

NWRI Expert Panel for the California Department of Public Health

CV for Proposed Expert Panel Member:

- R. Rhodes Trussell, Ph.D., P.E., BCEE (Panel Chair)



**R. Rhodes Trussell, Ph.D., P.E.,
BCEE**

EDUCATION:

Ph.D., Sanitary Engineering, *University of California, Berkeley*

M.S., Sanitary Engineering, *University of California, Berkeley*

B.S., Civil Engineering, *University of California, Berkeley*

Graduate, *Stanford Executive Program*

REGISTRATION:

Civil Engineer, State of California - No. 25107

Corrosion Engineer, State of California - No. 745

CERTIFICATION:

Board Certified Environmental Engineer,
American Academy of Environmental
Engineers

HONORS

1995 National Academy of Engineering

2001 AAMWA Boyd Award

2005 AEESP/AEE Pohland Medal

2010 AWWA Black Award

2012 IWA's Global Water Award

SUMMARY:

Dr. Trussell is recognized, worldwide, as an authority in methods and criteria for water quality and in the development of advanced processes for treating water and wastewater to achieve the highest standards. He is often called upon to help utilities effectively

manage critical projects involving regulatory authorities and public health. Dr. Trussell has also for more than 40 years maintained an active practice in the corrosion of materials in water systems, having conducted more than a dozen pipe-loop tests. He is sought nation wide as a consultant on water problems having advised the Cities of San Diego, Los Angeles, San Francisco, Oakland (EBMUD), Concord (CCWD), Portland, OR; Tacoma and Seattle, WA, Boston, MA; New York; and Washington DC and many others. Recent projects include: Advice on post treatment to the Monterey Regional Desalination Project; Development of water quality and treatment documents for the Woodland Davis Water Supply Project; Expert Testimony on contamination/corrosion of a liquid chlorine system at a major water treatment plant (Archer Western Contractors, Ltd. v. The City of Austin); Consulting with the Korean Water Corporation on the design of ozonation and GAC facilities for their Sunnam water treatment plant (207 mgd); Review of the design of a 30 mgd membrane filtration ozonation facility for the Clark County Reclamation District; Lead and Copper treatment for the Camp Pendleton Marine Corps Base; Participation in the DEC Review for USBR's proposed facilities for the San Luis Drain (\$2.3 billion); Report on Compliance with the Lead and Copper Rule for the San Francisco Public Utilities Department (300 mgd); evaluating Desalting for the City of Carlsbad, CA.; assisting the San Diego County Water Authority in a Design/Build/Operate effort for a 100 mgd membrane/ozonation/GAC plant; and reviewing the lead problem in Washington, D.C. for USEPA Office of Water. Dr. Trussell is available to review and advise on any complex water quality problem. He has special interest in reuse, desalting, membrane filtration, disinfection and corrosion.

Dr. Trussell served as Member and Chair of the Water Science and Technology Board for the National Academies from 1988 to 2007 and as a member of the EPA Science Advisory Board from 1998 through 2005. He was also the Vice Chair of the NRC Committees on Indicators of Pathogens and Drinking Water Contaminant Candidates. For the International Water Association, Dr. Trussell serves as a member of the Scientific and Technical Council, and was also a member of the Program Committees for the Convocations in Berlin 2001, Melbourne 2002, Marrakech 2004, Beijing 2006, and World Congress in Vienna, 2008. Dr. Trussell is a Board Certified Environmental Engineer in the American Academy of Environmental Engineers and is a member of the Academy's Committee for Certification by Eminence. Dr. Trussell served as the Chair of the Research Advisory Committee and is now a member of the Board of Directors for the WaterReuse Foundation. He also serves on the Board of Directors of the Water Environment Research Foundation. Dr. Trussell was elected to the National Academy of Engineering in 1995, served as a member of the Academy's Peer Committee for Civil Engineers for 2001-2003, served on the selection committee for the Academy's "\$1 million" Grainger Prize for 2006-2007, on the presently on the Academy's Membership Committee (2006-2009) and on the Membership Policy Committee (2010-2012).

EMPLOYMENT HISTORY

TRUSSELL TECHNOLOGIES, INC. PASADENA, CA (2003-Present)

Chairman, CEO and founder of the company. Technology in the water world is rapidly changing. Many in the industry see choosing among the many technical opportunities as fraught with risk. Change takes place so quickly and there are so many things going on that it's difficult to make good choices.

Yet new technologies and new regulations are forcing change. Trussell Technologies seeks to be the trusted advisor that understands new technologies; how to test them, how to understand and predict their behavior, and how to reduce the risks associated with embarking on a new way of doing things.

UNIVERSITY OF CALIFORNIA, IRVINE (2003-Present)

Adjunct Professor of Environmental Health, Science, and Policy, School of Social Ecology, University of California, Irvine

MWH, INC. INTERLOCKEN, CO. (2001-2003)

Senior Vice President, Manager of Global Water Knowledge Center 2001-2002. Led Company's effort to author new textbook, *Water Treatment: Principles and Design*, published by John Wiley & Sons in 2005.

MONTGOMERY WATSON, INC. PASADENA, CA (1992-2001)

Senior Vice President, Director of Corporate Development, Board Member and Member of the firm's Executive Committee from when the firm was created in 1992 until merger with Harza in 2001. Participated in 13 mergers/acquisitions during that time.

JAMES M. MONTGOMERY CONSULTING ENGINEERS, INC. PASADENA, CA (1972-1992)

Entered as Senior engineer in Pasadena Water Department, became Vice President Head of Environmental Sciences Department, became head of Specialized Resources Group, founded both the company's laboratory and research group, became Corporate Director of Water, became Senior Vice President and Director of Applied Technology for the firm, 1972-1991. Director of Corporate Development, charged with strategic planning and mergers

and acquisitions, 1992. Member of the firm's Board of Directors 1983, 1985-1992. Member of the Firm's Executive Committee from 1985-1992.

UNIVERSITY OF CALIFORNIA (1966-1972)

Ph.D. Research: Dr. Trussell developed a methodology for making predictions in water chemistry. The method is in use in the Environmental Engineering field.

CONSULTING WHILE AT U.C. (1966-1972)

While in school, Dr. Trussell worked as a consultant with Dr. Jerome F. Thomas, the firm of Pomeroy, Johnston and Bailey, and James M. Montgomery, Consulting Engineers, Inc. Studies included internal and external corrosion of private, municipal, and industrial iron, copper and stainless steel piping; corrosion of buried iron and steel piping and other equipment; industrial water treatment; design, operation, and maintenance of cooling towers; proper operation of boilers and associated condensate return systems; the preliminary design of chlorination facilities for a large municipality; solid waste management; design of individual home waste disposal systems; demineralization; and advanced wastewater treatment.

PROJECT EXPERIENCE (Selected projects):

Santa Margarita Water District

Title: Copper Tubing Corrosion

Year: 2011-2012

Homeowners in the SMWD service area have reported copper pitting of consumer plumbing as a problem occurring in new construction built in the early 2000s. Trussell Tech was retained to write a Technical Memorandum to provide a brief background on the copper pitting issue; briefly summarize the claims made and the technical reports filed; look at the existing water quality of the treated water from Metropolitan Water District of Southern California's (MWD) Diemer Water Treatment Plant (WTP) that feeds the SMWD's

water distribution system; provide a visual evaluation of existing pipe materials through photographic evidence including discussion of evaluation techniques planned for pipe materials sent to EPA's lab in Cincinnati, Ohio; and provide recommendations, schedule, and budget of next steps including a twelve-month test with a pipe loop setup at SMWD's pump station to evaluate treatment alternatives including phosphate addition and disinfection.

Role: *Technical Director*

Monterey Regional Water Pollution Control Agency (MRWPCA)

Title: Groundwater Replenishment Project

Year: 2012-present

MRWPCA is planning to develop and implement a Groundwater Replenishment Project in the Seaside Groundwater Basin. It is planned to percolate into the basin either advanced treated water from the Salinas Valley Water Reclamation Plant and/or agricultural drainage from Blanco Drain. The estimated amount of water that could be provided by the project is approximately 2,800 acre-feet per year (AFY), which will supplement the natural recharge to the basin by approximately a factor of two. Trussell Tech was retained to assist with source water characterization, to evaluate Membrane Bioreactor (MBR) technology as an alternative secondary treatment approach to the existing trickling filters, and to evaluate post treatment stabilization and dual purpose pipeline considerations.

Role: Technical Advisor

Water Reuse Research Foundation (WRRF)

Title: Equivalency of Advanced Treatment Trains for Potable Reuse

Year: 2012-present

Trussell Technologies is lead firm on WRRF 11-02 potable reuse project in partnership with Carollo, University of Arizona, and numerous utilities. This important project serves to bridge the gap from indirect potable reuse projects in place today to future direct potable reuse projects that reduce the role of the environmental buffer. The project involves three overarching tasks: (1) background research and criteria development including literature review with focus on health

criteria and regulations, process models, and alternative treatment trains; review of available public health criteria including international, federal, state, and local regulations and guidance; development of criteria for direct potable reuse that are protective of public health through an Independent Advisory Panel and workshop; development of additional criteria to compare unit processes and treatment trains; and culminating in a State-of-the-Science report; (2) Toolbox for integrated treatment trains, a computer model that provides information on integrated water reuse treatment trains for DPR; and (3) Treatment Train Development and Validation, involving validation of the relevant treatment trains at the pilot-, near-full-scale, and full-scale including testing with reclaimed water from the LACSD's San Jose Creek WRP with advanced treatment processes including ozonation and biological filtration, among other technologies.

Role: Principal Investigator (PI)

Upper San Gabriel Valley Municipal Water District

Title: Groundwater Recharge project

Year: 2012-present

Trussell Technologies is serving as Technical Advisor for Upper District's Indirect Reuse Action Plan (IRAP). This involves identifying and assisting the District in tasks required to permit, construct, operate, and pay for advanced treatment facilities to produce highly treated recycled water for groundwater recharge in the Main San Gabriel Basin. This involves interactions with CDPH and the RWQCB on regulatory considerations including the CDPH's draft groundwater recharge reuse requirements. It also involves identification and piloting of advanced treatment technologies including ozone/biological filtration.

Role: Technical Advisor

PACE Engineers, Inc. (for SMWD)

Title: Treatment for Corrosion Control

Year: 2012

Working as a sub for PACE, Trussell Tech developed a TM for SMWD for evaluation of treatment technologies for corrosion control treatment to resolve excessive copper

concentrations in consumer plumbing exposed to groundwater serving Nichols Institute in SMWD's service area. Treatment evaluated included air stripping, caustic addition and/or orthophosphate addition. Orthophosphate ended up being the best choice based on previous experience at nearby Camp Pendleton.

Role: Technical Director

Santa Ana Watershed Project Authority

Title: Inland Empire Brine Line Solids Control

Date: 2011 – Present

The Santa Ana Watershed Project Authority (SAWPA) operates the Inland Empire Brine Line, a brine line used to convey wastes (desalter discharge, domestic and industrial wastewater) to Orange County for treatment, prior to discharge. Trussell Technologies has been retained by SAWPA to investigate the formation and composition of solids within the brine line, as well as sampling procedures and potential mitigation strategies, given that Orange County uses solids loading as a parameter for billing SAWPA. Dr. Trussell has overseen these efforts in the capacity of Technical Advisor, providing critical insight into the characterization of the solids and the implications of non-representative sampling on the solids loading.

Role: *Technical Advisor*

Santa Margarita Water District

Title: Copper Tubing Corrosion

Year: 2011-2012

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provide recommendations, schedule, and budget of next steps including a twelve-month test with a pipe loop setup at SMWD's pump station to evaluate treatment alternatives including phosphate addition and disinfection.

