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Systematic Evaluation of Salt Cavern Well Integrity

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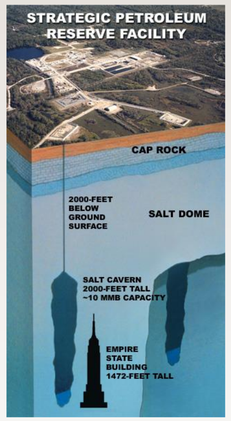
Abstract

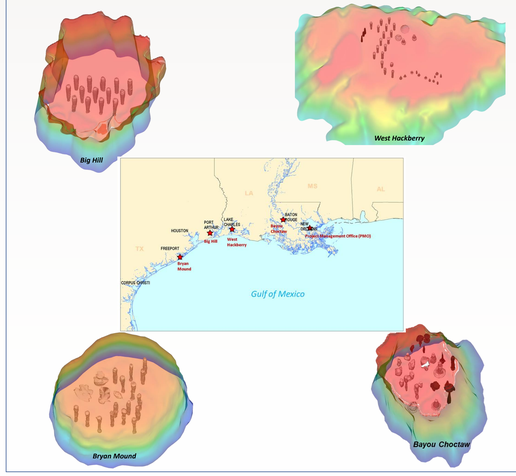
The U.S. Strategic Petroleum Reserve (SPR) holds a reserve of crude oil (~700 million barrels) to help ease any interruptions in oil import to the United States. The oil is stored in a set of 63 underground caverns distributed across four sites along the U.S. Gulf Coast. The caverns were solution mined into salt domes at each of the four sites. The plastic nature of the salt is beneficial for the storage of crude oil as it heals any fractures that may occur in the salt. The SPR is responsible for operating and maintaining the nearly 120 wells used to access the storage caverns over operational lifetimes spanning decades. Salt creep can induce deformation of the well casing which must be remediated to insure cavern and well integrity. This is particularly true at the interface between the plastic salt and the rigid caprock.

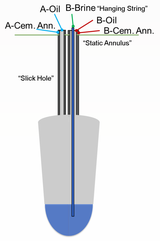
The Department of Energy, the SPR Management and Operations contractor, and Sandia National Laboratories has developed a multidimensional well-grading system for the salt cavern access wells. This system is designed to assign numeric grades to each well indicating its risk of losing integrity and remediation priority. The system consists of several main components which themselves may consist of sub-components. The main components consider such things as salt cavern pressure history, results from geomechanical simulations modeling salt deformation, and measurements of well casing deformation due to salt creep. In addition, the geology of the salt domes and their overlying caprock is also included in the grading. These multiple factors are combined into summary values giving the monitoring and remediation priority for each well.

US Strategic Petroleum Reserve

- SPR is spread across 4 Gulf Coast site locations
- Current oil inventory of about 700 million barrels
- Composed of 63 caverns solution-mined into salt domes
- About 120 cavern access wells – differing completions
- Length of cased well sections range from ~1400 to ~2500 feet
- Mixture of pre-existing and purpose built caverns
- SPR – owned by DOE
  - Managed/operated by FFPO
  - SNL geotechnical advisors







Background - Motivation

- The SPR must maintain the integrity of cavern access wells to meet drawdown requirements
  - Wells occur in differing geologic settings
  - Differing well completions
  - A multitude of cavern geometries
- Some well failures have occurred at some SPR sites
- Evidence from multi-arm caliper logs of accumulating casing deformation
- Need to prioritize remediation/monitoring resources

Solution

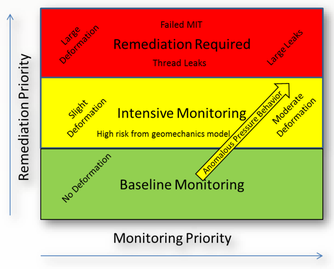
Develop a multi-dimensional well integrity assessment tool. This tool will provide a numeric grading of each well's likelihood of experiencing integrity issues. These grades can then be used in allocating remediation resources. Discussions amongst subject matter experts resulted in the inclusion of the following main well grading components:

1. Cavern pressure history
2. Multi-arm caliper survey results
3. Geomechanical simulation results
4. Geological elements
5. Well history
6. Cavern Geometry
7. Offsite activities

Remediation Grade

Monitoring Grade

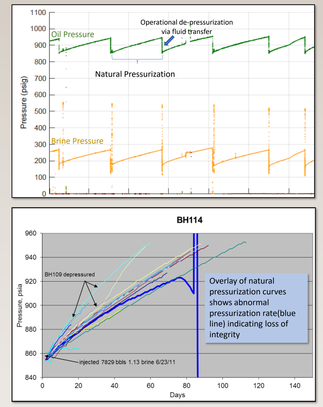
Each main component may have various sub-components.



Well Grading Components

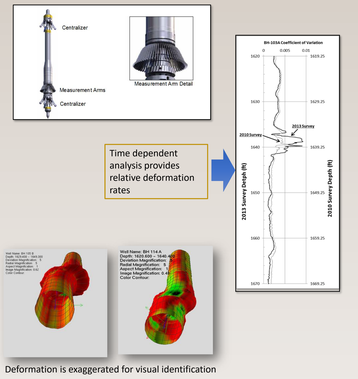
Cavern Pressure History

Cavern pressure is an immediate indicator of integrity issues



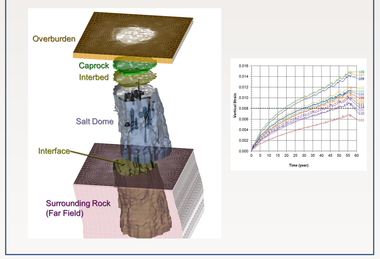
Multi-Arm Caliper

Radial measurements of inner casing informs on deformation which may lead to loss of well integrity



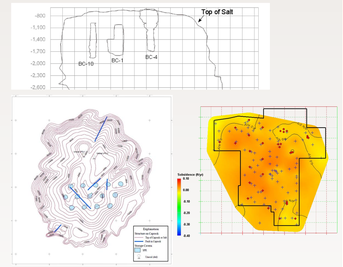
Geo-mechanical Simulations

Stress/Strain data from simulation results are used to inform on which wells may exhibit future integrity issues



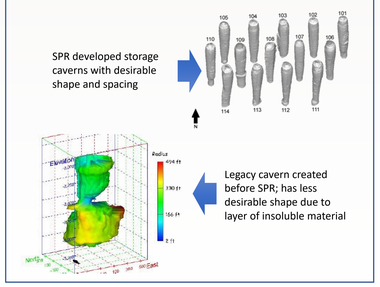
Geological Elements

Properties of the salt dome and caprock which can impact well integrity (faults, caprock thickness, subsidence etc.)



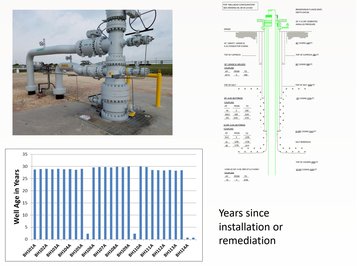
Cavern Geometry

Shape of cavern and its proximity to edge of the salt dome and to other caverns can inform on potential integrity issues



Well History

The age, deviation from vertical, and any historical integrity issues are useful in determining potential for future issues



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