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Board of Regents ~ Committee on Education Policy and Student Life

Monday, June 5, 2023 ~ 12:00 p.m.

Zoom Details to be Provided to Committee

Public Listen-Only Access: 1-443-353-0686 ~ Conference ID: 620 455 44#

Public Session Agenda

Action Items

1. Academic Program Proposals:
 - a. Towson University: Doctor of Philosophy (Ph.D.) in Sustainability and Environmental Change
 - b. University of Maryland, Baltimore County: Master of Science (MS) in Cybersecurity
2. Motion to Adjourn



TOPIC: Academic Program Proposal:
Towson University: Doctor of Philosophy (Ph.D.) in Sustainability and Environmental Change

COMMITTEE: Education Policy and Student Life

DATE OF COMMITTEE MEETING: Monday, June 5, 2023

SUMMARY: Towson University proposes to create a Doctor of Philosophy (Ph.D.) in Sustainability and Environmental Change (SEC) degree. The Ph.D. in SEC is an interdisciplinary, research-focused program that will strengthen students’ research skills and deepen their understanding of sustainability issues and novel solutions to environmental challenges. Students pursuing the Ph.D. will become proficient in research methods and analyses relevant to their dissertation topics while also gaining exposure to diverse perspectives pertinent to addressing complex environmental problems. Students will engage with faculty and environmental professionals in identifying and pursuing research projects aimed at understanding how anthropogenic environmental change and sustainability practices are impacting both human and ecological systems.

The proposed Ph.D. degree will require a minimum of 60 credits, including nine credits of foundation courses, three credits of seminar courses, at least 24 credits of electives, three credits of dissertation proposal, and at least 21 credits of dissertation research.

In seeking to address one of society’s most pressing needs, and with its rigorous curriculum and strong research focus, the proposed Ph.D. in SEC fully aligns with TU’s newly revised mission to foster “intellectual inquiry and critical thinking, preparing graduates who will serve as effective leaders for the public good.”

TU possesses the necessary faculty expertise and financial, administrative, technical, and other infrastructure resources to adequately support the program.

ALTERNATIVE(S): The Regents may not approve the program or may request further information.

FISCAL IMPACT: No additional funds are required. The program can be supported by the projected tuition and fee revenue.

CHANCELLOR’S RECOMMENDATION: That the Education Policy and Student Life Committee recommend that the Board of Regents approve the proposal from Towson University to offer the Doctor of Philosophy (Ph.D.) in Sustainability and Environmental Change.

COMMITTEE RECOMMENDATION:

DATE:

BOARD ACTION:

DATE:

SUBMITTED BY: Alison M. Wrynn

301-445-1992

awrynn@usmd.edu

March 15, 2023



Melanie L. Perreault, Ph.D.
Interim President

Office of the President
8000 York Road
Towson, MD 21252-0001

Jay Perman, M.D.
Chancellor
University System of
Maryland
3300 Metzerott Road
Adelphi, MD 20783

Dear Chancellor Perman:

Towson University seeks your review and approval to offer a **Doctor of Philosophy (Ph.D.) in Sustainability and Environmental Change** in accordance with the Code of Maryland Regulations (COMAR) BB.02.03.06.

The proposed program will strengthen students' research skills and deepen their understanding of sustainability issues and novel solutions to environmental challenges. Students pursuing the Ph.D. will become proficient in research methods and analyses relevant to their dissertation topics while also gaining exposure to diverse perspectives pertinent to addressing complex environmental problems.

Students will engage with faculty and environmental professionals in identifying and pursuing research projects aimed at understanding how anthropogenic environmental change and sustainability practices are impacting both human and ecological systems.

If you have any questions or require additional information, please contact Rhodri Evans, Assistant Provost for Assessment, Accreditation and Compliance, at rhodrievans@towson.edu or by phone at 410-704-3312.

Thank you in advance for your review.

Sincerely,

A handwritten signature in blue ink, appearing to read 'Melanie Perreault'.

Melanie Perreault, Ph.D.
Interim President

MP/rjme

cc: Dr. Darlene Smith, Special Advisor to the Senior Vice
Chancellor, USM
Dr. Cynthia Cooper, Acting Provost for Academic Affairs
Dr. Clare N. Muhoro, Acting Vice Provost for Academic Affairs
Dr. Sidd Kaza, Associate Provost for Research and Dean of
Graduate Studies
Dr. Christopher J. Sallee, Interim Dean, Jess and Mildred Fisher
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UNIVERSITY SYSTEM OF MARYLAND INSTITUTION PROPOSAL FOR

- New Instructional Program
- Substantial Expansion/Major Modification
- Cooperative Degree Program
- Within Existing Resources, or
- Requiring New Resources

Towson University

Institution Submitting Proposal

Sustainability and Environmental Change

Title of Proposed Program

Doctor of Philosophy

Award to be Offered

Fall 2023

Projected Implementation Date

0420.02

Proposed HEGIS Code

03.0103

Proposed CIP Code

Environmental Science and Studies Program

Department in which program will be located

Dr. Christopher Salice

Department Contact

410-704-4290

Contact Phone Number

csalice@towson.edu

Contact E-Mail Address



Signature of President or Designee

March 15, 2023

Date



A PROPOSAL FOR A PH.D. IN
SUSTAINABILITY AND ENVIRONMENTAL CHANGE
AT TOWSON UNIVERSITY

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A. Centrality to Institutional Mission Statement and Planning Priorities

A1. Program Description and Alignment with Institutional Mission

Towson University (TU) proposes to create a Doctor of Philosophy (Ph.D.) in Sustainability and Environmental Change (SEC) degree to be housed in the Environmental Science and Studies Program (ENVS), which is an entity within the Jess and Mildred Fisher College of Science and Mathematics (FCSM). The new Ph.D. degree will draw on existing faculty expertise from FCSM and across several other colleges at TU, including the College of Liberal Arts, the College of Health Professions, and the College of Business and Economics. The ENVS Program has offered a Bachelor of Science (B.S.) in Environmental Science and Studies degree and a Master of Science (M.S.) in Environmental Science degree since 1997. The ENVS Program is inter- and multi-disciplinary, leveraging courses and faculty expertise from the aforementioned colleges at TU. The Ph.D. degree will build upon the success and expertise of our existing bachelor's and master's ENVS Program, amplifying TU's interdisciplinary research focus by addressing the most pressing environmental problems in the region and around the world.

The Ph.D. in SEC is a research-focused program that will strengthen students' research skills and deepen their understanding of sustainability issues and novel solutions to environmental challenges. Students pursuing the Ph.D. will become proficient in research methods and analyses relevant to their dissertation topics while also gaining exposure to diverse perspectives pertinent to addressing complex environmental problems. Students will engage with faculty and environmental professionals in identifying and pursuing research projects aimed at understanding how anthropogenic environmental change and sustainability practices are impacting both human and ecological systems.

The proposed Ph.D. in SEC will contribute to TU's momentum in centering diversity, equity, and inclusion at the core of our mission and promote our goal of inclusive excellence through the development of academic programs that reflect the diversity of our student body, that of the state of Maryland, and the nation as a whole. This program will provide opportunities for students from groups historically underrepresented in the field of environmental sustainability and create an inclusive learning and research environment in which all students thrive. TU has demonstrated progress toward increasing diversity in environmental education, with 30 percent of ENVS undergraduates currently being from groups underrepresented in this field, while the proportion of ENVS master's students from underrepresented groups has increased from eight percent to 19 percent over the last five years. These numbers are substantially above the national average of students from groups historically underrepresented in the environmental sciences and geosciences workforce, which was approximately 11 percent in 2017.¹ TU's goal is to build on these gains with the aim of enrolling students, in part through a pipeline from our undergraduate program, who better reflect the demographics of TU's student body, which in itself is representative of Maryland's demographic population.

¹ Taylor, D.E., 2018, Enhancing racial diversity in the Association for Environmental Studies and Sciences, *Journal of Environmental Studies and Sciences*, volume 8, pp 379–384: <https://link.springer.com/article/10.1007/s13412-018-0518-1>



The proposed Ph.D. degree will require a minimum of 60 credits, including nine credits of foundation courses, three credits of seminar courses, at least 24 credits of electives, three credits of dissertation proposal, and at least 21 credits of dissertation research. Students with a master's degree in a related field or with relevant graduate coursework can transfer up to 24 credits of coursework (typically as electives) into the Ph.D. degree; all transfer credits must be approved by the SEC Graduate Program Director. Students will complete comprehensive examinations and defend a dissertation proposal, typically by the end of their second year of study. The dissertation proposal and the dissertation must articulate how the research informs our understanding of environmental sustainability. The dissertation must be a significant contribution to knowledge and suitable for publication in one or more peer-reviewed outlets (e.g., journals and/or book chapters).

This doctoral program in Sustainability and Environmental Change seeks to address one of the grand challenges facing humanity this century. Indeed, one of the United Nations [17 sustainable development goals](#) (#11) focuses on sustainability with an emphasis on making human settlements inclusive, safe, resilient, and sustainable. Solutions to the climate change and environmental degradation crises of the 21st century require collaborative thinking and “all hands-on deck” approaches.

With its rigorous curriculum and strong research focus, the proposed Ph.D. in SEC fully aligns with TU's newly revised mission to foster “intellectual inquiry and critical thinking, preparing graduates who will serve as effective leaders for the public good.” Moreover, the focus of the SEC doctoral program meets needs identified by the University System of Maryland (USM) in its current [Vision 2030 strategic plan](#), which states that USM institutions should seek to “advance our leadership in environmental sciences and deepen our international reputation for climate change and sustainability research.” In support of the goals outlined in the USM strategic plan, the Ph.D. in SEC will also contribute to “the number of cross-institutional, interdisciplinary, and interprofessional research collaborations among USM universities and centers,” and beyond. This commitment to interdisciplinarity and an “all hands” approach is evident by the fact that the proposed program will draw upon faculty expertise from across all six of TU's academic colleges. Furthermore, we envision this doctoral program as providing additional and significant impetus for TU to contribute further to the betterment of all institutions and students in Maryland.

A2. Strategic Goals Alignment and Affirmation of Institutional Priority

The proposed Ph.D. in SEC fully aligns with all six core goals outlined in Towson University's 2020-2030 Strategic Plan: educate, innovate, engage, include, support, and sustain. Above all, however, the institution's sustain goal (whereby the institution will act as a leader “in advancing sustainability of all resources—environmental, human, and financial”) is fundamental to the SEC program. It is well-recognized that anthropogenic impacts on the environment are having, and will continue to have, strong, negative impacts on human and ecological systems. This research-intensive doctoral program will help by addressing critical research needs now while also educating, training, and inspiring the next generation of environmental leaders for the public good. As such, this Ph.D. in SEC embodies TU's commitment to academic excellence and inquiry, interdisciplinary study, and dedication to



student (and faculty) intellectual and personal growth, as well as supporting the university's focus on diversity, equity, inclusion, and justice issues.

The introduction of this doctoral degree will also buttress another key priority at TU, which is to develop new doctoral programs that will, in accordance with the institution's [strategic plan](#) enhance TU's research capacity and reputation as a national leader in higher education. The proposed Ph.D. program builds on a strong history of environmental researchers at TU, with the last three USM Board of Regents Faculty Awards for Scholarship and Creative Activity being awarded to TU faculty whose research focuses on environmental issues and sustainability. This new Ph.D. program will provide additional support and capacity that builds on existing strengths and will position TU well for achieving R2 Carnegie status.

The proposed Ph.D. in Sustainability and Environmental Change is considered a priority by TU's leadership. The program, housed in the successful interdisciplinary ENVIS Program, directly supports TU's goal to capitalize on new, state-of-the-art facilities in STEM and health professions by taking advantage of the new Science Complex (completed 2021) and the new College of Health Professions (scheduled for completion in 2024). These new facilities and additional investments from TU will attract talented and interested faculty and professionals and help ensure that students in the program are successful and well-trained. In turn, SEC Ph.D. graduates will pursue careers in the academic, public, and private sectors, helping to identify, understand, and resolve critical environmental problems that impact human and ecological systems.

It is important to note that the proposed SEC doctoral program will advance objectives outlined in the USM strategic plan, which acknowledges that "higher education is essential to solving the greatest challenges of our age – crises of poverty and inequality, racial and social injustice, population health and health disparities, climate change and environmental degradation, civic disengagement and a weakened democracy." While the focus of the Ph.D. in SEC is clearly on climate change and environmental degradation, students will explore and be exposed to issues related to poverty and inequality, racial and social injustice, and population health and health disparities through the environmental lens.

A3. Five-year Funding Plan

This Ph.D. program will be funded with TU R2 investment funding and reallocated support from across the university, as this program is built primarily on already existing graduate courses and faculty expertise. That said, five new faculty will be hired to support and enhance the program. During the internal university review and approval process for new academic programs, funds have been committed from the Division of Academic Affairs in dialogue with TU Administration and Finance. Resources and expenditures anticipated for the first five years are presented in Section L, **Tables 7 and 8**. Graduate student stipends, modest library and operational support, and five new faculty lines will be dedicated to the growth and development of this program during the initial five years. As faculty and student research grows, significant external funds are expected to supplement university funding and be invested in the proposed program.



A4. Institutional Commitment

As outlined above, the proposed doctoral degree is integral to the university's current research-driven mission and strategic plan. The addition of the Ph.D. in SEC will significantly bolster faculty research productivity and will also provide added capacity to mentor undergraduate and master's-level students. TU's financial commitment to the program is evident in funding allocated to support the establishment and projected growth of the program over a five-year period (see Section L for further details).

The ENVS Program is housed administratively within FCSM, and the current Director is a faculty member in the FCSM department. However, the Assistant Director for the ENVS Program is a faculty member in the College of Liberal Arts and there are more than 40 faculty members from across six TU colleges who are affiliated with this entity (see Section I1 for a detailed listing). Administrative support for the Ph.D. in SEC will be provided by a new administrative assistant working through the existing ENVS Program, whose other staff and faculty are familiar with managing graduate education and the needs of graduate students. TU's Office of Graduate Studies will also support administrative and operational needs for the proposed Ph.D. in SEC, providing guidance and helping with reviewing student progression and success, graduate faculty status designations, and marketing.

TU's Office of Technology Services will provide support for general computing needs. More specialized technical support will come directly from the relevant colleges involved in the program, which have dedicated staff for computer technology needs, classroom support, and website development. This program will benefit from the laboratory and analytical facilities housed in the new 320,000 square foot Science Complex, access to specialized software such as ArcGIS (through the College of Liberal Arts), and through new state-of-the-art facilities with the forthcoming completion of a new building for the College of Health Professions. See Section K for more details about physical facilities and infrastructure available to support the program.

TU is committed to student success: Students admitted to the Ph.D. in SEC will be provided with sufficient time for program completion and financial support in the form of graduate assistantships. Degree completion for most full-time Ph.D. students is expected within four-to-five years of matriculation. Nevertheless, doctoral students are provided up to 10 years, if necessary, to complete their degree.

B. Critical and Compelling Regional or Statewide Need as Identified in the State Plan

B1. Program Demand and Need

The United Nations recognizes climate change as one of the major challenges of our time. The World Health Organization pointedly [states](#) that "the environmental crisis is a health crisis," while the USM strategic plan, as previously indicated, calls for action with respect to climate change and environmental degradation. These are not abstract concerns but are issues that directly affect Marylanders. Regionally, Maryland and the Mid-Atlantic are in the Chesapeake Bay watershed, and restoration and sustainability of the Chesapeake Bay has been an important national and regional environmental issue for decades.



While environmental issues including the climate crisis are widely recognized as one of the most important and costly challenges facing the world (see **Figures 1 & 2** below), the burden and costs of these impacts is disproportionately felt by economically disadvantaged groups at multiple scales. Hence, there is a clear, unequivocal societal need to prepare researchers, policy makers, educators, and professionals, who are representative of the diversity of the state and nation, to work toward addressing these pressing environmental challenges. The complex, multi-faceted nature of environmental problems necessitates a rigorous, interdisciplinary understanding of environmental and social science research methods to fuel future research, inform environmental policy, and educate future generations.

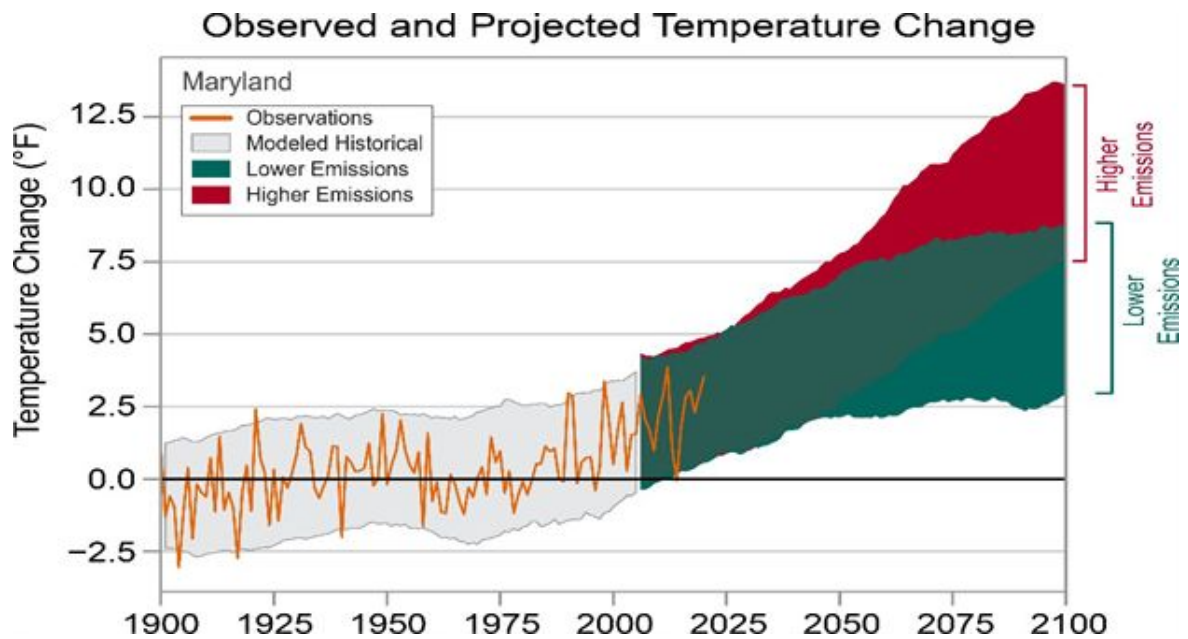


Figure 1: Observed and projected changes (compared to 1901-1960 average) near-surface air temperature for Maryland from NOAA National Centers for Environmental Information.

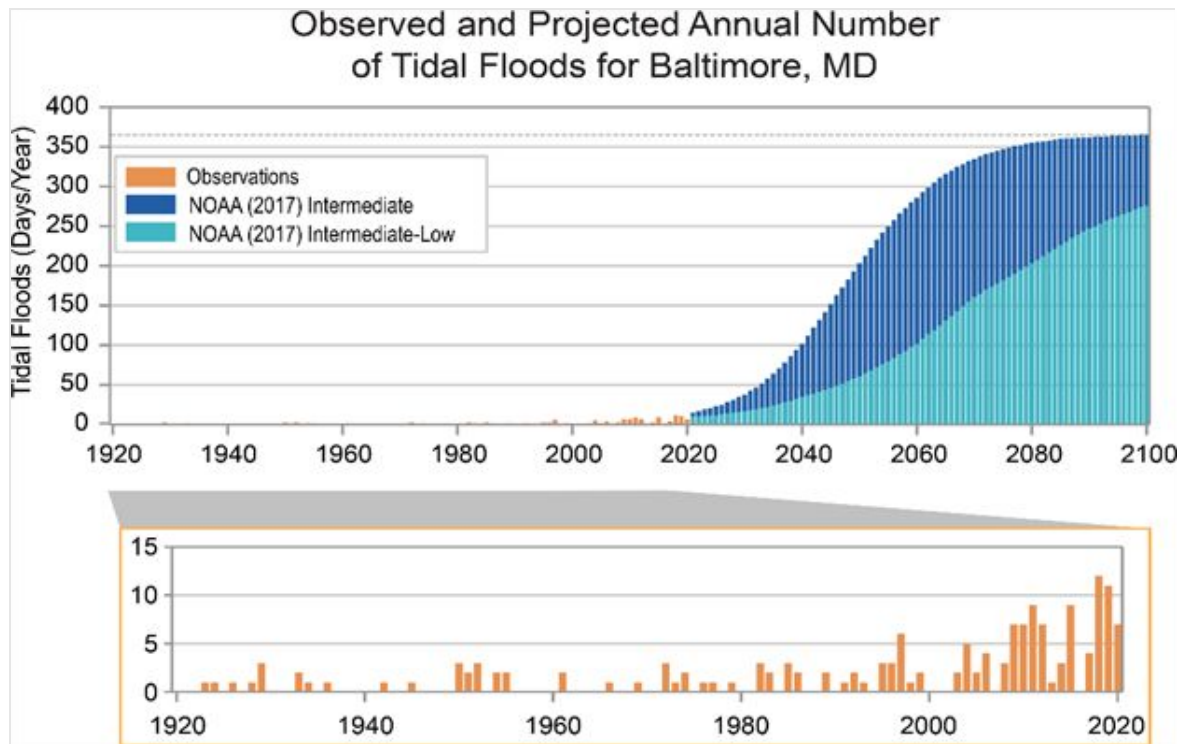


Figure 2: Observed and projected changes in annual number of tidal floods in Baltimore, Maryland from NOAA National Centers for Environmental Information.

B2. Alignment with Maryland State Plan for Higher Education

Two goals outlined in the 2022 Maryland State Plan for Higher Education are especially relevant to the proposed SEC program; these are focused on Student Success and Innovation. Priorities 5-7 under the Student Success goal seek to maintain a commitment to higher-quality postsecondary education (Priority 5), improve timely completion of programs (Priority 6), and enhance postsecondary education to promote lifelong learning (Priority 7). All these priorities are embodied by the spirit and practice of the SEC program. Faculty participating in the SEC degree are committed to providing students in the program with an outstanding Ph.D. experience that recognizes student success as the most important measure of the program's overall success.

Priority 8 under the Innovation goal is to promote a culture of risk-taking. Here, we recognize that to solve the region's (and world's) most important and pressing problems requires risk, which is inherent to all research. The SEC program will push and support students to pursue challenging problems and to grow as professionals prepared to take on important issues. The SEC program will draw students from a broad range of postsecondary bachelor's and master's programs such as environmental science, environmental studies, the classical sciences (biology, chemistry, physics), geography, and likely students from economics, social sciences, and human sciences. The interdisciplinary structure of the SEC program will



provide these students with an excellent foundation for their research and graduate studies, while benefitting from the cross fertilization of ideas and perspectives that comes from a diverse array of students, faculty, and collaborators.