Role: Technical Director

Rancho California Water District District/RMC Water and Environment

Title: Indirect Potable Reuse Conceptual Design Study

Year: 2011 to present

The Rancho California Water District (District) is evaluating alternatives and the viability of indirect potable reuse for augmenting their water supply. Indirect potable reuse alternatives cover a wide-range of possibilities from reservoir augmentation to surface spreading. The project aims to maximize the District's beneficial use of recycled water while meeting salt and nutrient plan objectives for the groundwater basin. Trussell Technologies, Inc. evaluated the various recycled water source water alternatives, developed treatment alternatives to minimize brine, and assisted with the evaluation of advanced water treatment process alternatives.

Role: Technical Advisor

Rancho California Water District

Title: Rancho California Alternative Secondary Treatment Evaluation

Year: 2011- present

The Rancho California Water District (District) owns and operates the Santa Rosa Water Reclamation Facility (SRWRF) in Murrieta, CA. Almost all of the wastewater treated at the SRWRF is reclaimed and reused locally for land irrigation. The heart of the treatment process at SRWRF is sequencing batch reactors (SBRs) that have historically performed poorly and struggle to handle peak flows. Trussell Tech is currently working with the District to assess the current performance of each process, document the current conditions of the facility, develop alternatives for either replacing or upgrading the secondary process, and evaluate and estimate these alternatives to provide the district with the best overall upgrade approach to reliably and

efficiently produce reclaimed water for the next 20-30 years.

Analyses of the past two years of data and communication with plant operators about treatment challenges form the basis for the recommendations. Focus has been placed on process targets and possible changes to reach optimal efficiency and performance with respect to coagulation, filtration, chlorination, and solids handling. Recommendations will be categorized based on immediate, short, and long-term time scales to enable the City to comprehensively plan capital improvements.

Role: Technical Advisor

Search Dog Foundation

Title: National Training Center Water Treatment Design

Year: 2010 to present

Search Dog Foundation (SDF) is currently planning and constructing their National Training Center (NTC) in the foothills of Santa Paula, CA to consolidate its canine kennels, search training sites, and offices. The NTC is located in a quiet, rural area, and their projected water demand of 4000 gallons per day must be met with an onsite groundwater well. Testing has shown this water quality to be challenging, containing elevated levels of total dissolved solids, sulfates, boron, iron, manganese, and potentially hydrogen sulfide. Also challenging is the client's request to have minimal trucking associated with water treatment and an impacted watershed (i.e., no conventional place to discharge the waste stream produced by water treatment). Trussell Technologies has evaluated multiple whole-system treatment technologies for the NTC, including solar distillation, thermal distillation, and reverse osmosis (RO) with pretreatment for producing drinking water; and thermal distillation and evaporative beds for brine minimization and treatment. Upon Trussell Technologies' recommendation, SDF has selected RO with pretreatment and evaporative brine beds for their overall water treatment system, and retained Trussell Technologies for the process design. To ensure successful RO performance, pretreatment involves tray aeration to oxidize iron, manganese, and hydrogen sulfide and greensand filtration. Post-treatment of the RO

permeate will involve boron ion exchange, calcite filtration for stabilization, and disinfection. RO brine and filter backwash water will be sent to the evaporative beds, where only solids will be retained, making this overall system essentially zero-liquid discharge. Trussell Technologies will continue to participate in final process design, as well as start-up testing and evaluation of the new water treatment system, enabling the NTC to have a safe and reliable drinking water supply.

Role: Technical Advisor

MWH / City of Tacoma Dept. of Public Utilities (Tacoma Water)

Engineering Analysis and Technical Review Services for The Green River Filtration Facility
Year: 2010-2012

MWH Americas, Inc. (MWH) provided design consultant services to the City of Tacoma, Department of Public Utilities, Water Division (Tacoma Water) for design and construction of a new filtration facility for the Green River supply to meet the requirements of the Long Term 2 Enhanced Surface Water Treatment Rule (LT2ESWTR). Successful implementation of this project will provide significant benefits to Tacoma Water, its Regional Water Supply System Partners (Partners) and other wholesale customers.

The Green River Filtration Facility (GRFF) will be constructed on the site of the existing Green River Headworks Facilities. It will treat water supplied from the Green River downstream of Howard Hanson Dam and from the North Fork Well Field (NFW). The initial maximum filtration capacity of the new facilities will be 150 mgd with an ultimate filtration capacity of 168 mgd. Planned capacity will be 90 mgd when operating in conventional mode (with pretreatment preceding the filters). Currently, maximum and annual average treatment flows are approximately 110 mgd and 60 mgd, respectively, but are anticipated to increase after construction of the GRFF. Trussell Tech provided engineering analysis, oversight and technical review services as a subconsultant to MWH.

Role: Technical Director

West Basin Municipal Water District

Title: SWRO Demonstration
Year: 2008-present

Trussell Technology assisted WBMWD in the design and now the operation of their full-scale seawater desalination facility in Redondo Beach, CA. Operational assistance includes management of the system for manufacturing preformed chloramines, monitoring and control of water quality in the seawater, the product water, and the seawater discharge. The firm also manages the quality control on the bench-scale unit for post treatment.

Role: Technical Advisor

West Yost Associates

Title: Davis-Woodland Water Supply Project

Year: 2009-present

Trussell Technologies has provided water quality and treatment support to West Yost Associates in the development of the Davis-Woodland Water Supply Project, a 52 mgd project which will take water from the Sacramento River, treat it and supply it to these two Central Valley Communities. The project is utilizing a design-build-operate method of delivery and Trussell supervised extensive water quality monitoring, coordinated with the California Department of Health, prepared white papers on key water quality issues, conducted bench testing on treatment, prepared a 15% design of the benchmark process train, including process flow sheet, design criteria, hydraulic profile, and site layout, equipment selection. The firm has also prepared major portions of the RP and draft service contract.

Role: Technical Director

RMC Environment/ Marina Coast Water District

Title: Marina Coast Regional Desalination Project

Year: 2009-2012

The Marina Coast Water District was working with Cal Am and Monterey County to develop a 10 mgd regional desalination project. Trussell Technologies did the preliminary process design including flow sheet, design criteria, process modeling, water quality goals, and equipment selection and interaction with the California Department of Health. The effort included extensive evaluation of GWUIDI criteria, alternatives for disinfection and an extensive

examination of alternatives for corrosion control, including a preliminary design.

Role: Technical Director

Private Client

Title: Water Filtration Development

Year: 2009

Developing advanced water filtration technology for a private client via market and regulatory investigation, experimentation, design and collaboration with academic and manufacturing partners, including comparisons of various attributes with multicriteria decision making tools (e.g., Target Plot-/Spider Diagram) and development of a technology roadmap.

Role: Technical Director

RMC Environment/ Marina Coast Water District

Title: Marina Coast Salinas River Surface Water Treatment Plant Conceptual Design and Permitting

Year: 2009

The Marina Coast Water District is developing new water supply options including a surface water treatment plant on the Salinas River in Monterey County. The project consists of seasonal diversion of excess Salinas River surface water and treating it at a surface water treatment plant to provide a potable water supply directly to urban users. Trussell Technologies, Inc was hired by RMC Environment to prepare a conceptual design of the plant, assist with the process selection, and the Department of Public Health permitting, including the preparation of the sampling plan. The primary treatment processes proposed for this facility are high rate sedimentation (Actiflo) followed by microfiltration (MF) membranes. These processes were selected for their ability to meet water quality goals, large turndown requirements, and in the case of Actiflo, ability to handle rapid changes in turbidity.

Role: *Project Advisor*

City of San Diego

Title: Innovative Brine Minimization Treatment Train

Year: 2009

In order to diversify its potable water supply portfolio, the City of San Diego is conducting a 12 month San Pasqual Brackish Groundwater Desalination Demonstration Project. In addition to investigating the efficacy of various wells to extract sustained production volumes from the shallow aquifer, the Demonstration Project is aimed at determining the operational parameters that will be necessary for sustained operation of a reverse osmosis plant. This project will investigate precipitative softening processes using two of the most promising technologies (i.e. tubular membrane filtered lime slurry reactor and a pellet reactor) and a biological reducing process to eliminate oxyanions (i.e. sulfate, nitrate). The overall treatment train objectives are to minimize the total brine volume and the mass of salt contained in this brine without using any cost-prohibitive thermal processes currently incorporated in treatment schemes that approach the recoveries described here (i.e. zero liquid discharge (ZLD) at 97%).

Role: *Project Advisor*

Sunnyslope County Water District

Title: Treatment of Groundwater Using Precipitation Softening

Year: 2008-2009

The District faces increasingly stricter regulations on its wastewater discharge, which limits the concentrations of sodium, chloride, and total dissolved solids that are allowed. Unfortunately, the groundwater available to the District is hard and self-regenerating water softeners (SRWS) are in common use throughout the service area, which increases all three constituents of concern. RMC retained the services of Trussell Technologies to evaluate treatment alternatives that could reduce the water hardness and the total dissolved solids concentration without using complex or expensive treatment processes. Trussell Technologies evaluated softening treatment alternatives using a 'Softie Model' to compare a pellet reactor, to a high rate solids contactor with lime, along with a high rate solids contactor with lime and potassium soda ash. In addition to evaluating lime softening of the groundwater, Trussell Tech was tasked with modeling softening processes to treat the brine from a primary reverse osmosis operating on the

groundwater. Modeling the operation of a secondary RO system treating the softened RO brine is also part of this project. Trussell Tech will participate in an evaluation of additional brine minimization alternatives such as: evaporation ponds, VSEP and thermal processes.

Role: *Technical Director*

West Basin Municipal Water District

Pilot Operation Of Novel High-Rate Granular Media Filtration As Pre-Strainer To Microfiltration On Open- Intake Seawater Source

Year: 2009

West Basin MWD's El Segundo, CA pilot test site, have successfully employed a 100-micron disc filter for this application. The District has now investigated an alternate approach to pre-straining, using a high- rate granular media filter (GMF) in place of the disc filter. The goal is a more robust pretreatment process that can accomplish the straining requirements at a reduced total water cost.

To evaluate the GMF concept, two pilot trains were operated with identical microfiltration (MF) systems operating downstream of the pre-straining processes. The high rate GMF and disc filter processes were operated in parallel on the raw ocean water that was pre-screened with a 1.6 mm basket strainer. This enabled the performance of the GMF / MF combination to be compared to the disc filter / MF combination. Data was generated for typical seawater conditions as well as impaired seawater conditions that occurred as a result of algal blooms and storm events. West Basin MWD plans to continue to evaluate the process benefits and the economics of these two pre-strainer technologies to determine the most cost-effective and robust pretreatment system (pre-strainer + MF).

Role: *Technical Advisor*

City of Austin, Texas

Title: Chlorine contamination

Date: 2008-2009

The City of Austin substantially expanded the city's water treatment plant and, as part of the process, it constructed facilities to receive, store, evaporate and deliver liquid chlorine. Storage facilities are sufficient for 48 tons of liquid

chlorine. During the start-up of the facilities, contamination began to appear in the chlorine and a dispute has arisen between the City and the contactor as to the cause of the contamination. The City has retained Dr. Trussell to serve as an expert witness on its behalf.

Role: *Expert Witness*

MWH/West Basin Municipal Water District

Title: West Basin Red Tide Project

Year: 2007 – 2008

Working with MWH, Trussell Tech has been retained along with the University of Southern California to develop and conduct a comprehensive monitoring program for stormwater impacts on the SWRO treatment process and resulting permeate water quality, and marine phytoplankton and biotoxin production impacts on the SWRO process and resulting permeate water quality. The monitoring program will develop real-time monitoring surrogates and utilize state-of-the-art technologies to demonstrate the public health and operational significance of these events. The algal toxin information generate by the project is novel both in the context of seawater desalination, as well as in the context of fundamental research in marine biology and oceanography. Trussell Tech has developed the stormwater monitoring program and is coordinating the RO testing related to the algal toxins identified for study by USC.

