Sixth Annual Conference on Carbon Capture & Sequestration

Risk Assessment

Assessment of the Potential for CO_2 Leakage through Wells at the Pembina Cardium CO_2-EOR Pilot Operation in Alberta, Canada

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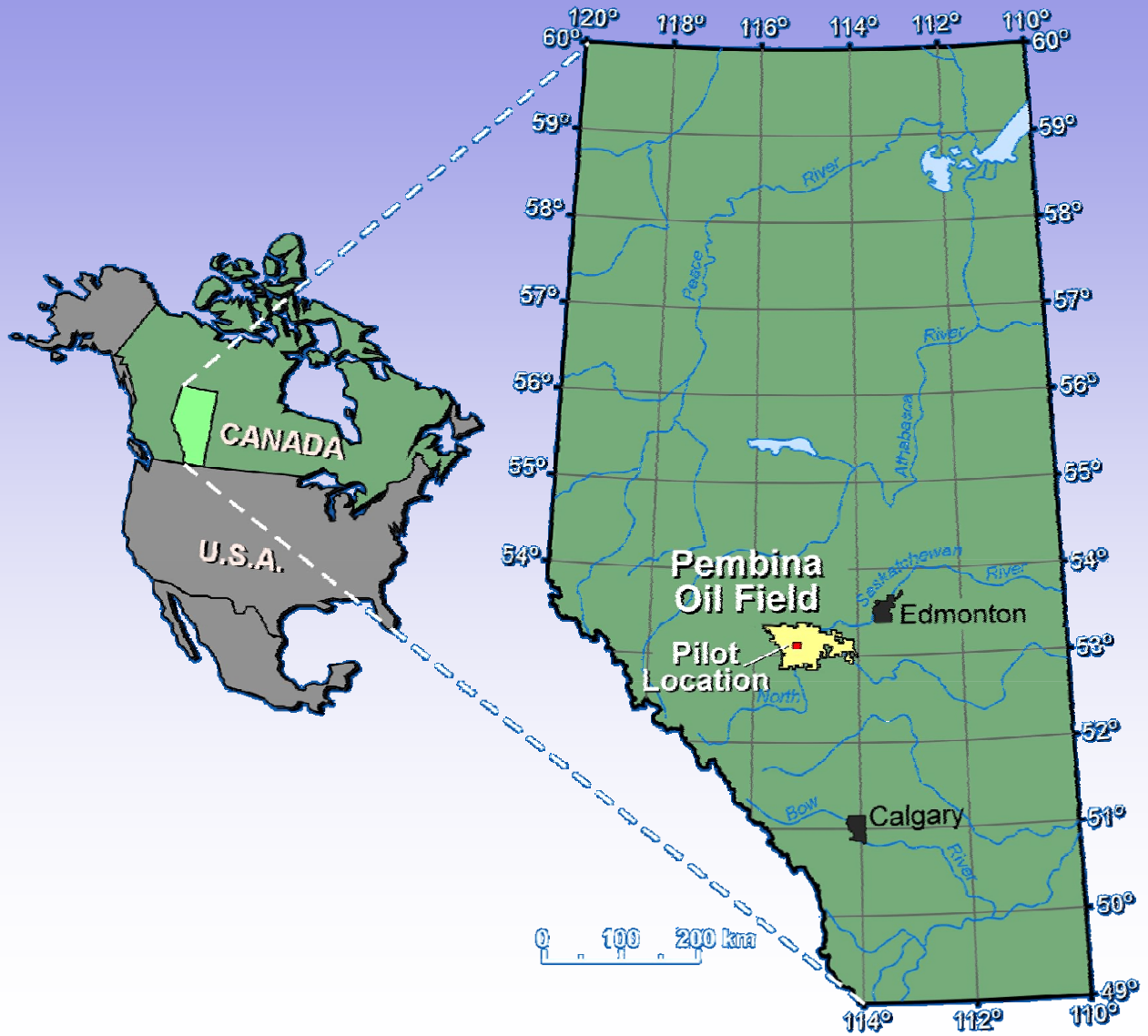
Study Structure

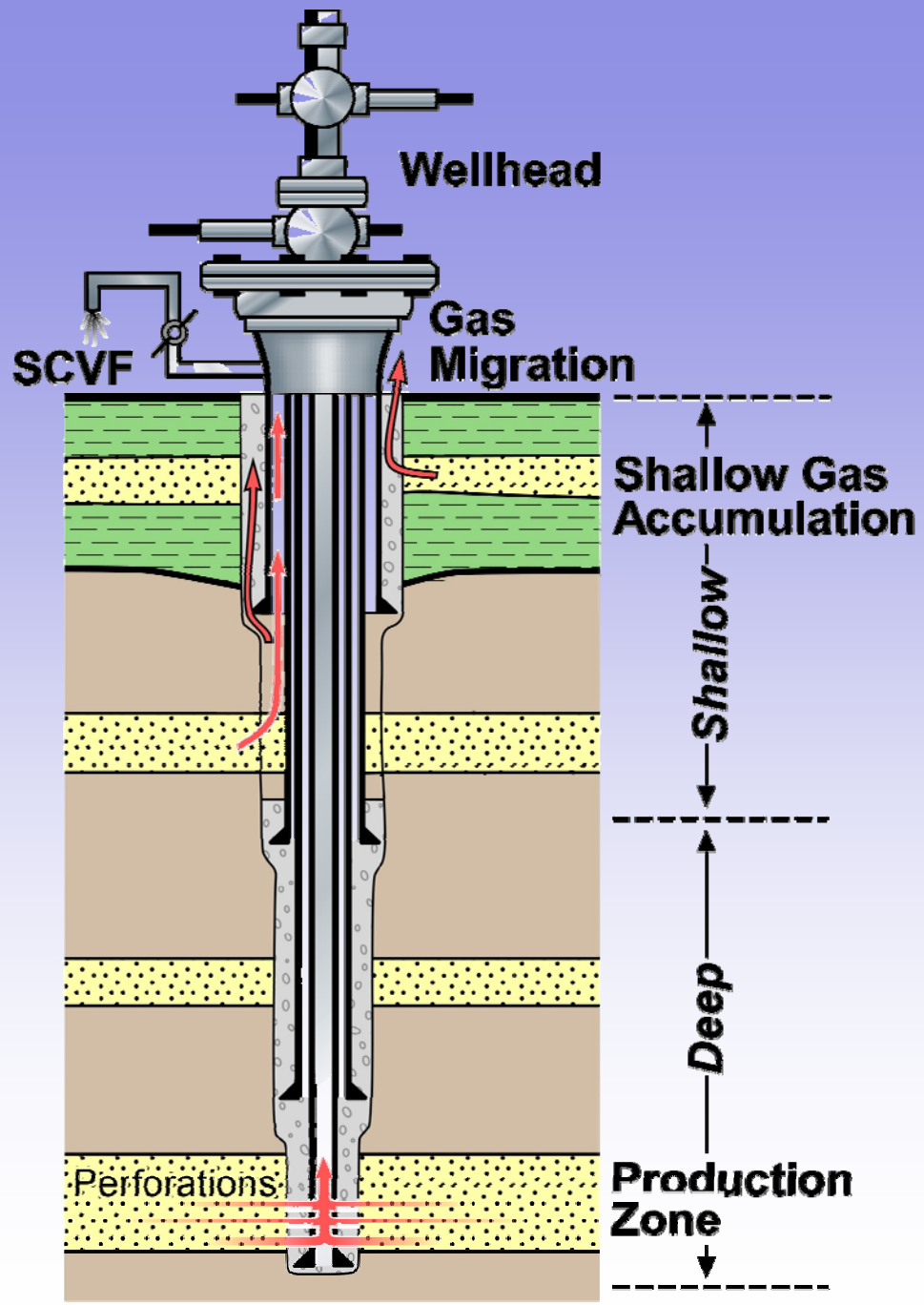
- Development of criteria for evaluating the potential for leakage along wells based on province-wide information about surface casing vent flow (SCVF), gas migration (GM) and casing failure (CF)

- Application of these evaluation criteria to the Pembina Cardium CO_2-EOR pilot operation in west-central Alberta