C. Quantifiable and Reliable Evidence and Documentation of Market Supply and Demand in the Region and State

C1. Pipeline and Employment Opportunities

As indicated above, there is an overwhelming need for environmental sustainability professionals. Although doctoral programs exist in Maryland that provide students with the opportunity to conduct research focused on environmental issues, there are none that explicitly require the concept of sustainability in coursework and none that require students to address the implications of their research on sustainability.

Due to the specialized nature of the positions for which applicants with the proposed doctoral degree would be suitable, representative data for these professional subsets are difficult to obtain. However, **Table 1** below shows a sampling of potential occupations for which graduates of the proposed Ph.D. program would be compatible. As a research doctoral program, the expectation is that graduates will be prepared for senior-level research and related positions. As an example, it is common for new employees with a Ph.D. to be hired as senior scientists or senior managers in regional environmental consulting firms, to enter the academic profession, or to work for government and non-governmental organizations.

Table 1. Projected Growth of Select Occupations Related to the Sustainability and Environmental Change Ph.D. in Maryland from 2020-2030

Occupation	2020-2030	
	Projected Growth	Projected Annual Openings
Environmental scientists, post-secondary education	15.9%	368
Environmental scientists, including health	9.8%	2867
Forestry and conservation scientists post- secondary education	20.7%	35
Geoscientists	3.3%	433
Hydrologists	3.2%	65
Life scientists	8.6%	431
Natural science managers	3.5%	4349
Soil and plant scientists	8.6%	680
Urban and regional planners	12.8%	1169
Zoologists and wildlife biologists	8.8%	435

Source: [Maryland Department of Labor, Maryland Occupational Projections – 2020-2030 – Workforce Information and Performance](#).

Jobs in the field of sustainability and environmental change do not neatly map onto job categories analyzed by the U.S. Bureau of Labor Statistics (BLS). Information about green jobs, of which many or most fall into the category of sustainability, were collected from [2010-13](#), but then data collection was stopped in 2013 due to spending cuts in federal funding.



Individuals working in SEC jobs come from a diverse set of backgrounds. Those working in science and science-related fields, as graduates from this program would do, often need more than a Bachelor of Science degree to “conduct research or develop new products.” Relevant categories for sustainable jobs related to this Ph.D. (could) include chemists and material scientists, conservation scientists, environmental scientists, natural science managers, and soil and plant scientists. Sustainability positions also fall into several other categories such as managers for operations and those working on economics or logistics. Graduates of this Ph.D. program will be particularly well situated to work with and communicate and/or serve multiple [sustainability roles](#).

For the period 2021-2031, job growth in the various relevant categories relating to environmental and sustainability occupations is projected to be close to the national average (five to six percent) according to [BLS](#). However, growth in Maryland and the Mid-Atlantic is likely to be higher than the national average, given the focus on Chesapeake Bay restoration as well as other regional environmental issues. As an example, in 2022 the following occupations experienced annual growth of between five and six percent: [conservation scientists, environmental scientists, and natural science managers](#).

C2. Market Demand

See **Table 1** for expected growth in careers aligning with the research and professional training entailed in the proposed Ph.D. in Sustainability and Environmental Change. All selected occupations are projected to show positive growth, with several exceeding the projected Maryland average growth rate of 9.5 percent between 2020 and 2030.

Additionally, data from the U.S. Bureau of Labor show convincingly that employees with a Ph.D. have higher earning potential and lower unemployment compared to other categories (see **Figure 3**). Interestingly, the demand for tenure-track faculty positions with a Ph.D. degree in fields related to SEC is expected to grow, on average, by greater than 10 percent.

It is an unfortunate reality that as the climate crisis continues, the workforce need for advanced-level education and training in sustainability and environmental change will increase. It is also important to note that there is likely high-level research, management, administrative, and leadership positions in environment-relevant fields that graduates from the SEC program would be well-equipped to perform. The program is designed to provide an in-depth educational experience in SEC while also providing the tools to successfully design methodological approaches to obtain robust data and information, conduct statistical analyses, synthesize and present information, and manage complex projects. These skills translate well to a wide array of professions across academic, government, NGO, and private institutions. One of the strengths of this proposed Ph.D. program is that it can provide opportunities for graduates through the close relationships that TU faculty have established with regional collaborators such as the U.S. Geological Survey, U.S. Department of Defense, EA Engineering, Science, and Technology, the Maryland Stream Restoration Association, Maryland Department of the Environment, Ecotone, and a host of others.



C3. Anticipated Vacancies and Training Needs

The proposed Ph.D. program is designed to produce graduates with distinctive skills from multiple disciplines and prepared to work on issues related to sustainability and environmental change, including extensive training in high-level research methods.

Graduates will be well positioned for employment across a range of industries in Maryland, the Mid-Atlantic, and beyond. Table 1 illustrates the projected higher than average growth in positions as well as projected annual openings for environmental scientists. Graduates also would be well prepared to pursue positions in state and federal scientific or regulatory agencies such as the Maryland Department of Environment or U.S. Environmental Protection Agency; environmental consulting firms; academic positions; and program administration positions. Individuals holding doctoral degrees have the second highest weekly earnings and the lowest unemployment rates in the U.S. (see **Figure 3**).

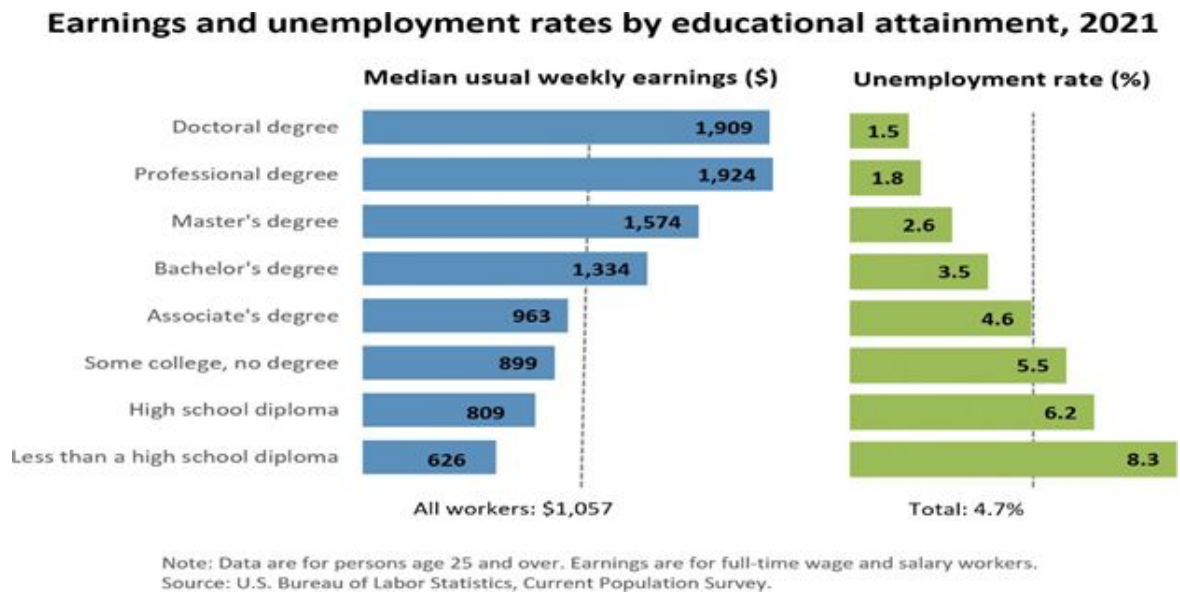


Figure 3. [Earning and Unemployment Rates by Education Attainment](#), 2021 from the U.S. Bureau of Labor Statistics

C4. Projected Supply of Prospective Graduates

While there are few Ph.D. programs in the state that focus specifically on sustainability and environmental change, many programs at the bachelor and master's level provide the education and training necessary for prospective doctoral students in this field. According to MHEC enrollment data, there is evident demand for programs related to sustainability and environmental science/studies and enrollment has remained steady over the period 2017-2021 (see **Table 2**). In addition to these programs, prospective graduate students may also be recruited from cognate programs in biology, ecology, geography, earth sciences, various health sciences, political science and other social sciences, and urban studies or planning. Many such programs are offered across the state and enjoy strong levels of historical enrollment.



Table 2. Enrollment Trends in Bachelor's and Master's programs in Environmental Science/Studies and Sustainability in Maryland (2017-2021)

SCHOOL NAME	DEGREE LEVEL	PROGRAM NAME	2017	2018	2019	2020	2021
Frostburg State University	BACHELORS	ENVIRONMENTAL ANALYSIS & PLANNING	22	22	22	17	3
Salisbury University	BACHELORS	ENVIRONMENTAL STUDIES	159	170	168	147	113
Towson University	BACHELORS	ENVIRONMENTAL SCIENCE AND STUDIES	187	206	208	192	182
Towson University	MASTERS	ENVIRONMENTAL SCIENCE	33	24	23	22	22
University of Baltimore	BACHELORS	ENVIRONMENTAL SUSTAINABILITY	39	32	28	21	14
Univ. of MD, Baltimore	MASTERS	MARINE-ESTUARINE-ENV SC (W/UMBC,UMCP,UMES)	1	0	0	0	1
Univ. of MD, Baltimore County	BACHELORS	ENVIRONMENTAL STUDIES	21	5	5	1	3
Univ. of MD, Baltimore County	BACHELORS	ENVIRONMENTAL SCIENCE	62	19	5	3	6
Univ. of MD, Baltimore County	BACHELORS	GEOGRAPHY AND ENVIRONMENTAL STUDIES	33	48	53	64	53
Univ. of MD, Baltimore County	BACHELORS	ENVIRONMENTAL SCIENCE AND GEOGRAPHY	72	120	134	124	119
Univ. of MD, Baltimore County	MASTERS	MARINE-ESTUARINE-ENV SC (W/UMAB,UMCP,UMES)	0	1	2	3	5
Univ. of MD, Baltimore County	MASTERS	GEOGRAPHY & ENVIRONMENTAL SYSTEMS	10	12	12	14	27
Univ. of MD, College Park	BACHELORS	ENVIRONMENTAL SCIENCE & TECHNOLOGY	220	217	192	173	172
Univ. of MD, College Park	BACHELORS	ENVIRONMENTAL SCIENCE AND POLICY	248	290	283	270	280
Univ. of MD, College Park	MASTERS	ENVIRONMENTAL SCIENCE & TECHNOLOGY	25	20	15	14	12
Univ. of MD, College Park	MASTERS	MARINE-ESTUARINE-ENV SC (W/UMAB,UMBC,UMES)	32	43	47	43	33
Univ. of MD, College Park	MASTERS	ENVIRONMENTAL HEALTH SCIENCES	0	2	2	3	4
Univ. of MD Eastern Shore	BACHELORS	ENVIRONMENTAL SCIENCE	43	40	38	33	39
Univ. of MD Eastern Shore	MASTERS	MARINE-ESTUARINE-ENV SC (W/UMAB,UMBC,UMCP)	13	9	8	8	9
Univ. of MD Global Campus	BACHELORS	ENVIRONMENTAL MANAGEMENT	403	404	391	411	386
Univ. of MD Global Campus	MASTERS	ENVIRONMENTAL MANAGEMENT	219	213	195	176	184
St. Mary's College of Maryland	BACHELORS	ENVIRONMENTAL STUDIES	55	69	73	99	83
Goucher College	BACHELORS	ENVIRONMENTAL STUDIES	31	16	22	21	23
Goucher College	MASTERS	ENVIRONMENTAL STUDIES	4	4	2	1	0
Hood College	BACHELORS	SUSTAINABILITY STUDIES	0	0	0	0	1
Hood College	BACHELORS	ENVIRONMENTAL STUDIES	18	12	11	13	15
Hood College	MASTERS	ENVIRONMENTAL BIOLOGY	39	39	41	28	25
Johns Hopkins University	BACHELORS	GLOBAL ENVRMNTL CHANGE & SUSTAINABILITY	32	18	9	9	8
Johns Hopkins University	BACHELORS	ENVIRONMENTAL SCIENCE	0	14	19	21	16
Johns Hopkins University	MASTERS	GEOGRAPHY & ENVIRONMENTAL ENGINEERING	92	81	75	58	60
Johns Hopkins University	MASTERS	ENVIRONMENTAL ENGINEERING AND SCIENCE	59	46	59	62	51
Johns Hopkins University	MASTERS	ENVIRONMENTAL PLANNING & MANAGEMENT	32	35	28	33	37
Johns Hopkins University	MASTERS	ENVIRONMENTAL SCIENCES AND POLICY	207	205	248	283	254



SCHOOL NAME	DEGREE LEVEL	PROGRAM NAME	2017	2018	2019	2020	2021
Johns Hopkins University	MASTERS	SUSTAINABLE ENERGY	0	0	0	16	41
Loyola University Maryland	BACHELORS	SUSTAINABILITY MANAGEMENT (B.B.A.)	0	0	0	0	16
McDaniel College	BACHELORS	ENVIRONMENTAL STUDIES	33	22	35	35	34
Mount St. Mary's University	BACHELORS	ENVIRONMENTAL SCIENCE	8	2	10	15	14
Stevenson University	BACHELORS	ENVIRONMENTAL SCIENCE	17	19	25	39	25
Washington College	BACHELORS	ENVIRONMENTAL SCIENCE	51	62	48	46	39
Washington College	BACHELORS	ENVIRONMENTAL STUDIES	0	0	0	0	22
TOTALS			2,520	2,541	2,536	2,518	2,431

Source: [Trends in Fall Enrollment by Program 2008-2021, MHEC](#)

D. Reasonableness of Program Duplication

D1. Similar Programs

The proposed Ph.D. in SEC does not substantially overlap with any other doctoral program in Maryland. The interdisciplinary focus and approach of the proposed program, incorporating both the science of environmental change and the study of sustainability, differentiates the TU program from others. None of the existing environmental doctoral programs in Maryland incorporate perspectives from such a broad range of faculty (in the sciences, social and health sciences, economics, humanities, arts and design, etc.). This interdisciplinary focus is illustrated by more than 50 percent of faculty affiliated with the program coming from TU colleges other than the Fisher College of Science and Mathematics, including the College of Liberal Arts, College of Fine Arts and Communication, College of Health Professions, College of Business and Economics, and College of Education (see Appendix D). Specifically, integrated training in social sciences along with environmental sciences will provide SEC students with a combination of skills in critical and analytical thinking and professional competencies that are critical for addressing complex problems. The SEC doctoral program will build on the strength of the undergraduate ENVS program at Towson, which currently enrolls 182 students and includes classes and instructors from four of TU's six academic colleges.

All four of the environmental Ph.D. programs in Maryland—the Environmental Science and Technology Ph.D. at the University of Maryland–College Park, the Marine Estuarine Environmental Sciences (MEES) Ph.D. across multiple USM campuses, the Bio-Environmental Sciences Ph.D. at Morgan State University (MSU), and the Geography and Environmental Systems Ph.D. at the University of Maryland–Baltimore County (UMBC)—appear, in contrast to TU's proposed program, to be strongly focused on the scientific study of environmental systems. For example, MSU's Bio-Environmental Sciences Ph.D. is heavily focused on the biological sciences, with additional electives in chemistry and physics. While UMBC's Geography and Environmental Systems Ph.D. addresses issues in sustainability and ecology, it includes a stronger emphasis on spatial science and geographic information systems (GIS) than TU's proposed program.

TU's proposed Ph.D. in SEC will be listed under the Classification of Instructional Programs



(CIP) code 03.0103 Environmental Studies, which is intended to capture the interdisciplinary nature of TU's program, indicating that it goes beyond a primarily science-based focus. None of the other four environmental Ph.D. programs in Maryland referenced previously use this same CIP code designation, nor does any other doctoral degree program in the state. Instead, three are classified under CIP codes that are reflective of doctoral programs that are predominantly science-based—the University Maryland-College Park's Environmental Science and Technology Ph.D. (03.0104 Environmental Science), USM's MEES Ph.D. (26.1302 Marine Biology and Biological Oceanography), and MSU's Bio-Environmental Sciences Ph.D. (26.1305 Environmental Biology)—whereas UMBC's Geography and Environmental Systems Ph.D. uses the 45.0701 Geography CIP code.

Given the substantial number of undergraduate degrees currently conferred in environmental science and studies in Maryland (see Table 2), which will likely serve as a direct pipeline into the Ph.D. in SEC, as well as the work force demand in the state and the Mid-Atlantic region for those trained in environmental issues, TU believes that the benefits this proposed doctoral program will bring to Maryland and the Mid-Atlantic would outweigh any potential issues of overlap with peer institutions' programs.

Importantly, this vital work to address problems and develop solutions related to climate change and environmental degradation will benefit most from cooperative and collaborative efforts across individuals, fields, and institutions. The proposed Ph.D. in SEC provides added momentum to TU's commitment to the public good and serves as an excellent opportunity to engage with other state institutions to effect meaningful change. To that end, leadership in TU's ENVS Program reached out to the Director of MSU's Bio-Environmental Science Ph.D. program on April 21, 2023, to notify MSU of our interest in developing a new doctoral program in SEC, discuss any potential concerns regarding TU's proposal, and explore possible areas for future collaboration. Following this initial communication, both institutions agreed to continue discussions for collaborative opportunities and further campus visits that would strengthen both programs. As well as engaging with Morgan State University, TU has communicated with our sister USM institutions during the development of the Ph.D. in SEC proposal, resulting in similar, positive interactions. TU envisions this doctoral program as a potential driving force for empowerment of the region's research and education engine to generate a well-trained, collaborative, and connected sustainability workforce.

D2. Program Justification

In the 21st century, Maryland, the Mid-Atlantic, and beyond are faced by “wicked” and complex environmental issues such as climate change, environmental degradation, and restoration of the Chesapeake Bay. The USM [Vision 2030 strategic plan](#) highlights the need for advancing leadership in environmental sciences and deepening the system's reputation for climate change and sustainability research under Priority 4 (Research). The Ph.D. in SEC will graduate individuals with interdisciplinary training and research at a high level that encompasses the natural sciences, social sciences, and beyond. These graduates will be particularly well poised to help address these issues through research, management of relevant scientific and management programs, and effective problem-solving and communication.



E. Relevance to High-demand Programs at Historically Black Institutions (HBIs)

Neither Bowie State University nor Coppin State University offer doctoral degree programs in this field. As outlined in section D1, both the MEES Ph.D. program, which the University of Maryland Eastern Shore (UMES) supports (along with other non-HBI USM institutions), and MSU's Bio-Environmental Sciences Ph.D. program have a much greater science focus than TU's proposed program, and therefore we do not believe that there is a substantive curricular overlap with TU's proposed SEC doctoral degree.

According to [MHEC enrollment data](#), there were 11 and 51 students enrolled respectively in these two Ph.D. programs in 2021, which represents approximately three percent and seven percent of total doctoral student enrollment respectively at UMES and MSU. There are other doctoral programs at UMES (for example, Educational Leadership, Pharmacy, and Physical Therapy) and MSU (for example, Community College Leadership, Engineering, and Public Health) that have much higher enrollments, and therefore the MEES and Bio-Environmental Sciences Ph.D. programs do not appear to be "high demand" programs relative to other doctoral programs at these two institutions.

UMES also offers a corresponding MEES program (again in collaboration with other non-HBI USM institutions) at the master's level, but no other HBI currently offers an environmental-related master's degree. TU anticipates that graduates of the MEES master's degree from UMES who are interested in pursuing a doctoral degree specializing in marine and estuarine environmental science will naturally gravitate toward UMES's MEES doctoral program, and therefore we do not foresee that TU's proposed program will impact enrollments at UMES.

F. Relevance to the Identity of Historically Black Institutions (HBIs)

[MSU's mission](#) commits the institution "to addressing societal problems, particularly those prevalent in urban communities," while [UMES's mission](#) commits it "to serving first-generation and underserved students." TU acknowledges that the purpose of the proposed SEC program does overlap to some extent with the institutional identities of MSU and UMES, since TU's program seeks to diversify the environmental sciences and studies professions, as is reflective of the core values of HBIs. However, TU firmly believes that climate change and environmental issues are so critical to the state, region, and planet, and the need to prepare qualified graduates who can help to address these challenges so urgent and pressing, that this overlap with HBI identities is justifiable. As indicated elsewhere in the proposal, TU regards the development of the Ph.D. in SEC as an opportunity for collaboration with other institutions (both HBI and non-HBI) that can only serve to strengthen the capacity of the entire higher education sector in Maryland to contribute meaningfully toward addressing current environmental challenges and preparing for those that lie ahead.

G. Adequacy of Curriculum Design, Program Modality, and Related Learning Outcomes

G1 Program Development and Faculty Oversight

The curriculum for the Ph.D. in SEC was developed by faculty from multiple colleges, principally the Fisher College of Science and Mathematics and the College of Liberal Arts,



drawing upon faculty members' expertise in environmental science, environmental studies, human-environment interactions, and environmental sustainability. Through an iterative and collaborative process, program requirements, courses, and milestones were discussed by the interdisciplinary team and reviewed for alignment with the proposed degree program and learning outcomes. Faculty members who will oversee the program are identified in Section I1; they are tenured and tenure-track faculty with diverse research and pedagogical expertise in sustainability, environmental change, and related disciplines.

G2. Educational Objectives and Learning Outcomes

The principal educational objective of TU's proposed Ph.D. in SEC is to train graduate students to become interdisciplinary scholars and independent researchers, with depth and breadth of knowledge commensurate with a doctoral-degree holder. Under the mentorship of their dissertation committee, recipients of the Ph.D. in SEC will have made substantial contributions to new knowledge by producing publication-quality research. Moreover, students earning the Ph.D. in SEC will be ready to solve complex environmental problems while forging cross-disciplinary collaborations.

The following are the proposed learning outcomes for students who enroll in the Ph.D. in SEC. Upon completion of the program, students will:

1. Obtain a depth of understanding and technical knowledge in the area(s) of study.
2. Devise novel research questions and design logical approaches to answer these questions.
3. Master methodologies for data collection and analysis necessary for independent research.
4. Generate publication-quality results from their dissertation research.
5. Communicate research findings and sustainability implications efficaciously to diverse audiences.

G3. Assessment and Documentation of Student Learning Outcomes

TU's Office of Assessment within the Division of Academic Affairs coordinates the assessment of student learning outcomes. Assessment of student learning occurs at the course, program, and institutional levels. Assessment includes academic and co-curricular activities. The Office of Assessment works collaboratively with faculty and staff to support analysis and research of TU's curriculum, courses, departments, and programs to improve student learning through effective, faculty- and staff-driven assessment of academic programs and student learning outcomes achievement.

Specifically, the Office of Assessment provides information and resources for assessment, maintains the technological infrastructure to support academic assessment, supports faculty and programs through workshops and consultation, and assists with collection, analysis, and distribution of institutional and programmatic assessment data.



The proposed Ph.D. in SEC will employ a variety of assessment measures appropriate at the doctoral level to assess student learning, including (but not limited to) course papers, presentations, course examinations, and comprehensive examinations. Additional assessment tools include the preparation and defense of a dissertation proposal and, ultimately, a dissertation. **Table 3** summarizes the program's learning outcomes and assessment methods.

