PINELLAS COUNTY RESTORE ACT DIRECT COMPONENT PROJECT PROPOSAL SUBMITTAL FORM

Based on the Transocean settlement and until the BP trial ends, it is estimated by March 31, 2015, $1,542,888 will be available in the Gulf Coast Restoration Trust fund for distribution to Pinellas County under the Direct Component allocation.

As a guideline, Pinellas County anticipates funding 3 to 7 projects not to exceed a total of $1,542,888 as part of the initial multiyear implementation plan (MYIP). It's anticipated that projects selected for MYIP inclusion that receive funding would not begin until after December 2015.

Please read through all the questions before beginning.

- Submitted projects must address one or more of the five Gulf Coast Ecosystem Restoration Council goals and one or more RESTORE Act-eligible activities.
- Projects submitted by FEBRUARY 6, 2015 will be eligible for inclusion in the initial Multiyear Implementation Plan (MYIP)
- The "Steps" and "Criteria" numbers in the application refer to questions that address the steps and criteria for selection and ranking projects. The selection and ranking criteria can be viewed at www.pinellascounty.org/restore/pdf/project-selection.pdf
- Answer each of the 29 questions as completely as possible, but keep responses focused.
- Submit one form per project.
- Once the form is successfully submitted, you will be contacted by Pinellas County.
- Send associated maps, charts, images, and budget information along with the title of your project in a Portable Document File (PDF) to restore@pinellascounty.org.
- Direct questions to restore@pinellascounty.org

Applicant Name: *(Include at least one Point of Contact (POC), phone number, email address, and organization name, if applicable)***:**

1. **POC Name:** Irvin Kety
2. **POC Organization:** City of Largo (Largo Wastewater Reclamation Facility)
3. **POC Title:** Director, Environmental Services Department
4. **POC Email:** ikety@largo.com
5. **POC Phone:** (727) 642 5055
6. **Proposed Activity Name:** Resilient and Sustainable Nutrient Control Strategies to Improve Water Quality and Protect Coastal Habitat

7. Restoration Council Goals Addressed:

(Step 1 and Step 2 - Criteria 1 and 2)

List which of the following goal(s) will be addressed and how each goal will be addressed.

A. **Restore and Conserve Habitat:** Lowering nitrogen loading to coastal waters will reduce habitat degradation caused by eutrophication, particularly in sea grass habitats. Nitrogen reduction strategies will be investigated at both a point (wastewater treatment plant) and non-point (stormwater retention pond) source of nitrogen loading. A successful project will demonstrate the adaptability and replicability of the proposed strategies throughout the County (and perhaps the State).

B. **Restore Water Quality:** The project objective is to reduce the nitrogen loading discharged from the Largo Wastewater Reclamation Facility (LWWRF) as well as stormwater ponds. The success of this project may embolden efforts to reduce point source nitrogen discharges, as the approach would be highly adaptable to other wastewater treatment facilities, putting the LWWRF at the forefront of technological innovation. The nitrogen reduction will allow the plant to more effectively reach new TMDLs set by the Tampa Bay Nitrogen Management Consortium (TBNMC). Additionally, phototrophic remediation has previously been shown to be successful for removal of metals (and microconstituent), which may be important in a future regulatory environment. Furthermore, since stormwater runoff accounts for approximately 63% of nitrogen loading to the bay (of which 20% originates from residential areas) (NEP, EPA-842F09001), the proposed nutrient reduction strategies will be adapted and piloted for use in stormwater retention ponds. If successful and replicated throughout the County, the proposed nutrient reduction strategies could have a significant impact on the health of coastal waters.

C. Replenish and Protect Living Coastal and Marine Resources

D. **Enhance Community Resilience:** The proposed nitrogen reduction strategy is passive, requiring minimal external energy input. Thereby, nutrient removal will still occur at the wastewater treatment plant during power outages and/or disaster scenarios, and can occur at non-point sources (such as a stormwater pond) where electricity is not readily available. At the wastewater treatment plant, reducing the need for tertiary denitrification (by removing nitrogen upstream in the treatment process) will lower nitrous oxide emissions (and thereby greenhouse gas emissions and atmospheric deposition of nitrogen). Moreover, the carbon dioxide sequestered during photosynthesis will further decrease the carbon footprint of the wastewater plant. An educated public is critical to enhancing community resilience, as public awareness promotes environmental stewardship and long-term thinking among the stakeholders. The project will provide invaluable educational opportunities for the hundreds of community members visiting the LWWRF each year. Project investigators will be happy to engage the public (and City officials) in explaining the innovative approach of the project during site visits or other educational outreach opportunities.

E. **Build and Revitalize the Gulf Economy:** Development and implementation of new nutrient management strategies and technologies may provide new job opportunities and training for engineers, technicians and operators, including a potential startup company based on the innovation demonstrated at Largo. Reducing the nutrient loading in

stormwater ponds may increase their social and aesthetic value, attracting residents of the neighboring community to spend time in the public space and increase home values.

