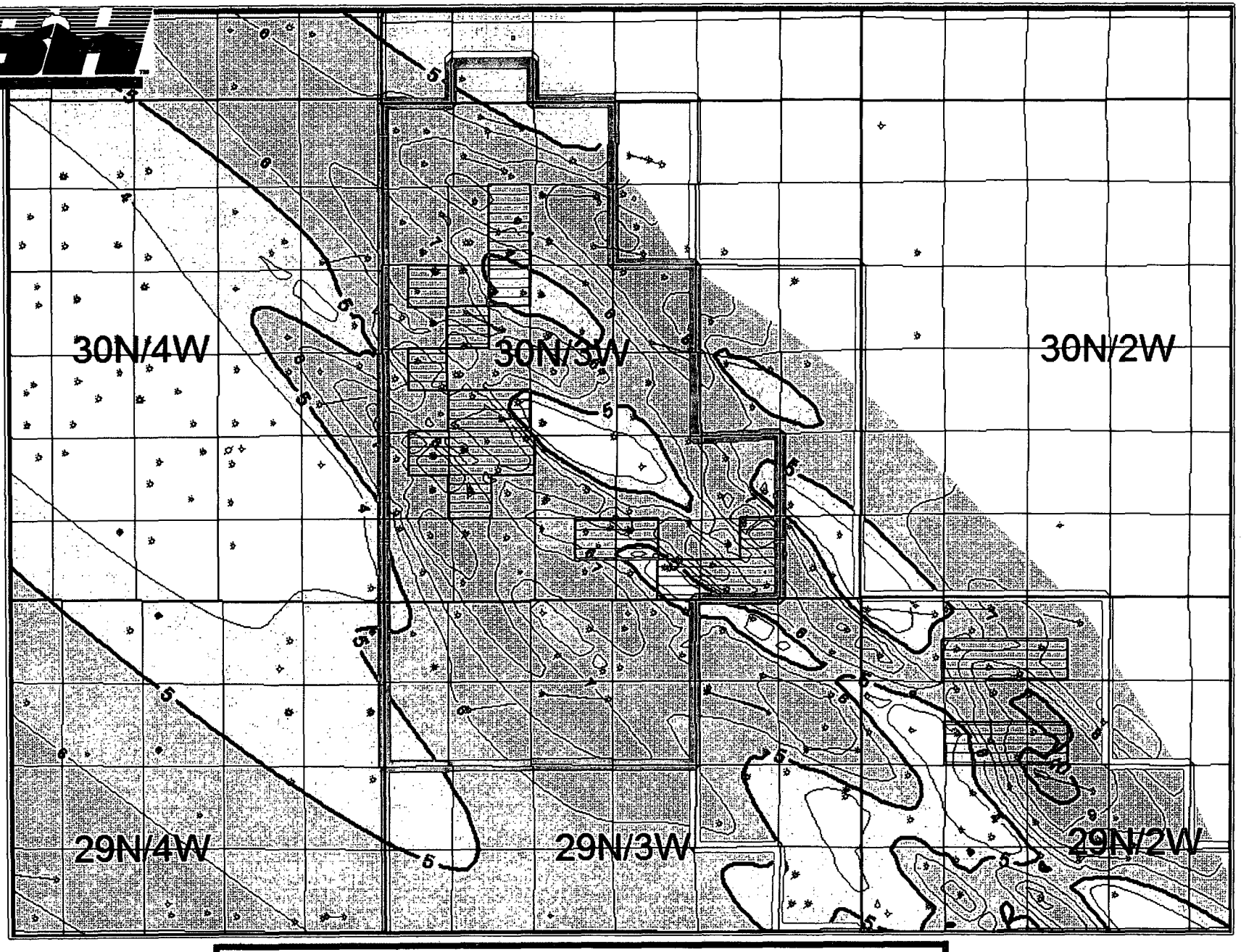

153x132
30N/4W
30N/3W
30N/2W
Increased Density Pilot Areas
29N/4W
29N/3W
29N/2W



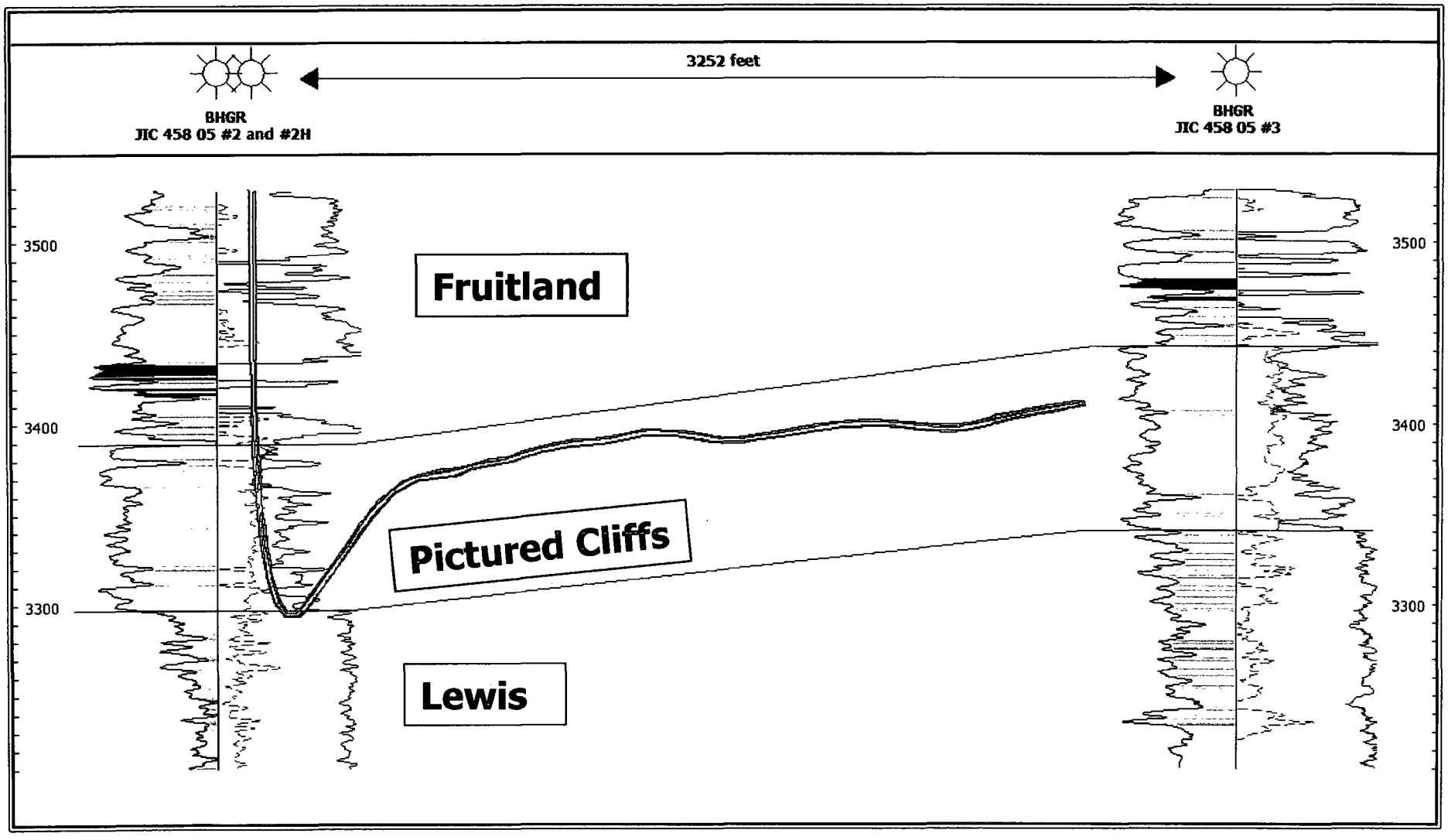
Pictured Cliffs NS Stratigraphic Cross Section



