COVER SHEET FOR GRANT PROPOSALS

State Board of Education

SBOE PROPOSAL NUMBER: (to be assigned by SBOE)	AMOUNT REQUESTED: $75,000

TITLE OF PROPOSED PROJECT: Pilot Scale Algae Resource Recovery Unit

SPECIFIC PROJECT FOCUS:

As natural resources dwindle, our society is quickly moving towards a need and desire for a more complete recovery of existing resources, including nutrients, liquid and solid waste, and greenhouse gasses otherwise released to the environment. Algae is the only alternative energy source that simultaneously produces valuable energy products, mitigates eutrophication of our lakes and rivers, and reduces the potential for nutrient contamination of our subsurface aquifers. Algae based alternative energy has not yet been tapped in Idaho, although the state offers great potential for algae crops. Idaho has unique resources that are ideal for algae based agriculture such as hot, arid summers combined with a high volume of agricultural irrigation water and nutrient laden waste streams that can be used as a low-cost resource for algal cultivation. By investing in and commercializing algal biomass production for alternative energy, Idaho will be at the forefront of innovative research and business development, maintaining pristine water quality of our lakes and rivers while capitalizing on the abundant and currently untapped wastewater resources.
We propose to construct, test, and operate a pilot-scale Algae Resource Recovery Unit (ARRU). The ARRU will be situated at a local dairy farm and will receive dairy barn wastewater as the sole nutrient source. This ARRU will improve overall economics of the dairy farm through a diverse portfolio of value propositions in the form of: 1) water quality trading credits that may be sold to industrial or municipal wastewater facilities and 2) a biomass based commodity that may be processed into either bio-crude or high protein cattle feed. The additional income derived from the ARRU is estimated to be up to $410 per cow/year for combined water quality trading and cattle feed. This is a significant value to the dairy operation where average returns are generally very narrow, averaging $41.25 per cow/year over a 20 year period.

PROJECT START DATE: July 1, 2016	PROJECT END DATE: June 30, 2017
NAME OF INSTITUTION: Boise State University	DEPARTMENT: Biological Sciences

ADDRESS: 1910 University Drive, Mail Stop 1515, Boise, ID 83725-1515

E-MAIL ADDRESS: kevinferis@boisestate.edu	PHONE NUMBER: (208) 426-5498

	NAME:	TITLE:	SIGNATURE:
PROJECT DIRECTOR/PRINCIPAL INVESTIGATOR	Kevin Feris	Professor	Not Required
CO-PRINCIPAL INVESTIGATOR	Maxine Passero	Lab Manager, Researcher	Not Required

NAME OF PARTNERING COMPANY: Idaho Dairymen's Association	COMPANY REPRESENTATIVE NAME: Bob Naerebout, Executive Director

NAME:		SIGNATURE:
Authorized Organizational Representative	Karen Henry, Executive Director	3/31/16

FY 2016 SBOE IDAHO INCUBATION FUND PROGRAM
Pilot Scale Algae Resource Recovery Unit

1. **Name of Idaho public institution:** Boise State University

2. **Name of faculty member directing project:** Kevin Feris

3. **a) Original proposed submission:** 2016 **b)** no previous awards

4. **Executive Summary:**

As natural resources dwindle, our society is quickly moving towards a need and desire for a more complete recovery of existing resources, including nutrients, liquid and solid waste, and greenhouse gasses otherwise released to the environment. Algae is the only alternative energy source that simultaneously produces valuable energy products, mitigates eutrophication of our lakes and rivers, and reduces the potential for nutrient contamination of our subsurface aquifers. Algae based alternative energy has not yet been tapped in Idaho, although the state offers great potential for algae crops. Idaho has unique resources that are ideal for algae based agriculture such as hot, arid summers combined with a high volume of agricultural irrigation water and nutrient laden waste streams that can be used as a low-cost resource for algal cultivation. By investing in and commercializing algal biomass production for alternative energy, Idaho will be at the forefront of innovative research and business development, maintaining pristine water quality of our lakes and rivers while capitalizing on the abundant and currently untapped wastewater resources.

We propose to construct, test, and operate a pilot-scale Algae Resource Recovery Unit (ARRU). The ARRU will be situated at a local dairy farm and will receive dairy barn wastewater as the sole nutrient source. This ARRU will improve overall economics of the dairy farm through a diverse portfolio of value propositions in the form of: 1) water quality trading credits that may be sold to industrial or municipal wastewater facilities and 2) a biomass based commodity that may be processed into either bio-crude or high protein cattle feed. The additional income derived from the ARRU is estimated to be up to $410 per cow/year for combined water quality trading and cattle feed. This is a significant value to the dairy operation where average returns are generally very narrow, averaging $41.25 per cow/year over a 20 year period [1].

