Department of Petroleum Engineering

WELL RISK ANALYSIS FOR THE SAN JUAN BASIN CARBONSAFE PHASE III

by

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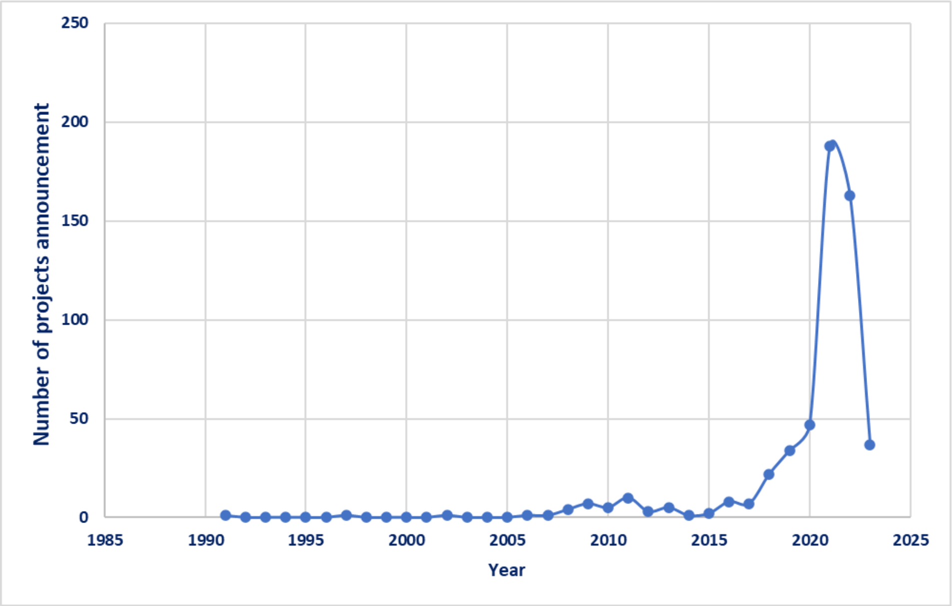
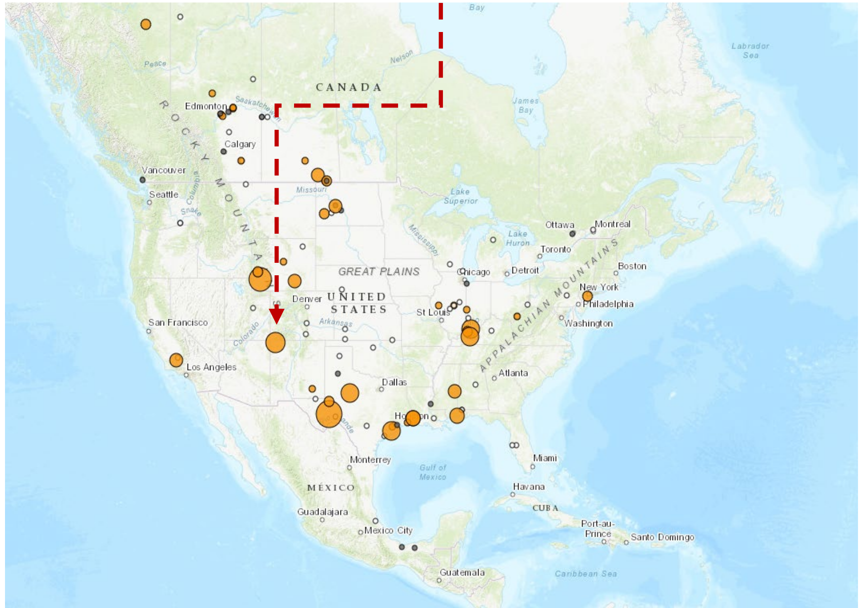
I. INTRODUCTION

Currently, the long-term Carbon Capture Utilization and Storage (CCUS) has received a lot of attention.



International Energy Agency (IEA) 2023, CCUS Projects Database, IEA, Paris, http://www.iea.org/data-and-statistics/data-product/ccus-projects-database

CO_2 storage projects supported by the Department of Energy are underway across the country, San Juan Basin is one of the places for CO_2 storage project



http://sccs.org.uk/resources/global-ccs-map

§146.84 Area of review and corrective action

"Owners or operators of Class VI wells must perform corrective action on all wells in the area of review that are determined to need corrective action"

Develop screening process to prioritize high risk wells

II. WELL RISK

§146.86 Injection well construction requirements.

"The owner or operator must ensure that all Class VI wells are constructed and completed to: (1) Prevent the movement of fluids into or between USDWs or into any unauthorized zones"

§ 146.88.a Injection well operating requirements.

"In no case may injection pressure initiate fractures in the confining zone(s) or cause the movement of injection or formation fluids that endangers a USDW"

§ 146.94 Emergency and remedial response.