Table 3. Learning Outcomes and Assessment Methods

Learning Outcome	Assessment Methods
1. Obtain a depth of understanding and technical knowledge in the area(s) of study.	<i>Measure 1A: Grade in ENVS 701 Science of Environmental Change</i> <i>Measure 1B: Grade in ENVS 702 Sustainability in a Complex World</i> <i>Measure 1C: Successful completion of comprehensive exams</i>
2. Devise novel research questions and design logical approaches to answer these questions.	<i>Measure 2A: Grade in a research methods course</i> <i>Measure 2B: Successful preparation and defense of a dissertation proposal</i>
3. Master methodologies for data collection and analysis necessary for independent research.	<i>Measure 3A: Successful completion of comprehensive exams</i> <i>Measure 3B: Successful preparation and defense of a dissertation</i>
4. Generate publication-quality results from their dissertation research.	<i>Measure 4A: Successful preparation and defense of a dissertation</i> <i>Measure 4B: Publication of at least a portion of the dissertation within 12 months of the dissertation defense</i>
5. Communicate research findings and sustainability implications efficaciously to diverse audiences.	<i>Measure 5A: Inclusion of sustainability implications within the dissertation proposal and the dissertation</i> <i>Measure 5B: Discussion of sustainability implications within the dissertation proposal defense and the dissertation defense</i>

Achievement of student learning outcomes will be documented in a variety of ways. For example, grades earned at the course level will be archived on student transcripts by TU's Office of Records and Registration. Successful preparation and defense of dissertation proposals and dissertations, as well as performance on comprehensive exams, will be documented by the SEC Graduate Program Director and associated academic staff.

Additionally, the final approved version of the dissertation will be submitted to the Office of Graduate Studies and archived in TU's library. More generally, assessment data will be recorded, archived, and tracked over time by the SEC Graduate Program Director, who will also draw on the expertise and resources of TU's Office of Assessment for assistance.

Each year, assessment data will be disseminated to and discussed with affiliated faculty and the Associate Dean in FCSM, who has overall responsibility for assessment within the college. Assessment data will drive discussions of programmatic improvement and enhancement by program leaderships and affiliated faculty.



G4. Program Requirements

This Ph.D. degree is a 60-credit, in-person program designed to be completed primarily via full-time study. Students may matriculate into the program after completing either a bachelor's or a master's degree in a discipline related to SEC (e.g., environmental science/studies, biology, chemistry, geography, geology, and health sciences, among others). Students with a master's degree may transfer up to 24 credits of relevant coursework into the Ph.D. program; transferred credits are subject to the approval of the SEC Graduate Program Director and will typically count as electives. Courses will be taught predominantly in-person on the main TU campus. Admitted students will be offered financial support in the form of a fellowship, research assistantship, and/or teaching assistantship so they can focus on their academic development throughout the degree program.

Program requirements include three foundation courses (nine credits), three semesters of the seminar course (three credits), elective courses (≥ 24 credits), a dissertation proposal (three credits), and dissertation research (≥ 21 credits). See below for a program outline, with course descriptions included in Appendix B and a year-by-year example program of study in Appendix C.

- **Seminar Course** (three credits): *ENVS 600 Environmental Science and Sustainability Colloquium* (one credit, must be repeated at least three times)
- **Foundation Courses** (nine credits): These courses cover fundamental scientific and social principles of SEC, as well as research tools germane to Ph.D. students.
 - **Scientific Principles** (three credits; *ENVS 701 Science of Environmental Change*)
 - **Social Principles** (three credits; *ENVS 702 Sustainability in a Complex World*)
 - **Research Methods** (three credits; see Appendix B for course options)
- **Elective Courses** (at least 24 credits with six to eight credits of broadening coursework; see Appendix B for course options)
- **Dissertation Proposal** (three credits): *ENVS 990 Dissertation Proposal*)
- **Dissertation Research** (at least 21 credits): *ENVS 997 Dissertation Research*)

Students will each identify and secure the commitment of a faculty mentor to serve as the dissertation advisor, who will also chair the student's dissertation committee. Dissertation committees will consist of a minimum of four faculty members, including the dissertation advisor. At least one member of the dissertation committee must have a primary appointment in a different college from that of the dissertation advisor; this requirement can be satisfied by having a dissertation committee member from another institution. All members of the dissertation committee must have graduate faculty (or associate graduate faculty) status as prescribed by the TU Office of Graduate Studies.

Dissertation committees will evaluate student performance regarding the preparation and defense of the dissertation proposal and the dissertation, in addition to the comprehensive exams. Upon successful completion of the dissertation proposal, the dissertation committee



is required to meet at least once every 12 months with the Ph.D. candidate. In addition to offering guidance to the Ph.D. candidate to promote timely degree completion, the dissertation committee is also charged with ensuring that the Ph.D. candidate receives satisfactory mentoring and guidance from the dissertation advisor.

G5. General Education Requirements

Not applicable.

G6. Specialized Accreditation and Certification

Not applicable.

G7. Outside Contracts

Not applicable.

G8. Program Information Assurances

A handbook will be provided to all incoming Ph.D. students outlining program policies, program curriculum and requirements, student expectations, technology requirements, campus supports and resources, and financial aid information. Students will provide a signature assuring their review and comprehension of the handbook's contents prior to the start of coursework. This handbook will be reviewed and updated on a regular basis to reflect changes in the program, support and resources, etc. For prospective students, the current version of the handbook will also be available on the program website.

G9. Advertising, Recruiting, and Admissions Materials Assurances

TU regularly reviews its advertising, recruiting, and admissions materials to ensure that they clearly and accurately represent programs and services available, and that there is consistency across different modes of communication such as the TU website, the academic catalog, other print and online promotional materials, etc. More specifically, a tenured or tenure-track faculty member will be appointed as SEC Graduate Program Director by the Dean of FCSM. Working in collaboration with the Office of Graduate Studies, the SEC Graduate Program Director will oversee recruitment, communicate with prospective students, supervise academic advising of enrolled students, and monitor student progress during their time in the program. As noted above, a student handbook will be available on the website to provide clear and accurate program information. An admissions committee of interdisciplinary faculty members will conduct annual evaluation of applications and issue admissions decisions using a pre-established, wholistic review framework based on existing doctoral program guidelines at TU.

H. Adequacy of Articulation

Not applicable.



I. Adequacy of Faculty Resources

I1. Quality of Program Faculty

TU's Environmental Science and Studies Program currently has an interdisciplinary leadership/administrative team that consists of four faculty (**Table 4**), a cadre of nine "guidance" faculty who are actively engaged in program leadership and well positioned to mentor doctoral students (**Table 5**), and 31 additional affiliated faculty across six colleges at the university who teach program-relevant courses and advise undergraduate and graduate ENVS students (**Table 6**). None of these faculty is appointed to the ENVS Program full-time, and all but the leadership team offer courses and advise students with the support of their home departments.

ENVS faculty includes some of the most productive at the institution, in terms of both external grants and publications, and enjoy a long history of interdisciplinary collaboration in the program. **Tables 4-6** list all current full-time ENVS-affiliated faculty, along with their home department, rank, and field of study. All tenured and tenure-track faculty have a doctoral degree (or other terminal degree) in relevant disciplines and conduct research in areas related to sustainability and/or environmental change. All faculty are eligible to serve as mentors and/or dissertation committee members. Due to most courses in the Ph.D. in SEC being either electives and/or housed administratively in other TU colleges, at this time it has yet to be determined which specific courses will be taught by individual faculty members.

Despite this sizable pool of faculty expertise, development of faculty resources to support the doctoral program is necessary. ENVS currently has zero contracted faculty lines, apart from administrative appointments among the leadership team. This proposal therefore includes a request for five new full-time faculty lines across ENVS-affiliated departments and colleges at TU, reflecting a minimum of 2.5 new faculty FTEs (five faculty with a 50 percent commitment to SEC), plus a full-time lecturer, who will be reallocated from existing resources (see Adequacy of Financial Resources below). These faculty would directly support, or indirectly offset, existing faculty workload for new course development, research enhancement, and mentoring of doctoral students. New faculty lines would reflect both internal demand and the projected supply of prospective doctoral students (see above) with targeted hires in the Fisher College of Science and Mathematics, the College of Liberal Arts, and the College of Health Professions. Faculty hires will occur during Years 2 through 4 of the proposed program.

**Table 4. ENVS Leadership Team**

Faculty Name and Highest Degree Earned	Home Department	Rank and Program Title	Field of Study
Chris Salice, Ph.D.	Dept. of Biological Sciences	Professor Director, Environmental Science & Studies Interim Dean, Fisher College of Science & Mathematics	Applied ecology; ecotoxicology; population dynamics
Joel Moore, Ph.D.	Dept. of Physics, Astronomy & Geosciences	Professor Interim Director, Environmental Science & Studies	Climate and the Earth's surface; carbon sequestration, soil and water quality; ecosystem sustainability
Sya Burynd Kedzior, Ph.D.	Dept. of Geography and Environmental Planning	Associate Professor Assistant Director, Environmental Science & Studies	Political ecology; environmental social movements; environmental knowledge studies
John Sivey, Ph.D.	Dept. of Chemistry	Professor Director, Environmental Science Graduate Programs	Analytical chemistry; aquatic chemistry; environmental organic chemistry

Table 5. ENVS Guidance Faculty

Faculty Name and Highest Degree Earned	Home Department	Rank	Field of Study
Michael Allen, Ph.D.	Dept. of Geography and Environmental Planning	Assistant Professor	Climatology; meteorology; public health cognate
Vanessa Beauchamp, Ph.D.	Dept. of Biological Sciences	Professor	Plant community ecology; wetland ecology; restoration; invasive species
Ryan Casey, Ph.D.	Dept. of Chemistry	Professor	Environmental chemistry; environmental toxicology; impacts of urban stormwater
Nicole Fabricant, Ph.D.	Dept. of Sociology, Anthropology, and Criminal Justice	Professor	Political economy; race/ethnicity and class; social movements; resource politics
Brian Fath, Ph.D.	Dept. of Biological Sciences	Professor	Systems ecology; network analysis; sustainability; environmental assessment
Jillian Fry, Ph.D.	Dept. of Health Sciences	Assistant Professor	Sustainable and healthy food systems; environmental health and environmental justice; public health policy
Sarah Haines, Ph.D.	Dept. of Biological Sciences	Professor	Science education; environmental education
Martin Roberge, Ph.D.	Dept. of Geography and Environmental Planning	Professor	Physical geography; hydrology; geomorphology; environmental applications of GIS
Jeremy Tasch, Ph.D.	Dept. of Geography and Environmental Planning	Professor	Political ecology of resource development

**Table 6. ENVS Affiliated Faculty**

Faculty Name and Highest Degree Earned	Home Department	Rank	Field of Study
Andrea Brace, Ph.D.	Dept. of Health Science	Associate Professor	Healthy eating behaviors among college students; stealth interventions; GIS mapping; worksite health promotion
Harald Beck, Ph.D.	Dept. of Biological Sciences	Professor	Mammal-plant interactions; tropical ecology
Alice Besterman, Ph.D.	Dept. of Biological Sciences	Assistant Professor	Coastal ecology
John Bullock, Ph.D.	Dept. of Political Science	Lecturer	Community development; public policy and planning
Michelle Casey, Ph.D.	Dept. of Physics, Astronomy and Geosciences	Assistant Professor	Invertebrate paleontology; conservation paleobiology
Caitlin Ceryes, Ph.D.	Dept. of Health Sciences	Assistant Professor	Environmental health and exposure sciences; environmental sustainability
Jacqueline Doyle, Ph.D.	Dept. Of Biological Sciences	Associate Professor	Conservation and population genetics
Natalia Fath, Ph.D.	Dept. of Geography and Environmental Planning	Lecturer	Landscape responses to climate and land-use/land cover changes; human dimensions of climate change
Laura Gough, Ph.D.	Dept. of Biological Sciences	Professor	Plant ecology
Sarah Gunning, Ph.D.	Dept. of English	Associate Professor	Technical writing; science writing
David Hearn, PhD.	Dept. of Biological Sciences	Associate Professor	Evolutionary, developmental, and ecological processes responsible for land plant diversity
Kimberly Hopkins, M.F.A.	Dept. of Art + Design, Art History, Art Education	Assistant Professor	Graphic design; materials
Kathryn Kautzman, Ph.D.	Dept. of Chemistry	Associate Professor	Analytical chemistry; atmospheric chemistry
Todd Kenreich, Ph.D.	Dept. of Secondary and Middle School Education	Professor	Environmental education; geographic education
John LaPolla, Ph.D.	Dept. of Biological Sciences	Professor	Systematics and taxonomy of ants
Kang Shou Lu, Ph.D.	Dept. of Geography and Environmental Planning	Professor	GIS; land use modeling; urban and regional planning
James Manley, Ph.D.	Dept. of Economics	Professor	Development economics; natural resource economics; health economics
Clare Muhoro, Ph.D.	Dept. of Chemistry	Professor	Environmental organic chemistry; science policy
Jay Nelson, Ph.D.	Dept. of Biological Sciences	Professor	Evolutionary physiology; physiological ecology of fishes
Karen Oslund, Ph.D.	Dept. of History	Professor	Environmental history; history of science and technology
David Ownby, Ph.D.	Dept. of Chemistry	Professor	Environmental chemistry; ecotoxicology



Faculty Name and Highest Degree Earned	Home Department	Rank	Field of Study
Makmiller Pedroso, Ph.D.	Dept. of Philosophy and Religious Science	Associate Professor	Philosophy of science; philosophy of biology
Thomas Rhoads, Ph.D.	Dept. of Economics	Professor	Applied microeconomics; environmental economics
Robert Rook, Ph.D.	Dept. of History	Professor	Environmental history, diplomatic and military history
Wilbur (Will) Ryan, Ph.D.	Dept. of Biological Sciences	Assistant Professor	Evolutionary ecology; climate change effects in marine invertebrates
Stephen Scales, Ph.D.	Dept. of Philosophy and Religious Science	Professor	Ethics; philosophy of science
Shannon Stitzel, Ph.D.	Dept. of Chemistry	Associate Professor	Analytical chemistry
Paporn Thebpanya, Ph.D.	Dept. of Geography and Environmental Planning	Professor	Physical geography; map design; applied GIS
David Vanko, Ph.D.	Dept. of Physics, Astronomy and Geosciences	Professor	Igneous and metamorphic petrology; public policy surrounding high-volume hydraulic fracturing and climate change
Chuyuan Wang, Ph.D.	Dept. of Geography and Environmental Planning	Assistant Professor	Remote sensing; GIS applications; urban climate and environment
Donn Worgs, Ph.D.	Dept. of Political Science	Professor	American politics; urban politics; community development

12. Ongoing Faculty Training

The Faculty Academic Center of Excellent at Towson (FACET) is Towson University's faculty development center. FACET's mission is to support an inclusive and collaborative faculty community and foster a culture of excellence in scholarship and teaching. FACET supports faculty through a combination of programs, resources, funding, and access to partners across campus. All faculty have access to programs, workshops, meetings, and conferences to support pedagogy that meets the needs of students. Working in collaboration with the Office of Technology Services, FACET also recommends, reviews, and provides programs to support faculty development and advancing skills with Blackboard, TU's learning management system. FACET provides one-on-one or small group, virtual or face-to-face meetings with an instructional design team, who also perform course reviews. Faculty may attend open meetings as well as request consultation from FACET staff.

J. Adequacy of Library Resources

Resources available through TU's [Cook Library](#) are sufficient to meet the needs of students and faculty in the proposed program. The library houses an extensive collection of materials, including more than 500,000 print and electronic volumes. In addition to a dedicated subject librarian, team of research librarians, and subject-specific research guides, the library provides access to 19 environmental science and studies subject-specific databases, such as GreenFILE, Scopus, ScienceDirect, JoVE Science Education Unlimited, JSTOR, and



SpringerLink. Cook Library also houses computer workstations with specialty software for data analysis, data visualization and mapping, as well as a dedicated reading room for graduate students.

In addition to Cook Library, faculty and students have access to materials through reciprocal agreements at nearby Baltimore institutions and across USM-affiliated institutions. Materials from other libraries across the country can be requested for loan through standard interlibrary loan (ILL) services. As part of this service, faculty and students have access to RAPID ILL, a service customary at high research activity institutions. The current turnaround time for article requests is typically less than 48 hours.

K. Adequacy of Physical Facilities, Infrastructure, and Instructional Equipment

K1. Assurance of Physical Facilities, Infrastructure and Equipment

TU's existing physical facilities, infrastructure and instructional equipment are sufficient to support the needs of the program. The proposed Ph.D. program will be administratively housed in the Fisher College of Science and Mathematics. TU opened the 320,000 square foot Science Complex building in 2021. The Science Complex includes new research laboratory facilities and instrumentation for analysis of environmental samples, ecotoxicological experiments, DNA analysis, and much more that will support Ph.D. students whose research includes experimental approaches. Additionally, TU has invested in expanded staff support by hiring five new positions to oversee research and teaching instrumentation and facilities. These new staff join the long-term staff position and cross-department support of research through the facilities of the Urban Environmental Biogeochemistry Laboratory.

Faculty involved in the program residing in other colleges are housed in modern facilities well suited for support of Ph.D. students--for example, the College of Liberal Arts building (completed in 2012) and the College of Health Professions building (\$185 million, 240,000 square foot building scheduled for completion in 2024). Additionally, the Smith building, the former home of the ENVS and other natural sciences programs and departments, has substantial renovations planned (scheduled for completion in 2025) that will include some facilities and space that will support the Ph.D. in SEC, particularly related to the space formerly occupied by the Urban Environmental Biogeochemistry Laboratory (~\$2 million space completed in 2012 that was partially funded with \$1.3 million in federal grants).

K2. Assurance of Distance Learning Resources

The proposed program is designed to be delivered in-person via traditional modes of face-to-face instruction. If distance learning resources are required, whether in an individual course or on a broader scale, TU is well positioned to provide adequate support.

The Faculty Academic Center of Excellence at Towson (FACET) offers training and certification programs for online and hybrid/blended instruction, Universal Design for Learning (UDL), and effective pedagogical approaches for enriching distance learning (including the Quality Matters Rubric). Both students and faculty can enroll in training modules that provide instruction in university-sponsored distance learning technologies,



including Blackboard, WebEx, Zoom, and Panopto. Technology support is available online, as well as via email, text, phone and on a walk-in basis at Student Computing Services and the Office of Technology Services.

L. Adequacy of Financial Resources with Documentation

With a formal shift in university mission to recognize research as a core component, Towson University is investing in doctoral research programs in areas of faculty specialization and research. The Ph.D. in SEC has adequate resources to meet the needs of starting this interdisciplinary program but will also require new faculty lines to provide necessary course content and, especially, mentoring and research enhancements. This degree program will be funded with existing resources, new graduate student funding, university R2 investment funds, and reallocated faculty effort from FCSM, the College of Liberal Arts, and the College of Health Professions. The majority of graduate courses already exist in focused areas such as ecology, environmental geography, sustainability, and research methods. A minimum of three existing faculty FTEs (~12 faculty with a 25 percent commitment to SEC), a Graduate Program Director, and administrative staff support will be reallocated from existing funds to support this program (**Table 7**).

Expenditures for the program include 3.5 faculty FTEs, to include five tenure-track research faculty (with a 50 percent commitment to SEC) and one lecturer who will support research faculty teaching in the program. Administrative support is also needed to be hired in year 2 to provide support to faculty, students, and SEC leadership. Faculty hires will occur during Years 2 through 4 of the proposed program. In addition to faculty resources, graduate assistantships for full-time doctoral students, library resources, operating, and faculty scholarship travel funds are requested (**Table 8**). As the program unfolds, TU anticipates the university's commitment to and investment in the strategic goal of achieving R2 Carnegie Classification, tuition and fees, and grant/fee-for-service activities, to provide adequate funding support.

Table 7. Programmatic Resources

Resources Categories	(Year 1)	(Year 2)	(Year 3)	(Year 4)	(Year 5)
1. Reallocated Funds	\$509,730	\$611,634	\$687,998	\$703,979	\$720,440
a. Reallocated Funds-Faculty Support ¹	\$354,450	\$456,354	\$532,718	\$548,699	\$565,160
b. Reallocated Funds-Admin Staff Support ^{1,2}	\$5,280	\$5,280	\$5,280	\$5,280	\$5,280
c. Reallocated Funds-University R2 Investment ³	\$150,000	\$150,000	\$150,000	\$150,000	\$150,000
2. Tuition/Fee Revenue^{3,4}	\$46,224	\$107,124	\$183,892	\$265,171	\$299,135
Number of Full-time Students	4	9	15	21	23
In-State	4	9	15	21	23
Out of State	0	0	0	0	0
Annual Tuition Rate In-State ⁵	\$8,676	\$8,936	\$9,204	\$9,480	\$9,765
Subtotal Tuition	\$34,704	\$80,427	\$138,061	\$199,083	\$224,581



Resources Categories	(Year 1)	(Year 2)	(Year 3)	(Year 4)	(Year 5)
Student Fees	\$2,880	\$2,966	\$3,055	\$3,147	\$3,241
3. Grants, Contracts & Other Sources	\$0	\$0	\$0	\$0	\$0
4. Other Sources	\$0	\$0	\$0	\$0	\$0
TOTAL (Add 1 - 4)	\$555,954	\$718,758	\$871,890	\$969,150	\$1,019,575

¹ Re-allocated funds are based on incumbent faculty FTEs dedicated to the proposed program with salary and fringe rates. Salary and fringe rates increase by three percent annually.

² This is a Graduate Program Director position.

³ University funds will be reallocated and invested in this program to support of the TU strategic priority to achieve R2 Carnegie Classification.

⁴ Student enrollments are calculated at 100 percent in-state because all students in the program will be research or graduate assistants. It is anticipated that all students will enroll on a full-time basis.

⁵ Tuition and fees increase by three percent annually.

Please note that Tables 7 and 8 project that the proposed program will operate with small deficits in Years 4 and 5, which is not an uncommon scenario for Ph.D. programs. TU recognizes that the establishment of this research program will require upfront investment. The university plans to support the program continually with designated strategic R2 investment dollars and anticipates that, once established, the program will draw indirect costs from extramural grants. These two additional revenue streams should ensure that the program operates at a minimum on a revenue-neutral basis and remains financially viable after Year 5.