Role: *Project Manager*

West Yost/ Davis-Woodland JPA

Project Title: Davis-Woodland's Sacramento River Surface Water Treatment Plant Conceptual Design and Permitting

Year: 2009-Present

The Cities of Davis (Davis) and Woodland (Woodland) and the University of California at Davis (UC Davis) are working in partnership to develop a regional water supply. The Davis-Woodland Water Supply Project (DWWSWP) is intended to divert and treat Sacramento River water and convey the resulting potable water to the project partners. Trussell Technologies, Inc was hired by West Yost to assist with the Department of Public Health permitting, including

the preparation of the sampling plan. In subsequent phases of the work Trussell Technologies, Inc will be involved in the following tasks: preparation of water quality performance specification, process selection, conceptual design, and bid package preparation.

Role: *Technical Advisor*

Camarillo Water Division/CDM

Pilot Plant Design and Operation of Camarillo's Groundwater Treatment Facility

Working with CDM, Trussell Technologies was retained by the City of Camarillo on a project to expand the groundwater supply for the City to reduce its dependence on imported water, while improving the quality of water ultimately discharged to the Calleguas Creek watershed. They are developing a groundwater treatment system that is capable of addressing current water quality concerns and also flexible enough to adjust to potential future water quality changes as they occur in the aquifer. Trussell Technologies evaluated emerging contaminants for the project including but not limited to hexavalent chromium and the issues considered for the City of Camarillo's wells are directly applicable to water quality issues that need to be evaluated for the SFB wells. The purpose of the pilot study is to demonstrate and select the most cost-effective treatment approach, providing specific information on operating performance, water quality, and projected treatment costs for the proposed treatment processes. Trussell Technologies is also involved in optimization of the desalination process and is evaluating a wide range of "new-era" low energy NF/RO membranes for the treatment of contaminated groundwater.

Role: *Technical Advisor*

Boyle/City of Huntington Beach

Title: Huntington Beach Desalter

Date: 2008

Working with Boyle, Trussell Technologies was retained by the City of Huntington Beach to provide expert technical advice on the implications for water quality and disinfection of introducing a seawater desalination source into its distribution system alongside its existing

sources. Dr. Rhodes Trussell and Dr. Hokanson advised the City on the matter.

Role: *Technical Advisor*

Boyle Engineering

Title: Water Quality Facilities for the Upper Chiquita Reservoir

Date: 2008

Boyle was retained by the Santa Margarita as the lead for a team to design the Upper Chiquita reservoir, a new, 2,700 Ac-ft treated water reservoir to provide emergency storage for agencies in South Orange County. Trussell Tech. was included as part of the team, responsible for portions of the design addressing water quality. The work included developing projections of chloramine decay over long periods of time, examination of DPB formation, including the potential formation of NDMA, examination of alternatives for maintaining a residual and/or controlling the presence of ammonia oxidizing bacteria (AOBs) in the reservoir effluent. The ultimate design makes provision for dissipation of the residual in the reservoir, rechloramination and UV disinfection to ensure the removal of AOBs that would proliferate therein. Trussell Tech analyzed the problem, examined alternatives, and developed P&IDs, design criteria, preliminary layouts and equipment selection.

Role: *Project Manager.*

Sydney Water Corporation

Title: Taste and Odour Management: Project report

Date: 2008

In February 2003, a serious taste and odor incident (MIB & Geosmin) occurred in the Prospect Reservoir, the location of Sydney's largest water treatment plant. Using high rate direct filtration (10 gpm/sf) and chlorination/chloramination, the plant has only limited taste and odor removal capability, particularly where MIB & geosmin are concerned. Three years later in January 2006 Sydney experienced another troublesome T&O incident in their Cascade System. Again MIB & Geosmin were implicated. In April of that same year, another serious T&O incident occurred in the Prospect system, this one more widespread than

the first. MWH-Australia was contracted by the Sydney Water Corporation to conduct a comprehensive review of taste and odor management in the Sydney water catchments. Dr. Trussell was retained to do an independent peer review of the draft report.

Role: *Peer Reviewer*

U.S. Department of Justice

Title: Expert Witness on BNR in the U.S. v. Eastern MWD et al

Date: 2007 - 2008

DOJ is representing Camp Pendleton MCB in lawsuit with Eastern MWD and Rancho California WD in connection with a 1990 Agreement between the Four Parties. Dr. Trussell prepared an expert witness report on the definition of best available treatment for nitrogen and phosphorous, on the cost of treatment to meet BAT and on the reasonableness of the cost of said treatment.

Role: *Expert Witness*

Beverage Company

Title: Assessment of the Risks of Recovery RO Systems Implemented to Improve Water Use Ratio in the Production of Beverage Products

Date: 2007-2008

Trussell Technologies was retained by a major beverage company to assess the risks to water quality of implementing a secondary stage of RO to increase recovery in the production of its products. Trussell Tech also developed strategies and guidelines for to provide to bottlers to minimize the risk of introducing secondary RO into the treatment train.

Role: *Project Manager*

Downey Brand Attorneys, LLP

Title: Expert Witness on BNR in the U.S. v. Eastern MWD et al

Date: 2007 - 2008

Downey Brand is representing Fallbrook PUD in lawsuit with Eastern MWD and Rancho California WD in connection with a 1990 Agreement between the Four Parties. Dr. Trussell prepared an expert witness report on the definition of best available treatment for nitrogen and phosphorous, on the cost of treatment to meet

BAT and on the reasonableness of the cost of said treatment.

Role: *Expert Witness*

City of San Juan Capistrano

Title: Testing, Evaluation, and Recommendations Relating to Colored Water

Date: 2007-2008

The City of San Juan Capistrano has retained the services of Trussell Technologies to provide troubleshooting and resolution of its colored water issues. Trussell Technologies, Inc. scope has entailed development of sampling plan to monitor the raw water quality, the water quality throughout the treatment plant as well as in the distribution system; performing data analysis and pretreatment/treatment alternatives evaluation including analysis of alternative oxidants and filtration technologies; performing colored water bench scale study and full-scale filter evaluation; and providing recommendations to enhance treatment process and distribution system operations based upon the sampling results.

Role: *Project Advisor*

Carollo Engineers

Title: Workshop on Silica removal

Date: 2007

Carollo has several projects where silica is the limiting constituent in concentrating the brine from RO facilities. Trussell Tech organized a workshop to discuss possible solutions to the issue.

Role: *Organizer, Expert*

CDM/Los Angeles Department of Water and Power (LADWP)

Title: Scattergood Generating Station Seawater Desalination Pilot Project

Date: 2007 - 2009

Trussell Technologies, Inc. is part of CDM's team for the Scattergood Desalination pilot project. This project is the next step for LADWP in their evaluation of the feasibility of seawater desalination to augment their available drinking water supply. Trussell Technologies, Inc. is tasked with developing the technical memorandum to identify the process trains that will be pilot tested in the upcoming years along with water quality goals for each treatment

process and a final treated water quality goal for distribution. This TM included the selection of an appropriate desalination process, pretreatment and coarse screening process. Trussell Technologies, Inc. is also tasked to perform an analysis on how LT2 SWTR would be applied to the selected treatment train.

Role: *Project Manager*

Boyle/City of Poway

Title: Bergland Water Treatment Plant Upgrade

Date: 2007-present

Working with Boyle, Trussell Technologies, Inc. was retained by the City of Poway to evaluate key water quality and treatment issues related to its Bergland Water Treatment Plant upgrade. Issues examined included investigating the levels of DBPs in the water, costing and ozonation alternative and determining whether it is needed based on the DBP levels in the water, and evaluating ancillary issues like the presence of quagga mussels in the source water.

Role: *Project Manager*

MWH/West Basin Municipal Water District

Title: Critical Raw Water Quality Issues

Unique to Seawater: Marine Phytoplankton Blooms, their Associated Biotoxins, and Transient Urban Stormwater Inputs

Date: 2007-present

Working with MWH, Trussell Tech has been retained along with the University of Southern California to develop and conduct a comprehensive monitoring program for stormwater impacts on the SWRO treatment process and resulting permeate water quality, and marine phytoplankton and biotoxin production impacts on the SWRO process and resulting permeate water quality. The monitoring program will develop real-time monitoring surrogates and utilize state-of-the-art technologies to demonstrate the public health and operational significance of these events. The algal toxin information generated by the project is novel both in the context of seawater desalination, as well as in the context of fundamental research in marine biology and oceanography. Trussell Tech is developing the stormwater monitoring program and coordinating

the RO testing related to the algal toxins identified for study by USC.

Role: *Project Reviewer*

Provost & Pritchard

Title: Peer Review of Impacts of Delta Water on Friant Kern Users

Date: 2007

Users of the Friant-Kern canal have been approached by the MWD of SC to consider an arrangement where MWD would use Friant-Kern Canal water during certain periods in return for providing State Project water during periods when Friant-Kern water is not so readily available. Provost & Pritchard was retained to review the impacts of the exchange on Friant-Kern users and Trussell Tech was retained to conduct a peer review of that study.

Role: *Peer Reviewer*

Los Angeles County Sanitation Districts

Title: Santa Clarita Valley Chloride Study

Date: 2007

The Los Angeles Regional Water Quality Control Board has issued a TMDL for chloride the Santa Clara River and, as a result, is considering limitations on the chloride on the wastewater discharged from the Saugus and Valencia water reclamation plants, operated by the Los Angeles County Sanitation Districts. The Districts retained Trussell Tech to determine the appropriate desalination technology, the amount of flow to be treated at each facility and to do a preliminary design of the required facilities.

Role: *Project Manager*

ECO Resources, Inc.

Title: San Juan Capistrano Water Recovery Facility

Date: 2007

ECO Resources, Inc., a division of Southern Water, Inc., operates a 4 mgd groundwater desalination facility in San Juan Capistrano, CA. Since its inception the facility has had difficulties meeting its production goals and its membranes have required excessive cleanings. Trussell Tech was retained to review the problem and examine possible remedies.

Role: *Technical Director*

West Basin Municipal District- Separation Processes, Inc.

Title: General Consulting on Desalination

Date: 2007

Trussell Technologies was part of the SPI team selected to provide consulting services to WBWD. Project involved review and comment on water quality data. Advice on use of pre-formed chloramines. Advice on the use of high rate coarse media filtration.

Role: *Project Advisor***Clark County Water Reclamation District**

Title: The Addition of Membrane Filtration and Ozonation to CCSD's advanced wastewater Treatment Plant

Date: 2007

Clark County Water Reclamation District retained the services of Trussell Technologies to prepare review and advise on the preparation of contract documents for constructing a 30 mgd tertiary facility using membrane filtration and ozonation at their Advanced Wastewater Treatment Plant. The review included an assessment of the necessary ozone dose as well as extensive discussions on the best approach for getting useful bids from competing membrane manufacturers.

Role: *Project Advisor***Beverage Company**

Title: Technical Advisory Committee

Date: 2007

A major beverage company established a technical advisory panel of five national experts and met with the panel to review their water treatment standards and practices and suggest possible weaknesses or changes.

Role: *Advisory Committee Member***Southwest Water Company Optimization of the San Juan Capistrano Groundwater Recovery Plant**

Date: 2006-2008

The Southwest Water Company (SWC) owns and operates a desalting facility to treat up to 5 mgd of highly mineralized groundwater for the City of San Juan Capistrano. The groundwater is also contaminated with iron and manganese. Trussell Technologies, Inc. assisted the SWC in

a project to rehabilitate the desalter. Trussell Tech diagnosed the cause of membrane fouling, identified changes in chemical feed methods to prevent clogging of pipelines with calcium carbonate, recommended changes in pretreatment to prevent future fouling, selected new membranes to replace old membranes which had ceased to meet requirements, met with CDPH and Southwest Water to discuss CDPH requirements and provided support to Southwest during implementation.

