Well Integrity - Response from Storage and EOR Operators

FEW0191 – Task 7

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Motivation

To define well integrity research needs based on input from CO_2 storage projects

Depleted oil and gas reservoir.
Weyburn, Canada
www.thestarphoenix.com

Projects span small demonstrations to commercial operations across the globe

Carbon Storage Atlas, 5th addition, 2015

Projects span small demonstrations to commercial operations across the globe

PROJECT LOCATION	OPERATIONS	RESERVOIR TYPE	OPERATOR/ PARTNER	DOE CONTRIBUTION
CarbFix Europe, Iceland	CO_2 stream from Hellisheidi geothermal power plant	Saline Basalt	Reykjavik Energy	Supporting Columbia University Lamont-Doherty Earth Observation to test tracer methods to assess trapping mechanisms in basalt formations.

PROJECT LOCATION	OPERATIONS	RESERVOIR TYPE	OPERATOR/ PARTNER	DOE CONTRIBUTION
Weyburn-Midale North America, Canada, Saskatchewan	2.8 million metric tons CO_2/year Commercial in 2000	Oilfield Carbonate EOR	Cenovus, Apache, Petroleum Technology Research Centre	DOE is a lead sponsor of the IEAGHG research project and U.S. scientists test multiple monitoring and simulation technologies.
Zama Oilfield North America, Canada, Alberta	360,647 tons of CO_2 injected during Phase III and 29,966 tons of CO_2 injected during Phase II	Oilfield Carbonate EOR	Apache (RCSP)	Supported the PCOR Partnership to conduct monitoring and reservoir modeling of CO_2 injection into pinnacle reefs.
Fort Nelson North America, Canada, British Columbia	Anticipated injection of >1 million metric tons CO_2/year 1.8 million metric tons acid gas/year Large-scale demonstration	Saline Carbonate Formation	Spectra Energy (RCSP)	Supporting the PCOR Partnership to conduct monitoring and reservoir modeling studies.
Aquistore North America, Canada, Saskatchewan	Up to 1,000 metric tons CO_2/day	Saline Sandstones	Petroleum Technology Research Centre	Supporting LBNL in performing seismic testing and distributed acoustic sensor monitoring, as well as the PCOR Partnership performing reservoir modeling and simulation.

PROJECT LOCATION	OPERATIONS	RESERVOIR TYPE	OPERATOR/ PARTNER	DOE CONTRIBUTION
Sleipner Europe, Norway, North Sea	1 million metric tons CO_2/year Commercial in 1996	Saline Marine Sandstone	StatoilHydro	Supporting Indiana University for reservoir modelling and the Scripps Institute of Oceanography for past time-lapse gravity surveys.
Snøhvit CO2 Storage Europe, Norway, North Sea	700,000 metric tons CO_2/year Commercial in 2008	Saline Marine Sandstone	StatoilHydro	Supported LLNL to simulate geomechanical conditions of the reservoir and caprock with a focus on probabilistic analysis of the potential for fault reactivation and dynamic well test analysis and continuous inversion of gage data.
CO2SINK, Ketzin Europe, Germany	60,000 metric tons CO_2 Demonstration 2008	Saline Sandstone	GeoForschungsZentrum, Potsdam	Supporting LBNL to deploy downhole monitoring technology based on seismic and thermal perturbation sensors and Multi-Phase Technologies, LLC, to conduct electromagnetic monitoring.

PROJECT LOCATION	OPERATIONS	RESERVOIR TYPE	OPERATOR/ PARTNER	DOE CONTRIBUTION
In Salah Gas Africa, Algeria	3.8 million metric tons CO_2 injected Commercial from 2004 – 2008	Gasfield Sandstone	BP, Sonatrach, StatoilHydro	Supporting LLNL and LBNL to test field and remote sensing monitoring technologies and modeling geomechanical and geochemical reservoir processes.
Otway Basin Australia, Victoria	65,000 metric tons CO_2 Stage I 2008, Stage II 2011	Gasfield and Saline Sandstone	CO_2CRC	Supporting LBNL to test multiple monitoring technologies at depleted gasfield and saline formations, including geochemical U-tube sampling and tracer studies, and seismic fiber optic acquisition.
Ordos Basin Asia, China	100,000 metric tons CO_2/year	Ordos Basin	Shenhua Coal	Supporting West Virginia University and LLNL in assessment of capacity for storage, and simulation of hydrogeologic and geochemical reservoir conditions.

