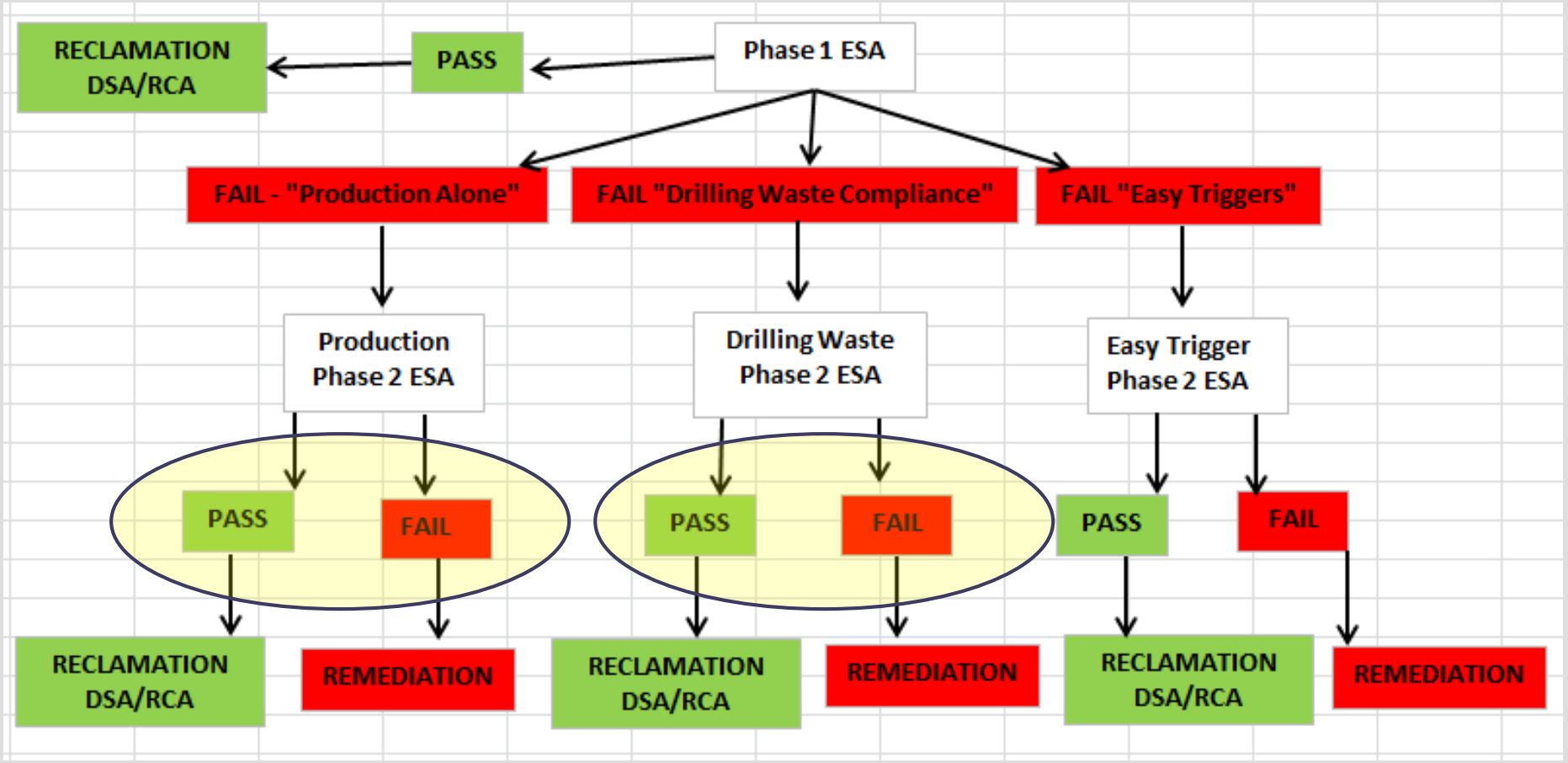
Evaluating Phase 1 ESA Production Triggers and Update to PTAC Drilling Waste Compliance Option Project

Adapting and Collaborating When Determining Risk

Presented by: Jim Purves, B.Sc., P.Ag.

Evaluation Focus



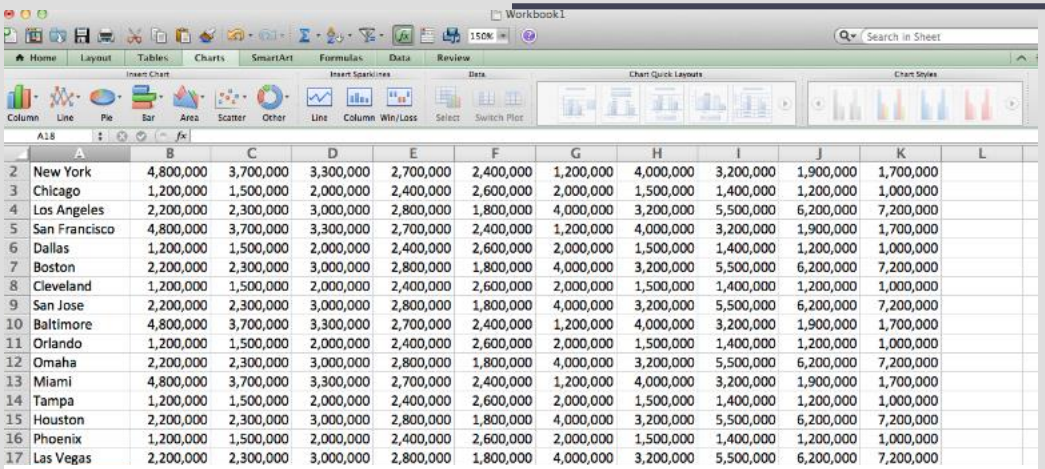
Phase 1 ESA “Easy Triggers’

- Historic spills/releases
- Salt water injection facilities
- Bare areas/reduced vegetation
- Historic flare pits
- USTs
- Landowner concerns
- Known contamination

