

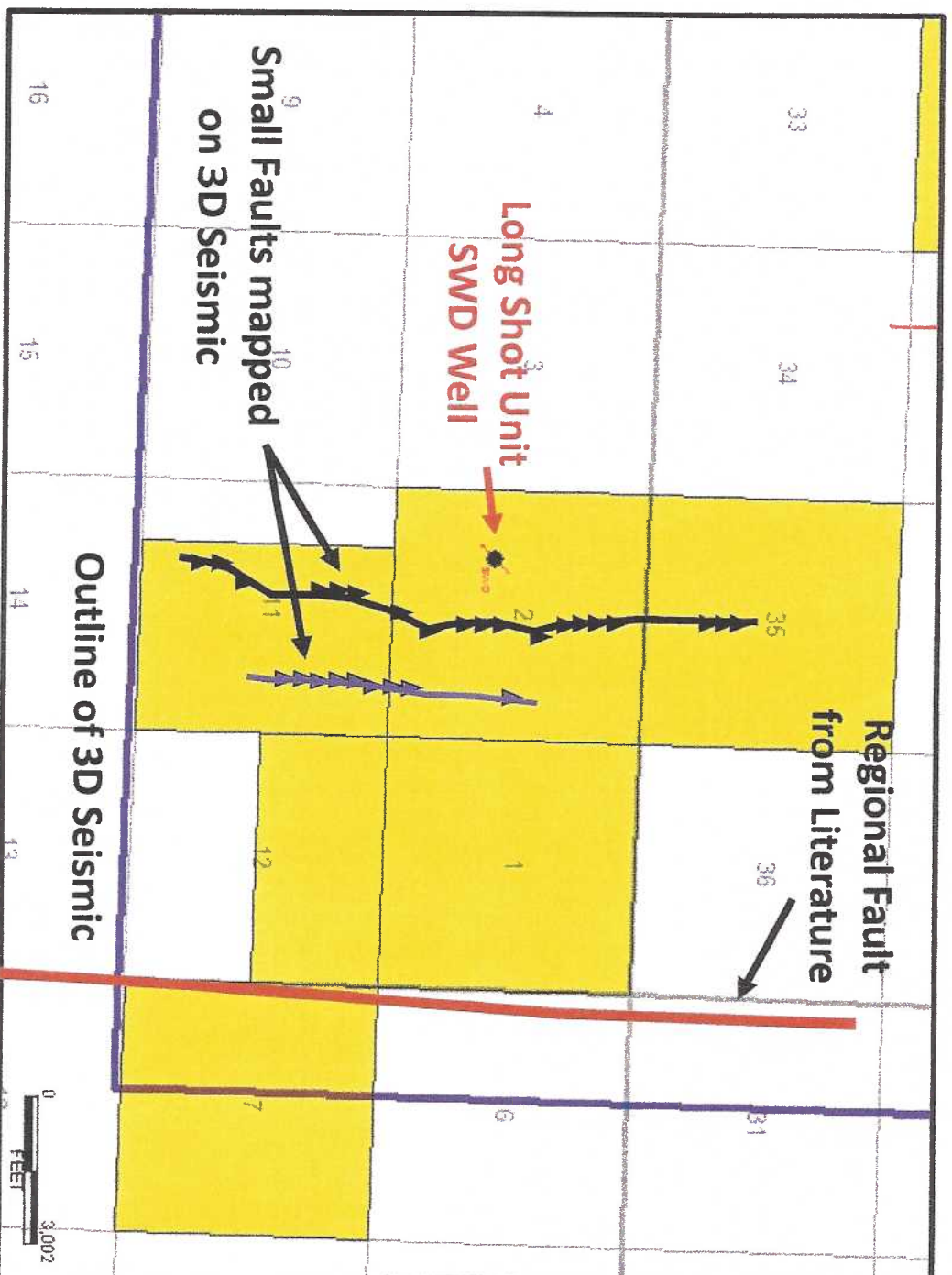
ADVANCE ENERGY PARTNERS HAT MESA, LLC
LONG SHOT UNIT SWD #1
SEC. 2, T22S, R33E
LEA COUNTY, NEW MEXICO

Single Well FSP Analysis

30

LONG SHOT SWD #1 LOCATION (SEC. 2, T22S, R33E, LEA CO., N.M.)

