

GRANT AGREEMENT

RIVERSIDE PUBLIC UTILITIES ENERGY INNOVATIONS GRANT PROGRAM

(Electrooxidative Route towards Nitrate Removal from Drinking Water Resources using Activated Carbon as Electroactive Substrate)

THIS AGREEMENT is made and entered into this _____ day of _____, 2016 by and between the CITY OF RIVERSIDE, a California charter city and municipal corporation ("City"), through its Department of Public Utilities ("RPU"), and THE REGENTS OF THE UNIVERSITY OF CALIFORNIA, ON BEHALF OF ITS RIVERSIDE CAMPUS, a California non-profit corporation ("Recipient"), with reference to the following:

RECITALS

WHEREAS, California Public Utilities Code ("Code") Section 385 provides that a local publicly-owned utility shall establish a non-bypassable, usage-based charge on local distribution service to fund investments by the utility and other parties in (1) cost-effective, demand-side, management services to promote energy-efficiency and energy conservation; (2) new investment in renewable energy resources and technologies consistent with existing statutes and regulations which promote those resources and technologies; (3) research, development, and demonstration programs for public interest to advance science or technology which is not adequately provided by competitive and regulated markets; and (4) services provided for low-income electricity customers, including but not limited to, targeted energy efficiency and rate discounts; and

WHEREAS, RPU has funds available pursuant to the requirements of Code Section 385 for the purpose of providing financial funding to its public and private post-secondary educational institution electric customers, whose primary activities are within the city limits of Riverside, for the purpose of promoting the development and demonstration of energy-efficiency, energy conservation, and investment in the advancement of renewable energy resource technology hereinafter referred to as the Energy Innovations Grant Program (the "Program"); and

WHEREAS, Recipient has submitted its Application and Proposal to RPU requesting funding from RPU's 2016-2017 Program, as set forth in Code Section 385 (the "Proposal"); and

WHEREAS, following screening by the RPU Program Committee and recommendation by the Board of Public Utilities and the City Council of the City of Riverside ("City Council"), the "Electrooxidative Route towards Nitrate Removal from Drinking Water Resources using Activated Carbon as Electroactive Substrate" project ("Grant Project") was selected for funding.

NOW, THEREFORE, in consideration of the mutual covenants herein set forth and the mutual benefits to be derived therefrom, the City and Recipient mutually agree as follows:

1. Grant Award. City hereby allocates to Recipient the amount of \$50,000 (the "Grant") for development and implementation of Recipient's Grant Project, for the purpose and subject to the terms hereinafter set forth. The Grant funds ("Grant Funds") will be paid from available RPU Program funds for the fiscal year 2016-2017.

2. Scope of Services. The Grant Funds shall be used in furtherance of the purposes set forth in Code Section 385 to develop and implement the Grant Project as more fully set forth in Recipient's Proposal attached hereto as Exhibit "A" and incorporated herein by this reference.

3. Independent Contractor.

a. Recipient is a California corporation and an electric customer whose primary activities are within the city limits of Riverside. All acts of Recipient and all others acting on behalf of Recipient relating to the performance of this Agreement shall be performed as independent contractors and not as agents, officers, or employees of City. Recipient, by virtue of this Agreement, has no authority to bind or incur any obligation on behalf of City. Recipient has no authority or responsibility to exercise any rights or power vested in City. No agent, officer, or employee of City is to be considered an employee of Recipient. It is understood by both Recipient and City that this Agreement shall not under any circumstances be construed or considered to create an employer-employee relationship or a joint venture.

b. Recipient is, and at all times during the term of this Agreement shall represent and conduct itself as, an independent contractor and not as an employee of City.

c. Recipient shall design, develop, and implement the Grant Project in its entirety. Recipient shall be responsible to City only for the requirements and results specified in the Proposal and, except as expressly provided in this Agreement, shall not be subjected to City's control with respect to determination of the Grant Project, selection of materials or the methods for

completion. However, Recipient agrees to be responsible to City for all of the foregoing with respect to the Proposal and description of the Grant Project under this Agreement.

d. If necessary, Recipient has the responsibility for employing other persons or firms at its sole cost to assist Recipient in fulfilling the terms and obligations under this Agreement.

e. If, in the performance of this Agreement, any third persons are employed by Recipient, such persons shall be entirely and exclusively under the direction, supervision, and control of Recipient. All terms of employment including hours, wages, working conditions, discipline, hiring, and discharging or any other term of employment or requirements of law shall be determined by Recipient.

f. It is understood and agreed that as an independent contractor and not an employee of City, neither Recipient nor Recipient's assigned personnel shall have any entitlement as a City employee, right to act on behalf of the City in any capacity whatsoever as an agent, or ability to bind the City to any obligation whatsoever.

g. It is further understood and agreed that Recipient must issue W-2 or other tax forms as required by law for income and employment tax purposes for all of Recipient's assigned personnel under the terms of this Agreement.

h. As an independent contractor, Recipient hereby indemnifies and holds City harmless from any and all claims that may be made against City based upon any contention by any third party that an employer-employee relationship exists by reason of this Agreement.

4. Effective Date and Funding of Grant.

a. This Agreement shall commence upon the date of its execution ("Effective Date") and shall terminate twelve (12) months from the date of Grant Project Initiation, as defined in Section 4.b ("Termination Date"), unless extended pursuant to Section 4.c or Section 6.

b. City shall provide Recipient the Grant Funds in three installments in accordance to the Milestone Schedule below. Recipient must achieve each Milestone Deliverable on or prior to the corresponding Milestone Date to be eligible for funding:

Milestones	Quarter 1			Quarter 2			Quarter 3			Quarter 4			Grant Funds
	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	
Objective 1 – Determine optimal operating conditions for nitrate elimination													\$20,000
Objective 2 – Identify nitrate transformation products and perform mass balance on Nitrogen													\$20,000
Objective 3 – Construct demonstration unit													\$10,000

c. If Recipient fails to achieve any one Milestone by the applicable Milestone Date therefor, Recipient shall immediately notify City of such failure and may request a Cure Period of up to thirty (30) days to achieve the missed Milestone. The requested Cure Period must be approved by City, and such approval shall not be unreasonably withheld, delayed or conditioned. For the avoidance of doubts, each Milestone Date in the Milestone Schedule may be extended by a maximum of thirty (30) days, and without prejudice to City's rights to terminate this Agreement under Section 20, all Milestone Dates subsequent to the missed Milestone Date as well as the Termination Date of this Agreement shall be extended accordingly on a day-to-day basis, *provided* that in no event shall the Termination Date of this Agreement be later than September 1, 2017.

d. The Grant Funds check will be issued to Recipient as named in Exhibit "A."

e. City reserves the right, in its discretion, to award a portion of the requested Grant Funds.