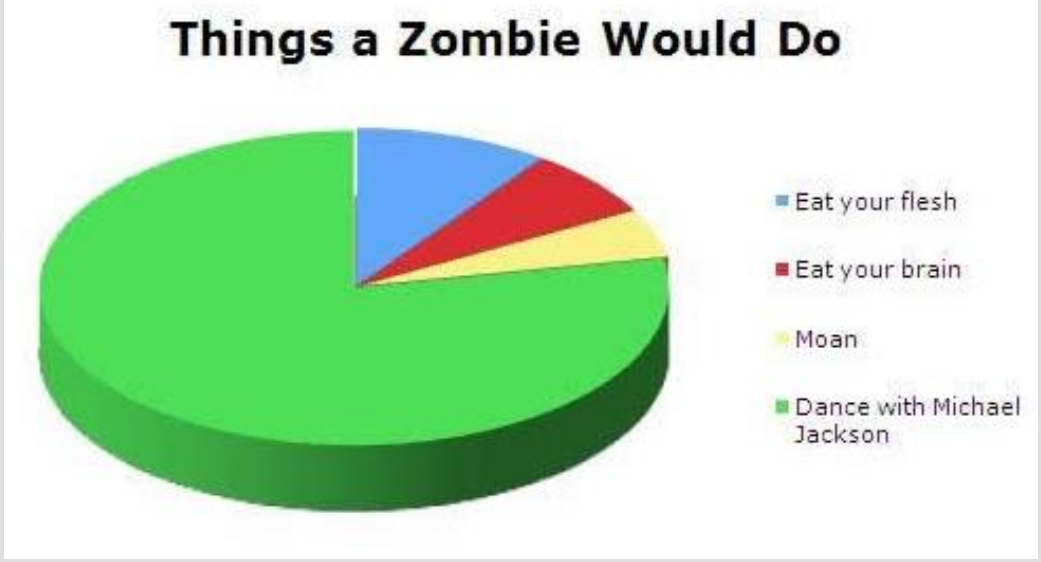
It Depends……

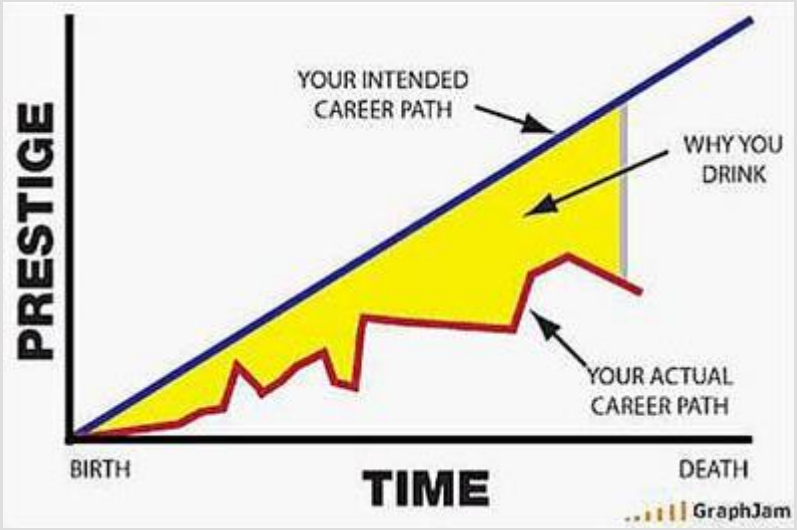
- Age of the facility
  - Ties into operational practices of the period
  - Ties into regulatory requirements of the period
- Type of facility
  (dry gas, wet gas, oil, or some combination)
- Length of production
- Volume of production
- Infrastructure setup

Production Rationale Evaluation Process

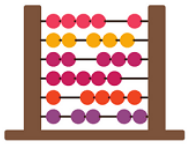


	A	B	C	D	E	F	G	H	I	J	K	L
2	New York	4,800,000	3,700,000	3,300,000	2,700,000	2,400,000	1,200,000	4,000,000	3,200,000	1,900,000	1,700,000	
3	Chicago	1,200,000	1,500,000	2,000,000	2,400,000	2,600,000	2,000,000	1,500,000	1,400,000	1,200,000	1,000,000	
4	Los Angeles	2,200,000	2,300,000	3,000,000	2,800,000	1,800,000	4,000,000	3,200,000	5,500,000	6,200,000	7,200,000	
5	San Francisco	4,800,000	3,700,000	3,300,000	2,700,000	2,400,000	1,200,000	4,000,000	3,200,000	1,900,000	1,700,000	
6	Dallas	1,200,000	1,500,000	2,000,000	2,400,000	2,600,000	2,000,000	1,500,000	1,400,000	1,200,000	1,000,000	
7	Boston	2,200,000	2,300,000	3,000,000	2,800,000	1,800,000	4,000,000	3,200,000	5,500,000	6,200,000	7,200,000	
8	Cleveland	1,200,000	1,500,000	2,000,000	2,400,000	2,600,000	2,000,000	1,500,000	1,400,000	1,200,000	1,000,000	
9	San Jose	2,200,000	2,300,000	3,000,000	2,800,000	1,800,000	4,000,000	3,200,000	5,500,000	6,200,000	7,200,000	
10	Baltimore	4,800,000	3,700,000	3,300,000	2,700,000	2,400,000	1,200,000	4,000,000	3,200,000	1,900,000	1,700,000	
11	Orlando	1,200,000	1,500,000	2,000,000	2,400,000	2,600,000	2,000,000	1,500,000	1,400,000	1,200,000	1,000,000	
12	Omaha	2,200,000	2,300,000	3,000,000	2,800,000	1,800,000	4,000,000	3,200,000	5,500,000	6,200,000	7,200,000	
13	Miami	4,800,000	3,700,000	3,300,000	2,700,000	2,400,000	1,200,000	4,000,000	3,200,000	1,900,000	1,700,000	
14	Tampa	1,200,000	1,500,000	2,000,000	2,400,000	2,600,000	2,000,000	1,500,000	1,400,000	1,200,000	1,000,000	
15	Houston	2,200,000	2,300,000	3,000,000	2,800,000	1,800,000	4,000,000	3,200,000	5,500,000	6,200,000	7,200,000	
16	Phoenix	1,200,000	1,500,000	2,000,000	2,400,000	2,600,000	2,000,000	1,500,000	1,400,000	1,200,000	1,000,000	
17	Las Vegas	2,200,000	2,300,000	3,000,000	2,800,000	1,800,000	4,000,000	3,200,000	5,500,000	6,200,000	7,200,000	





$$S = \sqrt{\frac{\sum |x - \bar{x}|^2}{n - 1}}$$



Where:

X is the first, second, third, etc. data value

$\bar{X}$ is the mean of the data set

n-1 is the number of sample values decreased

$|x - \bar{x}|^2$ represents the deviation from the sample mean

Regulatory Guidance Changes

1971: No oil or hydrocarbons in earthen pits

1994: IL-94-6 – production fluids no longer allowed to be received into earthen structures as of Dec 31/1996

1996: Flaring to earthen pits prohibited after July 1/1996

2001: Revision of Directive 055: Storage Requirements

2012: Revision of Directive 050

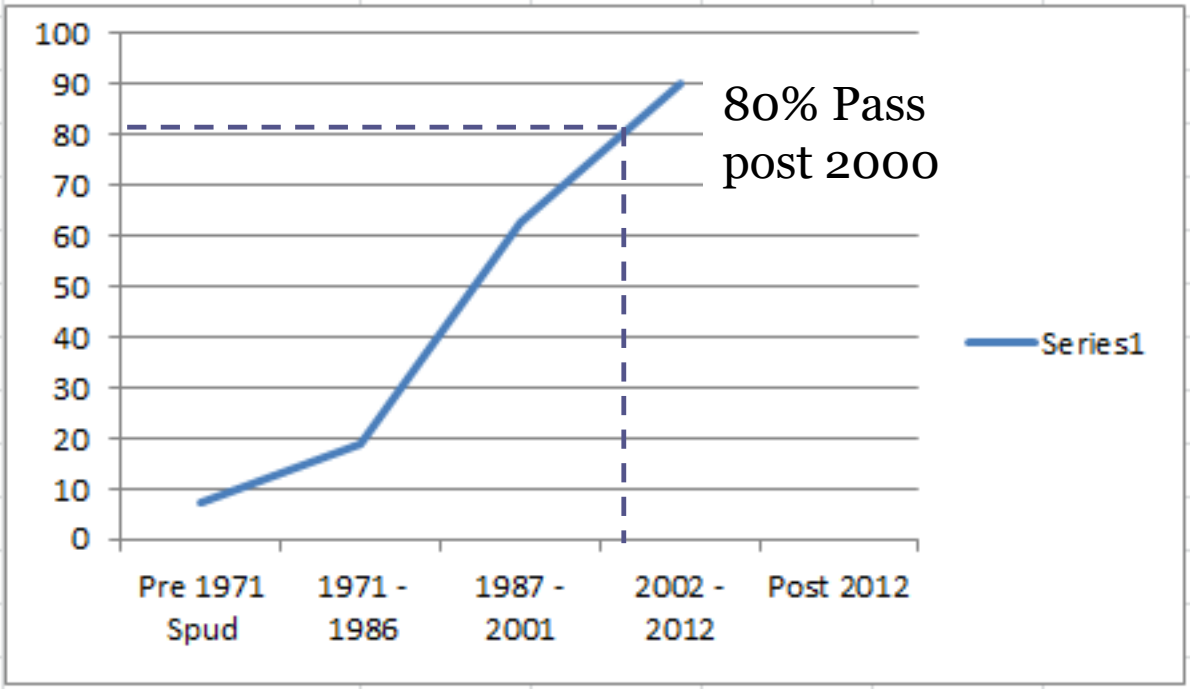
2016: Specified Enactment Direction (SED) 002

