World Water Forum College Grant Program
2007 Grant Proposals

College	San Diego State University
Faculty	Temesgen Garoma
Project	Disinfection of Secondary Effluent Using Surfactants Immobilized on the Surfaces of Minerals

ORIGINAL

SAN DIEGO STATE UNIVERSITY
Research Foundation

December 11, 2007

Ms. Benita Lynn Horn
Project Coordinator
Educational Unit, External Affairs Group
The Metropolitan Water District of Southern California
P.O. Box 54153
Los Angeles, CA 90054-0153

RE: *Disinfection of Secondary Effluent using Surfactants Immobilized on the Surfaces of Minerals*

Temesgen Garoma, Ph.D., P.E.
Department of Civil and Environmental Engineering

Dear. Ms Horn:

Enclosed please find the original proposal referenced above. San Diego State University Research Foundation is pleased to participate in the project referenced above. The principal investigator at San Diego State University is Dr. Temesgen Garoma. The budget for $13,200 has been approved by San Diego State University Research Foundation.

San Diego State University Research Foundation, a 501(c)(3) nonprofit corporation, administers grants and contracts on behalf of San Diego State University and its faculty. If this proposal is chosen for an award, funds should be drawn in favor of the San Diego State University Research Foundation.

Payments should be sent to:
San Diego State University Research Foundation
5250 Campanile Drive, Mail Code 1931
San Diego, CA 92182-1931

Please direct communications regarding this proposal to:

Programmatic
Temesgen Garoma
SDSU
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Thank you for your consideration of this proposal.

Gene Stein
Director, Sponsored Research Development
San Diego State University Research Foundation

Sponsored Research Services
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Disinfection of Secondary Effluent using Surfactants Immobilized on the Surfaces of Minerals

A. Institution

College	Department of Civil and Environmental Engineering San Diego State University
Address	5500 Campanile Drive
City, State, Zip Code	San Diego, CA 92182-1324
Website	http://www.engineering.sdsu.edu/civil/ http://attila.sdsu.edu/~garoma/
Make Check Payable to	San Diego State University Research Foundation

B. Project Type

Applicant	Check One
First Time – Local Project	√
First Time – Global Project	
Existing Project – Local Focus	
Existing Project – Global Focus	

C. Student Project Manager

Student Project Manager	Carlos Lau
Undergraduate or Graduate	Graduate
Department	Department of Civil and Environmental Engineering
School Address	5500 Campanile Drive, San Diego CA 92182-1324
Telephone	
Mobile Phone	858-361-4944
Email	carlosllau@gmail.com
Home Address (Optional)	

D. Faculty Project Manger

Faculty Project Manager	Temesgen Garoma
Department	Department of Civil and Environmental Engineering
School Address	5500 Campanile Drive, San Diego CA 92182-1324
Telephone	619-594-0957
Mobile Phone	
Email	tgaroma@mail.sdsu.edu
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E. Organizational Background

E-1. San Diego State University Research Foundation

Established in 1943, the SDSU Research Foundation is a self-financed 501(c)(3) nonprofit corporation. As an auxiliary organization within the California State University (CSU) system, authorized by the Education Code of the State of California, SDSU Research Foundation is chartered to provide and augment programs that are an integral part of the educational mission of San Diego State University. With over 5,800 employees, it is the largest auxiliary within the CSU system. The purpose of SDSU Research Foundation is to further the educational, research and community service mission of San Diego State University.

E-2. San Diego State University

Founded in 1897, San Diego State University (SDSU) is the third largest university in California and has a student body of approximately 34,500. SDSU awards bachelors, masters, and doctoral degrees in more than 150 fields. SDSU offers the most doctoral degrees of any campus of the CSU system, currently in sixteen academic and research discipline. In research, SDSU has been ranked the No. 1 most productive research university for two years in a row, among schools with 14 or fewer Ph.D. programs based on the Faculty Scholarly Productivity Index (Academic Analytics, 2007).

E-3. Department of Civil and Environmental Engineering

The Department of Civil and Environmental Engineering (Department) at SDSU offers bachelors degrees in Civil, Construction, and Environmental Engineering, masters degrees in Civil and Environmental Engineering, and a Ph.D. degree in Environmental Engineering with the University of California at San Diego. Over the past five years, the enrolment at the Department has increased by more than double and currently about 700 students are enrolled into the various programs at Department.