5. Performance.

a. Recipient shall perform in accordance to the Milestone Schedule in Section 4.b. Failure to promptly commence work and/or diligently pursue such work to completion may be grounds for termination of this Agreement.

b. Recipient shall be responsible to begin, proceed with, and complete the Grant Project according to the Milestone Schedule in Section 4.b and quarterly tasks completion deadline as set forth in the Project Timeline included in the Proposal.

c. For the Term of this Agreement, Recipient shall make its facility available for City's inspection of the Grant Project any time upon City's request.

d. If Recipient fails to meet a Milestone listed in the Milestone Schedule in Section 4.b by the end of the requested Cure Period, City may, at its sole discretion, terminate this Agreement pursuant to Section 19.a. In the event of such termination, Recipient agrees to return all previously released Grant Funds back to City within five (5) days of receipt of City's written termination notice.

e. Releasing of Grant Funds for the following Milestones will depend on Recipient meeting certain performance criteria detailed in Performance Standards attached hereto as Exhibit "D" and incorporated herein by this reference:

- i) Objective 1
- ii) Objective 2
- iii) Objective 3
- iv) Final Report

6. Extension. This Agreement may be extended from time to time, with mutual consent from both Parties, by quarterly increments following the completion of Quarterly Report II, *provided*, such extension shall be agreed upon, along with new Milestones for the duration of the extension, sixty (60) days prior to the original Termination Date.

7. Project Budget.

a. Recipient hereby certifies and agrees that the Grant Funds it receives shall be used entirely as set forth in the Project Budget attached hereto as Exhibit "B" and incorporated herein by this reference ("Budget").

- b. The Grant Funds represents the City's total contribution to the Grant Project.
- c. Recipient agrees that any amounts required to complete the Grant Project over and above the Grant Funds will be paid by Recipient.
- d. Recipient agrees funds over and above the Grant are available so as not to delay completion of the Grant Project due to insufficient Project funding.
- e. Recipient agrees to keep within the Budget, and any variations from the Budget will be reported to RPU.
- f. Recipient agrees to pay for all costs necessary to operate and maintain the Grant Project for the term of this Agreement.
- g. Recipient agrees to pay for all costs necessary to operate and maintain the Grant Project for the term of this Agreement.

8. Use of Grant.

- a. The Grant Funds shall be used exclusively for costs of the Grant Project as set forth in the Proposal and the Budget.
- b. Grant Funds shall not be used for any other purpose, including within limitation:
 - (i) As security or to guarantee payments for any non-Program obligations, nor as loans for non-Program activities; or
 - (ii) To pay for entertainment, meals, or gifts.

9. Intellectual Property Provisions. Recipient and RPU agree that all patents, software and copyrightable material shall be subject to the Intellectual Property Provisions attached hereto as Exhibit "C" and incorporated herein by this reference.

10. No Assignment or Transfer of Grant Funds. The Grant Funds are personal to Recipient, based upon the unique qualification of Recipient set forth in the Proposal and are for the purpose of accomplishing the goals set forth in the Proposal. Recipient shall not assign any right or obligation under this Agreement, and any such purported Assignment shall be void *ab initio*.

11. Transfer of Project Equipment.

- a. For any Grant Proposal that provides for the development, purchase, or installation of equipment paid for in whole or in part by Grant Funds:

(i) Recipient shall install and operate the equipment only at Recipient's business location within City's utility service territory; and

(ii) Recipient shall not remove or transfer any equipment developed, purchased, or installed, in whole or in part, with Grant Funds within five (5) years of the Effective Date, without the express written consent of City. City reserves the right to withhold such consent.

b. Recipient agrees that if it removes or transfers such equipment without City's consent as required herein, Recipient shall reimburse City the costs of equipment purchased, developed, or installed by Grant funding, proportionately as follows:

(i) Transfer or removal within first year from Effective Date—100%

(ii) Transfer or removal within second year from Effective Date—80%

(iii) Transfer or removal within third year from Effective Date—60%

(iv) Transfer or removal within fourth year from Effective Date—40%

(v) Transfer or removal within fifth year from Effective Date—20%

12. **Final Report.** Recipient shall prepare and submit to City a final report on or prior to the Termination Date. The final report shall include: title page, introduction and background, project objectives, project performance (including results of energy-savings monitoring), project expenses (including receipts) and project time line, conclusions, and recommendations.

13. **Interim Grant Project Changes.** Recipient shall promptly notify City in writing of any and all proposed Grant Project changes. Grant Project changes must be pre-approved by RPU and must be consistent with the purpose and scope of the Grant Project. A detailed description of Grant Project changes and impacts to the project schedule and/or Budget must be provided to RPU and approved prior to any changes to all or part of the Grant Project.

14. **Program Monitoring.**

a. Recipient shall maintain financial, programmatic, statistical, and other supporting records of the Grant Project feasibility study, design, development, installation, implementation, purchase of equipment, and energy-saving results. In addition, Recipient shall prepare and maintain the following records and reports to assist City in maintaining its record keeping requirements:

(i) Documentation of Grant Project expenses;

(ii) Documentation of energy use and energy cost-saving information, including a comparison of Recipient's energy consumption prior to implementation of the Grant Project, future estimated energy consumption, and estimated energy cost savings over a one-year period and a five-year period, as well as documentation of developmental concepts promoting energy conservation;

(iii) Quarterly progress reports on Grant Project deadlines as defined in Proposal; and

(iv) Any other related records and reports as City shall require from time to time.

b. Failure to keep and provide such records and reports may result in demand for return of Grant Funds to City.

15. Audits.

a. The Recipient's records in connection with the Grant Project shall be open to inspection and audit by an authorized City representative.

b. Said records shall be retained for no less than three (3) years after completion of the Grant Project.

c. Records which relate to (i) complaints, claims, administrative proceedings, or litigation arising out of the performance of this Agreement or (ii) costs and expenses of this Agreement to which City or any other governmental agency takes exception, shall be retained beyond the three (3) years until resolution or disposition of such appeals, litigation claims, or exceptions.

16. Taxes and License. Recipient understands and agrees that City has no obligation to pay or withhold state or federal taxes or to provide workers' compensation or unemployment insurance. Recipient, as an independent contractor, shall be responsible for any and all taxes that apply to it as an employer.