8. RESTORE Act Eligible Activities Addressed:
(Step 1 and Step 2 - Criteria 3 and 4)
List which of the following activities will be addressed and how each activity will be addressed.

1. **Restoration/protection of natural resources, ecosystems, fisheries, marine wildlife habitats, beaches, and coastal wetlands.**

Nutrient loading, in particular nitrogen, affect coastal habitats by causing eutrophication, harmful algal blooms, and shifts in flora/fauna. The proposed project will target both point and non-point sources of nutrient pollution, thereby protecting habitats and beaches otherwise affected by nutrient discharge.

2. **Mitigation of damage to fish, wildlife, and natural resources**
3. **Implementation of Federally-approved marine, coastal, or comprehensive conservation management plan, including fisheries monitoring**
4. **Workforce development and job creation.**

The proposed project will provide new job training opportunities for current engineers, technicians and operators, as well as cross-training opportunities for staff at other facilities. Lessons learned from the project will be presented at industry related conferences and workshops. Deploying the proposed innovative technologies may create new jobs and potentially new markets for harvested algal/duckweed biomass.

5. **Improvements to or on State parks in coastal areas affected by Deepwater Horizon oil spill**
6. **Infrastructure projects benefitting the economy or ecological resources, including port infrastructure.**

Advanced nitrogen removal at the LWWRF comes at a significant cost in energy and chemical usage. Further nitrogen reductions could be achieved with capital investment (i.e., new blowers and repiping the internal recirculation), but such improvements would be costly. The proposed project aims to improve the efficiency of existing infrastructure at the LWWRF, without requiring costly capital investment. The constraints of the LWWRF are not exclusive to this facility; other around Pinellas County and the State struggle with such equipment limitations. Lessons learned through this study could be adapted to other facilities facing similar goals for nutrient reduction with limited resources for capital investment. Existing stormwater retention ponds generally only provide flood mitigation functions with minimal water quality improvement, especially with nitrogen. The proposed project will develop a technology that can be used to retrofit stormwater ponds to enhance nutrient removal. Further, stormwater ponds are generally not considered an attractive feature in a residential area. The proposed nutrient removal strategies may potentially beautify an area by (1) providing greenery, (2) improving the water quality of the pond, (3) provide an educational opportunity to residents.

7. **Coastal flood protection and related infrastructure.**

The proposed technology is a passive treatment strategy that would work even in a natural disaster. Although it does not provide flood protection in itself, it could provide nutrient removal in flood waters routed to stormwater ponds. Removing the nutrient

loading during flood events would protect coastal habitats sensitive to shock loads of nutrients.

8. **Promotion of Gulf Coast Region tourism, including recreational fishing**
9. **Promotion of the consumption of seafood harvesting from the Gulf Coast Region**
10. **Planning assistance**

9. Previous Claim:

Is the proposed activity included in any claim for compensation paid out by the Oil Spill Liability Trust Fund after July 6, 2012? If yes, this activity is not eligible for Direct Component grant.

Yes: __

No: X

10. RESTORE Act Pinellas County priorities addressed:

(Step 2 - Criteria 5 and 6)

List which of the following priorities will be addressed and how each priority will be addressed.

a. **Protect and restore native habitats**

   Eutrophication caused by excessive nutrient runoff, especially nitrogen, is a major cause of water quality impairment and damage to native habitats such as sea grass beds, which serve significant ecosystem functions as habitat for shellfish, fish and a variety of benthic organisms at the base of the trophic pyramid. The proposed project involves the development of technology and strategies to effectively control nitrogen loading to the Gulf and Bay, thereby protecting sea grass and other coastal habitats.

b. **Provide stormwater quality improvements**

   The proposed project will be adapted to and piloted in stormwater retention ponds. The nutrient removal strategies will target nitrogen removal, but may also contribute to removal of heavy metals and/or other microconstituents.

c. **Create policies, programs, and/or mechanisms to remediate environmental and/or economic damages**

   Eutrophication caused by excessive nutrient runoff, especially nitrogen, is a major cause of water quality impairment (clarity, dissolved oxygen levels) and damage to sea grass beds, which have significant environmental and economic values. The proposed project involves the development of technology and strategies to effectively control nitrogen loading to the Gulf and Bay, thereby mitigating current environmental damages.

d. **Create policies, programs, and/or mechanisms to protect against future environmental and/or economic vulnerability**

   The proposed project is a mechanism to proactively reduce nitrogen below the impending TMDL limits imposed on the LWWRF, without requiring costly capital investment. Reducing nitrogen loading with the proposed passive approach will also provide potential cost savings at the LWWRF by 1) reducing methanol addition, 2) reducing the likelihood of violations and fines, 3) using existing infrastructure to keep capital costs low, 4) requiring little additional energy input. Furthermore, the proposed project will target stormwater retention ponds (non-point source for nutrient pollution). As non-point sources account for 63% of nutrient loading ((NEP, EPA-842F09001), the proposed

nitrogen reduction mechanism will protect coastal habitats against future environmental damage.