Mission of the Department

The mission of the Department is to provide a high quality undergraduate and graduate education in the civil, environmental, and construction engineering areas as well as the advising and other support needed to ensure the students' academic success and preparation for a productive engineering career. In addition, through research and continuing professional development, the faculty produce, enhance and promote new developments within their areas of expertise for the benefit of society and the furtherance of their profession.

Educational Objectives

The objectives of the Civil, Construction, and Environmental Engineering programs at the Department are to prepare graduates to practice in Civil, Construction, and Environmental Engineering by providing them with the ability to apply the basic principles of the mathematical, physical, and social sciences to the analysis and solution of Civil, Construction, and Environmental Engineering problems; to provide a basic understanding of issues faced during professional practice and a solid foundation for continuing education and graduate study.

Research

Active areas of research in the Department include construction, environmental, geotechnical, structural, transportation, and water resources engineering. The Department has well-equipped laboratories for experimental research in structural, geotechnical and geoenvironmental, environmental, transportation, and water resources engineering. In 2006, the faculty in the Department has attracted more than $2.5 million in external research grants.

Ongoing research projects in the Department that are related to water quality include:

- Understanding the fate of emerging contaminants in the environment and developing effective treatment methods for their removal from water.
- Developing treatment technologies for destruction of groundwater contaminants including fuel oxygenates and hydrocarbons.
- Developing treatment technologies for the removal of perchlorate from groundwater.
- Analyze irrigation runoffs for the presence of fertilizers, pesticides, and sediments as well as developing treatment methods.

F. Project Description

F-1. Background

Southern California, a desert region that relies on imported water, frequently faces critical water shortage. To ensure safe and affordable water supply, the region must diversify and increase its local portfolio. The use of recycled water for non-potable application, such as irrigation, groundwater recharge, seawater barrier, and industrial application can substantially supplement local sources, relieve much-needed potable water for other uses, and reduce the quantity of water imported to the region.

Disinfection is a major treatment step in the production of recycled water to ensure environmental and public health protection. During disinfection microorganisms that likely cause illness to humans are inactivated from the recycled water. *California Code of Regulation, Title 22, Reclamation criteria* establishes the criteria for water quality standards and treatment reliability to recycled water. The criteria were developed and regulated by the California Department of Heath Services (CDHS) which requires the total coliform level not to exceed 2.2 mg per 100 ml for disinfected tertiary effluent for unrestricted use.

The three most commonly used disinfection methods in the US are chlorination, ozonation, and ultraviolet (UV) disinfection. Chlorine is the most widely used disinfectant for wastewater and it can be applied as chlorine gas, hypochlorite solutions, and other chlorine compounds in solid or liquid form. Chlorine, being toxic if inhaled, is a major safety concern. Because of this, disinfection with chlorine gas is less preferred at wastewater treatment plants across the nation. There is a potential danger of gas leaks which could be caused by an accident during shipment of chlorine to the site and/or storage on site. Sodium hypochlorite is much easier to handle and poses no undue risks during shipping, onsite handling, and storage. However, the day to day cost of sodium hypochlorite as a unit cost per equivalent chlorine is approximately twice that of the cost of gaseous chlorine. Chlorine-based disinfection methods have also the disadvantage of producing toxic disinfection by-products.

Compared to chlorine-based disinfection methods, ozone and UV light have relatively high capital costs. Because ozone is a toxic chemical, ozone generators may leak and could create ozone hazard. Both ozone and UV technologies have advantages for wastewater applications because they do not require dechlorination prior to discharge. Neither ozone nor UV produces hazardous disinfectant by-products. However, if either of these methods is used to disinfect recycled water, chlorine or a chlorine-based disinfectant must be used to provide the residual disinfection capability needed in the recycled water distribution system.

In this research project the effectiveness of a new and innovative disinfection method for secondary effluent will be investigated. The method utilizes surfactants of quaternary ammonium compounds (QACs) immobilized on the surfaces of minerals to inactivate bacteria in secondary effluent. Preliminary study conducted in our lab indicates that surfactants-loaded on the surfaces of minerals effectively inactivated bacteria present in raw water obtained from the San Diego River.