Role: *Technical Director***Coachella WD - MWH**

Title: Ion Exchange to Remove Arsenic

Date: 2006

MWH had designed ion exchange facilities to remove arsenic from drinking water. The specification included limitations on the Langelier Index of the water produced in order to ensure that old, arsenic-containing, pipe scales in the distribution system would not be compromised. Some of the IX facilities were having difficulty meeting this requirement. Trussell Technologies was asked to analyze the cause of the problem.

Role: *Technical Advisor***West Basin Municipal District-MWH**

Title: Scoping Study for the Design of a 0.5 mgd Ocean Desalination Demonstration Facility

Date: 2006

Trussell Technologies was part of the MWH team selected to do a comprehensive scoping study for the design of a 0.5 mgd ocean desalination demonstration facility. Trussell Tech did the Water Assessment, looking at all water quality questions, both for the permeate and for environmental discharges. Trussell Tech also did assessments of pretreatment alternatives as well as reviewing the remainder of the preliminary design.

Role: *Project Advisor***Hankuk Engineering Company**

Title: Sungnam Water Treatment Plant

Date: 2006-2007

Hankuk Engineering Company (HEC) had been retained by the KOWACO, the largest water utility in So. Korea to upgrade KOWACO's largest water treatment plant. Trussell

Technologies traveled to Korea to review the project and provided advice on the design of systems for ozonation and granular activated carbon for removing the unusually high levels of 2-methyl iso borneol and geosmin in the raw water supply.

Role: *Project Manager*

Hankuk Engineering Company

Title: Seoul Water Treatment Plant

Date: 2006

Hankuk Engineering Company (HEC) had been retained by the City of Seoul, So. Korea to design a new, large water treatment plant. Trussell Technologies provided advice to HEC regarding the design of deep bed granular media filters.

Role: *Project Manager*

MWD- Geopentech

Title: Review of Perchlorate Treatment near Las Vegas Wash

Date: 2006-2007

Geopentech was conducting a study for MWDSC on the contamination of Lake Mead with perchlorate being discharged by former rocket fuel manufacturers whose wastes are tributary to the Las Vegas Wash. Trussell Tech was retained, together with Black and Veatch to review treatment processes being used or proposed by those industries to remove perchlorate and to advise MWDSC s to their efficacy.

Role: *Project Manager*

Sydney Water Corporation – SKM - Reiss Env.

Title: Sydney Water Reuse Program

Date: 2006

Trussell Technologies was a member of the team examining reuse alternatives for Sydney Water. The work includes an extensive review of existing use of advanced treatment for reuse.

Role: *Project Manager*

Castaic MWD - Carollo Engineers

Title: AwwaRF Project 3182 – An Electrochemical Reactor to Minimize Brominated DBPs: Impact on Coagulation and Ozonation

Date: 2006

Along with Castaic MWD, Carollo Engineers is conducting bench and pilot studies examining a

new innovative electrochemical reactor to minimize the formation of brominated DBPs during disinfection.

Role: *Technical Adviser*

MWH-ARD

Title: WERF Pharmaceuticals Study

Date: 2006

Under the auspices of an unsolicited proposal to WERF, the MWH Applied Research Department conducted a study examining the effectiveness of alternative biological process on the removal of pharmaceuticals and personal care products. Among other things the study demonstrated that an SRT of over 10 days ensures much greater removal. Dr. Trussell is an adviser on the project

Role: *Technical Adviser*

LACSD- Kennedy-Jenks Engineers

Title: WERF Disinfection Study

Date: 2006

Working in conjunction with the Los Angeles County Sanitation Districts, Kennedy-Jenks Engineers is conducting a WERF on alternatives for the disinfection of wastewater. The study includes an extensive survey of existing practice. Dr. Trussell is an adviser on the project

Role: *Technical Adviser*

Tucson Water- Malcolm Pirnie

Title: Tucson Water, Water Quality and Implementation Program

Date: 2006 - 2007

MPI was retained by Tucson Water to conduct an extensive study of alternatives for augmenting the City's water supply. Part of the program includes review by a panel of six independent outside experts. Dr. Trussell was a member of that panel

Role: *Panel Member*

Clark County Water Reclamation District

Title: Cost Estimate for the Addition of Membrane Filtration to CCSD's advanced wastewater Treatment Plant

Date: 2006

Clark County Water Reclamation District retained the services of Trussell Technologies to prepare an independent estimate of the cost of constructing a 30 mgd tertiary membrane facility

at their Advanced Wastewater Treatment Plant. The estimate included the cost of several alternatives, including two alternative Greenfield facilities, as well as a possible retrofit to existing alum flocculation basins.

Role: *Technical Advisor*

Water Replenishment District of Southern California

Facility Evaluation and Resolving Membrane Fouling at the Leo Vander Lans Water Treatment Facility

Year: 2008

Trussell Technologies, Inc. has been retained by the District as a membrane and process consultant to optimize the performance of a 3 MGD MF/RO reclamation plant. Trussell Tech is tasked with analyzing the performance and condition of the MF and RO membranes, probing the causes of membrane fouling, and identifying the key foulants causing the sub-optimal plant performance. The task also includes development of a cleaning protocol so that foulants from the full-scale RO trains can be removed. In addition, Trussell Tech will provide recommendations on how best to operate the LVL Facility to minimize future membrane fouling rates

Role: *Technical Advisor*

Separation Processes, Inc.

Title: Treatment Alternatives for Removing Barium from CAP Water

Date: 2006

SPI was doing a study on the alternatives for desalinating CAP water and the precipitation of barium sulfate had been identified as limiting water recovery. Trussell Technologies explored treatment alternatives, including lime softening and ion exchange. The outcome of the project was a unique ion exchange strategy that cuts costs by taking advantage of the higher preference of most cation resins for barium ion.

Role: *Technical Director*

Metropolitan Water District and Participating Water Agencies

Title: Cost Alternatives for Reducing Contaminants of Concern from the Discharge of

the Sacramento Regional Wastewater Treatment Plant

Date: 2006

MWD So. Cal., on behalf of a group of fifteen water agencies using water drawn from the Sacramento-San Joaquin Delta, retained Trussell Technologies, Inc. to develop an estimate of the cost of meeting five alternative levels of four contaminants of concern (orthophosphate, total inorganic nitrogen, total organic carbon and C. parvum) from the discharge of the Sacramento Regional Wastewater Treatment Plant. The estimate included the cost of converting all, or portions of the existing HPOAS facility, to more modern nutrient removal processes ranging from the Modified Ludzack-Ettinger process to a modified Bardenpho process.

Role: *Principal-in-Charge*

Rick Brady & Associates – Camp Pendleton Marine Corps Base (MCBCP)

Title: Investigation of Copper Mitigation Measures for the North System

Date: 2006 - present

Through Rick Brady & Associates, MCBCP retained the services of Trussell Technologies to provide assistance in troubleshooting and resolving the recent copper problems in the groundwater supply of the Northern system on the base.

Role: *Project Manager*

Los Angeles Superior Court

Title: Appraiser, LASC Case No. BC 315186 City of Santa Monica v. Baron & Budd P.C. et al.

Date: 2005 - 2007

Dr. Trussell was appointed by Superior Court Judge David Minning as the Appraiser in a suit between Santa Monica and a group of attorneys that had represented the City in an earlier suit. The Appraiser's assignment was to determine the value of the Settlement in that earlier suit. The Appraisal involved estimating the cost to design, permit, build and operate a water treatment plant to remove methyl tertiary butyl ether and tertiary butyl alcohol from groundwater until the groundwater was no longer contaminated. The project involved the 10% design of a \$60M UV/H₂O₂ advanced oxidation facility followed by GAC adsorption. Dr. Trussell

organized an extensive team of outside consultants to accomplish the effort.

Role: *The Appraiser*

Rick Brady & Associates – Camp Pendleton Marine Corps Base (MCBCP)

Title: Investigation of Copper Mitigation Measures for the North System

Date: 2006-2007

Rick Brady & Associates retained the services of Trussell Technologies to provide assistance in troubleshooting and resolving the operational problems experienced with the new iron and manganese removal facility in the Southern water system at Camp Pendleton.

Role: *Project Manager*

Bureau of Reclamation

Title: Review of Bureau Plans for a System to Treat Agricultural Runoff

Date: 2005 - 2006

When the Bureau of Reclamation committed to build aqueducts to serve farms in the San Joaquin Valley, it also committed to construct a drain to remove salt-laden agricultural runoff. The so called “San Joaquin Drain” ran into serious environmental opposition and was never completed. Nevertheless, the courts maintained that the USBR continued to have the responsibility to provide for disposal of the agricultural drainage. To resolve the issue, the Bureau has undertaken an extensive program of treatment research. Trussell Technologies has been retained to review the output from that program.

Role: *Project Manager*

Rick Brady & Associates – Camp Pendleton Marine Corps Base (MCBCP)

Title: Investigation of Lead Mitigation Measures for the South System

Date: 2005 - 2006

Through Rick Brady and Associates, MCBCP retained the services of Trussell Technologies to provide assistance in troubleshooting and resolving the recent lead problems in the groundwater supply of the Southern system on the base.

Role: *Project Manager*

MWH – San Francisco Public Utilities Department

Title: Comprehensive Report on Lead and Copper Rule Compliance

Date: 2005 - 2006

Working with MWH, Trussell Technologies was retained to prepare a comprehensive report on the implementation of the lead and copper rule in the San Francisco Water System, and in the Regional Water Systems also served by SFPUC. The study addressed past and current practice, compared it to the practices of several other U.S. cities treating similar water supplies and recommended pH adjustment as corrosion control treatment. The study also included an extensive assessment of the impact of this strategy on the protection of cement-based assets in the system and made recommendations to maximize their protection. Finally the study examined the rationale for water quality parameters in the system to address copper and lead rule requirements. In the end all the recommendations of the study were approved by CDHS. At the present time SFPUC is conducting monitoring of consumer plumbing to confirm the success of the program.

Role: *Project Manager*

Desalination and Water Reuse Task Force

Title: State-of-the-Science Report on Membranes

Date: 2005

Trussell Technologies has been retained by the D&WRTF to develop a state of the science report on membranes in desalination and reuse. This report is one of three reports to be used by the group to identify information gaps to be supported by its research monies.

Role: *Project Manager*

City of Carlsbad, CA

Title: Assessing Boron and Chloride in Desalted Seawater

Date: 2005

The City of Carlsbad, CA., is evaluating a proposal where Poseidon Resources, Inc. would provide desalted water to the City. Trussell Technologies has been retained to assist the City in understanding alternatives for improving the removal of boron and chloride, and in conducting investigations to understand the impact of future

boron and chloride levels on the plant life in the City.

Role: *Project Manager*

Metropolitan Water District of Southern California

Title: Review Panel on Recreation in Lake Perris

Date: 2005

MWD retained a panel of specialists, to review a study it conducted examining the impact of recreation on the microbiological quality of the water in Lake Perris, and the alternatives for reducing its impact. Dr. Trussell was a member of that panel.

Role: *Consultant*

City of Carlsbad, CA

Title: Assessing Corrosiveness of Desalted Seawater

Date: 2005

The City of Carlsbad is evaluating a proposal where Poseidon Resources, Inc. would provide desalted water to the City. Trussell Technologies was retained to assist the City in understanding and reviewing the plans for and conduct of studies to assess the corrosiveness of the desalted water.