Pictured Cliffs Net Sand

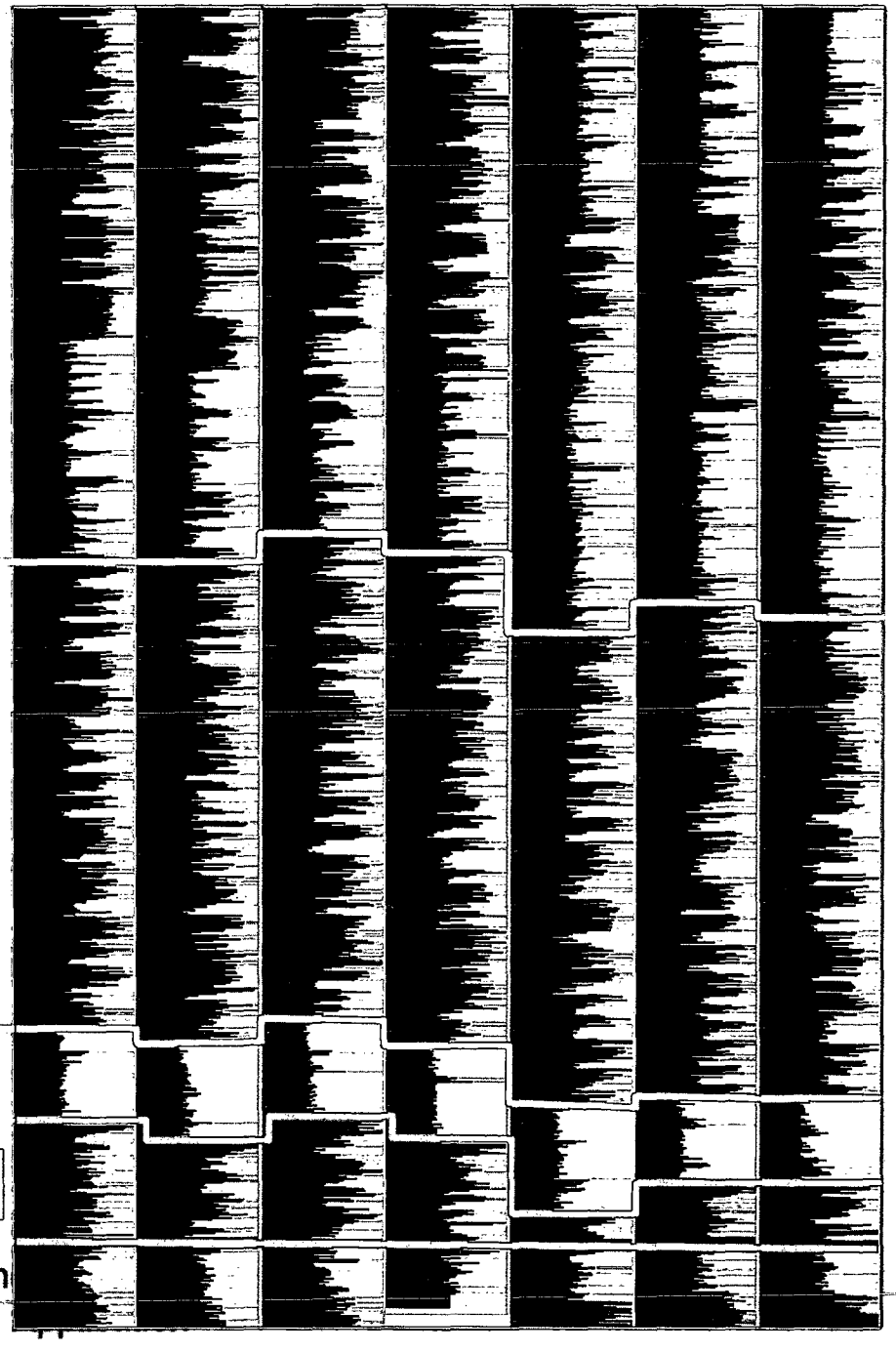


Pictured Cliffs Hydrocarbon Pore Height



Pictured Cliffs Updip Horizontal Well

Application



San Jose

Nacimiento