Overall Phase 2 Pass/Fail %

All Sites

Sort by Spud Date	# of sites	Pass (n)	Pass %	Fail (n)	Fail %
All Sites	141	104	74	37	26

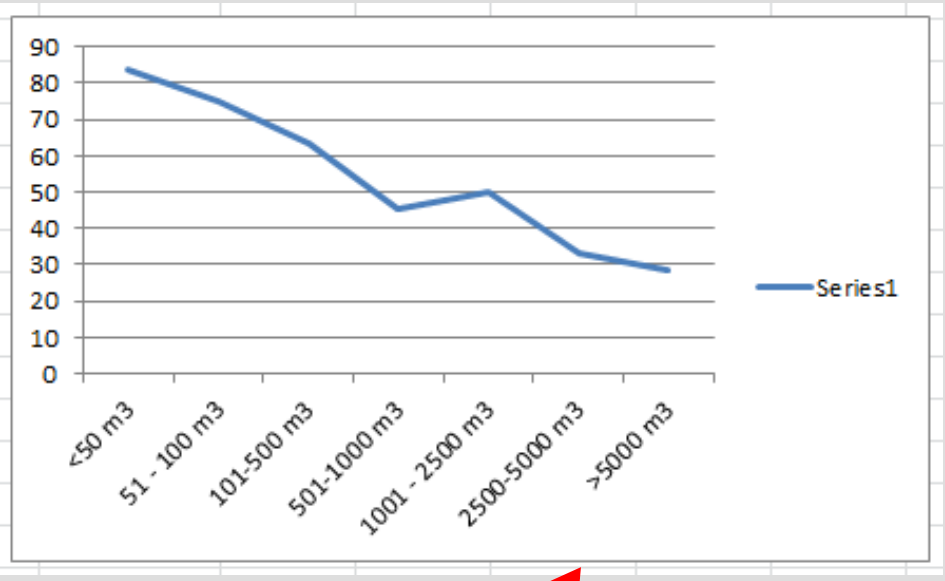
Oil Gas and Water					
Sort by Spud Date	# of sites	Pass (n)	Pass%	Fail (n)	Fail %
All Sites	140	72	51	68	49
Pre 1971 Spud	14	1	7	13	93
1971 - 1986	37	7	19	30	81
1987 - 2001	59	37	63	22	37
2002 - 2012	30	27	90	3	10
Post 2012	0				