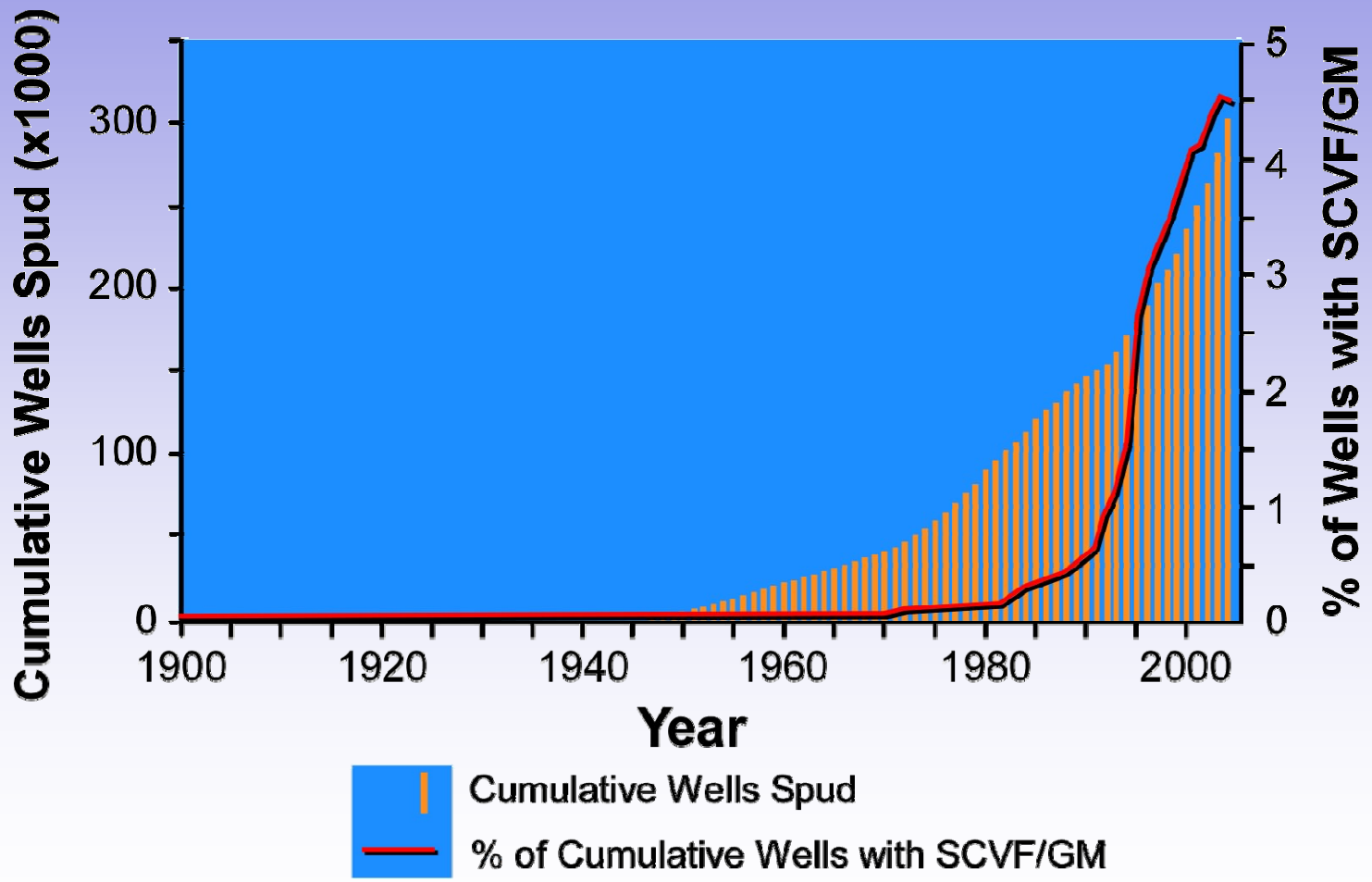
Location of the Pembina-Cardium CO_2-EOR Pilot



Surface Casing Vent Flow and Gas Migration Flow Pathways in a Well



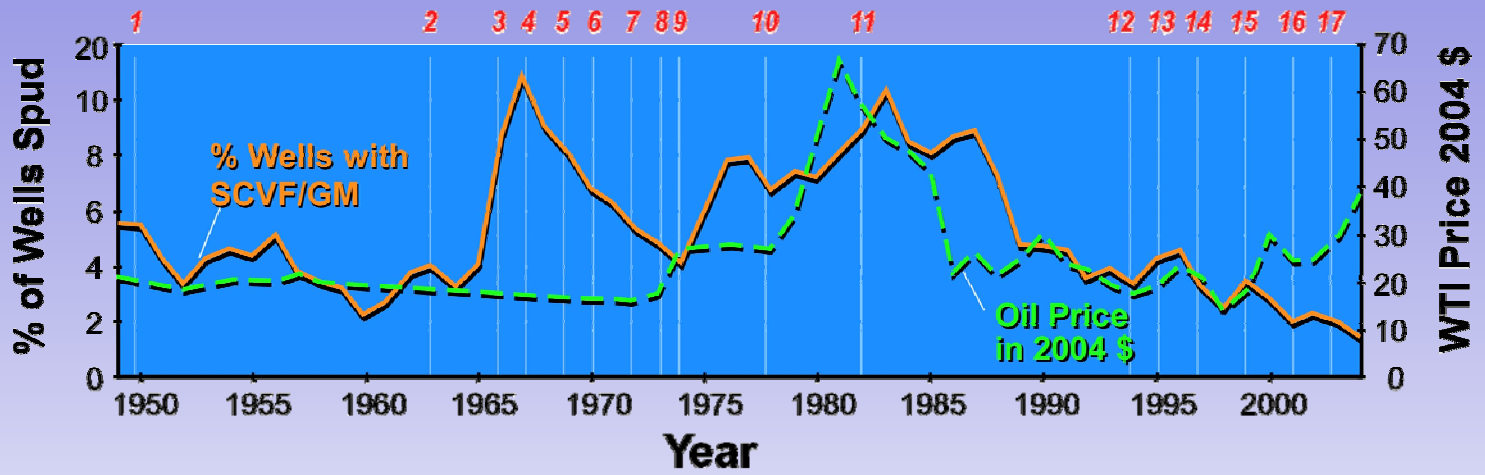
Wells with SCVF/GM Compared with Wells Drilled - Cumulative -



