

Mr. Patterson has over 25 years experience as an environmental chemist and has been involved with remedial investigation, design, and construction; risk assessment; geochemistry; and environmental fate and transport analyses for hazardous waste and mining sites. Recent experience includes project management and remedial planning for a number of legacy sites for a large aerospace company, including coordination with other consultants, cost analyses, and strategic planning. Also, strategic planning and permitting to facilitate closure of two former gold mines, one in California, the other in Idaho. Areas of technical expertise include project management, ground water fate and transport, air quality, evaluation of baseline water chemistry and impacts, performing multi-pathway risk assessments for federal and state Superfund sites, support for environmental decision-making using the risk-based approach, and data analysis to support risk assessments and impact evaluations. Expert on issues of perchlorate in the environment (occurrence, sources, remediation, treatment, health effects, regulatory issues, etc.).

SELECTED PROJECT EXPERIENCE

- Project Manager/Senior Scientist, Confidential Mining Client, Cupertino California. Performed water quality evaluations in support of closure planning. Included water and mass balance modeling to predict water quality for surface and ground water following reclamation, and development of contingency mitigation strategies to passively treat (in-situ) ground water collecting in a backfilled pit.
- Project Manager/Senior Scientist, Gualcamayo Mine, San Juan, Argentina. Performed air quality impacts analysis to support improvements to dust mitigation strategies for the mine. Evaluated air quality data, performed a human health risk assessment, evaluated long distance fate and transport of fugitive dust, evaluated monitoring program, and developed and analyzed alternative approaches for mitigation of fugitive dust emissions from mining at the top of a mountain.
- Project Manager/Senior Project Scientist for detailed evaluation of water balance and geochemistry, a monitoring program, and water management programs at the Royal Mountain King Mine in Calaveras County, California. Also developed closure alternatives and evaluated key closure concerns (feasibility analyses) for the mine, negotiating with regulators to develop an overall closure plan that manages residual mine waste and contaminated ground and surface water. Included demonstration of the Technical Impracticability of ground water restoration, computer modeling of ground water flow with an in-house finite element model, analysis of geochemical reactions in reclaimed waste rock piles and their impact on ground and surface water quality, evaluation of impacts of pit dewatering activities on ground water conditions, projections of pit filling and pit water quality, and fate and transport analysis of seepage from a tailings impoundment. Also conducted a feasibility study for the improved capture of leachate and seepage from waste rock piles. Prepared permit application and supported permitting for a unique NPDES discharge that utilizes blending with seasonal flows in a nearby creek to meet water quality objectives. Also supported passive treatment evaluations and analysis of implementation of passive wetlands treatment systems to manage salt-laden leachate from the overburden piles. Developed and refined a successful test of in-situ arsenic

treatment in Skyrocket Pit Lake to reduce arsenic concentration and improve the flexibility of water management activities.

