

MUHAMMAD ZULQARNAIN, PhD

Senior Reservoir & Subsurface Engineer | Reservoir Simulation, Risk Analysis & CCUS

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PROFESSIONAL SUMMARY

Petroleum engineer with 15+ years of subsurface engineering experience spanning reservoir simulation, computational fluid dynamics (CFD), geomechanics, and quantitative risk assessment across conventional oil and gas and carbon capture, utilization, and storage (CCUS). Builds and calibrates dynamic reservoir and CFD models, develops statistical and reduced-order models for storage efficiency and leakage risk, and applies fault tree/event tree methods to well-control and containment risk. Six years as an LSU postdoctoral researcher on DOE-funded and industry-sponsored subsurface projects, followed by 3+ years leading technical and regulatory workstreams — including EPA Class VI UIC permitting — for CO₂ storage projects at Advanced Resources International. Background in Python/MATLAB-based data analysis and machine learning, with a PhD in Petroleum Engineering from Louisiana State University.

CORE COMPETENCIES

Reservoir Simulation & Multiphase Flow Modeling • Computational Fluid Dynamics (CFD, ANSYS Fluent, VOF) • Geomechanical Modeling & In-Situ Stress • Static Earth Modeling & Seismic Interpretation • Quantitative Risk Assessment (QRA) & Fault/Event Tree Analysis • Statistical & Reduced-Order Modeling (Response Surface Methods, Machine Learning) • CCUS Site Screening & Characterization • EPA Class VI UIC Permitting & AoR Delineation • Well Log Interpretation • GIS Spatial Risk Mapping • Technical Mentoring & Supervision • Python / MATLAB / SQL / Machine Learning

PROFESSIONAL EXPERIENCE

Senior Consultant, Carbon Geological Sequestration | Advanced Resources International, Inc. — Columbus, OH
Jan 2023 – Present

- Delineated the Area of Review (AoR) for five CO₂ storage projects across different U.S. states using pressure- and transport-based reservoir modeling; authored the corresponding AoR, PISC, and Project Narrative permit sections, including early PISC-termination justification on all five and lowermost USDW depth determination for threshold-pressure calculations on four of five.
- Built coupled geomechanical models to estimate injection-induced in-situ stress change for two of the five projects; for one project, additionally built the static earth model (SEM) in Petrel and performed seismic interpretation supporting AoR delineation.
- Evaluated legacy well plugging and cementing records — including Class I, II, III, V, and water wells — to assess corrective-action risk from artificial penetrations across five sites, and completed a standalone well-integrity risk-rating study for a commercial client, assigning quantitative risk ratings to individual wellbore penetrations.
- Presented AoR modeling results to EPA Region 4 reviewers in response to Requests for Additional Information (RAI), and drafted a Subpart RR Monitoring, Reporting, and Verification (MRV) plan for EPA submission, including one incorporating Life Cycle Assessment (LCA) to meet the Puro Standard; reviewed a client's Class VI permit application and a separate MRV plan prepared by outside consultancies for technical completeness and regulatory defensibility.
- Performed CCUS site screening and characterization across multiple states, determining CO₂ storage capacity and injectivity via full dynamic reservoir modeling for two sites and simplified analytical estimates for others; mentors junior engineers on reservoir modeling setups.
- Presented research at CCUS industry conferences (2024–2026) and authored a paper accepted for GHGT-18 (Melbourne, Australia, Oct 2026).

Postdoctoral Researcher, Carbon Geological Sequestration | Louisiana State University, Dept. of Petroleum Engineering — Baton Rouge, LA
Jan 2017 – Dec 2022

- Built more than 14 site-specific CO₂ sequestration models across South Louisiana saline formations from the ground up: well log interpretation (SP, resistivity), petrophysical analysis, static earth model construction in Petrel, and dynamic reservoir simulation in CMG GEM, under DOE-funded (CarbonSAFE, SECARB) and industry-sponsored programs.