Carbon Storage Atlas, 5th addition, 2015

Accomplishments

- Survey has been vetted by Industry and DOE
- Sent to the operators of 52 sites
- Responses are anonymous
- 16 responses 23Aug2019

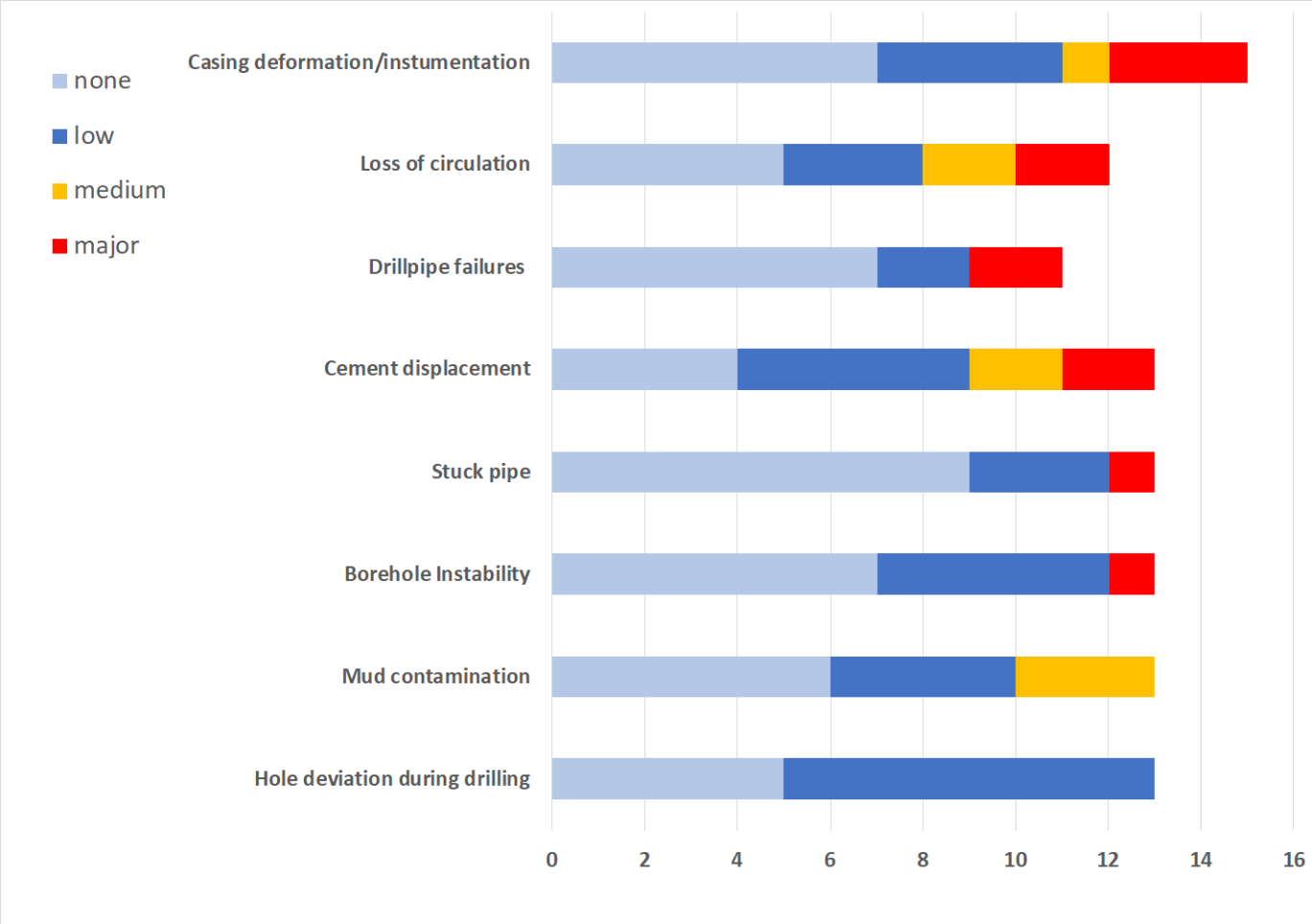
Preliminary Survey Results

- Most projects are on shore
  - Saline reservoirs and CO_2-EOR operations
  - More than 1000 meters deep
  - Less than 70°C
  - At or below hydrostatic pressure
- CO_2 injection
  - 1 to more than 9 years
  - Less than 10,000 to more than 1,000,000 tonnes
  - 10,000 to 1,000,000 tonnes/year
- Most wells are vertical
- Number of wells
  - 1 to more than 100 injection wells
  - 1 to 100 legacy wells

Survey suggests that most integrity issues are manageable

- We will highlight issues that could benefit from additional information
  - Construction
  - Operations
  - Material Degradation
  - Risk factors leading to leakage
  - Leakage Monitoring