F-2. Research Objective

The main objective of this research is to evaluate the effectiveness of surfactants immobilized on the surfaces of minerals to disinfect secondary effluent. It is well known that surfactants of quaternary ammonium compounds (QACs) exhibit biocidal capabilities in aqueous solution [1-3]. Therefore, it is hypothesized that if these surfactants are adsorbed on the surfaces of minerals, the surfactant-loaded minerals can be used to inactivate bacteria.

F-3. Disinfectant Capabilities of Surfactants

Surfactants are surface active agents, which means they are active at a surface and are characterized by their tendency to absorb at surfaces and interfaces [4]. They are constituted by two molecules with two different structural elements: a hydrophobic hydrocarbon (water repellent) group and a hydrophilic polar (water attracting) group. Surfactants are classified as anionic or cationic depending on the charge of the hydrophilic structural [4, 5]. Anionic surfactants, such as sodium dodecyl sulfate (SDS), exhibit some antimicrobial effect only in acid media (pH in the range of 2 to 3), but they have strong detergent properties [6]. In aqueous solutions they dissociate to a large anion, responsible for the strong detergent properties, and a small cation [5]. Their antimicrobial effect is restricted mainly to gram-positive bacteria. Acid formulations of anionic surfactants are used as disinfectants in the dairy, beverage and food processing industries, and homes [5, 6].

Cationic surfactants, such as cetyltrimethylammonium bromide (CTAB), dodecyltrimethylammonium bromide (DTAB), and tetradecyltrimethylammonium bromide (TTAB), possess strong bactericidal, but weak detergent properties. Cationic surfactants usually signify quaternary ammonium compounds (QACs) [7]. The antimicrobial properties of QAC's depend on their structure and size, especially on the length of the chain. The efficacy of QAC's increases with temperature and pH [5].

QACs are widely used for the control of bacterial growth in clinical and industrial environments [8], domestic cleaning and disinfection [11], and surface disinfection in the food industry [8]. QAC's mode of action is attributed to their positive charge, which forms an electrostatic bond with negatively charged sites on microbial cell walls [7]. Those electrostatic bonds create stresses in the wall, leading to cell lysis and death. QACs also cause cell death by protein denaturation, disruption of cell-wall permeability and reduction of the normal intake of life-sustaining nutrients to the cell [9]. Some QACs appear to rupture the cell membrane. For CTAB, the primary site of action has been suggested to be the lipid components of the membrane, causing cell lysis as secondary effect [10].

F-4. Experimental Plan

Material and Methods

The research project requires, planning, designing, and conducting a number of adsorption and disinfection experiments. In the current project, the disinfection capability of two types of surfactants, namely didodecyldimethylammonium bromide (DTAB) and cetyltrimethylammonium bromide (CTAB), will be evaluated. Granular activated carbon with 4-12, 12-20, and 20-40 particle mesh sizes will be used as a mineral. Total Organic

Carbon (TOC) Analyzer (Shimadzu TOC-5000A) will be used to measure the TOC for the surfactants. Coliform, fecal coliform, and entercocci concentrations in the secondary effluent and disinfected wastewater will be measured using the Colilert and Colisure method (Standard Methods 9223).

Adsorption Experiment

Adsorption experiments for the selected surfactants and minerals will be conducted to determine surfactant-mineral combinations with highest affinities. The experimental data will be used to generate isotherms representing the relationship between the aqueous phase concentration of the surfactants (mg/L) and the amount of surfactants adsorbed on the surface of minerals (mg/g). Either the Freundlich or Langmuir isotherm will be used to analyze the experimental data.

Disinfection Experiment

The activated carbon will be loaded with each surfactant to their maximum capacity which will be determined from adsorption experiment. Disinfection experiments will be performed in batch mode on secondary effluent that will be obtained from the Padre Dam Water Recycling Facility (owned and operated by the Padre Dam Municipal Water District, a local water agency and project partner). Control experiments will also be conducted on secondary effluent using the surfactants only (without activated carbon) and the activated carbon only (without surfactants) in order to account for the contribution of the surfactants and the activated carbon in inactivating the bacteria.

F-5. Project Outcome

The major expected outcomes of the project are:

- The findings of the research will be submitted for publications in per-reviewed journals and for presentations at local and national level conferences. Additionally, the research results will be distilled into sections of a Masters thesis for one student.
- The results from the research will be utilized to design a flow-through column system which in turn will be used to determine the design flow rate, surfactant dosage, surfactant-loaded media depth, and other operational parameters for a plot-scale test of the proposed disinfection method.
- The results from the current project will also be used to seek funding from Water Reuse Foundation or State Water Resources Control Board for evaluating the effectiveness of surfactants to inactivate virus in secondary effluent.
- The new technology could be extended for disinfection of stormwater by using surfactants immobilized on the surface of minerals as a filter media and thus reduce the pollution of water bodies.