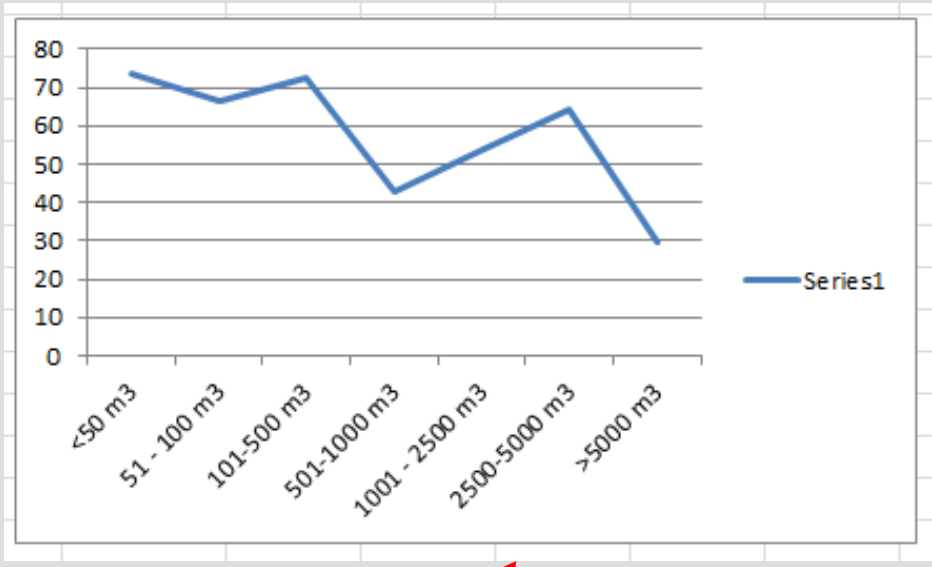


Oil, Gas and Water Wells

By Spud Date

Oil, Gas and Water Wells

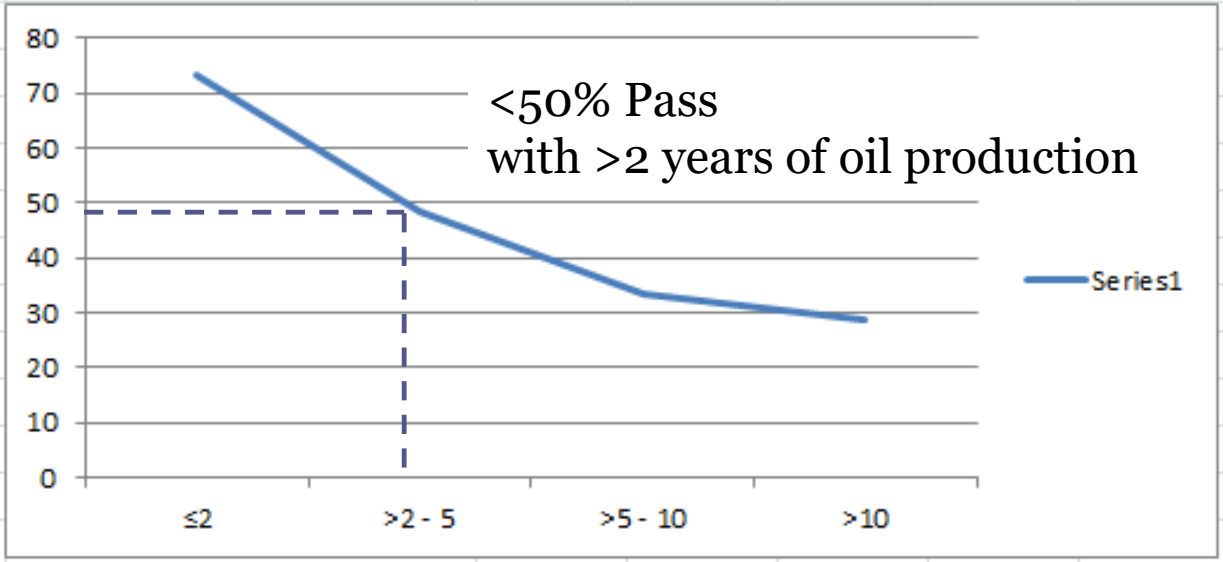




By Volume of **Oil** Produced

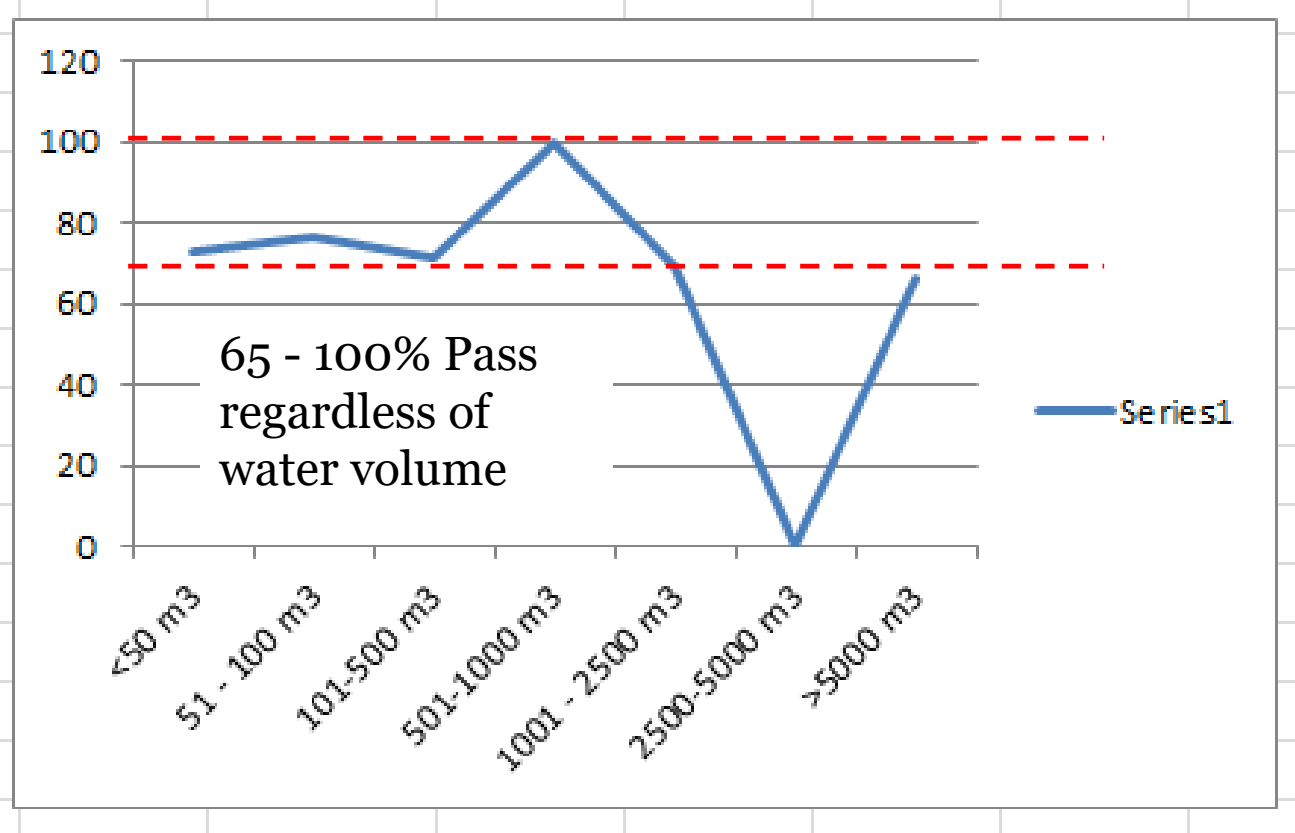
By Volume of **WATER** Produced

Sort by Years of Oil Production	# of sites	Pass (n)	Pass%	Fail (n)	Fail %
All Sites	140	72	51	68	49
≤2	56	41	73	15	27
>2 - 5	31	15	48	16	52
>5 - 10	18	6	33	12	67
>10	35	10	29	25	71