Table 8. Programmatic Expenditures

Expenditure Categories	Year 1	Year 2	Year 3	Year 4	Year 5
1. Total Tenure Track Faculty Expenses (b + c below)	\$0	\$111,200	\$229,072	\$294,930	\$303,778
a. #FTE	0	1	2	2.5	2.5
b. Total Salary ¹	\$0	\$80,000	\$164,800	\$212,180	\$218,545
c. Total Benefits (39% fringe rate)	\$0	\$31,200	\$64,272	\$82,750	\$85,233
2. Total Lecturer Expenses (b + c below)	\$73,670	\$75,880	\$78,157	\$80,501	\$82,916
a. #FTE	1	1	1	1	1
b. Total Salary ¹	\$53,000	\$54,590	\$56,228	\$57,915	\$59,652
c. Total Benefits (39% fringe rate)	\$20,670	\$21,290	\$21,929	\$22,587	\$23,264
3. Admin Support (b + c below)	\$0	\$69,500	\$71,585	\$73,733	\$75,945
a. Admin salary ¹	\$0	\$50,000	\$51,500	\$53,045	\$54,636
b. Admin Benefits (39% fringe rate)	\$0	\$19,500	\$20,085	\$20,688	\$21,308
4. Equipment	\$0	\$0	\$0	\$0	\$0
5. Library²	\$30,000	\$30,000	\$30,000	\$30,000	\$30,000
6. New or Renovated Space	\$0	\$0	\$0	\$0	\$0



Expenditure Categories	Year 1	Year 2	Year 3	Year 4	Year 5
7. Other Expenses (a + b + c + d below)	\$171,704	\$297,427	\$451,066	\$608,090	\$665,593
a. Travel	\$10,000	\$10,000	\$10,000	\$10,000	\$10,000
b. Program Support/Operating	\$25,000	\$25,000	\$25,000	\$25,000	\$25,000
c. Tuition Waiver	\$34,704	\$80,427	\$138,066	\$199,090	\$224,593
d. Student Stipends ³	\$102,000	\$182,000	\$278,000	\$374,000	\$406,000
TOTAL (1-7)	\$275,374	\$584,007	\$859,880	\$1,087,254	\$1,158,232

¹ Salaries increase by three percent per year.

² Yearly ongoing subscriptions of \$30,000.

³ Doctoral student assistantships (two fellowships; remaining assistantships per program cohort – this represents a high-end estimate as TU anticipates some students will be supported from external funding).

M. Adequacy of Provisions for Evaluation of Program

M1. Procedures for Evaluating Courses, Faculty and Student Learning Outcomes

Course evaluation begins during the initial development of the course in the curricular review process. Course proposals are evaluated for:

- Appropriateness of course difficulty and workload.
- Effective assessment and grading practices in the course.
- Course syllabus consistency with the guidelines established by TU, which reflect best practices in course development.

These elements of a course are reviewed by the program, the FCSM curriculum committee, and the University Curriculum Committee. The primary focus at the program level is to ensure course content accuracy and program alignment, the focus at the college and university level is to facilitate the production of quality course proposals. In addition, college and university level reviews include addressing any resource issues, determining if conflicts exist between departments/colleges.

Existing courses are evaluated through regular review by program faculty and student evaluations. Faculty regularly review courses to determine if the course meets overall program objectives. Additionally, instructors are observed by peers on a routine basis, with more frequent observations if faculty are new to a course or the university. If a course review indicates concerns or problems with a course, faculty work to develop strategies for addressing/rectifying problems. Student course evaluation takes place at the end of every semester. Using a tool developed by TU faculty that allows for quantitative and qualitative feedback, students give feedback on instructors (e.g., ability to communicate clearly; quality of student- instructor interaction; preparedness) and suggest “improvements” for a course.

Evaluation of faculty takes place using policies and procedures established by TU’s promotion and tenure/reappointment committees and merit evaluation process. This evaluation occurs at the department, college, and university level. The main areas of evaluation include teaching, scholarship, and service. Tools used as part of the annual evaluation process include review of the individual’s portfolio that includes, but is not limited to, the following:



- Evidence of scholarship (e.g., articles in scholarly journals; presentations at scholarly meetings).
- Service work.
- A synopsis of teaching related-activities (e.g., courses taught; new instructional procedures; interdisciplinary, diversity, international, and technology-related projects).
- Review of course syllabi.
- Peer teaching observation reports.
- Quantitative and qualitative student evaluation of instruction.

Section G3 outlines the various assessment measures that will be employed throughout the program and shows their alignment with specific student learning outcomes. For the dissertation research courses, student achievement is assessed via the preparation and oral defense of the dissertation proposal and dissertation, whereas in the traditional instructor-led courses, assessment measures exist for each learning outcome. On an annual basis, specific learning outcomes are identified for assessment purposes. The SEC Graduate Program Director, with the support of TU's Office of Assessment, will oversee the processes involved in the assessment of student learning outcomes, including collection and analysis of data, and creation of action plans, as necessary.

M2. Evaluation of Program Educational Effectiveness

The assessment of this program will be guided by the university's Office of Assessment, following established TU policies and procedures, including review of the program's assessment plan to ensure that learning outcomes remain appropriate, and students are meeting expectations. The program will work closely with multiple units within TU, such as the Office of the Provost, Enrollment Services, Student Services, etc., to review data on a regular basis (e.g., each semester or annually) and, when needed, develop action steps or plans to improve the program. Effectiveness will be assessed in relation to student retention, progress toward degree completion, career outcomes for graduates, student and faculty satisfaction, cost-effectiveness, and other key performance indicators.

Additionally, TU will conduct a comprehensive evaluation of the Ph.D. program every seven years as part of the USM-mandated Periodic Review of Academic Programs process. The purpose of the review is to promote continuous program improvement and ensure that the needs of students are being met. Each program will prepare a self-study, engage an external reviewer to evaluate the program and identify strengths and areas for improvement, and submit a final report to the USM Board of Regents for review and approval.

N. Consistency with the State's Minority Student Achievement Goals

TU has a strong record of a commitment to diversity, equity, and inclusion principles. This is evidenced by the fact that Towson is only one of a handful of universities in the country to have no achievement gap, meaning that underrepresented student groups achieve the same or better academic success as the entire student population. In 2020, the university introduced its inaugural Diversity Strategic Plan. The plan, "*A More Inclusive TU: Advancing*



Equity and Diversity (2020–25),” which is firmly grounded in the premise that TU's ongoing success is dependent on the university's capacity to shift perspectives and approaches and strategically place diversity, equity, and inclusion at the core of its mission. Diverse faculty recruitment is a TU institutional goal and faculty recruitment at the University is designed to reach and attract a diverse pool of candidates. Through diverse faculty recruitment, TU strives to foster a learning community that reflects the population of our campus, region, and state, and supports recruitment and retention of a diverse student population along with academic achievement of students from minority and underrepresented backgrounds.

The proposed Ph.D. in SEC aligns with TU's Diversity Strategic Plan by providing opportunities for students and faculty to address diversity, equity, inclusion, and justice (DEIJ) in the curriculum, through interdisciplinary studies, and through engagement with the complex challenges associated with sustainability and environmental change. In the curriculum, the required core course *ENVS 702: Sustainability in a Complex World* would explore human responses to environmental change and human dimensions of sustainability, including differential impacts and responsibilities borne by individuals and communities in the pursuit of sustainability. Other courses include a significant DEIJ-related focus or emphasis, including graduate seminars and electives like *GEOG 624: Geographies of Consumption and Waste* or *WMST 545: Women, Environment and Health*. The ENVS Program boasts 47 affiliated faculty across all TU colleges and represents a significant spectrum of expertise and approaches related to the study of sustainability and environmental change. These faculty respond to Goal 3.1.2 from the Diversity Strategic Plan to “foster a spirit of collaboration across units.”

As an interdisciplinary program targeted at students with academic backgrounds in the natural, physical, and social sciences, the Ph.D. in SEC would be well positioned to recruit students interested in studying sustainability from a variety of perspectives and pursuing research-related careers in a wide range of fields. The program anticipates recruiting students into the doctoral program from TU's diverse undergraduate population and from institutions across and outside of the state. Indeed, the SEC program will be well positioned to help diversify the regional environmental workforce which, historically, is racially homogenous.

Maryland's HBIs offer a number of master's-level programs graduating students prepared for entry into the proposed Ph.D. program, including the M.S. in Applied Molecular Biology and Biochemistry at Coppin State University, the Master's in City and Regional Planning (MCRP) and Master of Public Health (MPH) at Morgan State University, and the M.S. in Marine-Estuarine-Environmental Sciences at the University of Maryland Eastern Shore, in addition to other undergraduate programs across the HBIs. Collaboration between TU and Maryland's HBIs in advertisement and recruitment for the proposed program will enhance the diversity of the program's student body and aligns with the state's goal to increase minority student achievement, as well as fostering collaboration among institutions.

O. Relationship to Low Productivity Programs Identified by the Commission

Not applicable.



P. Adequacy of Distance Education Programs

Not applicable. The majority of courses will be delivered on the main TU campus via face-to-face instruction. Following the COVID-19 pandemic, some classes have been offered with hybrid components, with some sessions scheduled on campus and others delivered synchronously or asynchronously online. Should faculty develop new hybrid courses, the Faculty Academic Center for Excellence at Towson (FACET) has both training and certification processes in place to assure that courses meet quality standards and faculty maintain access to updated evidence-based resources and techniques for designing and delivering effective online and hybrid courses.



Appendix A. Relevant Program Summaries^[1]

University System of Maryland (University of Maryland College Park, University of Maryland Center for Environmental Science, University of Maryland Eastern Shore, University of Maryland at Baltimore, and University of Maryland, Baltimore County)

Master's and Doctorate in Marine, Estuarine, and Environmental Science (MEES)

The MEES graduate program is an interdisciplinary environmental science program supported by multiple partner campuses across the University System of Maryland. Aimed toward graduate students with research interests in fields of study that involve interactions between biological, physical, and chemical systems in the marine, estuarine, freshwater, or terrestrial environments, the MEES curriculum is designed around four interdisciplinary foundational areas: (1) environment and society; (2) earth and ocean sciences; (3) ecological systems; and (4) environmental molecular science and technology. Most classes in the 30-unit master's or 36-unit doctoral curriculum are offered via distance using interactive video technology.^[2] In 2019-2020, 57 students were enrolled in the master's program and 83 enrolled in the doctoral program across all five institutions.

Goucher College

Master's in Cultural Sustainability (MACS)

The MACS program emphasizes professional development for future community leaders by bringing together knowledge from anthropology, history, folklore, ethnomusicology, communications, business and management, linguistics, and activism to teach students how to effect positive, community-driven change. The 42-unit master's program combines required courses in cultural sustainability, policy, and community-based research design, along with elective courses in cultural sustainability and management.^[3] In 2019-2020, the program enrolled 16 graduate students.

Master's in Environmental Sustainability and Management (MAES)

Previously the Master's in Environmental Studies, the MAES' interdisciplinary online program is designed for working professionals preparing for environmental careers in the public and private sector. The program promotes systems thinking as a framework for examining environmental threats and devising management solutions.^[4] The 36-unit curriculum emphasizes systems science, policy, and management. In 2019-2020, the program enrolled two students.

Hood College

Master's in Environmental Biology

The Master's in Environmental Biology is designed to develop the knowledge and skill sets of environmental professionals and educators in research or non-research tracks. The 33-unit program provides a foundation in ecology, pollution biology, resource management and biostatistics with electives that allow students to tailor the program to their own needs.^[5] In 2019-2020, the program enrolled 41 master's students.



Johns Hopkins University

Graduate/Post-Baccalaureate Certificate in Climate Change, Energy and Environmental Sustainability

The certificate program is targeted toward professionals working in the public and private sectors, including engineers, scientists, and managers, who work in climate change, energy planning, alternative energy technologies, and transportation. The online curriculum consists of five courses in management, science, and technology. In 2019-2020, there were zero students enrolled in the certificate program.

Graduate/Post-Baccalaureate Certificate, Post-Master's Certificate, and Master's in Environmental Planning and Management

The Environmental Planning and Management program emphasizes the relationship between environmental engineering, science, and public policy analysis, with an emphasis on the role of economic factors in the planning and management of environmental resources. Curriculum for both the graduate and post-master's certificates require five courses in environmental engineering, planning, and management. Curriculum for the master's program requires ten courses and includes additional courses in ecology, chemistry, and biology.^[6] In 2019-2020, there were 28 students enrolled in the master's program and one student enrolled in the post-baccalaureate certificate program.

Master's in Environmental Sciences and Policy (ES)

The MS-ES program focuses on environmental policy as it relates to business, politics, and ethics. The 30-unit curriculum includes six focus areas: conservation biology, international environmental policy, sustainability, climate and energy, remediation, compliance, and assessment, and environmental justice and equity.^[7] In 2019-2020, there were 248 students enrolled in the graduate program.

Master's in Energy Policy and Climate (EPC)

The MS-EPC program prepares students to shape energy policies for a sustainable future. The 30-unit curriculum includes five optional focus areas in energy, climate change, policy, social perspectives in climate and energy, and modeling.^[8] In 2019-2020, there were 108 students enrolled in the graduate program.

Morgan State University

Post-Baccalaureate Certificate in Sustainable Urban Communities

The online post-baccalaureate certificate program is aimed toward professionals in urban design and management. The 15-unit program includes core courses in sustainable urban communities and concentration courses in community, design and construction, or the natural systems in urban areas.^[9] In 2019-2020, there were zero students enrolled in the graduate program.

Doctorate in Bio-Environmental Sciences

The doctoral program in bio-environmental sciences examines the interactions between



biological systems and the environment and emphasizes the use of innovative applied research tools and fundamental research. Curriculum in the program's standard track requires 60-units, while the accelerated track (for students who already possess a master's degree) requires 36-units, with core courses in bioenvironmental sciences, biotechnology, bioethics, and chemistry.^[10] The program provides a list of electives from subject areas such as environmental biology, environmental chemistry, environmental ecology, environmental health science, environmental biophysics, and bioinformatics and computational biology. In 2019-2020, there were 24 students enrolled in the doctoral program.

Towson University

Post-Baccalaureate Certificate and Master's in Environmental Science

The graduate program in environmental science (ENVS) is an interdisciplinary program with core courses taught by biologists, geologists, and chemists. The program seeks to provide students with the ability to collect and evaluate geological, chemical, and ecological data associated with creating and resolving solutions to the most pressing environmental issues and problems currently faced by metropolitan areas. The 18-units post-baccalaureate and 30-unit master's curriculum are structured around core courses in environmental geology, chemistry, law, and ecosystem ecology, with focus areas in water resource management and assessment, biological resources management, wetlands assessment and management, and environmental spatial analysis.^[11] In 2019-2020, there were zero students enrolled in the post-baccalaureate program and 23 students enrolled in the master's program.

Master's in Geography and Environmental Planning

The master's in Geography and Environmental Planning combines comprehensive studies of physical and human geography with an emphasis on global skills and geographic techniques. The 36-unit curriculum includes required courses in geographic theory and research design along with specializations along with electives in eight areas of specialization: area studies, geographic information systems, cartography, environmental and urban planning, environmental assessment, energy resources, policy issues, and urban studies. In 2019-2020, 14 students were enrolled in the master's program.

University of Maryland Global Campus

Master's in Environmental Management

The Global Campus' fully online graduate program in environmental management is aimed at mid-career professionals looking to enhance decision-making skills and gain practical experience in environmental management. The 36-unit master's program follows a strict program of study including 12 required courses in environmental systems, communications, law and policy, auditing, risk assessment, and various aspects of management.^[12] In 2019-2020, 195 students were enrolled in the master's program.

University of Maryland, Baltimore County

Master's and Doctorate in Geography and Environmental Systems (GES)

The GES graduate programs work at the interface between natural science, social science,



public policy, engineering, and information technology. Curriculum for both the 30-unit master's program and the 44-unit doctoral program includes required courses in geography and environmental systems, research methods, GIS, statistics, and a department seminar, along with electives in social science methods, remote sensing, computation methods and modeling, or environmental science field and laboratory methods.^[13] In 2019-2020, 12 students were enrolled in the master's program and 20 students were enrolled in the doctoral program.

University of Maryland, College Park

Master's and Doctorate in Environmental Science and Technology (ENST)

The graduate programs in ENST allow students to work in one of four areas of specialization: soil and watershed sciences, ecological technology design, wetland science, and ecosystems health and natural resource management. The curriculum in the 24-unit master's program is structured around core requirements in research methodology, communication and professional development, statistics, and a graduate seminar, along with coursework in the student's area of specialization. The doctoral program requires completion of 50-units beyond the bachelor's degree, as well as additional statistics and seminar courses beyond those required in the master's program.^[14] In 2019-2020, 15 students were enrolled in the master's program and 22 students were enrolled in the doctoral program.

[1] All enrollment data from the Maryland Higher Education Trend Data and Program Inventory, accessed 9 January 2023: <https://data.mhec.state.md.us/>

[2] "MEES Curriculum," University of Maryland, accessed 12 January 2023: <https://www.mees.umd.edu/curriculum>

[3] "M.A. in Cultural Sustainability", Goucher College, accessed 12 January 2023: <https://www.goucher.edu/learn/graduate-programs/ma-in-cultural-sustainability/>

[4] "Graduate Studies in Environmental Sustainability and Management", Goucher College, accessed 12 January 2023: <https://www.goucher.edu/learn/graduate-programs/ma-in-environmental-sustainability/>

[5] "Environmental Biology (M.S.)", Hood College, accessed 12 January 2023: <https://www.hood.edu/graduate/academics/programs/environmental-biology-ms>

[6] "Environmental Planning and Management", Johns Hopkins University, accessed 12 January 2023: <https://e-catalogue.jhu.edu/engineering/engineering-professionals/environmental-engineering-science-management-programs/environmental-planning-management/>

[7] "Master of Science in Environmental Sciences and Policy," Johns Hopkins University, accessed 12 January 2023: <https://landing.advanced.jhu.edu/mSES>

[8] "Master of Science in Energy Policy and Climate," Johns Hopkins University, accessed 12 January 2023: <https://landing.advanced.jhu.edu/mSEPC>

[9] "Sustainable Urban Communities (Certificate), Program Information", Morgan State University, accessed 12 January 2023: https://catalog.morgan.edu/preview_program.php?catoid=13&poid=2684

[10] "Bioenvironmental Sciences (PhD), Program Information", Morgan State University, accessed 12 January 2023: https://catalog.morgan.edu/preview_program.php?catoid=13&poid=2586



[11] “Environmental Science Post-Baccalaureate Certificate”, Towson University, accessed 12 January 2023: <https://www.towson.edu/fcsm/departments/environsci/grad/sciencepbc/> and “Environmental Science (M.S.)”, Towson University, accessed 12 January 2023: <https://www.towson.edu/fcsm/departments/environsci/grad/science/>

[12] “Environmental Management”, University of Maryland Global Campus, accessed 12 January 2023: <https://www.umgc.edu/online-degrees/masters/environmental-management>

[13] “Geography and Environmental Systems,” University of Maryland, Baltimore County, accessed 12 January 2023: <https://ges.umbc.edu>

[14] “Graduate Programs,” University of Maryland, College Park, accessed 12 January 2023: <https://enst.umd.edu/graduate>



Appendix B. Descriptions of Course Options in Program Outline

LIST OF REQUIRED COURSES

ENVS 600 ENVIRONMENTAL SCIENCE AND SUSTAINABILITY COLLOQUIUM (1)

Current and emerging issues at the nexus of environmental science, sustainability, and policy. Professional development and career advancement skills will be covered.

ENVS 701 SCIENCE OF ENVIRONMENTAL CHANGE (3)

Examination of physical, chemical, and biological processes causing environmental change. Overview of scientific approaches used to understand impacts to ecological and human systems.

ENVS 702 SUSTAINABILITY IN A COMPLEX WORLD (3)

Examination of social dimensions of sustainability and environmental change. Interdisciplinary survey of key issues and approaches from geography, political science, economics, and health sciences for understanding human impacts and responses to environmental change.

ENVS 990 DISSERTATION PROPOSAL (3)

Preparation and defense of a doctoral dissertation proposal under the guidance of the dissertation advisor.

ENVS 997 DISSERTATION RESEARCH (1-6)

Independent research guided by the dissertation advisor. May be repeated up to a total of 21 units.

LIST OF EXISTING GRADUATE-LEVEL RESEARCH METHODS COURSES

Students select one course from the following options. Students without previous coursework and/or experience in research design should enroll in GEOG 621.

BIOL 603 DATA ANALYSIS AND INTERPRETATION FOR BIOLOGISTS (3)

Information, techniques, and skills useful in gathering, analyzing, and interpreting data in the Biological Sciences. Topics include introduction to the role of statistical analysis in the biological sciences, hypothesis testing, experimental design, and current controversies in use of statistics in the biological sciences.

BIOL 609 COMMUNITY ANALYSIS AND BIOASSESSMENT (3)

Principles of design of environmental sampling studies, statistical analysis of data composed of multiple species, and environmental variables. Use of statistical software for data analysis projects. Emphasis on application of these methods in bioassessment of aquatic ecosystems, as well as community ecology and evolution.

GEOG 516 QUANTITATIVE METHODS IN GEOGRAPHY (3)

Focus on statistical problems associated with the analysis of geographic data. Emphasis on the unique spatial problems of point pattern analysis, aerial association, and regionalization.



GEOG 523 GIS APPLICATIONS (3)

Geographic information systems for solving real-world problems; vector-based GIS software, microcomputers for development of a GIS application.

GEOG 583 FIELD GEOGRAPHY (2-6)

Practical laboratory experience in techniques in the collection and analysis of data by observations, measurement, mapping, and photographic records. Such techniques are to be applied to selected geographic problems.

GEOG 587 ENVIRONMENTAL IMPACT ANALYSIS (3)

The collection and analysis of physical, social, biological, and economic information for the preparation of environmental impact statements (EIS).

GEOG 620 QUALITATIVE METHODS (3)

Exploration of qualitative methods in geography. Basic principles of research design, ethical and procedural considerations.

GEOG 621 RESEARCH DESIGN (3)

Reviewing the literature, formulating a research question, and finding appropriate methodology to generate data and answer the research question.

GEOG 622 PROBLEMS AND ANALYSIS IN GEOGRAPHY (3)

Application of research methods to the analysis of geographic problems.

GEOG 631 ADVANCED REMOTE SENSING: DIGITAL IMAGE PROCESSING AND ANALYSIS (3)

Satellite sensors, satellite data acquisition, field data collection and measurements, and the processing and analysis of various types of remotely sensed digital imagery.

HLTH 625 RESEARCH METHODS IN HEALTH (3)

Study of research and statistical designs in health science and allied health disciplines.

SOCI 582 RESEARCH METHODS (3)

A consideration of methodology of sociological research; the various steps in conducting research projects, from statement of the problem to final analysis of data.

LIST OF EXISTING GRADUATE-LEVEL ELECTIVE COURSES ^a

Students will complete a minimum of 24 units of electives, selected in consultation with the dissertation advisor and/or the Graduate Program Director. At least two courses (6-8 credits) must be broadening courses that are selected from subject areas outside the student's main field of research.

BIOL 502 GENERAL ECOLOGY (4)

Effects of the abiotic and biotic environment on distribution and abundance of organisms: organization of biological communities, ecosystems, evolution of different reproductive



strategies and application of ecological principles to natural resource conservation.

