

HOUSTON KEMPTON

PROFESSIONAL PROFILE

Mr. Houston Kempton is a geochemist with 17 years of experience, specializing in environmental geochemistry and hydrogeology related to modeling the mobility and removal of metals at hardrock mines. His specific mining expertise includes prediction and management of water quality in mine pit lakes, management of waste rock and tailings, determination of natural attenuation, apportionment of contaminant liability, selection of water treatment, and policy strategies to address model uncertainty and long-term environmental impacts. Mr. Kempton's notable contributions include directing development of a predictive model of pit-lakes (applied to 19 mine pits), developing field- and laboratory-scale methods to measure pyrite oxidation, and pilot testing of in-situ groundwater remediation technologies. Related experience includes studies of electrochemical reactions of uranium and selenium, geophysical surveys (electromagnetic induction and seismic refraction), aquifer testing, and sampling of water for metal speciation to support risk assessment and model calibration.

Major clients on mining projects have included Phelps Dodge, Newmont Gold, Santa Fe Pacific Gold, Echo Bay Mining, Battle Mountain Gold, the Bureau of Land Management (US), and the State of California (US).

CREDENTIALS

MS, Geology, University of Colorado, 1987

BS, Geology and Geography, Mary Washington College, 1982

Continuing Education and Training

Mine Safety and Health training

Hazardous Waste Operations and Emergency Response 40-hour training program

Hazardous Waste Operations Management and Supervisor 8-hour training program

RELEVANT EXPERIENCE

Mining

Battle Mountain Gold Mine, Nevada—Managed a hydrochemical investigation to support an EIS for expansion of the Battle Mountain gold mine in Nevada. Components included acid-base characterization of five deposits, preparation of a waste rock management plan, prediction of future water quality and ecological risk from pit-lakes, design of covers and chemical waste amendments, and potential long-term effects on groundwater.

Environmental Guidance Document—Prepared technology-selection-criteria guidance on waste rock amendment, vegetated caps, and pit-lake management for an EPA Technology Bulletin on hard-rock mining.

Developed a computer model to predict post-closure chemical composition of mine pit lakes- Components included sulfide oxidation, acid and metal release, groundwater inflow, and chemical precipitation/adsorption reactions. Probabilistic results support environmental policy and ecological risk analyses. The model has been applied by our group to predict water quality in 18 potential pit lakes, including properties owned by Newmont, Echo Bay, Battle Mountain, BHP, Homestake, and others.

Developed waste rock management plans at three Nevada mines—Components incorporated cap design, lime amendment, and probabilistic assess of random emplacement to achieved environmental stability with minimal schedule constraints and repeat handling.

Directed limnology study of three mine pit lakes in Nevada—The study was coordinated with the State of Nevada and Santa Fe Pacific Gold Corporation, and involved analysis of biological productivity, physical stratification,

limnologic modeling, and speciation of mercury and arsenic in water, plants, and invertebrates to support ecological risk assessments.

Directed an environmental study of the Twin Creeks Mine in Nevada—Included design of the waste rock management plan, estimating future pit-lake water quality, degradation and attenuation of cyanide released from tailings, and treatment and disposal groundwater from dewatering.

Developed a laboratory method for measuring the dependence of pyrite oxidation rates on moisture—Application at 2 mines demonstrated that pyrite oxidation and acid release from mine waste and tailings slowed dramatically when moisture was below ~1 percent.

Developed a simple and rapid in situ field method for measuring pyrite oxidation rates in waste rock and pit benches—Results have been used to calibrate pyrite oxidation models at 5 mines.

Designed an interceptor well system for a dissolved solids plume at a Wyoming carbonate mine—Used a numerical, 3-dimensional groundwater model to evaluate evaporation pond leakage

Conducted water and sediment sampling, then designed and implemented experiments to measure the effect of metals and acid from mine tailings on sediments in a Montana River—Results were used to estimate metal distribution in river sediments, and calculate the effects of acidic tailings runoff during storms on river water quality.

Assessed impacts of seepage from abandoned mines on surface water quality – including flow measurement, quality sampling, and surface water modeling (EPA model WASP4), for an RI/FS of the Clear Creek, Colorado (USA) superfund site for the Colorado Dept. of Environmental Quality and U.S. EPA.

Expert review on costs for long-term management of arsenic-contaminated mine-pit lake for the State of California—Developed cost estimates for in-situ and ex-situ options for perpetual treatment of arsenic in outflow from a mine pit lake.

Directed laboratory tests of permeable reactive barrier and field-scale pilot test of electron donor injection—supporting a feasibility study of alternatives for long-term in-situ remediation of metal-contaminated groundwater from a former smelter.

Developed a method for in situ remediation of metals-contaminated groundwater -- to replace source-removal or pump-and-treat. Lab and modeling studies confirmed highly effective remediation of chromium and arsenic.