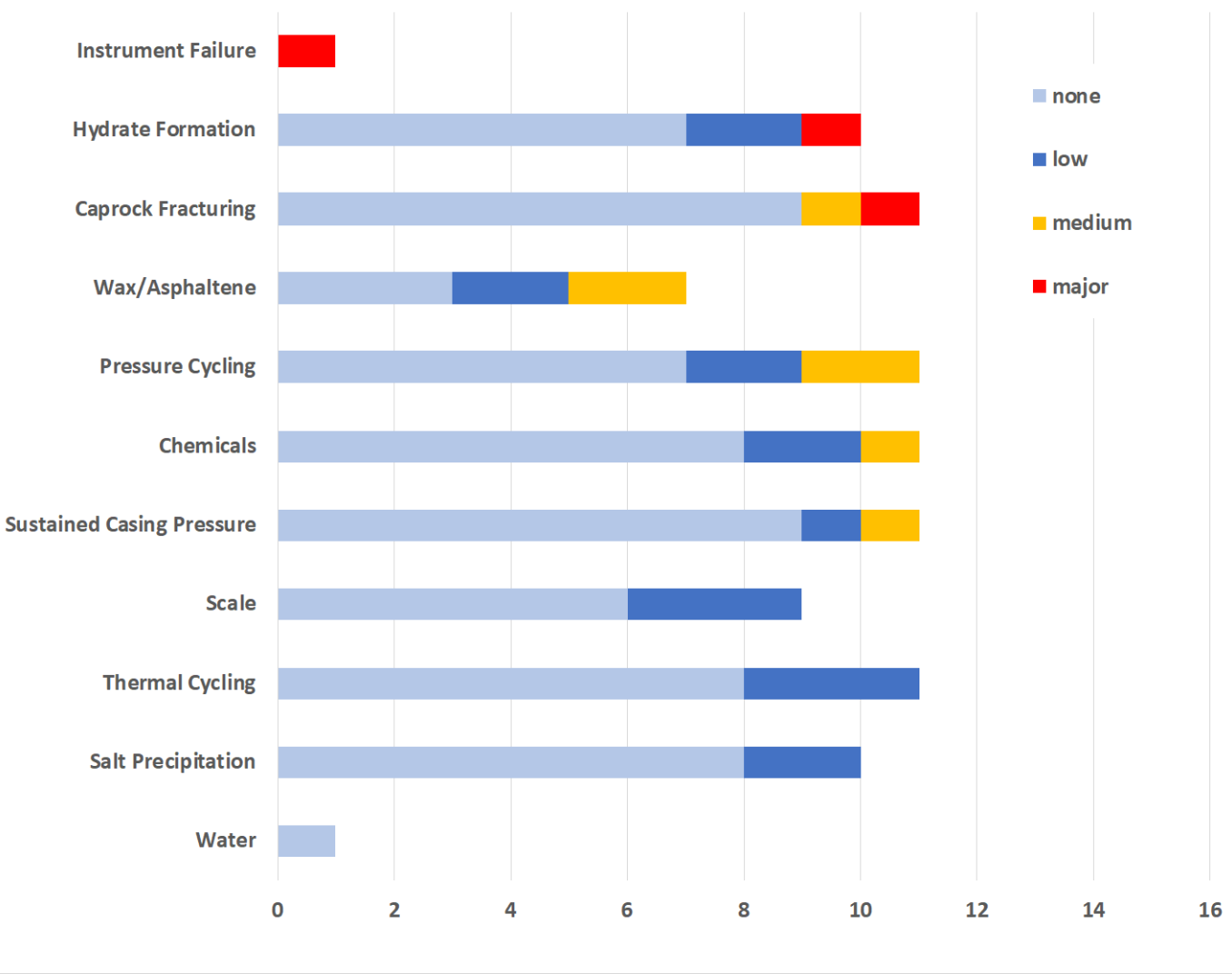
Construction - Impacts



Construction

- Research Recommendations
  - Better characterization of stress state and geology near the well bore
  - Well designs that accommodate the state of stress and local geology

