

Integrating Risk Assessment Methods for Carbon Storage: A Case Study for the Quest Carbon Capture and Storage Facility

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Overview

Objective:

- Increase utilization of NRAP tools by the carbon capture and storage (CCS) community

Approach:

- Apply NRAP tools to sites that use other common risk assessment approaches to determine site risk
- Demonstrate how NRAP tools can augment or complement these risk assessment methods

Case Study:

- Shell's Quest CCS Facility

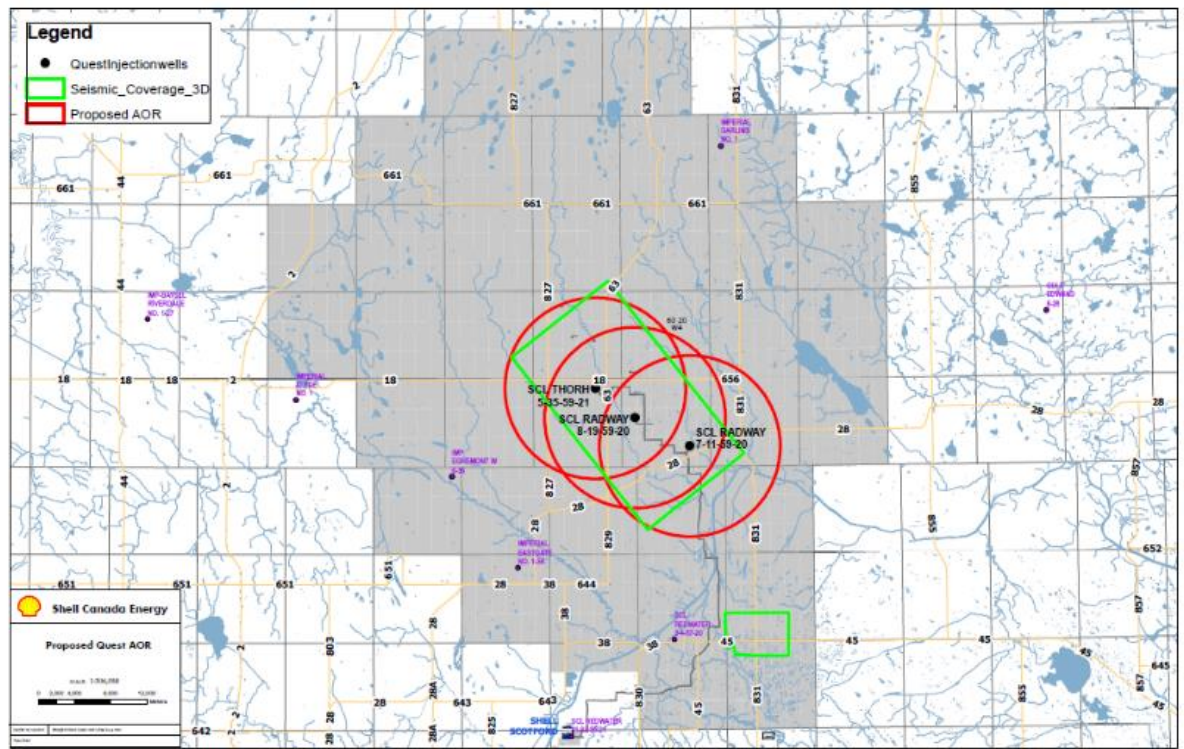


Figure 1. Map of Quest CCS project.¹

Approach

Reservoir Model:

- Recreated Quest Petrel model using Gen-4 Modeling Report.²
- No well data or seismic data
- Could not make facies model
- Matched reported reservoir pressure
- 1.08 Mtpa injection in 2 wells

