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**BEFORE THE PUBLIC UTILITIES COMMISSION**  
**OF THE STATE OF CALIFORNIA**

In the Matter of the Application of California-American Water Company (U 210 W) for a Certificate of Public Convenience and Necessity to Construct and Operate its Coastal Water Project to Resolve the Long-Term Water Supply Deficit in its Monterey District and to Recover All Present and Future Costs in Connection Therewith in Rates.

Application 04-09-019  
(Filed September 20, 2004;  
Amended July 14, 2005)

**DIRECT TESTIMONY OF R. RHODES TRUSSELL, Ph.D., P.E.**  
**(PHASE 2 REGIONAL PROJECT COST ISSUES)**

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June 24, 2009

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Application 04-09-019  
(Filed September 20, 2004;  
Amended July 14, 2005)

**DIRECT TESTIMONY OF R. RHODES TRUSSELL, Ph.D., P.E.**

**I. Introduction**

Q1. What is your name and employer?

A1. My name is R. Rhodes Trussell, Ph.D., P.E. I am the president of Trussell Technologies, Inc. Pasadena, California.

Q2. What is your background?

A2. Before founding Trussell Technologies, Inc in 2003, I worked from 1972 to 2003 for MWH, Inc. formerly Montgomery Watson Harza, Inc., Montgomery Watson, Inc. and James M. Montgomery Consulting Engineers, Inc. in Pasadena, California. I have a B.S. and M.S. in Civil Engineering and a Ph.D. in Sanitary Engineering from the University of California at Berkeley. I am a registered Civil and Corrosion Engineer in the State of California with 37 years of experience. I have authored more than 200 publications and I am coauthor of the textbook, *Water Treatment: Principles and Design*, published by Wiley in 2005. I am an expert on the methods and Criteria for Water Quality and in the development of advanced processes for treating water or wastewater to achieve the highest standards. I have worked on the

1 process design for dozens of treatment plants, ranging from less than 1 to more  
2 than 900 mgd in capacity and have experience with virtually every physiochemical  
3 process and most biological processes as well. I have served for more than ten  
4 years on EPA's Science Advisory Board where I chaired the Committee on  
5 Drinking Water. I also served as a member and later as Chair of the Water Science  
6 and Technology Board for the National Academies. I was elected to the National  
7 Academy of Engineers in 1995, where I have served as a member of the Peer  
8 Committee for Civil Engineering, The Membership Committee, and the Grainger  
9 Prize Committee. I have served on eight committees of the National Research  
10 Council on national water issues. A copy of my current CV is attached to this  
11 testimony as Exhibit RRT-1.  
12

13  
14 Q3. What is your role on the project?

15 A3. I am the Technical Director for the portion of the work conducted by Trussell  
16 Technologies, Inc. Trussell Technologies, Inc. is a subconsultant to RMC Water  
17 and Environment (RMC). The Marina Coast Water District (MCWD) hired RMC  
18 to provide engineering services for the Groundwater Desalination plant and the  
19 Salinas River Surface Water Treatment plant projects. Trussell Technologies, Inc.'s  
20 role on the projects is to assist RMC with predesign tasks and to work with the  
21 California Department of Public Health regarding permitting. While working on  
22 permitting, we drafted documents to be sent to CDPH and MCWD received a letter  
23 from CDPH on May 12, 2009, allowing it to operate the proposed desalination  
24 plant (attached as Exhibit RRT-2: Desalination Treatment Plant - Source Water  
25 Quality Monitoring Plan Marina Coast Water District.) In addition to the  
26 permitting documents, we prepared the following: Conceptual Design of  
27 Desalination Facilities TM2 – April 11, 2008 (attached as Exhibit RRT-3), Water  
28 Quality Goals and Design Criteria for the Groundwater Desalination Facility TM3-

1 March 23, 2009 (attached as Exhibit RRT-4), Process Description and Design of  
2 Desalination Facility TM4 – June 19, 2009 (attached as Exhibit RRT-5),  
3 Equipment Data Sheets for the Marina Coast Water District Desalination Plant  
4 TM5 – June 19, 2009 (Attached as Exhibit RRT-6).  
5  
6

7 Q4. Where have you looked at desalination plants before?

8 A4. While at my former employer, I served as a senior advisor on the design of the  
9 Point Lisas Desalter in Trinidad, the largest Desalter in the Western Hemisphere at  
10 the time (2001-2003). Recent desalination plant projects I have been involved with  
11 since founding Trussell Technologies, Inc include the Poseidon Desalination  
12 Project for Carlsbad, CA (2003-2006); the Temporary Ocean Water Desalination  
13 Demonstration Plant for West Basin Municipal Water District, California (2006-  
14 present); the San Juan Capistrano Desalter for the City of San Juan Capistrano,  
15 California (2007-2008), the Water Replenishment District of Southern California's  
16 Leo van der Lans Desalter (2007-present), the Los Angeles Department of Water  
17 and Power's seawater desalination project (2008), the Long Beach Municipal  
18 Water District Seawater demonstration plant (2008), the City of Huntington Beach  
19 Seawater Plant (2007), the City of Camarillo groundwater Desalter (2008), the  
20 Puerto Peñasco Desalination Plant, Mexico (2008-2009).  
21

22 Q5. Is boron or chloride concentration in the product water a concern in a project like  
23 this one, and if so, why?