17. Publicity. The City acknowledges that the name "University of California" is the property of the State of California and that City's use of the name "University of California" must also comply with section 92000 of the California Education Code. Recipient agrees to cooperate

with the City in publicizing, advertising, or otherwise promoting the Program or Grant Project in accordance with the California Education Code section 92000.

18. General Compliance with Laws. Recipient shall keep fully informed of federal, state, and local laws and regulations which in any manner affect the performance of services by Recipient pursuant to this Agreement and shall at all times observe and comply with all such laws and regulations.

19. Non-Discrimination. Except as provided in Section 12940 of the California Government Code, during Recipient's performance of this Agreement, Recipient shall not discriminate on the grounds of race, religious creed, color, national origin, ancestry, age, physical disability, mental disability, medical condition including the medical condition of Acquired Immune Deficiency Syndrome (AIDS) or any condition related thereto, marital status, sex or sexual orientation, genetic information, gender, gender identity, or gender expression, in the selection and retention of employees and subcontractors and the procurement of materials and equipment. Contractor shall also comply with the requirements of the Americans with Disabilities Act in the performance of the Agreement.

20. Termination.

a. In the event of a substantial failure of performance by Recipient, City may terminate this Agreement upon a ten (10) day written notice to Recipient. The ten-day notice period shall be used by both parties in an attempt to negotiate resolution of disputes and remedy any breach.

b. In the event of a material breach of this Agreement by Recipient, City may terminate this Agreement and Recipient agrees to refund the Grant Funds to City within five (5) days of receipt of the City's written notice of such termination. Recipient agrees that any of the following, individually or collectively, shall be conclusively deemed a material breach or breaches of the Agreement:

(i) Recipient's fraudulent misrepresentation as to Recipient's use of the Grant Funds or as to any material matter in the Grant application and Proposal;

(ii) Delay in beginning, development, or completion of the Grant Project without written approval of extensions by RPU's General Manager; or

(iii) Substantial changes in the Grant Project or use of Grant Funds.

20. Contract Administration. A designee of City will be appointed in writing by City's Public Utilities General Manager to administer this Agreement on behalf of City and shall be referred to herein as Contract Administrator.

21. Certifications. Recipient certifies to City that Recipient will select equipment or products on the basis of Recipient's own investigation including without limitation as to the effectiveness, merchantability, and fitness of the equipment or products for the Grant Project and that Recipient has not relied on any statement by City or an agent of City in making such selection.

22. Amendments. This Agreement may be modified or amended only by a written agreement executed by the City and Recipient.

23. Venue. Any action at law or in equity brought by either of the parties hereto for the purpose of enforcing a right or rights provided for by this Agreement shall be tried in a court of competent jurisdiction in the County of Riverside, State of California, and the parties hereby waive all provisions of law providing for a change of venue in such proceedings to any other county.

24. Notices. Service of any notices, bills, invoices, or other documents required or permitted under this Agreement shall be sufficient if sent by one party to the other by United States mail, first class postage prepaid and addressed as follows:

City of Riverside

City of Riverside
Department of Public Utilities
3750 University Avenue
Riverside, CA 92501
Attention: Lynn Scott
Account Manager/Producer

Recipient

University of California, Riverside
Office of Research and Economic Development
200 University Office Building
Riverside, CA 92521-0217
Attn: Tim LeFort
Principal Sponsored Programs Officer

Either party may change such address by giving notice to the other party in writing herein.

25. Assignment. It is mutually understood and agreed that this Agreement shall not be assigned to any third party by either City or Recipient.

26. Severability. Each provision, term, condition, covenant, and/or restriction, in whole and in part, in this Agreement shall be considered severable. In the event any provision, term, condition, covenant, and/or restriction in this Agreement is declared, in whole and/or in part, invalid, unconstitutional, or void for any reason, such provision or part thereof shall be severed from this

Agreement and shall not effect any other provision, term, condition, covenant, and/or restriction of this Agreement, and the remainder of the Agreement shall continue in full force and effect.

27. Authority. The individuals executing this Agreement and the instruments referenced herein on behalf of Recipient each certifies that they have the legal power, right, and actual authority to bind Recipient to the terms and conditions hereof and thereof.

28. Entire Agreement. This Agreement constitutes the final, complete, and exclusive statement of the terms of the agreement between the parties pertaining to the subject matter of this Agreement and supersedes all prior and contemporaneous understandings or agreements of the parties. Neither party has been induced to enter into this Agreement by, and neither party is relying on, any representation or warranty outside those expressly set forth in this Agreement.

29. Exhibits. The following exhibits attached hereto are incorporated herein to this Agreement by this reference:

Exhibit "A" – Recipient's Proposal

Exhibit "B" – Project Budget

Exhibit "C" – Intellectual Property Provisions

Exhibit "D" – Performance Standards

(Signatures on Following Page)

IN WITNESS WHEREOF City and Recipient have caused this Agreement to be duly executed on the day and year first above written.

CITY OF RIVERSIDE, a California
charter city and municipal corporation,
through its Department of Public Utilities

THE REGENTS OF THE UNIVERSITY
OF CALIFORNIA, ON BEHALF OF ITS
RIVERSIDE CAMPUS, a California non-
profit corporation

By: _____
City Manager

By: _____

Attest: _____
City Clerk

Its: _____

Approved as to Form:

By: _____

By: *Susan Wilson*
Assistant City Attorney

Its: _____

EXHIBIT "A"

Recipient's Proposal

TITLE PAGE

An Electrooxidative Route Towards Nitrate Removal from Drinking Water Resources using Activated Carbon as Electroactive Substrate

David Jassby

Department of Chemical and Environmental Engineering

Bourns Hall A241

University of California, Riverside

Riverside, CA 92521

e-mail: djassby@engr.ucr.edu, phone: (951)-827-6475

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Executive Summary

The goal of this project is the development of an electrochemical system designed to remove nitrate from groundwater through an *oxidative* process. Nitrate is the most common groundwater contaminant; consuming water with elevated nitrate concentrations has been associated with different adverse health effects, including blue baby syndrome and thyroid cancer. Due to nitrates high solubility, this ion travels freely in groundwater. The removal of nitrate from contaminated groundwater is typically achieved through reverse osmosis (RO) or ion exchange. However, these techniques are expensive and both produce high concentration nitrate brines that require special treatment and disposal. Thus, an alternative treatment system that can eliminate nitrate in a cost-effective manner is sorely needed. We have developed a nitrate removal system that is based on a granular activated carbon (GAC) packed bed column, where the GAC serves as an anode, and a thin metal sheet serves as a cathode. Nitrate contaminated water is flowed through the GAC electrode, which is charged with a low potential (5 V). Our preliminary data demonstrates that the system is able to remove nearly 40% of the nitrate with a hydraulic retention time of two minutes. Critically, the removal mechanism is not an adsorptive process; rather, the nitrate is electrochemically transformed on the GAC electrode. Analysis of the water coming out of the GAC porous electrode did not find any other ions (such as NH_4^+ , or NO_2^-), while analysis of gasses formed during the process did not find any NO_x species. Thus, it is likely that the only transformation product is N_2 gas, which is harmless and can be safely vented to the atmosphere.