Role: *Project Manager*

MWD-Geopentech

Title: Perchlorate and the Colorado Aqueduct

Date: 2005

Geopentech has been retained by the Metropolitan Water District of Southern California to examine several issues related to gaining a better understanding of the history and fate of perchlorate in the Colorado River Aqueduct. Dr. Trussell serves as a project consultant on questions of treatment and water chemistry

Role: *Consultant*

EPA Office of Water

Title: Estimate of National Occurrence of waterborne Disease Associated with Community Water system Drinking Water

Date: 2005

In September 2005, the EPA prepared a paper entitled, *Estimating the National Occurrence of Waterborne Disease Associated with Community Water System Drinking Water*". The report was a

preliminary estimate of GI illness attributable to drinking water. Dr. Trussell was retained by the U.S. EPA as an independent reviewer to comment on the analysis in the paper and on its conclusions.

Role: *Independent Reviewer*

MWH Constructors

Title: Northeast Water Purification Plant

Date: 2004

MWH Constructors built a 40 mgd water purification plant to treat water from Lake Houston and serve portions of the City of Houston. Dr. Trussell was retained to provide consulting services on the treatment process during startup.

Role: *Project Consultant*

MWRA

Title: Lead and Copper Rule/Corrosion Strategy for the Greater Boston Area

Date: 2004

For more than 20 years, MWRA has been struggling to find the water treatment necessary to control the corrosion of lead to levels that will allow it to comfortably meet the EPA Lead and Copper Rule. In the Fall of 2004, the utility faced a particularly important milestone where it must meet the lead action level. MWRA staff organized a five-member Panel of nationally recognized experts to review their past actions and to provide advice on future actions that might be taken. Dr. Trussell was a member of that panel.

Role: *Panelist*

San Diego Water Authority

Title: Twin Oaks Valley DBO

Date: 2004

Dr. Trussell was a member of a five-member Board of Senior Consultants retained by the San Diego Water Authority to act as an independent expert body to support the Water Authority during its effort to proceed with a design-build-operate procurement for a 50 to 100 mgd water treatment plant in northern San Diego County.

Role: *Board Member*

Carollo Engineering

Title: Water Treatment Consulting

Date: 2004-present

The firm of Carollo Engineering established a general contract for the services of Dr. Trussell to assist the firm in its water treatment efforts.

Role: *Consultant*

McGuire and Associates

Title: Reservoir Augmentation in San Diego, CA

Date: 2004

Teamed with PBS&J, McGuire and Associates was retained to review alternatives for recycling in the City, specifically reservoir augmentation. Dr. Trussell was part of the technical team that will provide technical analysis of treatment alternatives and assessment of potential contaminants.

Role: *Consultant*

EPA-Environomics

Title: Review of Washington D.C. Lead Problem

Date: 2004

In July 2002, and in two subsequent samplings, the lead levels in Washington, D.C. tap water have suddenly increased. On behalf of the EPA Office of Water, the firm of Environomics retained Dr. Trussell and three additional national experts to review the efforts being made to address the problem.

Role: *Consultant*

City of Carlsbad, CA

Title: Poseidon Agreement

Date: 2004

The City of Carlsbad is evaluating a proposal where Poseidon Resources, Inc. would provide desalted water to the City. Trussell Technologies, Inc. was retained by the City to provide advice on the technical aspects of the agreement between Poseidon and the City.

Role: *Consultant*

City of Carlsbad, CA

Title: Impact of Desalting on Cost of Water

Date: 2003-2004

The City of Carlsbad evaluated a proposal where Poseidon Resources, Inc. would provide desalted water to the City. Trussell conducted an analysis which compared the cost of desalted water to the cost of imported water over a 20-year horizon.

Role: *Consultant*

Portland Water Bureau - Murray, Smith and Associates, Inc.

Title: Portland, OR. Blending and Operations Study

Date: 2003-2004

The Portland Water Bureau is considering augmenting the Bull Run Water Supply with local water near the Bull Run Headworks. Through MWH and Murray, Smith and Associates, Dr. Trussell was retained to provide technical review on the effort.

Role: *Consultant*

Brown and Caldwell

Title: Water Treatment Consulting

Date: 2003-2004

The firm of Brown and Caldwell established a general contract for the services of Dr. Trussell to assist the firm in its water treatment efforts.

Role: *Consultant*

Chino Basin Watermaster - Black and Veatch

Title: Removal of Perchlorate, Nitrate, Arsenic and Synthetic Organics in Chino Basin Groundwater

Date: 2003-2004

The firm of Black and Veatch retained Dr. Trussell to assist the firm in a review of approaches to the removal of nitrate, perchlorate, arsenic, and selected synthetic organics from groundwater in the Chino Basin.

Role: *Consultant*

Denver Water Board - MWH

Title: Denver Water Moffat Water Supply Project Indirect Potable Recycling White Paper

Date: 2003-2004

The City of Denver is experiencing extreme water shortages and has retained the Denver office of MWH, Inc. to assist them in developing an indirect potable reuse project for the water supply for the Moffat water treatment plant. Dr. Trussell was retained as a member of an Advisory Panel to review a white paper for the project.

Role: *Consultant*

Arapahoe County Water and Wastewater Authority - Richard P. Arber and Associates

Title: TAC, Water Purification Project for Arapahoe County Water and Wastewater Authority

Date: 2003

The Arapahoe County Water and Wastewater Authority (ACWWA) and the Cottonwood Water Sanitation District (CWSD) are located in a part of Colorado near Denver that is experiencing extreme water shortages. The two utilities have retained Richard Arber and Associates to assist them in developing an indirect potable reuse project using the alluvium adjacent to Cherry Creek. Dr. Trussell was retained as a member of an Advisory Panel for the project.

Role: *Consultant*

MHW, Inc. Applied Research Department

Title: USBR MBR Pilot Study

Date: 2003

MWH's ARD group has been conducting a long-term pilot-scale study of four Commercial MBR technologies for possible application for water reclamation at the Point Loma WWTP for the City of San Diego. Dr. Trussell was retained as a member of an Advisory Panel for the project.

Role: *Consultant*

City of Torrance

Title: Remediation of the Madronna Marsh

Date: 2003

The City of Torrance maintains the Madrona Marsh as one of the last remaining examples of the vernal marshes that once dotted the Pacific Flyway. The Marsh had been subjected to significant pollution and had been substantially impacted. Dr. Trussell was retained to review the situation and advise on possible remediation alternatives.

Role: *Consultant*

MWH, Inc. Las Vegas

Title: Application of Membrane Filtration and MBR to phosphate reduction

Date: 2003

MWH retained Dr. Trussell to assist in the review of alternatives using membrane filtration and MBR for phosphate reduction at the Clark County Sanitation District. The review included detailed discussions with four manufacturers about the cost of MBR.

Role: *Consultant*

Metropolitan Water District of Southern California

Title: Chlorine/Chlorine Dioxide Alternatives Study

Date: 2002-2003

At the request of several of its member agencies, the Metropolitan Water District of Southern California conducted bench, pilot and full-scale studies examining alternatives to ozonation as a treatment strategy for the three plants it operates which blend Colorado Water and State Project Water. The District assembled a panel of experts to review the progress of that study.

Role: *Panel Member*

Portland Water Bureau/US EPA

Title: Panel to Review Methods Copper Lead Rule Compliance

Date: 2002

Portland, Oregon has been having difficulties meeting the lead rule; in spite of changes made in chemical treatment. With the U.S. EPA, the Water Bureau convened a blue ribbon panel of experts to review recent treatment practices and recent lead sampling data and to help the Bureau consider alternatives for addressing the issue

Role: *Panel Member*

AWWARF/EPA/MWH

Title: Treatability of Perchlorate in Groundwater Using MfBR Technology--Phase III

Date: 2002-2003

The pilot-scale design from the earlier study was revised and improved. They continued to remove perchlorate and showed considerably more promise for scale-up. Nevertheless, significant scale-up issues remain. The process was also shown to be capable of removing perchlorate and nitrate from ion exchange brine

Role: *Technical Advisor*

City of San Diego

Title: Membrane Bioreactor Study

Date: 2001-2003

In a U.S.B.R funded study, the City examined four different alternative OEMs for MBR that might be applied at the City's Point Loma WWTP. The evaluation included application of these

technologies, both before and after enhanced primary treatment. Costs were also prepared for a 1, 5, and 10 mgd reclamation facility using the technology.

Role: *Technical Advisor*

AWWARF/EPA/MWH

Title: Treatability of Perchlorate in Groundwater Using MfBR Technology--Phase II

Date: 2002-2003

The pilot scale design for a membrane fiber biological reactor (MfBR) to remove both nitrate and perchlorate from groundwater was built and operated at a La Puente well site. The study established the feasibility of the process, but raised some significant scale-up issues.

Role: *Technical Advisor*

City of San Diego

Title: Upgrading the Otay Water Treatment Plant

Date: 2002

The City was considering several alternatives for remodeling their Otay Water Treatment Plant, so that it could comply with upcoming regulations. The City's budget had been severely cut and a special study was conducted to examine alternatives. Issues included meeting the requirements of the interim enhanced surface water treatment rule and upcoming requirement on disinfection byproducts.

Role: *Chair of Technical Advisory Group*

IONICS, INC.-MWH

Title: Pretreatment for 36 mgd desalter at Point Lisas, Trinidad

Date: 2001-2002

Ionics, Inc. prepared the successful bid for the desalter to provide drinking-quality water for the Trinidad and Tobago Water and Sewage Authority. The desalter was constructed with an ultimate capacity of 30 mgd. MWH Inc. was charged with design of the system to pretreat the water for the seawater reverse osmosis (SWRO) as well as certain other support facilities. Based on Ionic's experience with projects at other locations, the bid was prepared to include coagulation, sedimentation, and two-stage, dual-media filtration. After the Ionics team was selected, Dr. Trussell led a more detailed evaluation of pretreatment options,

recommending coagulation and sedimentation followed by a single-stage, deep-bed, dual media filter. Pilot tests conducted in parallel with construction demonstrated the validity of the improved filter design, allowing for the elimination of the second stage of filtration.

Role: *Technical Consultant*

AWWARF/EPA/MWH

Title: Treatability of Perchlorate in Groundwater Using MfBR Technology--Phase I

Date: 2001-2002

Northwestern University had developed and patented a biological process for the removal of perchlorate and nitrate using only hydrogen gas. This study was to further develop the process at bench scale and to design the reactor for a further pilot-scale study.

Role: *Technical Advisor*

East Bay Municipal Utilities District

Title: Treatment alternatives to meet emerging regulations

Date: 2002

The Districts asked Dr. Trussell to review an alternatives analysis that District Staff had prepared with the assistance of consultants, to address emerging contaminants.

Role: *Peer Reviewer*

AWWARF/EPA/MWH

Title: Treatability of Perchlorate in Groundwater Using Ion Exchange Technology--Phase II

Date: 2001-2003

Studying an optimized ion exchange process at pilot scale to assess its performance in treating low concentration perchlorate contamination of groundwater.

Role: *Technical Advisor*

AWWARF/University of Houston/MW

Title: Treatability of Perchlorate in Groundwater by Ion Exchange Technology—Phase I

Date: 2000-2002

Evaluated, through proof-of-concept laboratory studies, the feasibility of an optimized ion exchange process for treating low concentration perchlorate contamination of groundwater. Further research will be conducted in project

Role: *Technical Advisor*

Aerojet General

Title: GET/E/F Treatment Study on Perchlorate Removal

Date: 2001-2002

Aerojet ran a three-year study developing and testing a biological process for Perchlorate Removal at pilot and full-scale. Dr. Trussell served as a member of a Blue Ribbon Panel that reviewed the progress of the study

Role: *Panel Member*

Los Angeles Department of Water and Power

Title: Conversion to Chloramines for Residual Maintenance

Date: 2000- 2002

In seeking to meet upcoming changes in the regulation of disinfection byproducts, Department staff had written a white paper recommending converting the system to chloramines for residual maintenance. Implementing the decision is complicated by the sheer size of the system and by the number of large open, finished water reservoirs. MW was retained to do a comprehensive study examining the feasibility of conversion to chloramines and identifying the key projects that would be required to make implementation possible.

