

Geological, Hydrogeological and Related Subsurface Conditions Affecting Well Integrity: How Do We Identify and Evaluate Potential Risk Factors Based on Available Data?*

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Abstract

Groundwater protection is a primary concern for oil and gas related exploration and production activities in America. Maintaining well integrity is the primary tool for protecting our nation's groundwater resources from accidental well releases. Thorough evaluation of geologic and related technical considerations is critical to ensure well integrity and groundwater protection. Substantial risk is directly associated with inaccurate technical evaluations that lead to compromised annular seals, resulting in subsequent gas or fluid migration to the surface or groundwater aquifers. Well bores represent primary potential vertical gas migration conduits. Numerous leaking wells are documented at American oil and gas fields, some with catastrophic results. Most leaks are associated with abandoned oil and gas wells and old dry holes, but could include newly constructed wells with defective annular seals.

Many factors contribute to leaks in operating or abandoned wells, including engineering design and construction challenges. Several geologic factors that may cause or contribute to well integrity are listed below and discussed in the presentation. Geologic and other factors affecting annular seals and confinement include: (1) “Shallow” gas bearing zones, (2) aquifers, especially artesian aquifers, (3) “mud cake” on borehole wall, and (4) fractured zones. Thoroughly evaluating downhole conditions for geological risk factors is fundamental to design well completions that address potentially problematic subsurface geologic conditions, and thereby minimize potential adverse consequences. This presentation covers geological, hydrogeological and related subsurface risk factors that may adversely affect well integrity, and techniques to identify potential adverse downhole conditions from typical borehole logs.

GEOLOGIC, HYDROGEOLOGIC AND RELATED SUBSURFACE CONDITIONS AFFECTING WELL INTEGRITY

How do we identify and evaluate potential risk factors based on available data?