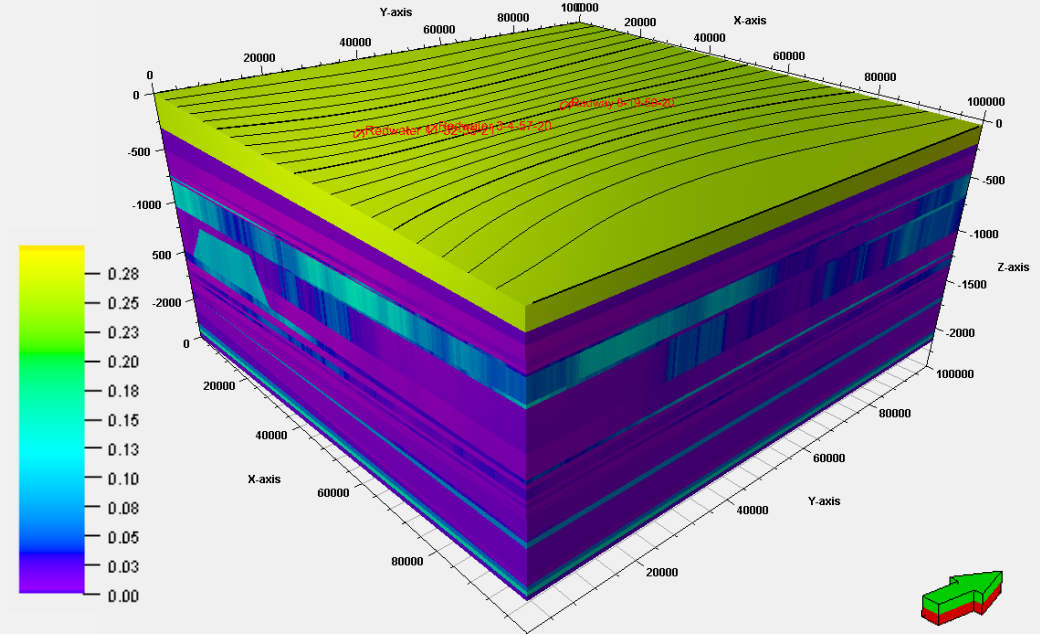


Figure 2. Cross section of Petrel reservoir model.

Open-IAM³ Model:

- Built system model representative of Quest site
- Performed risk-based Area of Review (AoR) analysis⁴
- Considered both open and cemented wellbores