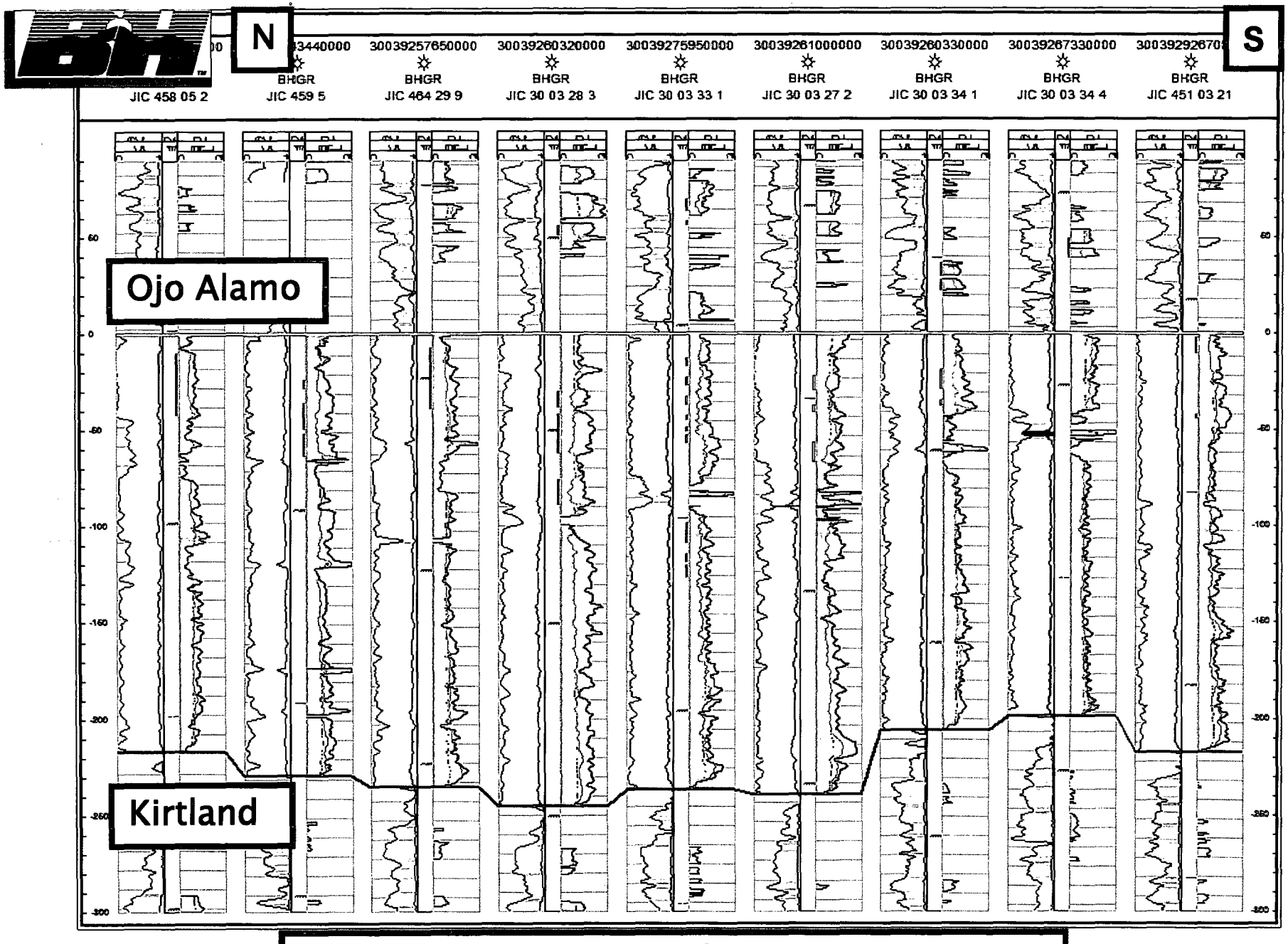
T

Ojo Alamo

K

Kirtland / Fruitland

Pictured Cliffs



Ojo Alamo NS Stratigraphic Cross Section

Overview – Reservoir Engineering Pictured Cliffs (PC)