F-6. Environmental Benefits

The research has a potential to develop and pioneer a cost-effective disinfection method for secondary effluent and could result in an increased use of recycled water in Southern California and other parts of the nation. The increased use of recycled water has many environmental benefits, including:

- It conserves drinking water and thus decreases the diversion of water from sensitive ecosystems.
- It decreases wastewater discharges into oceans, rivers, and other water bodies.
- It relieves the much-needed potable water for other uses.
- It provides drought protection.
- It decreases the quantity of water imported to Southern California.

F-7. Project Schedule

The project duration is seven months. Assuming project start date of June 2008, Table 1 provides detailed project timeline.

Table 1: Proposed Project Schedule

TASK	PROJECT DURATION						
	Jun-08	Jul-08	Aug-08	Sep-08	Oct-08	Nov-08	Dec-08
Adsorption Experiment							
Adsorption Experiment for CTAB							
Adsorption Experiment for DTAB							
Disinfection Experiment							
Disinfection Experiment for CTAB							
Disinfection Experiment for DTAB							
Project Report							
Preparation of Draft and Final Project Report							
Result Dissemination							
Prepare Manuscript for Publications							
Prepare Manuscript for Local and National Conference							

Literature Citied

1. Merianos, J.J. Quaternary ammonium antimicrobial compounds. In: *Disinfection Sterilisation and Preservation* (Block, S.S., Ed.), 4th Edn., **1991**, pp. 225-255. Lea and Febinger, Philadelphia.
2. Hugo, W.B. and Russell, A.D. Types of antimicrobial agents. In: *Principles and Practice of Disinfection, Preservation and Sterilisation* (Russell, A.D., Hugo, W.B. and Ayliffe, G.A.J., Eds.), 2nd Edn., **1991**, pp. 7-88. Blackwell Scientific Publications, Oxford.
3. Moussa, F.W., Gainor, B.J., Anglen, J.O., Christensen, G. and Simpson, W.A. Disinfecting agents for removing adherent bacteria from orthopaedic hardware. *Clin. Orthop.* **1996**, 329, 255-262
4. Jonsson, B.; Lindman, B.; Holmberg, K.; Kronberg, B., *Surfactants and Polymers in Aqueous Solution*. 1998; p 438 pp.
5. Paulus, W., *Microbicides for the Protection of Materials. A Handbook*. **1993**; p 494
6. Moussa, F.W., Gainor, B.J., Anglen, J.O., Christensen, G. and Simpson, W.A. Disinfecting agents for removing adherent bacteria from orthopaedic hardware. *Clin. Orthop.* **1996**, 329, 255-262

7. McDonnell, G.; Russell, A. D., Antiseptics and disinfectants: Activity, action, and resistance. *Clinical Microbiology Reviews* **1999,** 12, (1), 147-179.

8. Mereghetti, L.; Quentin, R.; Marquet-Van der Mee, N.; Audurier, A., Low sensitivity of Listeria monocytogenes to quaternary ammonium compounds. *Applied and Environmental Microbiology* **2000,** 66, (11), 5083-5086.

9. Cloete, T. E.; Jacobs, L.; Brozel, V. S., The chemical control of biofouling in industrial water systems. *Biodegradation* **1998,** 9, (1), 23-37.

10. Gilbert, P.; Allison, D. G.; McBain, A. J., Biofilms in vitro and in vivo: do singular mechanisms imply cross-resistance? *Journal of Applied Microbiology* **2002,** 92, 98s-110s.

11. Glover, R. E.; Smith, R. R.; Jones, M. V.; Jackson, S. K.; Rowlands, C. C., An EPR investigation of surfactant action on bacterial membranes. *Fems Microbiology Letters* **1999,** 177, (1), 57-62.

G. Project Management Team

The project organizational chart (Figure 1) shows the project management team. SDSU's project team will work closely with the Metropolitan Water District of Southern California, other project sponsors, and the Padre Dam Municipal Water District (a local water agency and project partner) on the project. A brief highlight of the qualifications and responsibilities of each team members is presented below.