General CO_2 Leakage Assessment Criteria

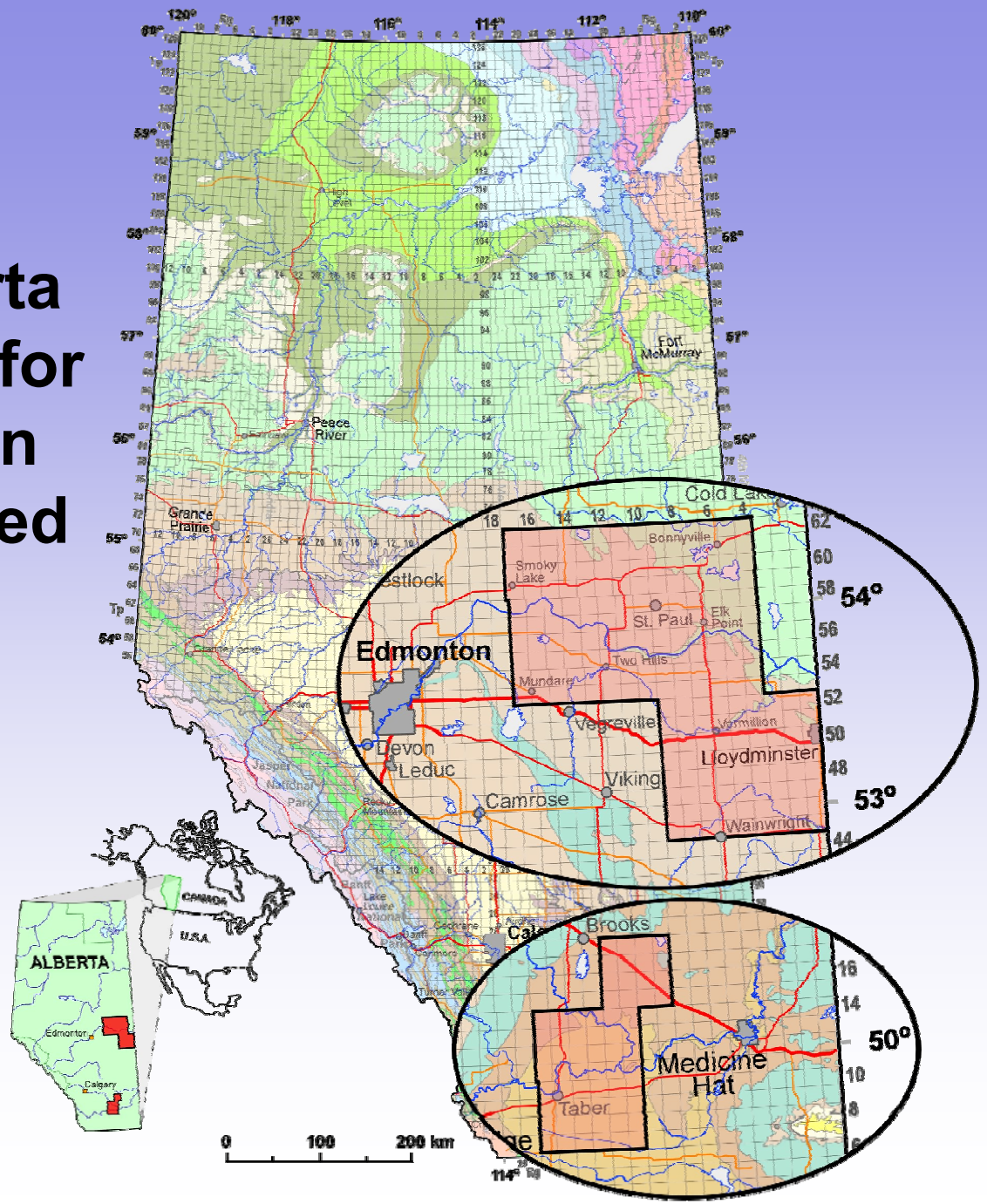
- Well age
- Well status
- Well casing
- Region (Test Area or not)
- Well direction
- Well cementing
- Level of drilling activity
- Global and local events
- Regulatory framework during well's life