Role: *Technical Advisor*

Northwestern University/Montgomery Watson

Title: Application of Bioreactor Systems to Low-Concentration Perchlorate-Contaminated Water

Date: 1999-2001

Evaluated the efficiency of a biological process to reduce perchlorate concentrations of up to 1,000 micrograms per liter to levels of 4 - 18 micrograms per liter. Evaluated the impact of co-contaminants on process performance, characterize process effluents, and define post treatment requirements. Included pilot-scale testing. Process received a U.S. Patent.

Role: *Technical Advisor*

Portland Water Bureau

Title: Conduct of Bench Studies with Medium and Low Pressure UV

Date: 1999-2001

The Portland Water Bureau, as a conduit for a group of several of the largest unfiltered water agencies has asked MW to conduct bench

studies to confirm the inactivation of *Cryptosporidium* with medium pressure UV, to establish if infectivity studies will show that same inactivation with low pressure UV, and to determine if these technologies will also cost effectively address *Giardia* and viruses.

Role: *Technical Director*

Los Angeles Department of Water and Power

Title: Conduct of Bench and Pilot Studies with Medium Pressure UV

Date: 1999-2001

The Los Angeles Department of Water and Power is under the process of applying for a permit to avoid filtration at the Encino and Stone Canyon Reservoirs. A critical part of the City's long-term plan is the use of medium pressure UV for control of *Cryptosporidium*. In order to get a permit under the SWTR, the technology must be approved by the State and EPA for its effectiveness in removing *Giardia* and enteric viruses as well. The project will include bench studies to develop survival curves for *Cryptosporidium*, *Giardia* and enteric viruses; the development of a public-domain model to calculate the UV dose for a given full-scale reactor; pilot studies to confirm the model and bench-scale results and the development of a technique to confirm the RTD in the reactor meets standards.

Role: *Technical Director*

Los Angeles Department of Water and Power

Title: Filtration Avoidance Criteria

Date: 1998-2001

The Los Angeles Department of Water and Power is under direct order from the California Department of Health Services to filter the water at Stone Canyon Reservoir. Local citizens hired an outside consultant that recommended that medium pressure UV be used in place of filtration. MW was retained to review the consultant's recommendation and later, to help the Department pursue an application for avoiding the filtration requirement.

Role: *Technical Director*

City of San Diego

Title: Repurification

Date: 1998-1999

The repurification project was proposed implementation of indirect potable reuse and involved extensive study. Managing operations, coordinating sampling, organizing/ordering lab supplies, performing seeding experiments, data collection and data analysis were routine tasks performed during this project.

Role: *Technical Director*

Australian Water Services

Title: Cryptosporidium Crisis

Date: 1998

Early in the 1990's MW was part of a four-firm consortium that designed the Prospect Water Filtration plant, a 3,800 mL/day water treatment plant that is the largest of three plants serving the Metropolitan Area of Greater Sydney. In July 1998, a local laboratory reported levels of Cryptosporidium in the distribution system as being unusually high. Recognizing that its client may be at risk, MW appointed Dr. Trussell to follow up. Dr. Trussell followed the issue through the crisis and, in consultation with the client, sent two specialists to Sydney; one, a nationally recognized expert in treatment for cryptosporidium removal worked in the client's offices for three months, helping them deal with the crisis. The other, MW's principle engineer with the most recent experience in designing a large scale ozone system, went to Sydney and worked with the local office to produce a predesign and cost estimate for this important treatment alternative. By assisting the client to stay ahead of the problem, MW was able to help them stay out of trouble during the crisis.

Role: *Appointed MW Representative*

The San Benito County Water District

Title: Membrane Feasibility Studies

Date: 1998

The San Benito County Water District is interested in examining aquifer storage and recovery as a means for augmenting their water supply in areas where recharge through surface spreading is not possible. Studies will examine the feasibility of membrane filtration as a pretreatment for the injection process.

Role: *Technical Director*

The North Holland Water Authority (PWN) Amsterdam, Netherlands

Title: The PWN Hermskeerk WTP,

Date: 1993-1995

Dutch water utilities are facing increasingly strict standards for the drinking water. Meanwhile, the quality of the River Rhine, their principle supply, continues to decline due to municipal, industrial and agricultural discharges from countries upstream, particular France and Germany. PWN, a drinking water utility that serves a part of Amsterdam, draws an increasing portion of its supply indirectly from the Rhine and faces increased mineralization, more organics, and more microbiological contaminants. Meanwhile new Dutch drinking water standards have been established. Dr. Trussell served the technical reviewer for a scoping study MW and it's Dutch partner, Witeeven + Bos, recently completed. Two basic alternatives were chosen for further study, conventional treatment followed by reverse osmosis, post ozonation, and GAC and conventional treatment followed by ultrafiltration and reverse osmosis. As a result of that effort, the MW/W+B team is now embarked on a predesign study for a 75 mgd plant that includes choosing among these processes. Dr. Trussell assembled a unique team from MW's operations in the U.S., Australia, Holland, and England to complete the project.

Role: *Technical Advisor*

Portland Water Bureau, Portland, OR

Title: Corrosion Study

Date: 1993/95

The Portland Water Bureau retained MW to conduct an evaluation of treatment and non-treatment alternatives for optimizing the reduction of lead and copper corrosion byproducts in consumer plumbing. The study involved pilot studies of elevating the pH, elevating the pH and the alkalinity, adding orthophosphate, and adding silicates as well as an extensive evaluation of non-chemical options.

Role: *Technical Advisor*

East Bay Municipal Utilities District, Oakland, CA

Title: Blue Water Project

Date: 1991-1993

Black Hawk, CA: A mysterious corrosion problem developed in the copper plumbing of approximately one thousand homes in some of the most expensive developments in the EBMUD service area. The problem manifested itself when water with a deep blue color sporadically emanated from taps in these homes. It took three years and substantial resources to solve the problem in a cooperative effort between, EBMUD, the developers, the plumbers, the manufacturers of building materials, various City and County building authorities, and the Alameda County Department of Health Services. A large number of corrosion specialists were involved and a number of public meetings, press conferences and TV interviews were also held. At one point a local talk show host came on site and made it his mission to solve the problem. As the lead technical advisor to EBMUD, Dr. Trussell provided guidance for the technical investigation and helped the District represent itself to citizens, to other outside experts, to the developers, and to the Health Department.

Role: *Technical Director*

The Rotterdam Water Authority, Rotterdam, Netherlands – Witeven+Bos

Title: The Berenplaat Expansion

Date: 1993/95

The Berenplaat, the largest water treatment plant in Holland (155 mgd) and the place where the THMs were originally discovered, takes water from the River Rhine, treats it, and serves it to the City of Rotterdam. The water is currently treated with conventional lime softening, filtration and chlorine disinfection. Dutch citizens are very concerned about the unpleasant chlorine taste in their water and about the potential health risk associated with the by-products of chlorination. As a result, Rotterdam has set a goal of treating River Rhine water so thoroughly that no chlorine residual is necessary in the distribution system. Dr. Trussell was a key technical reviewer on a MW/W+B team from three countries that worked with staff at the Berenplaat as well as KIWA, the Dutch Water Research Center, to develop the process for the plant. The proposed process, which includes ozonation, biologically active carbon, aeration, a second stage of physiochemical carbon adsorption, and

disinfection with ultraviolet light has been verified with large scale pilot studies.

Role: *Technical Advisor*

Melbourne Water Board, Melbourne, Australia

Title: Workshop on Nutrient removal in Municipal Wastewater Treatment

Date: 1994

The Melbourne Water Board was having problems with stimulation of algal growths in the waterways for which it had jurisdiction and nutrients being discharged from municipal wastewater treatment plants had been implicated. The Water Board retained Montgomery Watson to convene a workshop with technical experts on the subject and to produce a state of the art report on technologies for nitrogen and phosphorus removal from municipal effluents. As lead technologist for the project, Dr. Trussell served as convenor for the workshop and editor of the report.

Role: *Convenor/Editor*

Sydney Water Board, Sydney Australia

Title: Sydney Water Board Drinking Water Program

Date: 1990-1994

At the present time virtually all the water supplying the City of Sydney, Australia receives chloramination as its only treatment. As a result of more restrictive regulations as well as rising consumer standards, a decision was made to treat the water supply. Ultimately Sydney plans on building four new water plants ranging from 60 to 950 mgd in capacity. The Sydney Water Board is self-regulating and Dr. Trussell, as part of The Prospect Group, a venture involving MW, CDM and two Australian engineering firms, worked with the Board to help resolve certain key elements of their water quality standards and to conduct pilot, prototype studies and a predesign work for two of the four plants - including the 950 mgd Prospect Plant. Eventually it became clear that Sydney would privatize the construction and operation of these plants. Dr. Trussell was instrumental in bringing together members of Australian Water Services (AWS), the company that won the contract for the largest of the four plants. At the present time the Prospect Group is

working for AWS, completing the design of the plant

Role: *Technical Advisor*

Portland Water Bureau, Portland, OR

Title: Filtration Study

Date: 1989-1992

Following the passage of the EPA Surface Water Treatment Rule, the Portland Water Bureau retained MW to do pilot and predesign studies of the Bureau's Bull Run Supply. Extensive pilot and predesign studies were conducted, including extensive work establishing the effectiveness of free chlorine, combined chlorine and ozone on the disinfection of *Giardia lamblia*. Dr. Trussell was a regular technical advisor on this effort which involved interaction with two blue ribbon panels composed of technical experts from around North America (one on water treatment and one on disinfection of *Giardia lamblia*). Both of the technical panels had representatives from the Oregon State Department of Health Services and the EPA. Public input was also important and included workshops and focus groups with stakeholders as well as ordinary citizens.

Role: *Technical Advisor*

Palm Beach County Utilities District: MW was retained by PBCUD to operate as the District's engineer for two five year periods. During that period Dr. Trussell served as a key technical advisor in an evaluation of methods for enabling the system to meet the new coliform rule, in pilot studies evaluating ozonation as an alternative for color removal, in the design of full scale ozonation facilities, and in the conduct of pilot studies to deal with biodegradable carbon resulting from the ozonation process.

Coalition of West Coast Suppliers: The EPA Lead Rule: During the period when the EPA was developing the Lead and Copper Rule, Dr. Trussell worked with an informal consortium of water suppliers (Portland, OR, Seattle and Tacoma, WA, San Francisco, CA, East Bay Municipal Utilities District, Oakland, CA, American Water Works Service Co., Paramus, NJ, and New York City, NY) to ensure that the EPA had the best possible data for making decisions on the lead rule. The effort included

helping to organize the utilities, several meetings with the group and with the EPA, collecting, compiling and organizing data for EPA's consideration and informal meetings with EPA to help ascertain the meaning of the data. These efforts helped the EPA to balance some practical considerations as well as the concerns of Congress in their decision making.

Contra Costa Water District - Randall-Bold WTP

The Contra Costa Water District was searching for a way to reduce the cost and increase the appeal of a project involving a water plant that would serve the Eastern zone of their District. Working with staff, Dr. Trussell developed a new process that reduced capital cost while also improving the flavor of the water, providing a barrier against pesticide spills from Delta agriculture, and eliminating the byproducts of chlorination almost entirely. Because the process was new, extensive pilot and prototype studies were required, both to verify the technical performance of the process and to allow the Health Department to review evaluate it. Today Contra Costa has one of the most advanced water treatment plants in the country, producing unusually low turbidities, THMs below 10 g/L, and a water of excellent taste.

Portland Water Bureau - Corrosion Study: In the early 1980's the Portland Water Bureau was challenged by the Citizens for a Lead-Free Environment who asserted that the Portland water supply resulted in excessive lead levels in consumer plumbing. After extensive interviews, the Water Bureau retained MW with Dr. Trussell in charge to conduct a study to examine the question. The progress of the effort, that included extensive sampling in consumer's homes, was reviewed by a Panel of local Citizens convened for that purpose. As a result of the study, 50/50 lead solder was banned in the State of Oregon. MW is still working with the Water Bureau on the corrosion issues today.