24 A5. Boron, sodium and chloride are all unusually high in seawater and, as a result, all  
25 three are of concern in the desalinated water as well. Elevated levels are associated  
26 both with adverse effects on public health and with adverse effects on the plant life  
27 in local landscapes. High chloride levels are also associated with corrosion. Public  
28 health limits generally have greater visibility, and as a result, impacts on

1 horticulture and corrosion are often not fully appreciated by desalination advocates.  
2 Nevertheless, it is these latter requirements that are more stringent and, as a result,  
3 govern the treatment required.  
4

5 The California Department of Public Health (CDPH) has set limits on chloride and  
6 boron due to public health considerations. For boron, CDPH has established a  
7 Notification Limit (NL) of 1 part per million (ppm), and for chloride, CDPH has  
8 established a secondary Maximum Contaminant Level (MCL) of 250 ppm. It is  
9 also well-known that high sodium intake is associated with hypertension and EPA  
10 has discussed a sodium MCL as low as 25 ppm, but none has made a decision not  
11 to promulgate.  
12

13 Q6. What levels of boron are found in the existing potable supplies?

14 A6. Boron is usually below the detection limit in the existing potable water supplied by  
15 California American Water (CAW). Levels as high as 0.2 ppm have been reported.  
16 Boron is also below the detection limit in much of the water supplied by MCWD.  
17 Again levels slightly above 0.1 ppm have been reported.  
18

19 Q7. When did you first encounter high boron as an issue in a domestic water supply?

20 A7. In 1966. I was working for James M. Montgomery Consulting Engineers, Inc. Our  
21 client was the Rancho California Water Company.  
22

23 Q8. What levels of boron were in this groundwater?

24 A8. As I recall some of the wells had boron levels above 1 ppm.  
25

26 Q9. What did you recommend?

27 A9. We recommended they limit the use of the wells with high boron and seek to gain  
28 access to water from the Colorado Aqueduct.

1 Q10. What levels of boron are produced by seawater reverse osmosis (SWRO)?

2 A10. The concentration of boron in seawater is much higher than in conventional water  
3 supplies. The anticipated boron concentration in the permeate water from a SWRO  
4 system ranges between 0.6 and 1.6 ppm, but concentrations just at below or just  
5 above 1.0 ppm are common.  
6

7  
8 Q11. Is this level of boron safe?

9 A11. From the standpoint of public health, more or less. From the standpoint of the  
10 local plant life, no. The CDPH Notification Limit (NL) of 1 ppm has only one  
11 significant figure, so boron levels as high as 1.44 ppm technically meet this public  
12 health requirement. On the other hand, because plants are more sensitive to boron,  
13 the primary issue with boron removal in this application is the potential for adverse  
14 impact to residential and public landscaping and to commercial and retail nurseries.  
15

16 Q12. What does boron do to plants and what levels are safe for them?

17 A12. Boron has been shown to be toxic to many plants at concentrations above 0.5 ppm.  
18 Plant toxicity from boron can result in leaf burn, leaf cupping, chlorosis (i.e.,  
19 chlorophyll deficiency), anthocyanin (blue and red leaves), rosette spotting,  
20 premature leaf drops, branch dieback, reduced growth, and in extreme cases,  
21 necrosis (i.e., cell death). The majority of published research on boron toxicity has  
22 focused on yield reduction in agricultural crops and not the impact on plant  
23 appearance. However, the appearance of many landscape plant species found in  
24 California can be affected by boron as well. In a study conducted as part of the  
25 Carlsbad project the following trees and plants were found to be adversely affected  
26 by boron levels of between 0.5 and 1.0 ppm: Orange, Lemon, and Coast Redwood  
27 trees; Chinese holly, Juniper, Xylosma, Camelia, Crape Myrtle, Gardenia, Giant  
28 Bird of Paradise, Heavenly Bamboo, Hydrangea, Lily of the Nile, Philodendron,

1 Photinia, Pink Trumpet Vine, the common Rose, Southern Magnolia, Violet  
2 trumpet vine, and Wheeler's dwarf pittosporum. The study reported that even at  
3 concentrations as low as 0.5 ppm, there are plants that are sensitive to boron,  
4 orchids being a well-known example.  
5

6  
7 Q13. What are the levels of chloride and sodium produced by SWRO?