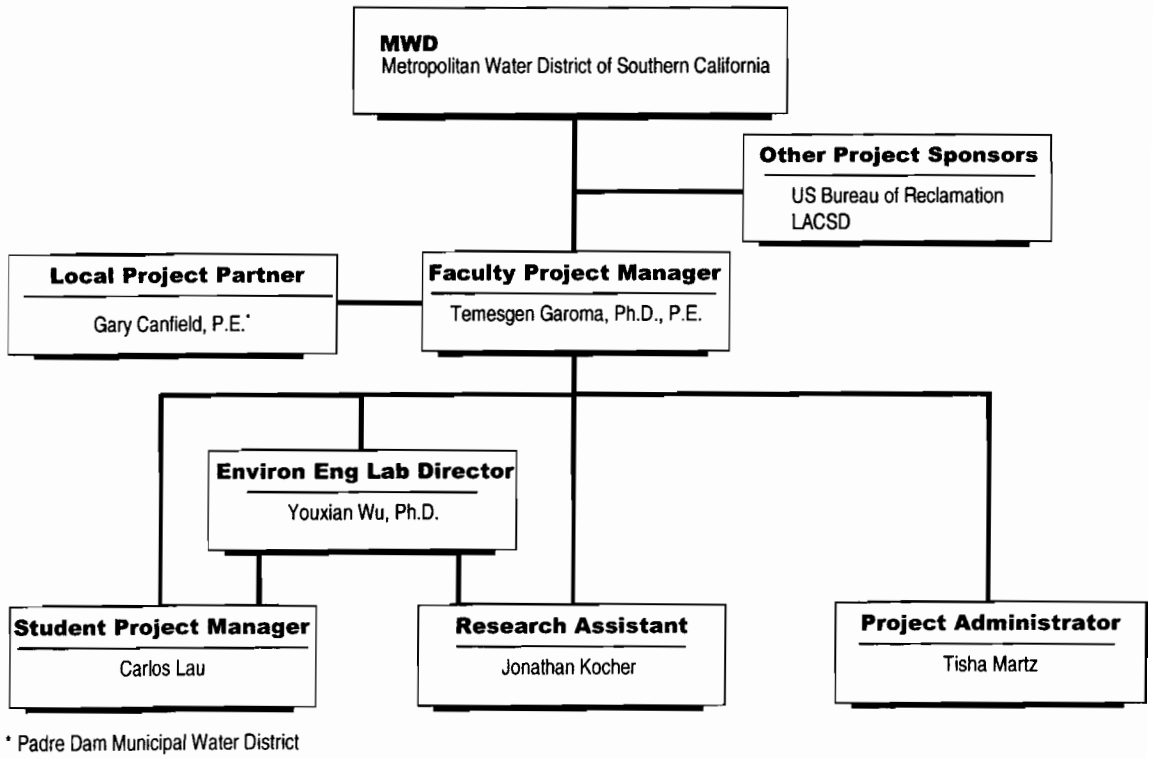

Figure 1: Project Organizational Chart

Temesgen Garoma, Ph.D., P.E. – Faculty Project Manager: Temesgen Garoma is an Assistant Professor in the Department of Civil and Environmental Engineering at SDSU. Dr. Garoma will be responsible for managing the project, providing technical guidance for the project team, planning and designing the experimental setup, and overseeing the day to day activity of the project. He has extensive research experience in the removal environmental pollutants from water using chemical, advanced oxidation, and biological treatment processes. Dr. Garoma has published his research findings in premier journals in the area of Environmental Engineering, such as Environmental Science & Technology and ASCE Journal of Environmental Engineering, as well as presented at national and local conferences (***see selected publication below***). He has over ten years of professional experience and has been involved in the design of treatment processes for removal of pollutants from water and wastewater, master plan study for wastewater collection and water distribution systems, and feasibility study for recycled water projects.

Selected peer-reviewed publications

- Garoma, T. and Gurol, M.D. (2006) "Oxidation of Methyl tert-Butyl Ether (MTBE) in Aqueous Solution by an Ozone/UV Process." *J. Environ. Eng.*, 132, 1404-1412.
- Garoma, T. and Gurol, M.D. (2005) "Modeling Aqueous Ozone/UV Process Using Oxalic Acid as Probe Chemical." *Environ. Sci. Technol.*, 39, 7964-7969.
- Garoma, T. and Gurol, M.D. (2004) "Degradation of tert-Butyl Alcohol in Dilute Aqueous Solution by an O3/UV Process." *Environ. Sci. Technol.*, 38, 5246-5252.

