

## Keith J. Halford, Senior Hydrologist, [Halford Hydrology LLC](#)

1000 W. Robinson St., Carson City, NV 89703

[khalford@halfordhydrology.com](mailto:khalford@halfordhydrology.com)

775-842-7982

### **SKILLS**

- Aquifer-test analysis
- Development of groundwater-flow models
- Programming for hydrologic applications

### **EDUCATION**

Louisiana State University, Petroleum, Civil, and Mechanical Eng., Ph.D. 1992

Louisiana State University, Petroleum and Mechanical Engineering, M.S. 1985

Louisiana State University, Petroleum Engineering, B.S. 1984

### **EXPERIENCE**

Developed, calibrated, and published models that simulated groundwater flow in humid ([Halford 1997](#); [Spechler and Halford, 2001](#)) and arid climates ([Halford and Plume, 2011](#); [Fenelon and others, 2016](#); [Halford and Jackson, 2020](#)). More types of measurements are compared to their simulated equivalents, which has expanded objective functions of successive models. Improved understanding and identified more errors by visualizing more aspects of model results.

Developed the Multi-Node Well (MNW) package for MODFLOW, which simulates wells that can withdraw water from multiple cells ([Halford and Hanson, 2002](#); [Konikow and others, 2009](#)). Created T-COMP for sampling simulated transmissivities from MODFLOW models that are readily compared to aquifer-test results in a PEST objective function ([Halford, 2016](#)).

Developed many Excel workbook applications and add-ins for analysis of hydrologic problems. Workbook applications have ranged from aquifer-test analysis ([Halford and Kuniansky, 2002](#)) to geochemical analysis with Piper plots and Stiff diagrams that are mapped in Google Earth ([Halford Hydrology, 2023](#)). An Excel Add-In, [SeriesSEE](#), was developed analyzing time series with water-level models that allow detection and isolation of small drawdowns from pumping ([Halford and others, 2012](#)).

Technically reviewed groundwater aspects of multiple Environmental Impact Statements (EIS), including the Clark, Lincoln, and White Pine Counties Groundwater Development Project that was proposed by Southern Nevada Water Authority (SNWA). Reviewed hundreds of articles and reports for the USGS and more than a half-a-dozen scientific journals, including [Groundwater](#) and [Water Resources Research](#).

## **SIGNIFICANT PROJECTS**

### **Goldstrike-Gold Quarry Dewatering, Carlin Trend model**

A single groundwater-flow model for assessing regional effects of dewatering and water management along the Carlin Trend was developed for Nevada Gold Mines LLC (NGM). The integrated model was developed with MODFLOW6, which is supported by the U.S. Geological Survey ([Langevin et al., 2017](#)). The revised model incorporated experience and information from the 30-year history of models developed by Barrick Gold and Newmont Mining. The integrated model was calibrated with [PEST](#) to historical pumping, water-level changes, and streamflow changes between 1987 and 2019.

### **Death Valley Regional Analysis, DV3 model**

Groundwater flow and development were characterized in four groundwater basins of the Death Valley regional flow system with calibrated, groundwater-flow models that distributed hydraulic properties with a simplified hydrogeologic framework ([Halford and Jackson, 2020](#)). Water-level changes in Devils Hole were explained by natural changes in recharge and pumping, where the 2.6-ft range of measured water-level changes in Devils Hole was simulated with a root-mean-square error of 0.2 ft during the 70-year period of record. Ash Meadows and Alkali Flat–Furnace Creek Ranch groundwater basins are hydraulically connected near well AD-4, about 5 miles south of the town of Amargosa Valley, Nevada. Advective transport from nuclear tests was determined to be negligible.

### **Hydraulic Characterization of Pahute Mesa with an Integrated Analysis**

Consistent hydraulic properties of the volcanic rocks beneath underground nuclear-testing areas at Pahute Mesa were estimated by simultaneously interpreting 16 multiple-well aquifer tests with 11 numerical models ([Garcia, et al, 2017](#)). Drawdown from multiple-well aquifer testing was estimated and distinguished from natural fluctuations in more than 200 pumping and observation wells using analytical water-level models ([Halford, et al, 2012](#)). Drawdown was detected at distances greater than 3 miles from pumping wells and propagated across hydrostratigraphic units and major structures.

## **Modeling Water-Levels and Estimating Drawdowns, SeriesSEE**

Water-level modeling allows drawdowns of less than 0.05 ft to be reliably differentiated from natural water-level changes, “environmental fluctuations” ([Garcia, et al, 2013](#)).

Water-level modeling with Theis transforms has been implemented in the program SeriesSEE, which is a Microsoft® Excel add-in ([Halford, et al, 2012](#)). Drawdowns of less than 0.1 ft have been detected and estimated 33 miles from the pumping well ([Jackson and Halford, 2019](#)).

