UNIVERSITY OF DELAWARE

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FOR RESEARCH AND
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November 16, 2007

CW CESU Office
Appalachian Laboratory, UMCES
301 Braddock Road
Frostburg, MD 21532

SUBJECT: Application for New Partner to the Chesapeake Watershed CESU

Dear Executive Committee:

On behalf of the University of Delaware and Drs. Daniel Cha and William Ritter, please find enclosed our application for participation in the Chesapeake Watershed Cooperative Ecosystem Studies Unit (CW-CESU).

We have reviewed the general CESU descriptive materials and the CW CESU Cooperative and Joint Venture Agreement (2006-2011) and agree to abide by all the responsibilities and expectations of a Partner Institution.

If you have question regarding the technical portion of the application, please contract Dr. Daniel Cha at (302) 831-2435. All other administrative questions should be referred to me at (302) 831-8618.

Sincerely,

Geraldine E. Hobbs

Geraldine E. Hobbs
Contract and Grant Administrator

University of Delaware Application for Participation in Chesapeake Watershed Cooperative Ecosystems Studies Unit (CW-CESU)

Contact Information

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Background

This packet constitutes a formal application of the University of Delaware for participation in the Chesapeake Watershed Cooperative Ecosystems Studies Unit (CW-CESU). The University of Delaware has a strong, multidisciplinary approach to the biological, physical, social, and cultural sciences needed to address resources issues and interdisciplinary problem-solving at multiple scales and in an ecosystem context at the local, regional, and national level. We have doctorate programs in the atmospheric, ocean, and space sciences and related fields, including climatology, water resources, marine studies and oceanography, astrophysics, space physics, environmental engineering, and public policy. Our efforts are multi-faceted, as is evidenced by related research in five of the University's seven colleges. Our faculty and researchers have made and continue to make definitive and substantial contributions in these areas, and the University administration has maintained a commitment to atmospheric, ocean, and space science-based research and education. This supporting documentation highlights the numerous activities related to the these programs.

Related Programs

Research relevant to the CW-CESU can be found in twelve departments spread across five of our seven colleges on campus, including the *College of Agriculture & Natural Resources*, the *College of Arts & Sciences*, the *College of Engineering*, the *College of Marine and Earth Studies*, and the *College of Human Services, Education, & Public Policy*. We offer a total of 35 different graduate degrees and have a substantial number of related research facilities. In addition, these groups are noticeably interdisciplinary as a number of researchers enjoy adjunct

or joint appointments among the various departments, centers, and programs listed in the remainder of this document.

College of Engineering

The graduate engineering program at the University of Delaware was ranked 11th among graduate engineering programs in the country by *The Princeton Review* in 2006. The Department of Civil and Environmental Engineering offers concentrations in structural, geotechnical, transportation, and environmental engineering, water resources engineering, and coastal engineering, with increasing research addressing environmental processes; CEE also house centers focusing on coastal research as well as the study of metals in the environment. The Department of Mechanical Engineering focuses on biomechanics, composite materials, environmental fluid mechanics, manufacturing processes, and robotics and controls. In recent years, the faculty have broadened their research into microphysics and mixing related to atmospheric clouds. Both departments maintain strong research and teaching ties with the Physical Ocean Science & Engineering Program in the College of Marine and Earth Studies. This includes graduate and advanced undergraduate courses in fluid dynamics and geophysical fluid dynamics that are cross-listed in both colleges.

College of Marine and Earth Studies

The College of Marine and Earth Studies is an interdisciplinary college centered on the marine, geological, and environmental fields. Research in geological sciences includes coastal and coastal plain geomorphology, sedimentology, geophysics, and paleontology. Research in marine biology-biochemistry includes molecular biological, biochemical, and ecological research in a broad spectrum of global ecosystems. Research in marine policy focuses on public issues regarding the law of the sea, ports and shipping, marine minerals, ocean and coastal zone management, fisheries, naval affairs, marine biotechnology, and the global environment. In oceanography, research centers on physical, geological, biological, and chemical problems in both coastal and marine environments using traditional sampling techniques as well as novel *in situ* sensors and analytical tools and remote sensing, as well as issues related to global environmental change, including physical and chemical interactions between the atmosphere and the ocean. Research in physical ocean science and engineering focuses on coastal physical oceanography, coastal engineering, ocean acoustics, nearshore processes, environmental fluid dynamics, climate change, air-sea interactions and estuarine dynamics using the tools of fluid dynamics and wave mechanics. This program has strong research and teaching connections with the Departments of Mechanical Engineering and Civil and Environmental Engineering. This includes graduate and advanced undergraduate courses in fluid dynamics and geophysical fluid dynamics that are cross-listed in both colleges.