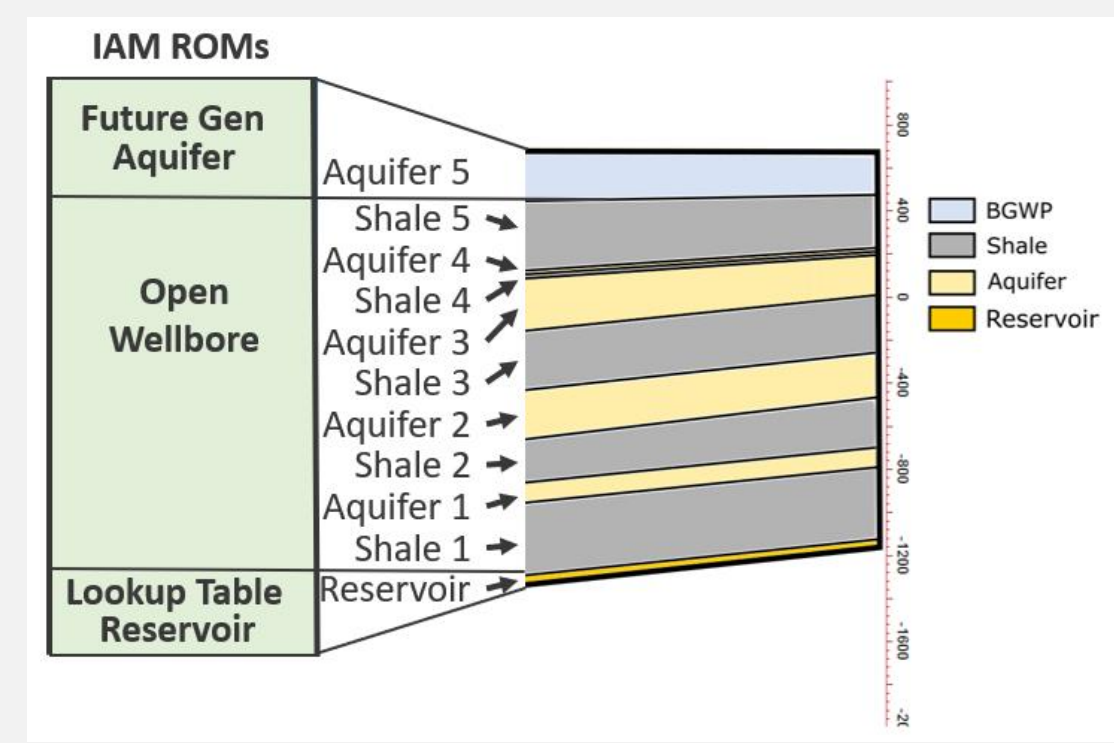


Figure 3. Open-IAM model conceptual model.

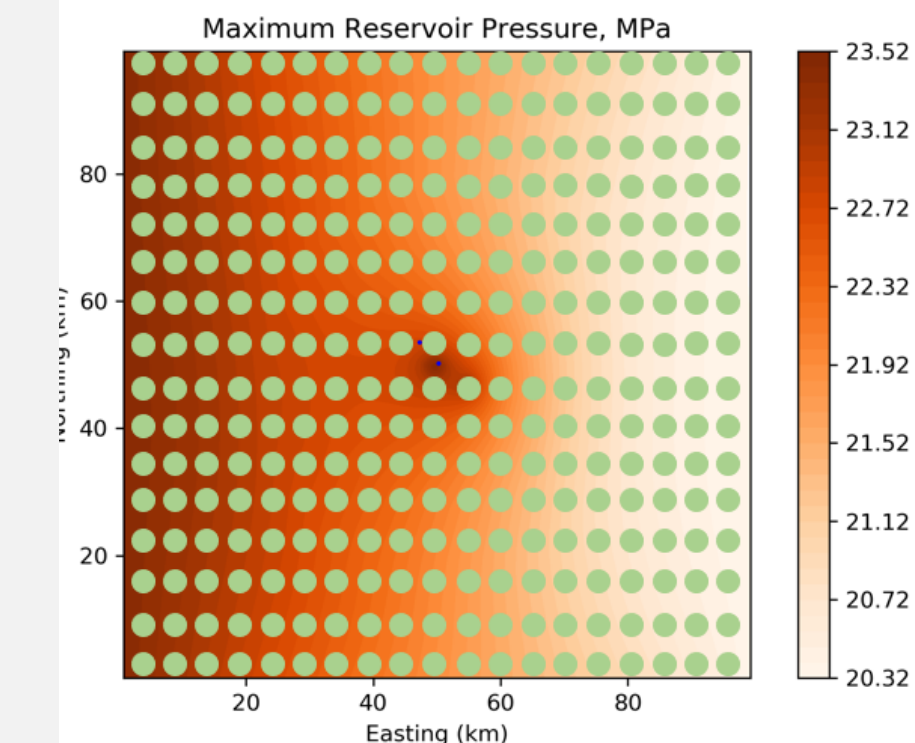


Figure 4. Open-IAM simulation approach.