"The Director may allow the operator to resume injection prior to remediation if the owner or operator demonstrates that the injection operation will not endanger USDWs."

Well will be considered high-risk whenever it has chances of leakage or fluid immigrating to USDWs or unauthorized zones.

III. RISK SCORE

- Applying Risk Assessment method to calculate Risk Score to choose high risk wells
- The Risk Score is the product of Severity Score (SS) and the Weighting Factor (WF)

Weighting Factor × **Severity Score** = **Risk Score**

Weighting Factor

- Range (1 – 5)
- 11 factors
- Reflect the impact of the factor on wellbore integrity

Severity Score

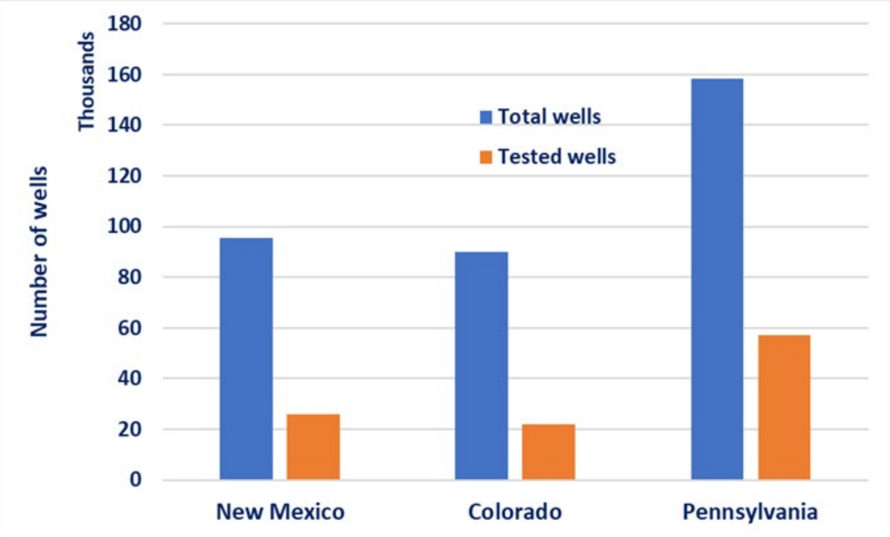
- Range (1 – 5)
- Reflect the severity of each category in each factor