The specific objectives of this project include: 1) determine optimal operational conditions that maximize nitrate removal from simulated groundwater; 2) identify nitrate transformation products; and, 3) construct and test demonstration unit.

The successful completion of this project will demonstrate a transformative electrochemical treatment method capable of abiotic denitrification. The system will eliminate nitrate from contaminated groundwater, making previously contaminated resources available for drinking water production. The nature of the technology, which is based on an electrochemical packed-bed reactor, makes it highly scalable and appropriate for applications ranging from point-of-use to utility level. Furthermore, this technology could be used to treat other nitrate-contaminated streams, such as the RO retentate produced during wastewater reuse activities.

BACKGROUND AND OBJECTIVES

The overall goal of this project is the development of a new electrochemical treatment system designed to remove nitrate from groundwater. The system is based on the use of a packed bed granular activated carbon (GAC) column, where the GAC is used as an anode and a metal ring as a cathode. Our preliminary results demonstrate that nitrate ions are electrochemically transformed on the electrically charged GAC electrode, resulting in the formation of nitrogen gas; importantly, when the hydraulic residence time (HRT) in the GAC column was two minutes, nitrate concentrations were reduced by 26 ppm. To the best of our knowledge, this is the first report of an *oxidative* process capable of eliminating nitrate in an aqueous environment, although such reactions have been reported in the gas phase ¹. This project addresses the need for a compact, simple and robust technology capable of rapidly eliminating nitrate contamination from drinking water resources. The main advantage of this technology is its ability to *abiotically* denitrify water, with the only transformation product (based on our preliminary information) being nitrogen gas. This technology has the potential

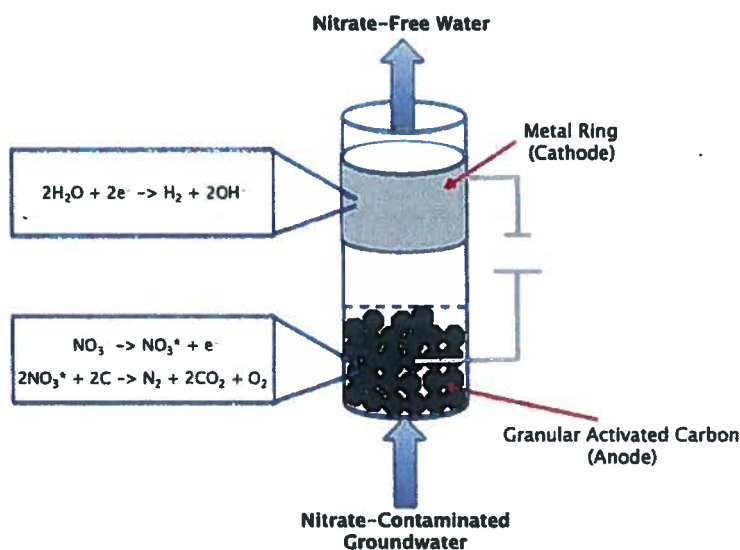


Figure 1. GAC packed bed column used to *oxidatively* transform nitrate to nitrogen *via* a nitrate radical mechanism.

of transforming drinking water treatment processes for nitrate-contaminated waters, which are a growing concern for many utilities and individual well owners in California.

Current denitrifying methods used to treat nitrate-contaminated drinking water resources rely on physical

separation (reverse osmosis (RO)), adsorption (ion exchange (IX)), or catalytic transformation ². While effective, these technologies suffer from several disadvantages. Both RO and IX are expensive and produce concentrated brine that requires further (and costly) treatment. Catalytic denitrification requires the use of expensive noble metal catalysts and the use of hydrogen gas ³; furthermore, the presence of carbonates in the water significantly inhibits the catalytic reactions, requiring longer contact times and making the treatment of alkaline waters difficult ³. While biological denitrification is used extensively in wastewater treatment, there are significant barriers to the implementation of this technology towards drinking water treatment, including the fear of bacterial contamination in the finished product, enhanced organic loading and increased chlorine demand in the treated water ³.

A graphical summary of the research Objectives of this project is presented in Figure 1. We will utilize our expertise in electrochemistry, aquatic chemistry, and water treatment technologies ⁴⁻⁸ to fabricate and test an electroactive GAC packed-bed column, and apply it towards the oxidative treatment of nitrate-contaminated water. This project addresses Riverside Public Utilities' interest in water reclamation and strategic water research by creating a water treatment process that can eliminate the most ubiquitous inorganic contaminant in groundwater, which can allow for the utilization of groundwater previously considered too contaminated, using a simple, scalable technology that produces no waste products.

Occurrence, Reasons, and Importance of Nitrate in Drinking Water Resources

Nitrate contamination of drinking water resources is a persistent and growing problem ⁹. Across the United States and in many parts of the world, elevated nitrate concentrations in groundwater and surface waters are impacting the viability of these water bodies as drinking water resources ⁹. In many cases, elevated nitrate concentrations in groundwater and surface water are a result of farming practices such as over fertilization of fields and poor animal waste practices ⁹.

Elevated nitrate concentrations in drinking water have been associated with a range of adverse health effects, such as cancer, Methemoglobinemia, and thyroid hypertrophy ¹⁰. Communities across California, including in the Inland Empire, currently struggle with elevated nitrate concentrations in their drinking water resources ¹¹.