5. "Gap" project objective and total amount requested

Project objective: Wastewater-to-algae research began six years ago at Boise State University (BSU) and is ongoing today. This research has yielded multiple externally funded projects, graduate students, publications, and a pending patent. Our research and development has ranged from laboratory to greenhouse scale as we maintain a primary focus on dairy wastewater remediation. We propose to build on this knowledge by constructing a pilot scale ARRU. This large scale experimentation and demonstration of our technology is necessary to generate ñreal-worldò value estimates for algal biomass production and water quality trading (WQT) scenarios. The information obtained from this work will be used to accurately project dairy based income potential for multiple value propositions that may be realized with a full scale system.

Total amount requested: A total of $75,000 is requested to construct, test, and run the pilot scale ARRU reactor. A majority of funds will be used for equipment, material, and travel ($41,242) with the remainder being used for labor costs for the twelve month period ($33,758).

6. Description of how resource commitments reflect the priorities of the home institution

The continued development of the algae biofuels and bio-products program at BSU is supported by the Department of Biological Sciences and the State of Idaho, as we have received funding through the Idaho National Laboratory and the Center for Advanced Energy Studies. Additionally, the Environmental Protection Agency (EPA) and the US Department of

Agriculture (USDA) focus on agriculture-to-algae research and both agencies have provided multiple funded grants to support our researchers and graduate students over the years. The proposed project is a continuation of recent collaborations with the University of Idahoôs Civil Engineering department (Erik Coats) whereby focus has been on development of value added products from dairy wastewater systems, such as bio-plastics, biogas, and algae based products [2, 3]. We have leveraged these investments to construct, test, and operate greenhouse scale algal cultivation systems, in which we have demonstrated the potential for this technology to upcycle dairy wastewater into valuable commodities, Figure 1.

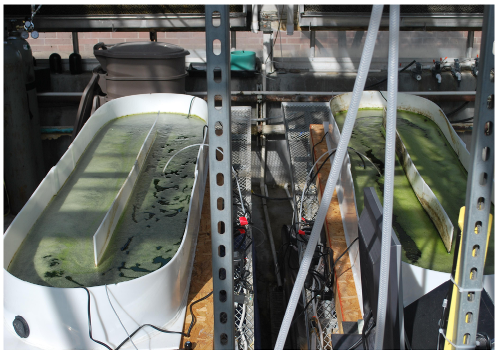


Figure 1. BSUôs greenhouse raceways used for algal biofuel and bio-products research.

7. Evidence that the project will have a potential impact to the economy of Idaho

The ~530,000 dairy cows in Idaho generate an estimated 3 million tons of dry manure each year (2010) [4], with each ton containing approximately 4.5 kg of nitrogen (N) and 0.82 kg of phosphorus (P) [5]. These waste streams are traditionally dealt with via land application, a practice that can threaten waterways due to runoff and infiltration, facilitating the release of N and P to surrounding waters and causing aquifer contamination and/or surface water eutrophication and hypoxia [6, 7]. Resource recovery of the P emitted from Idaho dairies can be upcycled to create significant value added products, including WQT credits for statewide watersheds. In addition, a biomass based commodity will be cultivated and harvested with the option for pivoting the value proposition between bio-crude, cattle feed, or other products based on market pricing and demand. A model 200 head dairy farm is used for income projections, generating an estimated ~1,100 tons of manure per year and ~11 tons of P. A reasonable algal P uptake rate of 60% of available manure based P can be assumed, with the following value propositions:

1) **Water quality trading:** The market value of P based water quality trading is estimated at $20 per kg [8]. Income potential stands at ~ **$132,000 per year** for the 200 head farm or $660 per cow/year.

2) **Bio-crude commodity***: Dry algae biomass production is estimated at 660 tons/year, with bio-crude production from hydrothermal liquefaction at 35,000 L/year. Income potential from bio-crude is projected at ~ **$11,000 per year** or $55 per cow/year.

    *Assuming biomass at 4% lipids. Bio-crude priced at West Texas Intermediate @ $0.31/Liter

3) **Cattle feed commodity***: 660 tons of dry algae biomass per year can be substituted for high protein cattle feed with an income potential of ~ **$125,000 per year** or $625 per cow/year.

    *High protein cattle feed priced at Dry Distiller's Grain commodity pricing @ $190/ton

Pizarro et al. calculated the capital cost for a 27 acre dairy based algal attached growth system to be $1.68 million with an operating cost of $454 per cow/year for wet algae production [9]. Based on the value propositions mentioned above and 20-year amortization of capital on estimates from Pizarro et al., the profit/loss from an ARRU can be estimated to be: **-$160 per cow/year** for combined WQT and bio-crude products and **$410 per cow/year** for combined WQT and cattle feed products. Currently, a net loss is projected for the combined WQT and bio-crude products, although fluctuating oil prices may push this option to profit in the future. These biomass production estimates are consistent with published attached growth biomass yield estimates of 25 $g \cdot m^{-2} \cdot day^{-2}$, see section 9 below.