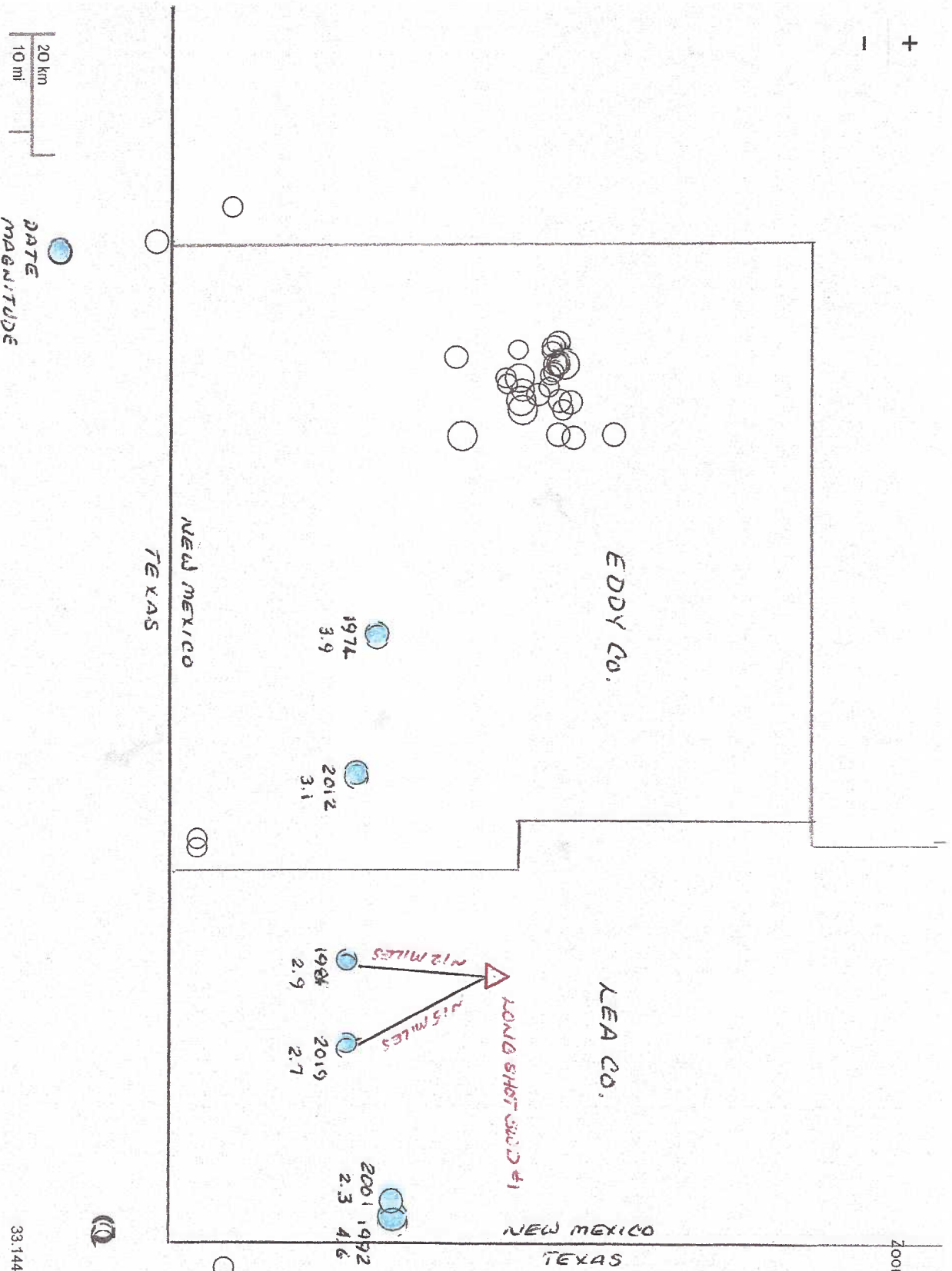
Long Shot Well Fault Map





Zoom to...

+
|



USGS DATABASE EARTHQUAKE EPICENTERS RELATIVE TO LONG SHOT SWDD
(1900-2020)

Fault Slip Potential

Fault Selector:

- All Faults
- Fault #1
- Fault #2
- Fault #3
- Fault #4
- Fault #5
- Fault #6
- Fault #7
- Fault #8
- Fault #9
- Fault #10
- Fault #11
- Fault #12
- Fault #13
- Fault #14

Calculate

MODEL INPUTS

GEOMECHANICS

PROB. GEOMECH

HYDROLOGY

PROB. HYDRO

INTEGRATED

Stress Data

- ☒ Specify All Three Stress Gradients [psi/ft]
- ☐ Use A-Phi Model

Vertical Stress Gradient [psi/ft]

1.1

Max Horiz. Stress Gradient [psi/ft]

1.22

Min Horiz. Stress Gradient [psi/ft]

0.693

Max Hor Stress Direction [deg N CW]

71

Initial Res. Pressure Gradient [psi/ft]

0.43

Reference Depth for Calculations [ft]

17000

OK

All

2035 2040 2045
years]

Fault Slip Potential

Fault Selector:

- All Faults
- Fault #1
- Fault #2
- Fault #3
- Fault #4
- Fault #5
- Fault #6
- Fault #7
- Fault #8
- Fault #9
- Fault #10
- Fault #11
- Fault #12
- Fault #13
- Fault #14

Calculate

MODEL INPUTS

GEOMECHANICS

PROB. GEOMECH

HYDROLOGY

PROB. HYDRO

INTEGRATED

Hydrology Data

☒ Enter Hydrologic Parameters

☐ Load External Hydrologic Model

Aquifer Thickness [m]

Porosity [%]

Permeability [mD]

400

8

65

OK

y northing [km]

8
6
4
2
0
-2
-4
-6
-8

25 2030 2035 2040 2045
Time [Years]

Fault Slip Potential

Injection Wells

Fault Selector:

- All Faults
- Fault #1
- Fault #2
- Fault #3
- Fault #4
- Fault #5
- Fault #6
- Fault #7
- Fault #8
- Fault #9
- Fault #10
- Fault #11
- Fault #12
- Fault #13
- Fault #14

Enter Wells Manually

Load Wells Complete .csv

Number of wells:

1

x [km]

y [km]

Inj. Rate [bbl/day]

Start Year [yr]