Results

Open Wellbore Simulations

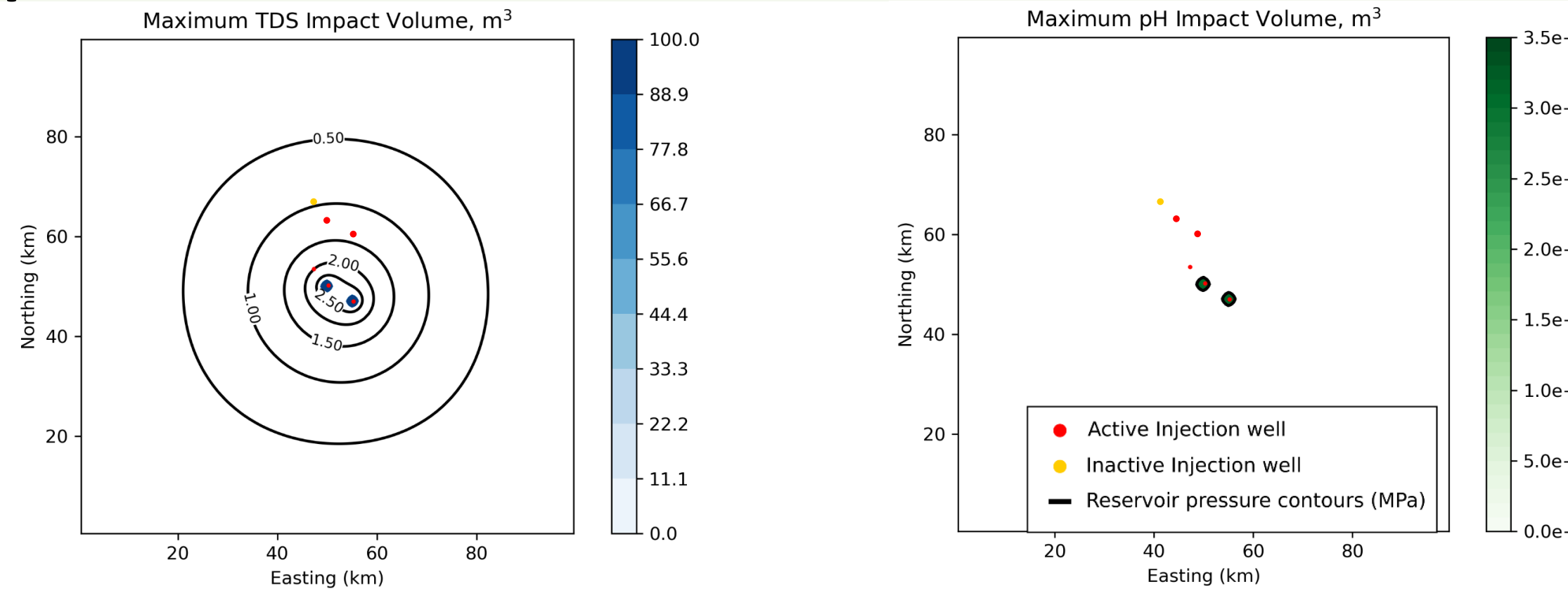


Figure 5. Spatial extent and volume of TDS (left) and pH (right) impact volumes at Shell Quest site for risk-based AoR calculation with open wellbore model.

- 7.4 MMT brine leaked, 96.0 m³ total dissolved solids (TDS) impact plume
- 2.0 MMT CO₂ leaked, 96.0 m³ TDS impact plume

Cemented Wellbore Simulations

- Multi-segmented wellbore ROM: 1×10⁻¹² m² (high perm.)