- Project Manager/Senior Project Scientist, Red Hill Mercury Mine, Tustin, CA. Project involved investigation of historic (1880s – 1940s) mercury mine and mining activities in a residential area of Orange County, California. Project involved Phase I activities, site reconnaissance and field mapping of mine features and geology, development of alternative project scenarios, and comparative analysis of the alternative scenarios in support of strategic planning.
- Project Manager, Crafton Redlands Plume Project. Included coordinating technical resources, stakeholder negotiations, strategic planning, feasibility study evaluations, design, construction, and operations and maintenance of facilities to contain and remediate a large plume of perchlorate and trichloroethylene in the Inland Empire in Southern California. Also include budgeting, scheduling, cost control, procurement, reports to management, and other project management activities. Annual budget on the project is \$20 to \$30 million.
- Project Manager/Senior Technical Consultant; various sites across the country. In support of a large aerospace corporation that has a portfolio of sites across the country, performed evaluations of strategies for remediation of a large number of sites. Included review of site conditions, critical reviews of data and modeling, development of conceptual site models, development of alternatives for remediation, risk evaluations, cost estimating, regulatory compliance assessments, cost allocation support, and strategic planning using quantitative and semi-quantitative tools.
- Conceptual design and cost estimating for remediation at a former airplane manufacturing site in Middle River, Maryland on Chesapeake Bay. Included investigating natural resource trustee and agency requirements to establish cleanup levels, evaluation of data to develop ranges of sediment for removal, and working with contractors to develop conceptual design and implementation plans for dredging and disposal of sediments. The sediment volume to be managed ranged up to 300,000 cubic yards (bank volume).
- Project Manager/Senior Project Scientist; Beartrack Mine, Salmon, ID. Supported closure planning, and closure implementation for a heap leach, acid-generating waste rock piles, and a pit lake. Performed water quality assessments, developed site conceptual model, evaluated performance of remedial and closure measures, performed site-wide water balance and supported water management planning, provided technical support in regulatory task force meetings and addressed technical issues that were identified. Evaluated treatment alternatives, including scoping and evaluating treatability testing for leachate from the heap and from the backfilled pit(s). Performed detailed treatment assessment for mercury and supported treatability testing for mercury in the heap leach effluent. Supported Stormwater and Individual NPDES permitting.
- Senior Project Manager for design and implementation of remedial action to remove and/or cap contaminated sediments for remediation of the Lockheed Martin Harbor Island Shipyard Sites in Seattle, Washington. Also included strategic planning and peer

review of project costs. Project included detailed review of project remediation requirements, stakeholder requirements, risks and environmental impacts, and project costs to develop an overall strategy to complete the remediation of the site(s) with minimal residual liability to the client and lowest long-term overall project cost. Project involved negotiating with several federal and state agencies and the natural resource trustees. Construction work included sheet pile installation, pier demolition, sediment dredging, capping, and habitat enhancement. Project completed in two years; valued at approximately \$20 million. Approximately 100,000 cubic yards (bank volume) of sediment and 20 tons of debris were removed to off-site disposal or recycling facilities.

- Senior Project Scientist for design and implementation of remedial action to identify and remove PCB-contaminated sediments from a stream and millpond near Hayton, Wisconsin. Project involved developing remedial design using geomorphological principles to identify where stream sediments had been deposited since the time of the spill and statistical analysis of data to define how much material had to be removed to achieve cleanup levels in the stream. The project also involved conceptual design for dredging of the millpond and development of sediment disposal plans and facilities. The volume of sediment is expected to be on the order of 50,000 cubic yards of in-place material.
- Senior Project Manager for Burbank and Glendale Operable Units of the San Fernando Valley Superfund Site. Included management of large (9,000 and 5,000 gpm) pump and treat systems for regional cleanups, coordination with municipalities, water agencies, state and federal regulatory agencies and private industry, and strategic planning and development.
- Senior Project Manager for a wood treatment/Superfund Site in Gainesville, Florida. Work included field investigations of contaminant nature and extent in soil and ground water, revising the ROD remedy for subsurface soils containing creosote DNAPL, ground water fate and transport modeling using FLOWPATH and MODFLOW (used in conceptual design of remediation facilities), and analysis of the Technical Impracticability of ground water restoration in DNAPL source areas. Performed detailed analyses of ground water chemistry to assess natural background metals concentrations and the potential for natural attenuation of organic constituents. Also performed feasibility study analyses to support selection of a final remedy. Project value approximately \$900K per year.
- Project Manager for Fast Track Remedial Design to control surface soils, Creosote DNAPLs, LNAPLs, and ground water contaminated with arsenic and pentachlorophenol at a wood treatment/Superfund site in Weed, California. Included demonstration of Technical Impracticability for ground water restoration in DNAPL areas, selection and justification of a more cost-effective remedy using risk-based decision making, computer modeling of ground water flow using MODFLOW, design of slurry wall and RCRA-equivalent cell for remediation, treatability studies for inorganic and organic soils remediation, construction and operation of landfarm facility and asphalt wearing surface test pad, and design engineer/construction quality assurance for construction of remediation facilities.