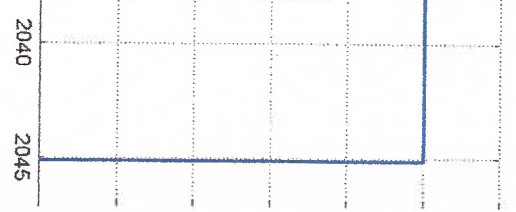
End Year [yr]

1	0	0	25000	2020	2045
2					
3					
4					
5					
6					
7					
8					

Calculate

OK

INTEGRATED



Fault Slip Potential

Fault Selector:

- All Faults
- Fault #1
- Fault #2
- Fault #3
- Fault #4
- Fault #5
- Fault #6
- Fault #7
- Fault #8
- Fault #9
- Fault #10
- Fault #11
- Fault #12
- Fault #13
- Fault #14

Calculate

MODEL INPUTS

GEOMECHANICS

PROB. GEOMECH

HYDROLOGY

PROB. HYDRO

INTEGRATED

Fault Data

Number of faults (max 500)

14

Friction Coefficient mu

0.58

☐ Random Faults

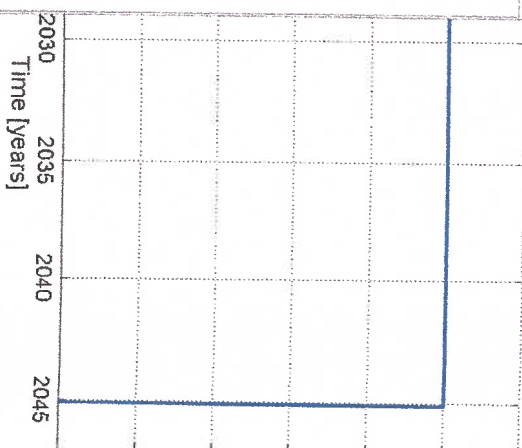
☒ Enter Faults

	X [East km]	Y [North km]	Strike [Deg]	Dip [Deg]	Length [km]
1	-0.0200	-1.7600	15	88	0.3000
2	0.0460	-1.4900	20	88	0.3000
3	0.1000	-1	0	88	0.7000
4	0.1500	-0.4800	20	88	0.4100
5	0.2200	-0.0500	363	88	0.5000
6	0.2500	0.2000	20	88	0.2000
7	0.3000	0.5800	0	88	0.6700
8	0.3000	1.2200	0	88	0.6700
9	0.8250	-1.2000	0	88	0.4100
10	0.8500	-0.7000	5	88	0.5800
11	0.9000	-0.3000	3	88	0.3000
12	0.9500	0.0500	10	88	0.4100
13	2.9000	-1.2000	5	88	2.9000
14	3	1.1000	0	88	2.2000

Load File

Help

OK



Fault Segment Locations and Orientations
Relative to Long Shot SWD #1

Fault Slip Potential

Fault Selector:

- All Faults
- Fault #1
- Fault #2
- Fault #3
- Fault #4
- Fault #5
- Fault #6
- Fault #7
- Fault #8
- Fault #9
- Fault #10
- Fault #11
- Fault #12
- Fault #13
- Fault #14

Calculate

MODEL INPUTS

GEOMECHANICS

PROB. GEOMECH

HYDROLOGY

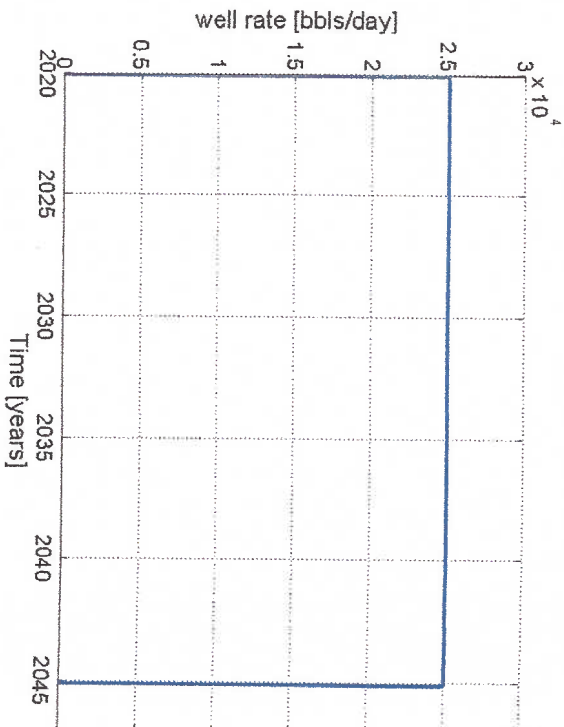
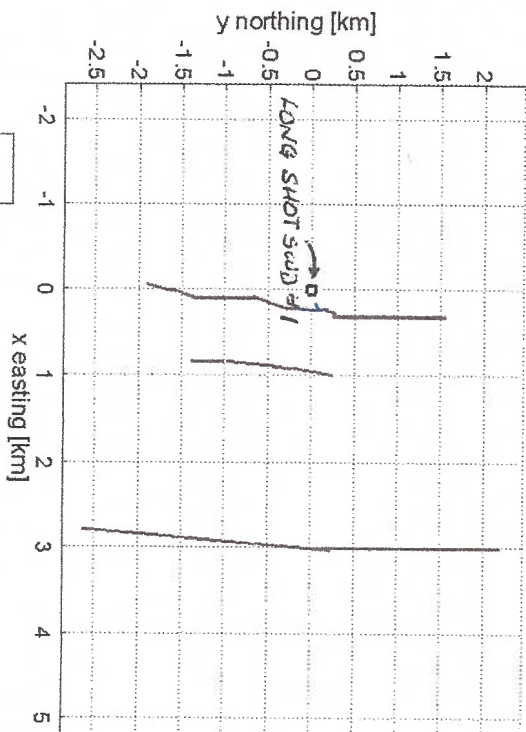
PROB. HYDRO