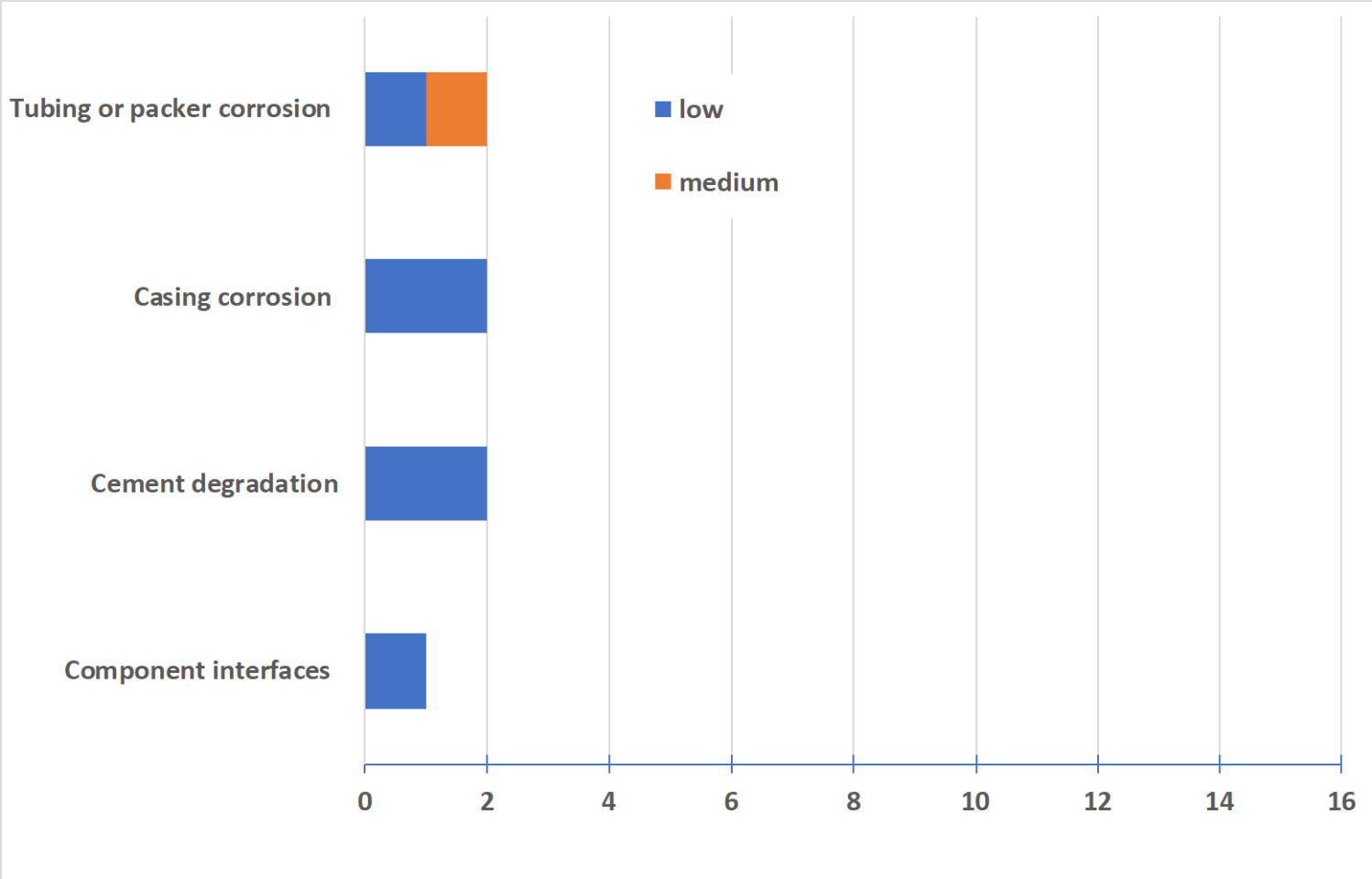
Operations - Impacts



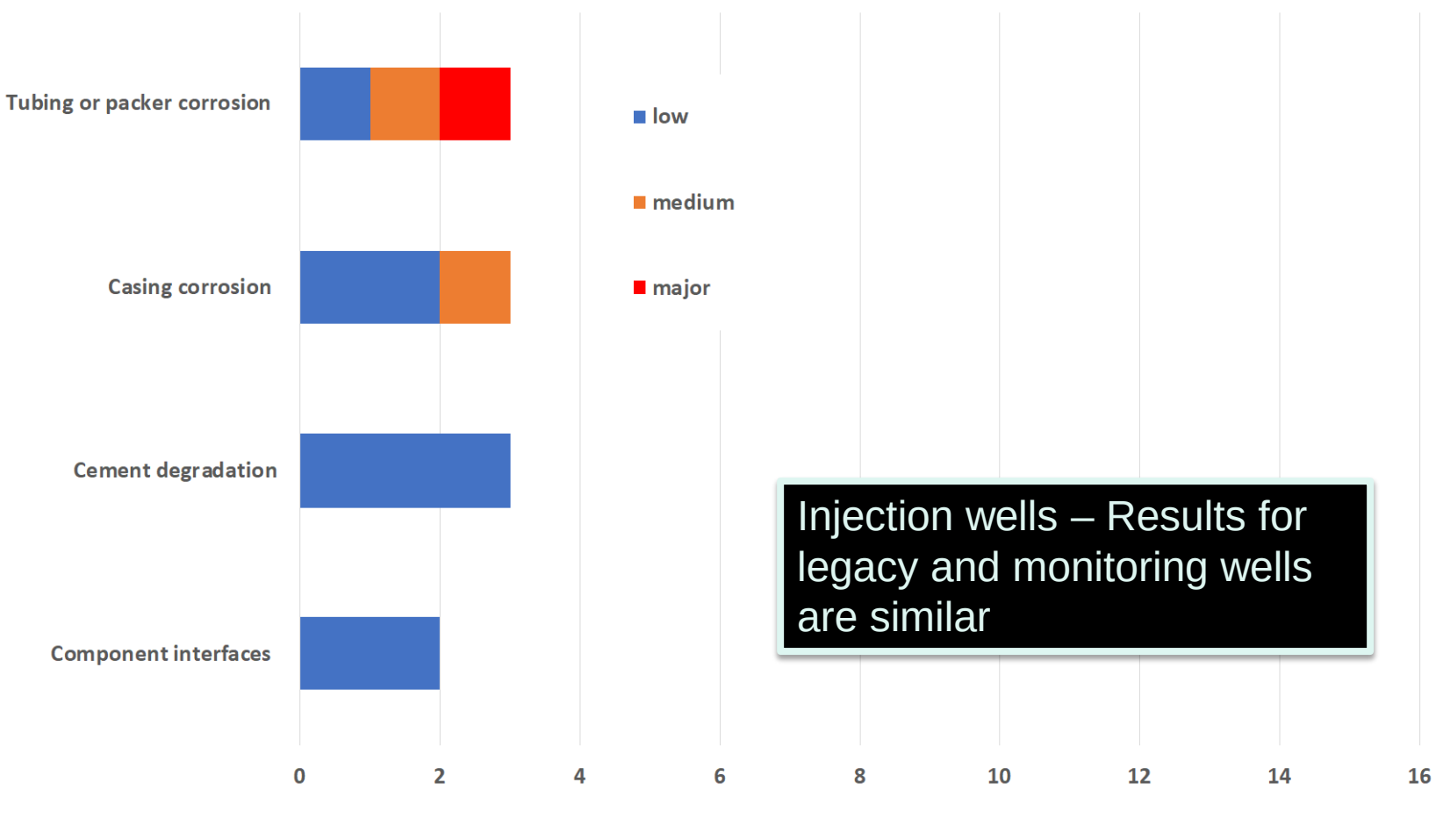
Operations

- Research Recommendations
  - Robust instrumentation