- Developed a response-surface model of CO₂ dynamic storage efficiency in high-permeability saline aquifers using Hammersley Sequence Sampling and regression analysis across roughly 200 reservoir simulation runs; published in Greenhouse Gases: Science and Technology (2019).
- Developed a Well Leakage Index (WLI) and Site Well Leakage Index (SWLI) — analytical reduced-order models quantifying legacy wellbore leakage risk to USDWs from wellbore geometry, buffer-layer thickness, and formation boundary conditions; published in Greenhouse Gases: Science and Technology (2019).
- Evaluated production and reservoir records for offshore Gulf of Mexico oil and gas fields under a DOE-funded project, estimating CO₂ storage/EOR capacity and ranking fields for further storage-integrity analysis; co-authored a DOE-NETL regional carbon capture and storage report, building reservoir simulation models for candidate saline storage sites and mapping legacy well penetrations to assess vertical containment risk.
- Served as manuscript reviewer for the ASME Journal of Energy Resources Technology, the Journal of Petroleum Science and Engineering (Elsevier), and the International Journal of Greenhouse Gas Control (5+ manuscripts).

Postdoctoral Researcher, Multiphase Flow & Well Control | Louisiana State University, Dept. of Petroleum Engineering — Baton Rouge, LA

Aug 2015 – Dec 2016

- Applied high-fidelity 3D CFD (ANSYS Fluent, Volume of Fluid method) to model high-speed, large-diameter multiphase pipe flow for a BOEM-funded flow-loop project, identifying flow-regime transitions and benchmarking predictions against laboratory flow-loop data and offshore field production data; verified 1D/mechanistic wellbore flow models against the CFD results.
- Simulated drilling blowout fluid conditions using 3D CFD to represent worst-case-discharge scenarios that cannot be physically reproduced in laboratory or field tests.

Manager, Technical — Design & Fluid Mechanics Engineering | Centre of Excellence in Science & Applied Technologies (CESAT) — Islamabad, Pakistan

Sep 2003 – Apr 2008

- Developed and validated CFD solvers for aerodynamic and industrial flow design; led a team of engineers and mentored junior staff on CFD tools and techniques.

EDUCATION

PhD, Petroleum Engineering (Minor: Geology) — Louisiana State University, 2015. Dissertation: Deepwater GoM Oil Spill Scenarios Development and Their Associated Risk Analysis (QRA, Fault Tree/Event Tree modeling of well-control systems).

MSc, Petroleum Engineering — Louisiana State University, 2012.

MSc, Nuclear Engineering — PIEAS, Islamabad, Pakistan, 2003.

MSc, Physics — Quaid-i-Azam University, Islamabad, Pakistan, 2001.

CERTIFICATIONS & TECHNICAL SKILLS

IBM Machine Learning Professional Certificate, Coursera — 2022. IBM Data Science Professional Certificate, Coursera — 2019. WellCAP Drilling/Workover Supervisor Level, IADC — 2011 (expired).

Reservoir Simulation: CMG GEM, STARS | Geomodeling: Petrel | Programming: Python, MATLAB, SQL | GIS: ArcGIS, QGIS, Folium | Visualization: Tableau, Power BI | CFD: ANSYS Fluent.

SELECTED PUBLICATIONS (FULL LIST ON GOOGLE SCHOLAR)

Zulqarnain, M., Sears, S.O., Zeidouni, M., Hughes, R.G., Carlson, D., & Rivera, C.F. (2023). GCS site selection in saline Miocene formations in South Louisiana. International Journal of Greenhouse Gas Control.

Zulqarnain, M., Zeidouni, M., & Hughes, R.G. (2019). Response surface modeling of CO₂ dynamic storage efficiency factor in high permeability thick sandstones. Greenhouse Gases: Science and Technology.

Zulqarnain, M., Zeidouni, M., & Hughes, R.G. (2019). Field-scale well leakage risk assessment using reduced-order models. Greenhouse Gases: Science and Technology.

Dismukes, D., Zeidouni, M., Zulqarnain, M., Hughes, R.G., et al. (2019). Integrated Carbon Capture and Storage in the Louisiana Chemical Corridor. U.S. DOE, National Energy Technology Laboratory.