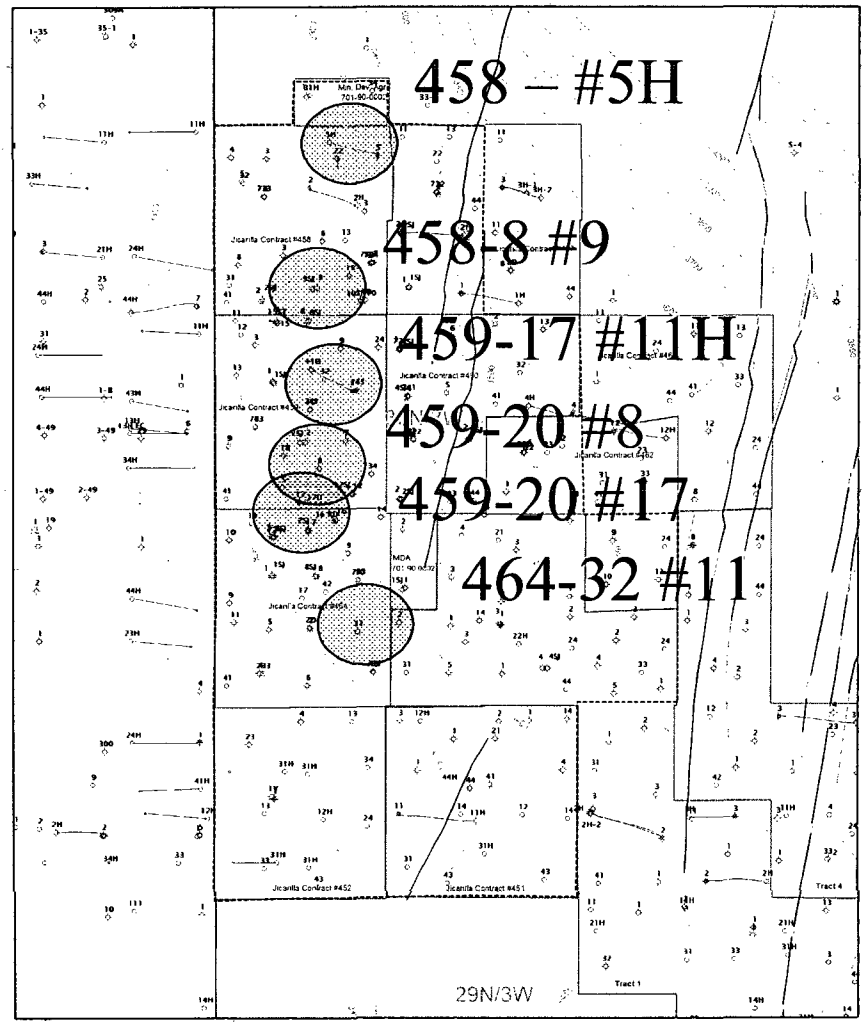
- Recommendation
- RTA analysis
- Idealized recovery
- EUR vs. OGIP
- Recovery Efficiency vs. OGIP

Recommendation – (PC)

Increased well density in the PC project area is technically justified

- **Two vertical wells per 160-acre drainage unit, or**
- **Two horizontal wells per 320-acre drainage unit.**

RTA Analysis -



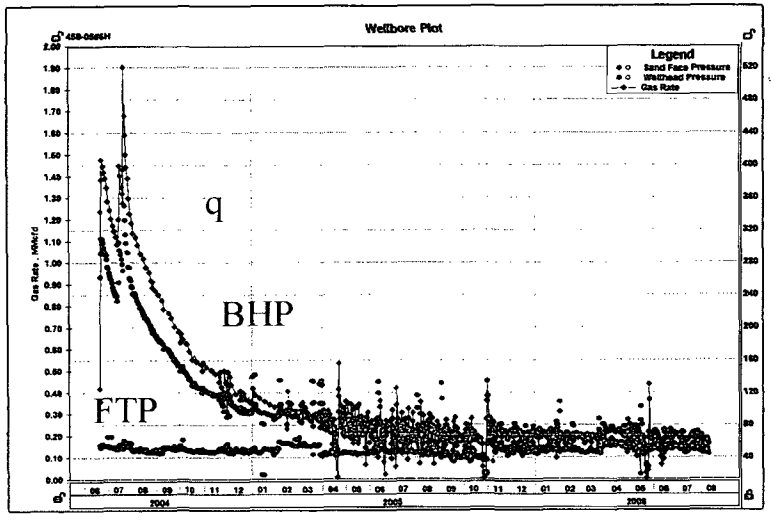
East Blanco Increased Density Application