Incidence of SCVF/GM in Alberta Wells versus Regulatory Measures and Oil Price

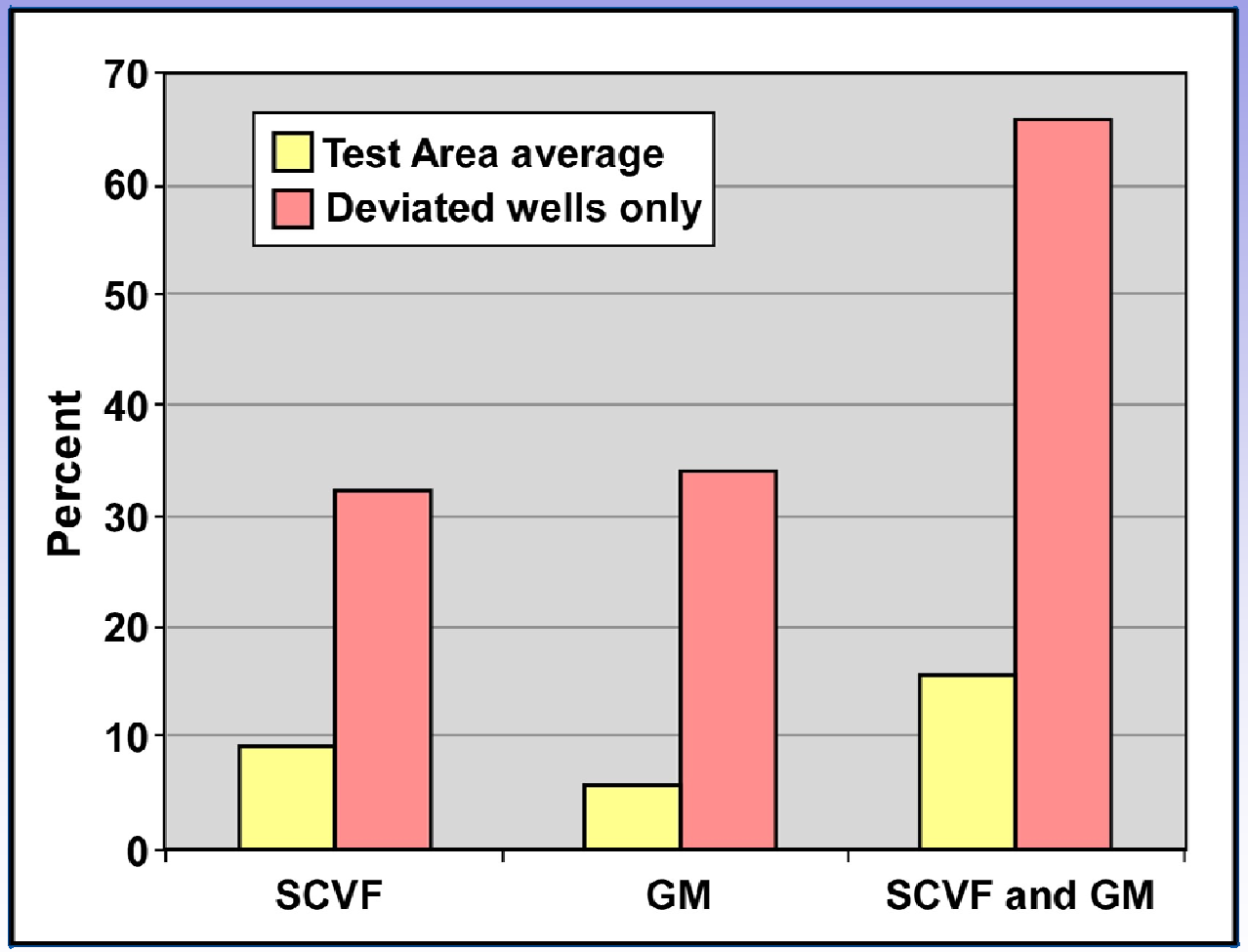


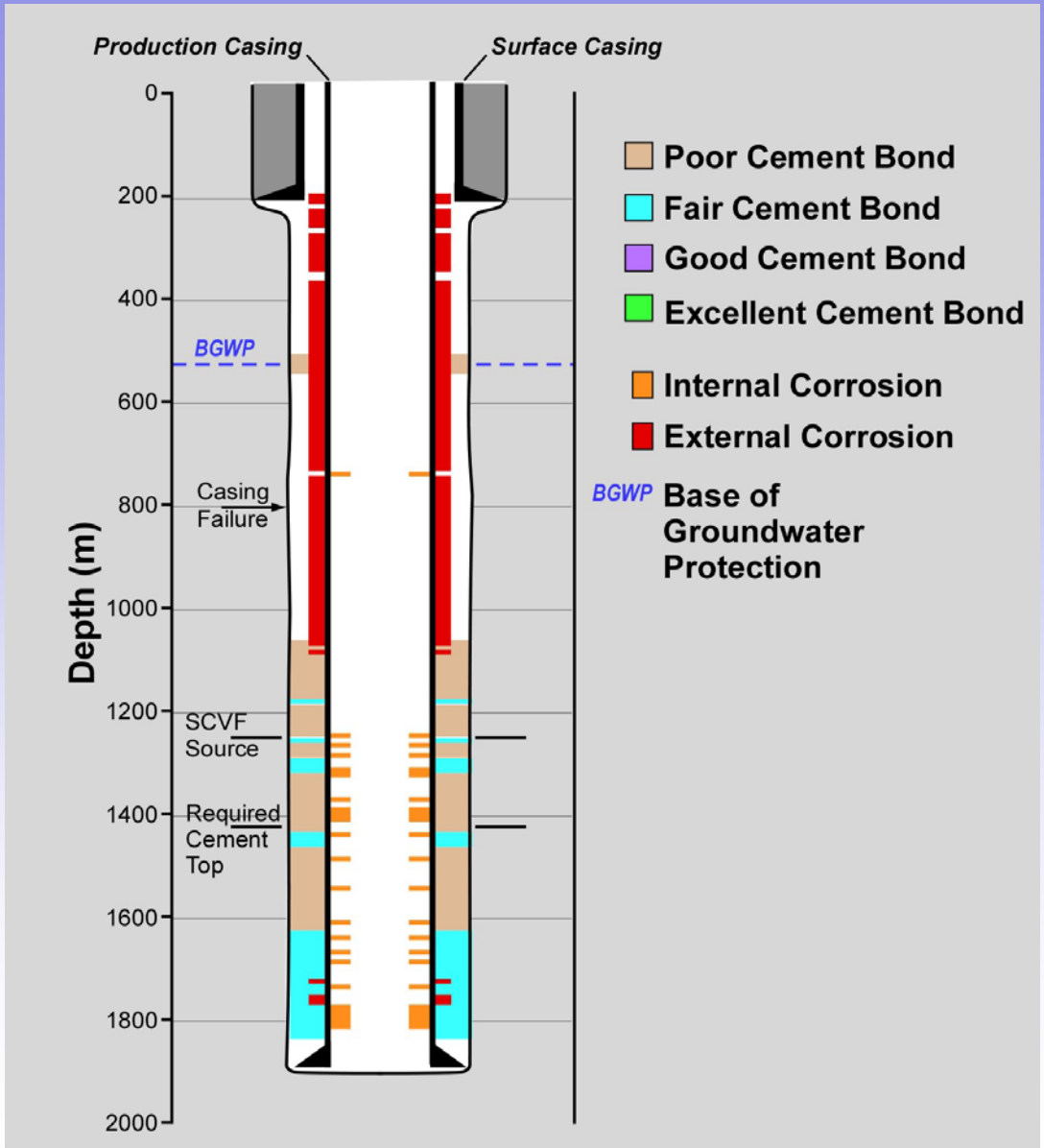
1. Oil and Gas Act
2. First SC requirements
3. First cement requirements
4. Update of SC requirements
5. Update of SC and cementing requirements
6. Intermediate casing
7. Conductor pipe requirements
8. Update of SC requirements for SE Alberta
9. Update of SC requirements for south-central Alberta
10. Cementing guide
11. Update of cementing guide
12. Requirements for GW protection and SCVF checking
13. 10-year inactive well program initiated
14. Well abandonment guide, sour well licensing
15. Requirements for SCVF/GM testing
16. Long Term Liability program replaces 10-year inactive well program
17. Update of allowable gradient for serious SCVF

Areas in Alberta where Testing for Gas Migration was/is Required



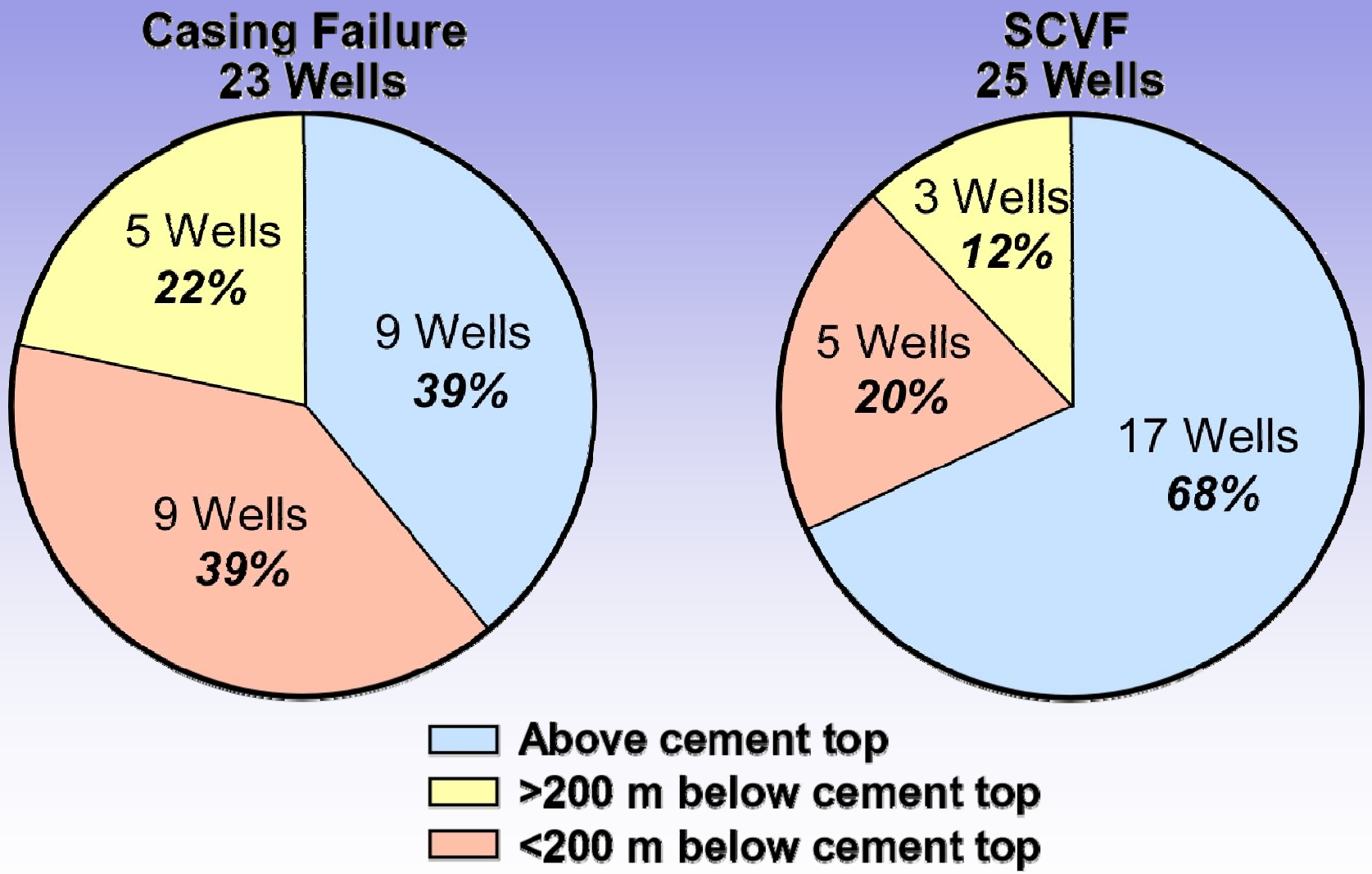
Comparison between SCVF/GM Occurrence in all Wells and Deviated Wells in the Test Area, Alberta





Example of Cement and Casing Quality in a Well in the Haynes Field, Alberta

Location of SCVF and Casing Failure in Relation to Well Cement



Impact on Well Leakage

No Apparent Impact

- Well operational mode: production, injection or disposal
- Presence of H_2S and/or CO_2
- Completion interval

Minor Impact

- Licensee
- Depth of surface casing
- Total depth
- Well density

Factors of Major Impact on Well Leakage

DIRECT

- Geographic area
- Well deviation
- Well type: drilled and abandoned, or cased and abandoned
- Abandonment method (bridge plugs, other)
- **Uncemented casing**