  - Improved understanding between injection, pressure, and materials and caprock performance
  - Improved understanding between fluid chemistry, temperature and pressure on hydrate/organic solids formation

Impacts: Acute degradation of wellbore materials



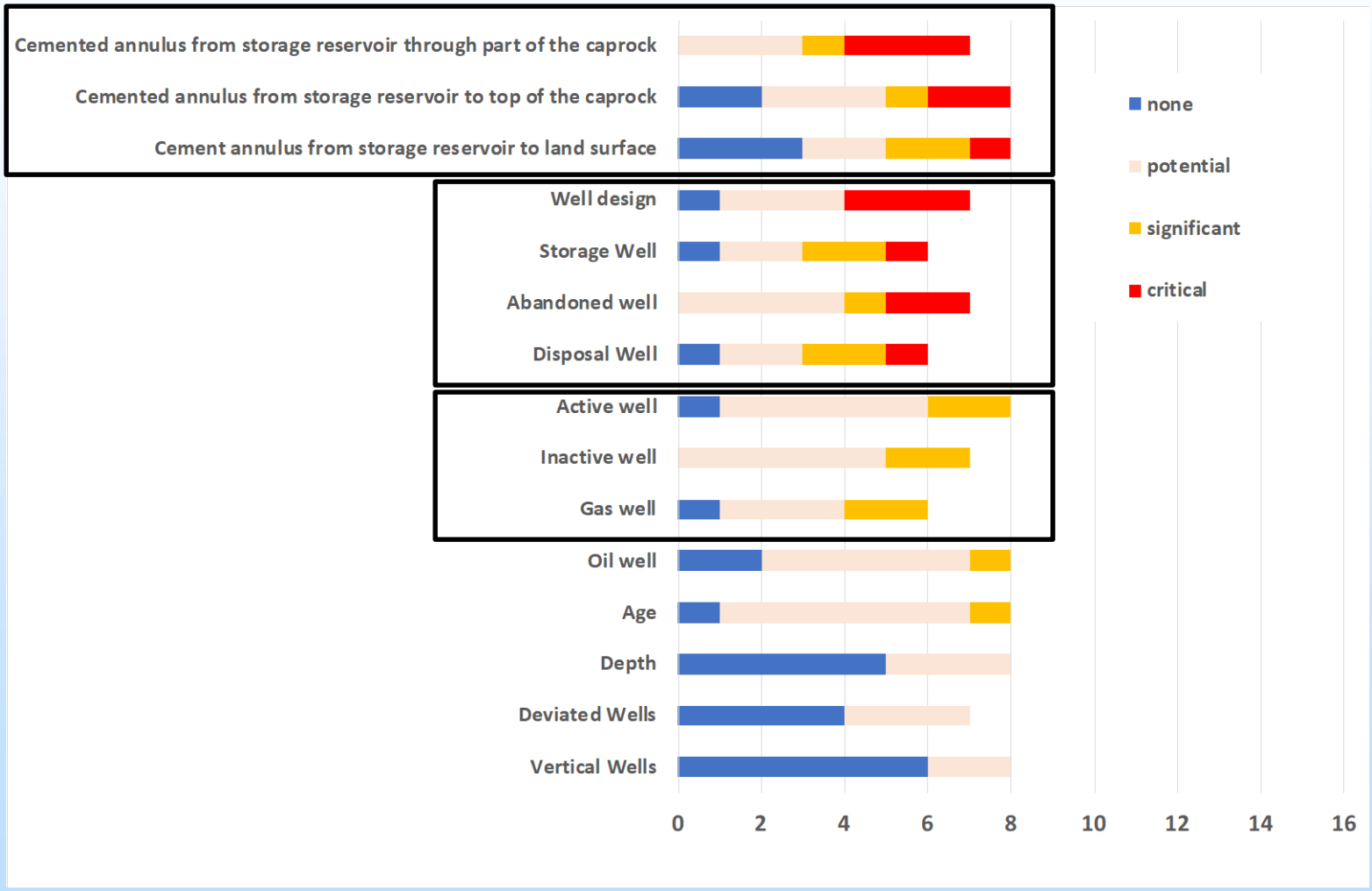
Impacts: Chronic degradation of wellbore materials