8. The market opportunity

a) Describe need the project would address

Idahoøs dairy industry production stands at 3rd in the nation and is a significant contributor to Idahoøs economy. The industry as a whole is under increasing pressure to mitigate run off and ground water infiltration of N and P from wastewaters. The goal of the federal Clean Water Act (1972) is to ñrestore and maintain the integrity of the nationøs watersò and requires adoption of water quality standards necessary to protect aquatic life, human health, and the environment. The Idaho Department of Environmental Quality states that 36% of Idahoøs streams do not meet water quality standards and are subject to total maximum daily load limits (TMDLs) for multiple parameters, including N and P. The lower Boise phosphorus TMDL was approved by EPA in 2015 and requires a combined 77% reduction from non-point sources, stormwater, wastewater, and improvement in ground water quality [10]. To meet these goals, municipal wastewater treatment plants (WWTPs) are required to reduce P discharge by 97% in the summer (May-Sept) and 89% in the winter. Unfortunately, the TMDL provides no reserve for future population growth so increased discharge can only occur through a combination of expensive additional treatment infrastructure plus WQT. In addition, an agricultural P discharge reduction of 61% is necessary for the TMDL goal to be met. The Lake Lowell Watershed (LLW) within the Lower Boise River Subbasin is another area that surpasses the TMDL, requiring a 56% reduction of P inflow to meet the 70 µg/L limits [11]. The LLW is dominated by farms, irrigated crops, and pasture land, including seventeen dairies that are nonpoint sources contributing to the TMDL.

b) Describe applications and markets for the technology. Include market size and demand projections

See response for section 7 above and 8 (c) below.

c) Describe the product, its potential market audience, the competition, and barriers to market entry

Water Quality trading: The emerging WQT industry has tallied $52 million in transactions between 2000 and 2008 in the U.S. [12]. Currently, 16 states have active WQT programs with 24 programs operating under specific national pollutant discharge elimination system (NPDES) permits or state water quality guidance. Such programs include the Maryland and Virginia Chesapeake Bay and Oregonôs Willamette, Rogue, and Lower Columbia Rivers [13]. Under Idahoôs water quality standards (IDAPA 58.01.02.055.06), water quality development and improvements to TMDLs may be accomplished through WQT. The WQT framework developed for the Lower Boise River (2000) allows for point and nonpoint source reduction in P with target trading partners identified as NPDES permit holders [14]. Nonpoint source agriculture P mitigation is accomplished through best management practices (BMPs), addressing the farm P surplus with soil and water conservation practices [15]. We maintain that an ARRU system will be consistent with current BMPs for agricultural P mitigation, particularly in the case where algae biomass is used for cattle feed.

Cattle feed: The guideline for feeding crude protein for early lactating dairy cows is 17-19% of dry mass and is an important component of the total mixed rations traditionally used for dairy feed [16]. Crude protein content of algae varies by species with *C. vulgaris* generally ranging between 51-58% dry matter [17], comparing favorably to traditional ruminant feed stocks, i.e. corn contains 10% crude protein while soybeans contain 37% [17]. Additionally, algae biomass is a source of n-3 fatty acids and lactating cows have been shown to increase milk n-3 fatty acid yield, particularly docosahexaenoic acid (DHA), with the inclusion of an algal biomass diet [18]. The use of algae as cattle feed can be useful in closing the P mass balance around dairy farms, allowing for onsite recycling of P that follows with the USDA guidelines for BMPs [15].

Bio-fuel: Algae based bio-crude is a direct replacement for crude oil and may be processed into transportation fuels as well as a multitude of hydrocarbon based commodities. The EPA's Renewable Fuel Standard (RFS) requires that 3.6 billion gallons of advanced renewable biofuels be blended into transportation fuel in 2016, with algae and cellulosic biofuel making up the majority of this requirement. Compliance of the RFS is monitored through the renewable identification number (RIN) system, whereby refiners, blenders, and importers are required to meet a renewable volume obligation (RVO). Businesses falling under the RVO may satisfy requirements by blending biofuel or by purchasing RINs from other entities that exceed their RVO. Economic incentive is realized in RIN credits that are bought and sold on the market; the current equivalent RIN allocation for algae biofuel is 1.7 per gallon compared to 1.0 per gallon for ethanol with an approximate trading value is $0.50 per RIN. One local biofuel blending company, Campo & Poole (Ontario, OR) has expressed interest in purchasing algae biofuels from western Idaho and eastern Oregon. Campo & Poole distributes B10 to B100 blends and is currently selling in excess of 20 million gallons of biodiesel (B10 to B100) per year with sources from as far away as Canada.