INDIRECT

- Economic activity
- Regulatory changes
- Well age

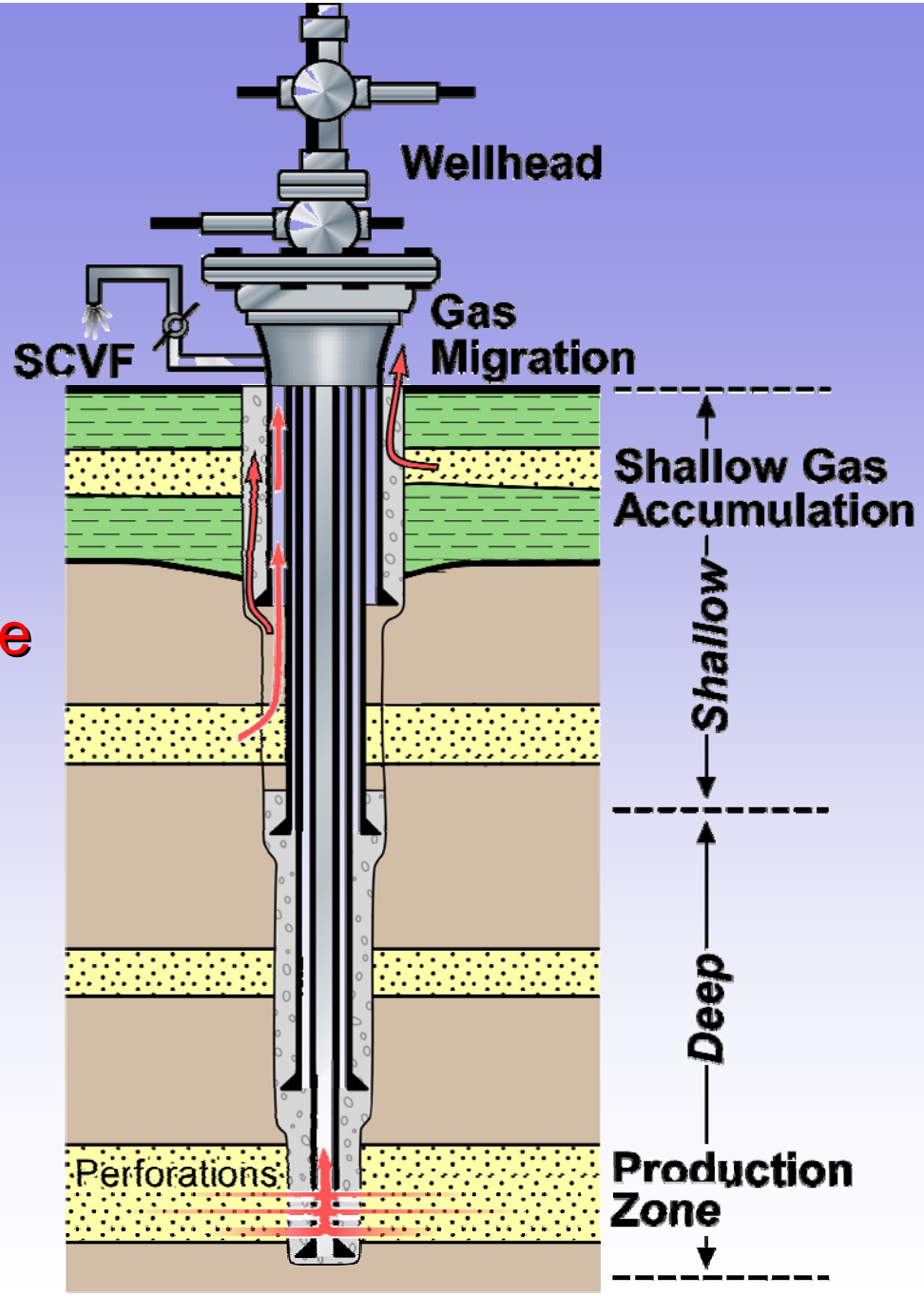
Leakage Potential along a Well

Shallower, upper part

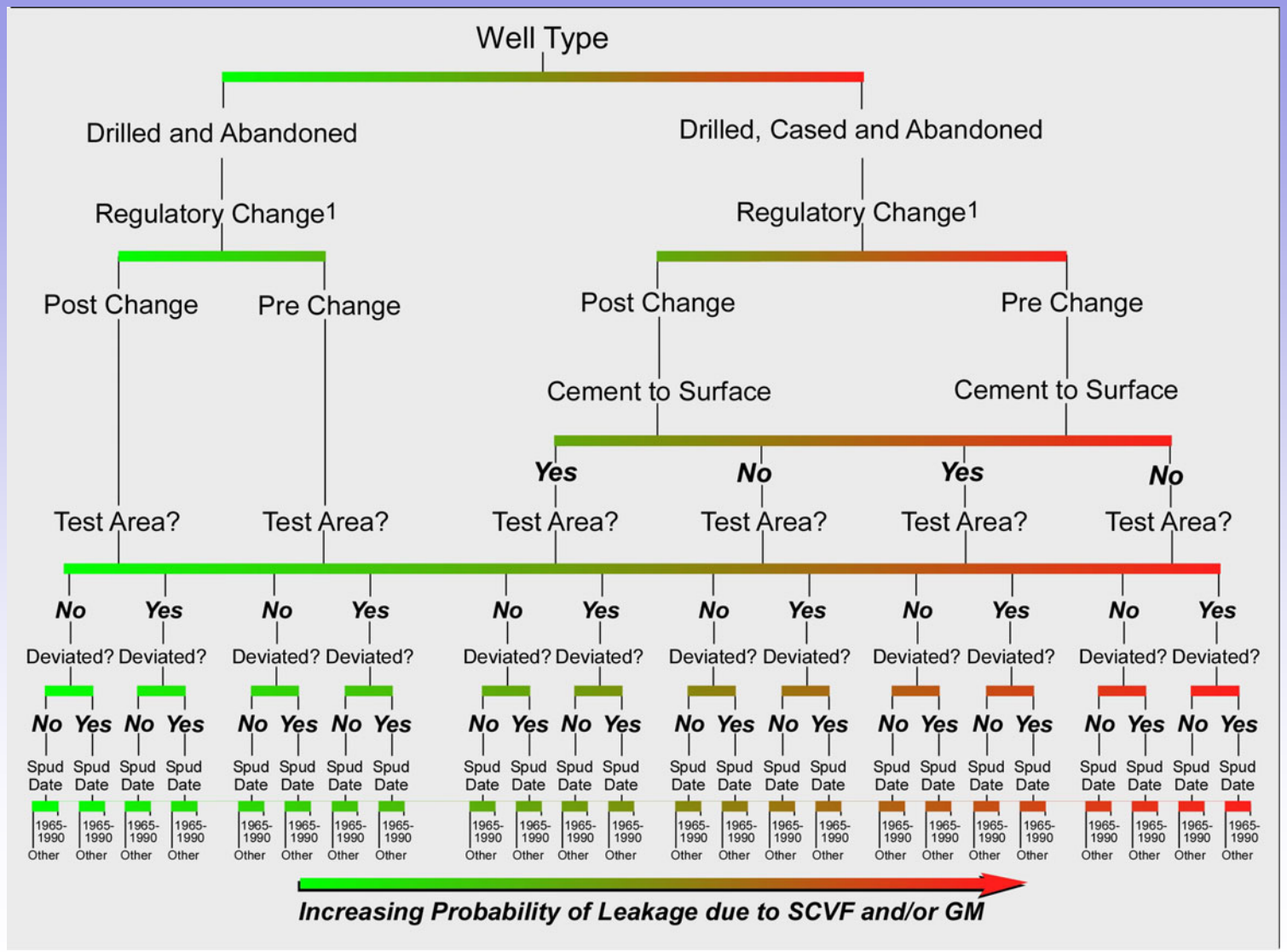
Higher potential for leakage

Deep, lower part completed in producing zones