e. Provide climate change/sea-level rise planning, adaptation and/or related community engagement
f. Provide flood and storm protection to infrastructure and other publically owned assets that consider resilience and changing sea levels
g. Implement or further actions in the Pinellas County Post Disaster Redevelopment Plan Link to Plan: http://www.postdisasterplan.org/pdrp.shtml
h. **Diversify and improve the economy including tourism**
   The proposed project will provide new job training opportunities for current engineers, technicians and operators, as well as cross-training opportunities for staff at other facilities. Lessons learned from the project will be presented at industry related conferences and workshops. Deploying the proposed innovative technologies may create new jobs, startup company, and potentially new markets for harvested algal/duckweed biomass.
i. Promote sustainable recreational fishing and consumption of seafood dependent on Gulf ecosystem, and/or protect or promote working waterfronts

11. Project Location

(Step 1)

As applicable, describe the location, attach a map and indicate the address, city, zip code, longitude/latitude, and watershed:

The proposed project will be implemented at the Largo Wastewater Reclamation Facility, located at 5100 150th Ave, Clearwater, 33760 (See Figure 1), and stormwater retention sites located within the City of Largo, chosen during the Task 1 Baseline Evaluation phase of the project

12. Region or Geographic Area Impacted by Project

(Step 1 and Step 2 - Criterion 7)

Provide a description of the project area or region in which environmental or economic benefits will be realized. Be as specific as possible by listing cities or geographical boundaries and why.

The proposed project will be implemented at the Largo Wastewater Reclamation Facility, directly impacting the City of Largo and Tampa Bay, and indirectly the Gulf of Mexico. The City extends to the Gulf Coast, and wastewater generated near the coast is collected via sewer and routed to LWWRF (Figure 1). Nitrogen reductions at the effluent discharge location will affect the habitat quality in Old Tampa Bay, Tampa Bay, as well as the Gulf. On the other hand, stormwater retention ponds within the city boundary of Largo are discharged to both the Bay and Gulf, depending on location. Therefore, excess nutrients in stormwater runoff have the potential to directly impact the Gulf.

Discussion of Specific Activity

Describe the project by responding to each of the following topics.

13. **Project Description – Discuss the essential elements of the project. Include what is proposed, clearly list major project tasks or program milestones, the project duration, and why it should be done.**

Motivation, *Point Source Focus*: The Largo Wastewater Reclamation Facility (LWWRF) treats approximately 11.5 million gallons of wastewater every day, turning much of this "waste" into reclaimed water and commercial fertilizers. The primary steps to treatment occur in an A^2O process, followed by clarification, filtration, further denitrification, disinfection, and de-chlorination (Figure 2). This final denitrification step requires methanol addition to drive the microbial conversion of nitrate to nitrogen gas. Due to equipment limitations, the A^2O process at Largo cannot be easily modified to further reduce nitrogen loading. Further reductions could be achieved with capital investment (i.e., new blowers and repiping the internal recirculation), but such improvements would be costly. Therefore, the tertiary denitrification filters are responsible for reducing the nitrogen (nitrate) loading from 8 mg L^{-1} to 1 mg L^{-1} using methanol, which is a costly step of treatment.

The plant's effluent contains approximately 2.5 mg-nitrogen L^{-1} on average, which includes a recalcitrant organic nitrogen portion of approximately 1 mg L^{-1}. Based on EPA Nitrogen Total Mass Daily Loadings (TMDL) set in 1998, the allowable nitrogen discharge limits for point sources (including LWWRF) are subject to decrease in the near future. New nitrogen limits for the LWWRF will be based on loading levels from 2003-2007, according to the Tampa Bay Nitrogen Management Consortium (TBNMC). In light of impending regulatory changes and recent external circumstances which decreased demand for the facility's reclaimed water (which provides a 90% N credit that has historically helped the facility reach permitting requirements), the LWWRF is targeting a future effluent concentration of 1.5 mg nitrogen L^{-1}. For these reasons, the LWWRF is seeking a solution to reduce nitrogen that uses existing infrastructure with minimal capital investment and will reduce the need for methanol.

Motivation, *Non-Point Source Focus:* Non-point sources account for over 63% of nitrogen loading to Tampa Bay, with 20% of this portion coming from residential stormwater discharge (NEP, EPA-842F09001). Treating stormwater is difficult because (1) topography and other challenges can make collection inefficient and infrastructure intensive, (2) its intermittent and seasonal nature, (3) unpredictable quality (i.e., constituents present), (4) unpredictable loading (i.e., constituent concentration). Because collection systems are often decentralized, passive low maintenance stormwater treatment systems may be ideal for many isolated retention ponds.