RESEARCH TO DATE

We have conducted preliminary experiments using small-scale column experiments to demonstrate the feasibility of our technology. We constructed GAC packed-bed columns (1 cm in diameter) packed with 4.5 gr of GAC (6-14 mesh, Fisher Scientific). A titanium wire was used to deliver the electrical potential to the packed GAC, and a stainless steel ring electrode was used as the counter electrode (Figure 1). The column was connected to a DC power source and fed a NaNO_3 (40 ppm) solution at a rate of 1 ml/min while different potentials were applied to the GAC. The HRT of the water in the GAC was determined to be 2 minutes. Periodically, we measured the concentration of the nitrate and total nitrogen in the column effluent using ion chromatography (IC) and a total nitrogen analyzer (TN), respectively. In addition, we used a NOx analyzer to measure if any NOx was formed during the experiment; here, column effluent was collected in a sealed beaker, with the NOx analyzer measuring any NOx coming out of the water or bubbling out of the column.

The GAC packed bed columns were run with a constant nitrate feed concentration (40 ppm), and nitrate concentrations in the column outflow were tracked over time (Figure 2). Under all conditions, effluent concentrations exhibited typical adsorption column trends, with breakthrough taking place after several hours (Figure 2). However, our results demonstrate that progressively higher anodic potential (0 V, 1 V, 2.5 V, 5 V) lead to increased removal of nitrate from the column effluent. For example, when 5 V (anodic) were applied to the GAC nitrate concentrations were only 14 ppm at breakthrough, a 65% reduction over an HRT of 2 minutes (Figure 2). Both the control (0

V) and a cathodic GAC (-5 V) showed little nitrate removal (Figure 2). This suggests that it is the *oxidative* conditions on the GAC that lead to the excellent nitrate elimination from the feed water. TN analysis of the effluent demonstrated identical concentrations to those measured using the IC, indicating that all of the remaining nitrogen in the column effluent was nitrate (data not shown). This suggests that no undesirable products, such as nitrite, chloramines, or n-nitrosodiamine (NDMA), were formed during the electrochemical reactions, although a more detailed study is needed to exclude the formation of small concentrations of these compounds (particularly NDMA). Additionally, no NO_x was detected from the column. All together, this strongly suggests that the main transformation product of this electrochemical reaction was nitrogen gas.

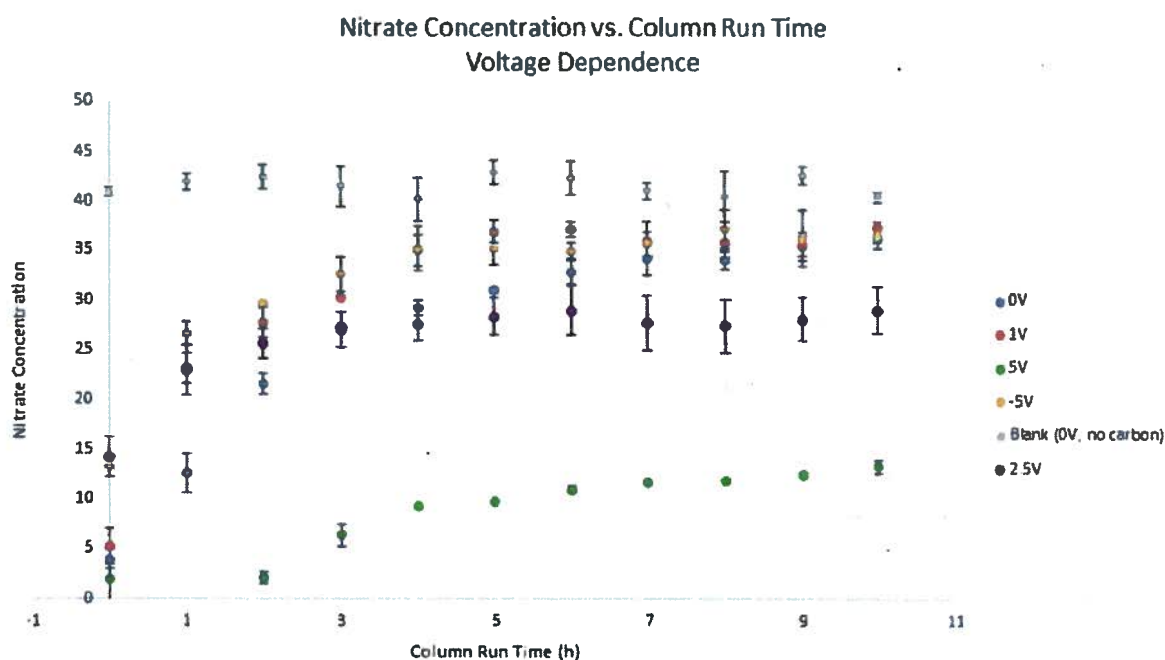


Figure 2. Nitrate concentrations in column effluent over time as a function of applied potential.

Research Plan

Our *long-term goal* is to develop a transformative nitrate treatment process that can be implemented at scales ranging from point-of-use to treatment plant. The objective of this project is to identify the transformation products resulting from the electrochemical oxidation of nitrate on GAC as well as develop a mechanistic understanding of this process. This project is based on the *central hypothesis* that nitrate elimination can be facilitated through an electrochemical oxidative reaction in the presence of GAC. The *rational* behind this project is that a cheap abiotic treatment process capable of converting nitrate to nitrogen gas without the use of expensive catalysts or gasses will increase the availability of safe drinking water to multiple entities in the state of California.

We intend to test our hypothesis by pursuing the following Objectives:

1. Determine optimal operational conditions (HRT, potential) needed to eliminate nitrate from model groundwater and surface water and evaluate the impact of other aqueous constituents (carbonates, natural organic matter, divalent ions) on performance (Months 1-6).
2. Identify nitrate transformation products and close the nitrogen mass-balance, as well as identify other electrochemically-generated species, such as chlorine (Months 1-6).
3. Construct larger demonstration unit capable of treating 500 mL/min of water (Months 6-12).

BUDGET PROPOSAL

Project Title: An Electrooxidative Route Towards Nitrate Removal from Drinking Water Resources using Activated Carbon as Electroactive Substrate

Sponsor: Riverside Public Utility

Principal Investigator: David Jassby

Department: Chemical and Environmental Engineering

Period of Performance: 07/1/2016 – 06/30/2017

	No. of People	salaries	benefits	<u>TOTALS</u>
A. Senior Personnel	1	\$5,977	\$759	\$6,736
B. Other Personnel	1	\$12,777	\$11,076	\$23,853
C. Fringe Benefits	Included above			
D. Permanent Equipment	0			
E. Travel 0 Domestic 0 Foreign 0				
F. Other Direct Costs (Supplies)				\$5,433
G. Subcontract				
H. AND MORE IF NECESSARY				
TOTAL DIRECT COST				\$36,021
TOTAL INDIRECT COST				\$13,979

TOTAL REQUESTED YEAR 1:

****GRAND TOTALS \$50,000**

*Note: Give information in detail. Include number of people, number of months (time) they will be needed, % of time they will be used; Rate of salaries paid, benefits paid, health insurances etc.; list equipment purchased and leased; travel time for meetings and conferences etc., other direct cost such as supplies etc.