Pacific Section AAPG – Oxnard CA

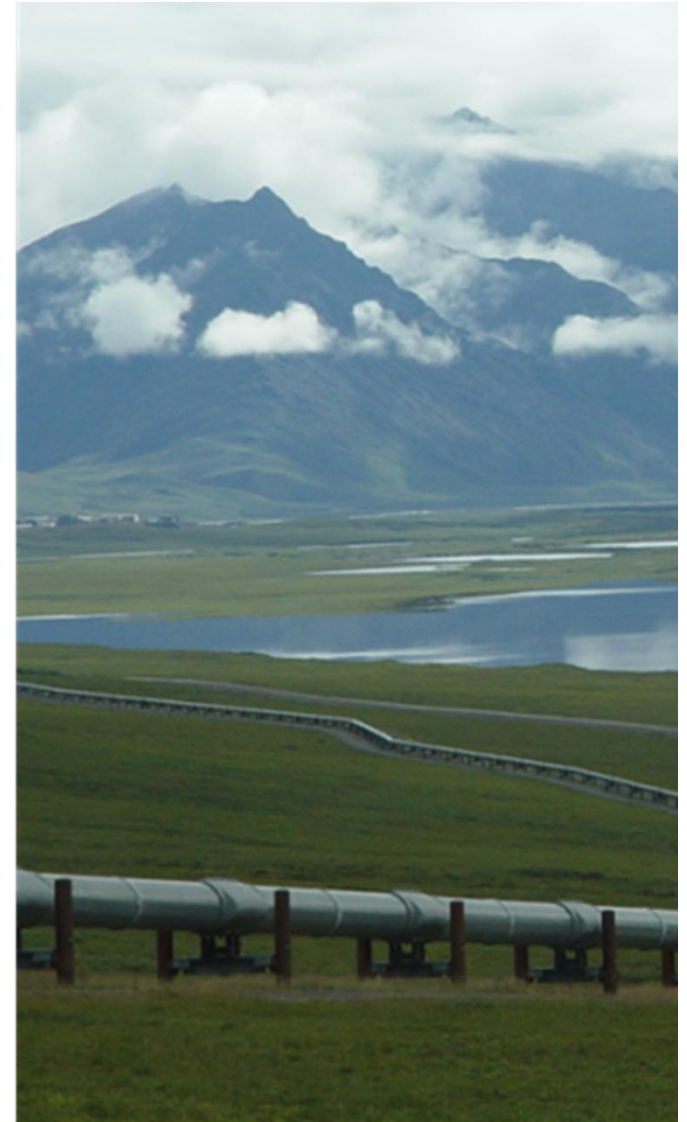
PRESENTATION OVERVIEW



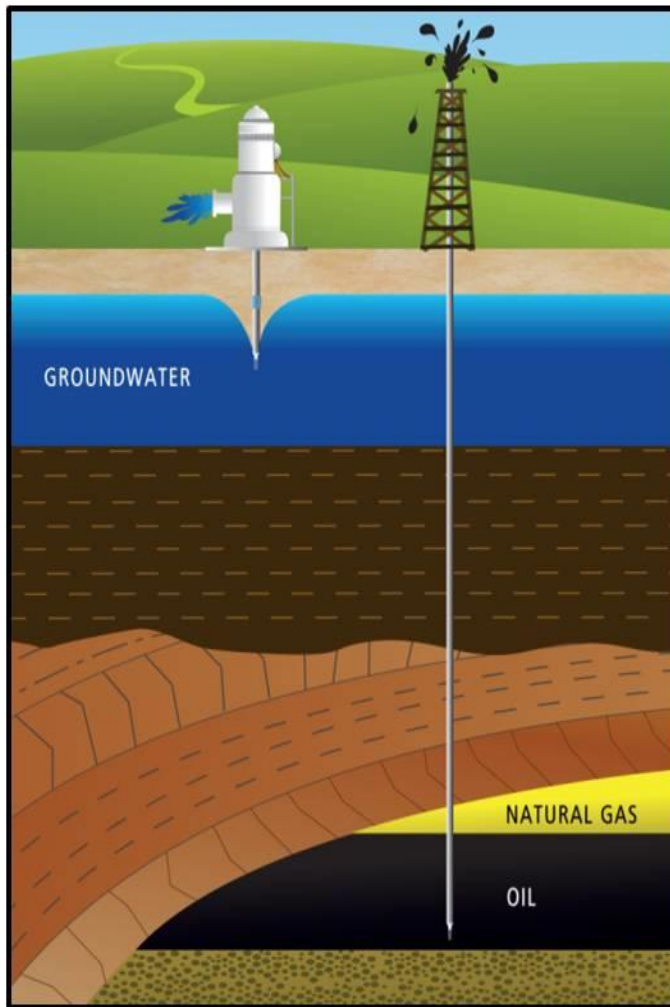
- **Introduction**
- **Issues & concerns**
 - Public perceptions
 - Potential impacts
- **Subsurface conditions**
 - Geological & hydrological
 - Others
- **Typical datasets available**
- **What does the data say?**
- **Risk management**
- **Summary & conclusions**

INTRODUCTION

- **Uncertainty surrounds new environmental regulations in California**
- **Draft EIRs under preparation by California Dept. of Conservation, Kern County**
- **Senate Bill 4 – requires reporting, monitoring and review for well permits**
- **New or pending requirements with other agencies – Kern County, SCAQMD, cities**
- **Implications?**
 - Oil and gas producers must address undefined technical requirements
 - Who are the technical experts?
 - How do we evaluate potential risks?
- **Public perceptions**