Oil, Gas and Water Wells

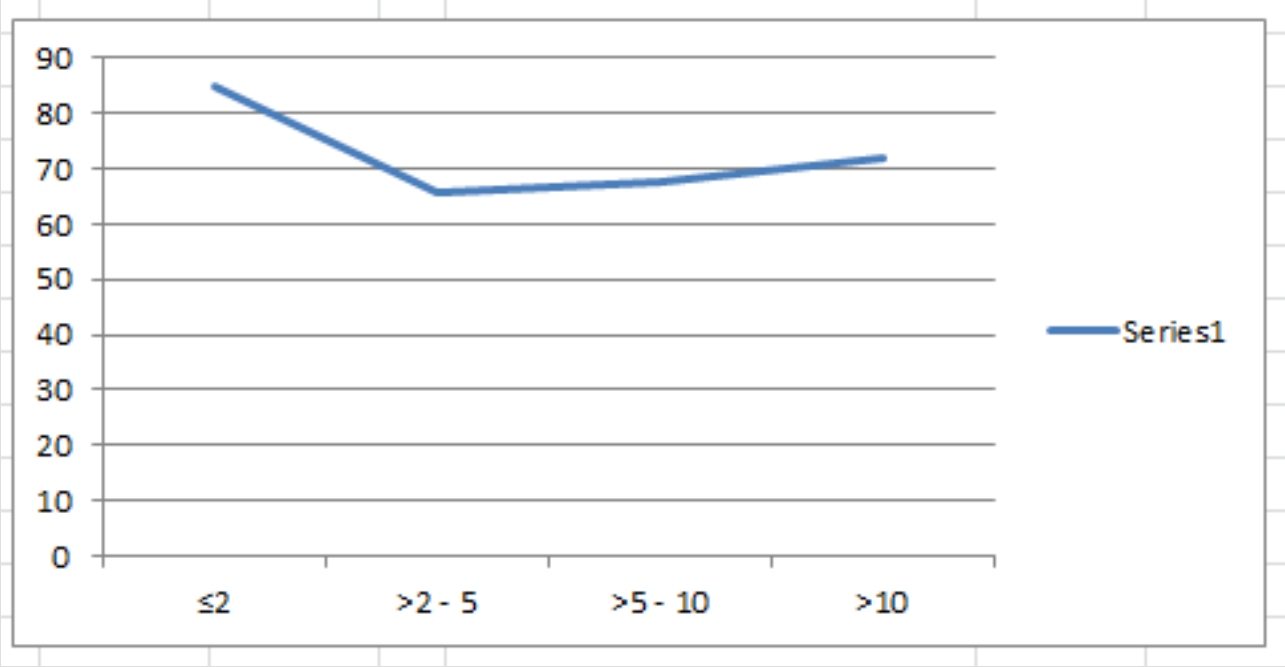
By Length of Oil Production



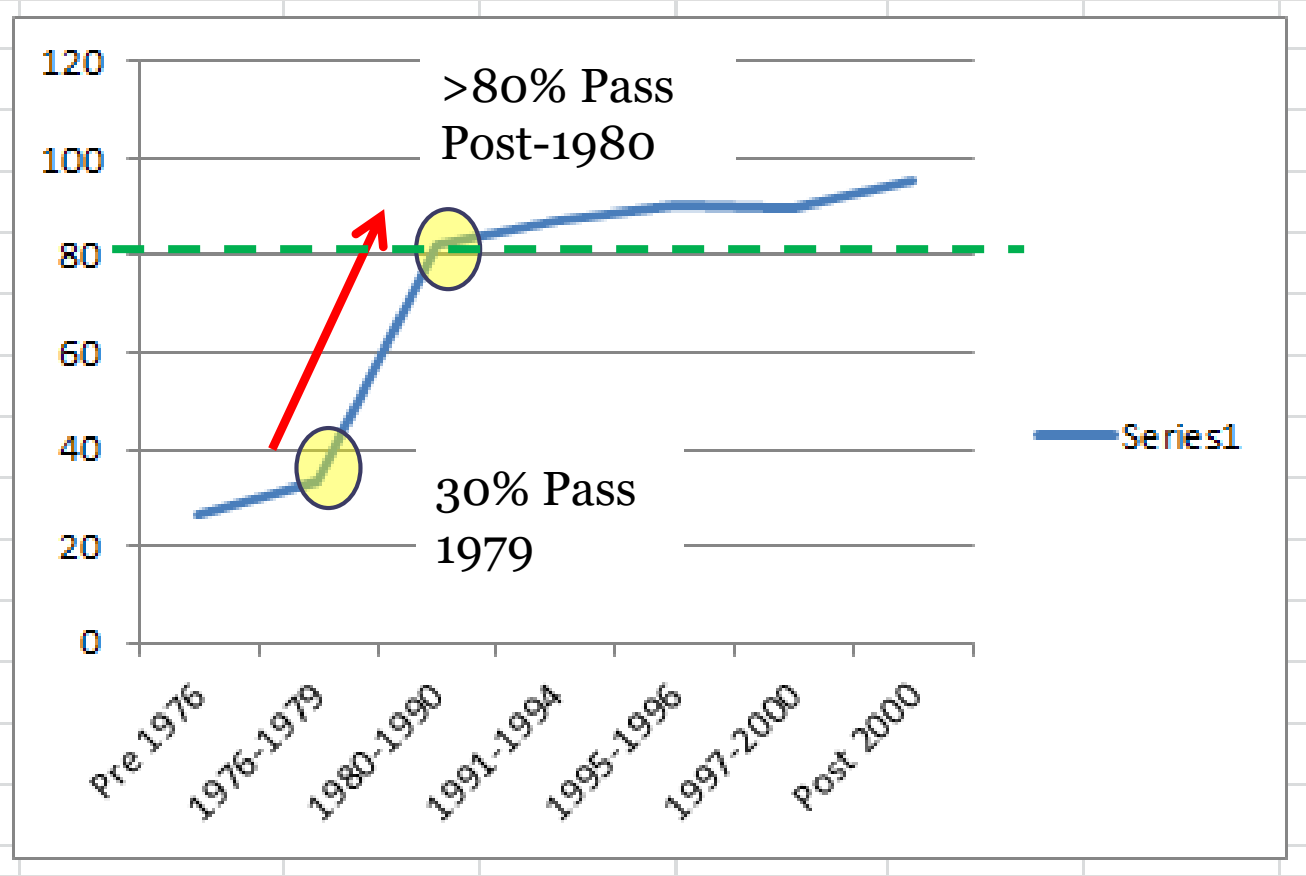
Gas and Water Wells

By Volume of Water

Gas and Water Wells



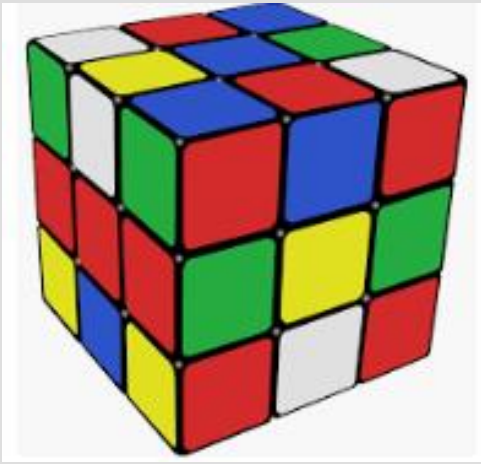
By Length of Production



Gas and Water Wells

By Spud Date

Events of 1980



Dry Gas Wells

Dry Gas			
Sort by Spud Date	# of sites	Pass%	Fail %
All Sites	12	58.4	41.6
Pre 1971 Spud	1	0	100
1971 - 1986	1	0	100
1987 - 2001	8	75	25
2002 - 2012	2	50	50
Post 2012			

Production Rationale Matrix

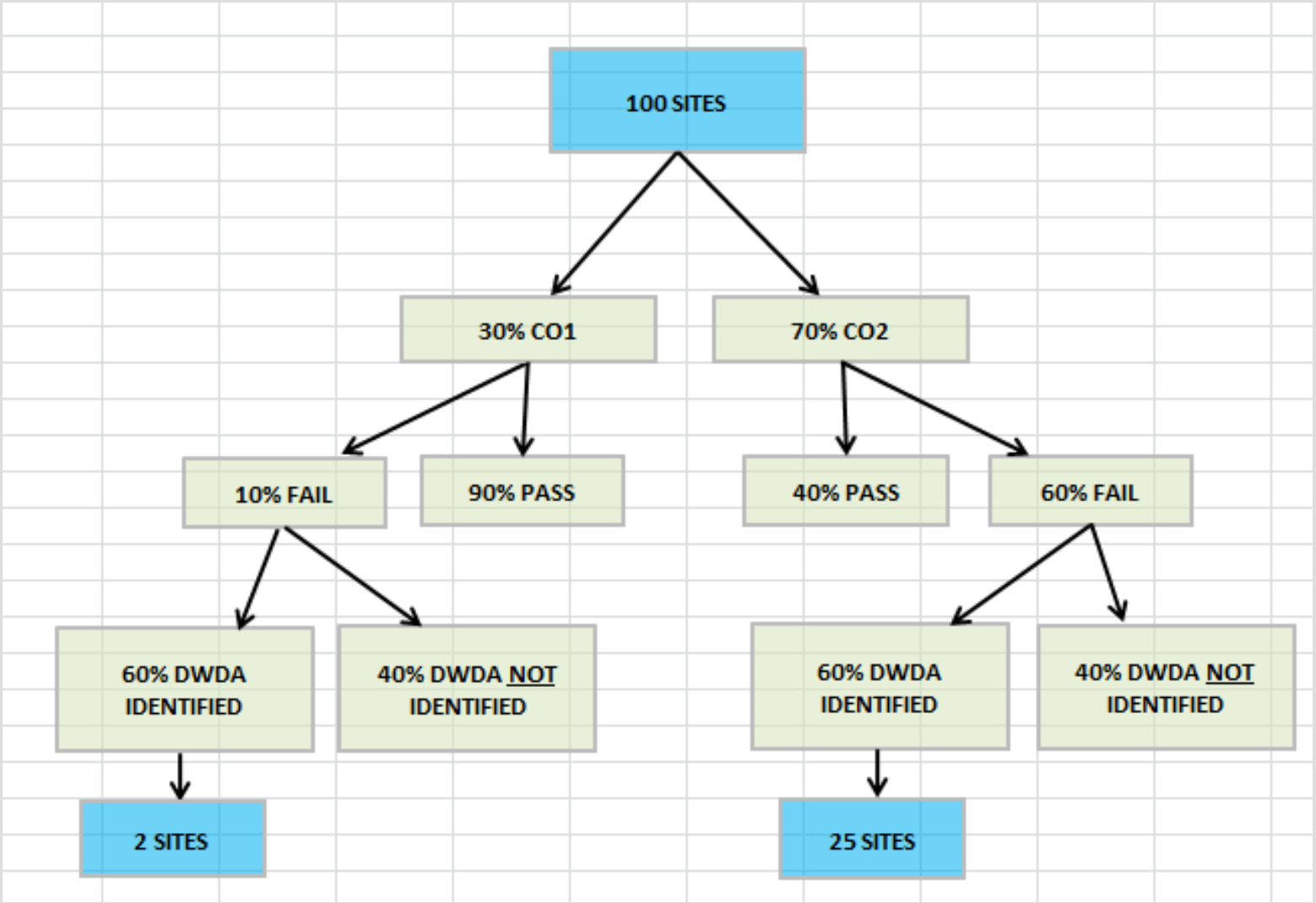
- Utilize dates of major Regulatory criteria changes
- Spud date certainly had the largest influence
- Volume of production and length of production are influential, but mainly on the low end (low volume and short production lengths)