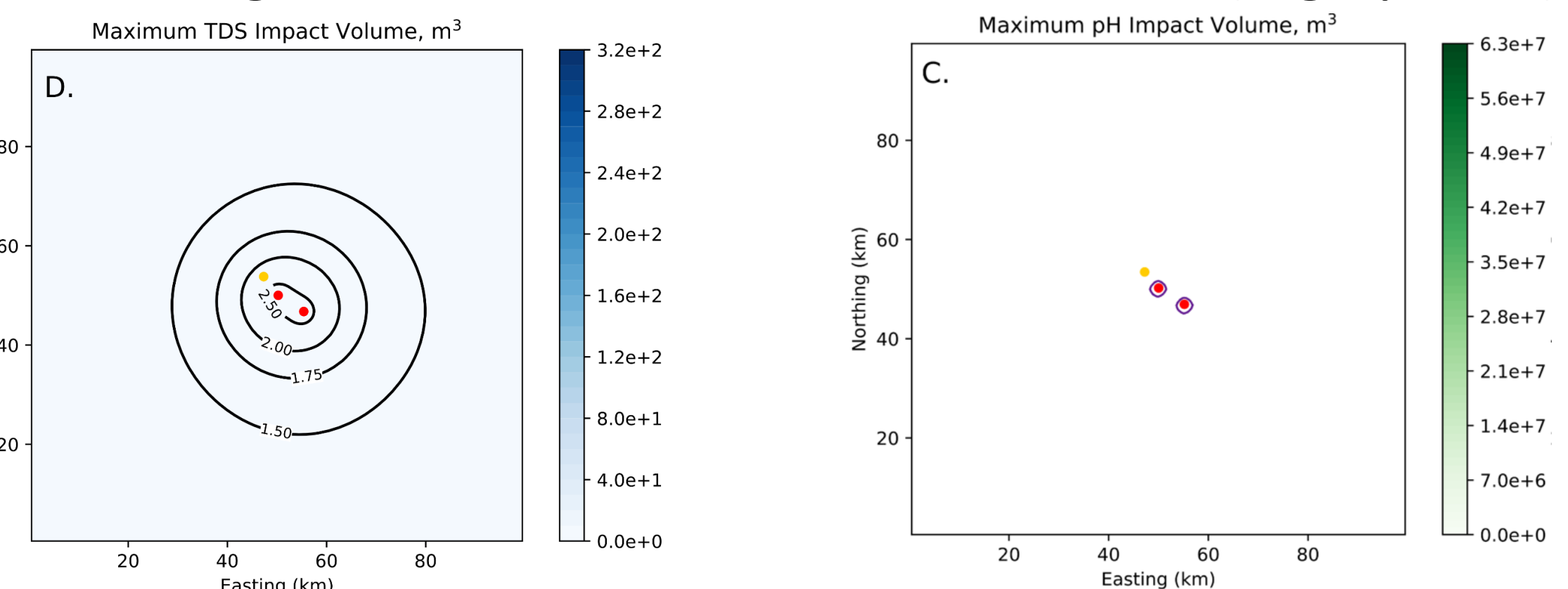


Figure 6. Spatial extent and volume of TDS (left) and pH (right) impact volumes at Shell Quest site for risk-based AoR calculation with multi-segmented wellbore model.

- < 1 m³ TDS impact plume No CO₂ impact plume

Stochastic Simulations

- Vary well permeabilities between 1×10⁻¹² and 1×10⁻¹⁶ m²
- Assume impact threshold of 1 m³
- Calculate % of realizations with impact