COMMON ISSUES AND CONCERNS

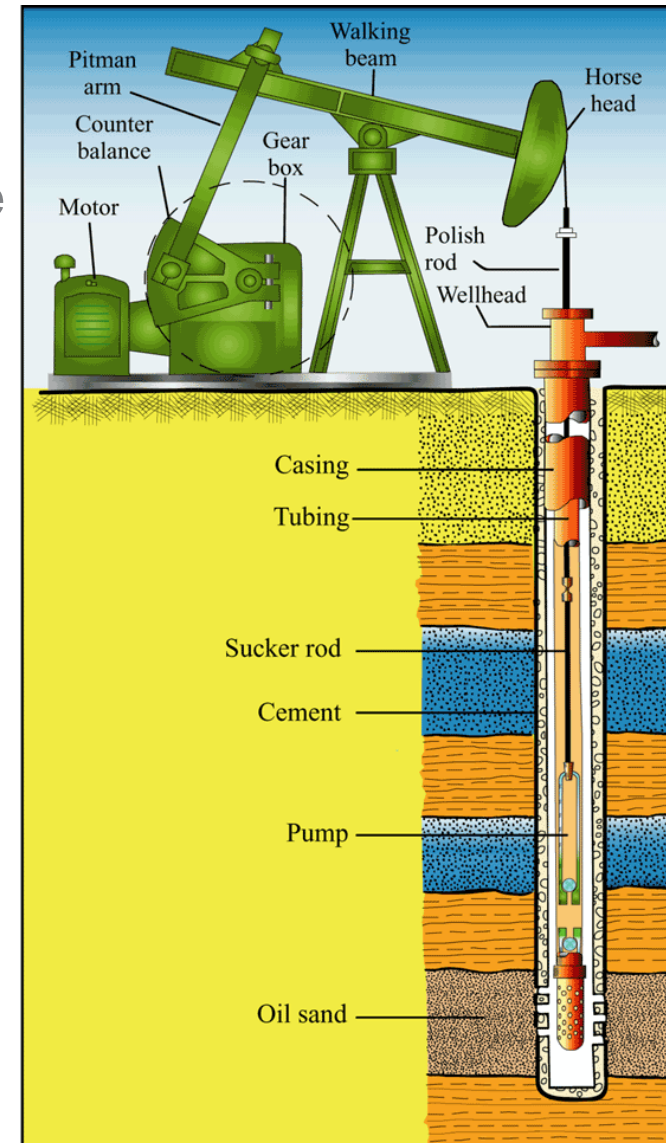
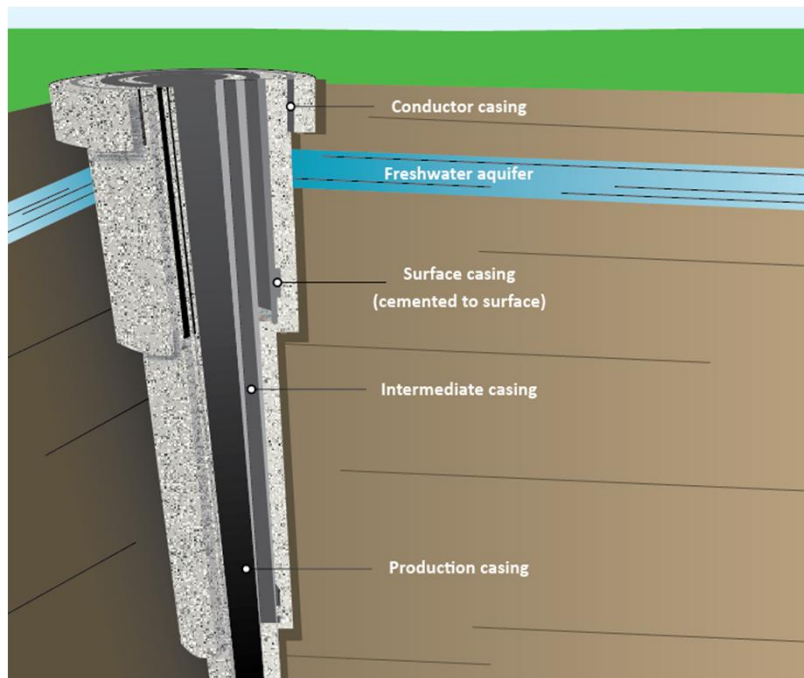


- **Primary public concerns in California cover many issues**
- **Three most often heard issues:**
 - Groundwater supplies and contamination
 - Induced seismicity and increased earthquake risks
 - Public exposure to hazardous chemicals
- **Are these concerns valid?**
- **Do we have the data to address these issues?**

TYPICAL OIL WELL

Potential Impacts

- Compromised annular seals
- Migration conduits to aquifers or surface
- Increased potential for corrosion and casing integrity degradation



POTENTIAL IMPACTS TO WELL INTEGRITY

GEOLOGICAL & HYDROGEOLOGICAL CONDITIONS

FRACTURED ZONES

- Migration pathways
- Fluid loss
- Annular space volumes

PERMEABLE LAYERS

- Water loss – lost circulation
- Cement jobs & displacement

GROUNDWATER

- Artesian conditions
- Annular seal integrity



POTENTIAL IMPACTS TO WELL INTEGRITY

OTHER SUBSURFACE CONDITIONS

- **OVER PRESSURED GAS ZONES**
 - Control with heavy mud
 - Cement bond with formation
 - Gas bubbles in cement
- **HIGH PERMEABILITY LAYERS**
 - Thick mud cake
 - Invasion
 - Affects cement bond with formation



TYPICAL DATASETS AVAILABLE

- **Resistivity logs with multiple curves (depths)**
- **Porosity logs**
- **Caliper curves for pad device logs**
- **Mud weight testing and modifications**
- **Gas monitoring during drilling**
- **Driller's logs**
- **Mud logs**
- **Geologic observations & descriptions**



EVALUATING DATA – WHAT SHOULD WE LOOK FOR?