Developed cost estimates for removal of dissolved metals in mine-pit lakes – used to support closure feasibility alternatives at various US mines.

SELECTED PUBLICATIONS AND PRESENTATIONS

Peer Reviewed Articles (journals and reviewed conference proceedings)

Kempton, J.H., and D. Atkins. 2000. **Delayed environmental impacts from mining in semi-arid climates.** Proceedings from the 5th International Conference on Acid Rock Drainage, Society for Mining, Metallurgy, and Exploration, May 21-24, Denver, Colorado, pp. 1299-1307.

Kempton, H., W. Locke, D. Atkins, and A. Nicholson. 2000. **Probabilistic quantification of uncertainty in predicting mine pit-lake water quality.** Mining Engineering, October 2000, pp. 59-64.

Martin, T. and H. Kempton. 2000. **In-situ stabilization of metal –contaminated groundwater by hydrous ferric oxide: an experimental and modeling investigation.** *Env. Sci. and Technol.* 34(15), 3229-3234.

Martin, T. and J.H. Kempton. 1999. **In-situ stabilization of metal-contaminated groundwater.** In: Mining and the Environment II, September 13-17, Sudbury, Canada: Conference Proceedings Vol. II. Pp. 611-615. (Presented by H. Kempton)

Kempton, J.H., D. Swanson, M. Bennett, R. McDonald, W. Locke, C. Gillespie, M. Lechner, and P. Maley. 1997. **Application of probabilistic acid/base accounting to minimize waste-rock handling in semi-arid climates.** In: Proc. Fourth International Conference on Acid Rock Drainage. May 31–June 6, 1997. Vancouver, British Columbia, Canada.

Kempton, J.H., W. Locke, D. Atkins, A.D. Nicholson, M. Bennett, L. Bliss, and P. Maley. 1997. **Probabilistic prediction of water quality in the Twin Creeks Mine pit lake, Golconda, Nevada, USA.** In: Proc. Fourth International Conference on Acid Rock Drainage. May 31–June 6, 1997. Vancouver, British Columbia, Canada.

Atkins, D., J.H. Kempton, T. Martin. 1997. **Limnologic conditions in three existing Nevada pit lakes: observations and modeling using CE-QUAL-W2.** In: Proc. Fourth International Conference on Acid Rock Drainage. May 31–June 6, 1997. Vancouver, British Columbia, Canada.

Bennett, M.W., J.H. Kempton, and P. Maley. 1997. **Application of geological block models to environmental management.** In: Proc. Fourth International Conference on Acid Rock Drainage. May 31–June 6, 1997. Vancouver, British Columbia, Canada.

Davis, A., J.H. Kempton, and A. Nicholson. 1994. **Groundwater transport of arsenic and chromium at a historical tannery, Woburn, Massachusetts, U.S.A.** *Appl. Geochem.* 9:569–582.

Kempton, J.H., A.O. Davis, and R.L. Olsen. 1992. **Remediation of solvent contaminated soils by aeration.** *J. Environ. Qual.* 21:121–128.

Ruby, M.V., A.O. Davis, J.H. Kempton, J.W. Drexler, and P.D. Bergstrom. 1992. **Lead bioavailability: dissolution kinetics under simulated gastric conditions.** *Env. Sci. Technol.* 26(6):1242–1248.

Kempton, J.H., D.D. Runnells, and R.D. Lindberg. 1990. **Numerical modeling of platinum Eh measurements using heterogeneous electron-transfer kinetics.** In: Chemical Modeling of Aqueous Systems II. R.L. Bassett and D. Melchior (eds). American Chemical Society Symposium Series, Washington, DC.

PRESENTATIONS, NON-REVIEWED PUBLICATIONS, AND ABSTRACTS

Martin, T., W. McNab, H. Kempton. 2003. **Cost-Benefit Analysis of Sulfide-Based Treatment Technologies for Remediation of Metal-Contaminated Groundwater.** Manuscript In: Proceedings, National Ground Water Association Conference on Remediation: Site Closure and the Total Cost of Clean-up, New Orleans, LA, Nov. 12–14.

Kempton, J.H., M. Martin, T. Martin. 2003. **Comparative Cost Analyses of Technologies for Treating Sulfate- and Metal-Contaminated Groundwater.** (Manuscript in: Acid Rock Drainage Sixth International Conference, 12–18 July, 2003, Cairns, North Queensland, Australia, The Australasian Institute of Mining and Metallurgy (AusIMM)).

Kempton, J.H. 2003. **Addressing the Dilemmas of Long-Term Mining Impacts using a Framework of Sustainability and Adaptive Management.** [(Manuscript in: Acid Rock Drainage Sixth International Conference, 12–18 July, 2003, Cairns, North Queensland, Australia. The Australasian Institute of Mining and Metallurgy (AusIMM).]