INTEGRATED

Stress Regime: Strike-Slip Faulting

Select Well:

All



Fault Slip Potential

Fault Selector:

- All Faults
- Fault #1
- Fault #2
- Fault #3
- Fault #4
- Fault #5
- Fault #6
- Fault #7
- Fault #8
- Fault #9
- Fault #10
- Fault #11
- Fault #12
- Fault #13
- Fault #14

Calculate

MODEL INPUTS

GEOMECHANICS

PROB. GEOMECH

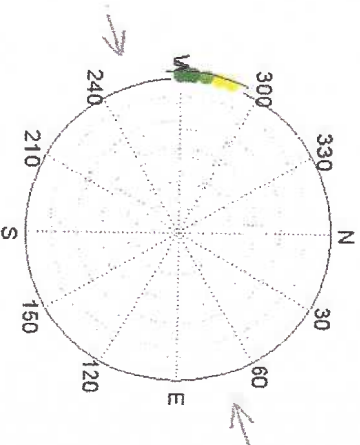
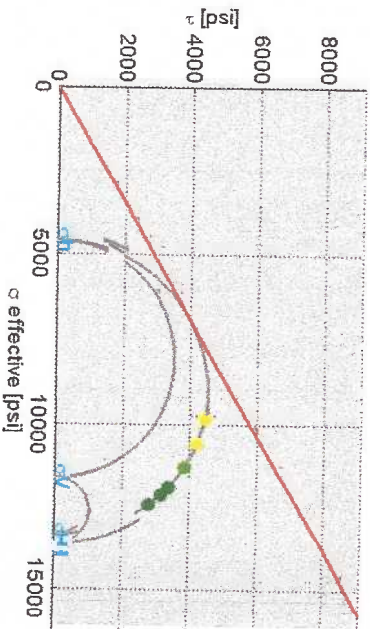
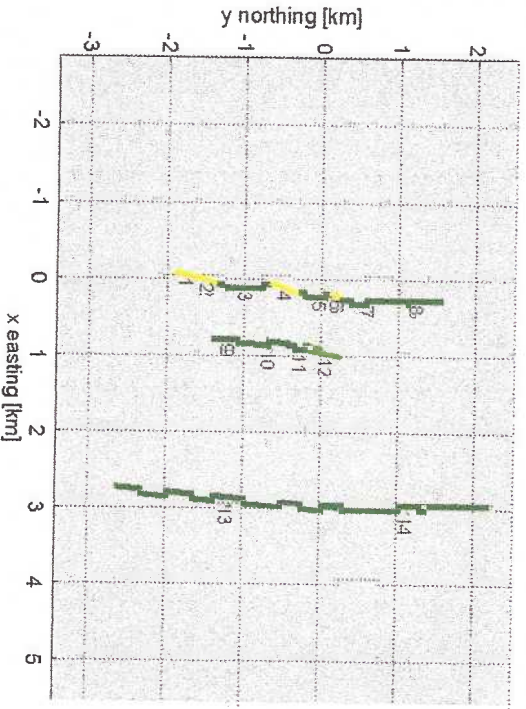
HYDROLOGY

PROB. HYDRO

INTEGRATED

a) Fault Number

Help



FAULT SEGMENTS

Fault Slip Potential

Fault Selector:

- All Faults
- Fault #1
- Fault #2
- Fault #3
- Fault #4
- Fault #5
- Fault #6
- Fault #7
- Fault #8
- Fault #9
- Fault #10
- Fault #11
- Fault #12
- Fault #13
- Fault #14