Scope of Work: The overall goal of the proposed project is to demonstrate and implement technologies to decrease nitrogen loading from point and non-point sources, which will be carried out in four Tasks: 1) Baseline Evaluation; 2) Duckweed Technology; 3) Microalgae Technology; 4) Systems Modeling. Tasks 2A and 3A will be deployed in the clarifiers and sand filters at the Largo Wastewater Treatment Facility (Figure 3), and Tasks 2B and 3B will be deployed at a stormwater pond in Largo. The proposed strategy takes advantage of synergies available in phototrophic treatment strategies and high-nutrient water (i.e., wastewater and stormwater). These synergies are highlighted in Figure 4. The entire project will be completed within 2 years of the start, with each Task lasting approximately 1) 2

months; 2) 18 months; 3) 18 months (overlapping with Task 2); 4) 21 months (intermittent throughout the project; dependent on data collection). A more detailed timeline is illustrated under Question 26.

1) ***Baseline Evaluation*****:** the objective of the first task will be to measure nitrogen species (ammonia, nitrate, nitrite) in the influent and effluent of the clarifier, sand filters, and stormwater pond. Phosphorous, organics (BOD/COD), carbon dioxide, and dissolved oxygen concentration will also be measured at each location. Phosphorous and carbon dioxide concentrations, in particular, will be checked for potential nutrient limitation. In the case of the LWWRF, historical plant data will be mined for long-term and seasonal assessment. Field sampling will be performed to coordinate USF and LWWRF sampling methods and gain logistical familiarity with the facility's equipment and infrastructure (i.e., optimal sampling & deployment locations). Potential surface area for phototrophic cultivation will be quantified. A suitable stormwater retention pond will be scouted for assessing the proposed nitrogen reduction strategies in a non-point source of nutrient loading. It is anticipated that the retention pond will be located in an area with good access to better coordinate sampling events and laboratory/field work.
2) ***Duckweed Technology*****:** the objective of the second task will be to test controlled duckweed cultivation as a means to reduce nitrogen loading.
    a. Task 2A. Duckweed will be grown in one of two parallel clarifiers, and the influent/effluent concentration of nitrogen species (i.e., ammonia, nitrate, nitrite) in the phototrophic and control clarifiers will be compared (Figure 5). Harvesting schedules and mechanisms will be explored (particularly those using existing infrastructure). Duckweed will also be grown in the sand filters to increase treatment surface area. Nitrogen removal will be quantified based on influent/effluent concentrations and compared to baseline data measured in Task 1. Laboratory analyses will characterize organic and nutrient content in the duckweed and evaluate the potential improved dewaterability of biosolids with the addition of duckweed.
    b. Task 2B. Duckweed will be deployed using a contained cultivation system in a stormwater retention pond. Growth kinetics, nitrogen uptake, and nitrogen content in biomass determined in controlled experiments in Task 2A will be used to extrapolate growth data to nutrient removal in Task 2B. Harvesting mechanisms and schedules will be explored
3) ***Microalgae Technology*****:** the objective of the third task will be to test microalgae cultivation as a means to reduce nitrogen loading.
    a. Task 3A. Microalgae (e.g., *Chlorella sorokiniana*) will be cultivated in semi-closed floating photobioreactors (ICARUS) (Figure 6) deployed in one of two parallel clarifiers. Influent/effluent nitrogen concentration will be compared to the control clarifier and baseline data from Task 1 (Figure 5). An algae membrane bioreactor system will be installed on the scaffolding of the traveling bridge sand filters. The influent/effluent nitrogen concentration of the reactor will be monitored for N reduction, and general energy requirements will be assessed. Biomass productivity in both cultivation configurations will be quantified. Lab scale tests will determine nutrient and metals content of the biomass and the effect of microalgae on biosolids dewaterability.

b. Task 3B. The ICARUS system (Figure 6) will be deployed in a stormwater retention pond to determine nitrogen reduction and biomass production potential. Lab analysis will determine nitrogen content of algal biomass, which will be used to extrapolate nitrogen uptake potential. Data from Task 3A can also be used to calculate nitrogen removal correlated with algal biomass production. A portion of the stormwater pond could be sectioned out, such that the nitrogen mass balance of the ICARUS system could be more closely measured.

4) ***Systems Modeling***: the objective of the fourth task will be to extrapolate nutrient removal potential under different operational assumptions: 1) type of phototrophic organism grown; 2) type of configuration employed (microalgae); 3) nutrient availability (check for CO2 or P limitation); 4) surface area availability; 5) seasonal variations. A techno-economic analysis will be conducted to determine the potential benefits of reduced methanol load, improved dewaterability, and potential market for bioproducts (i.e., fertilizers, animal/fish feed), while taking into account additional energy requirements or capital investments. The framework for the model has been developed by members of the project team.[1]

14. Project Manager and Key Project Team Members - include credentials and experience doing similar work.

Project Manager: **Irvin Kety, P.G**., Director of Environmental Services Department, City of Largo
Principal Investigator: **Daniel Yeh, Ph.D., P.E., LEED AP BD+C**, Associate Professor, Department of Civil and Environmental Engineering, University of South Florida
Investigator: **Ivy Drexler, Ph.D.,** Research Associate, Department of Civil and Environmental Engineering, University of South Florida