Kempton, J.H. 2002. **Addressing the Dilemmas of Long-Term Environmental Impacts from Hard Rock Mining.** Presented at Hardrock Mining 2002: Issues Shaping the Industry, May 7–9. Westminster, CO. Sponsored by U.S. EPA Office of Research and Development.

Atkins, D., and J.H. Kempton. 2000. **Assessing the impacts of waste-rock backfill on pit-lake water quality.** U.S. EPA Workshop on the Characterization, Modeling, Remediation, and Monitoring of Pit Lakes, April 4–6, Reno, NV. (Abstract, presented by D. Atkins)

Kempton, J.H., and D. Atkins. 2000. **Permitting mine pit lakes: Economic and policy considerations.** U.S. EPA Workshop on the Characterization, Modeling, Remediation, and Monitoring of Pit Lakes, April 4–6, Reno, NV. (Abstract, presented by H. Kempton)

- Kempton, J.H. 2000. **Cost-saving strategies in environmental mine management**. SME Annual Meeting, Salt Lake City, UT, February 28-March 1. Preprint 00-125. (Presented by H. Kempton)
- Kempton, J.H., and D. Atkins. 2000. **Strategies for permitting mines with delayed environmental impacts**. SME Annual Meeting, Salt Lake City, UT, February 28-March 1. Preprint 00-126. (Presented by H. Kempton)
- Kempton, H., and T. Martin. 1999. **New methods for *in-situ* remediation of metals-contaminated groundwater**. Society for Mining, Metallurgy, and Exploration Annual Meeting, March 1-3, Denver, CO (Preprint). (Presented by H. Kempton)
- Kempton, H., and T. Martin. 1998. **Remediation of metal-contaminated groundwater by *in situ* formation of adsorptive substrates**. Groundwater Protection Council Annual Forum, September 19-23, Sacramento, CA. (Abstract, presented by H. Kempton)
- Kempton, H., and D. Atkins. 1998. **Realistic expectations and research directions for predictive pit-lake water quality modeling**. Conference on Hazardous Waste Research, May 19-21, Snow Bird, UT. (Abstract, presented by D. Atkins)
- Peterson, L.D., D.A. Swanson, D.A. Atkins, M.W. Bennett, C.L. Travers, and J.H. Kempton. 1998. **Sulfide oxidation in pit-backfilled waste-rock facilities**, in Proceedings of the fifth international conference on Tailings and Mine Waste '98, Fort Collins, CO. 26-28. January. pp. 579-587.
- Atkins, D., T. Martin, M. Bennett, and H. Kempton. 1998. **Pit-lake limnology**. Conference on Hazardous Waste Research, May 19-21, Snow Bird, UT. (Abstract, presented by D. Atkins)
- Kempton, H., W. Locke, D. Atkins, and A. Nicholson. 2000. **Probabilistic quantification of uncertainty in predicting mine pit-lake water quality**. Society for Mining, Metallurgy, and Exploration, Annual Meeting, March 9-11, Orlando, FL. Preprint 98-150. (Presented by H. Kempton)
- Swanson, D.A., J.H. Kempton, C. Travers, and D. A. Atkins. 1998. **Predicting long-term seepage from waste-rock facilities in dry climates**. Society for Mining, Metallurgy, and Exploration, Annual Meeting, March 9-11, Orlando, FL. Preprint. (Presented by D. Swanson)
- Locke, W., J.H. Kempton, D. Atkins, R.R. McDonald, L.N. Bliss, and C.L. Travers. 1997. **Comparison of the measured and modeled geochemical composition of a Nevada pit lake**. American Chemical Society 214th National Meeting, September 7-11, Las Vegas, NV. (Abstract 021, presented by W. Locke)
- Atkins, D., T.L. Cook, and J.H. Kempton. 1997. **Measurement and simulation of pyrite oxidation in the blasted rock of an open pit mine**. 4th International Symposium on Environmental Geochemistry, October 5-10, Vail, CO. USGS Open File Report No. OF97-496. (Abstract, presented by D. Atkins)
- Kempton, J.H., T.L. Cook, D. Atkins, D., and M. McHugh. 1997. **Moisture and salinity limits on pyrite oxidation in semi-arid climates**. 4th International Symposium on Environmental Geochemistry, October 5-10, Vail, CO. USGS Open File Report No. OF97-496. (Abstract, presented by T. Cook)
- Atkins, D. H. Kempton, and P. Maley. 1996. **Mercury speciation and partitioning in three open-pit mine lakes in Nevada, USA**. Fourth International conference on Mercury as a Global Pollutant, August 4-8, Hamburg, Germany. Poster #127 (Presented by D. Atkins)
- Kempton, H., C. Wisdom, and P. Maley. 1996. **Assessing the effects of evaporative concentration on water quality in the Twin Creeks Mine terminal lake**. Poster P0374, Society of Environmental Toxicology and Chemistry, November 17-21, Washington, DC. (Presented by H. Kempton)
- Kempton, H., W. Locke, D. Atkins, L. Bliss, A. Nicholson, and P. Maley. 1996. **Predicting water quality in mine pit lakes: How far into the future to forecast?** Geological Society of America Annual Meeting, October 28-31, Denver, CO. (Abstract 22242, presented by H. Kempton)
- Kempton, H., W. Locke, D. Goode, D. Atkins, A. Nicholson, and P. Maley. 1996. **Factors influencing the geochemical evolution of the Twin Creeks Mine pit lake**. Geological Society of America Annual Meeting, October 28-31, Denver, CO. (Abstract 23494, presented by W. Locke)