College of Agriculture & Natural Resources

In the College of Agriculture & Natural Resources, allied programs are located in the Department of Entomology & Wildlife Ecology and the Department of Plant and Soil Sciences, along with the Delaware Water Resources Center and the Environmental Soil Chemistry Group. The Department of Entomology & Wildlife Ecology prepares students for research, teaching, and

Extension careers in entomology, ecology and wildlife conservation by emphasizing whole-organism biology, conservation biology, and the interactions between humans and other species. In addition, the Department of Plant and Soil Sciences focuses on the very active teaching, research, and outreach programs in the areas of landscape horticulture, plant science, and environmental soil science.

College of Human Services, Education, & Public Policy

In the College of Human Services, Education, & Public Policy, the Center for Energy and Environmental Policy addresses a wide spectrum of issues from climate change to energy transformation, and sustainable development. The Center is composed of faculty with backgrounds in a variety of disciplines including economics, geography, political science, engineering, urban planning and environmental studies.

Faculty Expertise

Ecosystems-related research at the University of Delaware is quite broad and diverse. The following are just examples of faculty with expertise in relevant areas:

- **Herbert E. Allen, Professor, Civil & Environmental Engineering** – environmental chemistry; fate and effects of pollutants in water, sediment, and soil; bioavailability of trace metals; development of environmental standards; ecological risk assessment; analytical chemistry
- **Lee G. Anderson, Professor, Marine Policy** – fisheries economics and management, effects of implementation and operation of individual transferable quota regimes in fisheries management, and fisheries simulation models.
- **Mohsen Badiey, Professor, Physical Ocean Science & Engineering** – estuarine dynamics, coastal oceanography, ocean acoustics, waves physics, signal processing, underwater acoustic communication.
- **John Byrne, Professor, School of Urban Affairs & Public Policy** – technology, environment and society, international political economy, sustainable development, environmental justice.
- **Daniel K. Cha, Professor, Civil & Environmental Engineering** – population dynamics of biological wastewater treatment processes; biotransformation of environmental contaminants in natural and engineered systems
- **Pei C. Chiu, Associate Professor, Civil & Environmental Engineering** – fate and transformation of organic chemicals in aquatic and terrestrial environments as well as in engineered treatment systems, chemical and microbiological degradation of chlorinated solvents and nitrogenous pollutants in anaerobic environmental systems, the role of black carbon as a catalyst for the redox transformation of organic contaminants in reducing environments.
- **Thomas M. Church, Professor, Oceanography** and **Chemistry** – transport of continental emissions to the ocean, chemistry of marine precipitation, trace element deposition to natural waters, trace metal transport and cycling in salt marsh, estuarine, coastal, and open waters, redox processes of metals, sulfur, and nutrients, sea water precipitates and oceanic mineralization.