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- Senior Project Manager for remedial design, construction, and construction quality assurance at the Waste Disposal, Inc. Superfund Site in Santa Fe Springs, California. Included preparation of remedial design plans, specifications, and report for EPA approval; also preparation of remediation management plans (RAWP, QAPP, SAP, CQAP, HASP, etc.) for EPA approval. Performed CQA for construction of RCRA Subtitle C and Subtitle D-equivalent caps. Constructed soil gas control system. Also managed site operations maintenance and monitoring. Project value of approximately \$5 million.
- Senior Project Scientist for the Koppers Industries, Inc. Feather River Superfund site in California. Performed analysis of chemical data to guide excavation and cleanup of soil contaminated with pentachlorophenol, dioxins/furans and CCA components.
- Project Manager for evaluation of ground water flow and constituent fate and transport at the Casmalia Resources Hazardous Waste Management Facility near Santa Maria, California. Work included critical review of baseline conditions, ground water quality and flow analyses, and evaluation of efficiency of various response actions. Also prepared closure cost estimates, draft ground water monitoring plan, and general workplan, sampling and analysis plan, quality assurance project plan, and health and safety plan.
- Senior Project Manager for strategic aquifer management planning for Perchlorate and TCE in Regional Ground Water Resource. Supported a confidential client in Southern California to develop a strategy for remediation/containment of a contaminant plume that covers approximately 20 square miles of an important drinking and agricultural water resource. The project involved developing approaches for managing approximately 50,000 acre-feet per year of water pumped from the aquifer in a manner that did not cause significant spreading of the plume, but provided continued beneficial use of the water by several municipalities. The project included projections of water use, analysis of the water supply systems, analysis of blending capabilities and procedures, development of pumping and treatment strategies, and negotiating and coordinating with water purveyors, municipalities, regulatory agencies, and responsible parties. Of particular importance was the lack of a feasible treatment method for one of the contaminants (perchlorate). Estimated costs of the alternative approaches range from \$50 million to \$270 million.
- Senior Project Manager for Whittaker Bermite facility in Santa Clarita, California. As part of an activity where TRC was considering assuming the environmental compliance liability for the perchlorate contamination site, performed a detailed review of site hydrogeologic and contaminant conditions. This included identifying ground water pollutant source areas, conducting hydrogeologic evaluations, developing hydrogeologic and contaminant transport conceptual models, and assessing the extent of perchlorate impact. Based on these evaluations, aquifer management plans were prepared to remediate source areas, restore the local water supplies and to provide for perchlorate plume capture and ultimate remediation. Used the plans to develop reliable life cycle cost analyses and to accurately identify and price out the project and risk costs.
- Senior Project Scientist for developing ground water management/monitoring plan for a rare earth element mine in Mountain Pass, California. Included geochemical

characterization of waste rock and tailings, computer modeling of ground water flow using MODFLOW and constituent migration using MT3D, analysis of 20 years of ground water monitoring data, evaluation of baseline ground water chemistry, evaluation of pH water quality and development of health protective cleanup standards.