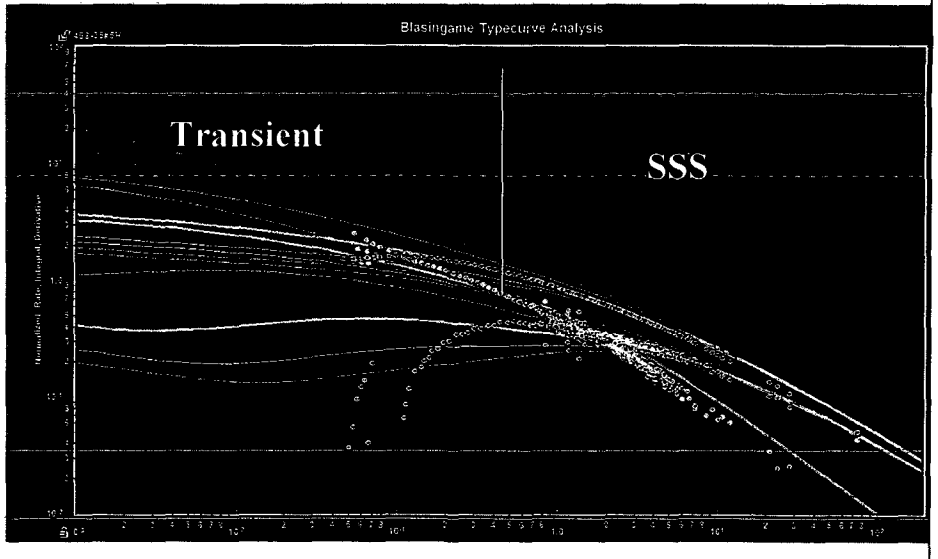
RTA Analysis

Assumptions/Requirements

- Hurst Van Everdingen (H-VE) idealized reservoir
- Measured or calculated sand-face pressures and rates
- Radial, fractured or horizontal well
- Well petrophysics and fluid properties
- Well diagram
- Model computes normalized productivity (q/dp) and material balance time ($Q/(q\rho)$)
- Continuous well test without shutting the well in

RTA Technique





S

K, md

Xf, ft

OGIP

A

East Blanco Increased Density Application

RTA Results
PC

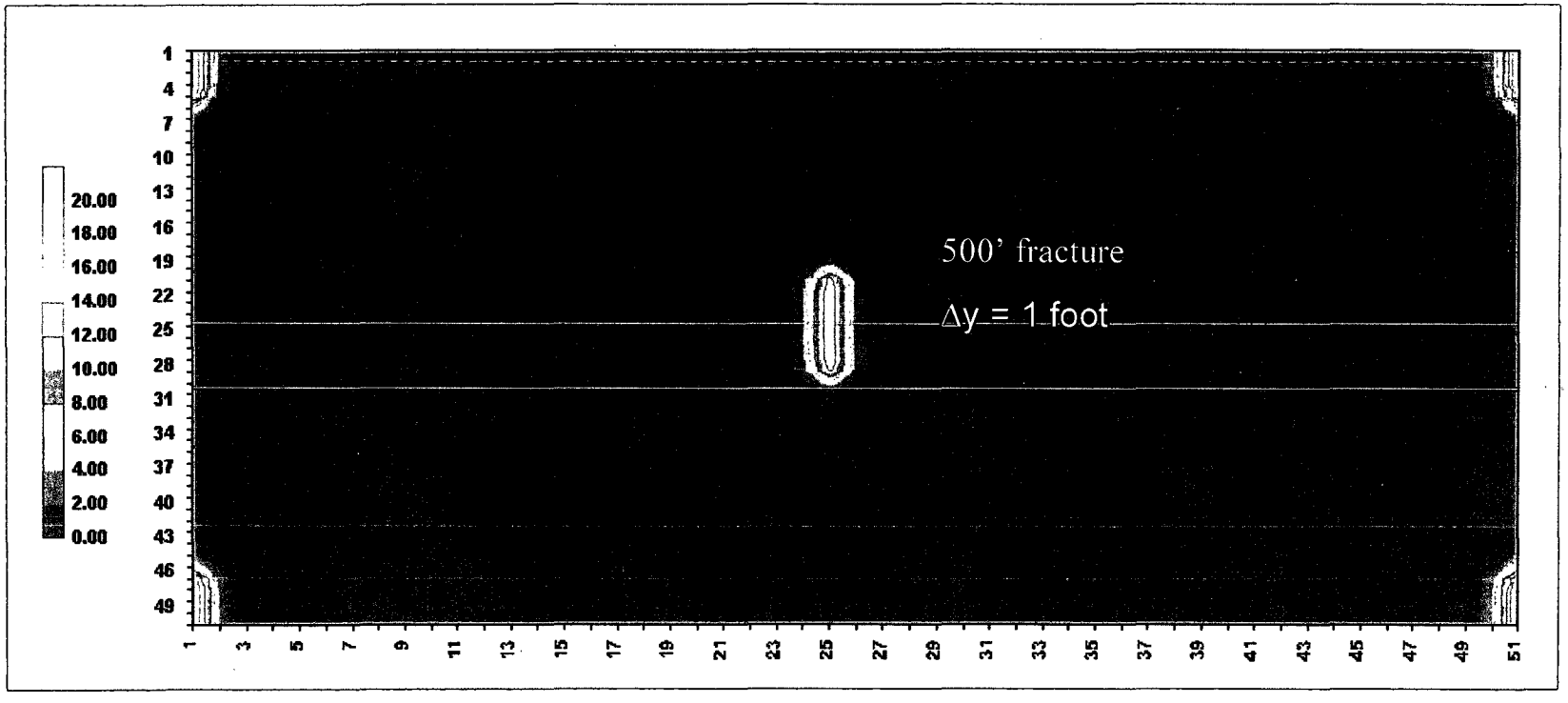
RTA Results Well	Picture Cliffs RTA Blasingame							NPI						FMB	Trad	Fetk
	h	Phi	k	Xf/2	Leff	A	OGIP	h	Phi	k	Xf/2	A	OGIP	OGIP	OGIP	OGIP
JIC 464-32#11	64	0.114	0.283	<10		47	707	64	0.114	0.09	80	45	630	740	650	587
JIC 459-20#8	57.5	0.115	0.09	653		123	618	57.5	0.115	0.08	630	115	1520	2508	1727	na
JIC 459-20#17	55	0.115	0.05	82		47	597	55	0.115	0.01	388	44	380	650	803	476
JIC 459-17#11H	57	0.123	0.012		1800	42	640	57	0.123	0.04	382	42	640	850	880	1186
JIC 458-8#9	50	0.113	0.03	<10		19	233	50	0.113	0.016	20	12	100	452	540	116
JIC 458-5#5H	46	0.113	0.006		3000	42	516	46	0.113	0.029	760	42	460	575	520	650