****Grand Total should equal grant amount applying for.**

REFERENCES

- (1) Li, T.; Minami, W.; Kim, H. *Environmental science & technology* **2005**, *39*, 9665.
- (2) Kapoor, A.; Viraraghavan, T. *Journal of Environmental Engineering* **1997**, *123*, 371.
- (3) Pintauro, A.; Batista, J.; Levec, J. *Catalysis Today* **2001**, *66*, 503.
- (4) Ronen, A.; Duan, W.; Wheeldon, I.; Walker, S.; Jassby, D. *Environmental science & technology* **2015**, *49*, 12741.
- (5) Dudchenko, A. V.; Rolf, J.; Russell, K.; Duan, W.; Jassby, D. *Journal of Membrane Science* **2014**, *468*, 1.
- (6) Duan, W.; Dudchenko, A.; Mende, E.; Flyer, C.; Zhu, X.; Jassby, D. *Environmental Science: Processes & Impacts* **2014**, *16*, 1300.
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- (8) de Lannoy, C.-F.; Jassby, D.; Davis, D.; Wiesner, M. *Journal of Membrane Science* **2012**, *415*, 718.
- (9) Nolan, B. T.; Ruddy, B. C.; Hitt, K. J.; Helsel, D. R. *Water Conditioning and Purification* **1998**, *39*, 76.
- (10) Organization, W. H. *Guidelines for drinking-water quality: recommendations*; World Health Organization, **2004**; Vol. 1.
- (11) Esser, B.; Hudson, B.; Moran, J.; Beller, H.; Carlsen, T.; Dooher, B.; Krauter, P.; McNab, W.; Madrid, V.; Rice, D. *US Department of Energy Lawrence Livermore National Laboratory* **2002**.

List (name) all Researchers

Dr. David Jassby

Katherine Muller (graduate student)

BIOGRAPHICAL SKETCH

David Jassby

Assistant Professor of Chemical and Environmental Engineering

A241 Bourns Hall, University of California, Riverside, CA 92521; 951-827-6475 (phone), 951-827-5696 (fax); djassby@engr.ucr.edu

Education

Hebrew University	Biology	B.S., 2002
UC Davis	Environmental Engineering	M.S., 2005

Duke University	Environmental Engineering	Ph.D., 2011
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Duke University	Environmental Engineering	Post-doctoral, 2012
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Academic Experience

2012. University of California, Riverside. Assistant Professor, Department of Chemical and Environmental Engineering, Bourns College of Engineering.

Awards

Senol Utku Award – High Distinction	2011
Jeffery B. Taub Environmental Engineering Graduate Student Award	2010
California Lake Management Society Scholarship	2004

Professional Accreditation

Professional Engineer (still need to take Seismic Principles and Surveying exams), California 2013

Publications

1. A. Ronen, W. Duan, I. Wheeldon, S. Walker, D. Jassby, Microbial Attachment Inhibition through Low-Voltage Electrochemical Reactions on Electrically Conducting Membranes, *Environmental Science & Technology*, 49 (2015) 12741-12750.
2. A.V. Dudchenko, J. Rolf, L. Shi, L. Olivas, W. Duan, D. Jassby, Coupling Underwater Superoleophobic Membranes with Magnetic Pickering Emulsions for Fouling-Free Separation of Crude Oil/Water Mixtures: An Experimental and Theoretical Study, *ACS Nano*, 9 (2015) 9930-9941.
3. S.-R. Chae, T. Noeiaghaj, H.-C. Jang, S. Sahebi, D. Jassby, H.-K. Shon, P.-K. Park, J.-O. Kim, J.-S. Park, Effects of natural organic matter on separation of the hydroxylated fullerene nanoparticles by cross-flow ultrafiltration membranes from water, *Separation and Purification Technology*, 140 (2015) 61-68.
4. D. Jassby, Y. Xiao, A. Schuler, Biomass density and filament length synergistically affect activated sludge settling: Systematic quantification and modeling, *Water Research*, 48 (2014) 457-465.
5. A.V. Dudchenko, J. Rolf, K. Russell, W. Duan, D. Jassby, Organic fouling inhibition on electrically conducting carbon nanotube–polyvinyl alcohol composite ultrafiltration membranes, *Journal of Membrane Science*, 468 (2014) 1-10.
6. W. Duan, A. Dudchenko, E. Mende, C. Flyer, X. Zhu, D. Jassby, Electrochemical mineral scale prevention and removal on electrically conducting carbon nanotube–polyamide reverse osmosis membranes, *Environmental Science: Processes & Impacts*, 16 (2014) 1300-1308.

7. G. Sahoo, D. Nover, S. Schladow, J. Reuter, D. Jassby, Development of updated algorithms to define particle dynamics in Lake Tahoe (CA-NV) USA for total maximum daily load, *Water Resources Research*, 49 (2013) 7627-7643.
8. C.-F. de Lannoy, D. Jassby, K. Gloe, A.D. Gordon, M.R. Wiesner, Aquatic biofouling prevention by electrically charged nanocomposite polymer thin film membranes, *Environmental Science & Technology*, 47 (2013) 2760-2768.
9. D. Jassby, J. Farner Budarz, M. Wiesner, Impact of aggregate size and structure on the photocatalytic properties of TiO₂ and ZnO nanoparticles, *Environmental Science & Technology*, 46 (2012) 6934-6941.
10. C.-F. de Lannoy, D. Jassby, D. Davis, M. Wiesner, A highly electrically conductive polymer-multiwalled carbon nanotube nanocomposite membrane, *Journal of Membrane Science*, 415 (2012) 718-724.
11. D. Jassby, M. Wiesner, Characterization of ZnS nanoparticle aggregation using photoluminescence, *Langmuir*, 27 (2011) 902-908.
12. D. Jassby, S.-R. Chae, Z. Hendren, M. Wiesner, Membrane filtration of fullerene nanoparticle suspensions: Effects of derivatization, pressure, electrolyte species and concentration, *Journal of Colloid and Interface Science*, 346 (2010) 296-302.
13. A.J. Schuler, D. Jassby, Distributed state simulation of endogenous processes in biological wastewater treatment, *Biotechnology and Bioengineering*, 97 (2007) 1087-1097.
14. A.J. Schuler, D. Jassby, Filament content threshold for activated sludge bulking: Artifact or reality?, *Water Research*, 41 (2007) 4349-4356.