BIOL 506 LIMNOLOGY (4)

Physical, chemical, and biological factors that affect fresh-water organisms, and some of the standard methods used to analyze these factors.

BIOL 510 CONSERVATION BIOLOGY (4)

Application of ecological theory to conservation of biological diversity. Exploration of past and present processes leading to and maintaining diversity and how such processes are impacted by human disturbance.

BIOL 518 MICROBIOLOGY (4)

Biology of micro-organisms with emphasis on bacteria. Microbial morphology, physiology and genetics, and the role of micro-organisms in natural processes and disease. Laboratory will include methods of observing, isolating, and identifying bacteria.

BIOL 519 ENVIRONMENTAL MICROBIOLOGY (3)

Biology and ecology of microorganisms in natural and anthropogenic environments. Culture-based and molecular methods for detection, evaluation, and manipulation of microorganisms and their metabolism.

BIOL 532 VASCULAR PLANT TAXONOMY (4)

A study of the history and principles of vascular plant systematics with laboratory time devoted to collection and identification of plants in the local flora.

BIOL 535 PLANT ECOLOGY (4)

Environmental factors and processes which control plant distribution, plant communities and vegetational biomes of North America.

BIOL 546 TROPICAL ECOLOGY AND CONSERVATION (3)

Evolution and ecology of tropical ecosystems. Mechanisms that maintain tropical diversity, species interactions, anthropogenic impacts, and conservation strategies.

BIOL 547 TROPICAL FIELD ECOLOGY (4)

Field course set in the tropical rainforest. Includes exploration of different tropical ecosystems and training in techniques to carry out field research. Students will develop a research proposal and conduct their independent research projects including data collection, statistical analyses, write up, and an oral presentation of results.

BIOL 552 WETLAND ECOLOGY (4)

Wetland ecology and wetland management, with special focus on wetland of the Mid- Atlantic

^a With advance permission of the SEC Graduate Program Director, Graduate Special Topics, Directed Reading, and Independent Study courses in BIOL, ECON, GEOG, GEOL, HUMA, HLTH, IHSM, POSC, SOCI, and WMST may also be counted for elective credit, depending on the course theme or sub-topic.



region. Emphasis is on biological, physical, chemical, and ecological aspects of wetlands. The course also deals with valuation, classification, delineation, and management of wetlands for biotic resources and water management.

BIOL 555 FISH BIOLOGY (4)

Introduction to the evolutionary history, functional biology, ecology, and conservation of fishes. Laboratory experiences emphasize both identification of fishes and experiments designed to understand their functional biology.

BIOL 556 ORNITHOLOGY (4)

Evolutionary history, morphology, physiology, behavior, and ecology of birds.

BIOL 561 ENTOMOLOGY (4)

Laboratory and field course in insects. Identification and recognition of the more common families and orders and a study of their structure, behavior, ecology, economic importance, and control.

BIOL 567 HERPETOLOGY (4)

Systematic survey of modern reptiles and amphibians. Emphasis is placed on the evolution of morphological and behavioral traits which have enabled reptiles and amphibians to successfully exploit their individual habitats. Laboratory includes systematic classification, student seminars and field work.

BIOL 584 SEMINAR IN ECOLOGY, EVOLUTION AND BEHAVIOR (1)

Discussion and analysis of current research in ecology, conservation biology, environmental science, evolution, and animal behavior.

BIOL 610 POPULATION AND COMMUNITY BIOLOGY (3)

Processes in biological populations, including population growth, competition, and predation, are analyzed using conceptual-systems models and simple mathematical models.

BIOL 611 GLOBAL CHANGE BIOLOGY (3)

An investigation of global change with an emphasis on biological responses. Interdisciplinary exploration includes climate change, other human activities contributing to global change, climate policy, and mitigation.

BIOL 619 ENVIRONMENTAL MICROBIOLOGY (3)

Topics to be covered include: the historical importance of environmental microbiology, the different methods of molecular genetic analysis, microbially mediated biogeochemical cycles and their global importance, the adaptability of microorganisms to different environments, microbial functional metabolic plasticity facilitating xenobiotic compound degradation, and the use and importance of metagenomics in environmental microbiology.

BIOL 654 LANDSCAPE ECOLOGY (3)

Spatial and temporal landscape heterogeneity; how it arises, its quantification and its



influence on population, community, and ecosystem dynamics over multiple scales.

ECON 505 MICRO ECONOMICS (1.5)

Covers comparative advantage, supply and demand, elasticity, opportunity cost, competition and monopoly, and externalities. Emphasizes understanding concepts that are useful in making effective choices in a variety of economic and managerial situations.

ECON 506 MACRO ECONOMICS (1.5)

Covers economic growth, monetary and fiscal policy, inflation, and unemployment. Emphasizes understanding concepts, such as Federal Reserve policy, which are useful for managerial decision-making.

ENVS 582 ENVIRONMENTAL EDUC & SERVICE LEARNING IN THE TROPICS (3)

Designed for those majoring in the sciences or education fields with an interest in environmental education. Coursework will take place largely in the tropics of Costa Rica. Emphasis will be placed on the application of forest ecology concepts to PreK-12 environmental education and human use and management of natural resources in the tropics.

ENVS 601 TOPICS IN ENVIRONMENTAL GEOLOGY (4)

Geological concepts related to developed and developing areas; topics include earth materials, soils and soil formation, hydrological cycle, and waste management; water management; and geological issues in land-use decision making.

ENVS 602 ENVIRONMENTAL CHEMISTRY (4)

Principles of chemistry applied to environmental pollutants; physio-chemical processes controlling pollutant transport, fate, and distribution; partitioning of water, soil, and air as they relate to biotic systems.

ENVS 603 ENVIRONMENTAL LAW AND REGULATIONS (3)

Operation of the American legal system as it functions to control and remediate environmental problems; emphasis on the law and legal processes which govern environmental disputes; function of legal institutions in these disputes; role of regulations in environmental protection.

ENVS 604 ECOSYSTEM ECOLOGY (4)

Principles of ecosystem ecology; factors controlling ecosystem structure and function; energy balance and biogeochemical cycles. Emphasis on ecological impacts of human alterations and urbanized ecosystems. Development of student capacity for "systems thinking" via modeling in field and laboratory based investigative projects. Implications for environmental management from local to global scale.

ENVS 611 WATER POLICIES OF THE UNITED STATES (3)

History and application of the Clean Water Act, including ongoing actions and case studies.



ENVS 620 ENVIRONMENTAL POLICY AND SUSTAINABLE MANAGEMENT (3)

Analysis of the scientific approach to solve environmental problems within the socioeconomic concerns involved in formulating and administering environmental policy. Energy, management, policy, and sustainability are considered.

ENVS 625 SCIENCE AND POLICY OF THE CHESAPEAKE BAY RESTORATION (3)

Will provide students with a basic understanding of the key physical, chemical, and biological processes taking place in America's largest estuary. The class will explore how an understanding of these important ecosystem components has informed scientists, managers, legislators, and other stakeholders about the causes of the Bay's degradation and has provided insight into the formulation of a strategy for its protection and restoration. In addition to class lectures, projects and possibly in-field experiences, regional Chesapeake Bay experts from the academic, political, and regulatory sectors will provide students with a "real world" perspective on both the opportunities and obstacles in the effort to "Save the Bay."

ENVS 630 CONCEPTS OF ENVIRONMENTAL ENGINEERING (3)

Introduction to the principles and concepts of environmental engineering for non-engineers; review and discuss methods of assessment and design; modeling methods used; critical assessment of design and different design paradigms; problem solving approaches.

ENVS 635 WETLANDS IDENTIFICATION, CONSERVATION AND DELINEATION (4)

The ecological, chemical, and physical principles of wetlands biology; characterization, description, and mapping of wetland habitats. Wetlands regulations and their ecological basis including hydric soil field indicators, interrelationship of landscape, vegetation, and soils. Use of topographic maps, aerial photography, National Wetland Inventory maps and simple survey techniques.

ENVS 640 ECOTOXICOLOGY (3)

Fate, activity, and dose-response relationships of organisms to environmental toxicants; their absorption, distribution, metabolism, and excretion; evaluation of physical, chemical, and biological factors that influence toxicity. Quantitative methods and models used in acute and chronic toxicity studies.

ENVS 645 FLUVIAL GEOMORPHOLOGY AND HYDROLOGY (4)

Hydrologic and morphologic characteristics of streams and valley floors; landscape evolution by stream erosion and deposition, rainfall runoff relationships. Field exercises include quantitative analysis of fluvial processes, channel forms, mapping, topographic surveying, report writing.

ENVS 650 AQUEOUS GEOCHEMISTRY (4)

Application of thermodynamics, mass balance, systems science, and kinetics to understanding mineral-water-contaminant interactions in natural and impacted aquatic systems on a variety of spatial and temporal scales.



ENVS 670 INDEPENDENT STUDY IN ENVIRONMENTAL SCIENCE (1-3)

Studies in selected content areas tailored to student needs.

ENVS 680 SELECTED TOPICS IN ENVIRONMENTAL SCIENCE (1-4)

Topics in environmental science will be chosen. Course content and field exercises will be determined as to complement course offerings in environmental science.

GEOG 502 ENERGY RESOURCES (3)

Spatial patterns of traditional and alternative forms of energy will be analyzed. The many facets of the energy problem will be analyzed including physical deposits, economic variables, public policy implication and geographical patterns.

GEOG 503 SOILS AND VEGETATION (3)

A resource study of the world's soils and plant formations with emphasis placed upon their genesis and spatial differentiations.

GEOG 504 INTRODUCTION TO REMOTE SENSING AND PHOTOGRAMMETRY (3)

Fundamentals and the development of remote sensing, the nature of electromagnetic radiation and its interaction with the atmosphere and surface objects, photographic systems, aerial photography, and photogrammetry basics.

GEOG 510 HISTORICAL GEOGRAPHY OF URBANIZATION (3)

Spatial and temporal development of urbanization and urban morphology from the rise of civilization in the ancient Near East to the contemporary post-industrial city. The entire scope of urban functions is surveyed, with the emphasis on the city as a man-made environment.

GEOG 512 ECONOMIC GEOGRAPHY (3)

Designed to explain the location of economic activities through a series of principles and theories. Emphasis on the various sectors of the economy, transportation, and economic development.

GEOG 515 CLIMATOLOGY (3)

Character, causes and distribution of climatic types. Emphasis upon world pattern.

GEOG 517 METEOROLOGY (3)

Examines the composition and structure of the atmosphere, thermodynamic processes, forces and related small- and large-scale motions, air masses, fronts, tropical cyclones, solar and terrestrial radiation, general circulation, and weather forecasting.

GEOG 519 POLITICAL GEOGRAPHY (3)

Effect of political groupings upon human's use of the world and the influence of the geographic base upon political power.

GEOG 520 POPULATION GEOGRAPHY (3)

General population theory, data sources for population geographers and the processes of



fertility, mortality, and migration. Patterns of population growth and change are viewed from both temporal and geographical perspectives.

GEOG 522 URBAN SYSTEMS I (3)

Survey of the structure, functions, forms, and development of urban units. Emphasis upon the locational features of social, economic, and cultural phenomena; fieldwork required.

GEOG 526 FEMINIST GEOGRAPHIES (3)

Exploration of the intellectual foundations of the feminist critique; geographies of women and gender; influence of feminism across the discipline of geography.

GEOG 552 SEVERE AND HAZARDOUS WEATHER (3)

Examines the complexities and power of severe and hazardous weather, providing an understanding of the way events, such as thunderstorms, tornadoes, and hurricanes, develop and evolve within the atmosphere. Topics include the descriptions and physical explanations of the types of severe and hazardous weather along their societal and political implications.

GEOG 553 COMPREHENSIVE PLANNING (3)

The integration of separate urban systems into the comprehensive design of an urban region. Special emphasis will be placed on neighborhood, community, and town planning.

GEOG 557 STUDIES IN NATURAL HAZARDS (3)

The nature, frequency of occurrence and distribution of environmental hazards and their impact on humans.

GEOG 587 ENVIRONMENTAL IMPACT ANALYSIS (3)

The collection and analysis of physical, social, biological, and economic information for the preparation of environmental impact statements (EIS). Prerequisite: 6 hours of geography or consent of instructor.

GEOG 624 GEOGRAPHIES OF CONSUMPTION AND WASTE (3)

Introduction to geographic relationships associated with contemporary consumption and waste disposal activities.

GEOG 625 PLANNING FOR A SUSTAINABLE REGION (3)

The theory and practice of comprehensive regional planning as well as methods for assurance sustainability.

GEOG 652 GEOGRAPHIES OF HEALTH (3)

Interrelationship between health and our social and physical environments. Emphasis on geographic approaches to inequalities in health, well-being, and care.

GEOG 654 CLIMATE CHANGE: SCIENCE TO POLICY (3)

A survey of past, current, and future climate change. Emphasis on Earth's radiation balance, causes of climate change, observed and predicted signals of climate change, and impacts



and mitigation of climate change.

GEOG 683 SEMINAR: ENVIRONMENTAL PROBLEMS IN MARYLAND (3)

Individual research on a selected environmental problem in Maryland.

GEOG 515 HYDROGEOLOGY (4)

Geologic aspects of ground water; origin, occurrence, and movement.

GEOG 557 PHYSICAL OCEANOGRAPHY (3)

Physical, chemical, and geologic characteristics of ocean basins, boundaries and sea water including origin and behavior of waves and currents.

HUMA 612 ENVIROHUMANITIES (3)

Graduate seminar addressing the intersection of the humanities and the environment in a range of disciplines, including geographic, literary, artistic, architectural, and historic perspectives.

HUMA 613 DISEASE, LIFE, AND DEATH (3)

Graduate seminar discussing global views and perceptions of disease, life, and death.

HUMA 615 POWER (3)

Graduate seminar interrogating global perceptions, views, instances, implications, and implementations of power.

HLTH 551 INTRODUCTION TO ENVIRONMENTAL HEALTH (3)

Examination of the interrelationships between humans and their environment. Emphasis is placed upon health aspects of pollution, housing, sanitation, radiation, behavioral disorders, and epidemiology.

HLTH 618 INTRODUCTION TO PUBLIC HEALTH (3)

Study of disease prevention and health promotion with a focus on community efforts to improve the public's health.

IHSM 633 DISASTER RESPONSE AND COMMUNITY HEALTH (3)

Addresses the need for professionals to incorporate an all-hazards approach for disaster management and community health. Students will identify key international and national policies and their impact upon community health and national security. Students will be engaged in field work with the community of their choice to plan, implement, and evaluate a project designed to actively involve community members in some aspect of disaster preparedness.

POSC 504 POLITICS OF METROPOLITAN GROWTH AND CHANGE (3)

Examination of the political economy of metropolitan growth; role of federal, state, and local actors and policies in shaping development.



POSC 505 URBAN GOVERNMENT AND POLITICS (3)

The political history of American cities from the 18th century through the recent reform movement. City charters, home rule, types of executives, political machines, and the metropolitan area.

POSC 507 CONTEMPORARY INTERNATIONAL POLITICS (3)

Computer simulation (conducted jointly with colleges and universities throughout the world) is used to study formulation and implementation of contemporary international politics.

POSC 521 POLITICS AND ENVIRONMENTAL POLICY (3)

Analysis and investigation of U.S. environmental problems from a political perspective.

POSC 539 POLITICS OF THE DEVELOPING WORLD (3)

An examination of the causes of poverty in the developing world. Particular attention is given to the roles of the international system, domestic politics, and the natural world.

SOCI 529 DEMOGRAPHY (3)

Social, economic, and political problems related to changes, distribution, and movement of population; analysis of contemporary population trends in the United States and the world.

WMST 545 WOMEN, ENVIRONMENT AND HEALTH (3)

Relationships between economic development, health, and the environment from a global perspective with a focus on women's roles in environmental management; how women's activism effects social and public policy agendas.

WMST 550 B-MORE: BALTIMORE AND URBAN COMMUNITIES (3)

Analyzes significant political, economic, and cultural issues facing Baltimore and other urban communities including poverty, discrimination, economic development, and the criminal justice system, with special attention to gender, race, class, and youth activism.

WMST 613 WOMEN AND HEALTH (3)

An interdisciplinary study of women's health from a holistic perspective that builds on socioeconomic, political, and biological aspects of women's health.

Appendix C. Example Program of Study ^a

Year	Fall	Spring	Summer	Credits
1	<ul style="list-style-type: none"> • ENVS 600 Environmental Science and Sustainability Colloquium (1) • ENVS 701 Science of Environmental Change (3) • <i>Elective (3)</i> 	<ul style="list-style-type: none"> • ENVS 702 Sustainability in a Complex World (3) • Research Methods Course (3) • ENVS 997 Dissertation Research (1) (Identify Topic, Literature Review) • <i>Elective (3)</i> 	Dissertation Research Continues	17
2	<ul style="list-style-type: none"> • ENVS 600 Environmental Science and Sustainability Colloquium (1) • ENVS 997 Dissertation Research (2) (Literature Review, Research) • <i>Elective (3)</i> • <i>Elective (3)</i> 	<ul style="list-style-type: none"> • ENVS 990 Dissertation Proposal (3) (Literature Review, Proposal) • <i>Elective (3)</i> • <i>Elective (3)</i> 	Comprehensive Exams and Proposal Defense	18
3	<ul style="list-style-type: none"> • ENVS 600 Environmental Science and Sustainability Colloquium (1) • ENVS 997 Dissertation Research (3) (Research, Analysis, Writing) • <i>Elective (3)</i> 	<ul style="list-style-type: none"> • ENVS 997 Dissertation Research (3) (Research, Analysis, Writing) • <i>Elective (3)</i> 	Dissertation Research Continues	13
4	<ul style="list-style-type: none"> • ENVS 997 Dissertation Research (6) (Research, Analysis, Writing) 	<ul style="list-style-type: none"> • ENVS 997 Dissertation Research (6) (Analysis, Writing) 	Dissertation Defense	12
TOTAL CREDITS				60

^a Required foundation, seminar, and dissertation courses are in bold; electives are in *italics*; degree milestones are in plain text. For lists of research methods and electives courses, see Appendix B.



Appendix D. Faculty Expertise Supporting Environmental Ph.D. Programs in Maryland

	TU	MSU	UMBC
<i>Fisher College of Science and Mathematics</i>			
Biology	12	17	
Chemistry	6	8	
Computer Science		2	
Geosciences	3		
Physics		6	
<i>College of Health Professions</i>			
Health Sciences	3		
<i>College of Liberal Arts (CLA)</i>			
Geography	9		12
Other Departments*	8		
<i>College of Business & Economics</i>	1		
<i>College of Education</i>	1		
<i>College of Fine Arts & Communication</i>	1		
<i>Non-Academic Units</i>			
Patuxent Environmental & Aquatic Research Lab		3	
NASA/Joint Center for Earth Systems Technology			12

*Includes English, History, Philosophy and Religious Studies, Sociology

Note that CLA faculty represent 39 percent of the total TU faculty associated with the proposed Ph.D. in SEC program, and that more than 50 percent of the TU come from outside the Fisher College of Science and Mathematics.



BOARD OF REGENTS
SUMMARY OF ITEM FOR ACTION,
INFORMATION, OR DISCUSSION

TOPIC: Academic Program Proposal:
University of Maryland Baltimore County (UMBC): Master of Science (MS) in Cybersecurity

COMMITTEE: Education Policy and Student Life

DATE OF COMMITTEE MEETING: Monday, June 5, 2023

SUMMARY: UMBC proposes a new Master of Science in Cybersecurity. After a short transition period, the proposed M.S. in Cybersecurity will replace the existing M.P.S. in Professional Studies: Cybersecurity track as UMBC's primary graduate degree in the cybersecurity domain. The Department of Computer Science and Electrical Engineering (CSEE) and College of Engineering and Information Technology (COEIT) work closely with their respective advisory boards to build external relations to make sure that UMBC is responsive to the regional and national needs of industry stakeholders in providing affordable, accessible ways to effectively enhance the professionalism and diversity of Maryland's cybersecurity workforce. This proposal for UMBC's campus in Catonsville for an M.S. in Cybersecurity will be a non-thesis, course-based degree consisting of 10 courses/30 credits, with 6 core and 4 elective courses. Core courses focus on the operational and theoretical aspects of cybersecurity. Elective courses allow students to dive deeper or specialize on more granular topics that are relevant to their personal interests or professional needs. A subsequent submission will propose offering the program at the Universities at Shady Grove.

Maryland remains a global hub of cybersecurity employment. A total of 31,000 unique job postings for cyber/information security engineers or analysts were posted in the Baltimore and Washington, DC metropolitan areas between July 2021 and July 2022. The proposed degree supports the greater Washington region's economic growth, the third-largest economy in the United States, and the seventh-largest global economy. This region is expected to add 130,000 jobs that require digital skills in the next five years. By launching this new graduate degree program, UMBC will continue directly contributing to USM's strategic priorities to help meet these critical needs in the State and region.

ALTERNATIVE(S): The Regents may not approve the program or may request further information.

FISCAL IMPACT: No additional funds are required. The program can be supported by the projected tuition and fee revenue.

CHANCELLOR'S RECOMMENDATION: That the Education Policy and Student Life Committee recommend that the Board of Regents approve the proposal from UMBC to offer the MS in Cybersecurity.

COMMITTEE RECOMMENDATION:

DATE: June 5, 2023

BOARD ACTION:

DATE:

SUBMITTED BY: Alison M. Wrynn

301-445-1992

awrynn@usmd.edu

UNIVERSITY SYSTEM OF MARYLAND INSTITUTION PROPOSAL FOR

- New Instructional Program
- Substantial Expansion/Major Modification
- Cooperative Degree Program
- Within Existing Resources, or
- Requiring New Resources

UMBC

Institution Submitting Proposal

Cybersecurity

Title of Proposed Program

Master of Science

Spring 2024

Award to be Offered

Projected Implementation Date

MHEC to determine

11.1003

Proposed HEGIS Code

Proposed CIP Code

Computer Science & Electrical Engineering

Anupam Joshi

Department in which program will be located

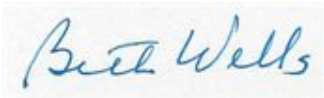
Department Contact

410-455-2733

joshi@umbc.edu

Contact Phone Number

Contact E-Mail Address



May 31, 2023

Signature of President or Designee

Date



May 01, 2023

Office of the President
University of Maryland, Baltimore County
1000 Hilltop Circle, Baltimore, MD 21250

Phone: 410-455-2274
Fax: 410-455-1210

Jay Perman, M.D.
Chancellor
University System of Maryland
3300 Metzerott Road
Adelphi, MD 20783

Dear Chancellor Perman:

UMBC seeks approval to offer a Master of Science (M.S.) in Cybersecurity in the Department of Computer Science and Electrical Engineering (CSEE). The proposed M.S. will replace the existing M.P.S. in Professional Studies: Cybersecurity track as UMBC's primary graduate degree in the cybersecurity domain. The rigorous nature of our master's and doctoral programs is consistent with UMBC's role as one of three principal centers for research and doctoral-level training in the University System of Maryland (USM) as an R-1 (Very High) Carnegie classification.