- **Biliana Cincin-Sain, Professor, Marine Policy** – integrated coastal management-cross national studies, U.S. national ocean and coastal policy, implementation of Earth Summit agreements, marine biotechnology policy; ecosystem management and GIS/remote sensing applications, offshore marine aquaculture.
- **James J. Corbett, Associate Professor, Marine Policy** – international maritime transportation and pollution issues, domestic policy issues related to the Maritime Transportation System (MTS), science and technology policy related to coastal and transportation systems, interdisciplinary technology-policy decision-making.
- **Dominic M. DiToro, Edward C. Davis Professor, Environmental & Coastal Engineering** – development and application of mathematical and statistical models to stream, lake, estuarine, and coastal water and sediment quality problems, development of water and sediment quality criteria, sediment flux models for nutrients and metals, and integrated hydrodynamic, sediment transport and water quality models.
- **Charles E. Epifanio, Professor, Fisheries Oceanography** – regulation of fisheries recruitment by atmospheric and physical oceanographic processes, transport of larval fish and invertebrates in the coastal ocean, bio-physical coupling in the coastal ocean.
- **Jeremy Firestone, Assistant Professor, Marine Policy** and **Legal Studies** – international, U.S. ocean, and environmental law and policy, roles of law, science, values, culture, economics, and policy analysis, governance, regulation and intergovernmental relations, fish and wildlife resource management (marine mammals, fish, aquaculture, invasive species), and renewable energy policy.
- **Richard W. Garvine, Professor, Physical Ocean Science & Engineering** – physical oceanography of the coastal ocean and estuaries, shelf circulation driven by buoyant coastal discharge, coastal upwelling circulation on wide continental shelves, mixing processes between freshwater plumes and the coastal ocean, the input of terrestrial fresh water to the deep ocean and its impact on climate models, the role of coastal circulation in the dispersal and recruitment of blue crab larvae, wind power resources in the coastal ocean.
- **James L. Glancey, Associate Professor, Mechanical Engineering** and **Bioresources Engineering** – development of automated measuring systems for shallow depth estuary surveillance, theoretical and experimental simulations of the biomechanics of human falls, new hand and power tool designs to reduce biomechanical injuries associated with long-term vibration exposure, automated manufacturing techniques for resin transfer molded composites, measurement of the dynamics loads and stressed in ladders.
- **Pablo Huq, Associate Professor, Physical Ocean Science & Engineering** – experimental fluid mechanics, transport phenomena, turbulence and mixing, and geophysical fluid dynamics.
- **Paul T. Imhoff, Associate Professor, Civil & Environmental Engineering** – landfill hydrodynamics, water saturation measurement in unsaturated porous media, gas tracer testing, flow in two-dimensional porous media.
- **Shreeram Inamdar, Assistant Professor, Bioresources Engineering** – role of wetlands and riparian zones on the exports of solutes across catchment scales, pollutant loading from an agricultural watershed, response of a pond/lake ecosystem to these loadings, effectiveness of best management practices for reducing the loads.
- **David L. Kirchman, Professor, Marine Studies** – microbial ecology of heterotrophic and photoheterotrophic bacteria in aquatic environments (mainly estuaries and oceans),

bacterial and degradation of macromolecules and other organic compounds, phylogenetic structure of bacterial assemblages as revealed by molecular techniques.

- **A.D. Kirwan Jr., Professor, Physical Ocean Science & Engineering** – dynamics of mixing and stirring processes and the transport of matter and energy in natural environments, quantifying small-scale dynamical processes in the coastal ocean, Rapid Environmental Assessment.
- **Willett Kempton, Associate Professor, Marine Policy** – anthropological studies of policy, environmental and energy policy, offshore wind power, vehicle-to-grid power.
- **James T. Kirby, Professor, Civil & Environmental Engineering** and **Marine Studies** – ocean wave processes, nearshore hydrodynamics and sediment transport, time series analysis and signal processing, tsunamis.
- **Nobuhisa Kobayashi, Professor, Civil & Environmental Engineering** and **Physical Ocean Science & Engineering** – swash motions, sediment transport.
- **Bruce L. Lipphardt, Jr., Associate Research Scientist, Physical Ocean Science & Engineering** – quantitative use of high resolution disparate ocean data, process studies of surface currents in Monterey Bay, process studies of surface currents on the Louisiana-Texas shelf, application of dynamical systems tools to study coastal transport and mixing.
- **George W. Luther III, Professor, Marine Studies, Chemistry & Biochemistry, Civil & Environmental Engineering,** and **Plant & Soil Science** – redox reactions in the environment, trace element speciation in marine waters and sediments including metal-ligand complexes, biogeochemical processes in marine environments, application of molecular orbital theory to geochemical processes, *in situ* electrochemistry and microelectrode technology.
- **Gerard J. Mangone, Research Professor, International and Maritime Law** – international and maritime law; shipping and ports; coastal zone law, historic development and application of U.S. admiralty law, organization and management of shipping and ports, development of coastal zone law.
- **Douglas C. Miller, Associate Professor, Oceanography** – deposit- and suspension-feeding by marine benthos in relation to near-bottom flow and sediment transport, with particular interest in the responses of marine polychaete worms, role of submarine groundwater discharge in distributions of sandflat infauna and biological productivity, distribution and formation of temperate worm-reef communities and utilization of these hard-bottom habitats by motile invertebrates, including non-indigenous species.
- **George R. Parsons, Professor, Marine Policy** – environmental economics, coastal and ocean resource management, non-market valuation, random utility models, hedonic price models.
- **Jack A. Puleo, Assistant Professor, Civil & Environmental Engineering** – video analysis of coastal processes, optical and radar remote sensing of surf zone, sediment transport modeling, swash zone processes.
- **Jonathan H. Sharp, Professor, Oceanography** – microbial biogeochemistry of major bioelements in estuarine, coastal, and oceanic waters, refinement of analytical methodology for improved long-term and large-area trend assessment, coral reef biogeochemistry, translation of aquatic chemistry research for resource management.
- **William J. Ullman, Professor, Oceanography** – groundwater biogeochemistry, coastal, estuarine and near shore processes, oceanography of shallow estuaries and lagoons, watershed processes, geochemical cycles, early diagenesis of sediments, fate of aquatic