9. The technology and path to commercialization

The ARRU will be constructed based on our group's current extensive knowledge of dairy based algae cultivation. The attached growth system will contain three main parts: the headworks, the floway, and the effluent flume. The unit will be modeled from Walter Adey's Algal Turf Scrubber (ATS™) whereby biomimicry of the highly productive ocean coral reefs provides high biomass yields [19-21]. Versions of the ATS™ have been implemented in several states to help mitigate eutrophication in lakes and streams, although to our knowledge none have utilized dairy wastewater.

Figure 2. Pilot scale algal growth bed (AGB) flow way and headworks at Noland WWTP

Other projects with this technology include an algal growth bed (AGB) constructed at the University of Arkansas Center for Agricultural and Rural Sustainability (CARS). The AGB was constructed downstream from the city of Fayetteville Wastewater Treatment Plant discharge point. The 1 x 300 foot floway averaged a biomass yield of 26 $g \cdot m^{-2} \cdot day^{-1}$ (March through November) and reduced P discharge into the Illinois River. This successful project led to collaboration with Fayetteville's Noland WWTP and CH2M Hill for construction of a phase II AGB to remove P from the plant's effluent, Figure 2.

An ATS™ design was installed near the Port of Baltimore to remove nutrients and sediments while adding dissolved oxygen to the harbor. The group from the University of Maryland including Dr. Patrick Kangas and Dr. Peter May are pushing to gain EPA's BMP certification for the process.

Examples of commercial scale algal turf scrubber operations include 1) a Tilapia fish farm in Falls City, Texas where a turf scrubber system was used to clean fish wastewater, and 2) a WWTF in northern Central Valley California where the system provided tertiary water treatment, producing 35 $g \cdot m^{-2} \cdot day^{-1}$ of dry biomass [22].

10. Commercialization partners

As this is a multi-faceted and emerging industry, we have engaged many players to ensure proper execution and to account for the needs of all parties involved. We have networked with academic, industry, agriculture, and government stakeholders within the state, including: The University of Idaho's Department of Civil Engineering and Dr. Erik Coats, The Center for

Advanced Energy Studies, The Idaho Dairymen Association, the City of Boise, Idaho Department of Environmental Quality, Idaho Soil and Water Conservation Commission (SWC), Idahoǿs USDA office, and Campo & Poole Distributing (Ontario, OR).

In addition to the above mentioned entities, recent Boise State University and University of Idaho graduates have established a small business entity for the purpose of commercializing the algae biofuel and bio-mass process. This business, Cyanergy LLC, is actively pursuing federal Small Business Innovative Research (SBIR) funding to further promote commercialization efforts.

11. Specific project plan and detailed use of funds

Our diverse group of professionals offers extensive algae cultivation and wastewater knowledge with the primarily focus of utilizing wastewater based mediums for value added products. We feel that a pilot-scale algal system co-located alongside a local dairy farm is the critical next step needed to establish a basis for Idahoǿs WQT market as well as algae biomass end products. The funds from this proposal will be utilized according to the following tasks.

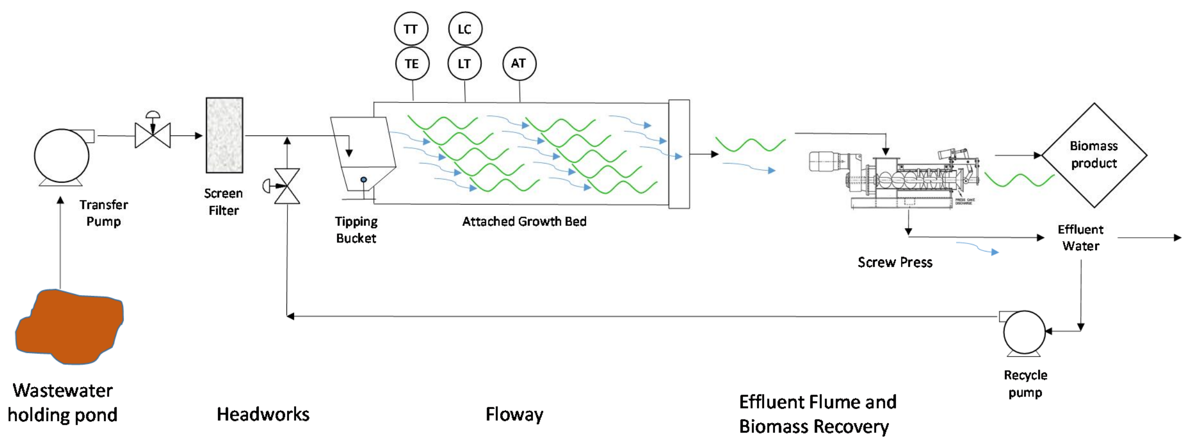
Task 1 – Pilot scale ARRU construction and water testing. Our multidisciplinary team will coordinate to produce a construction design for the proposed ARRU to be completed by the time these SBOE funds are awarded. This unit will be a standalone unit that may be broken down and re-located when needed. A schematic is shown in Figure 3.