Less potential for leakage



Assessment of the Potential for Well Leakage

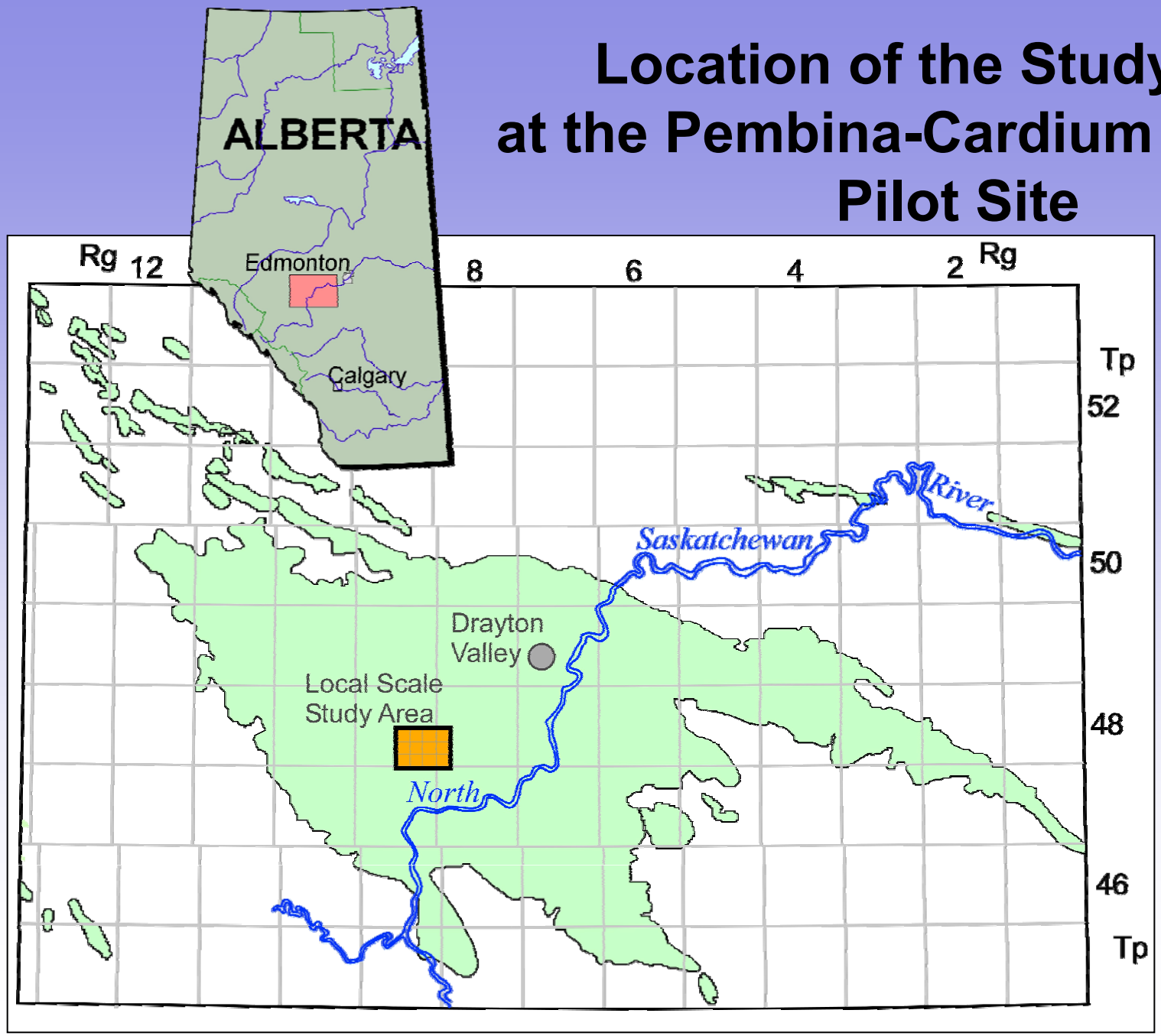


Watson & Bachu, SPE Paper 106817

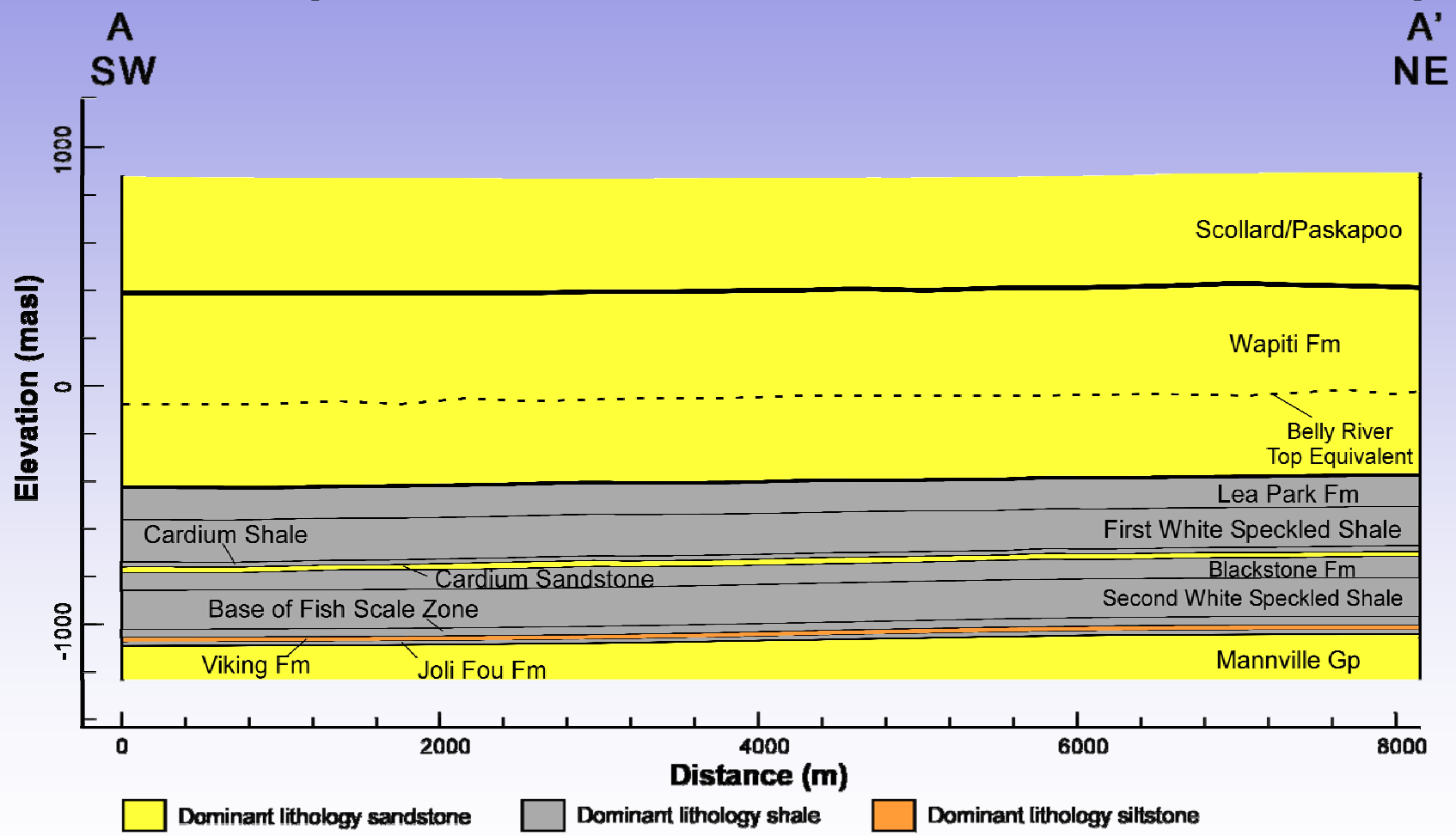
Risk Rating of Wells at the Pembina Cardium