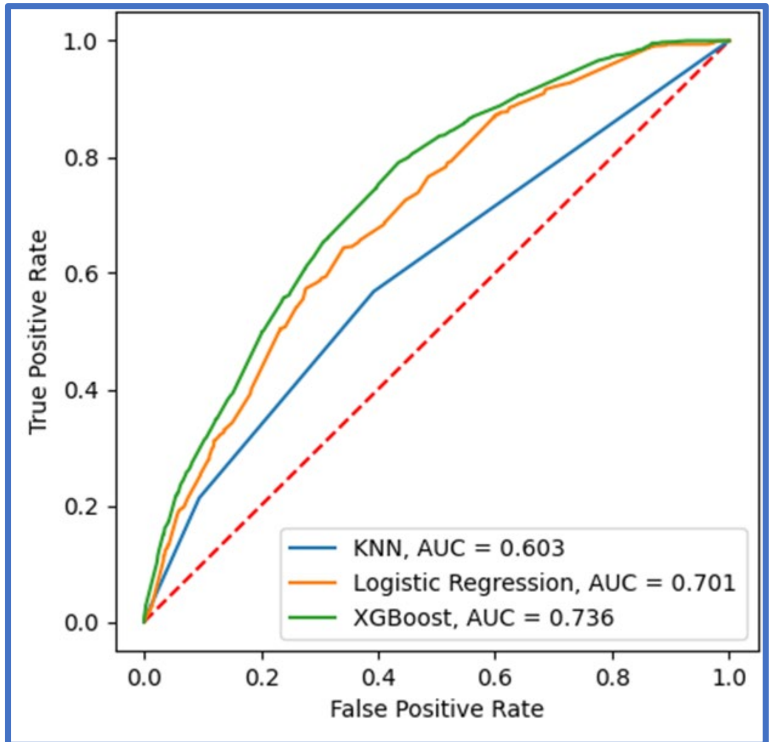
III.1. Data Processing

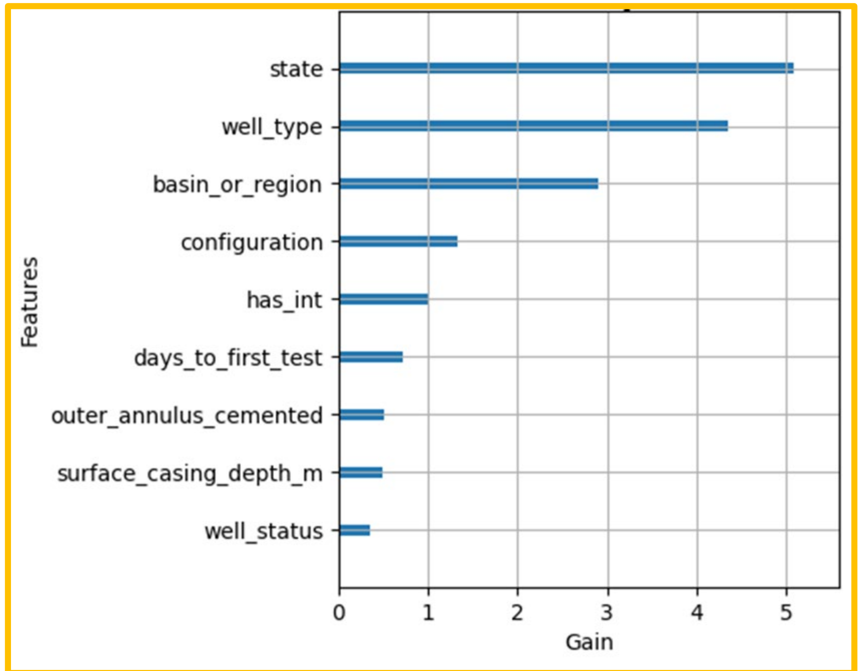
Based on testing records collected in 3 states from (Greg Lackey et al, 2021)

Using ROC-AUC to choose the best algorithm for the data set

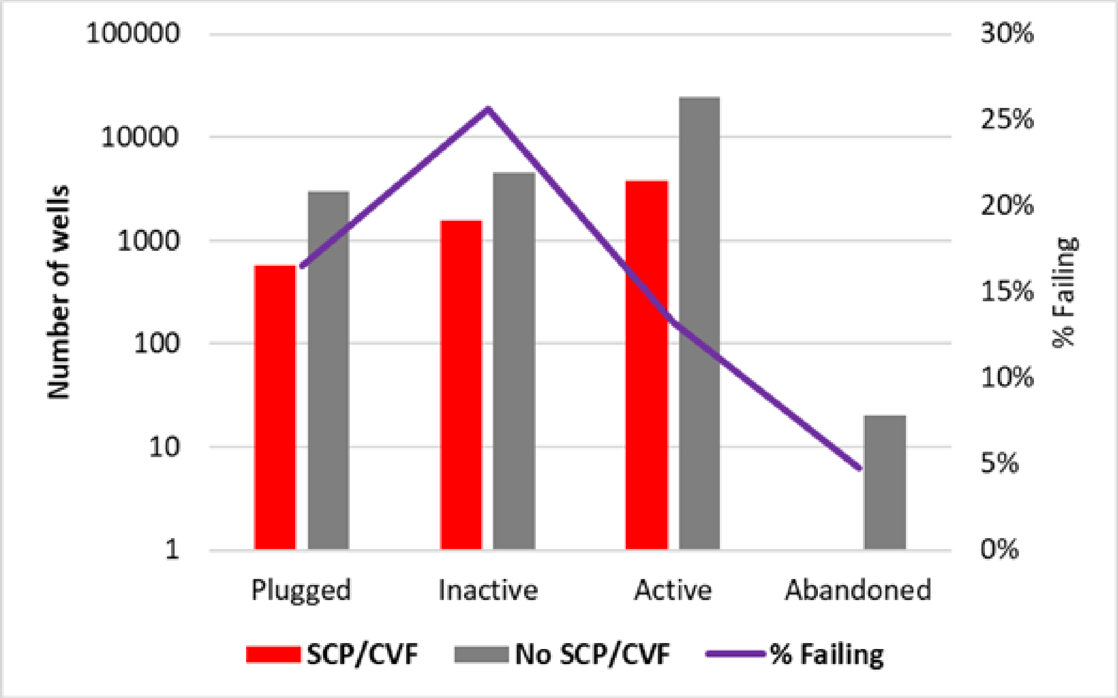
Apply feature importance for evaluating the effect of each factor on SCP and CVF