- Project Manager for development of unique hydrologic model for expansion design and repermitting of a 115-acre wastewater evaporation facility for a mine in southeastern California. Included detailed analysis of ground water hydrology in a 510-square-mile basin, evaluation of the role of capillary suction and ground water evaporation in augmenting the disposal of wastewater, detailed review of ground water geochemistry and quality, and analysis of pond operation data. Also performed saturated and unsaturated flow modeling.
- Project Manager for evaluation of waste water management/disposal at the Jamestown Mine near Jamestown, California. Included evaluation of effects of pit filling on ground water and surface water conditions, detailed geochemical evaluations of waste rock and process water, computer modeling to project pit filling and pit water quality, evaluation of ground water geochemical conditions and flow, and water balance modeling to support design and regulatory approval of water disposal systems. Obtained NPDES permit for discharge of water from the tailing impoundment. Also performed analysis of nature and extent of water quality impacts and fate and transport analysis.
- Senior Project Scientist for evaluation of containment, copper inventory, and environmental effects associated with proposed alternative heap leach facilities at Cyprus Amax's Cerro Verde Mine near Arequipa in Peru. Included development of geochemical testing protocols, evaluation of site-wide hydrologic and geologic conditions, field testing and cost analyses.
- Senior Project Manager for analysis and conceptual engineering for acid rock drainage issues at the Andina Mine operated by Codelco north of Santiago, Chile. This copper mine was planning expansion to up to 150,000 tons per day, but as part of expansion would be required to mitigate existing and projected future impacts due to acid drainage from waste rock. The mine is located in very steep terrain and gets over 10m of snow per year. Acid drainage flows were up to 2,000 liters per second with a pH of <1 and copper concentration of 3 mg/L. Impacts extended over 30 km downstream in an important agricultural river. The proposed remedy included copper recovery to offset costs, storage, neutralization, evaporation, and discharge.
- Project Manager for containment assessment, copper inventory and loss analysis, and evaluation of supplemental engineering control measures for Run of Mine Dump Leach Facility at Phelps Dodge El Abra Mine in Northern Chile. Involved site reconnaissance, detailed evaluations of hydrologic conditions and site data, and analysis of engineering and operational controls to meet regulatory and corporate environmental protection requirements.
- Project Manager for evaluation of regional acid rock drainage problems at a large number of historic mines in three river basins in northern Peru. Included development and implementation of field evaluation of acid rock drainage (ARD) conditions, and the

preparation of conceptual designs for remediation including stream diversions, covers and underground mine sealing.

- Project Manager for geochemical field evaluation at Homestake's Santa Fe Gold Mine in western Nevada. Included evaluation of acid generating conditions in overburden, their effect on mine reclamation vegetation, and conceptual design for mitigation.
- Project Manager for a study of the disposition and management of residual industrial and domestic solid and liquid wastes at BHP's Tintaya Copper mine in southern Peru. Included field evaluation of waste stream volumes and characteristics, development of waste management plans, spill management plans, and conceptual design of waste disposal and water treatment facilities.
- Senior Project Scientist for preparation of EIR/EIS of the proposed Briggs Gold Mine in Inyo County, California. Work included analysis of emissions, dispersion, and impacts of fugitive mobile and process sources. Both hazardous and criteria pollutants were included in the analysis.
- Project Manager for environmental audit/review at Fairbanks Gold Mining, Inc. Fort Knox Mine near Fairbanks, Alaska. Included review of ore and overburden geochemistry, evaluation of water management and ground water conditions, and detailed review of waste management and practices and compliance with environmental regulations.
- Project Scientist for an expedited nationwide due diligence review of agency files to support acquisition of metal and coal mining properties in eight states and onshore and offshore oil and gas producing properties in three states. Particular emphasis was placed on evaluation of past and present environmental liabilities and the adequacy of reclamation and closure cost estimates.
- Senior Project Scientist for preliminary fate and transport analysis and risk assessment for a former Class I landfill in California.
- Senior Project Scientist for evaluation of fate, transport and potential health impacts of landfill gas on nearby residents for a confidential client in California.
- Project Scientist for preparation of an AB2588 risk assessment for the Baillard Landfill in Ventura County. The risk assessment was performed as part of the environmental documentation for the site EIR/EIS, and included emissions estimation, air dispersion modeling, and human health risk assessment according to SCAQMD and CARB protocols.
- Senior Project Scientist for preparation of a ground water monitoring program for the Fort Irwin Road Land Treatment Facility near Barstow, California. Included characterization of baseline ground water quality, development of statistical data evaluation methods, and designation of monitoring point and constituents of concern.
- Senior Project Scientist for preparation of health risk assessment, air quality technical report, and air quality impacts analysis for the Environmental Impact Statement / Environmental Impact Report (EIR/EIS) for the Mesquite Regional Landfill in Imperial County, California. This included emissions calculations of fugitive process and mobile

sources, dispersion modeling, and health and environmental impacts analysis. Hazardous and criteria pollutants were included in the analyses.