The CSEE department and College of Engineering and Information Technology (COEIT) work closely with their respective advisory boards and UMBC's Office of Institutional Advancement to build external relations to make sure that we are responsive to the regional and national needs of our industry stakeholders.

Offered first at UMBC's campus in Catonsville, with a plan to seek subsequent approval for the Universities at Shady Grove (USG), the proposed M.S. in Cybersecurity will be a non-thesis, course-based degree consisting of 10 courses/30 credits, with 6 core and 4 elective courses. Core courses focus on the operational and theoretical aspects of cybersecurity. Elective courses allow students to dive deeper or specialize in more granular topics that are relevant to their personal interests or professional needs.

Maryland remains a global hub of cybersecurity employment. For example, a total of 31,000 unique job postings for Cyber/Information Security Engineers or Analysts were posted in the Baltimore and Washington DC metropolitan areas between July 2021 and July 2022. This region supports the greater Washington region's economic growth, the third-largest economy in the United States, and the seventh-largest global economy. This region is expected to add 130,000 jobs that require digital skills in the next five years. Accordingly, as a public research university, UMBC is ideally positioned to offer innovative, accessible, affordable, educational programs to meet the needs of students in in-demand fields.

Because there is no current crosswalk for identifying a HEGIS code to match our requested CIP code 50.0102, UMBC leaves it to MHEC to supply the HEGIS code for this program.

Thank you very much for your review of this proposal.

Sincerely,

Valerie Sheares Ashby
President

C: Antonio Moreira, Vice Provost for Academic Affairs, UMBC
Beth Wells, Director of Academic Administration, Assistant Vice Provost Emerita, UMBC

UMBC Master of Science (M.S.) in Cybersecurity Narrative

A. Centrality to Institutional Mission and Planning Priorities:

- 1) The UMBC Department of Computer Science and Electrical Engineering (CSEE) proposes to launch a Master of Science (M.S.) in Cybersecurity. Upon final approval, after a short transition period, the proposed M.S. in Cybersecurity will replace the existing M.P.S. in Professional Studies: Cybersecurity track as UMBC's primary graduate degree in the cybersecurity domain. The rigorous nature of our master's and doctoral programs are consistent with UMBC's role as one of three principal centers for research and doctoral-level training in the University System of Maryland (USM) as an R-1 (Very High) Carnegie classification. The CSEE department and College of Engineering and Information Technology (COEIT) work closely with their respective advisory boards and UMBC's Office of Institutional Advancement to build external relations to make sure that we are responsive to the regional and national needs of our industry stakeholders and providing affordable, accessible ways to effectively enhance the professionalism and diversity of Maryland's cybersecurity workforce.

Offered first at UMBC's campus in Catonsville, with a plan to seek subsequent approval to offer the program at the Universities at Shady Grove (USG), the proposed M.S. in Cybersecurity will be a non-thesis, course-based degree consisting of 10 courses/30 credits, with 6 core and 4 elective courses. Core courses focus on the operational and theoretical aspects of cybersecurity. Elective courses allow students to dive deeper or specialize on more granular topics that are relevant to their personal interests or professional needs.

Maryland remains a global hub of cybersecurity employment. For example, a total of 31,000 unique job postings for Cyber/Information Security Engineers or Analysts were posted in the Baltimore and Washington DC metropolitan areas between July 2021 and July 2022. It supports the greater Washington region's economic growth, the third-largest economy in the United States, and the seventh-largest global economy. This region is expected to add 130,000 jobs that require digital skills in the next five years. Accordingly, as a public research university, UMBC is ideally positioned to offer innovative, accessible, affordable, educational programs to meet the needs of students in in-demand fields.

- 2) As presented in the *University System of Maryland (USM) 2020 Strategic Plan's* Theme 2: *Maryland's Economic Development and the Health and Quality of Life of Its Citizens-Ensuring Maryland's Competitiveness in the New Economy*, a major goal is to enhance programs essential to the state's overall competitiveness in critical areas such as STEM, education, health care, cybersecurity. The USM Strategic Plan also provides a call to "Fuel Maryland's knowledge-based economy and enhance the quality of life of its citizens by increasing the number of graduates produced in workforce areas that are key to the state's ability to thrive and compete (including STEM, education, nursing, health care, cybersecurity, and other disciplines) and promoting improved health care and other critical services." (p.16) By launching this new graduate degree program, UMBC expects to continue directly contributing to USM's strategic priorities by creating a new graduate degree to help meet these critical needs in the State and region.

UMBC's Strategic Plan declares "UMBC is a dynamic public research university integrating teaching, research, and service to benefit the citizens of Maryland ... UMBC contributes to the economic development of the state and the region through entrepreneurial initiatives, workforce training, K-16 partnerships, and technology commercialization in collaboration with public agencies and the corporate community. UMBC is dedicated to cultural and ethnic diversity, social responsibility, and lifelong learning" (p.5). Security-related initiatives such as cybersecurity specifically are identified as an institutional priority (p.6), which UMBC is already actively involved with through innovative education, research, and assorted local, regional, and global partnerships. These goals are reflected in UMBC's institutional priorities and aligned with the USM's *2020 Strategic Plan* and the *2022 MHEC Statewide Plan*. Recent (2022) permanent new State funding for UMBC's cybersecurity mission further demonstrates UMBC's recognized capabilities in conducting meaningful cybersecurity education and research activities that directly support Maryland's workforce needs in this critical field.

- 3) The program will be funded entirely through tuition revenues managed by the Division of Professional Studies (DPS). Additional support services such as technology support, library services, marketing, and related academic/program support will be drawn from UMBC's existing institutional capabilities. Special learning experiences, research opportunities, and/or technologies for students may be funded through faculty-led grant efforts, such as UMBC's federal Scholarship-for-Service program, and/or obtained via internships with local companies or government organizations, including BWTECH@UMBC.
- 4) a) Security-related studies like cybersecurity are an institutional priority under UMBC's *Strategic Plan*. As such, and since cybersecurity across government and industry sectors continues to be a critical concern for Maryland and the world, UMBC is committed to providing the necessary administrative, financial, and technical support to launch, grow, and sustain this Masters in Cybersecurity. Technical support for students and faculty is available through Blackboard and other web-based technologies supported by UMBC's Division of Information Technology (DOIT), in-class time, and faculty office hours.

b) Launch of this new graduate degree will present no challenge or obstacles to currently enrolled (or future) students from completing their graduate studies in cybersecurity at UMBC.

B. Critical and Compelling Regional or Statewide Need as Identified in the State Plan:

1a) UMBC's first graduate cybersecurity program, the Master's in Professional Studies (M.P.S.) track in Cybersecurity, was launched in 2011 after consultation with a focus group that included members from federal, state, and local employers to identify their need for qualified talent to help grow their burgeoning cybersecurity workforce. UMBC faculty and staff anticipated a great need for cyber practitioners in the Baltimore and Washington MSAs at a time when there were few other cybersecurity graduate programs in Maryland. Given the ongoing workforce need to develop qualified cybersecurity practitioners across the region, UMBC's MPS cybersecurity degree is offered at UMBC's Main Campus and at the Universities at Shady Grove (USG).

The *2022 MHEC Statewide Plan* identifies cybersecurity and IT fields as key industries for Maryland (p.46). Public universities like UMBC offering such in-demand programs increases affordable (p.29) and geographical access (p.28) to quality workforce-centric education for prospective students and provides State employers with a robust pool of highly educated future employees to meet critical workforce needs (p.45). Such degree programs also foster expanded opportunities for minority and under-represented students to enhance their knowledge (p.46) and gain meaningful employment opportunities throughout the State: in this case, UMBC's proposed MS Cybersecurity will be offered at first at its Catonsville campus. A subsequent proposal will request to add it later at the Universities at Shady Grove. And, as a graduate degree, this proposed MS Cybersecurity offers working professionals opportunities to support lifelong learning and career development/changes (pp.46 & 56). Accordingly, this proposed degree is aligned with MHEC's goals and guidance regarding Maryland's higher education priorities. Relatedly, the *USM Strategic Plan* notes that STEM industries and education will continue to experience above-average growth, and that the USM can better support growth in Maryland's economy by increasing degree output in quickly growing fields and strengthening industry collaboration to address skills gaps.

The *2022 MHEC Statewide Plan's* discussion call for expanded STEM and cybersecurity education in Maryland is reflected in other areas as well. Several initiatives have come out of the state government reaffirming official commitment to Maryland's cybersecurity posture. In May 2022, Governor Larry Hogan signed SB 812 which established the Office of Security Management within the existing Department of Information Technology, SB 754 expanding the capacity of the Department of Emergency Management to include a Cyber Preparedness Unit with additional staff lines, and HB 1205 instituting a requirement for public and private water or sewer systems serving 10,000+ users to perform vulnerability assessments and develop incident response plans.¹ And in July 2001, the

¹ The Office of Governor Larry Hogan, Maryland.gov, Governor's Press Release Bills to be Signed by the Governor on May 12, 2022, at <https://governor.maryland.gov/wp-content/uploads/2022/05/Press-Release-Abbreviated-Signed-May-12-2022-1.pdf> (visited October 31, 2022).

State Legislature established the innovative Maryland Institute for Innovative Computing (MIIC) at UMBC, which among other initiatives, created Computing Innovation Rapid Response Teams of undergraduate and graduate students to develop and support real-time solutions to IT and data concerns in state agencies via internships and capstone experiences and further enhanced the UMBC-led Maryland Technology Internship Program (MTIP) supporting government IT operations across the State. Students in the proposed M.S. in Cybersecurity would be well-positioned to participate in these initiatives to gain real-world experience and future employment within Maryland's rich technology ecosystem. Initiatives like these directly reflect and support the goals of the *2022 MHEC Statewide Plan*, *USM Strategic Plan*, and UMBC's institutional priorities as a state university.

In October 2022, the Department of Labor announced funding from Employment Advancement Right Now (EARN), a program designed to provide upskilling opportunities to 100 state employees through industry-recognized training including cybersecurity.² Moreover, improving cybersecurity maturity continues to be a priority for the Department of Information Technology, as defined in the July 1, 2020 – June 30, 2023 statewide master plan where Goal 4 – Create Measurable Improvements in the Cybersecurity Posture of the State outlines a commitment to “enhance network boundary protection”, “implement a statewide vulnerability management program”, “establish a statewide cybersecurity incident response capability”, and “reduce mean time to respond (MTTR) through security orchestration, automation, and response (SOAR)”.³ As with most cybersecurity initiatives, these require an ongoing stream of qualified entry-level and mid-career employees, preferably with strong cybersecurity education backgrounds from Maryland universities like UMBC and thus also reflect the *2022 MHEC Statewide Plan's* emphasis on STEM and cybersecurity programs in Maryland.

These reflect a few of the ongoing and compelling cybersecurity needs in the region. Practitioner-oriented programs like this proposed MS in Cybersecurity specifically are designed to foster the advancement and evolution of knowledge and address critical societal needs. With UMBC and the M.P.S. in Cybersecurity's already proven reputation and current, flexible, and agile curriculum, given the continued (if not increased) workforce demand for qualified cybersecurity professionals as identified in the *2022 MHEC Statewide Plan* and *USM Strategic Plan*, UMBC expects to continue directly support the goals of those plans by developing innovative educational programs and opportunities, such as this new MS in Cybersecurity in order to provide the flexible ability for prospective students to upgrade their occupational, vocational, technical, and/or professional skills to meet job market requirements.

C. Quantifiable and Reliable Evidence and Documentation of Market Supply and Demand in the Region and State:

- 1) The target market for this proposed MS in Cybersecurity are early-to-midcareer IT and cybersecurity professionals currently working, or hope to be working in an IT or cybersecurity (or cyber operations) capability in any number of federal, state, or local government organizations or private companies located in Maryland. Desired candidates for admissions are college graduate with current IT or cybersecurity industry experience and/or a solid academic background in computer science, information systems, or from a field related to working in cybersecurity. However, given the interdisciplinary nature of cybersecurity, prospective students may come from outside those disciplines, such as from the law enforcement, legal, contracting, or business community. Students may also be early-career and recent graduates looking to expand their knowledge as they enter the Maryland STEM workforce.
- 2) According to the Bureau of Labor Statistics' *Occupation Outlook Handbook*, 'Information Security Analyst' is one of the 20 occupations with the highest projected percent change of employment between 2021-31. This job has a 10-year growth rate of 35% and a national average salary of \$102,600. About 19,500 openings for information security analysts are projected each year, on average, over the decade. Many of those openings

² Maryland Department of Labor, Maryland.gov, MD Department of Labor To Fund Critical Cybersecurity Upskilling Opportunities for State Employees, at <https://www.dlrl.state.md.us/whatsnews/labortofundcriticalcybersecurityupskilling.shtml> (visited October 31, 2022).

³ Department of Information Technology, Maryland.gov, Statewide Information Technology Master Plan July 1, 2020 - June 30, 2023, at <https://doit.maryland.gov/Publications/Information-Technology-Master-Plan-2020-2023.pdf> (visited October 31, 2022).

are expected to result from the need to replace workers who transfer to different occupations or exit the labor force, such as to retire.⁴

- 3) The Baltimore-Washington region in particular is a hotspot for the cybersecurity workforce. According to data gathered from Lightcast, a labor market analytics tool, there were 19,293 cyber-related job postings in the Washington and Baltimore MSA in 2021. The national average for an area this size is 4,829 employees. The job posting activity in this region also is high: while the national average for an area this size is 421 job postings per month, there are 1,714 postings per month in the Washington-Baltimore area. Regional employers hiring cybersecurity professionals include the federal and state government, Amazon, Leidos, ManTech, Booz Allen Hamilton, and Capitol One, among many others.⁵ Moreover, according to *The Industries of the Future* (Ross, 2016), “over the 20 years from 2000 to 2020, the cybersecurity market will have grown from a \$3.5 billion market employing a few thousand people working in IT departments to a \$175 billion market providing critical infrastructure to just about every kind of business, big and small.”
- 4) See #3 above for the current projected supply of prospective graduates in the cybersecurity field.

D. Reasonableness of Program Duplication:

- 1) UMBC’s Division of Professional Studies (DPS) identified and compared cybersecurity programs in the region. While it concludes that no direct program duplication exists with this proposed M.S., UMBC believes that this degree is aligned with and fully supports the 2022 MHEC *Statewide Plan* and USM’s *Strategic Plan* by contributing to the range of cybersecurity programs available in the State, even if they may overlap and/or duplicate others to varying degrees. Ultimately, our goal is to actively support the goals of MHEC, the USM, and UMBC by providing maximum flexibility, affordability, and accessibility to students in order to upgrade their occupational, vocational, technical, and/or professional skills to meet critical workforce and job market requirements.
- 2) A comparison of regional programs with UMBC’s proposed Master of Science (M.S.) in Cybersecurity is found in Appendix 2.
- 3) UMBC is classified as a doctoral university with very high research activity by the Carnegie Classification of Institutions of Higher Education. No other USM institution is designated a Center of Academic Excellence in both Cyber Defense Education (CAE-CD) and Cybersecurity Research (CAE-R) by the National Security Agency (NSA) and Department of Homeland Security (DHS). Building upon that foundation, this proposed M.S. degree in cybersecurity gives students the formal, conceptual, and technological skills necessary for professional practice to fill management, analytical, investigative, operational, and/or technical leadership roles along with the opportunity to engage in applied or theoretical cybersecurity research if desired.

E. Relevance to High-demand Programs at Historically Black Institutions (HBIs)

- 1) The MS in Cybersecurity does not duplicate existing graduate programs at HBIs in the Baltimore or Washington region. The University of Maryland, Eastern Shore (UMES) does offer a graduate degree program leading toward a M.S. in Cybersecurity Engineering and Technology, however, that program is outside of the Baltimore and Washington region where UMBC is located. Morgan State University offers an M.S. in Advanced Computing, however, that program does not have a specific focus in cybersecurity, thus, there is no duplication of their program.

F. Relevance to the identity of Historically Black Institutions (HBIs)

- 1) This program does not duplicate existing programs at HBIs, and it is expected to have no impact on the

⁴ Bureau of Labor Statistics, U.S. Department of Labor, Occupational Outlook Handbook, Information Security Analysts, at <https://www.bls.gov/ooh/computer-and-information-technology/information-security-analysts.htm> (visited September 08, 2022).

⁵ Source: Lightcast™, https://a.economicmodeling.com/analyst/?t=3w4h8#h=hy5jD&page=occupation_snapshot&vertical=standard&nation=us, accessed 9/9/2022.

identity or mission of any of the HBIs, as described above. Since 2017, UMBC has been designated a Minority Serving Institution.

G. Adequacy of Curriculum Design, Program Modality, and Related Learning Outcomes

- 1) This practitioner-oriented curriculum was developed by faculty within the UMBC Department of Computer Science and Electrical Engineering (CSEE), drawing upon their expertise in the areas of cybersecurity and related disciplines. CSEE's industrial advisory board members also provide expert insights that inform the program. Program faculty, as subject-matter-experts, also regularly discuss emerging trends or current events that may require updating or creation of curricular modules and/or incorporating specialized instructional tools/platforms such as Metasploit, FTK, Wireshark, Tableau, Ghidra, and other cybersecurity tools into the curriculum.

The MS in Cybersecurity will be overseen by full-time Graduate Program Director and member of the CSEE faculty with a strong cybersecurity background. The GPD, as a direct report to the Chair of Computer Science and Electrical Engineering, is supported as needed by the Chair in matters related to faculty/program oversight, mentoring, and related issues. The GPD also works with the UMBC DOIT, CSEE's IT office, DPS IT staff, and other campus leaders on technology innovations related to the program or any new learning capabilities/platforms deployed, such as cybersecurity ranges and test environments. The Cybersecurity Graduate Program Director is a member of the Computer Science Graduate Committee and works with that committee on areas of mutual interest and oversight, to include recruiting, cross-program collaboration, new course ideas, and program innovations.

- 2) As a program targeting adult learners and working professionals, courses in this proposed degree will be taught in-person, hybrid, and online modalities to provide greater flexibility and accessibility to students. As with other workforce-oriented graduate programs in the region focusing on the cybersecurity discipline, students completing the core MS Cybersecurity curriculum will be expected to:
 - a. Successfully demonstrate knowledge of interdisciplinary cybersecurity principles, practices, theories, operational insights, industry organizations, and technologies associated with cybersecurity. (SLO-1)
 - b. Effectively identify and analyze threats, vulnerabilities, and risks to assorted cyber infrastructures and develop/apply the appropriate technical or procedural countermeasures to address or mitigate them. (SLO-2)
 - c. Understand the role of cybersecurity within modern organizations and appreciate its assorted social/legal/policy/ethical issues. (SLO-3)
 - d. Demonstrate the ability to conduct scholarly and/or professional-level research and the various skills necessary in the cybersecurity profession such as team collaboration, critical thinking, time management, and effective communication. (SLO-4)
- 3) Learning outcomes to assess the success of the program in meeting these objectives are included in Appendix 4. The UMBC Graduate School, College of Engineering and Information Technology, Department of Computer Science and Electrical Engineering, Division of Professional Studies, and Provost's Office tracks enrollments, retention, time-to-degree, and graduation rates for all programs. The Division of Professional Studies also is developing tools and mechanisms to track career placements. Appendix 6 describes the mechanisms used by the program to assess and document student learning competencies/outcomes (SLOs) in support of program objectives.
- 4) The MS Cybersecurity program consists of 30 credits divided into 18 credits in the degree core and 12 credits as electives. The degree core includes a 3-credit capstone project research course. For increased curriculum flexibility, there is no set sequence of required courses, except that the project course (CYBR 624) generally is taken after the other core courses have been completed successfully and that students new to cybersecurity are encouraged to start with CYBR 620 in their first semester. Additionally, prospective students holding

certain current industry certifications may, upon proper documentation, request CYBR 620 be waived, and that another course be used to satisfy that credit requirement (usually a fifth elective.).

Core courses are aligned with reasonable needs and expectations of the cybersecurity industry and practitioners. Given the interdisciplinary nature of the cybersecurity field and need to present students the opportunity to be flexible in their study foci based on their specific interests or needs, they may take appropriate electives from another program or department to fulfill their credit requirements after consultation with their advisor to determine the course's relevance to the degree program and the student's qualifications. Students also may receive credit for conducting appropriate independent study projects or partaking in industry or government-centric internships in the cybersecurity domain. Degree requirements for the M.S. in Cybersecurity are contained in Appendix 3. Course descriptions for core courses and electives owned by the Cybersecurity program are shown in Appendix 7.

- 5) Gen Ed Requirements: N/A
- 6) Accreditation or Certification Requirements: N/A
- 7) Other Institutions or Organizations: The department does not currently intend to contract with another institution or non-collegiate organization for this program.
- 8) Student Support: Detailed in Appendix 5.
- 9) The primary audience for the M.S. Cybersecurity is the early-to-midcareer working professional in the cybersecurity or related field from government or industry within Maryland. Local and regional marketing will be conducted by the Division of Professional Studies (DPS), while national and international marketing is handled by the UMBC Graduate School. Marketing is accomplished via the program's website, department website, and other local or global marketing sites/activities by the Graduate School, College of Engineering and Information Technology (COEIT), and DPS. All marketing materials and websites are reviewed regularly to ensure currency and accuracy of courses, degree paths, job outlooks, technology requirements, etc. Working with the Graduate School, COEIT, and DPS, the GPD is involved in the development and approval of degree marketing outreach to ensure it accurately reflects the program and services available to it at UMBC.

The M.S. in Cybersecurity program website, FAQ, advising information, syllabi, and marketing outreach provides students with clear, complete, timely, and accurate information on the program curriculum, course and degree requirements, how students and faculty will interact (both in class and for advising purposes), the expected/desired technology competencies, minimum technical requirements (e.g., computer and internet capabilities), identifies Blackboard as the program's LMS, and the range of academic policies and support services available (e.g., financial aid, degree completion, payment policies, academic integrity, etc.). Additional information for student may be found on the UMBC Graduate School, Registrar, Student Business Services, and Veterans Affairs websites.

Admission is for fall and spring semesters only. Applicants must have a four-year baccalaureate degree from a regionally accredited U.S. institution, or an equivalent non-U.S. university and a desired minimum cumulative GPA of 3.0 (on a 4.0 scale) in all prior undergraduate and graduate degrees. International applicants must in addition provide evidence of English proficiency, financial certification, and appropriate visa documentation. A narrative statement by the student discussing their background, interests, and goals for their cybersecurity studies and career is required. GRE scores are not required, however the UMBC Graduate School requires the TOEFL or a similar exam for those who do not have a degree from the US or whose prior instructional language was not English. The M.S. Cybersecurity Admissions Committee will make a final determination of an applicant's suitability for the program in coordination with the UMBC Graduate School. Maryland residency is not required to enroll, however as a USM institution, Maryland residents pay a reduced in-state tuition rate.