Key features of this ARRU will include:

- The Headworks containing a screen filter, a holding tank, a transfer pump, and a tip bucket.
- The Floway will be constructed on a polypropylene base material followed by an attached growth material. Sensors will monitor and data log pertinent variables (i.e. temperature, water level, ammonia, nitrate, and phosphorus).

- <u>The Effluent Flume and Biomass Recovery</u> will contain a holding/settling tank, a transfer pump, and a screw press. Additionally, a water recycle stream will provide dilution of the incoming wastewater.

Figure 3. Schematic of Algae Resource Recovery Unit
TE = temperature element; TT = temperature transmitter; LT = level transmitter; LC = level control; AT = analyzer transmitter



Task 2 – 10 month dairy operation and data acquisition

The ARRU is expected to be operational at the dairy for a 10 month period, with one person dedicated to maintenance, harvesting, and data collection. During this time, data collection will consist of biomass productivity, biomass quality, cattle feed productivity, bio-crude potential, N removal, P removal, and WQT productivity. Information from the 10 month run is expected to be used for design of a full scale ARRU, including capital and operating costs estimates and value propositions.

12. Institutional and other sector support

The ARRU will be instrumental in establishing value propositions that include biomass based products (biofuel, cattle feed, and slow release fertilizer) and the secondary value proposition of WQT that is yet untapped in Idaho, enhancing the opportunity for commercialization of an algae agriculture infrastructure in the state.

Appendices

<u>Facilities & Equipment</u>

Boise State University

Facilities

Boise State University is the fastest growing university in Idaho with the most rapidly increasing research portfolio among the three research institutions in the state. Undergraduate enrollment has been > 18,000 over the last three years and approximately 2000 graduate students. Dedicated laboratory space with essential equipment and instrumentation is available along with office and greenhouse space. In addition, the Department of Biological Sciences also has multi-user facilities that this project will have access to that include laminar flow cabinets, centrifuges, autoclaves, microscopes, plate readers, etc. A valuable asset to the proposed work scope is the state-of-the art greenhouse. The greenhouse is divided into a head house and four bays. Temperature, watering, and light can be controlled separately in each of the bays by a fully automated system. One of the bays is 400 sq. ft. and the other three 200 sq. ft. each. This facility also has suitable bench space for set up, maintenance and operation of pilot-scale algal cultivation systems. Boise State University has guaranteed us sufficient space in the greenhouse facility to construct and run our experiments. All costs associated with maintaining climate controls, water supplies, and water removal will be covered by the Boise State Universities Biological Sciences Greenhouse Facility.

Equipment

- Dr. Feris has been supplied with approximately 750 sq. ft. of dedicated research lab space for these and other experiments, in addition to the departmentally available sterilization, storage, and other facilities.
- Agilent 6890N GC (network communication) Dual split/splitless inlet with Electronic Pressure Control FID Detector and Thermal Conductivity Detector (TCD) with Electronic Pressure Control. Dual 7683 injection towers and autosampler 100-sample tray. GC system includes an Agilent 7694 headspace sampler for measurement of volatile organics associated with intact solid and liquid environmental samples.
- Applied Biosystems 310 Capillary Electrophoresis DNA Analyzer
- Applied BIosystems 7300 Real-time PCR machine
- Techne Genius Thermocycler with 96-well block
- ESCO Airstream PCR Cabinet model PCR-3AX
- Molecular biology supplies (e.g. electrophoresis rigs, pipettors, freezers, refrigerators, microcentrifuges, etc.)
- -20oC and -80oC freezers for storage of clones and environmental isolates
- Microbiological culturing supplies
- Incubators, water baths, etc.
- Autoclave
- Shaking and static incubators (both dark and those with controlled light sources)
- UV-Vis Hach 2800 spectrophotometer
- Zeiss Confocal microscope

- BioTex Synergy MX fluorescent plate reader
- Nanodrop ND-1000 spectrophotometer for quantifying DNA for plasmid sequencing, transformation studies, etc..
- Bio-Rad Gel doc XR for agarose gel imaging

Multi-User University equipment

- Lachatôs QuikChem® 8500 Series 2 Flow Injection Analysis System
- ThermoElectron X-Series II quadrupole ICPMS
- FlashEA 1112 NC Analyzer

Biographical Sketch

Kevin P. Feris, Ph.D. (Co-PI)
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Boise, ID 83725