University of South Florida Membrane Biotechnology Lab. The focus of Dr. Daniel Yeh's Membrane Biotechnology Lab (MBL) is developing new technological applications to recycle wastes (i.e., wastewater, food waste) to resources (i.e., freshwater, nutrients, energy, biofuels) using closed loop systems. He is the inventor on four (issued or pending) patents which he plans to commercialize through a startup company, BioRenew, Inc. Recently awarded the USF Excellence in Innovation Award and the 2014 Cade Museum Prize for Innovation, Dr. Yeh is directing the lab towards developing innovative technologies with high potential for commercialization. There are currently six graduate and undergraduate students dedicated to algal research, a focus of the lab since 2009. At least one post-doctoral researcher (Dr. Drexler) and one graduate assistant will be solely dedicated to the proposed project. The MBL has the capability to measure relevant parameters related to algae cultivation and water quality, including nutrients, carbon, and dissolved gases. Nanotechnology and cell imaging facilities at USF house various equipment (SEM, TEM, AFM, XRD, confocal and optical microscopes, etc.) that will be used to study biofilm and membrane materials. Dr. Yeh is the PI of an NSF project responsible for the initial development of the ICARUS technology (http://tinyurl.com/NSF-ICARUS). Dr. Yeh's team has experience managing complex projects aimed at technology development. He has advanced a novel anaerobic membrane bioreactor technology for wastewater treatment from TRL3-TRL7

(TRL=NASA's technology readiness level) and is presently implementing a TRL7 field demonstration in India through funding from the Bill & Melinda Gates Foundation and India's Dept. Biotechnology/Biotechnology Industry Research Assistance Council. The project is complex and fast-tracked towards commercialization, requiring partnerships between academia, private industry (in India, USA and Netherlands), non-profit, as well as foreign governments (national and local).

15. Environmental and/or Economic Benefits - Describe environmental and/or economic benefits of the project.

Reducing nitrogen loading with the proposed passive approach will also provide potential cost savings at the LWWRF by 1) reducing methanol addition, 2) reducing the likelihood of violations and fines, 3) using existing infrastructure to keep capital costs low, 4) requiring little additional energy input. Adding duckweed and/or algae may improve sludge dewaterability (incurring further cost savings in reduced energy and polymer demands), and the biomass addition may improve the nutrient content and quality of soil amendment pellets. Phototrophic remediation has previously been successful in metals (and microconstituent) removal, which may be important in a future regulatory environment. Duckweed and microalgae have potential commercial value outside of pelletization, which may bring further economic benefits to the facility.

16. Technical Feasibility - Describe technologies and relevant past experience or proven success with similar projects.

Approach: The proposed work will integrate conventional engineered wastewater treatment processes with a passive natural system approach. Controlled growth of phototrophic organisms (i.e., duckweed and/or microalgae) will be used to remove nitrogen (as ammonia and nitrate) in the clarifiers and sand filters at the LWWRF (Tasks 2A and 3A). The approach will utilize the existing infrastructure footprint by growing the organisms at the clarifier and filter surfaces. Similar technology will be deployed at a stormwater treatment pond to investigate the removal mechanism at non-point sources of nutrient loading (Tasks 2B and 3B). Energy inputs for the systems will be minimal, as cultivation is driven by solar energy. Harvesting can be done with existing skimming equipment at the LWWRF, but manual techniques will be explored in the stormwater pond. It is anticipated that the project will require two years to complete (to adequately understand seasonal variations).

***Duckweed*:** Duckweed has been previously used to treat wastewater, particularly in the removal of organic loading, nitrogen, and total suspended solids.[2-4] Duckweed has been successfully grown (and uninhibited) in the temperature range 10-34°C, which should span the typical temperature range expected at the LWWRF. Nitrogen uptake was improved in low organic loading conditions, and the simpler molecular compounds resulting from anaerobic digestion should be easily assimilated. Duckweed production has ranged from 2.7 – 16.4 g m^{-2} day^{-1} dry weight, with a typical nitrogen content in dry biomass in the range of 0.059-0.070 g-N g^{-1} biomass.[2] Duckweed is typically used for ammonia removal, since ammonia is directly used by plants to make protein.[3] Nonetheless, in the absence of ammonia, duckweed will revert to nitrate assimilation.[5] Duckweed inadvertently growing in part of the sand filters currently at the LWWRF

(where nitrogen speciation is identical to that of the clarifiers) has been observed to be removing over 1 mg L^{-1} of nitrate based on field grab samples. If the removal rate seen in the filters, which is unmanaged and not optimized, can be managed and accelerated in the clarifiers, significant cost savings in downstream methanol usage can be realized. In order to optimize nitrogen removal, plants must be harvested. Typical post-harvest biomass density ranges from 400-600 g m^{-2}, with a harvest frequency between 4-6 days. In the proposed case study (Task 2A), duckweed will be grown in the clarifiers in a controlled manner (retained by the inner ring) and harvested using the existing skimmer arms. Harvested duckweed will be examined for ability to enhance the dewaterability of biosolids and enhance nutrient values of pelletized biosolid fertilizer. For Task 2B, duckweed cultivation will be demonstrated in a stormwater pond in a floating containment system which facilitates harvesting. The use of the harvested duckweed for either fertilizer or biofuel feedstock will be examined.