- **Mud logs**
 - Water influx – losing mud weight
 - Mud/water loss into formation
 - Gas “kicks”
- **Caliper logs – repeat sections**
 - Fractures
 - Thick mud cake
 - Washouts
- **Resistivity logs**
 - Deep invasion
 - Interbedded zones – micro tools
- **Porosity logs**
 - Neutron
 - Density
 - Sonic

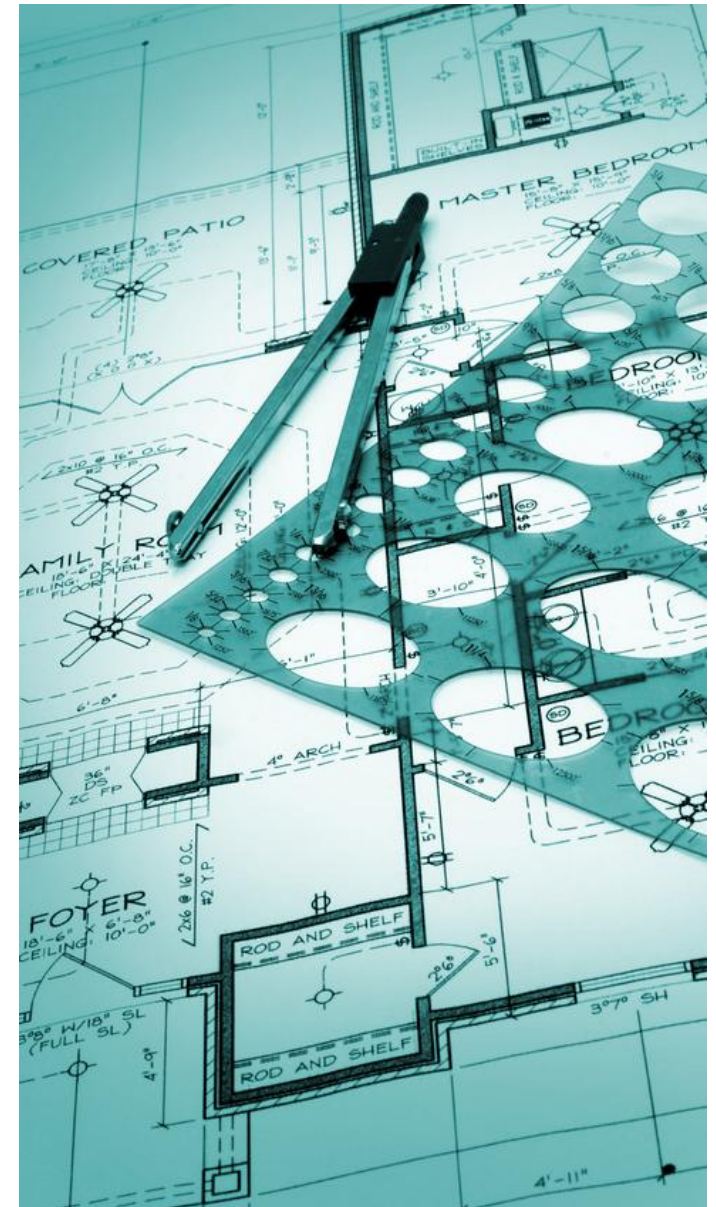
RISK ASSESSMENT & MANAGEMENT

■ Well integrity

- Most releases associated with well failures
- Evaluate geophysical logs
- Analyze other downhole data
- Review well design
- Construction inspection & well testing

■ Comply with new CA regulations

- Public noticing & disclosure
- Groundwater monitoring & testing
- Seismic monitoring
- Regulations will evolve



Summary and Conclusions

- O&G wells designed & constructed to protect environment
- Compromised well integrity – important potential GW risk
- Data available to evaluate potential risks & impacts
- Additional technical knowledge & skills required to assess risks
- Potential new roles for engineers, hydro & petroleum geologists
- Review & comment on new draft regulations



Questions

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