Idealized Recovery Factors

- H-VE Reservoir
- 160-acre well spacing
- Average PC properties
- 51 x 50 x 1 3-d model
- Single phase reservoir
- Fractured well (in grids)

PC2		
Parameter	Units	Value
h	ft	55
phi	dim	0.115
kx	md	0.061
ky	md	0.061
Swc	dim	0.5
Pinit	psia	1150
Tres	ft	120
Rhog	dmi	0.66
z	dim	0.88
OGIP	MMcf	1755
Xf/2	ft	250
Kf	md	21

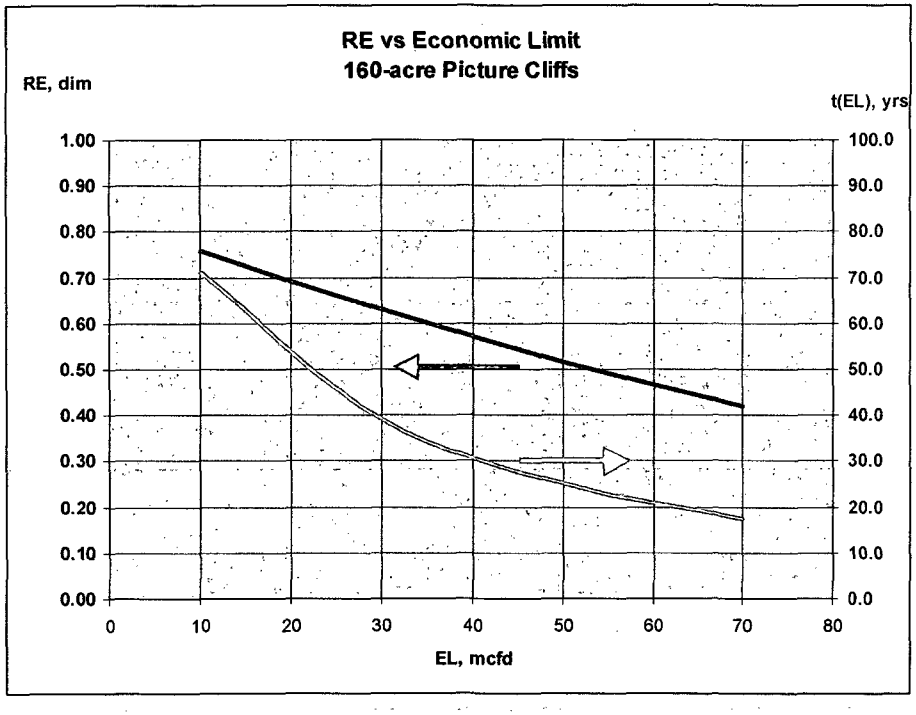
Grid Permeability



East Blanco Increased Density Application

Ideal PC Recovery Efficiency Results

- RE very sensitive to EL
- RE not as sensitive to k
- Time to EL is excessive
- Ideal model results in higher RE than actually observed in practice
- Even simple reservoir heterogeneity can impact RE
- Ideal RE is .76 at 10 EL

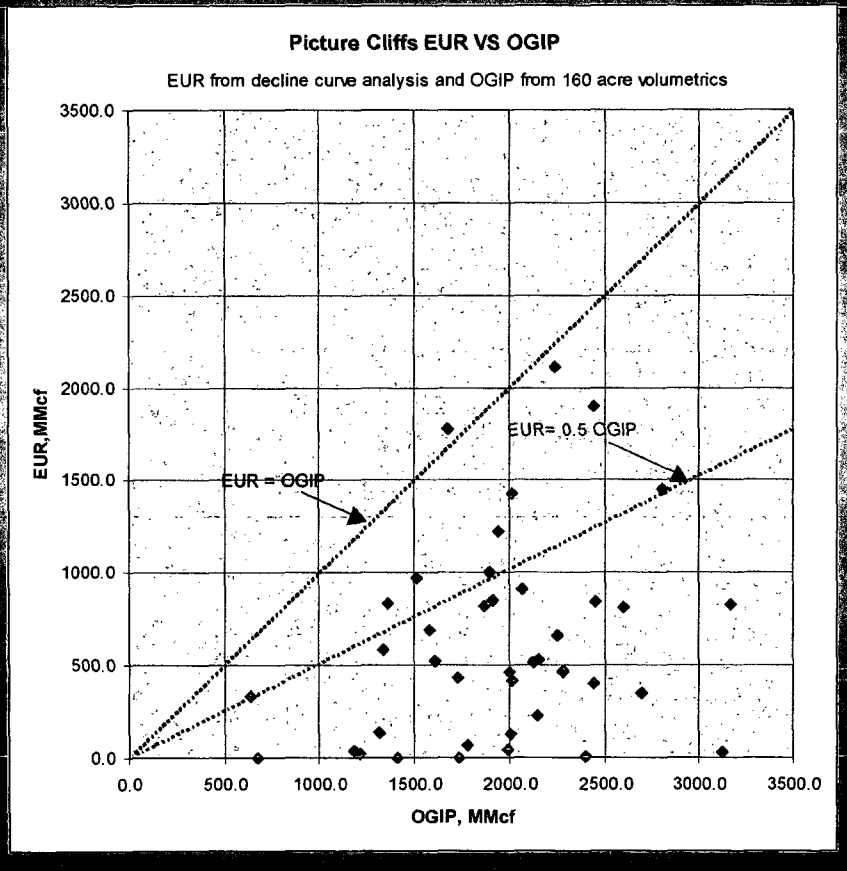


PC single zone statistics
Project area only

	EUR	OGIP	RE
N	41	41	41
max	2107	3171	1.060
min	0	633	0.000
average	617	1953	0.316
geomean	246	1859	0.132
median	490	1998	0.247