Selected conference presentations

- Garoma, T. (2007) "Challenges in Serving Isolated Pockets of Developments and Collection System Master Planning for Fast Growing Cities." *CWEA Annual Conference*, April 17-20, 2007, Ontario, California.
- Garoma, T. (2006) "Current Trends in Collection System Modeling and Master Planning." *American Public Works Association*, Central California Chapter, February 16, 2006, Bakersfield, California.
- Garoma, T. and Gurol, M.D. (2004) "Oxidation of Groundwater Contaminated with MTBE and TBA by O3/UV Process." *The 10th International Conference on Advanced Oxidation Technologies for Water and Air Remediation*, October 24-28, 2004, San Diego, California.
- Garoma, T.; Gurol, M.D.; Loraine, G. (2003) "Application of Ozone/UV Process for MTBE and TBA Removal." *International Ozone Association 16th World Congress*, August 31-September 5, 2003, Las Vegas, Nevada.
- Garoma, T. and Gurol, M.D. (2004) "The Removal of Methyl tert-Butyl Ether (MTBE) and tert-Butyl Alcohol (TBA) in Dilute Aqueous Solution by Ozone/UV Process." *2004 Annual Conference & Exposition, AWWA*, June 13-17, 2004, Orlando, Florida.

Gary Canfield, P.E. – Local Water Agency Representative: Gary Canfield is a plant manager at the Padre Dam Water District (a local water agency and project partner) with more than 25 years of professional experience. Mr. Canfield will provide technical assistance on as-needed basis.

Padre Dam Municipal Water District: The Padre Dam Municipal Water District (District) is a local water agency and partner on the project. The District provides water, wastewater, and recycled water services to 125,000 residents in the San Diego suburbs. The District owns and operates the Padre Dam Water Recycling Facility which has a design capacity of two million gallons per day (mgd). The treatment processes at the facility includes BardenPho® treatment process, tertiary filters, and a chlorine contact chamber. About one mgd of the recycled water is utilized at the Santee Lakes Recreation Preserve and the remaining is distributed in a separate delivery system to customers for irrigation and commercial uses.

Youxian Wu, Ph.D. – Director Environmental Engineering Lab at SDSU: As the director of the Environmental Engineering lab, Dr. Wu is responsible for overall management of the lab, instrument operation and maintenance, and student training in instrument operation.

Carlos Lau – Student Project Manager: Carlos Lau is a graduate student in the in Environmental Engineering program at SDSU and holds a B.S. degree in chemical engineering. Mr. Carlos will be responsible for sample collection, lab experiments, and data analysis. As a research assistant, he was involved on a number research projects and has served as a lead lab supervisor on some of these projects.

Jonathan Kocher – Research Assistant: Jonathan Kocher is an undergraduate student in the Environmental Engineering program at SDSU. Mr. Kocher will assist the student project manager in sample collection, lab experiments, data analysis, and other project related activities.

Tisha Martz – Project Administrator: Tisha will handle project administration activities, such as budget control, student timesheet, and purchase of supplies.

In the table below the contact information for each project team members are provided.

	Name	Title	Address	Phone & Email
1	Temesgen Garoma	Dr.	Department of Civil and Environmental Engineering 5500 Campanile Drive, San Diego CA 92182-1324	619-594-0957 tgaroma@mail.sdsu.edu
2	Gary Canfield	Mr.	Padre Dam Municipal Water District 9300 Fanita Parkway Santee, CA 92071	619-258-4695 gcanfiel@padre.org
3	Carlos Lau	Mr.	Department of Civil and Environmental Engineering 5500 Campanile Drive, San Diego CA 92182-1324	858-361-4944 carlosllau@gmail.com
4	Jonathan Kocher	Mr.	Department of Civil and Environmental Engineering 5500 Campanile Drive, San Diego CA 92182-1324	619-459-4267 jonathankocher@gmail.com
5	Tisha Martz	Ms.	SDSU Research Foundation 5250 Campanile Drive, San Diego, CA 92182-1934	tmartz@foundation.sdsu.edu 619-594-1177

H. Project Budget

H-1. Project Fund

Description	Amount	Notes
Grant Fund Required from MWD	$9,900	This is the amount of grant fund required from MWD.
Additional Grant Fund provided by SDSU Research Foundation	$3,300	This is a 25% matching fund that will be provided by the Department of Civil and Environmental Engineering and used for 273 hours of the stipends for one graduate and one undergraduate student (***See enclosed letter***).
Project Total	$13,200	This is the total project cost.