Book Chapters

1. Jassby, D.; Xiao, Y.; Gondikas, A.; Wiesner, M., The Role of Advanced Technologies in Tapping Unconventional Texas Waters. In *Water Policy in Texas: Responding to the Rise of Scarcity*, Griffin, R. C., Ed. Rff Press: 2010.

Funded Research Projects

1. Anaerobic sequencing batch membrane bioreactor with electrically conducting nanofiltration membranes for recalcitrant organic contaminant degradation (PI); US Air Force Center for Engineering and the Environment; 10/1/2013 – 09/31/2015 (Expired); \$401,000
2. Enhanced oil recovery from oil-in-water emulsions through the coupling of magnetic amphiphilic nanoparticles with electrofiltration (PI); American Chemical Society Petroleum Research Fund – Doctoral New Investigator Award; 08/1/2014 – 08/31/2016; \$110,000
3. Coupling ferromagnetic particles and electrically conducting carbon nanotube-polymer composite ultrafiltration membranes for fouling-free oil/water separations (PI); Office of Naval Research; 08/1/2014 – 07/31/2017; \$400,000
4. Fouling-resistant membranes for treating produced waters for beneficial reuse in advanced energy systems (co-PI; with RTI International); US Department of Energy; 10/1/2014 – 09/31/2017; \$80,000 for UCR
5. Enhanced oil recovery from oil-seawater mixtures through the coupling of magnetic nanoparticles and electrically conducting ultrafiltration membranes (PI; with RTI International); US Department of Interior; 11/1/2014 – 10/31/2015 (Expired); \$509,000
6. Enhanced Resilience of Local Agricultural Water Supplies through the Reuse of Municipal and Agricultural Wastewater: A Dynamic Analysis of Technological and Policy Options (co-PI with Dr. Kurt Schwabe, UCR); US Department of Agriculture; 1/1/2015 – 12/31/2016; \$150,000

7. A Forensic Approach Towards Biofilm Management (co-PI with Dr. Sharon Walker, UCR); National Science Foundation; 3/1/2015 – 2/28/2018; \$315,000
8. Graphene Nanoparticle Electrocatalytic and Functional Membranes for Water Treatment (PI); U.S.-Israel Binational Science Foundation; 10/1/2015 – 9/31/2019; \$86,000
9. Membrane Distillation for Desalination of Impaired Water using Geothermal Energy (co-PI; Subcontractor to NREL – grant awarded, currently under negotiation with NREL); Department of Energy; 03/1/2016 – 02/28/2018; \$430,000
10. Biological-thermochemical biomass processing with membrane separation: a conversion of dairy effluents into distilled water and nutrients (co-PI with Dr. Sharon Walker, UCR); US Department of Agriculture; 1/1/2016 – 12/31/2018; \$150,000
11. CAREER: Beyond Condensation Reactions and Polymer Casting: New Water Treatment Membrane Materials Through Electropolymerization (PI; Award in progress); National Science Foundation; 07/1/2016 – 06/31/2021; \$547,000

Service Activities

Outreach and Educational Activities

1. RCC military veteran mentoring and research opportunities in the Jassby lab at UC Riverside
2. UCR Undergraduate mentoring and research opportunities in the Jassby lab at UC Riverside.
3. NanoDays outreach activity at Marbles Children's Museum in Raleigh, NC.
4. Mentoring of undergraduate and high-school students through CEINT at Duke University.

Conferences and Symposium Organizer

1. ACS 87th Colloid and Surface Science Symposium, 6/13, UC Riverside
2. ACS 246th National Meeting, Division of Environmental chemistry, Session on Membranes for Water Purification, Fall 2013, Indianapolis
3. NAMS 24th Annual Meeting, Session on Electrically Enhanced Membrane Operations, Spring, 2014
4. ACS 248th National Meeting, Division of Environmental chemistry, Session on Reactive Membranes and Surfaces in Water Treatment, Fall 2014, San Francisco
5. ACS 250th National Meeting, Division of Environmental chemistry, Session on Sensing of Environmental Contaminants, Fall 2015, Boston

Publication Reviewer

Reviewer for *Environmental Science and Technology*, *Water Research*, *Journal of Colloid and Interface Science*, *Water Environment Research*, *Journal of Membrane Science*, *Scientific Reports*, *Environmental Science and Technology Letters*

Student Advising

Post-Doctoral Advisor

Dr. Avner Ronen (Bard Scholar)

Dr. Adam Slade

Dr. Binod Chauhadri

Thesis Advisor (PhD)

Alexander Dudchenko

Wenyan Duan

William Wehner

Katherine Muller

Xiaobo Zhu

Caroline Kim

Quynh Tran

Unnati Rao

[illegible]

Quarter 4	
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\$20,000

\$20,000

\$10,000

EXHIBIT "B"

Project Budget

Exhibit B

BUDGET PROPOSAL

Project Title: An Electrooxidative Route Towards Nitrate Removal from Drinking Water Resources using Activated Carbon as Electroactive Substrate

Sponsor: Riverside Public Utility

Principal Investigator: David Jassby

Department: Chemical and Environmental Engineering

Period of Performance: 07/1/2016 – 06/30/2017

	No. of People	salaries	benefits	<u>TOTALS</u>
A. Senior Personnel	1	\$5,977	\$759	\$6,736
B. Other Personnel	1	\$12,777	\$11,076	\$23,853
C. Fringe Benefits	Included above			
D. Permanent Equipment	0			
E. Travel 0 Domestic 0 Foreign 0				
F. Other Direct Costs (Supplies)				\$5,433
G. Subcontract				
H. AND MORE IF NECESSARY				
TOTAL DIRECT COST				\$36,021
TOTAL INDIRECT COST				\$13,979

TOTAL REQUESTED YEAR 1:

****GRAND TOTALS \$50,000**

*Note: Give information in detail. Include number of people, number of months (time) they will be needed, % of time they will be used; Rate of salaries paid, benefits paid, health insurances etc.; list equipment purchased and leased; travel time for meetings and conferences etc., other direct cost such as supplies etc.