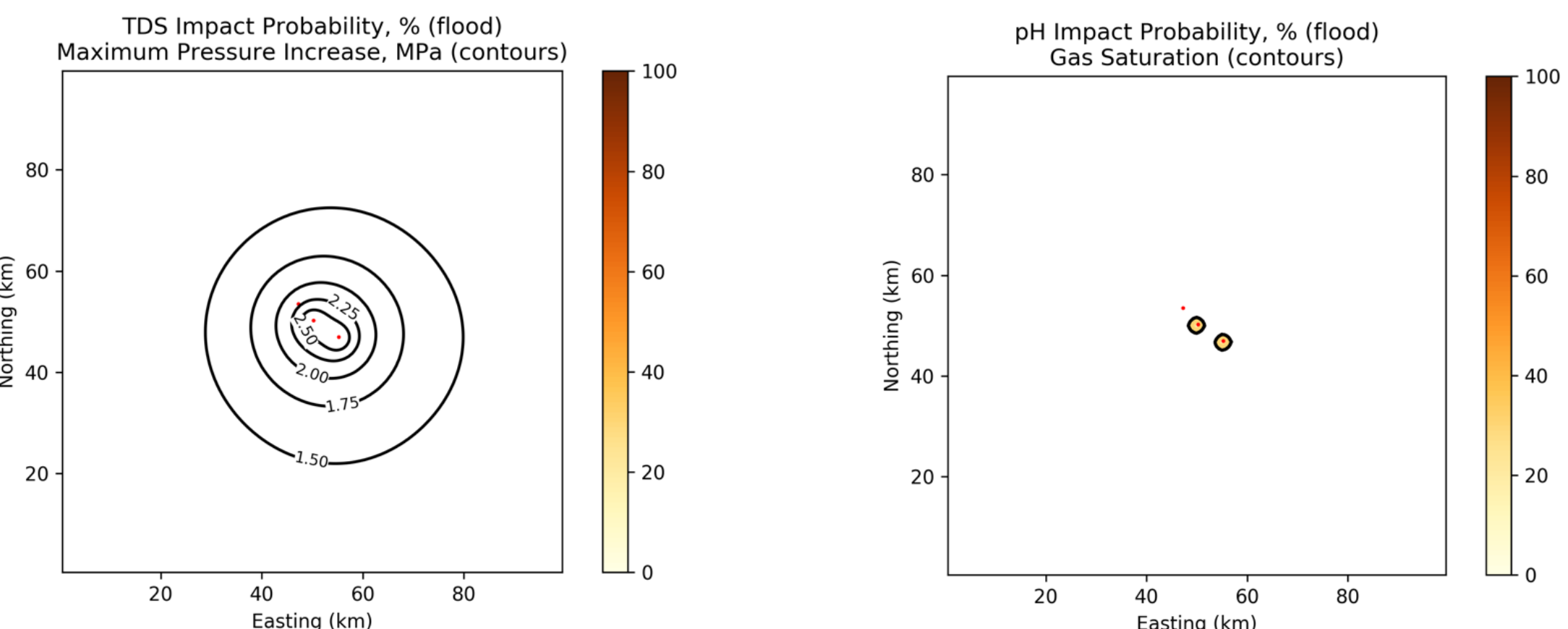


Figure 7. Probability of a TDS (left) or pH (right) impact at Shell Quest site calculated with the multi-segmented wellbore model.

- pH impact probability 1- 32% inside the CO₂ plume
- 0% TDS impact probability

Risk-Based AoR Comparison

AoR Determination

- Risk-based approach justifies AoR based on 2.5 MPa contour.

AoR Comparison

Original AoR :

- 3,780 km²

Revised AoR:

- 461 km² (12.2%)

Risk-based AoR:

- 102 km² (2.7%)

TDS & CO₂ Plume :

- 29.3 km² (0.8%)