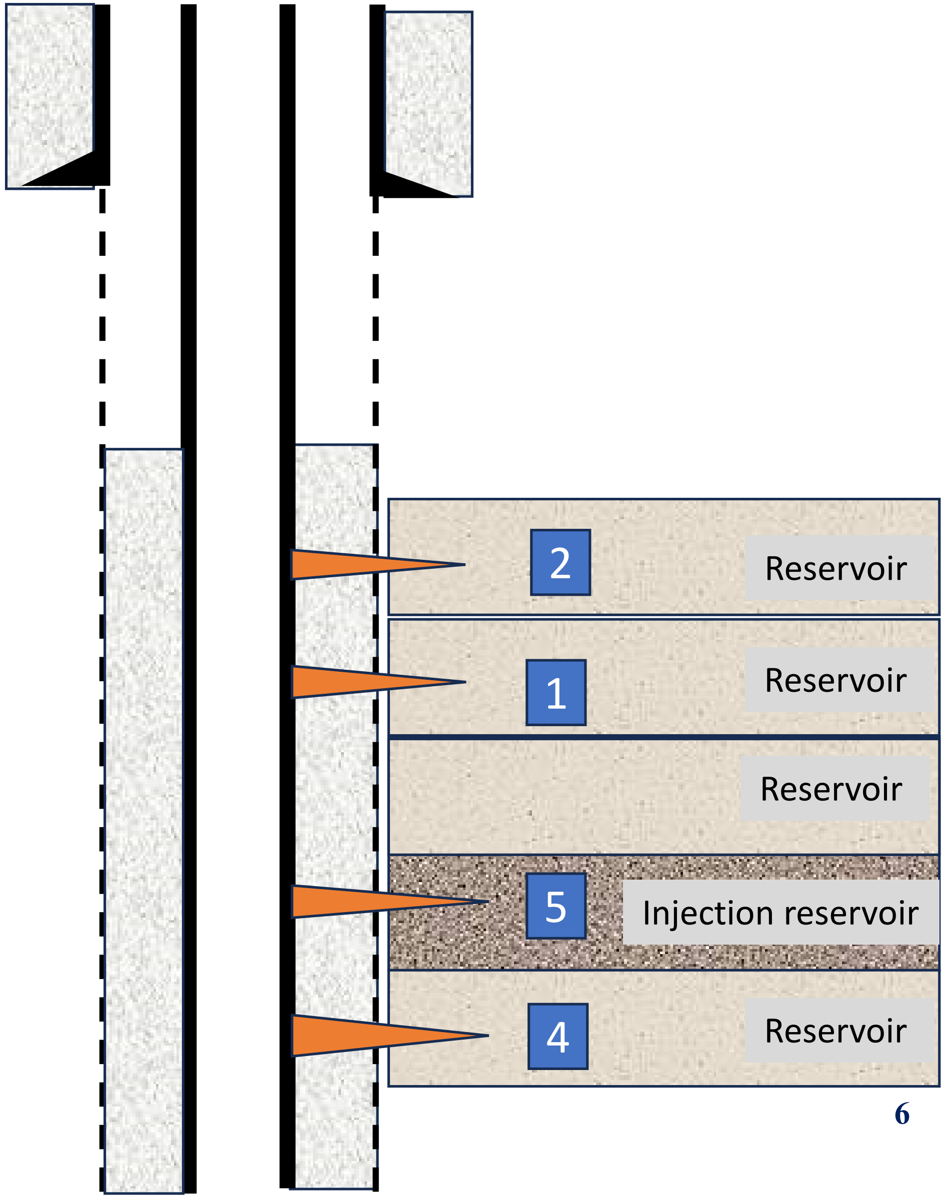




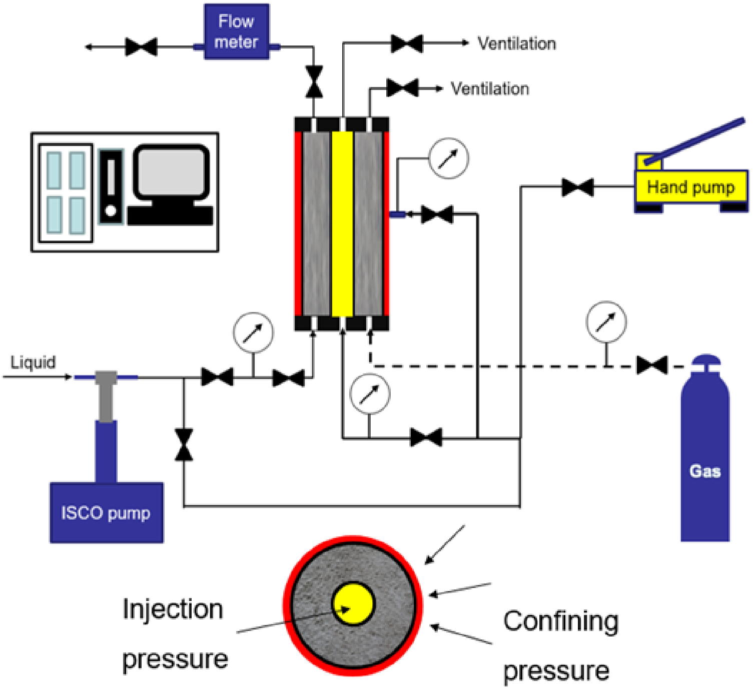
III.2. Assigning Score

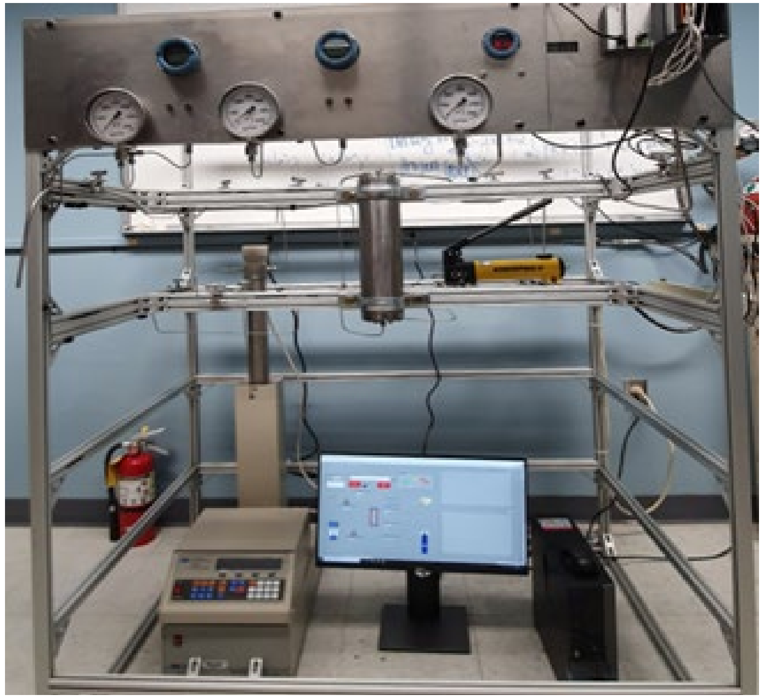


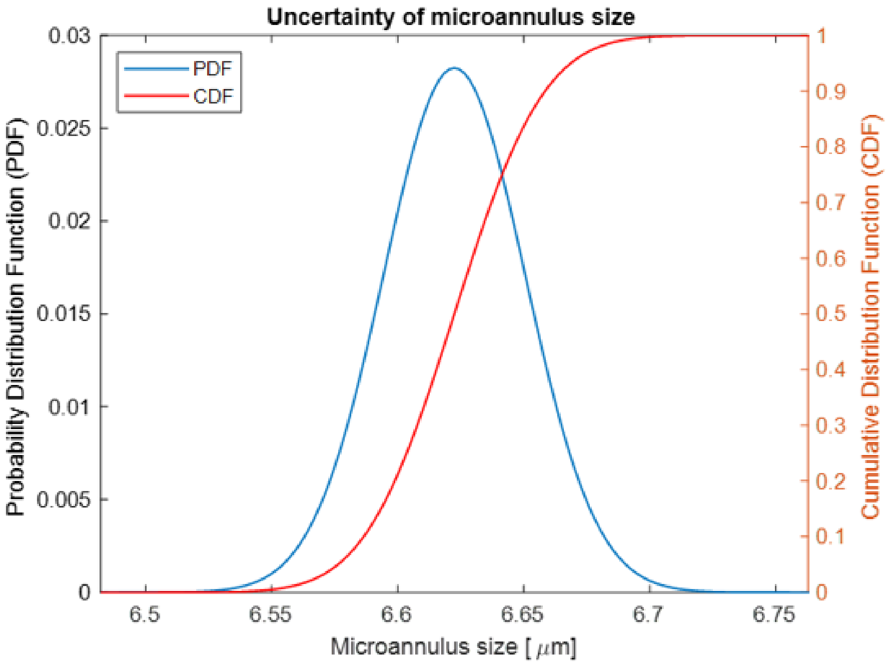
Well Status	SS
Plugged	4
Inactive	5
Active	3
Abandoned	1

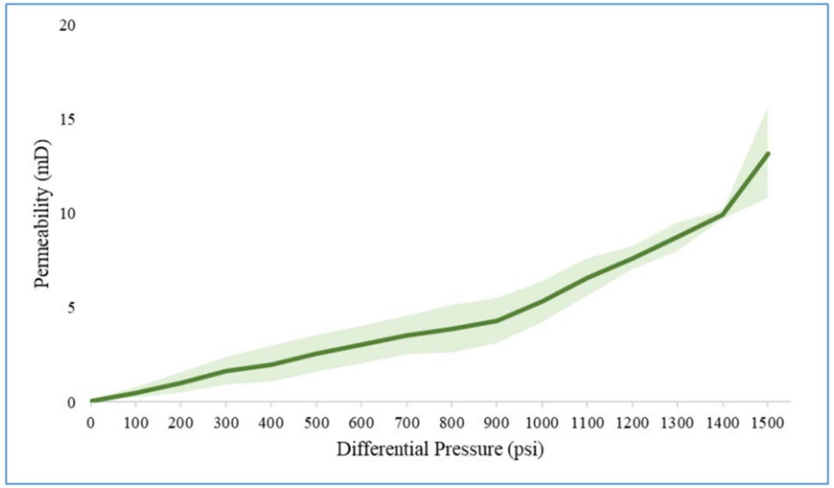


III.3. Estimated leakage rate









$$k = k_0 + 0.0065\Delta P \; for \; class \; C \; cement$$

$$Q_{bulk\_fluid} = \frac{kA}{\mu L}\left(P_{up} - P_{down}\right)$$

$$Q_{bulk\_gas} = \frac{kA}{\mu L}\frac{\left(P_{up}{}^2 - P_{down}{}^2\right)}{2P_{down}}$$