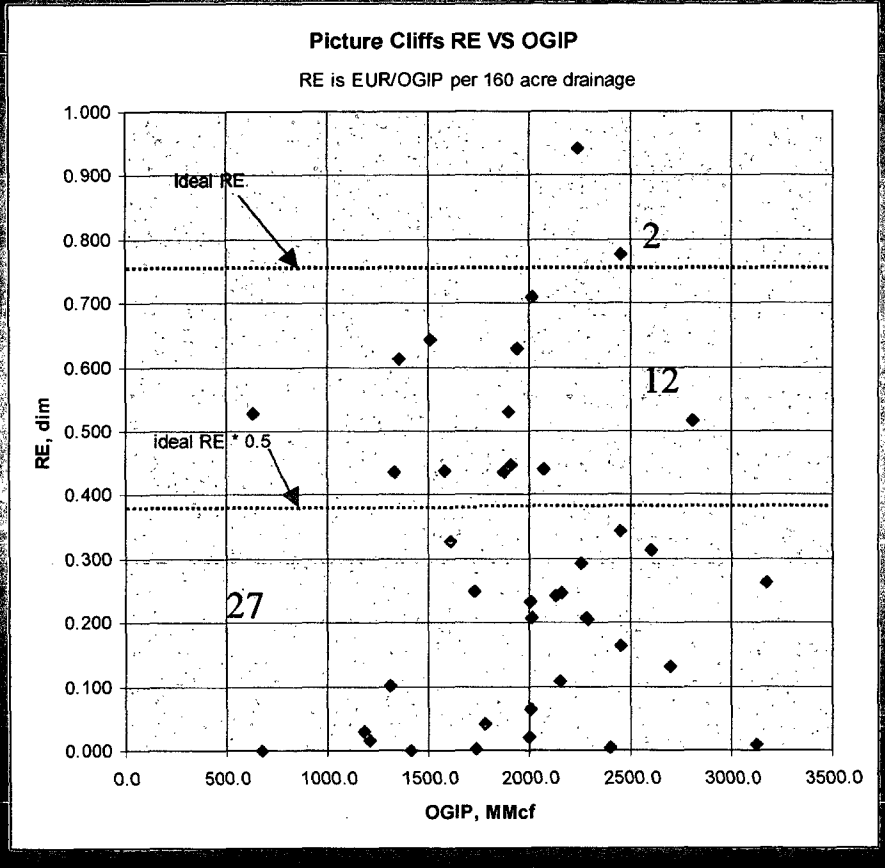
OGIP is volume in 160-acre drainage

PC EUR vs. OGIP



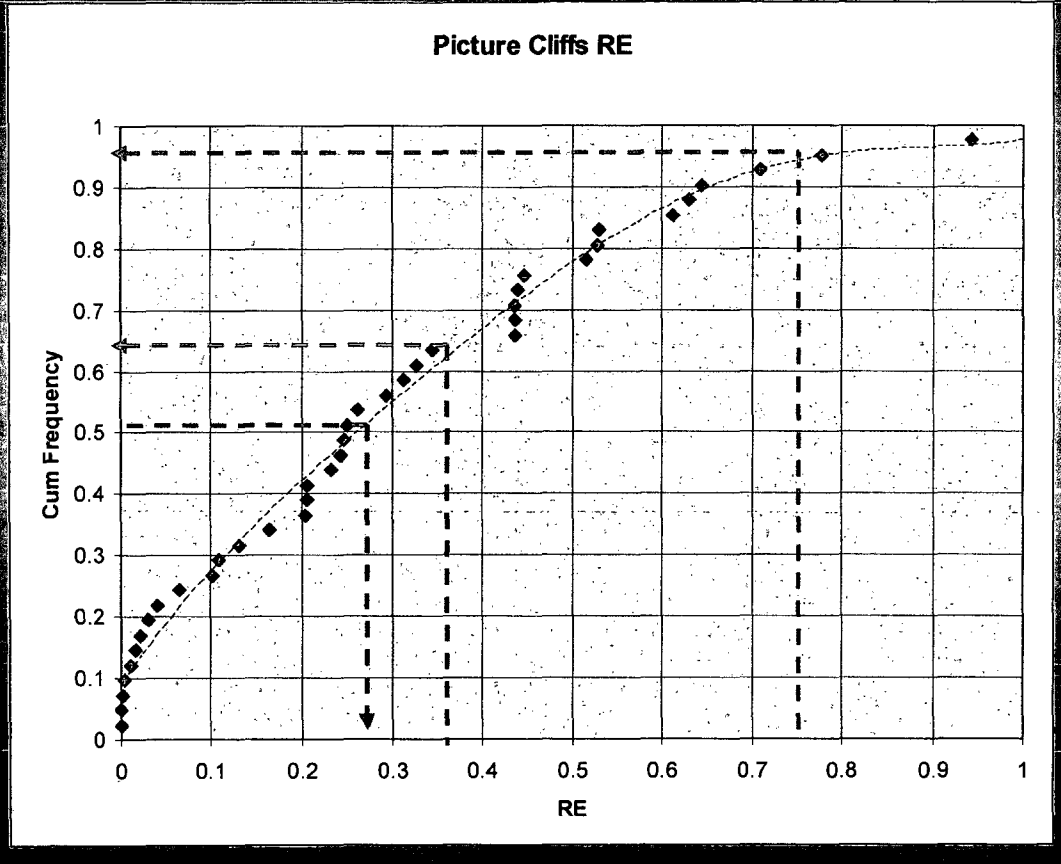
East Blanco Increased Density Application