As of Fall 2022, UMBC's existing Graduate Cybersecurity Program is majority-minority in terms of student demographics: International: 30%; White: 29%; African American: 18%; Asian: 13%; Hispanic: 5%;

Other/Unknown: 3%; and 2 or more races: 2%. The program is 68% male and 32% female. Minority representation enrolled in the program is significantly higher both for minority representation (41% vs. 26%) and for women (32% vs. 17%) compared to in the broader cybersecurity field⁶.

Since 2012, UMBC has been a productive member of the prestigious federal Scholarship-for-Service (SFS) program offered by the National Science Foundation. Students with US citizenship may apply for this merit-based program that provides full-time tuition and a generous stipend (\$34,000) for up to three years' graduate study in exchange for working for the federal, state, or tribal government in a cybersecurity role after graduation for each year of funding. UMBC's SFS scholars must undertake a summer internship, obtain a federal security clearance, and participate in UMBC's SFS cohort activities during the year, to include the annual Winter Study. Institutions participating in the SFS program are very attractive to students seeking to enter the federal or State cybersecurity workforce, often within Maryland and the National Capitol Region. Opportunities also exist for domestic students to apply for the Department of Defense's Cybersecurity Scholarship Program (CySP) as well. Several UMBC MPS cybersecurity MPS graduate students enrolled at both UMBC's Catonsville campus and at the Universities at Shady Grove (USG) have benefited from these attractive federal opportunities supporting their graduate education.

- 10) The MS Cybersecurity requires 30 credits and 10 courses, as shown in Appendix 3. Appendix 7 provides descriptions for these courses.

H. Adequacy of Articulation - N/A

I. Adequacy of Faculty Resources

- 1) Faculty supporting the program are full-time, tenured, or tenure-track and hold terminal degrees in their respective fields. Specific course assignments have not yet been made and change on a regular basis. Appendix 8 lists faculty supporting the M.S. Cybersecurity. Additional adjunct faculty may be included in the future based on program requirements.
- 2) Faculty teaching in this program have access to instructional development opportunities available via the UMBC Center for Applied Learning and Teaching (CALT) and other on-campus professional development activities. For any online elements of coursework, faculty can work with UMBC's own instructional design team to incorporate best (and accessible) practices when teaching in the online environment. UMBC's DOIT offers on-demand and in-person assistance to faculty on the use of Blackboard's many features to help ensure the platform helps foster a quality learning experience for students and faculty alike regardless of in-person, hybrid, or online modalities. Program and department faculty also are encouraged to share best pedagogical practices with colleagues in this program and the broader CSEE department. Several internal grant opportunities exist to support innovation in faculty pedagogy as well.

J. Adequacy of Library Resources

- 1) On behalf of UMBC's President and Librarian, the Science Librarian of the Albin O. Kuhn Library has assessed library resources required for this program. The assessment concluded that UMBC's library can meet, with its current expansive in-person and online resources, the curricular and research needs of the M.S. in Cybersecurity program faculty and students. (Note: To facilitate greater accessibility and affordability for students, wherever possible and practicable, UMBC's Graduate Cybersecurity Program uses open-access materials and publicly-available resources for instructional and enrichment activities.)
- 2) No additional library resources are required.

⁶ <https://www.isc2.org/-/media/Files/Research/Innovation-Through-Inclusion-Report.ashx>

K. Adequacy of Physical Facilities, Infrastructure and Instructional Equipment

- 1) UMBC has access to excellent resources and facilities for this program at its campus locations. There are sufficient classrooms and conference rooms at the Catonsville and Shady Grove campuses to accommodate students, all equipped with technology and software to support instruction, collaboration, and communication. UMBC's internet, software, and computing capabilities are more than adequate to meet program needs – including assorted cybersecurity range environments to facilitate sensitive cybersecurity activities such as penetration testing, vulnerability/malware analysis, or reverse engineering.
- 2) All faculty and student are assigned a UMBC institutional email address. Email is the primary form of outreach on campus and in the program.
- 3) All faculty and students have access to the University's learning management system (Blackboard Ultra) for classroom and research purposes, in addition to other online collaborative tools supported by UMBC's DOIT such as Microsoft Office/360, Google Suite, and Webex. Should it be necessary, UMBC is well-equipped to handle pivots to remote learning, such as due to pandemics or weather emergencies. Faculty who want to take a deliberate and holistic approach to prepare their hybrid courses may be supported by UMBC's Planning Instructional Variety for Online Teaching (PIVOT) program. PIVOT focused on best practices for using online instruction tools such as Blackboard, Panopto, Voice Thread, etc. that also are available at UMBC. To ensure access to instructional, research, and collaboration tools, the minimum computing requirements and technical competency expectations for students are posted on the program's website⁷.

L. Adequacy of Financial Resources with Documentation

The M.S. in Cybersecurity will be self-supported through tuition revenue with the potential of receiving industry and faculty research support over time. As it is anticipated that enrollments will generate sufficient revenue to more than cover expenses, there is no significant financial impact with this proposal. As with all self-supporting graduate programs at UMBC, enrollment growth will be regularly monitored and additional, full-time faculty will be hired and/or existing part-time faculty invited to become full-time faculty to facilitate instruction and program activities across two campus locations. See Appendix 10 and 11 for program budget information.

M. Adequacy of Provisions for Evaluation of Program

- 1) Cybersecurity program faculty periodically review syllabi, rubrics, readings, labs, and projects to ensure a standard student experience and that materials used and presented remain relevant to and/or aligned with current industry trends, best practices in the discipline (i.e., the NIST Cybersecurity Framework), program objectives, and the institutional priorities called for in the *UMBC Strategic Plan*. The CSEE department, and UMBC generally, evaluates full-time faculty through the university's established promotion and tenure process in the traditional areas of teaching, research, and service. This process includes a review of their syllabi, labs, courseware, samples of student products, classroom observation, and student surveys. Adjunct faculty are evaluated by full-time faculty members regularly to ensure quality of instruction, materials, and the student's course experience.

All UMBC faculty are evaluated via the administration of student surveys issued at the end of each semester. The data from this survey is shared with the instructor and publicly available via IRADS, while any qualitative comments received are shared only with the instructor. Additionally, faculty are encouraged to work with their colleagues and the UMBC Center for Applied Teaching and Learning (CALT), or Division of Information Technology (DOIT) for additional opportunities to conduct objective course assessment and/or enhancement. The Graduate Program Director likewise solicits, investigates, and attempts to resolve any student concerns regarding course or instructor quality and/or effectiveness.

⁷ <https://professionalprograms.umbc.edu/cybersecurity/additional-information/>

- 2) Program evaluation is carried out through assessment of learning outcomes. The primary outcomes for the MS in Cybersecurity and methods of outcome assessment are identified in Appendix 4. Along with the program and department, the College of Engineering and Information Technology (COEIT) Dean's Office regularly reviews student enrollment, retention, culture, and financial data from a strategic perspective to ensure program outcomes are aligned with the Colleges goals and UMBC's *Strategic Plan*. UMBC's Provost Office also engages in strategic and financial reviews of all UMBC programs. Exit surveys are conducted each year by the Office of Professional Programs as another gauge of the student educational experience and program quality.

The University System of Maryland's accountability obligation includes a requirement that each academic program be reviewed every seven years. Accordingly, UMBC conducts academic program reviews (APR) to gauge program effectiveness. As recognized by USM and the Council of Graduate Schools, the APR process has five general purposes: quality assurance, quality improvement, accountability, identification of strategies for improvement, and providing the institution with information for prioritization of resources. CSEE's graduate programs successfully completed their latest APR in 2018.

Taken together, UMBC has a robust, multi-stakeholder method to assess academic program effectiveness, learning outcomes, student retention, student/faculty satisfaction, and cost-effectiveness. These methods are supported by continual internal UMBC evaluation of industry trends and needs to ensure programs continue to meet current and future industry and workforce requirements.

N. Consistency with the State's Minority Student Achievement Goals

- 1) UMBC was designated a Minority Serving Institution in 2017 and is #1 in the nation for producing the most African American graduates who have gone on to earn MD-PhD degrees, according to the Association of American Medical Colleges (AAMC). According to NSF-NCSES data, from 2010-2019, UMBC was the #1 baccalaureate origin institution in the nation for African American students who go on to earn Ph.Ds in the natural sciences, engineering, life sciences, mathematics, and computer science. As of Fall 2022, UMBC's existing Graduate Cybersecurity Program is majority-minority in terms of student demographics: International: 30%; White: 29%; African American: 18%; Asian: 13%; Hispanic: 5%; Other/Unknown: 3%; and 2 or more races: 2%. The program is 68% male and 32% female. UMBC is pleased to report that minority representation enrolled in its Graduate Cybersecurity Program is significantly higher both for minority representation (41% vs. 26%) and for women (32% vs. 17%) compared to in the broader cybersecurity field⁸.

Among other active efforts to foster greater diversity in our campus community of scholars, UMBC joined the University Innovation Alliance (UIA) in June 2021. The UIA is the leading national coalition of public research universities committed to increasing the number and diversity of college graduates in the U.S., with a specific focus on low income, first-generation, and students of color. In the next phase of its work, the UIA will focus on eliminating disparities in educational outcomes based on race and ethnicity, in addition to disparities by income, first-generation college student status, gender, and geography. UMBC's Spring 2022 Diversity Report is available online⁹.

O. Relationship to Low Productivity Programs Identified by the Commission - N/A

P. Adequacy of Distance Education Programs

As a program targeting adult learners and working professionals, courses in this proposed degree will be taught in-person, hybrid, and online modalities to provide maximum flexibility and accessibility to students in this critical field. This practitioner-oriented curriculum was developed by faculty within the UMBC Department of Computer Science and Electrical Engineering (CSEE), drawing upon their expertise in the areas of cybersecurity and related

⁸ <https://www.isc2.org/-/media/Files/Research/Innovation-Through-Inclusion-Report.ashx>

⁹ <https://provost.umbc.edu/wp-content/uploads/sites/46/2022/04/Spring-2022-UMBC-Cultural-Diversity-Report.pdf>

disciplines. CSEE's industrial advisory board members also provide expert insights that inform the program. Program faculty, as subject-matter-experts, also regularly discuss emerging trends or current events that may require updating or creation of curricular modules and/or incorporating specialized instructional tools/platforms such as Metasploit, FTK, Wireshark, Tableau, Ghidra, and other cybersecurity tools into the curriculum. As part of the degree program, the online elements of this MS in Cybersecurity will be overseen by full-time Graduate Program Director and member of the CSEE faculty with a strong cybersecurity background. The GPD, as a direct report to the Chair of the Computer Science and Electrical Engineering, is supported as needed by the Chair in matters related to faculty/program oversight, mentoring, and related issues. Additionally, the Cybersecurity Graduate Program Director is a member of the Computer Science Graduate Committee and works with that committee on areas of mutual interest and oversight, to include new course ideas and program innovations. The minimum computer and technical requirements for students are posted on the program's website. Technical support for UMBC's platforms, such as email and Blackboard, is provided by UMBC's DOIT upon request to the Help Desk Request Tracker.

Students enrolled in online or hybrid elements of this program have access to the same technology support resources as all UMBC students, including through the Division of Information Technology (DOIT), Career Services, Off-Campus Student Services, Office of Equity and Inclusion, and the Graduate Student Association, among many others. Depending on the demands of the program, DPS may allocate additional staff and resources to assist as necessary, such as those on the Office of Professional Programs Student Success team. The Albin O. Kuhn Library is well-equipped to support remote research and learning, offering a comprehensive suite of resources both online and in-person.

In addition to using Blackboard or (in some cases) producing their own YouTube instructional videos supporting online course modalities, faculty wishing to take a deliberate and holistic approach to prepare or modify their online or hybrid courses are supported by UMBC's Planning Instructional Variety for Online Teaching (PIVOT) program. PIVOT focuses on best practices in higher education for using online instruction tools such as Blackboard, Panopto, Voice Thread, etc. that also are available at UMBC. Faculty teaching in online or hybrid modalities have access to instructional development opportunities through the UMBC Center for Applied Learning and Teaching (CALT) and other on-campus professional development activities and can work with UMBC's own instructional design team to incorporate best (and accessible) practices when teaching in hybrid or online environments.

Students enrolled in an online modality may conduct all necessary transactions entirely online. Official information about curriculum updates, new courses, internships, graduation deadlines, etc. are conveyed to students via the student email list as the program's official distribution medium and/or directly to the students who are on email lists maintained by UMBC's Graduate School (for graduations and academic affairs), Registrar (for scheduling), Student Business Services (for costs and financial aid), or other campus entities.

UMBC's Office of Accessibility & Disability Services (ADS) under the Division of Academic Affairs ensures that students with disabilities are afforded an equal opportunity to participate in and benefit from the programs, services, and activities of the University through the provision of accommodations and reasonable modifications that result in equal access and full inclusion, which reflects UMBC's commitment to fostering an accessible and inclusive environment for all members of the UMBC community. Assistance from the ADS team is available to all UMBC students regardless of learning modality.

Quality assurance of the curricular online components of the program are identical to those described in Section M above. When necessary or appropriate, additional QA support and guidance regarding online learning may be requested from the UMBC DOIT or CALT.

Appendix 1

Education and Training Needs by Source

According to the Bureau of Labor Statistics' *Occupation Outlook Handbook*, 'Information Security Analyst' is one of the 20 occupations with the highest projected percent change of employment between 2021-31. This job has a 10 year growth rate of 35% and a national average salary of \$102,600. About 19,500 openings for information security analysts are projected each year, on average, over the decade. Many of those openings are expected to result from the need to replace workers who transfer to different occupations or exit the labor force, such as to retire.¹⁰

The Baltimore-Washington region in particular is a hotspot for the cybersecurity workforce. According to data gathered from Lightcast, a labor market analytics tool, there were 19,293 cyber-related job postings in the Washington and Baltimore MSA in 2021. The national average for an area this size is 4,829 employees. **The job posting activity in this region also is high: while the national average for an area this size is 421 job postings per month, there are 1,714 postings per month in the Washington-Baltimore area.** Regional employers hiring cybersecurity professionals include the federal and state government, Amazon, Leidos, ManTech, Booz Allen Hamilton, and Capitol One, among many others.¹¹ Moreover, according to *The Industries of the Future* (Ross, 2016), "over the 20 years from 2000 to 2020, the cybersecurity market will have grown from a \$3.5 billion market employing a few thousand people working in IT departments to a \$175 billion market providing critical infrastructure to just about every kind of business, big and small."

¹⁰ Bureau of Labor Statistics, U.S. Department of Labor, Occupational Outlook Handbook, Information Security Analysts at <https://www.bls.gov/ooh/computer-and-information-technology/information-security-analysts.htm> (accessed 9/8/22).

¹¹ Source: Lightcast™, https://a.economicmodeling.com/analyst/?t=3w4h8#h=hy5jD&page=occupation_snapshot&vertical=standard&nation=us, accessed 9/9/2022.

Appendix 2

Greater Baltimore Metropolitan Region Program Duplication Discussion

Johns Hopkins University (JHU) offers a graduate degree program leading toward a M.S. in Cybersecurity. The program boasts foci in the following areas: analysis, assured autonomy, networks, and systems.

UMBC Response: The JHU program is mostly focused on secure software engineering, autonomous vehicle, and space cybersecurity. The program is more computer science- and engineering-oriented vs UMBC's proposed program, and due to its more selective admissions and pre-requisite requirements, requires prospective students to have engineering, computer science and information technology undergraduate degrees. By contrast, UMBC's proposed MS in Cybersecurity does not require specific academic prerequisites and is more focused on broad-based applied cybersecurity topics supplemented by technical and non-technical electives chosen by students to meet their personal or professional needs rather than specific sub-fields.

Morgan State University offers a graduate degree program leading toward an M.S. in Advanced Computing. The program does offer courses in cybersecurity but is focused more on the intersections between various computing disciplines. The program is very technical with courses such as Quantum Cryptography and Big Data Analytics.

UMBC Response: Morgan State does not offer a specific graduate cybersecurity degree program. However its M.S. in Advanced Computing offers some cybersecurity courses on network security, cloud security, security management, and cryptography but is mainly focused on technical aspects. By contrast, UMBC's proposed M.S. in Cybersecurity curriculum is entirely focused on cybersecurity topics, to include courses on non-technical topics such as cybersecurity risk and laws/policies which give students with non-technical backgrounds an opportunity to advance their cybersecurity knowledge.

Stevenson University offers a graduate degree program leading toward a M.S. in Cybersecurity and Digital Forensics. The program is centralized on digital forensics and analysis.

UMBC Response: Stevenson's program is online-only compared to UMBC's proposed M.S. in Cybersecurity, which is primarily lecture and hybrid-based. Stevenson's curriculum focuses primarily on the technical aspects of cybersecurity with a significant emphasis on network and file-based forensics. By contrast, UMBC's proposed M.S. in Cybersecurity curriculum takes a broader approach to cybersecurity, covering both technical and non-technical topics that are of interest to a wider range of cybersecurity practitioners and experience both in its core and elective offers from cybersecurity and other programs. While the proposed UMBC program includes a two-course forensics sequence as optional electives, it does not specialize in forensics.

Towson University offers an M.S. in Computer Science with a track in Cybersecurity.

UMBC Response: As a broad-based Computer Science degree, the only significant curricular exposure to cybersecurity in Towson's program are at least 3 security-related courses in the degree's specialty track in cybersecurity plus a student's thesis or project. By contrast, UMBC's proposed M.S. in Cybersecurity curriculum is entirely focused on cybersecurity topics, to include courses on non-technical topics such as cybersecurity risk and laws/policies which give students with non-technical backgrounds an opportunity to advance their cybersecurity knowledge.

The **University of Baltimore (UB)** offers two graduate degree programs in cybersecurity, both resulting in a M.S.: Cyber Forensics and Cybersecurity Management.

UMBC Response: The UB M.S. in Cybersecurity Management includes 3 courses focused on cybersecurity topics from a management perspective, however the rest of the degree consists of more traditional business leadership

and general management courses. The UB M.S. in Cyber Forensics, as the name implies, focuses primarily on computer and network forensics activities as a specialized subset of the cybersecurity field, with only 1 course covering the rest of the cybersecurity domain. UMBC's proposed M.S. in Cybersecurity curriculum is entirely focused on cybersecurity topics, to include courses on non-technical topics such as cybersecurity risk and laws/policies which give students with non-technical backgrounds an opportunity to advance their cybersecurity knowledge. UMBC's proposed M.S. degree does not address general business management or leadership topics outside of their relevance to cybersecurity. While the proposed UMBC program includes a two-course forensics sequence as optional electives, the program does not specialize in forensics as a primary focus.

The **University of Maryland, Global Campus (UMGC)** offers several graduate degree programs in cybersecurity resulting in a M.S.: Cyber Operations, CyberAccounting, Cybersecurity & Management Policy, Cybersecurity Technology, Cloud Computing Systems, Digital Forensics & Cyber Investigation, and Information Technology/Information Assurance. All programs are offered online with select options for hybrid learning.

UMBC Response: UMBC's single degree curriculum takes a broad approach to cybersecurity, covering both technical and non-technical topics that are of interest to a wider range of cybersecurity practitioners as opposed to the more specialized curriculum of UMGC's various degrees. UMBC's degree also allows students to take relevant courses from other programs, such as Computer Science, Computer Engineering, or Data Science to further enhance their education based on personal or professional requirements. UMBC students may also receive elective credit for internship/co-op opportunities, activities under the federal SFS program, or conduct for-credit independent research projects on cybersecurity items with regular and/or tenure-track faculty. UMBC's proposed M.S. in Cybersecurity program will be offered in-person and hybrid modalities, is a selective-admission program, and does not specifically target distance-learning markets.

The **University of Maryland, College Park (UMCP)** offers a graduate degree program leading toward a M.Eng. in Cybersecurity. The program is centralized on engineering applications with computer science principles. This 30-credit plan of study can be completed either in-person or online and is comprised of a combination of cybersecurity and technical courses.

UMBC Response: UMBC's is an M.S. degree, which differs from UMCP's M.Eng. degree, and does not specifically focus on engineering or computer science topics. In terms of program content, the UMCP curriculum is a fully technical program focused on software engineering, cryptography, and AI. UMBC's program, by contrast, does not have a specialized focus in engineering, offers both technical and non-technical courses such as cybersecurity risk and laws/policies which give students with non-technical backgrounds an opportunity to advance their cybersecurity knowledge. UMBC students desiring exposure to computing topics like AI or software engineering may take elective courses from the Computer Science or Software Engineering programs.

Capitol Technology University (CTU) offers 4 cybersecurity-related M.S. degrees. Three relate to the cybersecurity aspects of Aviation, Construction, Cyber Analytics) and one is a more general M.S. in Cybersecurity degree. Additionally, they offer a Technical MBA in Cybersecurity.

UMBC Response: CTU's M.S. in Cybersecurity core curriculum focuses primarily on technical and operational activities related to cybersecurity. Electives appear to be restricted to business or security topics. UMBC's core curriculum takes a similar broad approach to cybersecurity, however the core curriculum is not weighted as heavily on the technical aspects of cybersecurity. Rather, that emphasis is done via electives that may be technical or non-technical depending on a student's needs or professional requirements, with courses coming from Cybersecurity, Computer Science, Data Science, Computer Engineering, Software Engineering, Public Policy, or other graduate programs. Additionally, UMBC's program does not require foundational courses in security and/or operating systems for incoming students without technical academic or professional backgrounds. UMBC's M.S. Cybersecurity students also may receive elective credit for internship/co-op opportunities, activities under the federal SFS

program, or conduct for-credit independent research with regular and/or tenure-track faculty on cybersecurity topics

We did not find similar graduate programs at Bowie State University, Coppin State University, Loyola University Maryland, or Notre Dame of Maryland University.

Appendix 3 MS Cybersecurity Degree Requirements

The required core curriculum of the M.S. in Cybersecurity (18 credits) is as follows:

CYBR 620	Introduction to Cybersecurity (3)
CYBR 624	Cybersecurity Project (3) *
CYBR 650	Managing Cyber Operations (3)
CYBR 652	Enterprise Security (3)
CYBR 655	Security of Distributed Systems (3)
CYBR 658	Risk Analysis and Compliance (3)

(*) usually taken after other core courses are completed

Students must take 4 3-credit electives (12 credits) from the CYBR program or other graduate programs, such as Computer Science, Data Science, or Public Policy with the approval of their advisor. The UMBC Graduate Catalog¹² provides information and descriptions for those courses.