Degradation of Well Materials

- Research Recommendations
  - Corrosion of steel components

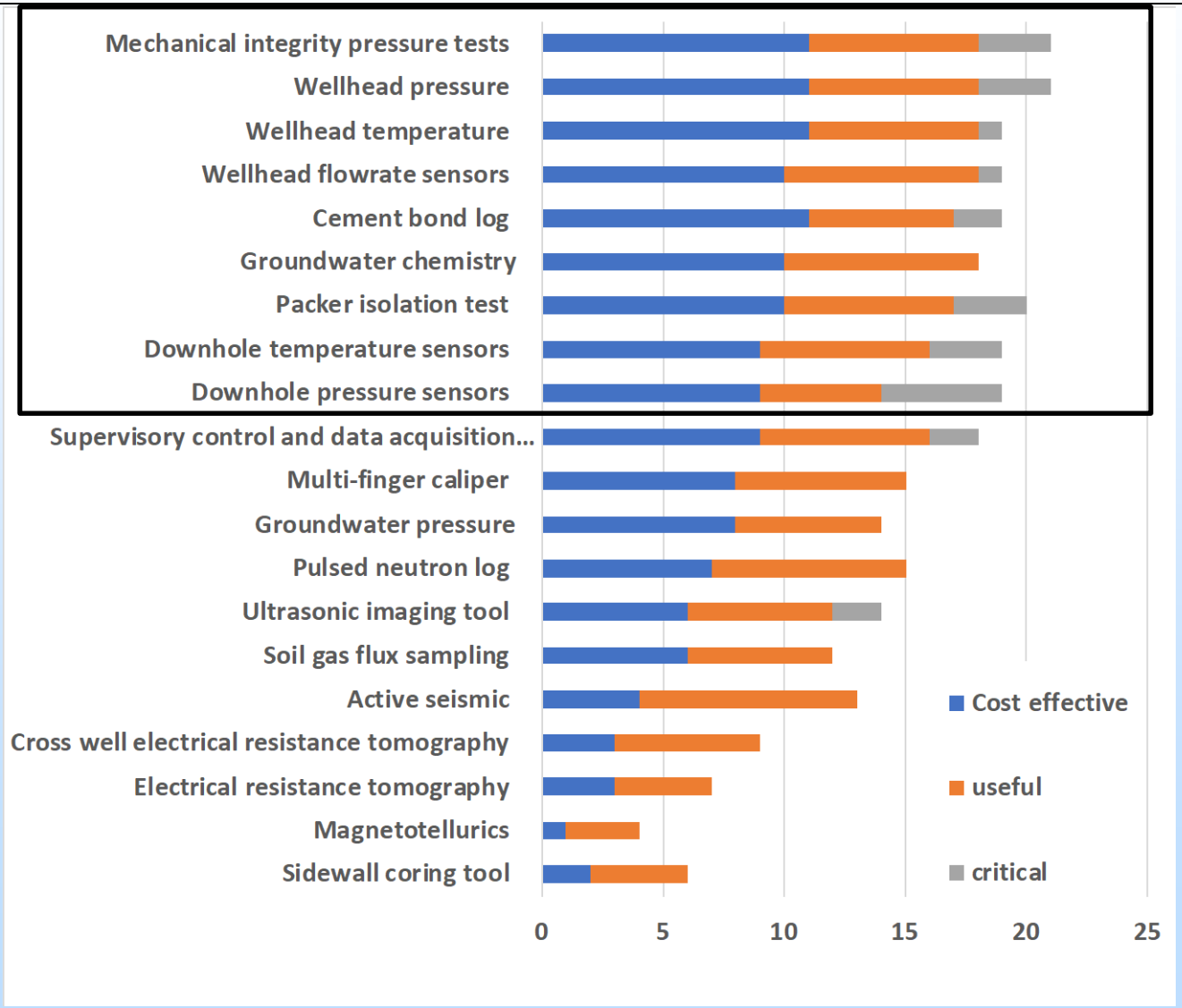
Risk Factors for Well Leakage



Risk Factors

- Research Recommendations
  - Standards for cemented interval needed to avoid leakage
  - Standards to evaluate the health of pre-existing wells

Cost effective and useful monitoring methods



Monitoring

- Research Recommendations
  - Improved methods to evaluate pre-existing wells
  - Improved methods to detect leakage

Project Summary

– Well integrity survey will result in a unique data set to guide future research investments on well integrity.

Next Steps

– Collect and evaluate additional responses to the survey
  - Contact Jaisree Iyer for survey
    – iyer5@llnl.gov
– Vet research recommendations with literature and experts
– Publish findings as research needs document

Appendix

Overview, Synergies, and Program Benefits

- **Problem Statement**
  - Our objective is to develop a *Well Integrity Research Needs* document that reports issues and insights from carbon storage projects. The report will provide a field-based assessment to better understand past incidents, to prevent them from happening in the future, to define for future research needs for successful commercialization of geologic CO_2 storage.