Develop a Decision Matrix which is DEFENDABLE

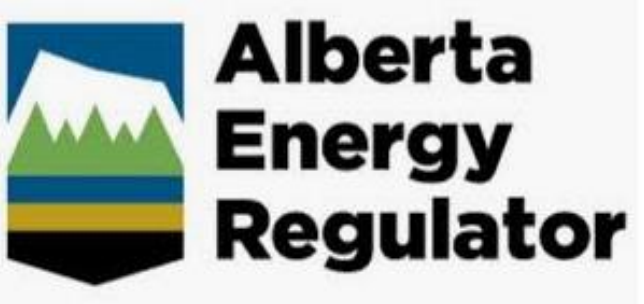
Drilling Waste Compliance Project

- Focused on drilling waste disposals prior to 2012
- Evaluate correlation between Compliance Option 2 triggers and actual Tier 1 exceedances during the Phase 2 ESA
- Use statistical analysis to determine relationships between the triggers
- Provide recommendations for proposed guideline adjustments

General Data Trending



PTAC Stage 1: Data Gathering



1681 Sites Reviewed
510 Candidate Sites Identified

Stage 2: Data Analysis

- Descriptive Statistics
(removing data outliers)

- Categorical Data
(two-way contingency tables, Pearson's Chi-square and/or Fisher Exact Tests)

- Predictive Modeling
(Multi-variable Binominal Regression)