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Phone: (208) 426-5498
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Education and Training

University of Alaska Anchorage, Biology, B.S. — 1995

University of Montana, Microbial Ecology, Ph.D. — 2003

University of California, Davis, Microbial Ecology, Post-Doctoral Researcher — 2003-2005

Professional Experience

Professor, Biology Department, Boise State University, Boise, ID — 2015- present

Associate Professor, Biology Department, Boise State University, Boise, ID — 2010- 2015

Assistant Professor, Biology Department, Boise State University, Boise, ID — 2005 ï 2010

Postdoctoral Research Associate, Microbial Ecology, Kate Scowôs lab University of California at Davis, Department of Land, Air, and Water Resources — 2003-2005

Research Assistant, Molecular Microbial Ecology Lab, University of Montana — 2000 - 2003

Microbiology laboratory instructor: University of Montana — 1998 - 2000

Laboratory Technician: Neurobiology Lab, University of Alaska Anchorage, Biological Sciences Department — 1997-1998

Laboratory Technician: Biogeochemistry Lab, University of Alaska Anchorage, Biological Sciences Department — 1996

Five products (i.e. publications) most closely related to the proposed project:

Coats, E.R., Searcy, E., Feris, K., Shrestha, D., McDonald, A.G., Briones, A. *et al.* (2013). An integrated two-stage anaerobic digestion and biofuel production process to reduce life cycle GHG emissions from US dairies. *Biofuels, Bioproducts and Biorefining*, 7, 459-473.

Passero, M., Cragin, B., Coats, E.R., McDonald, A.G. & Feris, K. (2015). Dairy Wastewaters for Algae Cultivation, Polyhydroxyalkanote Reactor Effluent Versus Anaerobic Digester Effluent. *BioEnergy Research*, 8, 1647-1660.

Passero, M.L., Cragin, B., Hall, A.R., Staley, N., Coats, E.R., McDonald, A.G. *et al.* (2014). Ultraviolet radiation pre-treatment modifies dairy wastewater, improving its utility as a medium for algal cultivation. *Algal Research*, 6, Part A, 98-110.

Smith, S.A., Hughes, E., Coats, E.R., Brinkman, C.K., McDonald, A.G., Harper, J.R. *et al.* (2016). Toward sustainable dairy waste utilization: enhanced VFA and biogas synthesis via upcycling algal biomass cultured on waste effluent. *Journal of Chemical Technology & Biotechnology*, 91, 113-121.

Thomas, P., Coats, E., Newby, D., Passero, M. & Feris, K.P. (in preparation). Algal polyculture diversity increases culture stability and annualized yield by inhibiting grazing pressure and not by over yielding. Planned submission to Algal Research Spring 2016.

<u>Five other significant products (i.e. a related patent and publications):</u>

Patent US 2015/02755166 71. Ultraviolet Radiation Pre-treatment of Wastewater Improving its Utility as an Algal Cultivation Medium. Inventors: Kevin P. Feris and Maxine Prior (now M. Passero).

Sorensen, P.O., Germino, M.J. & Feris, K.P. (2013). Microbial community responses to 17 years of altered precipitation are seasonally dependent and coupled to co-varying effects of water content on vegetation and soil C. *Soil Biology and Biochemistry*, 64, 155-163.

McTee, M.R., Gibbons, S.M., Feris, K., Gordon, N.S., Gannon, J.E. & Ramsey, P.W. (2013). Heavy metal tolerance genes alter cellular thermodynamics in Pseudomonas putida and river Pseudomonas spp. and influence amebal predation. *FEMS microbiology letters*, 347, 97-106.

Stanaway, D., Haggerty, R., Benner, S., Flores, A. & Feris, K. (2012). Persistent metal contamination limits lotic ecosystem heterotrophic metabolism after more than 100 years of exposure: A novel application of the resazurin resorufin smart tracer. *Environmental science & technology*, 46, 9862-9871.

Gibbons, S.M., Morales, S.E., Gannon, J.E., Feris, K., McGuirl, M.A., Ramsey, P.W. *et al.* (2011). Use of microcalorimetry to determine the costs and benefits to Pseudomonas putida strain KT2440 of harboring cadmium efflux genes. *Applied and Environmental Microbiology*, 77, 108-113.

<u>Synergistic Activities</u>

Project director for moderate scale multi-investigator FEWS related project: USDA NIFA Climate. PI: Feris, K. P.; Co-PIs: Coats, E. (UI), McDonald, A. (UI); Post-Guillen, D (INL), Hamilton, M. (CAES). Title: ñEnhancing greenhouse gas mitigation and economic viability of manure management systems via production of value added carbon sequestrationò. $681,143.