Coalition of U.S. Unfiltered Supplies, During the period when the EPA was developing the Surface Water Treatment Rule, Dr. Trussell worked with the City of Portland in assembling a consortium of unfiltered water supplies (Portland,

OR, Seattle and Tacoma, WA, San Francisco, CA, Casitas, CA, and New York City, NY) and in ensuring that the EPA had the best possible understanding of the practices and circumstances that made these water supplies safe. As a result of these efforts, the EPA visited the watersheds of most of these utilities and incorporated provisions in the final rule that allowed them to maximum potential to continue operation.

East Bay Municipal Utilities District /Contra Cost Water District- Water Supply Quality Study: MW was retained by the East Bay MUD and the Contra Costa WD to organize and evaluate a comprehensive water program to assess water quality in the current sources of supply for these utilities as well as alternate sources of water that both were considering throughout the Sacramento/San Joaquin River System. This survey included extensive sampling and analysis of raw waters throughout the northern California area and preparation of a report that addressed treatment of these supplies under a variety of conditions and mixes. Dr. Trussell was Project Manager.

Beaver Creek Water District: MW was retained to do a master plan, conduct pilot studies and for the design and construction supervision of a new water treatment plant for the District. Dr. Trussell served as a key technical advisor for the project.

Valley County Water District/EPA - Air Stripper: The VCWD retained MW to conduct extensive pilot studies for determining design criteria for removing organic solvents from their groundwater supply. These studies were then used in the design of an air stripper on one of the most heavily contaminated wells in the San Gabriel Valley. Dr. Trussell was Project Manager.

Portland Water Bureau - pH Adjustment Study: MW was retained by the Portland Water Bureau to conduct a pilot study of alternatives for adjusting the pH of Portland water. A number of options were considered and a pilot plant was constructed and operated to observe the stability of the water quality that resulted. Dr. Trussell was the principle investigator for this project.

Kaiser Steel – Groundwater Plume Characterization: MW was retained by the Kaiser to drill monitoring wells and produce a groundwater model describing the scope of the plume of contaminated water due to several decades of discharge of pickle liquor on the steel-mill site. The study resulted in one of the first models of the travel of contaminant plume in Southern California Groundwater. Dr. Trussell was Principle-in-Charge

Kaiser Steel – Hazardous Waste Evaluation: MW was retained by the Kaiser to conduct a survey of the Fontana Site to determine the actions required to comply with new Federal Law. The survey identified a number of issues, in particular the potential for a large plume of contaminated water drifting off-site. Dr. Trussell was the principle investigator for this project.

La Habra - Air Stripper: MW was retained by the City of La Habra to examine the means for removing organic solvents from the water in a new well the City had recently developed. Pilot studies demonstrated that air stripping would do the job and the first full-scale airstripper in So. California was designed and commissioned as a result. Dr. Trussell was Project Manager.

Pembroke Pines, FL - Air Stripping Study: The effluent from the Pembroke Pines WTP had THM levels approaching 1.0 mg/L, 10 times the proposed EPA MCL. Pilot studies demonstrated that air stripping could be effectively employed to remove these THM's after they were formed without removing a chloramine residual. Studies also demonstrated that the remaining TOX was unaffected. Dr. Trussell was principle investigator.

Contra Costa WD - Air Stripping Study: MW was retained by the Contra Costa Water District to conduct a pilot study of air stripping as a means for removing THM's from the treated water in the Bollman WTP. These were the first pilot studies that successfully demonstrated effective removal of bromoform from drinking water via air stripping. Dr. Trussell was principle investigator.

Four Agency Delta Study: Four major agencies using Delta water retained MW to develop a comprehensive assessment of Delta water using information gathered in the Contra Costa Study as well as additional information gathered by the California Department of Water Resources and the U.S. Bureau of Reclamation. This study compiled the most comprehensive assessment of Delta water quality assembled up to that time. Dr. Trussell was project manager.

Portland Water Bureau - Corrosion Study: MW was retained by the Portland Water Bureau to conduct a study of the corrosiveness of the Bull Run Water Supply. The study included a review of that statistics of consumer complaints, collection and analysis of standing and running water samples in consumer plumbing, examination of piping material from the Distribution system, pilot testing simulating consumer plumbing (copper and galvanized), certain pilot scale testing by the Water Bureau on lead release from lead pigtailed and frequent interaction with a panel of citizens. One of the principle outcomes was that Oregon was one of the first states to outlaw the use of 50/50 solder for copper tubing in residences. Dr. Trussell was project manager

Potomac Estuary Experimental Prototype: The Baltimore District of the U.S. Army Corps of Engineers is responsible for providing the water supply for the City of Washington, D.C. In the early 1980's, the COE proposed to consider taking water from the lower Potomac Estuary. As most of the water in the estuary would be wastewater during low flow periods, the District was required to conduct a full-scale investigation on the treatment of reclaimed wastewater for potable reuse. A full-scale, 1 mgd treatment facility was constructed and MW was retained to operate the facility and study the quality over a 30 month period. Dr. Trussell was heavily involved in the technical direction of the project, which involved the most extensive chemical analysis and health-effects testing that had ever been done up to that time. Along with the rest of the project team, Dr. Trussell helped present the results of the study to a special Committee of the National Academy of Sciences which had been

assembled to review the conduct of the study and its results. The Committee spoke positively about the MW effort.

Contra Costa Water Quality Study: MW was retained by the Contra Costa Water District to do a comprehensive assessment of the quality of the water in the Contra Costa Canal as well as other sources of supply in the Delta of interest to the District. This was the first comprehensive assessment of waters in the Delta and included extensive organics assays, virus assays, microbiological assays, asbestos, heavy metals and corrosivity. Dr. Trussell was the Project Manager.

MWD/EPA Study of Copper-Induced Pitting of Galvanized Pipe: MW was retained by the Metropolitan Water District of Southern California to conduct a large scale, EPA supported, pilot study on the pitting of galvanized pipe as a result of copper in the water supply. The study not only addressed the copper-induced pitting problem, but also addressed the problem of pipe quality as well. Dr. Trussell was Project Manager for the study.

The Contra Costa Water District - THMs: While the THM regulations were under development, Dr. Trussell worked extensively with the Contra Costa Water District to develop alternatives to meet the new regulations. These studies, which included examination of chloramination, ozonation, enhanced coagulation, GAC adsorption, and air stripping, were among the first to demonstrate the cost-effectiveness of chloramination in controlling THM formation. Working with the California Department of Health Services, an agreement was reached to allow the District to use chloramines for residual maintenance provided certain standards of treatment were met and that a short time of disinfection with free chlorine was also provided. This agreement served as a model that Cal DHS followed with numerous other utilities throughout California and which was eventually duplicated in nearly one third of the water supplies in the nation.

Pitting of Galvanized Pipe in Agoura: MW was retained to examine the cause of failure of

new galvanized pipe in several hundred homes in a development in the Agoura area. The cause was determined to be copper-induced pitting of the new galvanized pipe. Dr. Trussell was the project Manager.

EPA Selenium Analysis Study: EPA retained MW to evaluate alternative methods for differentiating between the principle forms of selenium found in drinking waters. Fluorometric and ion chromatographic methods were evaluated. Dr. Trussell was technical advisor.

Ramona Water District/EPA - Selenium Removal Study: MW was retained by the Ramona Water District to conduct a study on methods for removal of selenium from drinking water. Bench and pilot studies demonstrated that activated alumina would be effective but that the oxidation state of the selenium was also important. Dr. Trussell was principle investigator.

Aguadora de Nicaragua: The principle water supply for the City of Managua was Lake Asosoca, a collapsed volcanic feature between the City and Lake Managua. A large industrial complex had been constructed between the two lakes and the City was concerned about the potential for contamination being transported in the groundwater from the industries to the City's supply. Dr. Trussell did extensive surveys of the industries as well as chemical testing that demonstrated that small amounts of the organic chemicals being discharged by the industries were already showing up in the drinking water supply.

Water Factory 21: Once the Water Factory's R.O. plant was built and began groundwater injection, the California Department of Health Services required that the Orange County Water District, conduct extensive studies demonstrating that the process effectively removed viruses. Dr. Trussell worked with staff at the Water Factory, the California Department of Health Services, the Health Services research laboratory, Montgomery Laboratories, and the University of California Department of Health to develop and manage a five year program that confirmed the high quality of the Water Factory's product where viruses are concerned.

Sinotech Pingtung Industrial Waste Design: Sinotech was retained to design systems to collect and treat the wastes for a large industrial complex being built in Ping Tung. Dr. Trussell served as a technical expert advising Sinotech on the concept of the design, in negotiations with the Taiwan EPA, and in reviewing the detailed design of the facilities.

C & H Sugar Refinery Heat Dissipation Study: MW was retained by the C&H refinery in Crockett, California to evaluate the refinery's hot water discharges to the Sacramento River, and to develop alternative means for controlling the problems. The principle source of heat was the barometric condensers. Remedies considered included cooling towers and an outfall that dissipated the hot water in during periods of high tidal flux. Dr. Trussell served as technical director on the Project.

Dominguez Water Company: The Dominguez Water Co. retained MW to examine the cause of pitting-type failure of galvanized pipe in some 60 to 80 homes in a development in their water system. Though the cause could not be absolutely determined, copper-induced pitting was the principle suspected cause. Dr. Trussell was the principle investigator.

California Office of Water Recycling - Reuse in Cooling Towers: MW did a study of reuse of municipal effluents in cooling towers throughout the United States and as a result of the study, developed criteria for wastewater reuse in cooling towers in California.

Kenniwick WTP: The City of Kennewick wished to construct a new WTP drawing water from the Columbia River. MW conducted extensive pilot studies for the City that resulted the design of the first direct filtration plant with pre-ozonation in the United States. Dr. Trussell was the Project Manager

Casitas Municipal Water District: The Casitas Municipal Water District was considering the installation of a 20 mgd water treatment plant for Lake Casitas. Dr. Trussell managed a pilot study which demonstrated that direct filtration would be suitable treatment. The study also addressed the

potential impact of unscheduled shutdowns and sudden demand changes on water quality.

The Los Angeles Aqueduct Plant: Dr. Trussell was the technical director for the predesign pilot studies for the Los Angeles Aqueduct Plant. These extensive pilot and full-scale studies were conducted by MW staff as well as the staff of LADWP and resulted in the development of the advanced high-rate, deep-bed filtration process with ozonation which the plant uses today. Because of the importance of the Owens River supply and because of the innovative nature of the process, satisfying the concerns of the California Department of Health Services was a key element in the effort.

Water Factory 21: After the Water Factory was built and it became clear that the sea water desalination portion of the project would not be cost effective, MW was retained to help the District explore design alternatives that involved the desalination of the tertiary effluent produced by the Water Factory. The firm developed bid documents for the desalination process (a 5 mgd reverse osmosis plant) and designed the support facilities for the same. Dr. Trussell was involved in evaluating desalination process and assisted in the preparation of bid documents.

The City of San Diego - Alvarado/Miramar WTP Study: Once it became clear that the City would be receiving State Project water, MW was retained to do a comprehensive evaluation of both the Alvarado and Miramar WTPs. Dr. Trussell was did much of the process work for both projects. During the effort Trussell demonstrated an inexpensive interim modification of the filter control systems that allowed the plant to successfully operate at a capacity increase of 20%.

Chino Basin Municipal Water District, Plant No. 2: Trussell organized and executed a pilot and prototype scale program for evaluating ozonation/direct filtration as a technology for ensuring virus removal from the CBMWD secondary effluent. The process was demonstrated to produce more than 5 logs of

reduction of Polio virus and an effluent that was free of native viruses as well.