Below is a *sample* listing of regularly recurring elective courses from the CYBR program:

CYBR 621	Cyber Warfare (3)
CYBR 622	Global Cyber Capabilities and Trends (3)
CYBR 623	Cybersecurity Law and Policy (3)
CYBR 641	Cybercrime Investigations (3)
CYBR 642	Introduction to Digital Forensics (3)
CYBR 643	Advanced Digital Forensics (3)
CYBR 644	Cyber Practitioner Development Lab (3)
CYBR 688	Introduction to Reverse Engineering (3)
CYBR 691	Special Topics in Cybersecurity (assorted technical/non-technical topics) (3)
CYBR 696	Independent Study for Internships/Co-Ops (3)
CYBR 699	Independent Study in Cybersecurity (1-3)

For increased curriculum flexibility, there is no set sequence of required courses, except that the capstone (CYBR 624) generally is taken after the other core courses have been completed successfully and that students new to cybersecurity are recommended to start with CYBR 620 in their first semester. Additionally, prospective students holding certain current industry certifications may, upon proper documentation, request CYBR 620 be waived, and that another course be used to satisfy that credit requirement (usually a fifth elective.)

¹² <https://catalog.umbc.edu/index.php?catoid=32>

Appendix 4

Learning Outcomes & Assessments, MS in Cybersecurity

(SLO-1) Students will successfully demonstrate knowledge of interdisciplinary cybersecurity principles, practices, theories, operational insights, industry organizations, and technologies associated with cybersecurity.

MEASURE: Students will be required to successfully pass the required and elective courses in the degree program. They will be assessed on their understanding of these items with the goal of developing a robust and interdisciplinary knowledge of the cybersecurity domain. As appropriate, each course will assess students based on exams, individual or group projects, presentations, papers, lab exercises, and/or case studies.

CRITERION: Successful completion of each course with a B or better grade. The individual faculty member and/or the Cybersecurity Graduate Program Director will meet with students not meeting this criteria to help improve their performance or determine their continued enrollment in the program. The Cybersecurity Graduate Program Director reviews syllabi at least annually to ensure relevancy, currency, and pedagogical appropriateness.

ASSESSMENT: Each semester starting in Spring 2024 or upon program launch.

(SLO-2) Students will effectively identify and analyze threats, vulnerabilities, and risks to assorted cyber infrastructures and develop/apply the appropriate technical or procedural countermeasures to address or mitigate them.

MEASURE: Students will be assessed on their understanding of these items with the goal of putting theoretical and conceptual knowledge into direct operational and technical use. In this case, emphasis is on technical and operational elements of cybersecurity activities in the workplace. As appropriate, each course will assess students based on exams, individual or group projects, papers, lab exercises, and/or case studies.

CRITERION: Successful completion with a B or better grade. The individual faculty member and/or the Cybersecurity Graduate Program Director will meet with students not meeting this criteria to help improve their performance or determine their continued enrollment in the program. The Cybersecurity Graduate Program Director reviews syllabi at least annually to ensure relevancy, currency, and pedagogical appropriateness.

ASSESSMENT: Each semester starting in Spring 2024 or upon program launch.

(SLO-3) Students will understand the role of cybersecurity within modern organizations and appreciate its assorted social/legal/policy/ethical issues.

MEASURE: Students will be assessed on their understanding of these items with the goal of understanding the role of cybersecurity in the modern workplace, organization, nation, and society at large.. As appropriate, each course will assess students based on exams, individual or group projects, presentations, papers, literature reviews, and/or case studies.

CRITERION: Successful completion with a B or better grade. The individual faculty member and/or the Cybersecurity Graduate Program Director will meet with students not meeting this criteria to help improve their performance or determine their continued enrollment in the program. The Cybersecurity Graduate Program Director reviews syllabi at least annually to ensure relevancy, currency, and pedagogical appropriateness.

ASSESSMENT: Each semester starting in Spring 2024 or upon program launch.

(SLO-4) Students will demonstrate the ability to conduct scholarly and/or professional-level research and the various skills necessary in the cybersecurity profession such as team collaboration, critical thinking, time management, and effective communication.

MEASURE: Students will be assessed on their ability to develop and present scholarly or professional-grade written and oral deliverables such as analysis papers, presentations, and their capstone project. To meet these goals they will be expected to demonstrate effective organizational, time management, communication, critical thinking, and other such skills that contribute to an effective cybersecurity practitioner in the workplace. As appropriate, each course will assess students based on exams, individual or group projects, presentations, papers, literature reviews, and/or case studies.

CRITERION: Successful completion with a B or better grade. The individual faculty member and/or the Cybersecurity Graduate Program Director will meet with students not meeting this criteria to help improve their performance or determine their continued enrollment in the program. The Cybersecurity Graduate Program Director reviews syllabi at least annually to ensure relevancy, currency, and pedagogical appropriateness.

ASSESSMENT: Each semester starting in Spring 2024 or upon program launch.

Appendix 5 Student Support

The MS Cybersecurity graduate program director(s) is responsible for the majority of advising. Other faculty involved with courses and specialization may also advise students and/or participate on capstone project committees. The CSEE department is supported by the UMBC Division of Professional Studies (DPS) for program administrative support, recruitment, and marketing operations. Students in this program will have access to UMBC's wide range of support resources such as the Division of Information Technology (DOIT), Career Services, Off-Campus Student Services, Office of Equity and Inclusion, and the Graduate Student Association, among many others. Depending on the demands of the program, DPS may allocate additional staff and resources to assist as necessary, such as those on the Office of Professional Programs Student Success team. UMBC students and faculty use Blackboard as the official campus Learning Management System for course work and administration to support lecture, hybrid, and online learning modalities.

Students will be expected to have ready access to computers and the internet, with guidance on minimum technical requirements posted publicly on the program's website. Outside of lecture or in-person meetings, students and faculty will be expected to communicate through email, Blackboard, and UMBC's other collaborative platforms such as MyUMBC or Google Documents. Official information about curriculum updates, new courses, internships, graduation deadlines, etc. are conveyed to students via the student email list as the program's official distribution medium and/or directly to the students who are on email lists maintained by UMBC's Graduate School (for graduations and academic affairs), Registrar (for scheduling), Student Business Services (for costs and financial aid), or other campus entities. Technical support for UMBC's platforms, such as email and Blackboard, is provided by UMBC's DOIT upon request to the Help Desk Request Tracker. Information of interest to students, ranging from program and course information, academic expectations, tuition and fees, graduation requirements, and more, are located on UMBC's various public websites.

As of 2022, the only financial aid opportunities for this self-supported program are offered by the US government and open to US Citizens only (SFS and CySP) -- information can be found at cybersecurity.umbc.edu/scholarships/. Students seeking additional funding or employment to support their studies are encouraged to work with the Career Center to identify relevant opportunities.

UMBC's Office of Accessibility & Disability Services (ADS) under the Division of Academic Affairs ensures that students with disabilities are afforded an equal opportunity to participate in and benefit from the programs, services, and activities of the University through the provision of accommodations and reasonable modifications that result in equal access and full inclusion, which reflects UMBC's commitment to fostering an accessible and inclusive environment for all members of the UMBC community. Assistance from the ADS team is available to all UMBC students regardless of learning modality or campus location.

UMBC's Office of Equity and Inclusion has primary responsibility for managing UMBC's efforts related to Title IX as well as other civil rights issues, including discrimination, harassment, hate and bias. All faculty are considered 'responsible parties' regarding reporting requirements pursuant to UMBC's Title IX policies.

Appendix 6

Student Competencies Assessment

This appendix describes the quantitative and qualitative ways that M.S. Cybersecurity students will be assessed in their courses, which are aligned with the program objectives described earlier.

Quantitative assessment

- Maintenance of a 'B' or better cumulative GPA.
- Quizzes, mid-term, and/or final examinations as appropriate.
- Practical examinations to evaluate competency with cybersecurity tools and techniques.
- Written project analyses and/or case studies.
- Written assignments, including in-class writing assignments and research papers that require students to conduct independent or team-based research and analysis to produce deliverables supporting course objectives
- Oral assignments that include both presentation of individual or group work and critiquing the work of others.
- Experiential learning opportunities as offered through faculty-led research opportunities, internships, field experiences, independent studies, among other opportunities.
- Capstone course.
- Other assessment mechanisms that may become relevant or required by the cybersecurity industry.

Qualitative assessment

- Academic advising at the program level to ensure students maintain academic and program expectations to proactively head off potential obstacles to success.
- Individual, peer-group, and/or in-class critiques of student work.
- Direct engagement between faculty and students in classroom, lab, or online platforms.
- Capstone courses (CYBR 624) where students conduct a structured independent research effort to develop a scholarly or professional paper demonstrating their critical thinking skills, analytical capabilities, and/or accumulated technical expertise as a cybersecurity practitioner.

Appendix 7

MS in Cybersecurity Course Names and Descriptions (Core Courses and Program-Owned Electives)

CYBR 620: Intro to Cybersecurity (3 cr.)

This course introduces students to the interdisciplinary field of cybersecurity by discussing the evolution of information security into cybersecurity, cybersecurity theory, and the relationship of cybersecurity to nations, businesses, society, and people. Students will be exposed to multiple cybersecurity technologies, processes, and procedures, learn how to analyze the threats, vulnerabilities and risks present in these environments, and develop appropriate strategies to mitigate potential cybersecurity problems.

CYBR 624: Cybersecurity Project (3 cr.)

This is the capstone experience for graduate students in the M.P.S. Cybersecurity program. Normally taken in the final semester before graduation, the Cybersecurity Project provides an opportunity for students to carry out an individual piece of research (or project activity) on a specified topic in the cybersecurity or cyber operations domain. Their work should make an original contribution to the body of knowledge in the area of study or otherwise demonstrate the student's comprehensive knowledge of cybersecurity or cyber operations.

Prerequisite: Enrollment in CYBR M.P.S. program and completion of at least CYBR 620, CYBR 623, CYBR 650.

CYBR 650: Managing Cybersecurity Operations (3 cr.)

This course takes an operational approach to implementing and managing effective cybersecurity in highly networked enterprises. Topics include an evaluation of government and commercial security management models; security program development; risk assessment and mitigation; threat/vulnerability analysis and risk remediation; cybersecurity operations; incident handling; business continuity planning and disaster recovery; security policy formulation and implementation; large-scale cybersecurity program coordination; management controls related to cybersecurity programs; information-sharing; and privacy, legal, compliance, and ethical issues.

CYBR 652: Enterprise Security (3 cr.)

This class will take a technical approach in protection of information assets and systems by integrating technical controls with policies, best practices, and guidelines of cybersecurity. Taking both a policy-based and technical approach, this course examines external and internal security threats in highly connected enterprises and risks to the core business relative to people, processes, data, facilities, and technologies. How to implement and manage effective the major technical components of security architectures (firewalls, virtual private networks, etc.) and selected methods of attacking enterprise architectures also will be addressed.

CYBR 658: Risk Analysis and Compliance (3 cr.)

This course focuses on risk intelligence and risk-based planning for enterprise cybersecurity. This course analyzes external and internal security threats, failed systems development and system processes and explores their respective risk mitigation solutions through policies, best practices, operational procedures, and government regulations. Risk frameworks covered include NIST SP 800-53, SP 800-37, SP 800-39, and CERT/CC risk analysis guidelines.

CYBR 655: Security of Distributed Systems (3 cr.)

This course focuses the student on a broad range of topics relative to securing distributed systems. Students will gain an understanding of the principles and techniques behind the design of distributed systems along with their associated cybersecurity issues and remediation techniques. Cloud computing and the Internet of Things (IoT) will be major distributed environments examined.

Students also must take 4 3-credit electives (12 credits) from the CYBR program or other graduate programs (such as Computer Science or Data Science) with the approval of their advisor. A selected list of electives from the CYBR program is shown below...

CYBR 621 - Cyber Warfare (3 cr.)

This course addresses some of the unique and emerging policy, doctrine, strategy, and operational requirements of conducting cyber warfare at the nation-state level. It provides students with a unified battlespace perspective and enhances their ability to manage and develop operational systems and concepts in a manner that results in the integrated, controlled, and effective use of cyber assets in warfare.

CYBR 622 - Global Cyber Capabilities and Trends (3 cr.)

This course focuses on four general areas of cyber capabilities and trends in the global community: the theory and practice of cybersecurity and cyberwar; cyber capabilities of nation-states as well as non-state actors; trends in cyber-related strategies and policies; and cyber-related challenges facing the U.S. government. The course concludes with a national cybersecurity policy exercise that helps demonstrate the challenges and complexities of the dynamic and global cybersecurity environment.

CYBR 623 - Cybersecurity Law and Policy (3 cr.)

Students will be exposed to the national and international policy and legal considerations related to cybersecurity and cyberspace such as privacy, intellectual property, cybercrime, homeland security (i.e., critical infrastructure protection) and cyberwarfare, and the organizations involved in the formulation of such laws and policies. Broader technology issues also are discussed to demonstrate the interdisciplinary influences and concerns that must be addressed in developing or implementing effective national cybersecurity laws and policies.

CYBR 641 - Cybercrime Investigations (3 cr.)

This course examines US and international cybercrime law, legal procedures, and best practices needed to conduct effective and evidentiary-compliant computer forensics activities (such as search and seizure, chain of custody, documentation, courtroom preparation, etc.) and the dedication to gather facts that can lead to prosecutable legal outcomes. Students will be introduced to these topics through required readings, case studies, in-class lecture, scholarly articles, judicial opinions and classroom discussions.

CYBR 642 - Introduction to Digital Forensics (3 cr.)

This interactive hands-on course will provide an introduction to computer and network technical incident handling and forensics activities. Topics include disk and file system imaging and forensics, packet capture and analysis, basic malware examination, log file analysis, analysis of volatile data (such as RAM), the incident handling process, and more.

CYBR 643 - Advanced Digital Forensics (3 cr.)

This hands-on course expands upon the theory and application of digital forensics activities to provide students intensive experience using well known publicly available, digital forensic tools. Students will perform a series of digital forensic examinations on fictitious evidence (hardware, network, mobile) that model real-world criminal activity with the goal of developing proficiency in forensic analysis techniques based on real-world scenarios.

CYBR 644 - Cyber Practitioner Development Lab (3 cr.)

This interactive hands-on course will demonstrate how to scan, test, probe and secure systems and networks within a controlled environment. Among other things, students will learn how intruders obtain and escalate privileges and what steps can be taken to test and secure networked systems using commonly accepted tools and procedures. Attacks covered include social engineering, denial of service, buffer overflows, password cracking, rootkits, session hijacking, SQL injection, and web application exploits. Students completing this course successfully will be well-positioned to take cybersecurity certification examinations such as the Certified Ethical Hacker (CEH) but such exams are NOT included in the course.

CYBR 688 - Software Reverse Engineering (3 cr.)

This course explores a variety of analysis techniques used to understand the inner workings of a binary program or system of programs. This includes systems analysis, static code analysis, and dynamic code analysis. Students will gain hands-on experience using reverse engineering tools including system monitors, disassemblers, and debuggers, to perform important tasks such as evaluating program security, constructing interoperable software,

and understanding the nature of malware. By the end of the course, students should be able to apply a variety of tools and techniques in order to answer questions about a program's functionality without referring to its original source code.

CYBR 691 - Special Topics in Cybersecurity (3 cr.)

Courses on specialized or emerging cybersecurity topics offered on a timely or as-needed basis. This course can be repeated for credit. The description of the actual topic I list in the "note section" in the Schedule of Classes.

CYBR 696 - Independent Study for Interns and Co-op Students (3 cr.)

Supervision of student internship/co-op activities in the cybersecurity discipline. A short technical report that describes the activities conducted relevance to theoretical or operational concepts learned in other coursework and lessons gained through the internship/co-op experience is required at the end of the course. The course grade will be based on the technical report. The report will be submitted to the student's Graduate Program Director by the last day of the semester.

CYBR 699 - Independent Study in Cybersecurity (3 cr.)

Individualized research activities conducted under faculty supervision related to cybersecurity.

Appendix 8**Full-time Faculty Supporting the M.S. in Cybersecurity**

The CSEE faculty listed below supporting the M.S. in Cybersecurity are full-time regular faculty with cybersecurity expertise. Specific course/teaching assignments have not yet been made and change on a regular basis. Additional faculty, including full-time, part-time, and/or adjuncts may be included in the future to support instructional needs as needed.

Name	Highest Degree Earned, Field, Institution	Rank
Anupam Joshi	Ph.D., Computer Science, Purdue University	Professor
Richard Forno	Ph.D., Internet Studies, Curtin University of Technology	Principal Lecturer
Alan Sherman	Ph.D., Computer Science, MIT	Professor
Charles Nicholas	Ph.D., Computer Science, Ohio State University	Professor
Nilanjan Banerjee	Ph.D., Computer Science, University of Massachusetts	Professor
Tim Finin	Ph.D., Computer Science, Illinois Urbana-Champaign	Professor
Naghmeh Karimi	PhD., Computer Engineering, University of Tehran	Assistant Professor
Samuel Lomanaco	Ph.D., Mathematics, Princeton University	Professor
Christopher Marron	Ph.D., Mathematics, UVA	Professor of Practice
Gerald Tompkins	M.S., Computer Science, Johns Hopkins University	Lecturer
Mohamed Younis	Ph.D., Computer Science, New Jersey Institute of Technology	Professor

Appendix 9
Degree Path

There is no required path toward degree completion and students generally may take courses in any order. Most students are encouraged to start with CYBR 620 (Introduction to Cybersecurity), especially if they are new to the discipline. Other courses may be taken in any order except that the capstone project (CYBR 624) usually is taken after completing the five (5) core courses – most often during a student’s final semester.

There are no academic or knowledge prerequisites for the core courses required for degree completion. However, certain specialized electives may have academic, professional, or knowledge prerequisites such as CYBR 688 (Introduction to Reverse Engineering) or CMSC 649 (Malware Analysis). For highly specialized electives, students lacking the appropriate background are encouraged to speak with their respective program director and/or the course instructor before registering to determine their ability to complete such courses successfully.

Appendix 10

TABLE 1: PROGRAM RESOURCES					
Resource Categories	Year 1	Year 2	Year 3	Year 4	Year 5
1. Reallocated funds					
2. Tuition/fee Revenue (c + g below)	\$1,062,741	\$1,197,404	\$1,577,387	\$1,842,791	\$1,999,155
a. Number of F/T Students	52	65	92	102	106
b. Annual Tuition/Fee Rate	\$12,959	\$13,348	\$13,749	\$14,161	\$14,586
c. Total F/T Revenue (a x b)	\$678,557	\$873,643	\$1,270,379	\$1,450,244	\$1,549,907
d. Number of P/T Students	59	49	45	55	62
e. Credit Hour Rate	\$0	\$0	\$0	\$0	\$0
f. Annual Credit Hour Rate	\$6,480	\$6,674	\$6,874	\$7,081	\$7,293
g. Total P/T Revenue (d x e x f)	\$384,183	\$323,762	\$307,008	\$392,547	\$449,248
3. Grants, Contracts & Other External Sources	\$0	\$0	\$0	\$0	\$0
4. Other Sources	\$0	\$0	\$0	\$0	\$0
TOTAL (Add 1-4)	\$1,062,741	\$1,197,404	\$1,577,387	\$1,842,791	\$1,999,155

Appendix 11

TABLE 2: PROGRAM EXPENDITURES					
1. Faculty (b + c below)	\$230,960	\$237,889	\$245,025	\$252,376	\$259,947
a. Number of FTE	1	1	1	1	1
b. Total Salary	\$172,358	\$177,529	\$182,855	\$188,340	\$193,991
c. Total benefits	\$58,602	\$60,360	\$62,171	\$64,036	\$65,957
2. Admin. Staff (b + c below)	\$0	\$0	\$0	\$0	\$0
a. Number of FTE	\$0	\$0	\$0	\$0	\$0
b. Total Salary	\$0	\$0	\$0	\$0	\$0
c. Total benefits	\$0	\$0	\$0	\$0	\$0
3. Support Staff (b + c below)	\$0	\$0	\$0	\$0	\$0
a. Number of FTE	\$0	\$0	\$0	\$0	\$0
b. Total Salary	\$0	\$0	\$0	\$0	\$0
c. Total benefits	\$0	\$0	\$0	\$0	\$0
4. Technical Support and Equipment	\$3,080	\$3,172	\$3,268	\$3,366	\$3,467
5. Library	\$0	\$0	\$0	\$0	\$0
6. New or Renovated Space	\$0	\$0	\$0	\$0	\$0
7. Other Expenses *	\$692,815	\$735,014	\$882,521	\$988,540	\$1,055,167
TOTAL (add 1-7)	\$926,855	\$976,075	\$1,130,814	\$1,244,281	\$1,318,581

*includes operating expenses, administrative support, central campus overhead, part-time faculty, full-time faculty overload/onload transfers

Appendix 12

Educational Assessment Methods

Program evaluation is carried out through assessment of learning outcomes in accordance with UMBC's existing policies and procedures.

Cybersecurity program faculty periodically review syllabi, rubrics, labs, and projects to ensure a standard student experience and that materials used and presented remain relevant viz-a-viz current industry trends.

The CSEE department, and UMBC generally, evaluates full-time faculty through the university's established promotion and tenure process in the traditional areas of teaching, research, and service. This process includes a review of their syllabi, labs, courseware, samples of student products, classroom observation, and student surveys.

Qualified adjunct faculty, upon verification of their academic and professional credentials, are appointed members of the University of Maryland Baltimore Graduate School. Adjunct faculty are evaluated by full-time faculty members through regular curriculum reviews, mentoring, periodic classroom observation, and addressing student feedback promptly to ensure quality of instruction and the student's educational experience.

All UMBC faculty (regular and adjunct) are evaluated via the administration of online student surveys issued at the end of each semester. The data from this survey is shared with the instructor and publicly available via IRADS, while any qualitative comments received are shared only with the instructor. Faculty are encouraged to work with their program director, colleagues, UMBC's Center for Applied Learning and Teaching (CALT), or Division of Information Technology (DOIT) to conduct objective course assessment and/or pedagogical enhancement.

The Department of Computer Science and Electrical Engineering (CSEE) Chair and College of Engineering and Information Technology (COEIT) Dean regularly review student enrollment, retention, culture, and financial data from a strategic perspective to ensure program outcomes are aligned with Departmental and College priorities under UMBC's *Strategic Plan*. UMBC's Provost Office also engages in strategic and financial reviews of all UMBC programs. Exit surveys for graduating students are conducted each year by the Office of Professional Programs within the Division of Professional Studies (DPS) as another gauge of the student educational experience.

The University System of Maryland's accountability obligation includes a requirement that each academic program be reviewed every seven years. Accordingly, UMBC conducts academic program reviews (APR) to gauge program effectiveness, quality, and culture. As recognized by USM and the Council of Graduate Schools, the APR process has five general purposes: quality assurance, quality improvement, accountability, identification of strategies for improvement, and providing the institution with information for prioritization of resources. CSEE's graduate programs (including its current M.P.S. degree in Cybersecurity) successfully completed their last APR in 2018.

Taken together, UMBC has a robust, multi-stakeholder method to assess academic program effectiveness, learning outcomes, student retention, student/faculty satisfaction, cost-effectiveness, and workforce relevance. These methods are supported by continual internal UMBC evaluation of industry trends and needs to ensure its programs continue to meet current and anticipated industry and workforce requirements in Maryland and beyond.