H-2. Project Cost

Line Item	Amount	Description
Stipends for students	$6,190	This is intended to cover stipends for one graduate and one undergraduate student working quarter-time for seven months – June through December 2008 (563 hours) at a rate of $10 per hour plus 10% fringe benefits.
Lab supplies	$2,500	The project requires planning and conducting a number of laboratory experiments under various operational conditions. The requested fund will be used to purchase lab supplies, such as surfactants, activated carbon, chemicals, vials, gloves, bickers, and other miscellaneous supplies needed to conduct the experiments.
Office supplies	$700	The fund will be used for the purchase of office supplies such as lab notebooks, papers, printer cartridges, etc.
Conference registration	$1,000	The findings of the project will be submitted for publication in peer-reviewed journal and also in peer-reviewed conference proceeding. This funding will be used for conference registration fee. The student and faculty project managers will make the presentation.
Equipment Maintenance	$1,610	The research utilizes total organic carbon (TOC) analyzer to determine the residual surfactant concentration during isotherm experiment. This fund will be used to maintain and purchase consumables for the TOC machine.
Overhead Fee	$1,200	Overhead to cover administrative cost.
Total	$13,200	Total project cost

I. Signature Block

	Name	Signature	Date
Faculty Project Manager	Temesgen Garoma		12-05-07
Student Project Manger	Carlos Lau		12-05-07
Project Partner	Gary Canfield		12-5-07

PADRE DAM
Municipal Water District

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Benita Lynn Horn, Project Coordinator
Educational Unit, External Affairs Group
The Metropolitan Water District of Southern California
P.O.Box 54153 Los Angeles, California 90054-0153

1955 50 2005 ANNIVERSARY YEARS OF SERVICE

Dear Ms. Horn:

This letter is to confirm my support for the project proposed by Dr. Temesgen Garoma and his team at San Diego State University, Department of Civil and Environmental Engineering. The project evaluates the effectiveness of surfactants loaded onto the surfaces of minerals for disinfection of secondary effluent. The Padre Dam Municipal Water District (District) which provides recycled water for recreational, irrigation, and commercial uses supports the project and agrees to serve as the local partner for the effort. The District owns and operates a water recycling facility with a treatment capacity of two millions gallons per day. The District agrees to provide secondary effluent required for the project. I look forward to serving as the project management team on the project and offering my expert advice towards a successful completion of this project.

In summary, I support Dr. Garoma's application for the Southern California World Water Forum Innovative Conservation Research and Technology Grant Program (SCWWFGP) award. The grant would make possible the evaluation of this new and innovative disinfection technology.

Sincerely,

Gary Canfield

Plant Manager
Padre Dam Municipal Water District

SAN DIEGO STATE
UNIVERSITY

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December 5, 2007

Benita Lynn Horn, Project Coordinator
Educational Unit, External Affairs Group
The Metropolitan Water District of Southern California
P.O.Box 54153 Los Angeles, California 90054-0153

Dear Ms. Horn:

I wish to express my support for the research project entitled ***Disinfection of Secondary Effluent using Surfactants Immobilized on the Surfaces of Minerals*** proposed by Dr. Temesgen Garoma, an Assistant Professor in the Department of Civil and Environmental Engineering at San Diego State University. I fully endorse his proposal and attest that his research plan is supported by and integrated into the educational and research goals of the Department and the University. I am exited about Dr. Garoma's effort to address the critical water shortage faced by Southern California through his research project.

The Department will support the proposed research by Dr. Garoma, and will provide equipment and lab space needed to conduct the research project. In addition, the Department will provide financial support in the amount of $3,300 for one undergraduate research assistant for the proposed project duration of seven months.

In conclusion, I strongly support Dr. Garoma's application for the Southern California World Water Forum Innovative Conservation Research and Technology Grant Program (SCWWFGP) award. The funding provided by SCWWFGP award would make possible full achievement of this well-formulated research project.

Sincerely,

Janusz Supernak

Professor and Chair
Department of Civil and Environmental Engineering
San Diego State University