The Contra Costa Water Reuse Project: Dr. Trussell was technical director and project manager for the Contra Costa Industrial Reuse Project. The project included full-scale testing of reclaimed water in industrial cooling towers, an extensive industrial user cost study, a two year pilot scale study of softened water in cooling towers and the design of a 15 mgd system to further polish the effluent and serve it to several Contra Costa industries. The project required coordination with six major industries; the California Department of Health Services, the Central Contra Costa Sanitary District, the Contra Costa Water District, and the San Francisco Regional Water Quality Control Board.

Contra Costa Water District

Title: Design of 10 mgd Ion Exchange Softening Plant

Date: 1978

Dr. Trussell designed a 10 mgd ion exchange plant to soften reclaimed water produced by the Central Contra Costa Sanitation District to be used for cooling towers operated by the Shell and Phillips Petroleum Refineries and by PG&E. The plant used a counter-flow ion exchange process and achieved regeneration efficiencies of less than 1.15.

The San Diego Water Authority: The Water Authority was considering the construction of a water treatment plant to treat water imported from Northern California. Dr. Trussell conducted an evaluation of technologies appropriate for treating that supply.

Reedy Creek Improvement District: Dr. Trussell was retained by the Reedy Creek Improvement District, over a period of several years, to advise its operational staff on the operation of the District's activated sludge treatment plant. Trussell used innovative computer technology to communicate with the treatment plant operators and assist them in managing the plants operating conditions

Circus World Waste Study - MW was retained by Circus World Inc., to do a comprehensive study of all the solid and liquid waste treatment systems to emanate from the new amusement park in Orlando, FL. The project involved extensive characterization of a variety of animal wastes as well as designing a treatment system that addressed all the appropriate special quarantines and other regulations that apply to animal collections. Mr. Trussell was the project engineer.

The Seaworld Ozonation Study: Seaworld had a number of installations where recirculated water was used for the habitat for sea-going mammals such as killer whales and porpoises. Practice had been to disinfect these systems with chlorine, occasionally using breakpoint chlorination as a means for controlling the eye-irritation that stems from extensive exposure to chlorine. Dr. Trussell was hired to evaluate alternatives and, using field and pilot data developed the design criteria that are now used for ozonation in such recirculated seawater system throughout the industry.

Hollywood Presbyterian Hospital Waste Study - MW was retained by the Hollywood Presbyterian Hospital to review the problems in disposing of wastes from their new expansion. The timing of the expansion was unfortunate because, at the time, State Law required that all hospital wastes be incinerated, but the Southern California Air Quality Management District had recently set air quality limits that no such incinerator could meet. Mr. Trussell organized the bulk of the study and the issue was only resolved when members of all the relevant regulatory agencies were brought into one room so a compromise could be struck.

Rancho California On-Site Treatment Study - MW was retained by Rancho California, Inc. to conduct a study of on-site wastewater treatment for large rural lots in the development in an area with shallow soil and poor percolation rates. A manual was developed for use in site-by-site design of an evapotranspiration system to serve development in the area.

Power Plant in Needles, CA - A private utility was considering construction of a large power plant near Needles, CA. and was considering discharge of the waste brine to a deep aquifer via deep-well injection. Dr. Trussell conducted an evaluation of the interaction of the injection water and the deep aquifer water, demonstrating that significant scaling could be expected.

Rancho California Vail Lake Masterplan - MW was retained by Rancho California, Inc. to develop a water and sewer masterplan for the Vail Lake area. The effort included studies of land use, population estimates, and preliminary layouts of both sewers and water mains. Mr. Trussell conducted much of the work.

Corona Corrosion Study - MW was retained by Home Savings and Loan to find the cause, and recommend action, for the pitting failure of copper tubing in a number of homes in the vicinity of Corona, California. The homes, which were served by groundwater exhibited Type I pitting in the coldwater plumbing. Chemical treatment was recommended. Dr. Trussell conducted the investigation.

Crummer Ranch Study - Home Savings and Loan, owner of Crummer Ranch retained MW to basis for sizing the new sewer system being installed by the Triunfo Sanitation District in a service area that included the Crummer Ranch. New population estimates were developed and the size and cost of the sewer system was reviewed. Mr. Trussell did the larger share of the technical work

ORGANIZATIONS:

- American Association of Environmental Engineering Professors (Associate)
- American Chemical Society
- American Society of Civil Engineers
- American Institute of Chemical Engineers
- American Water Works Association (Life Member)
- California Water Pollution Control Association
- International Water Association
- National Association of Corrosion Engineers

- Sigma Xi - The Scientific Research Society of North America
- Water Environment Federation

PROFESSIONAL ACTIVITIES:

AAEE

Nominated to AAEE by AWWA
Cover person in Environmental Engineer, January 1997
Kappe Lecturer for Fall of 1999
Member, Certification by Eminence Committee, 2005-2007
Frederick G. Pohland Medal, For outstanding contributions to bridging environmental engineering research, education, and practice, 2005 (jointly awarded by AAEE & AAEEESP)

AAEESP

Invited Speaker to AAEESP forum at AWWA, 1989.
Invited member of Asilomar Panel on the New Frontiers in Environmental Engineering and Science, 1997p
Frederick George Pholand Medal, 2005, (jointly awarded by AAEE & AAEESP)

AWWA

Vice Chair Water Treatment Committee, California Section 1977-1980.
Co-chair National Research Committee on Particulates, 1978-1982
AWWA Representative to the Editorial Advisory Board of **Standard Methods for Examination of Water and Wastewater**, 1982-1989.
Member Editorial Board of **American Water Works Association Journal**, 1988-1994.
AWWA Representative to International Water Supply Association's Standing Committee on Water Quality and Treatment, 1990-1994
Member of AWWA International Committee 1990-present
Best Paper Award, Distribution Division, 2000
Best Paper Award, Distribution & Operations Division, 2001
Best Paper Award, Water Resources Division, 2001

AP Black Award, 2010

AWWARF

AWWARF - US/Holland Committee on Volatile Organic Compounds in Ground Water, 1982-1983
AWWARF - US/German Committee on Corrosion, 1983-1985
AWWARF - US/USSR Committee on Drinking Water Research, 1985-1987
AWWARF - US/French Committee on Mixing in Water Treatment 1988-1990
AWWARF - US/European Committee on Corrosion, 1991-1994

ASCE

Civil Engineering Research Foundation, CERF
Consultant Advisory Board, Civil Engineering Research Foundation, 1991-1998, Chairman Environmental Committee, 1993
Executive Committee, 1994.

ACS

Member Editorial Board of **Environmental Science and Technology**, 1978-1983
Member of magazine Editorial Board of **Environmental Science and Technology**, 2000-2005.

IWA

Member of Standing Committee on Water Quality and Treatment, 1990-1994
Member of Scientific and Technical Council, 1994-present
Chair, Committee on Disinfection, 1994-2002
Member, Programme Committee, 2000-2008

National Academy of Engineering

Peer Committee 2001-2003
Membership Committee 2005-2007
Grainger Prize Committee 2006-2007

National Research Council - Division on Earth and Life Studies Water Science and Technology Board
Chair 2002-2008

National Water Research Institute

Member of Clarke Prize Selection Committee
2006-2012
Member of Davis Water Supply Panel
Member of OCWD GWRS Panel

WaterReuse Association
Chairman of Research Advisory Committee,
2005-2007

Water Environment Research Foundation
Member, Board of Directors, 2007-2010

EPA ADVISORY ACTIVITIES

Science Advisory Board
Consultant to Sub Committee on
Drinking Water, 1988-1990
Member Committee on Drinking
Water, 1990-1992
Consultant to Committee on Drinking
Water, 1992-1994
Member, Committee on Drinking
Water, 1994 - 2005
Chair, Committee on Drinking Water,
2000-2004
Member, Executive Committee and
Board, 2000-2005

EPA Board of Scientific Counselors
Member of Committee on Arsenic in
Water, 1997

Other EPA Activities
Invited Speaker EPA Seminar Series
on Treatment Technology for Meeting
the NIPDWR 1976
Invited Speaker EPA Seminar Series
on Operation of Activated Sludge,
1977
Invited Speaker EPA Seminar on
Defluoridation of Drinking Water,
Dallas, Texas, 1978
Invited Speaker EPA
Seminar/Workshop on Corrosion in
Consumer Plumbing, Cincinnati,
Ohio, 1979
Invited Speaker EPA Seminar Series
on Treatment Technology for
Removing Organics in Drinking

Water, San Francisco and Dallas,
1979
Member EPA Arlie Conference on
Potable Reuse Criteria, Washington,
D.C., 1980
Member EPA Panel on Re-evaluation
of National Water Quality Criteria; The
Johns Hopkins University, 1983
Member of Consulting Panel to EPA
to Write Report to Congress on the
Relative Risks of Disinfection and
Disinfection By-products, 1987-88
Member of Panel appointed to review
office of pesticide program
regulations, 2000.

NATIONAL RESEARCH COUNCIL

Member National Academy of Sciences
Committee on Drinking Water
Chemicals CODEX, 1980-1982
Member National Academy of Sciences
Committee on 3rd Party Certification
of Drinking Water Chemicals, 1983-
1984
Member National Academy of Sciences
Committee on Irrigation Induced
Water Quality Problems, 1985-1989
*Elected to National Academy of
Engineering, Class of 1995*
Member of National Academy of Sciences
Committee on Viability of Potable
Reuse, 1996-1998.
Vice-Chair of National Academy of
Sciences Committee on Setting
Priorities for Drinking Water
Contaminants, 1998-1999
Member of Water Science and
Technology Board, 1999-2007,
Incoming Chair 2004-2007
Vice-Chair of National Academy of
Sciences Committee on Identifying
Future Drinking Water Contaminants,
1999
Vice-Chair of National Academy of
Sciences Committee on Categorizing
Drinking Water Contaminants for
Purposes of Regulation, 2000-2001.
Vice-Chair of National Academy of
Sciences Committee on Microbial
Indicators in Water

Member of Peer Committee for Section 4,
Civil Engineering, 2001-2004

OTHER ADVISORY PANELS

Member, Scholars Committee on Perchlorate,
Urban Water Research Center, Irvine, CA
2003-2004

HONORS:

1985 Who's Who in the West
1987 Who's Who in America
1989 Who's Who in Engineering
1990 American Academy of Environmental
Engineering (nominated by AWWA)
1995 National Academy of Engineering
1997 American Academy of Environmental
Engineering, Featured Cover Story
1998-1999 American Water Works Association,
Distribution & Plant Operations Division, Best
Paper Award
1999 American Academy of Environmental
Engineering: Kappe Lecturer
2000 American Water Works Association,
Distribution Division, Best Paper Award;
2001 Water Resources Division, Best Paper
Award
2001 American Water Works Association,
Distribution & Operations Division, Best
Paper Award;
2001 American Association of Municipal Water
Agencies Donald R. Boyd Award for
leadership and contributions to the drinking
water community
2003 American Water Works Association, Life
Member
2003 American Chemical Society, Life Member
2005 Association of Environmental Engineering
and Science Professors/American Academy
of Environmental Engineering – Frederick G.
Pohland Medal for outstanding contributions
to bridging environmental engineering
research, education and practice
2010 American Water Works Association, A.P.
Black Award
2012 International Water Association, Global
Water Award

PUBLICATIONS IN REVIEWED BOOKS AND JOURNALS

1. Thomas, J. F. and Trussell, R. R., "The Influence of Henry's Law on Bicarbonate Equilibria," **JAWWA V62(3)**:195 (March 1970).
2. Thomas, J. F. and Trussell, R. R., "Computer Application to Water Conditioning Calculations," **JAWWA V62(3)**:245 (April 1970); also published in *British Water Supply*, p. 22 (December, 1970), by request.
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