$$x^2 = \sum \frac{(O-E)^2}{E}$$

x^2 = The test statistic

O = Observed

E = Expected

$\sum$ = The sum of

$$Y = B_0 + B_1X_1 + B_2X_2 + \cdots \ldots \ldots . + B_kX_k$$

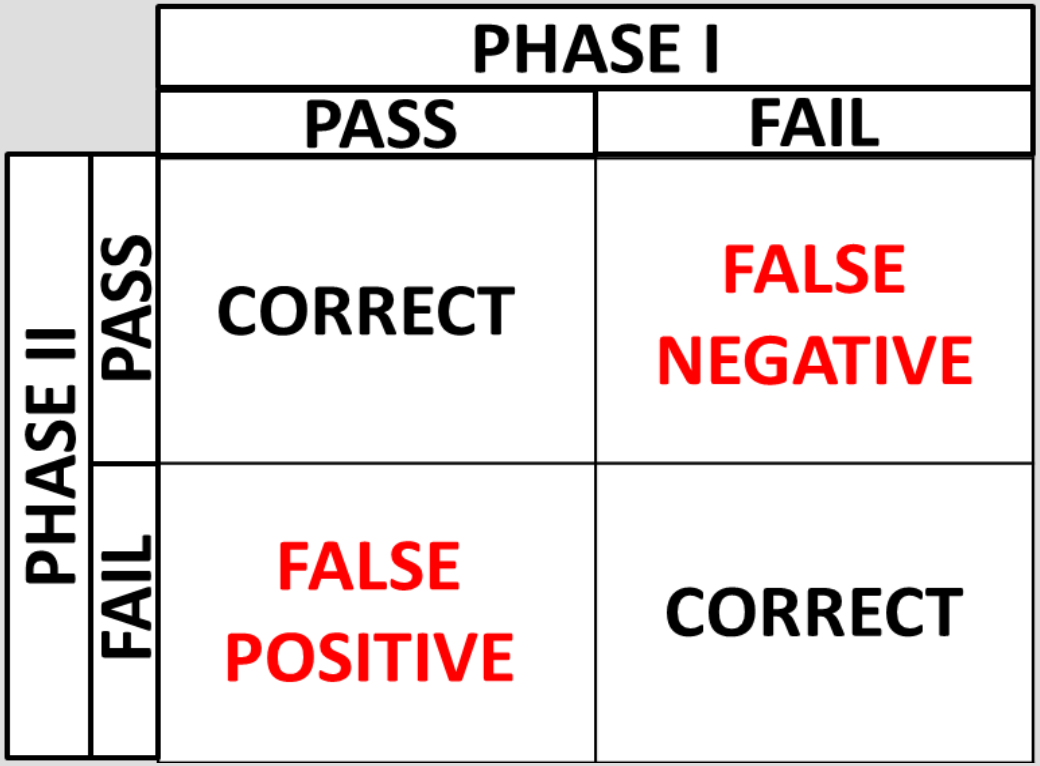
Y = Phase 2 Pass/Fail

B_0 = Constant

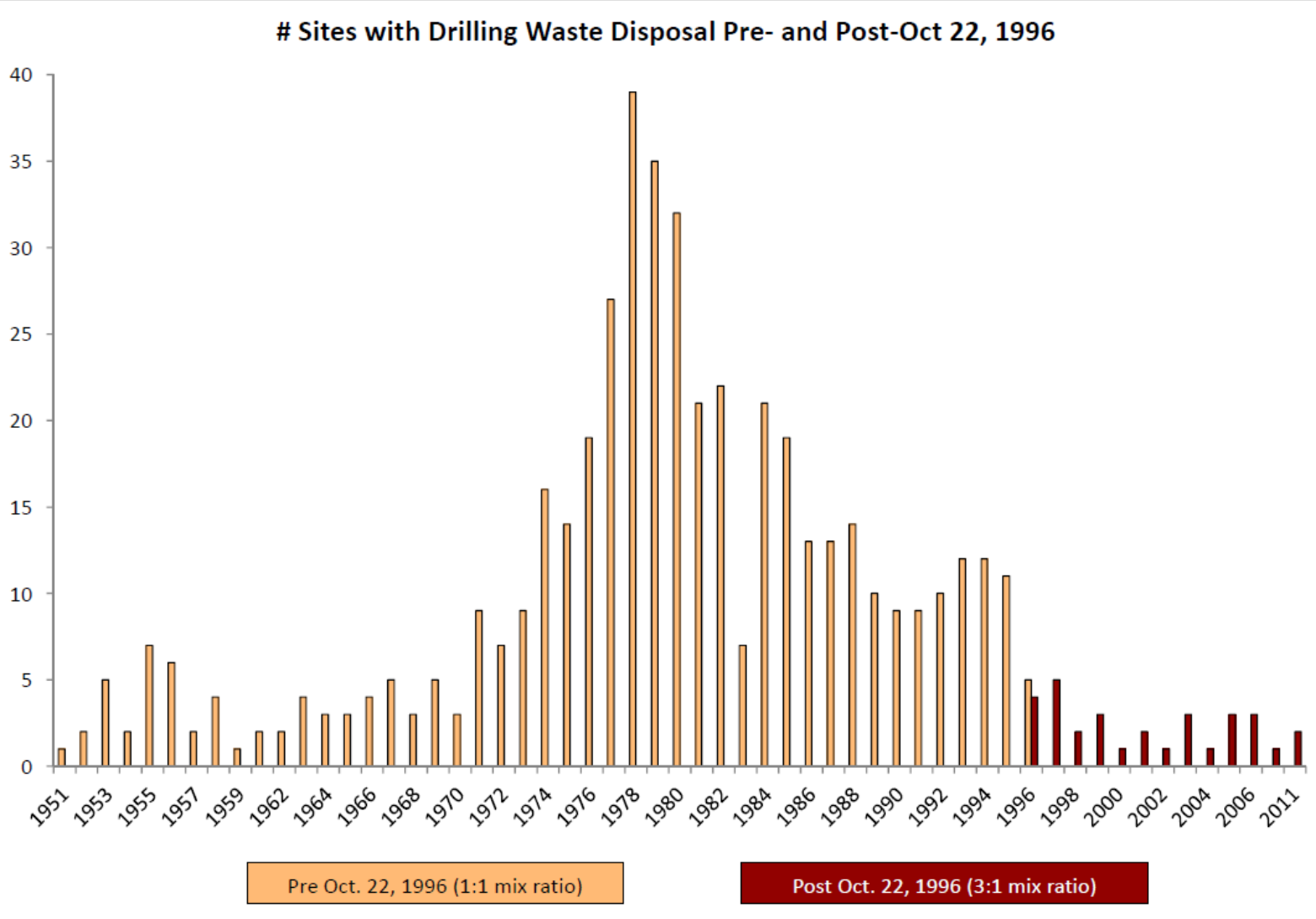
B_1 = Coefficient of variable X_1

X_1 = Independent PH 1 predictor variables (production amount, salt calculation, production years... etc.)

False Positive and False Negative Errors



Spud Date Distribution



Post-Disposal PHC Concentration

1996 D50
(0.5% Topsoil, 0.1% Subsoil)
TOTAL Hydrocarbons

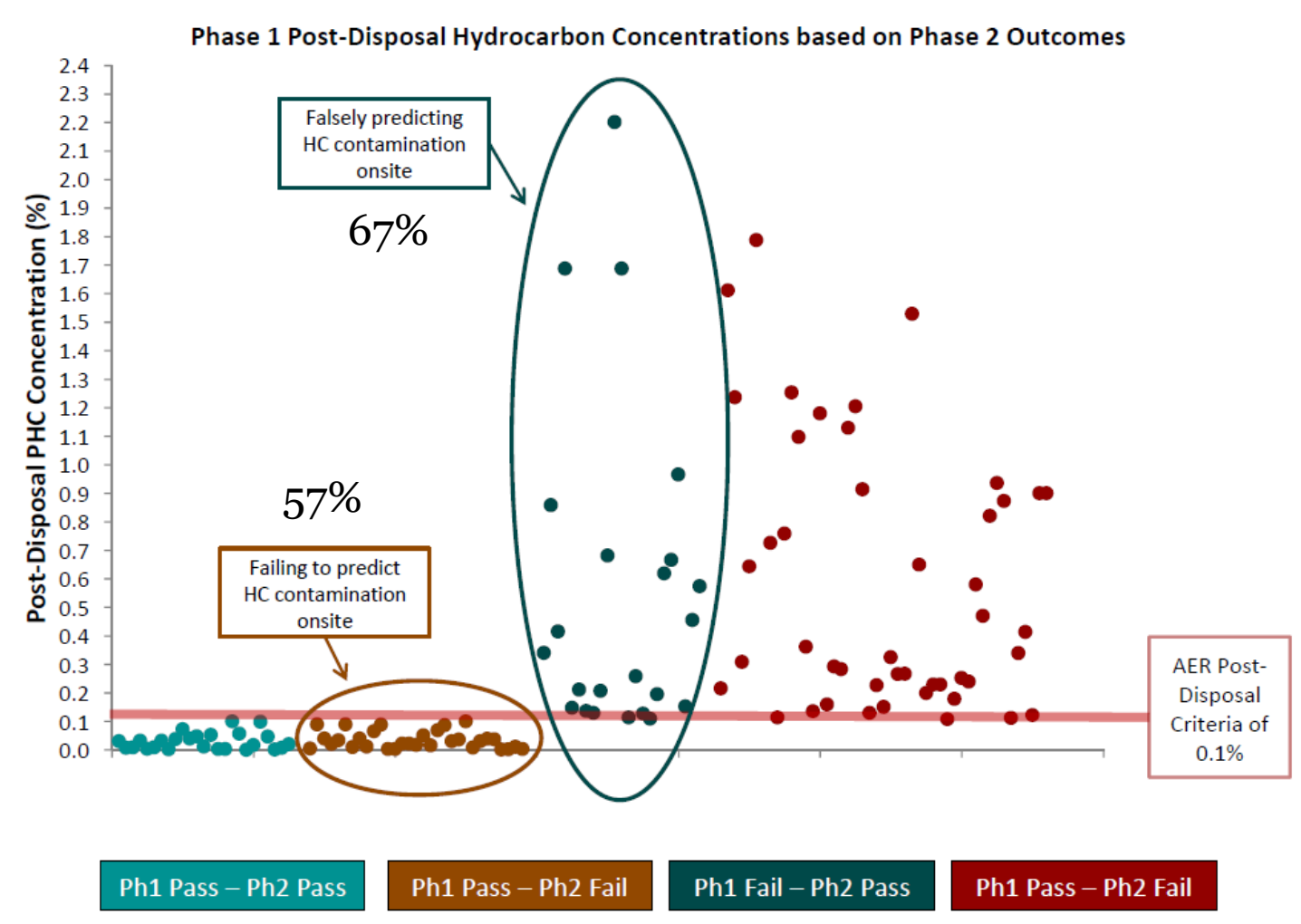
VS

Tier 1 Endpoints
BTEX, F1-F4 PHC

1996 D050 (0.1% Subsoil Total PHC) VS 2019 AB Tier 1

	BTEX and PHC (F1-F4)									
	Benzene	Toluene	Ethylbenzene	Total Xylenes	F1[2]	F2	F3	F4[3]	TOTAL PHC (mg/kg)	% Total PHC
AEP Tier 1 2019 Subsurface	0.046	0.52	0.073	0.99	420	300	2600	10000	13321	1.33
1996 D050 [PHC] - Subsoil	(X) 21739	(X) 1923	(X) 13698	(X) 1010	(X) 2.4	(X) 3.3	OVER	OVER	1000	0.1