Calculate

MODEL INPUTS

GEOMECHANICS

PROB. GEOMECH

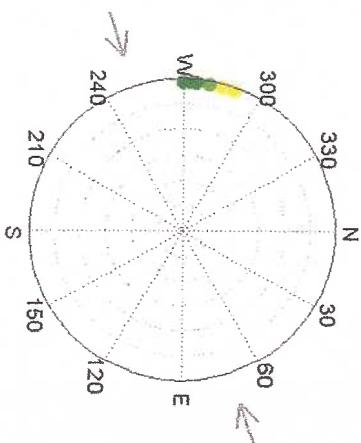
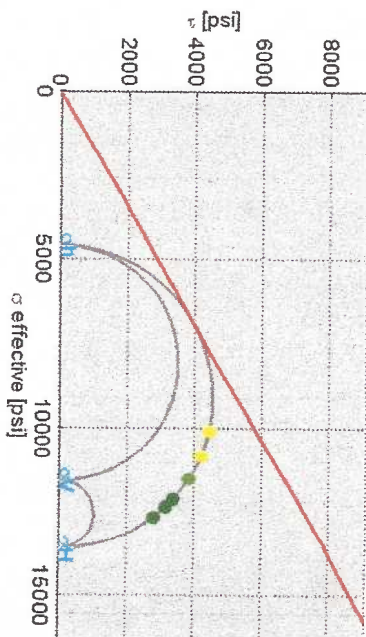
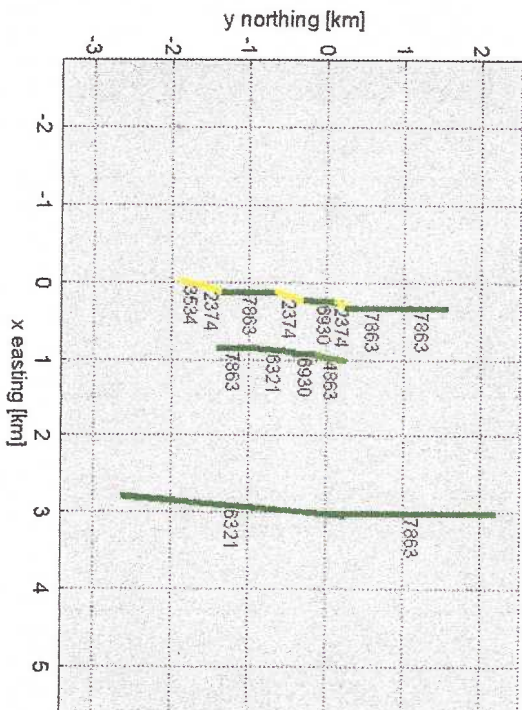
HYDROLOGY

PROB. HYDRO

INTEGRATED

d) PPF: Pore Pressure to Slip

Help



Stereonet Show:

Fault Normals

CALCULATED PORE PRESSURE NEEDED TO GENERATE
FAULT SLIP AT MIDPOINTS OF FAULT SEGMENTS

Fault Slip Potential

Fault Selector:

- All Faults
- Fault #1
- Fault #2
- Fault #3
- Fault #4
- Fault #5
- Fault #6
- Fault #7
- Fault #8
- Fault #9
- Fault #10
- Fault #11
- Fault #12
- Fault #13
- Fault #14

Calculate

MODEL INPUTS

GEOMECHANICS

PROB. GEOMECH

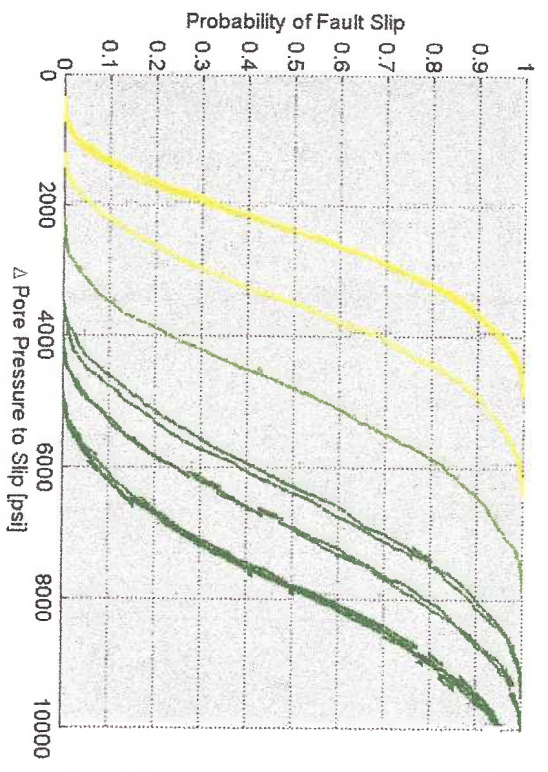
HYDROLOGY

PROB. HYDRO

INTEGRATED

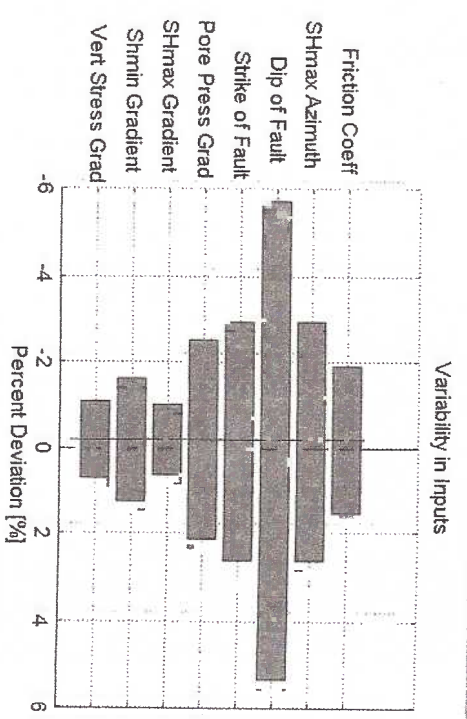
Load Distributions

Run Analysis

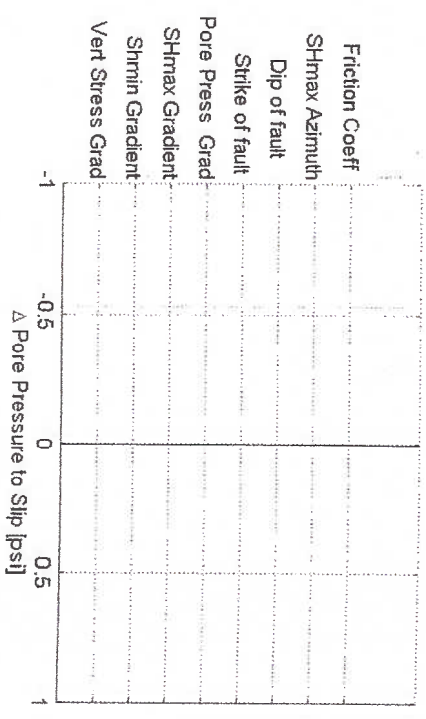


Export CDF data

Show Input Distributions



Choose a fault to see sensitivity analysis



FAULT SLIP PROBABILITY AS FUNCTION OF PORE PRESSURE INCREASE - ALL FAULT SEGMENTS

Fault Slip Potential

Fault Selector:

- All Faults
- Fault #1
- Fault #2
- Fault #3
- Fault #4
- Fault #5
- Fault #6
- Fault #7
- Fault #8
- Fault #9
- Fault #10
- Fault #11
- Fault #12
- Fault #13
- Fault #14

Calculate

MODEL INPUTS

GEOMECHANICS

PROB. GEOMECH

HYDROLOGY

PROB. HYDRO

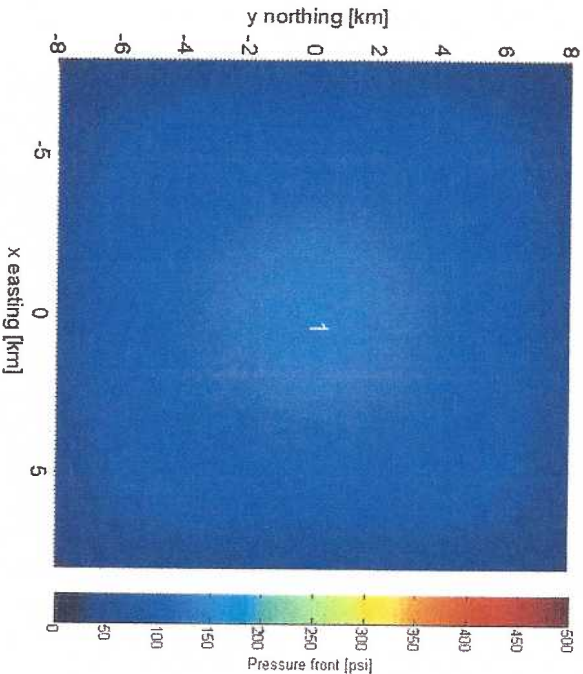
INTEGRATED

Max plot DP [psi]:

500

Select Well:

All

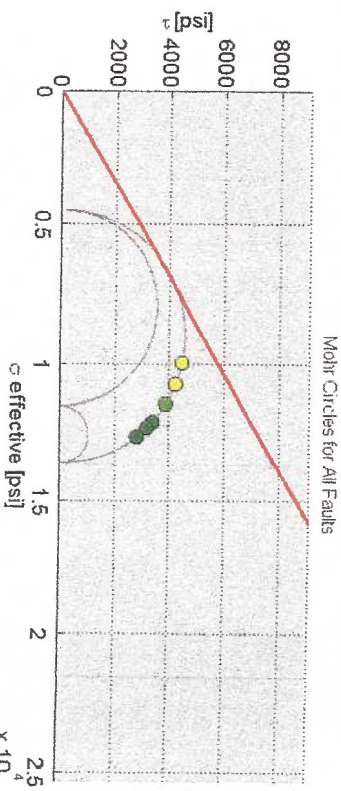
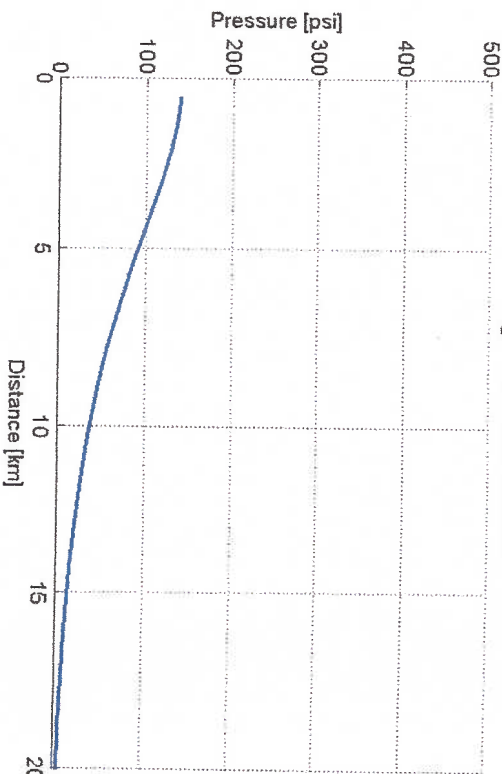


Export Hydrology

Year:

2047

Single Well Radial Solutions



GENERATED PRESSURE FRONT AFTER 25-YEAR DISPOSAL

Fault Slip Potential

Fault Selector:

Fault #1	0.000 FSP
Fault #2	0.000 FSP
Fault #3	0.000 FSP
Fault #4	0.000 FSP
Fault #5	0.000 FSP
Fault #6	0.000 FSP
Fault #7	0.000 FSP
Fault #8	0.000 FSP
Fault #9	0.000 FSP
Fault #10	0.000 FSP
Fault #11	0.000 FSP
Fault #12	0.000 FSP
Fault #13	0.000 FSP
Fault #14	0.000 FSP