***Microalgae*:** Microalgae have previously been used for nutrient polishing in wastewater treatment, particularly for nitrogen and phosphorous removal.[6] Microalgae biomass also has commercial potential in numerous markets.[7] In high rate algae ponds[8] and microalgae biofilms,[9] significant nitrogen and phosphorous removal has been achieved. However, light penetration and the potential washout of algal biomass may preclude typical suspended cultivation in phototrophic clarifiers or sand filters. Complete nitrogen removal also hinges on the harvesting of the algal biomass, which may be problematic in wastewater infrastructure. Therefore, two innovative approaches to cultivating microalgae in wastewater will be piloted.

1) A patent-pending cultivation method developed at the University of South Florida, the *Isolated Cultivation of Algal Resource Utilizing Selectivity* (**ICARUS**) (Figure 6), is a passive membrane photobioreactor that floats in existing wastewater infrastructure. A sub-micron semi-porous membrane on the bottom surface of the otherwise closed reactor isolates the algal crop from the wastewater. Invasive organisms in the growth medium are kept out of the algal culture, yet water and dissolved constituents pass through freely. As the algal biomass is confined to the photobioreactor, wash out and light penetration are no longer a concern. In earlier studies, ICARUS achieved more than double the typical biomass density seen in conventional closed photobioreactors (>10 g L^{-1}) (Figure 7), implying that the nutrient removal capability (as a result of assimilation and harvesting) is quite promising. During Task 3A, the ICARUS cells (Figure 6) will be deployed primarily in the outer ring of the clarifier (Figure 3). ICARUS will also be tested in a stormwater pond during Task 3B

2) Also for Task 3A, an algae membrane photobioreactor system will be built on the scaffolding of the traveling bridge in the sand filters. Effluent from the sand filters will be pumped into tubular photobioreactors, where algae remove nitrogen via assimilation and return the rest to the atmosphere. Algae are concentrated with a membrane for harvesting, and filtered effluent will flow to the denitrification filters. Adequate light penetration is expected in the proposed location, as shading is virtually nonexistent.

17. **Public Acceptance** - Describe any known or potential public approval or opposition to the project.
No known public opposition to the project is known. It is anticipated that the project would gain public approval due to its potential to save costs to the treatment plant (i.e., taxpayer dollars) and add aesthetic and educational value to stormwater retention areas.

18. Project Activity Budget Justification:

Provide the total project cost and costs by identified tasks for the following items. Provide specific justification for all that apply.

- **Personnel and fringe:**
  Costs include salary for postdoctoral researcher, graduate research assistant, undergraduate research assistants, partial salary for PI, and associated fringe and benefits. Per USF rules, graduate assistantship includes payment for tuition.

- **Travel including the number of trips and estimated cost per trip:**
  Travel includes an estimated 100 trips between USF and Largo over the two year project period for total of $3115 (100 trips x 70 mi per round trip x $0.445 per mile), plus $3000 allocated for the dissemination of research findings at national meetings or attending meetings with stakeholders in Florida.

- **All equipment greater than $1,000:**
  Equipment includes costs for fabrication of nutrient removal systems (ICARUS and duckweed containment), including pumps, motors, struts, piping/valves, containers, control and measurement, remote monitoring, membrane, and other hardware.

- **Supplies including a list of major types of supplies:**
  Supplies include consumable material for laboratory analyses mainly from Hach (nitrogen species, phosphorus, carbon, COD, solids, turbidity, optical density, compositional characterization, etc), general lab consumables, field instruments, and costs for maintenance of instruments used for the project.

- **Contractual costs:**
  None

- **Administrative costs not to exceed 3% of the total award:**
  Indirect costs is calculated as 3% of total direct costs.

- **Future costs related to maintaining the project, the funding source, and responsible entity:**
  It is anticipated that once proven successful, the technologies developed and demonstrated through this project will be continued and implemented by the City of Largo through the operating budget of Environmental Services.

	Task 1	Task 2	Task 3	Task 4	Total
Personnel and fringe	$38,126	$57,189	$57,189	$38,126	$190,631
Travel	$1,223	$2,140	$2,140	$612	$6115
Equipment	N/A	$16,000	$24,000	N/A	$40,000
Supplies	$4,500	$12,000	$12,000	$1,500	$30,000
Total Direct Costs					$266,746
Administrative costs (3%)					$8002
Total					**$274,749**

19. Describe how the project will utilize a collaborative approach that incorporates partnerships, if applicable.

(Step 2 - Criterion 8)

List any project partners and briefly describe their involvement and contribution to the project.