Phase 1 PHC Trigger VS Phase 2 Results



Salt and Default DST Triggers

- Salts - Sodium Hydroxide Equivalency (NaOH)
  0.026 and 0.035

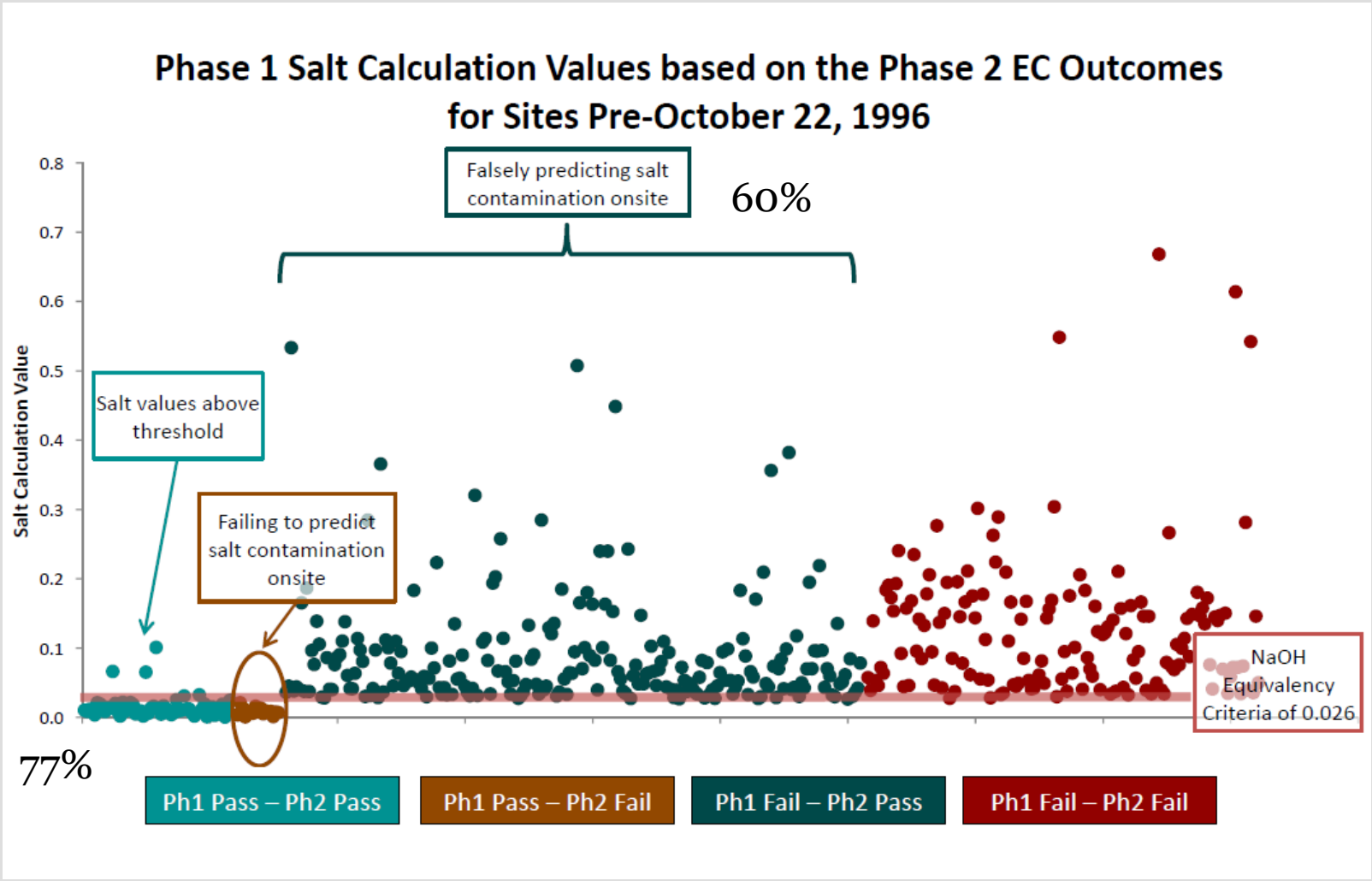
- DST default chloride concentration

350,000 mg/L - 2007

215,000 mg/L - 2012

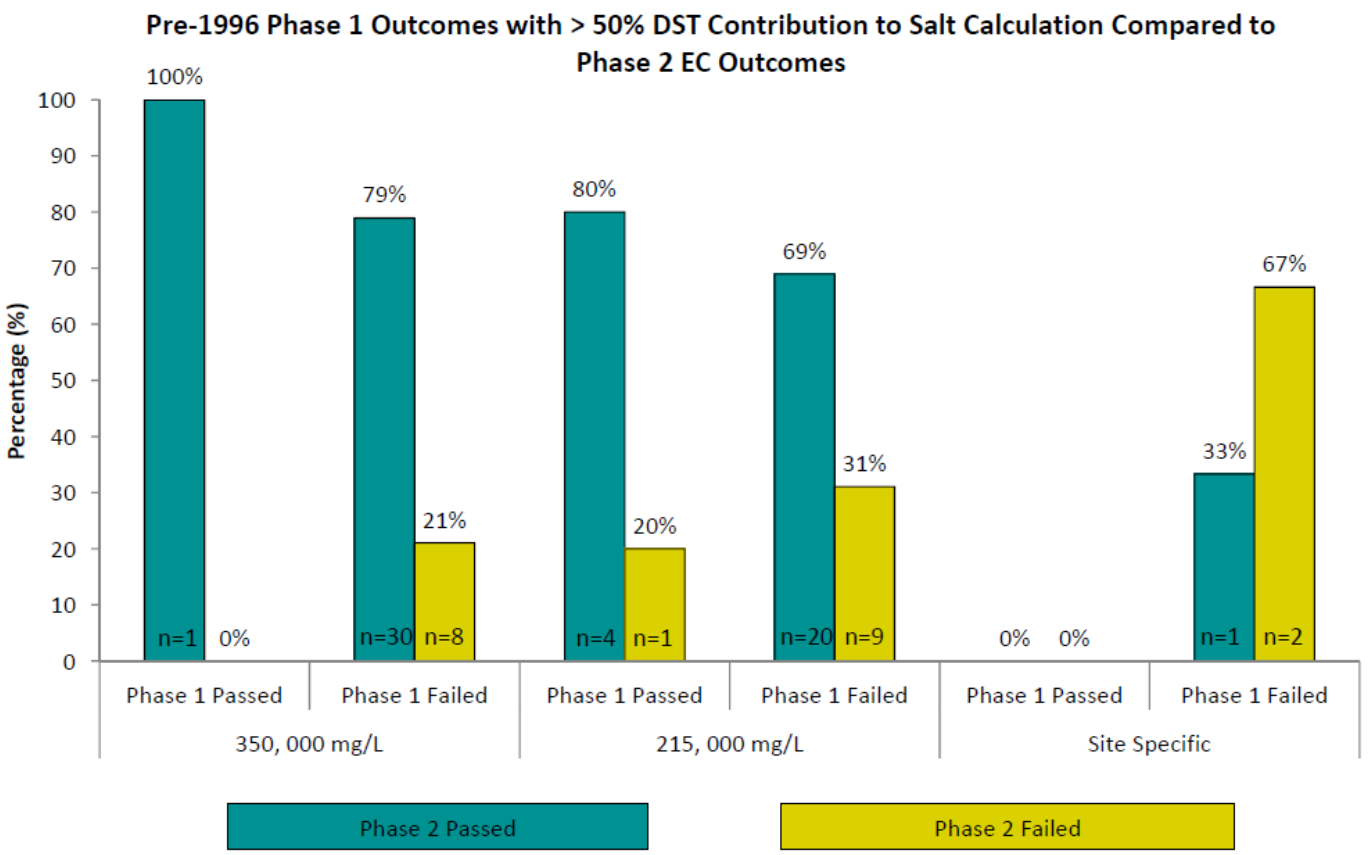
Too Conservative?

Salt Calculation Trigger VS Phase 2 Results



Default DST Chloride Concentration Vs Phase 2 Results

>50% DST



PHC, Salt and DST Opportunities

- Phase 1 post disposal PHC concentration is not an accurate predictor of Tier 1 exceedances during the Phase 2
- SALT Calculation likely too conservative
- Default Chloride DST concentration too conservative (215,000 mg/kg)
- Research chloride concentrations based on formation that the DST return was taken from
- Using formation specific DST chloride concentrations that more accurately reflect risk associated with your site

QUESTIONS??

Jim Purves, B.Sc., P.Ag.
Technical Advisor
jpurves@northshoreenv.com
780-913-6137

www.northshoreenv.com

NORTH SHORE
Environmental Consultants