CO_2-EOR Pilot Operation

Location of the Study Area at the Pembina-Cardium CO_2-EOR Pilot Site

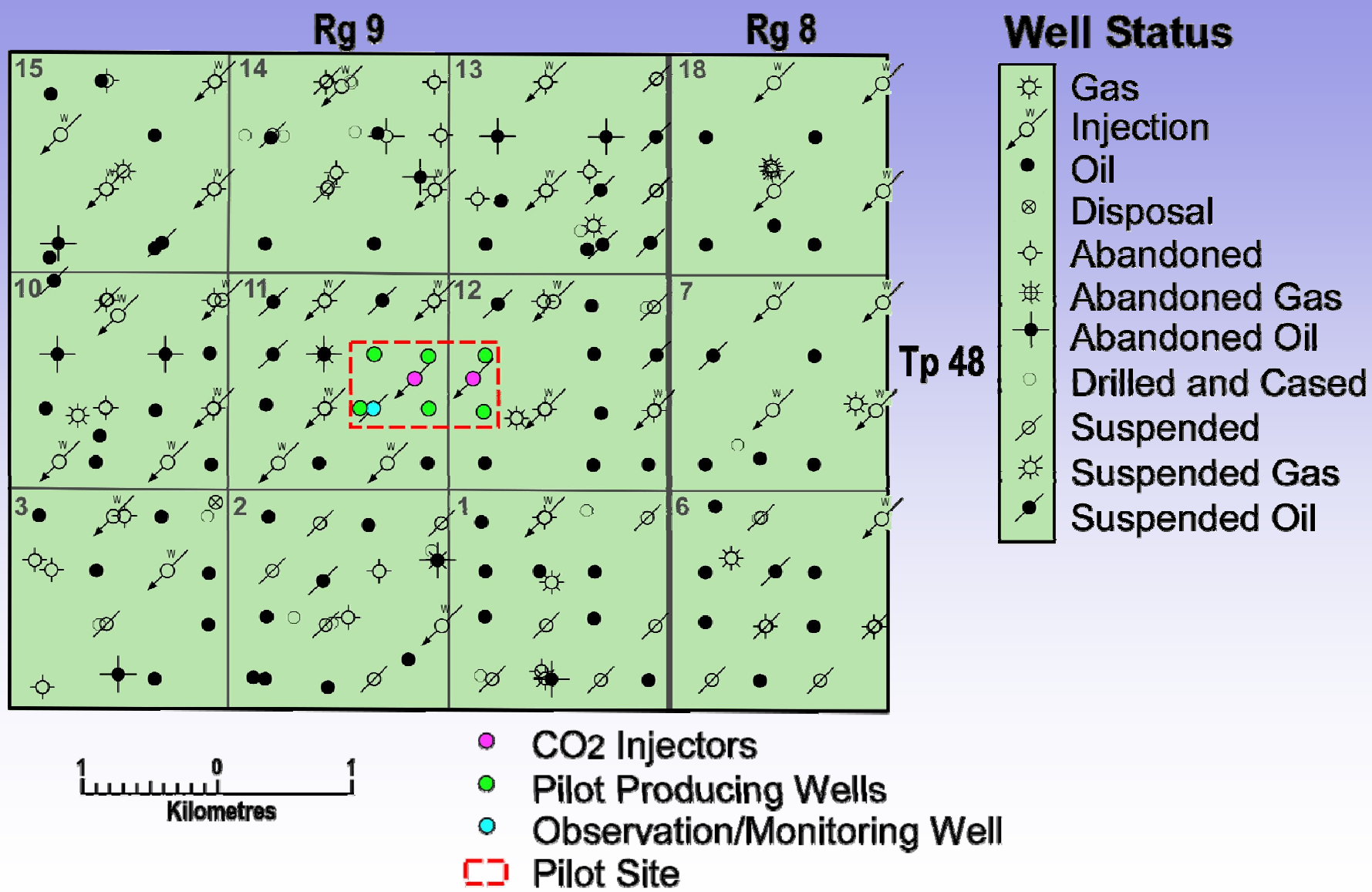


Dip Structural Cross-Section through the Local-Scale Study Area from the Base of Quaternary Drift to the Top of the Lower Cretaceous Mannville Group



Elevation in metres above sea level (masl)

Distribution of Wells in the Local-Scale Study Area



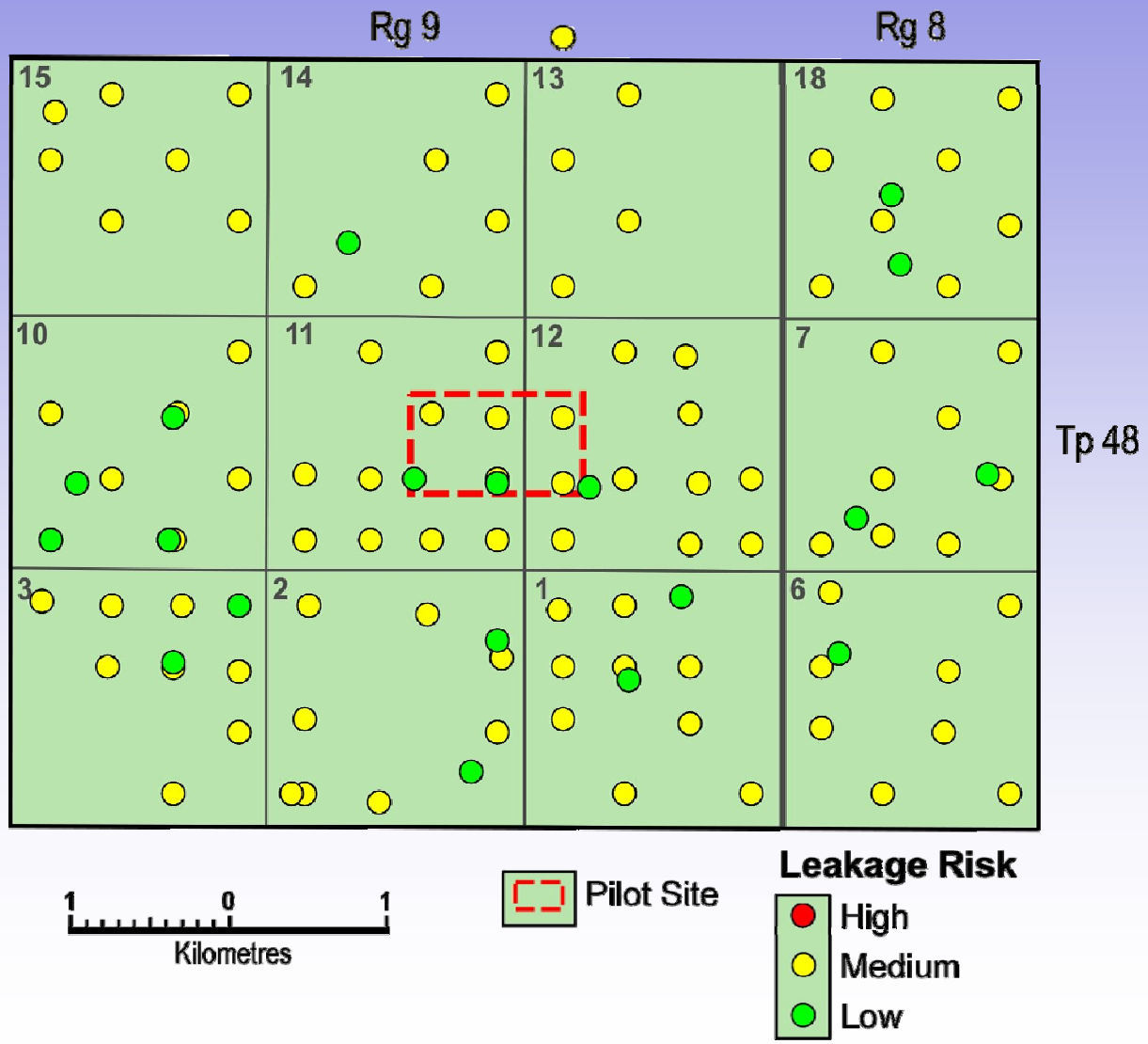
Status and Production Interval for Wells in the Pembina Cardium Local-Scale Study Area

Well Status	Edmonton Group	Cardium Fm.	Ellerslie Fm.	Ellerslie Fm. and Jurassic	Rock Creek Fm.	No Data
Oil		64	1			3
Gas	4		1			6
Injection		37				
Disposal		1				
Abandoned	1	3			1	4
Suspended		38		1		
Drilled and Cased						3
Miscellaneous						1
Total	***5***	***143***	***2***	***1***	***1***	***17***