The project is a partnership between the City of Largo, Largo Wastewater Reclamation Facility, and the Department of Civil and Environmental Engineering at University of South Florida. It is anticipated that City property (i.e., stormwater retention pond) will be utilized; the City will assume a supportive role by granting access to the property. The LWWRF is the site where wastewater-related trials will be conducted. Staff at the LWWRF will support the project by allowing access to the plant infrastructure, providing logistical support for deployment and sampling, and contribute experienced knowledge, site plans, and historical plant data where necessary. LWWRF staff may also conduct some laboratory work. The majority of the field work, sampling, and laboratory work will be conducted by USF personnel.

20. Describe how the project will support, further, or help implement one or more Pinellas County Comprehensive Plan Element goal(s) as identified in the overarching project goals, if applicable. Clearly list each Comprehensive Plan Element goal addressed.

(Step 2 - Criterion 9)

Link to Applicable Comprehensive Plan Element Goals:

www.pinellascounty.org/restore/pdf/comp-plan-goals.pdf

The proposed project addresses several Pinellas County Comprehensive Plan Element Goals, such as:

Future Land Use and Quality Communities, Goal 2. The proposed project has the potential to help beautify stormwater retention area, making them more walkable destinations in residential and commercial areas.
Natural Resource Conservation and Management, Goal 2. The proposed project's goal is to reduce nutrient loading to coastal waters, thereby supporting the protection and restoration of affected habitats.
Natural Resource Conservation and Management, Goal 4. The proposed project will provide educational opportunities to visitors of the LWWRF and the stormwater project site. The public can learn about nutrient loading, its effects on coastal habitats, and the innovative technology the County is investigating to mitigate nutrient pollution in both point and non-point sources. Their connection to their environment, particularly to water resources and coastal habitats, will be strengthened through education and awareness.
Natural Resource Conservation and Management, Goal 5. Similarly, educational opportunities will showcase the County as a leader in environmental stewardship, education, and innovation.
Natural Resource Conservation and Management, Goal 10. The proposed project will give the County an opportunity to discuss atmospheric nitrogen pollution (resulting from nitrification and denitrification) as well as greenhouse gas emissions, thereby improving the public awareness of these issues.
Recreation, Open Space and Culture, Goal 3. The proposed project has the potential to help beautify stormwater retention areas, providing improved recreational areas for residents and visitors of affected areas.
Economic, Goal 1. The proposed project will provide training opportunities for operators at LWWRF and cross-training opportunities for operators throughout the County. Biomass developed through the proposed technology may open new markets, such as fertilizers, animal or fish feed, or biofuels.

21. Describe the benefits the project will provide, for how long, and why:
(Step 2 - Criterion 10)
Benefits may be economic, social, and/or environmental. Explain how the benefits will or could be identified, assessed, and/or measured. Describe and quantify environmental and/or economic benefits as applicable [e.g., area restored (acres, linear feet), improved ecosystem services, jobs created/preserved, pollutants and/or nutrients removed (e.g., kg, pounds, tons)].
The project contributes to preserving the water quality of Tampa Bay and the coastal waterways by reducing nitrogen loading. The success of this project may embolden efforts to reduce point source nitrogen discharges, as the approach would be highly adaptable to other wastewater treatment facilities, putting the LWWRF at the forefront of technological innovation. The integration of conventional and natural wastewater treatment processes may also be applicable to stormwater treatment and provide job opportunities and training for operators. Reducing nitrogen loading with the proposed passive approach will also provide potential cost savings at the LWWRF by 1) reducing methanol addition, 2) reducing the likelihood of violations and fines, 3) using existing infrastructure to keep capital costs low, 4) requiring little additional energy input. Adding duckweed and/or algae may improve sludge dewaterability (incurring further cost savings in reduced energy and polymer demands), and

the biomass addition may improve the nutrient content and quality of soil amendment pellets. Phototrophic remediation has previously been successful in metals (and microconstituent) removal, which may be important in a future regulatory environment. Similarly, reducing the need for denitrification will lower nitrous oxide emissions (and thereby greenhouse gas emissions), and the carbon dioxide sequestered in photosynthesis will further decrease the carbon footprint of the plant. Duckweed and microalgae have potential commercial value outside of pelletization, which may bring further economic benefits to the facility. Lastly, the project will provide invaluable educational opportunities for the hundreds of community members visiting the LWWRF each year. Project participants will be happy to engage the public (and City officials) in explaining the innovative approach of the project during site visits or other educational outreach opportunities. The PI's lab has wide experience with engaging the public in prior research projects, and genuinely enjoys discussing our technology and research philosophy at community events.

22. Possible material risks to implement and maintain the proposed activity:
List possible material risks, e.g., operational, legal, regulatory, budgetary or ecological. Include brief description of mitigation strategy to address each identified risk.