Co-PI on for moderate scale multi-investigator FEWS related project: Idaho National lab. PIs: Deborah Newby (INL), Feris, K. P. (BSU), Erik Coats (UI) ñIntegrated Approach to Algal Biofuel, Bio-power, and Agricultural Waste Managementò. $250,153. 2012-2015

Co-PI on for moderate scale multi-investigator FEWS related project: Center for Advanced Energy Studies: ñDesign and Operational Improvements, and LCA in Anaerobic Digestion of Fermented Dairy Manure Using a 2-Stage process.ò PI: Erin Searcy (INL), Co-PIs: A Briones (UI), E Coats (UI), K Feris (BSU), D Keiser (UI), T Magnuson (ISU), A McDonald (UI), D Shrestha (UI). Total funding level: $592,000; Feris share of funding: $74,001. 2010-2012.

Hydroclimatology team member for Idaho NSF Epscor RII project 2008-2013 and Senior Personel with the newly developed Reynolds Creek Critical Zone Observatory (2014- present).

Proposal lead for development of a transdisciplinary PhD program in Ecology, Evolution, and Behavior at Boise State University

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Education:

University of Idaho, Boise, ID
M.S. in Biological and Agricultural Engineering 2013
Thesis: *Improving the Utility of Dairy Wastewater as an Algal Growth Medium*

Michigan State University, East Lansing, MI
B.S. in Chemical Engineering 1994

Honors, Awards and Presentations:

- **2015 Algal Biomass, Biofuels & Bio-products International Conference.** Poster session presentation: *Pilot Scale Algae Cultivation: UV Pre-Treatment Improves Integrity of C. vulgaris in Dairy Wastewater.* June 2015. San Diego, California.
- **2013 Algal Biomass, Biofuels & Bio-products International Conference**. Poster session presentation: *Ultraviolet Radiation Pre-treatment Modifies Dairy Wastewater, Improving Its Utility as a Medium for Algal Cultivation.* June 2013. Toronto, Canada.
- **2011-2013 Environmental Protection Agency Fellowship**. Science to Achieve Results (STAR) Graduate Research Fellowship award.

Publications:

- Passero M.L., Cragin B., Hall A.R, Staley N., Coats E. R., McDonald A.G, Feris K. **Ultraviolet radiation pre-treatment modifies dairy wastewater, improving its utility as a medium for algal cultivation**. *Algal Research.* October 2014.
- Passero M.L., Coats E.R, Cragin B., Feris K. **Dairy wastewaters for algae cultivation, polyhydroxyalkanoate reactor effluent versus anaerobic digester effluent**. *BioEnergy Research.* April 2015.
- Coats E., Searcy E., Feris K., Shrestha D., McDonald A., Briones A., Magnuson T., Prior M. **An integrated 2-stage anaerobic digestion and biofuel production process to reduce life cycle GHG emissions from U.S. dairies**. *Biofuels, Bioproducts & Biorefining*. April 2013.

Patents:

Ultraviolet Radiation Pre-Treatment Modifies Dairy Wastewater, Improving its Utility as a Medium for Algal Cultivation. Inventors: Maxine Passero, Kevin Feris. Filed March 2015. Serial No. 14/667,893.

Certifications:

Wastewater Operator I OIT certification

<u>Work Experience:</u>

Boise State University, Dept. of Biological Sciences
1910 University Drive, Boise, ID Dates: 2010 ï present
<u>Laboratory Manager (2014 – present)</u>
Responsible for overseeing laboratory activities for graduate level research, including SOP maintenance, budgeting, chemical stock inventory, MSDS recordkeeping, and maintenance of analytical instruments. This position requires a significant amount of technical writing and dissemination of research data, primarily manifested in manuscript development, presentations, project grant writing, and annual reporting to funding agencies.
<u>Research Assistant (2010 – 2014)</u>
Responsible for algal cultivation research under varying conditions and using multiple agricultural wastewater feed stocks. The primary goal of this project is to enhance growth rates, biomass productivity, and lipid accumulation while exhibiting wastewater remediation in coordination with carbon sequestration. This research is based on a holistic approach to global carbon reserves, using algae as a natural carbon sink and/or carbon recycle mechanism.
Additional responsibilities include:

- Method development and testing of wastewater parameters: N, NH_3, NO_3, P, PO_4, COD.
- Implementation of UV modification of wastewaters and quantification of subsequent algal growth kinetics, dissolved organic carbon, bacterial colony forming units, dissolved nutrient concentrations, and light attenuation characteristics (ex/em) in wastewaters.
- Grant writing and manuscript development and publication.

City of Boise (Public Works)
11818 Joplin Road, Boise, ID Dates: 2014 ï present
<u>*Water Quality Laboratory Technician* (part-time)</u>
Duties include processing and testing of municipal and industry water samples for purposes of city WWT permitting and billing. This position requires a general overall knowledge of the WWT process as well as new technologies coming online to ensure NPDES compliance.