- Senior Project Scientist for analysis of production and migration of hazardous constituents of landfill gas at the Operating Industries, Inc. Landfill Superfund site in Montebello, California. Included quantification of both subsurface (soil gas) and surface emissions, and analysis of potential health effects.
- Project Manager - Development of site hypothesis/natural attenuation approach for remediation of perchlorate at Lockheed Martin's former rocket manufacturing and testing facility near Beaumont, California.
- Testifying expert in defense of property owners at the LAUSD Proposed Southgate School Site whose facilities were being condemned under imminent domain.
- Senior Project Scientist for evaluation of contaminant conditions and remedial alternatives for an Air Products and Chemicals, Inc., facility in Wichita, Kansas.
- Senior Project Scientist for analysis of emissions, impacts and control strategies for toluene diisocyanate product lines at MacWhorter's (now Cargill's) plastic resins manufacturing facility in Southgate, California. Included detailed review of the AB2588 risk assessment, process improvements, and emission calculation methodologies. Also included negotiation with SCAQMD.
- Senior Project Scientist to support development of site hypothesis, including fate, transport, exposure, and risk analyses for remediation of uncontrolled releases from a former drum recycling plant in Emeryville, California.
- Project Scientist for preparation of expert testimony in defense of the Stringfellow federal Superfund site in California.
- Project Manager for a risk assessment and Remedial Investigation/Feasibility Study (RI/FS) of a former wood treatment products site. Included computer modeling of site constituents and negotiation of reasonable exposure scenarios and pathways for risk assessment. The project was completed under the direction of the California Environmental Protection Agency (Cal-EPA) as part of the California State Expenditure Bond Plan.
- Lead Scientist for preparation of two risk assessments for separate but adjacent Superfund sites. This project involved a multi-pathway assessment of abandoned used oil refineries and included air dispersion modeling and fate and transport analysis of more than 20 chemicals of potential concern. Used CHEMDAT7 model (predecessor of the current SIMS model) to assess hazardous air pollutant emissions from waste piles, pits, lagoons, and surface impoundments.
- Project Scientist for a risk assessment for the site of a former oil refinery on the California State Expenditure Bond Plan. Work included emissions quantification, air dispersion modeling, and assessment of hydrogeology in the area. Emissions were quantified using the CHEMDAT7 model (a predecessor to the SIMS model) to quantify hazardous air pollutant emissions from land treatment and landfarming activities. Also

performed pathways analysis and determined concentrations in environmental media to calculate doses through exposure pathways.

- Project Scientist for air dispersion modeling in support of a Safety Analysis Report and Environmental Report for a commercial uranium enrichment facility. Responsibilities included accident/consequence analysis using the TRIAD model and modification of the TRIAD computer code to accept unusual NRC meteorological conditions. Also reviewed uranium and hydrogen fluoride toxicological standards for applicability to residential exposure scenarios.
- Project Scientist for waste characterization plan and several accident/consequence analyses involving radionuclides as part of the Hanford Waste Nitrification Plant Project in Richland, Washington.
- Project Manager for a Phase I Site Investigation of a 450-acre parcel proposed as the location of a Resource Conservation and Recovery Act Treatment Storage and Disposal Facility (RCRA TSD) facility for ICI Explosives Environmental Services, Inc. in Camden, Arkansas.
- Project Scientist for preparation of a PSD air permit application for a major modification of the Valdez Marine Terminal, Alaska. The modification was in response to requirements of Clean Air Act Amendments of 1990 (ozone nonattainment, Title I). Included development of a complex emissions model that calculated emissions from marine and process sources as a function of pipeline throughput.
- Lead Scientist for preparation of RCRA and Air Quality permit applications for two commercial hazardous waste incinerators. Included development of strategy for the "Boiler/Industrial Furnace (BIF) Regulations." Included emissions calculation of hazardous and criteria pollutants. Performed dispersion modeling and developed ambient air toxics and criteria pollutant monitoring program for one of the facilities. Defended both permits in hearings by the state hazardous waste commission. Also developed trial burn plan.
- Lead Scientist for preparation and implementation of an air monitoring program to study air emissions from two abandoned oil refineries as part of an RI/FS. Program included quantification of both gaseous and particle-borne hazardous air pollutants.
- Lead Scientist for air dispersion modeling of cooling tower plumes from a large combined cycle gas-fired turbine. The project involved using a specialty model and modifying the computer code to accept unusual cooling tower conditions.
- Project Scientist and Quality Assurance (QA) Manager for an RI/FS and risk assessment, and assisted with an exposure assessment for a former pentachlorophenol wood treatment facility. Included QA checks of analytical data and data quality/usability analysis. Responsibilities also included emissions and dispersion modeling, setting data quality objectives and assisting with sampling plan.