1) Although it is expected that adequate nutrients are available at the target treatment locations, it is possible that a phosphorous or carbon dioxide limitation will exist. Task 1 will specifically investigate the concentration of these two important constituents prior to moving forward with phototrophic growth. If nutrient limitation is a concern after Task 1, other site locations (further upstream) will be explored. However, based on the successful inadvertent growth of duckweed at the plant, nutrient limitation is not expected.

2) As the phototrophic process will occur ahead of denitrification, photosynthetic dissolved oxygen production may potentially disrupt downstream anoxic conditions. Dissolved oxygen will be closely monitored at the effluent of the clarifier, and if necessary, at the influent of the denitrification filter. Due to the extensive agitation of the clarifier effluent in the exit flume, it is expected that photosynthetic contribution of DO will be negligible, and the clarifier effluent will off gas prior to denitrification.

3) As duckweed and microalgae uptake metals and other microconstituents, it is possible (though unlikely) that the addition of plant biomass may affect the quality of the soil amendment pellets. As such, laboratory experiments will investigate the metals content of the biomass to ensure its addition does not negatively impact the quality of existing biosolids.

23. Best Available Science:
Only answer if proposed activity will serve to protect or restore natural resources, otherwise, indicate "Not Applicable." Briefly describe how the project will use best available science with respect to peer reviewed literature, objective(s), and methodologically sound literature sources that support the scope of work, when available.

The impact of nutrients, in particular nitrogen, on Tampa Bay and Gulf of Mexico is well researched and documented. Policies have been developed and implemented (such as TMDL allocated N loadings per the TBNMC) based on known science of effect of nitrogen on these water bodies. The objective of the proposed work, to develop technologies and strategies which

can reliably and cost-effectively reduce N loading into Tampa Bay and Gulf of Mexico, is grounded on sound science. Throughout the project, we will use the best available science to design and implement the technologies and interpret the outcome of the research. Peer-reviewed scientific and industry literature will consulted and findings of this project will be published in peer-reviewed scientific and industry literature.

24. Matching/Other funding
(Step 2 - Criterion 11)
Indicate:

- The amount and percent of the total project cost secured and the source of each matching fund secured. Restore Act funds can be matched with other federal sources of funding.

- If matching funds are not secured, specify the amount of matching funds requested or expected.

USF recently applied for funding from the Department of Energy's Office of Energy Efficiency and Renewable Energy, *Targeted Algal Biofuel and Bioproducts* program (DOE/EERE/TABB) for a 4 year $1M project to develop algae biofuel technology using wastewater as a feedstock. Largo WWRF is one of the test sites for the DOE project. While the DOE project focuses on energy (biofuel production) and the proposed Restore Act project focuses on nutrient management, there is much synergy between the two projects. The DOE project can help strengthen the support system and technical infrastructure for the Restore Act project and vice versa. Both projects will involve the application of microalgae technology at the Largo WWRF.

- The date the amount of secured funds will be known.

USF's preproposal was reviewed favorably and was invited to submit a full proposal in December 2014. It is anticipated that decision for the DOE project will be made in April 2015. If awarded, the DOE project will begin in June 2015.

Readiness for Implementation
(Step 3)
Complete the following:

25. Will the project be completed within 5 years from date funding is confirmed?
Yes: _X_
No: __

26. Identify each project milestones and proposed duration (no. of months) to complete each step and the total number of months or years to complete the project.

Task		Year 1				Year 2			
		Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8

Baseline	Gather historical plant data	X							
	Identify pond location	X	X						
	Baseline field sampling	X	X						
Duckweed	LWWRF clarifiers	X	X	X	X				
	LWWRF sand filters	X	X	X	X				
	Stormwater pond (build ICARUS)			X					
	Stormwater pond (deployed)			X	X	X	X		
	Lab work (nutrient analyses, sludge dewaterability)		X	X	X	X	X		
Microalgae	Build ICARUS cells		X	X					
	Deploy ICARUS – clarifiers				X	X	X	X	
	Deploy ICARUS – sand filters				X	X	X	X	
	Build Algae MBR		X	X					
	Deploy Algae MBR				X	X	X	X	
	Deploy ICARUS – stormwater pond				X	X	X	X	
	Lab work (nutrient analyses, sludge dewaterability)		X	X	X	X	X	X	
Modeling	Data organization, confirm adequate variables are measured	X	X						
	Adjust/calibrate model framework			X	X				
	Duckweed simulations					X		X	
	Algae simulations								X

27. How long before the project can start after funds are available (months)?
The project could start immediately upon the release of funds.

28. Describe project design work, permit requirements and hurdles (federal, state, or local), and/or permitting that is in progress *(attach applicable permits or design work)*.
No permits are anticipated to complete the proposed work.

29. Describe any issues or reasons that may delay project start or completion.
None anticipated

END OF QUESTIONS

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7. Mata, T. M.; Martins, A. A.; Caetano, N. S., Microalgae for biodiesel production and other applications: a review. *Renewable and Sustainable Energy Reviews* 2010, *14*, (1), 217-232.
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