and marine pollutants, rock/water interactions, thermodynamic and kinetic modeling of rock/water interactions, role of bacteria and metabolic products on rock/water interactions, geochemistry of halogens, non-marine evaporite deposits.

- **Fabrice Veron, Assistant Professor, Physical Ocean Science & Engineering** – fluid dynamics: turbulence and mixing at the ocean surface, air-sea interactions, atmospheric and oceanic boundary layers, suspension dynamics (bubbles and sea spray), rain, ocean surface infra-red remote sensing, surface gravity capillary waves, wind wave generation, wave-current interactions, hydrodynamic stability, multiphase flow.
- **Young-Doo Wang, Professor, School of Urban Affairs & Public Policy** – Energy and water conservation policy, economic analysis of alternative energy options, econometric applications.
- **Kuo-Chuin Wong, Professor, Physical Ocean Science & Engineering** – estuarine dynamics, effect of spring-neap tidal modulation on stratification, effect of tidal rectification on long-term transport, wind and buoyancy driven currents in estuarine and coastal waters, exchange in coupled estuary-shelf systems, and examination of physical properties in coastal waters using broadband acoustic signals.
- **Xiao-Hai Yan, Professor, Oceanography** – satellite oceanography, ocean circulation and climate change, remote sensing of estuaries, coastal and open ocean waters, remote sensing image processing, air-sea interactions and upper ocean dynamics, remote sensing modeling, environmental remote sensing.

Related Centers

The following table lists research labs, centers, and institutes with expertise and facilities relevant to the areas encompassed by CW-CESU:

Research Lab/Center/Institute	Department or Program
Bartol Research Institute	Physics and Astronomy
Center for Applied Coastal Research	Civil & Environmental Engineering
Center for Marine Policy	Marine Policy
Center for Remote Sensing	Oceanography
Center for the Study of Metals in the Environment	Civil & Environmental Engineering
Delaware Biotechnology Institute	Delaware Biotechnology Institute
Delaware Geological Survey	-- *State of Delaware Agency* --
Delaware Water Resources Center	Plant and Soil Sciences
Halophyte Biotechnology Center	Marine Biology/Biochemistry
University of Delaware Sea Grant College Program	College of Marine and Earth Studies
Water Resources Agency	Urban Affairs & Public Policy

Summary of Graduate Degree Programs in Related Disciplines

Department or Program	# of Faculty	# of Research Staff†	# of Graduate Students	Degrees Awarded
Biological Sciences	46	0/16	72	Ph.D., M.S.
Civil & Environmental Engineering	22	1/2	78	Ph.D., M.A.S., M.S.
Energy & Environmental Policy	7	0/0	65	Ph.D., M.E.E.P., M.A.
Entomology & Wildlife Ecology	9	1/0	23	Ph.D., M.S.
Geography	12	4/0	43	Ph.D., M.S., M.A.
Geological Sciences	12	0/0	19	Ph.D., M.S.
Marine Biology/Biochemistry	13	4/0	38	Ph.D., M.S.
Marine Policy	6	1/0	33	Ph.D., M.M.P., M.M.M.
Mechanical Engineering	21	0/7	60	Ph.D., M.Egr., M.S.
Oceanography	8	0/0	23	Ph.D., M.S.
Physical Ocean Science & Engineering	8	2/2	10	Ph.D., M.S.
Physics & Astronomy	36	2/14	82	Ph.D., M.S.
Plant & Soil Sciences	28	2/21	32	Ph.D., M.S.

†Research Staff includes Research Faculty/Post-Doctorate Students.