Calculate

MODEL INPUTS

GEOMECHANICS

PROB. GEOMECH

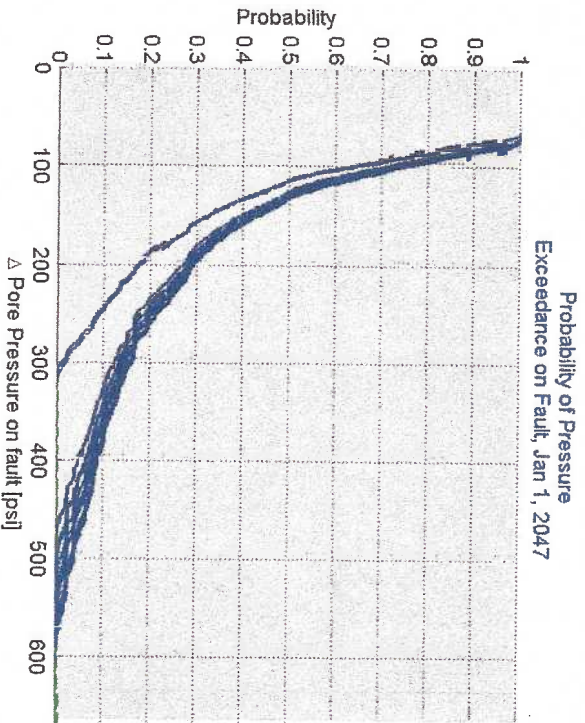
HYDROLOGY

PROB. HYDRO

INTEGRATED

Load Distributions

Run Analysis



Max Delta PP [psf]

666

Year:

2047

Export Blue Curves

Show Input Distributions

PROBABILITY OF PRESSURE EXCEEDANCE ON FAULT SEGMENTS IS SIGNIFICANTLY LESS THAN CONDITIONAL PROBABILITY OF SLIP

PROBABILITY OF PRESSURE EXCEEDANCE

Fault Slip Potential

Fault Selector:

All Faults

Fault #1	0.00 FSP
Fault #2	0.00 FSP
Fault #3	0.00 FSP
Fault #4	0.00 FSP
Fault #5	0.00 FSP
Fault #6	0.00 FSP
Fault #7	0.00 FSP
Fault #8	0.00 FSP
Fault #9	0.00 FSP
Fault #10	0.00 FSP
Fault #11	0.00 FSP
Fault #12	0.00 FSP
Fault #13	0.00 FSP
Fault #14	0.00 FSP

Calculate

MODEL INPUTS

GEOMECHANICS

PROB. GEOMECH

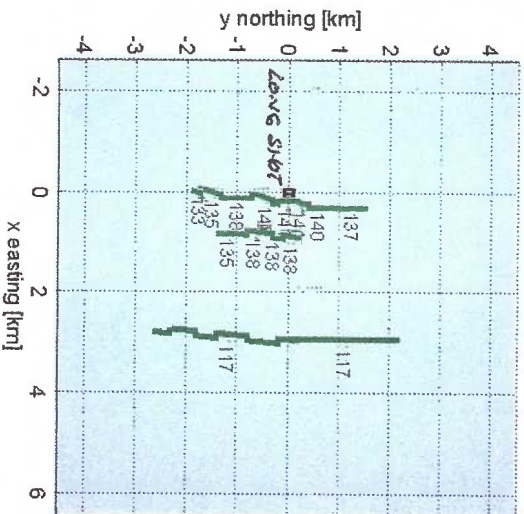
HYDROLOGY

PROB. HYDRO

INTEGRATE

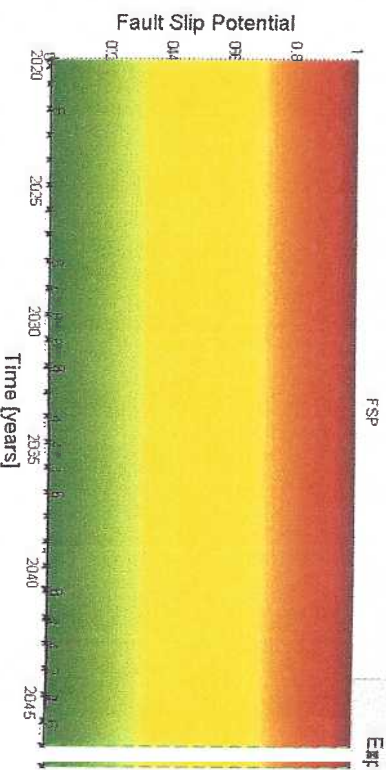
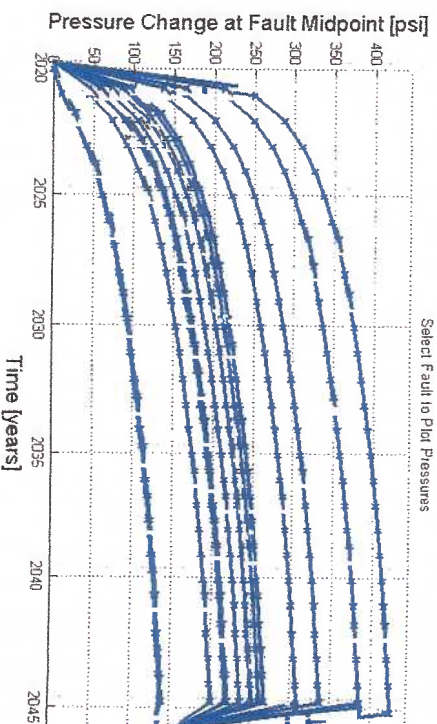
b) PP Change at Fault [psi]