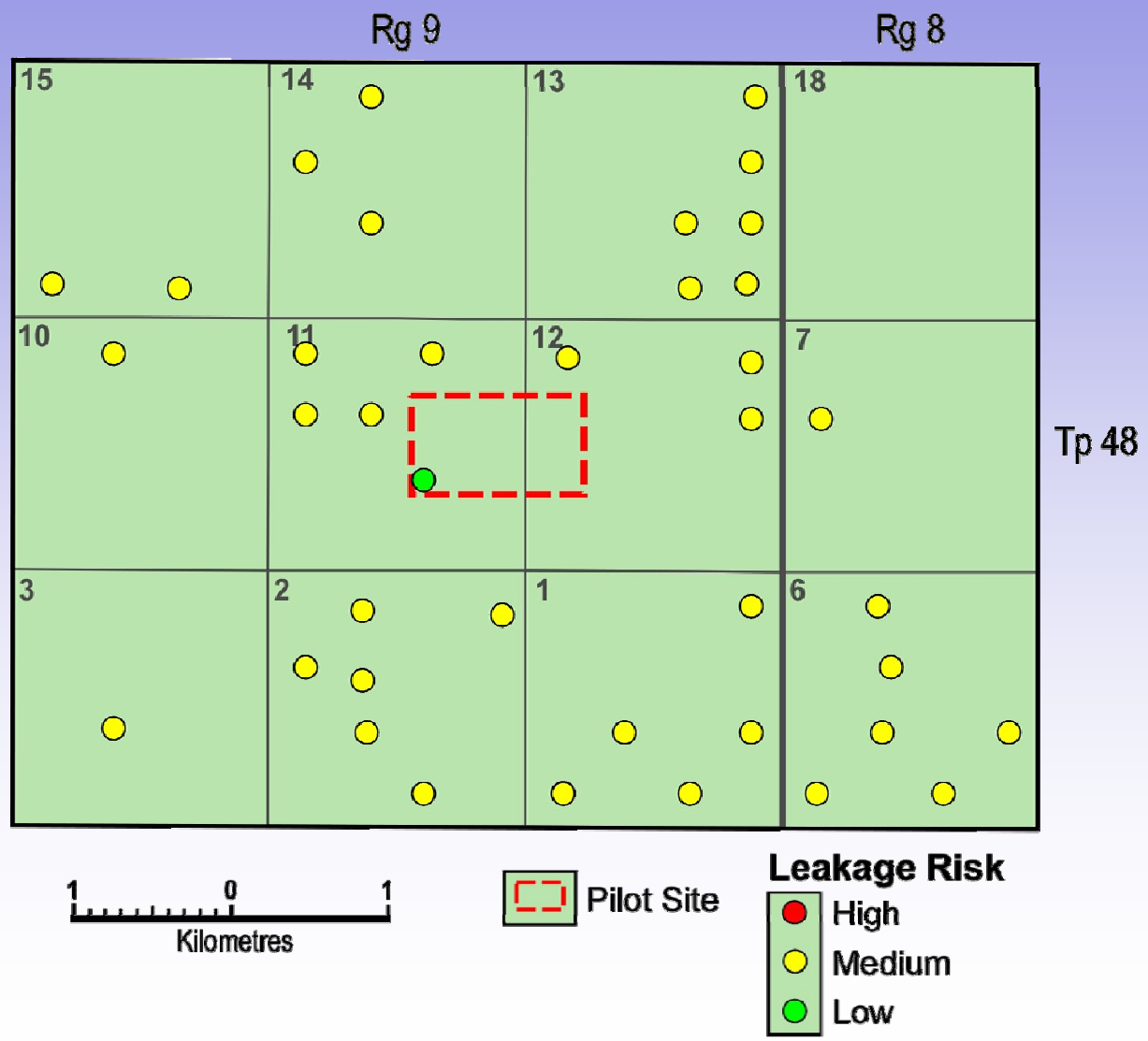
Leakage Risk Rating of Wells in the Pembina Cardium Local-Scale Study Area

Well Type	Risk Rating		
	High	Medium	Low
Active		94	26
Suspended		38	1
Abandoned	3	2	3
Drilled and Abandoned			1
Miscellaneous			1
Total	***3***	***134***	***32***

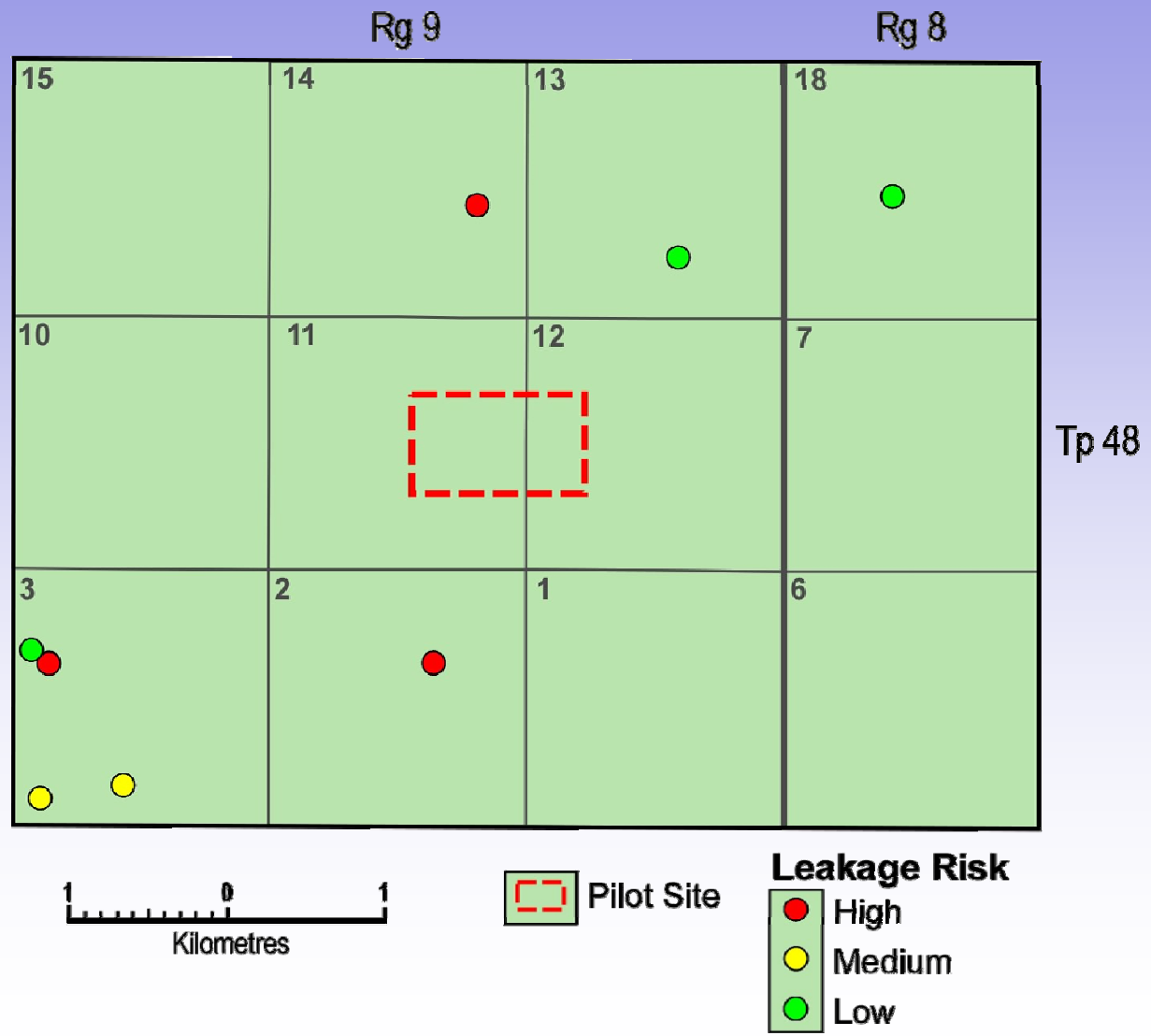
Leakage Risk Rating of Active Wells in the Pembina Cardium Local-Scale Study Area



Leakage Risk Rating of Suspended Wells in the Pembina Cardium Local-Scale Study Area



Leakage Risk Rating of Cased Abandoned Wells in the Pembina Cardium Local-Scale Study Area



Conclusions

- The majority of well leakage is due to time-independent mechanical factors controlled during well drilling, construction or abandonment, mainly cementing
- Uncemented casing is the main factor in SCVF/GM and/or casing failure occurrence
- Good quality cementing will likely protect wells against cement degradation and casing corrosion
- The deep portion of wells is usually well cemented and zonally isolated
- Good and properly-enforced regulations are key in controlling and detecting well leakage

Acknowledgements

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