  - Target CO_2 storage projects include DOE US Partnerships and international commercial projects.

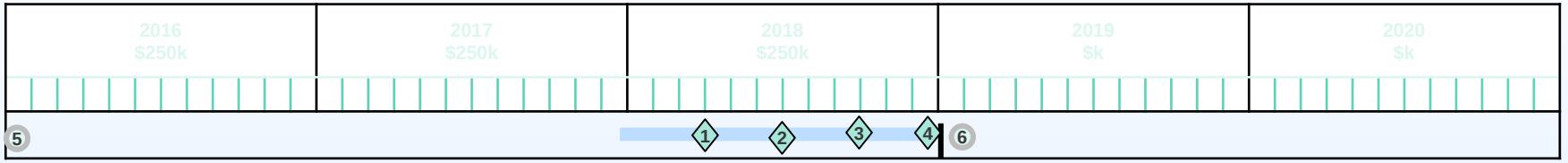
- **Research Partners: LLNL, NETL and SINTEF**

- **Research needs will be based on survey response from industry and literature.**

- **This work contributes to several Priority Research Directions for storage recommended in the Mission Innovation CCUS Workshop report.**
  - Optimizing injection of CO_2 by control of the near-well environment
  - Locating, evaluating, and remediating existing and abandoned wells
  - Establishing, demonstrating and forecasting well integrity

Task Subtitle

Task 7: Well Integrity Atlas



Milestones

1. Document completion, injection, and abandonment issues
2. Document risk assessment of legacy wells
3. Document monitoring methods to support accounting methodologies
4. Summarize research and monitoring needs to lower leakage risk through well bores

Chart Key

TRL Score

Go / No-Go Timeframe

Project Completion

Milestone

Go / No-Go

None

Impact

Key Accomplishments/Deliverables	Value Delivered
2018: Field based assessment of monitoring and research needs to lower leakage through well bores.	• Guiding document for future operators on how to avoid well integrity risks during and post injection.