Summary Plots



Year:

2047



PORE PRESSURE INCREASE AT FAULT SEGMENT MIDPOINTS
 OVER MODELLED 25-YEAR WELL LIFE FOR LONG SHOT SUB #1

Fault Slip Potential

Fault Selector:

All Faults		
Fault #1	0.00	FSP
Fault #2	0.00	FSP
Fault #3	0.00	FSP
Fault #4	0.00	FSP
Fault #5	0.00	FSP
Fault #6	0.00	FSP
Fault #7	0.00	FSP
Fault #8	0.00	FSP
Fault #9	0.00	FSP
Fault #10	0.00	FSP
Fault #11	0.00	FSP
Fault #12	0.00	FSP
Fault #13	0.00	FSP
Fault #14	0.00	FSP

Calculate

MODEL INPUTS

GEOMECHANICS

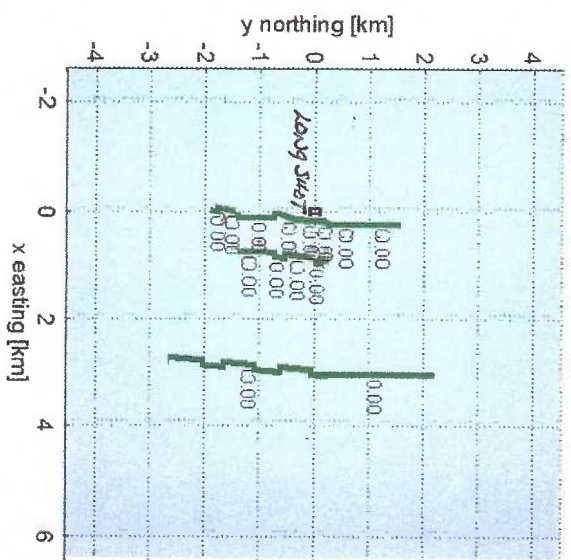
PROB. GEOMECH

HYDROLOGY

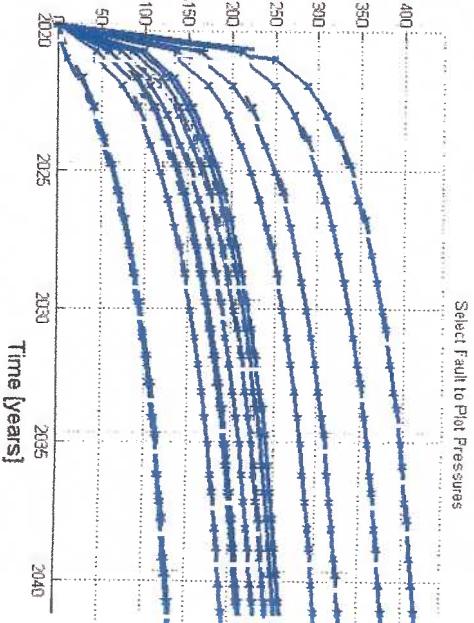
PROB. HYDRO

c) Fault Slip Potential

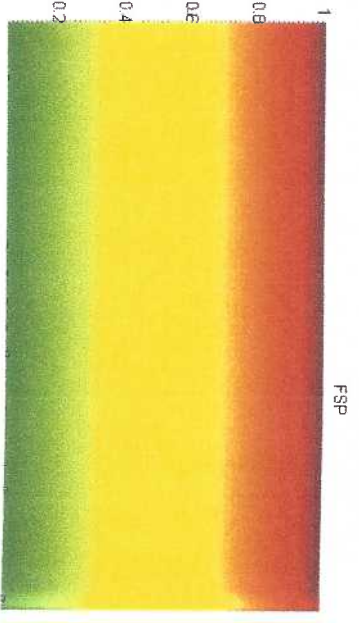
Summary Plots



Pressure Change at Fault Midpoint [psi]



Fault Slip Potential



INTEGRATED HYDROLOGICAL AND GEOMECHANICAL CALCULATION OF POTENTIAL FOR FAULT SLIP

SUMMARY

- Faults modelled for slip potential are two, 3D seismic identified, small, limited displacement faults and one larger industry recognized fault east of proposed location and beyond operator's seismic coverage. All faults modelled at 88° near vertical dip
- Matrix porosity derived from area offset well control in primary disposal zone. Permeability estimated from near offset formation character and comparison to area measured values
- Injection zone thickness and enclosing seals recognized from near offset well control
- Area maximum horizontal stress orientation identified from near offset microseismic studies

CONCLUSIONS

- Pore pressure increase to geomechanically create fault slip varies from 2374 psi to 7863 psi
- Calculated pore pressure increase over modelled 25-year period for Long Shot SWD #1 varies from 117 psi to 141 psi at fault segment midpoints
- Integrated hydrology and geomechanical analyses indicate **no potential for Long Shot SWD #1 to induce fault slip**
- Two seismic events >2.0 in area. Magnitude 2.7 event located approximately 15 miles southeast of Long Shot location, and 2.9 magnitude event approximately 12 miles south-southwest of location

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