- Bliss, L., J.H. Kempton, and P. Maley. 1996. **The importance of low detection limits in predictive modeling: A case study from two pit lakes in Nevada.** Geological Society of America Annual Meeting, October 28-31, Denver, CO. (Abstract 23497, presented by L. Bliss)
- Sampson, J., R. Pastorok, H., Kempton. 1996. **Reducing uncertainty in predictive ecological risk assessment at mine pit lakes in the Great Basin.** Poster 0235, Society of Environmental Toxicology and Chemistry, November 17-21, Washington, DC. (Presented by J. Sampson)
- Kempton, H., and S. Arbuckle. 1995. **Effect of moisture on the rate of pyrite oxidation in waste rock.** Northwest Mining Association; Mining, Exploration and the environment '95, May 1-5, Bellevue, WA. (Abstract, presented by H. Kempton)
- Kempton, H., D. Goode, D. Atkins, A. Nicholson, and C.L. Travers. 1995. **The use of non-parametric statistics to predict pit-lake water quality.** Northwest Mining Association; Mining, Exploration and the environment '95, May 1-5, Bellevue, WA. (Abstract, presented by H. Kempton)
- Kempton, H., D. Goode, D. Atkins, A. Nicholson, and A. Davis. 1995. **A model for prediction of post-closure water quality in mine pit lakes.** In: Proc. Mine Closure Conference. March 29–31, 1995, Reno, NV. pp. 173-186. (Sponsored by Nevada Mining Association, Reno, NV) (Presented by H. Kempton)
- Kempton, H., D. Goode, D. Atkins, A. Nicholson, C. L. Travers, and A. O. Davis. 1995. **A Monte Carlo model for prediction of water quality in mine pit lakes.** American Chemical Society 209th National Meeting, April 2-6, Anaheim, CA. (Abstract 038, presented by H. Kempton)
- Kempton, H., D. Goode, D. Atkins, C. Travers, A. Nicholson, and A. Davis. 1994. **Evaluation of mine pit lakes: a method for predicting bulk aqueous chemical compositions and quantifying associated uncertainty.** In: Proceedings of The Mining Environmental Management Conference (Sponsor: Mining World News and The Mining Journal), October 16-19, Sparks, NV. (Abstract, post presented by H. Kempton).
- Davis, A., J. Deen, C. Travers, D. Atkins, H. Kempton, and M. Bloom. 1994. **A comprehensive assessment of environmental issues at the Robinson Project porphyry copper mine, White Pine County.** In: Proceedings of The Mining Environmental Management Conference (Sponsor: Mining World News and The Mining Journal), October 16-19, Sparks, NV. (Presented by H. Kempton)
- Runnells, D.D., R.D. Lindberg, and J.H. Kempton. 1987. **Irreversibility of Se(VI)/Se(IV) redox couple in synthetic basaltic groundwater at 25°C and 75°C.** In: Materials Research Society Symposium Proceedings. Vol. 84.

OTHER PRESENTATION AND PUBLICATION FORMATS:

- Swanson, D., W.W. Wilson, L. Barbour, M. O'Kane, D. Williams, H. Kempton, R. Beckie, L. Smith, C. Nichol, and R. Nicholson. 2000. Short Course on: **Understanding Waste Rock Facilities in Dry and Wet Climates**, 5th International Conference on Acid Rock Drainage (Sponsor: Society for Mining, Metallurgy and Exploration), May 21-24, Denver, Colorado.
- Kempton, H. 1998. **Book Review (of Innovations in Groundwater and Soil Cleanup: From concept to Commercialization**, by the National Research Council). In: *Environment*, Vol. 40(7), p. 26.
- Runnells, D.D., R.E. Skoda, J.H. Kempton, R.D. Lindberg, D.A. Bright, C.G. Patterson. 1990. **Hydrogeochemical modeling of redox-sensitive elements in groundwater: Arsenic, Selenium, and iron.** Electric Power Research Institute Research Project RP8000-16