Department or Program	Degree Offered	Degrees Granted in Last 5 Years
Biological Sciences	Ph.D. in Biological Science	13
Biological Sciences	M.S. in Biological Science	20
Civil & Environmental Engineering	Ph.D. in Civil Engineering	32
Civil & Environmental Engineering	M.S. of Civil Engineering	78
Energy & Environmental Policy	Ph.D in Energy & Environmental Policy	29
Energy & Environmental Policy	Master in Energy & Environmental Policy	44
Entomology & Wildlife Ecology	Ph.D. in Entomology & Applied Ecology	2
Entomology & Wildlife Ecology	M.S. in Entomology & Applied Ecology	8
Entomology & Wildlife Ecology	M.S. in Wildlife Biology	1
Geography	Ph.D. in Climatology	10
Geography	M.S. in Geography	21
Geography	M.A. in Geography	7
Geological Sciences	Ph.D. in Geology	6
Geological Sciences	M.S. in Geology	15
Marine Studies	Ph.D. in Marine Studies	49
Marine Studies	M.S. in Marine Studies	68
Mechanical Engineering	Ph.D. in Mechanical Engineering	25
Mechanical Engineering	Master in Engineering: Mechanical	5
Mechanical Engineering	M.S. in Mechanical Engineering	45
Physics & Astronomy	Ph.D. in Physics	22
Physics & Astronomy	M.S. in Physics	9
Physics & Astronomy	M.A. in Physics	1

Department or Program	Degree Offered	Degrees Granted in Last 5 Years
Plant & Soil Sciences	Ph.D. in Plant & Soil Sciences	5
Plant & Soil Sciences	M.S. in Plant & Soil Sciences	8

Additional Information and Supporting Data

The websites for the related departments and programs are shown below:

College of Agriculture & Natural Resources

Department of Entomology & Wildlife Ecology	http://ag.udel.edu/enwc/
Department of Plant and Soil Sciences	http://ag.udel.edu/plsc/

College of Engineering

Department of Civil and Environmental Engineering	http://www.ce.udel.edu/
Department of Mechanical Engineering	http://www.me.udel.edu/

College of Marine and Earth Studies

Department of Geological Sciences	http://www.geology.udel.edu/
Marine Biology/Biochemistry Program	http://www.ocean.udel.edu/graduate/mbb/mbb.html
Marine Policy Program	http://www.ocean.udel.edu/graduate/marpol/marpol.html
Oceanography Program	http://www.ocean.udel.edu/graduate/ocean/oceanography.html
Physical Ocean Science & Engineering	http://www.ocean.udel.edu/graduate/posc/posc.html

College of Human Services, Education, & Public Policy

Center for Energy & Environmental Policy	http://ceep.udel.edu/ceep.html

The websites for the related research laboratories, centers, and institutes are as follows:

Bartol Research Institute	http://www.bartol.udel.edu/
Center for Applied Coastal Research	http://www.coastal.udel.edu/
Center for the Study of Metals in the Environment	http://www.ce.udel.edu/CSME/Index.html
Center for Climatic Research	http://www.udel.edu/Geography/CCR/
Center for Marine Policy	http://www.ocean.udel.edu/cmp/index.html
Center for Remote Sensing	http://newark.cms.udel.edu/crs/crs.html
Delaware Biotechnology Institute	http://www.dbi.udel.edu/
Delaware Environmental Observing System	http://www.deos.udel.edu/
Delaware Geological Survey	http://www.udel.edu/dgs/
Delaware Space Grant Consortium	http://www.delspace.org/
Delaware Water Resources Center	http://ag.udel.edu/dwrc/
Halophyte Biotechnology Center	http://www.ocean.udel.edu/halophyte/hbc.htm
Institute for Energy Conversion	http://www.udel.edu/iec/
Office of the State Climatologist	http://www.deos.udel.edu/stclim/
Offshore Wind Power Research Group	http://www.ocean.udel.edu/windpower
Permafrost Laboratory	http://climate.geog.udel.edu/~shiklom/udpg.htm
UD Sea Grant College Program	http://www.ocean.udel.edu/seagrant/
Water Resources Agency	http://www.ipa.udel.edu/wra/

Overhead Rate

The overhead rate will be 17.5% for activities conducted through the CESU, including research, technical assistance and educational services.