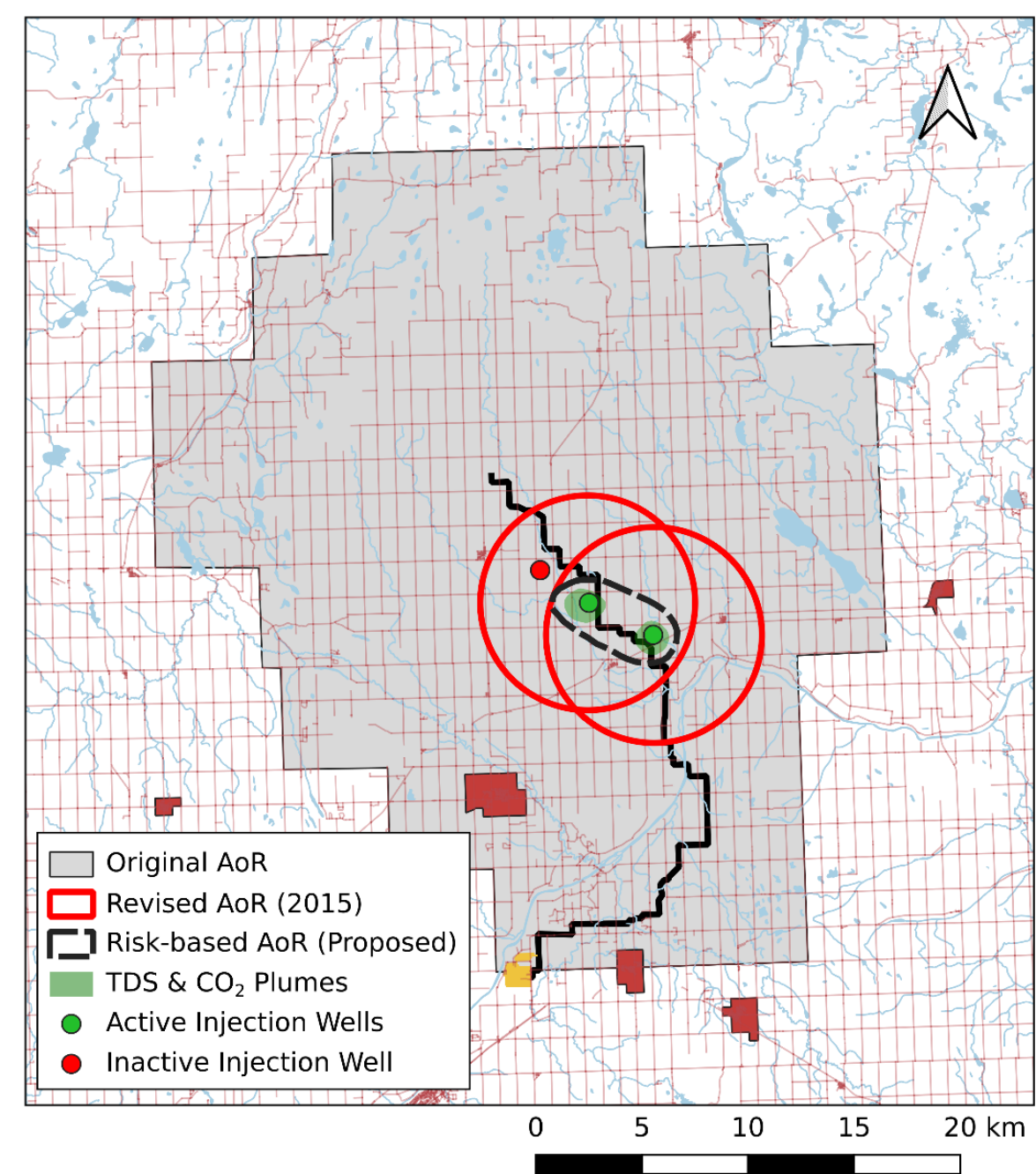


Figure 8. Comparison of AoRs used at the Quest site and the NRAP risk-based AoR calculated with the Open-IAM.

Conclusions & Next Steps

- Results from this effort support the revised AoR established by the Shell team during the operational period of the project.
- These results indicate the AoR could be further reduced due to the low impact risk to the groundwater if CO₂ and/or brine were to leak from the storage reservoir.
- Currently finalizing study and approach to complete final draft of study for journal submission.

References & Disclaimer

- ¹Shell, MEASUREMENT, MONITORING AND VERIFICATION PLAN, in Quest Carbon Capture and Storage Project. 2017, Shell Canada Limited. p. 1-38
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- ²Winkler, M., *Generation-4 Integrated Reservoir Modeling Report in Quest CCS Project*. 2011, Shell.
- ³Vasylykivska, V., et al., *NRAP-Open-IAM: A Flexible Open-Source Integrated-Assessment-Model for Geologic Carbon Storage Risk Assessment and Management*. Environmental Modelling & Software, 2021. **143**
- ⁴Bacon, D.H., D.I. Demirkanli, and S.K. White, Probabilistic Risk-Based Area of Review (AoR) Determination for a Deep-Saline Carbon Storage Site. International Journal of Greenhouse Gas Control, 2020. 102.
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