PC RE vs. OGIP



East Blanco Increased Density Application

Cum Frequency Plot for RE



East Blanco Increased Density Application

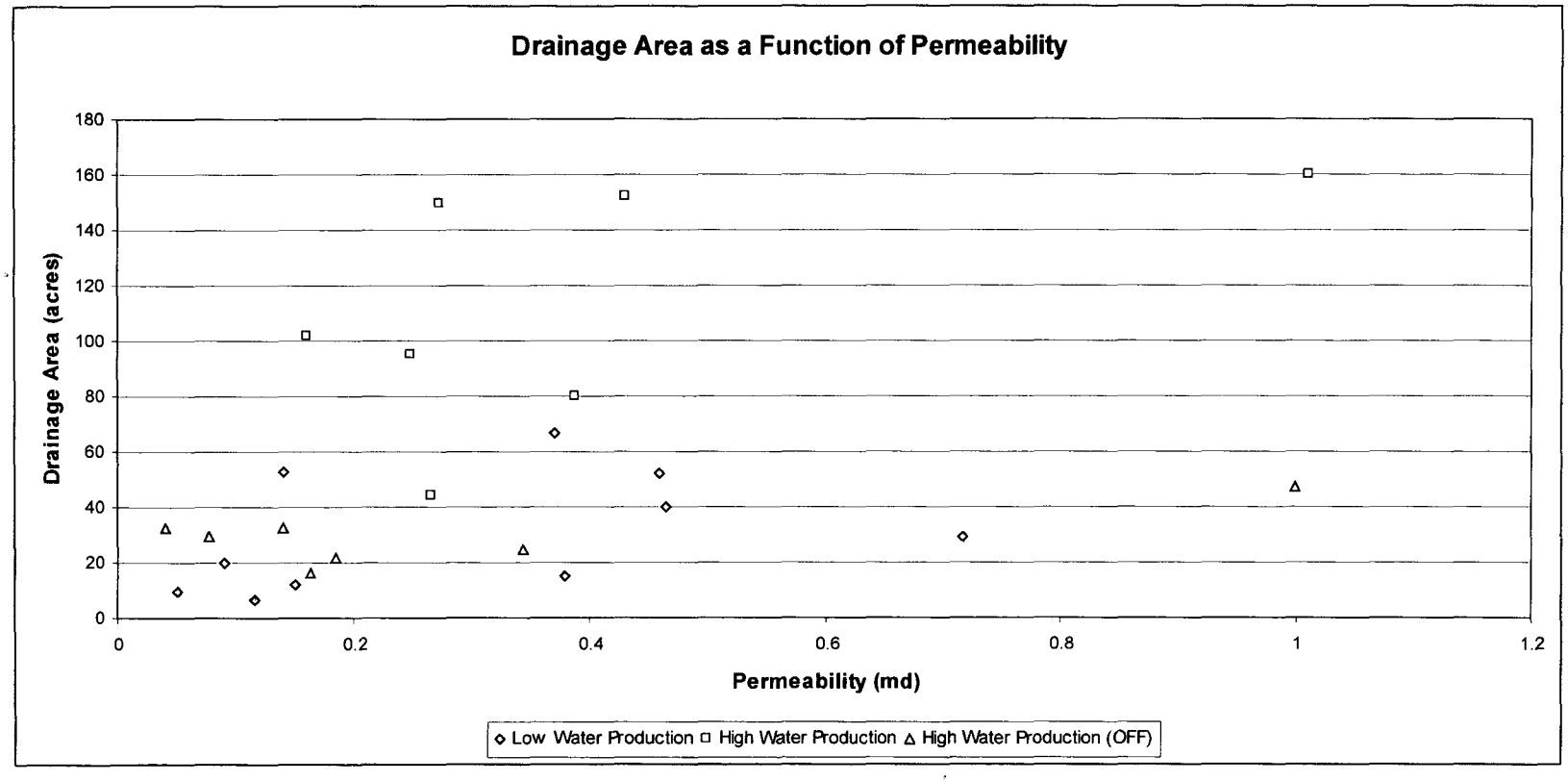
Pictured Cliffs Engineering Conclusions

- 80-acre well density is recommended in the project area to improve recovery
- RTA analysis indicates most wells are draining less than 80 acres
- Idealized model indicates high recovery within drainage volume
- Complex reservoir behavior (layers, anisotropy and limited continuity)
- Statistics on existing PC only completions supports recommendation
  - Half of the wells drain less than 30 acres
  - 65 % have less than idealized 80-acre RE
  - 5 % of wells have exceeded idealized 160-acre RE
- Additional tests (RFT and logs) are necessary to optimize PC recovery
- Additional experience with horizontal wells required to optimize design and reduce cost

Tertiary Expansion of Project Area

- Geology is complex
- Additional Engineering data required for proper evaluation.
- Data collected and analyzed to date indicates increased well density will result in incremental production.
- Tertiary zones will be penetrated as we drill to PC.

Tertiary RPI evaluation



East Blanco Increased Density Application