Dichlor Analytical Laboratories
2269 E. Commercial, Meridian, ID Dates: 2008 ï 2010
<u>Analytical Chemist</u>

- Food crop analysis, including solvent extraction, HPLC and gas chromatography of pesticide and sprout inhibitors from potato crops, pressure bruising, and sugar analysis.

Micron Technology
8000 Federal Way, Boise, ID Dates: 1995 ï 2000
<u>Photolithography Lead Engineer</u>
Responsibilities include:

- Supervision of shift engineers and technicians.
- Process issue resolution and communication with engineers and other areas of fabrication.
- Statistical analysis of product line, including defects, registration, and critical dimensions.
- Defect analysis for photolithography related issues, including identification of cause, initiation of corrective action and analysis and documentation and/or rework of affected product.

IDAHO IDA dairymen's association

March 8, 2016

Higher Education Research Council
Idaho Incubation Fund Program

To whom it may concern,

The Idaho Dairymen's Association fully supports the proposed research project involving a pilot scale algal resource recovery unit at Boise State University. With the third largest dairy industry in the United States and approximately 567,000 dairy cows, there is a large supply of nutrient rich water that could generate useful byproducts, providing a new source of income and increasing efficiency of dairy operations. Idaho dairymen could greatly benefit from new technologies for turning manure byproducts into other useful commodities, and new technologies will be vital for maintaining environmental quality and increasing sustainability in the future. The IDA is a proactive supporter of these initiatives to determine new markets for valuable dairy byproducts.

The potential water quality benefits and biofuel production of the algal resource recovery unit would open new markets for dairymen and provide income to offset part of the installation and operating costs. Also, utilizing high protein cattle feed generated through the treatment process would recycle nutrients brought into the system through imported feed. This could reduce the need for further inputs and promote a nutrient balance on the farm, which is essential for future nutrient management goals.

Increasing cost of production and increasing regulations to protect water quality are two major challenges surrounding the dairy industry. Idaho dairymen strive to be good stewards of the land while supporting their families and growing their businesses, and this technology could help with these efforts. Many dairymen already employ multiple manure treatment technologies that have been proven effective at separating solids and liquids, which is important from a nutrient management perspective. However, there is a tremendous need for technologies that harvest nutrients from various manure resources. This project will provide valuable information as to whether the algal resource recovery unit could be another tool for dairymen to utilize in the future. The IDA is excited to see this project get off the ground, and we look forward to learning more from this research.

Sincerely,

Bob Naerebout

Bob Naerebout
Executive Director
Idaho Dairymen's Association, Inc.

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SUMMARY PROPOSAL BUDGET			
Name of Institution: Boise State University			
Name of Project Director: Kevin Feris			

A. PERSONNEL COST (Faculty, Staff, Visiting Professors, Post-Doctoral Associates, Graduate/Undergraduate Students, Other)

Name/ Title	Salary/Rate of Pay	Fringe ~44%	Dollar Amount Requested
Maxine Passero / Research Staff 1400 hrs @ $21.64/hr	$30,296	$13,330	$43,626
% OF TOTAL BUDGET: 58%		SUBTOTAL:	$43,626

B. EQUIPMENT: (List each item with a cost in excess of $1000.00.)

Item/Description	Dollar Amount Requested
Site preparation	
Grading, compaction 1 x 50 meters (@$4.40 m^{-2})	220
Wooden frame and base 1 x 50 meters	650
Headworks	
Mixing/holding tank, screen filter, tip bucket, transfer pump	1,994
Floway	
HDPE liner, 1x50 meters (@$4.30 m^{-2})	2,097
Attached growth material Rachig rings, 1x50 meters	400
Monitoring	
YSI Exo1 Sonde water quality sensor (nitrate, ammonia, pH, dissolved oxygen)	2,500
Tip replacement	550
Biomass recovery	
Centrifugal pump, screen, conical settling tank	550
Screw press, biomass dewatering (Vincent CP-4)	5,000
Miscellaneous	
Utility equipment trailer	6,575
Laboratory consumables	2,500
Misc equipment, valves, fittings, piping	3,370
SUBTOTAL:	26,406

G. TRAVEL:

Dates of Travel (from/to)	No. of Persons	Total Days	Transportation	Lodging	Per Diem	Dollar Amount Requested
July 1, 2016 - June 31 2017 35 mi each way x 3 days/week x 52 weeks = 10,920 miles	1	365	car	0	$0.455 / mile	4,968
					SUBTOTAL:	4,968

H. Participant Support Costs:	0
1. Stipends	0
4. Other	0
SUBTOTAL:	75,000