$$Q_{micro} = \frac{\pi R_c \Delta P}{6\mu L}\delta R^3$$

III.4. Summary

No.	FACTOR	DESCRIPTION	SS	WF
1	Well Age	Before 1930, Unknow	5	1
		1930-1950	4	
		1950-1970	3	
		1970-1990	2	
		After 1990	1	
2	Wellbore Trajectory	Unknow	5	3
		Horizontal	4	
		Slanted	3	
		Deviated	2	
		Vertical	1	
3	Well Type	Undetermined	5	4
		Gas, Disposal, Injection	4	
		Oil, dry hole, monitoring	1	
4	Well Status	Inactive, undetermined	5	1
		Plugged	4	
		Active	3	
		Abandoned	1	
5	Estimated leakage rate (m3/year)	>50	5	5
		10-50	4	
		5-10	3	
		1-5	2	
		<1	1	
6	Number of casings	0	5	3
		1	4	
		2	3	
		3	2	
		>3	1	
7	Cement status	Any casings that do not have TOC reach to the surface plug	5	5
		Liners which have TOC below the previous casing shoe	2	
		Liners which have TOC above the previous casing shoe; or all casings have TOC reach to the surface plug	1	

No	FACTOR	DESCRIPTION		SS	WF
8	Distance SCS to Water Table (ft)	Within WT; >5000		5	1
		<50		4	
		50-2000		2	
		2000-5000		3	
9	Distance from TVD to Water Table (ft)	>1000		5	1
		1000-3000		4	
		3000-5000		3	
		5000-10000		2	
		>10000		1	
10	Stimulation	Acidizing	1 treatment	1.1	2
			2 treatments	1.2	
			>2 treatments	1.5	
		Hydraulic fracturing	1 treatment	1.1	
			2 treatments	1.2	
			>2 treatments	1.5	
		Perforation	1 perforation	1.5	
			>1 perforations	2	
11	Perforated Reservoir	Produced and injection reservoir are separated by a caprock or caprock is perforated with a shallow distance		1	5
		Caprock is perforated with a deep distance or; produced is separated from the injection reservoir by three others		2	
		Produced and injection reservoirs are seperated by two others		3	
		Produced and injection reservoirs are seperated by another reservoir		4	
		Produced reservoir is the same as the injection reservoir.		5	