## **RENDERING SCIENTIFIC JUDGEMENT**

- 2013-2018 Technical advisor and reviewer of Environmental Impact Statements (EIS) for Bureau of Land Management (BLM). Competing groundwater models reviewed for estimating effects of groundwater development in eastern and southern Nevada.
- 2006-2018, National Nuclear Security Administration / Nevada Site Office (NNSA/NSO)—Member of modeling subcommittee for underground test areas (UGTA)
- 2006-2018, National Nuclear Security Administration / Nevada Site Office (NNSA/NSO)—Member of technical working group for underground test areas (UGTA)
- 2015, Testified on effects of groundwater development in eastern Snake Valley, NV on Needlepoint spring in UT at Nevada State Engineering Hearing on Granite Peak change application, February 2-6, 2015.
- 2007-2012 Technical advisor and reviewer of Environmental Impact Statement (EIS) for Southern Nevada Water Authority’s (SNWA) Groundwater Development and Pipeline Projects in eastern Nevada.
- 2006-2009 Member of Consultative Workgroup (CWG) for remediation of hexavalent chromium contamination near PG&E Topock compressor station, Needles, California.
- 2006, Testified on methods of estimating recharge in Nevada at Nevada State Engineering Hearing on Kane Springs Valley, April 4-6, 2006.
- 2000-2010, Associate Editor for the journal Ground Water

## **SCIENTIFIC SOCIETIES**

- American Geophysical Union
- Geological Society of America
- Groundwater Resources Association of California
- International Ground Water Modeling Center
- National Ground Water Association
- Nevada Water Resources Association

## PROFESSIONAL POSITIONS

- 2019-present, Senior Hydrologist, Halford Hydrology LLC, Develop spreadsheet applications for hydrologic analysis, analyze aquifer tests, create groundwater-flow models, and critically review hydrologic projects.
- 2011-2018, Research Hydrologist, USGS Nevada Water Science Center, USGS, Developed advanced methods for drawdown detection and methods for integrated calibration of multiple stress-response groundwater-flow models.
- 2007–2011, Groundwater Specialist, Nevada Water Science Center (WSC), USGS, Guided groundwater science program in the Nevada WSC. Conducted individual studies and published results in scientific journals.
- 2005-2007, Ground-Water Specialist, California Water Science Center (WSC), USGS, Guided groundwater science program in the California WSC. Conducted individual studies and published results in scientific journals.
- 1999-2005, Ground-Water Specialist, Nevada District, USGS, Guided groundwater science program in the Nevada District. Conducted individual studies and published results in scientific journals. Developed expertise as a leading aquifer-test analyst.
- 2003-2005, Graduate Program of Hydrologic Sciences Faculty, University of Nevada, Reno. Advised students and lectured.
- 1997-1999, Ground-Water Modeling Specialist, USGS, Southeastern Region. Assisted groundwater investigators with FORTRAN and spreadsheet utilities, complex aquifer tests, parameter estimation, and optimization.
- 1993-1999, Hydrologist, USGS, Altamonte Springs, Florida. Investigated transport and fate of contaminants in surficial aquifers.
- 1993-1994, Adjunct Associate Professor, Florida University Civil Engineering Department, Gainesville, FL. Taught graduate, groundwater flow and solute transport courses.
- 1987-1993, Hydrologist, USGS, Baton Rouge, Louisiana

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[Halford, K.J., and Jackson, T.R., 2020](#), Groundwater characterization and effects of pumping in the Death Valley regional groundwater flow system, Nevada and California, with special reference to Devils Hole: U.S. Geological Survey Professional Paper 1863, 178 p., <https://doi.org/10.3133/pp1863>

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[Halford, K., 2019](#), Evaluation of groundwater-flow models for estimating drawdown from proposed groundwater development in Tule Desert, Nevada: U.S. Geological Survey Open-File Report 2019-1091, 21 p., <https://doi.org/10.3133/ofr20191091>.

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[Jackson, T. R., Halford, K. J., Gardner, P. M. and Garcia, A., 2018](#), Evaluating Micrometeorological Estimates of Groundwater Discharge from Great Basin Desert Playas. *Groundwater*, 56: 909–920. doi:10.1111/gwat.12647

[Smith, D.W., Moreo, M.T., Garcia, C.A., Halford, K.J., and Fenelon, J.M., 2017](#), A process to estimate net infiltration using a site-scale water-budget approach, Rainier Mesa, Nevada National Security Site, Nevada, 2002–05: U.S. Geological Survey Scientific Investigations Report 2017-5078, 22 p., <https://doi.org/10.3133/sir20175078>.

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