****Grand Total should equal grant amount applying for.**

EXHIBIT "C"

Intellectual Property Provisions

EXHIBIT C
INTELLECTUAL PROPERTY PROVISIONS

INTELLECTUAL PROPERTY PROVISIONS

(1) Recipient Rights, Responsibilities, and Indemnity

a. Patent rights for inventions conceived and first actually reduced to practice in performance of this Grant, whether actually patented or unpatented, will be the property of the Recipient whose employees or researchers are inventors of such inventions pursuant to U.S. Patent law. The Recipient shall grant a non-exclusive, non-commercial license to any patented invention to the sponsor, the City of Riverside. Recipients must obtain Agreements to effectuate the government use license with all persons or entities, except for the U.S. Department of Energy (DOE), obtaining ownership interest in such patent rights. Upon the perfecting of a patent application for subject inventions, Recipient will fill out and sign a Uniform Commercial Code (UCC.1) Financing Statement that documents the City of Riverside's use license.

The Recipient will disclose to the City of Riverside on a confidential basis all inventions, software, and copyrightable material that was first conceived or first actually reduced to practice in performance of this Grant.

Recipient and all persons and/or entities obtaining an ownership interest in invention(s) shall include within the specification of any United States patent application, and any patent issuing thereon covering a Subject Invention, the following statement:

"This invention was made with support from the City of Riverside. The City of Riverside has certain rights to this invention."

b. All software and copyrightable material first produced under this Grant shall be the property of the Recipient. The Recipient shall grant a non-exclusive, non-commercial license to any such software or copyrightable material to the sponsor, the City of Riverside.

c. Recipient shall provide the City of Riverside with a copy of all technical, generated, and deliverable data produced under this Agreement. Recipient does not have to copy and submit data the City has identified as being unusable for City purposes. For instance, some data may not warrant routine copying and shipping because the raw data is too disaggregated or voluminous for practical application. Recipient shall retain such data at the Recipient's facility for inspection, review, and possible copying by the City.

d. To the extent permitted by law, Recipient will defend and indemnify the City of Riverside from and against any claim, lawsuit, or other proceeding, loss, cost, liability, or expense (including court costs and reasonable fees of attorneys and other professionals) to the extent arising out of any third party claim solely arising out of the negligent act(s) or omission(s) by the Recipient, its employees, or agents, in connection with intellectual

property claims against either deliverables or the Recipient's performance under this Agreement.

e. In no event will the City of Riverside be liable for any special, incidental, or consequential damages based on breach of warranty, breach of contract, negligence, strict tort, or any other legal theory for the disclosure of Recipient's confidential information, even if the City of Riverside has been advised of the possibility of such damage. Damages that the City of Riverside will not be responsible for include, but are not limited to, loss of profit; loss of savings or revenue; loss of goodwill; loss of use of the product or any associated equipment; cost of capital; cost of any substitute equipment, facilities, or services; downtime; the claims of third parties including customers; and injury to property.

(2) City of Riverside Rights and Responsibilities

a. For all inventions that were first conceived and first actually reduced to practice in the performance of this Grant, the City of Riverside retains a no-cost, nonexclusive, nontransferable, irrevocable, perpetual, royalty-free, paid-up worldwide nonexclusive license to use or have practiced such rights for or on behalf of the City of Riverside for governmental purposes to the degree that is consistent with Federal law. The City retains the right to file a Uniform Commercial Code (UCC.1) Financing Statement on all subject inventions that are patented in order to document the City of Riverside's right to use such items for governmental purposes. Previously documented (whether patented or unpatented under the patent laws of the United States of America or any foreign country) inventions are exempt from this provision.

b. For software first developed in performance of this Grant, the Recipient shall grant the City of Riverside a royalty-free, no-cost, nonexclusive, irrevocable, nontransferable, world-wide, perpetual license to produce and use for governmental purposes.

c. For copyrightable material first produced in performance of this Grant, the Recipient shall grant the City of Riverside a royalty-free, no-cost, nonexclusive, irrevocable, nontransferable, worldwide, perpetual license to produce translate, publish, use and dispose of, and to authorize others to produce, translate, publish, use and dispose of all copyrightable material.

d. The City of Riverside shall not purposefully enter into competition with Recipient's Licensee or take affirmative actions intended to effectively destroy the commercial market where a Licensee has introduced a Licensed Product.

e. Data provided to the City of Riverside by Recipient, which data the City has not already agreed to keep confidential and which Recipient seeks to have designated as confidential, or is the subject of a pending application for confidential designation, shall not be disclosed by the City except as provided in Title 20 CCR, Sections 2506 and 2507 (or as they may be amended), unless disclosure is ordered by a court of competent jurisdiction.

f. It is the City of Riverside's intent to use and release project results such as deliverables and data in a manner calculated to further the intent of California Public Utilities Code, Section 385, while protecting proprietary or patentable interests of the parties. Therefore, the City agrees not to disclose confidential data or the contents of reports containing data considered by Recipient as confidential, without first providing a copy of the disclosure document for review and comment by Recipient. Recipient shall have no less than ten (10) working days for review and comment and, if appropriate, to make an application for confidential designation on some or all of the data. The City of Riverside shall consider the comments of Recipient and use professional judgment in revising the report, information or data accordingly.

EXHIBIT "D"

Performance Standards

EXHIBIT "D"

Performance Standards

In accordance to Section 4.b and Section 5.e in the Agreement, Recipient must meet certain Performance Standards applicable to each of the following Milestones before City releases the corresponding Grant Fund installment:

- A. Grant Project Completion Submit Final Report and certify that Unit is constructed and ready for demonstration
- B. Quarterly Report I Due by the last day of the 4th month of the contract. Determine optimal operating conditions for nitrate elimination. Failure to deliver determination of optimal operating conditions for nitrate elimination will be deemed non-performance and may be subject to reduced Grant Fund Payments based on the following schedule:

90 – 100% Accuracy = 100% Grant Fund Release
80 – 89% Accuracy = 90%
70 – 79% Accuracy = 75%
60 – 69% Accuracy = 50%
50 – 59% Accuracy = 30%
< 50% Accuracy = 0%

- C. Quarterly Report II Due by the last day of the 8th month of the contract. Report on identifying nitrate transformation products and perform mass balance on nitrogen. Failure to deliver report on identifying the nitrate transformation products and performance of mass balance on nitrogen will be deemed as non-performance and may be subject to reduced Grant Fund payments based on the following schedule:

90 – 100% Accuracy = 100% Grant Fund Release
80 – 89% Accuracy = 90%
70 – 79% Accuracy = 75%
60 – 69% Accuracy = 50%
50 – 59% Accuracy = 30%
< 50% Accuracy = 0%