IV. A CASE STUDY– Input Information

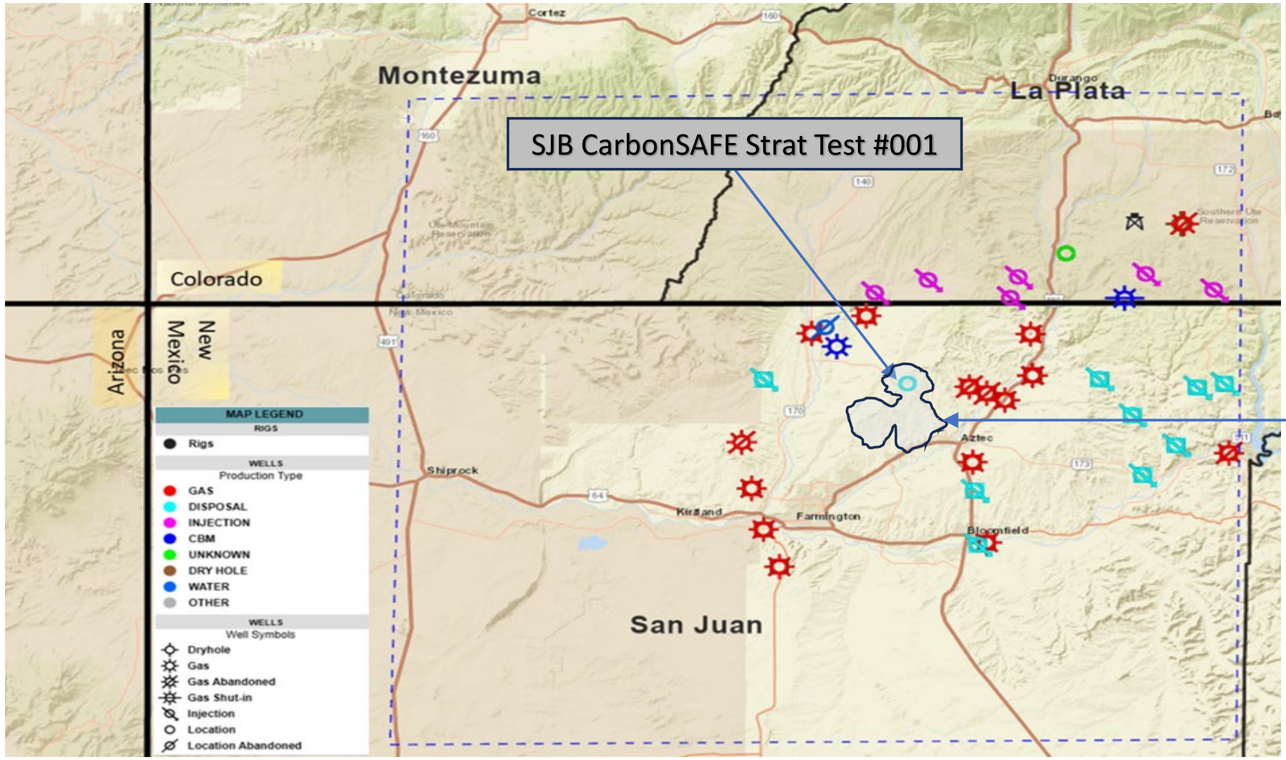
API	Well name	Well age	Well bore Trajectory	Well Type	Well status	Probable Leakage (m3/year)	Number of casing	Cementing status	Distance SCS to WT (ft)	Distance TVD to WT (ft)	Production status	Number of acidizing	Number of other treatments	Number of perforations	Further Popose	Perforated formation
0506707344	SOUTHERN UTE WDW 32-10	1989	Vertical	Injection	Active	0.060	4	5	0	9233	No	0	1	1	Non	Entrada Sandstone
0506707796	HENDRICKSON SWD	1991	Vertical	Injection	Active	6.533	4	5	0	8492	No	0	0	1	Non	Entrada Sandstone
0506709194	FERGUSON SWD	2006	Vertical	Undetermined	Active	12.578	3	5	337	8614	No	1	1	2	Non	Carmel Formation
506707123	SOUTHERN UTE WDW 32-11	1989	Vertical	Injection	Abandoned	34.165	4	5	0	8380	No	0	1	1	Non	Entrada Sandstone
506707682	SOUTHERN UTE WDW 32-12	1993	Vertical	Injection	Abandoned	19.829	2	1	300	6150	No	1		2	Non	Kirtland Sh./Fruitland Fm.
506707217	SOUTHERN UTE 32-10	1989	Vertical	Injection	Abandoned	23.012	4	1	116	8520	No	0	0	1	Non	Entrada Sandstone
0506706114	JESSIE HAHN	1976	Vertical	Dry hole	Abandoned	-	3	5	0	14103	No	0	0	1	Non	Kirtland Sh./Fruitland Fm.
506707216	SOUTHERN UTE 32-9	1989	Vertical	Coalbed methane	Plugged	-	2	5	114	9315	No	0	0	1	Non	Kirtland Sh./Fruitland Fm.
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
3004527799	E E ELLIOTT SWD	1990	Vertical	Disposal	Active	13.107	5	1	0	8136	No	1	3	3	Non	Entrada Sandstone
3004526970	PUMP CANYON SWD	1988	Vertical	Disposal	Active	12.532	5	5	95	8110	No	0	0	1	Non	Entrada Sandstone
3004530040	ARCH ROCK	2000	Vertical	Gas	Abandoned	39.794	3	5	0	13110	No	0	0	1	Non	AKAH
3004530922	PRETTY LADY 30 11 34	2002	Vertical	Disposal	Active	51.210	3	1	33	7475	No	1	1	1	Non	Cliff House Sandstone
3004528703	SAN JUAN 32 8 UNIT SWD	1992	Vertical	Disposal	Abandoned	4.647	4	5	57	8970	No	1	0	3	Non	Entrada Sandstone