8 A13. Although the total dissolved solids (TDS) in the desalinated water will be low,  
9 chloride and sodium comprise a majority of the TDS. The maximum chloride  
10 concentration for a single-pass reverse osmosis (RO) system is anticipated to be  
11 between 100 and 200 mg/L. The maximum sodium concentration for a single-pass  
12 RO system is anticipated to be between 50 and 180 mg/L.  
13

14 Q14. What are the levels of chloride and sodium in the current domestic water supply?

15 A14. The average chloride level in the water supplied by CAW is 69 ppm and the  
16 average chloride level in the water supplied by MCWD is 98 ppm. The average  
17 sodium level in the water supplied by CAW is 54 ppm and the average sodium  
18 level in the water supplied by MCWD is 66 ppm.  
19

20 Q15. What do chloride and sodium do to plants and what levels are safe for them?

21 A15. Chloride and sodium toxicity can be detrimental to the appearance of plants.  
22 Chloride and sodium toxicity have very similar impacts on plant life. Some of the  
23 better-known cases of chloride toxicity have occurred where Redwood and  
24 Avocado trees were converted from irrigation with local water supplies to recycled  
25 water, resulting in significant impacts on the health of these species. The most  
26 common symptom is tip burn, but chloride and sodium toxicity can also result in  
27 tattered leaves, reduced leaf size, reduced growth rates, yellowing of leaves in  
28 conifers, and in extreme cases, death. Similar to boron toxicity, chloride and

1 sodium will accumulate in the older leaves and these leaves will typically exhibit  
2 the symptoms first. In addition to similar toxicity effects, high levels of sodium  
3 (above 80 ppm) can shift the sodium absorption ratio, a measure of the competition  
4 between sodium and potassium versus calcium and magnesium, and research has  
5 shown that when the sodium absorption ratio is too high, soils with clay in them  
6 have reduced permeability. This also has adverse effects on plant life.  
7

8  
9 Q16. How are these concerns normally addressed?

10 A16. Most existing seawater desalination systems using reverse osmosis employ a  
11 complete or partial second pass in order to address this problem. Examples of such  
12 facilities include those at Trinidad, Ashkelon, Singapore, Fukuoka, Perth, and  
13 Tampa.  
14

15 Q17. How did you address this concern for the MCWD project?

16 A17. Preliminary modeling determined that a partial second pass of 20 to 90%, would be  
17 required in order to achieve the boron water quality goal of 0.5 mg/L depending on  
18 the type of membranes used in the first pass (standard or high boron rejection  
19 membranes) and the level of pH adjustment made to the feedwater prior to the  
20 second pass. This modeling work is based on the water quality information and  
21 design assumptions available at the time. Generally, the 0.5 mg/L boron goal is the  
22 most difficult to meet and, when achieving the boron goal, reasonable levels of  
23 chloride and sodium also result. When feedwater temperature is less than 17°C and  
24 the feedwater boron concentration is less than 4.4 mg/l, the second pass may not be  
25 required (especially when using the high boron rejection membranes). If other  
26 operating parameters are varied, such as recovery or flux, or if the feedwater boron  
27 concentration is higher than 4.4 mg/l, a larger second pass would be required. In  
28

1 the design of the MCWD facility we sized the second pass to handle 40 percent of  
2 the SWRO permeate.

3  
4  
5 Q18. Does this add much complexity to the treatment process?

6 A18. A full or partial second RO pass adds a treatment step to the process train. This  
7 additional treatment step consists of RO skids similar in complexity, but less  
8 extensive and less costly than the first pass RO skids. The second pass RO skids  
9 ancillary equipment includes second pass feed pumps, a caustic chemical feed  
10 system, a clean-in-place pump and a break tank.

11  
12 Q19. How much does adding a second pass affect the cost of the project?

13 A19. Adding a second pass does affect the cost of the project, but the degree to which  
14 the cost of the project is increased depends on the specific circumstances. For  
15 example a larger, more expensive second pass is required for plants with warmer  
16 water or water with higher salinity.

17  
18 Q20. Have you interfaced with CDPH on the desalination plant?