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- Project Scientist for the screening of Applicable or Relevant and Appropriate Regulations (ARARs) for an operable unit at a large Superfund site in Montana, including identification of hazards and evaluation of dispersion of smelter flue dust.
- Project Manager for preparation of an AB-2588 Air Toxics "Hot Spots" Emission Inventory Report for Texaco's 50,000 bbl/day Bakersfield Refinery. The project required the use of over 5,000 pieces of information to determine the emission of over 100 toxic substances, including phenol, formaldehyde, benzene, and petroleum hydrocarbons.
- Organized and implemented a basic research study of long-range atmospheric transport in the North Atlantic. Studied the transport, composition and fate of natural and anthropogenic aerosol particles from Bermuda. Used energy dispersive x-ray analysis for particle analyses and developed a computer program to model aerosol composition variations.
- Worked in a 2MW research reactor analyzing atmospheric and oceanographic samples using neutron activation analysis, GeLi gamma ray spectrometers, and alpha and beta counters. Also designed, built and operated an instrument to measure low levels of ^{222}Rn in air, and analyzed radiation from the Chernobyl accident for implication in atmospheric chemistry and long-range atmospheric transport.

EDUCATION

B.A. Chemistry/Biochemistry, University of California, at San Diego, San Diego, California, 1983
Ph.D., Atmospheric Chemistry, University of Rhode Island, Kingston, Rhode Island, 1988

PUBLICATIONS AND PRESENTATIONS

Sturchio, N. C., Hoaglund, J. R., Marroquin, R. J., Beloso, A. D., Heraty, L. J., Bortz, S. E. and Patterson, T. L. (2011), *Isotopic Mapping of Groundwater Perchlorate Plumes*. Ground Water, 49: no. doi: 10.1111/j.1745-6584.2011.00802.x.

Anderson, J.R., P.R. Buseck, T.L. Patterson and R. Arimoto (1999). *Characterization of the Bermuda Tropospheric Aerosol by Combined Individual Particle and Bulk Aerosol Analysis* Atmos. Environ 30:319-338.

Sterling, H.J., B.W. Jones, and T.L. Patterson. (1992). *Remediation Site Characterization Using an Integrated Database/CAD System*.

Patterson, T.L. and R. A. Duce (1990). *The Biogeochemical Cycle of Atmospheric Cadmium Over the Remote North Pacific Ocean*. Tellus, 43B: 12-29.

Uematsu, M., J.T. Merrill, and T.L. Patterson, R.A. Duce, and J.M. Prospero (1988). *Aerosol Residence Times and Loading Gas/Particle Conversion over The North Pacific as Determined from Chernobyl Radioactivity*. Geochem Jou., 22:157-163.

Patterson, T.L. (1988). *The Cycle of Atmospheric Cadmium over the Remote North Pacific Ocean*. Ph.D. Dissertation, University of Rhode Island, Graduate School of Oceanography.