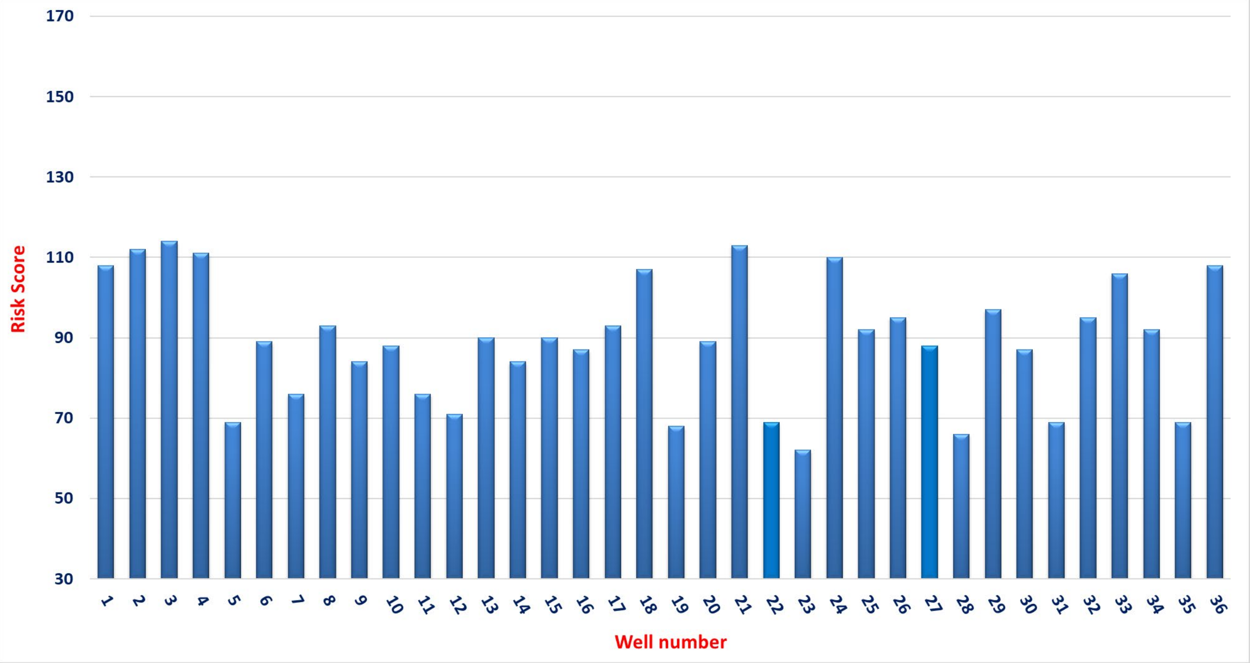
Well (i)	Well Age	Well bore Trajectory	Well Type	Well status	Probable Leakage	Number of casing	Cementing Status	Distance SCS to WT	Distance TVD to WT	Stimulation	Perforated Formation
1	2	1	4	3	2	1	5	5	2	2	5
2	1	1	4	3	3	1	5	5	2	2	5
3	1	1	5	3	4	2	5	3	2	3	4
4	2	1	4	1	4	1	5	5	2	2	5
5	1	1	4	1	4	3	1	3	2	2	1
6	2	1	4	1	4	1	1	3	2	2	5
...	...	...	...	...	...	...	...	...	...	...	...
35	1	1	4	3	5	2	1	4	2	2	1
36	1	1	4	1	2	1	5	3	2	2	5

IV. A CASE STUDY - Results

$$Risk\ Score = Severity\ score\ matrix\ \times Weighting\ factor\ vector$$

$$= \begin{bmatrix} 2 & 1 & 4 & 3 & 2 & 1 & 5 & 5 & 2 & 5 & 2 & 5 \\ 1 & 1 & 4 & 3 & 3 & 1 & 5 & 5 & 2 & 5 & 2 & 5 \\ 1 & 1 & 5 & 3 & 4 & 2 & 5 & 3 & 2 & 5 & 3 & 5 \\ 2 & 1 & 4 & 1 & 4 & 1 & 5 & 5 & 2 & 5 & 2 & 5 \\ 1 & 1 & 4 & 1 & 4 & 3 & 1 & 3 & 2 & 5 & 2 & 5 \\ 2 & 1 & 4 & 1 & 4 & 1 & 1 & 3 & 2 & 5 & 2 & 5 \\ \dots & \dots & \dots & \dots & \dots & \dots & \dots & \dots & \dots & \dots & \dots & \dots \\ 1 & 1 & 4 & 3 & 5 & 2 & 1 & 4 & 2 & 5 & 2 & 5 \\ 1 & 1 & 4 & 1 & 2 & 1 & 5 & 3 & 2 & 5 & 2 & 5 \end{bmatrix} \times \begin{bmatrix} 1 \\ 3 \\ 4 \\ 1 \\ 5 \\ 3 \\ 5 \\ 1 \\ 1 \\ 2 \\ 5 \end{bmatrix} = \begin{bmatrix} 113 \\ 117 \\ 124 \\ 121 \\ 84 \\ 99 \\ \dots \\ 89 \\ 108 \end{bmatrix}$$





Supercritical plume gas CO2 gas of scenarios in 30 years- at Entrada injection Zone

IV. CONCLUSION

The primary goals of this research are to develop a model for evaluating risk of wells in the AoR;

- Risk Assessment method, big data analytics and leakage rate model are used to build a model for evaluating risk of wells in the area
- Results shows that:
  - ✓ Leakage rate, perforated formation, cement status and well type have high impacts;
  - ✓ Wellbore trajectory, stimulation status and number of casings have medium impacts;
  - ✓ Surface casing depth, well age, and well status have lowest influences
- A case study on 36 wells on the AoR has been carried out.
- This technology effectively reduces the number of wells that need to reevaluate, which results in cost savings and time efficiency.

THANK YOU FOR YOUR ATTENTION