19 A20. Yes. I visited with CDPH to discuss the project, and since then I have corresponded  
20 and discussed it with them. I oversaw the preparation of the following documents  
21 sent to CDPH by Trussell Technologies, Inc: CDPH Permitting Meeting Handout  
22 for Desalination Plant (October 22, 2008) (Exhibit RRT-7), CDPH Monitoring  
23 Plan for the Water Supply Permitting of the Marina Coast Water District's  
24 Desalination Treatment Plant (December 22, 2008) (Exhibit RRT-8); a discussion  
25 on Groundwater Under the Direct Influence of Surface Water (January 25, 2009)  
26 (Exhibit RRT-9), Marina Coast Water District Desalination Treatment Plant-  
27 Source Water Quality Monitoring Plan First Quarter Sampling Results (June 3,  
28 2009) (Exhibit RRT-10), Response to the CDPH letter "Desalination Treatment

1 Plant - Source Water Quality Monitoring Plan Marina Coast Water District” (June  
2 12, 2009) (Exhibit RRT-11).

3  
4  
5 Q21. What is the status of your interface with CDPH on the desalination plant?

6 A21. The desalination plant sampling plan and permitting (and process selection)  
7 strategy has been approved by CDPH in their letter to the MCWD dated May 12,  
8 2009 (Attached as exhibit RRT-2). Their approval allows us to start construction of  
9 the proposed plant without delay and complete some of the testing and sampling  
10 requirement once the full-scale plant is on-line. On June 12, 2009, we responded  
11 to CDPH with a more detailed schedule of our sampling events and our  
12 construction plan. The response letter is attached as Exhibit RRT-11)

13  
14 Q22. Did you look at the Salinas River surface water treatment plant?

15 A22. Yes. I oversaw the preparation of the following documents prepared by Trussell  
16 Technologies, Inc: Conceptual Design of a Microfiltration Facility to Treat Salinas  
17 River Water – TM1 (April 11, 2008) (Exhibit RRT-12); CDPH Permitting Meeting  
18 Handout for Salinas River Surface Water Treatment Plant (October 20, 2008)  
19 (Exhibit RRT-13); CDPH Monitoring Plan for the Water Supply Permitting of the  
20 Marina Coast Water District’s Salinas River Surface Water Treatment Plant  
21 (December 15, 2008) (Exhibit RRT-14). I have prepared correspondence to be sent  
22 to CDPH and attended one meeting with CDPH regarding the water supply permit  
23 for this plant.

24  
25 Q23. What processes have you suggested?

26 A23. The primary treatment processes proposed for this facility are high rate  
27 sedimentation (Actiflo®) followed by microfiltration (MF) membranes. These  
28 processes were selected for their ability to meet water quality goals, large turndown

1 requirements, and in the case of Actiflo®, the ability to handle rapid changes in  
2 turbidity. The proposed treatment train consists of the following processes: 1)  
3 Pretreatment {a. Chemical coagulation with ferric chloride and polymer, b. High  
4 rate sedimentation (Actiflo® ballasted flocculation), and c. Automatic self-cleaning  
5 strainers (75 micron)}, 2) MF membrane treatment, 3) Primary disinfection with  
6 UV, 4) Primary and secondary disinfection with sodium hypochlorite.  
7  
8

9 Q24. Are there pesticides in the Salinas River that must be removed to produce potable  
10 water?

11 A24. There is agricultural runoff upstream of the potential future Salinas River plant  
12 intake, so we are looking closely at this issue. Our on-going sampling plan includes  
13 testing for every contaminant regulated by the CDPH (e.g., those with MCLs), as  
14 well as for all unregulated chemicals with a CDPH NL. These contaminants with  
15 MCLs and NLs include several herbicides and pesticides. In addition, the methods  
16 used to detect these regulated organic pollutants also detect many unregulated  
17 pesticides. Any chemicals detected in this survey will be monitored throughout all  
18 remaining sampling periods. Our plan allows for sampling during large winter  
19 storm event and an additional storm as well as during non-storm flow. Pesticides  
20 were not found in either of the two samples collected thus far. At the end of the  
21 sampling effort, when all the results are gathered, a decision will be made as to  
22 which contaminants are a concern for the future plant. CDPH's water supply  
23 permitting process will also include a vulnerability assessment and a watershed  
24 sanitary survey. These documents will include an assessment of possible  
25 contaminating activities that may impact the plant source water. The Monterey  
26 County Water Resources Agency is also monitoring the Salinas River for  
27 pesticides such as Chlorpyrifos and Diazinon. The data we have seen show non-  
28 detect for chlorpyrifos and diazinon concentrations ranging as high as 44.5 and 684

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ng/L, respectively. These pesticides are not regulated by CDPH or the EPA. The EPA has established a lifetime health advisory level of 100 ng/L for Chlorpyrifos and 20,000 ng/L for Diazinon.

Q25. If unacceptable levels of pesticides are found, how would you recommend they be addressed?

A25. If it is determined that pesticides are a concern by the process stated above, the treatment plant will be modified to address these pesticides. The modifications required will depend on which pesticides are found and at what levels. Carbon adsorption ozonation, and advanced oxidation are the principle process which would be considered.

Q26. Does this complete your testimony?

A26. Yes, it does.