

**REQUEST FOR AUTHORIZATION TO IMPLEMENT A BACHELOR OF SCIENCE  
IN ENVIRONMENTAL ENGINEERING AT UW-MILWAUKEE**

**ABSTRACT**

The proposed Bachelor of Science (B.S.) in Environmental Engineering will be offered by the Department of Civil and Environmental Engineering, within the College of Engineering & Applied Science. The program will require 125 credits of coursework that includes 21 credits of elective courses in a specialize track of the student's choice.

**PROGRAM IDENTIFICATION:**

**Institution Name**

University of Wisconsin-Milwaukee

**Title of Proposed Program**

Environmental Engineering

**Degree/major Designation**

B.S. Engineering/Environmental Engineering

**Mode of Delivery**

Primarily face-to-face classroom- and laboratory-based instruction

**Single Institution or Collaboration**

Single institution

**Projected Enrollment by Year Five**

91 students

**Tuition Structure**

Engineering undergraduate differential tuition

**Department or Functional Equivalent**

Department of Civil and Environmental Engineering

**College, School or Functional Equivalent**

College of Engineering & Applied Science

**Proposed Date of Implementation**

January, 2020

## **INTRODUCTION:**

### **Rationale and Relation to Mission**

According to the U.S Department of Labor Occupational Outlook Handbook (<https://www.bls.gov/ooh/architecture-and-engineering/environmental-engineers.htm>), Environmental engineers use the principles of engineering, soil science, biology, and chemistry to develop solutions to environmental problems. They are involved in efforts to improve recycling, waste disposal, public health, and water and air pollution control.

Occupational employment projections show a clear need for Environmental Engineers. The projection developed for Wisconsin by Labor Market Information (LMI) (<http://worknet.wisconsin.gov/worknet/daocprj.aspx?menuselection=da>) projected a 16.72% increase in employment for Environmental Engineers from 2014 to 2024. The U.S Department of Labor Occupational Outlook Handbook projected a nationwide 8% increase in employment for Environmental Engineers from 2016 to 2026.

The proposed program will contribute to fulfill UWM's mission to meet the diverse needs of Wisconsin's largest metropolitan area by developing a high quality undergraduate program appropriate to a major urban doctoral university, attracting highly qualified students, furthering academic and professional opportunities at all levels for women, minority, part-time, and financially or educationally disadvantaged students, establishing and maintaining productive relationships with appropriate public and private organizations, and providing educational leadership in meeting future social, cultural, and technological challenges. According to the American Society for Engineering Education (ASEE), female enrollment in Environmental Engineering programs grew from 38.3% in 2005 to 47.4% in 2014, and is the engineering discipline with the highest female enrollment. The proposed program will augment existing relationships with over 200 water technology businesses in the region, academic programs and economic development organizations dedicated to the advancement of freshwater technologies (The Water Council, <https://thewatercouncil.com/why-milwaukee/>). The program distinctly responds to the College of Engineering and Applied Science's mission "to educate students to become creative problem solvers, conduct leading-edge research with global impacts, and act as a catalyst for improved economic development and quality of life in Wisconsin."

### **How does it fit into the institution's overall strategic plan?**

The proposed program will promote the development of solutions to environmental problems, including those related to water and energy. The program certainly fits the UWM Strategic Plan, which identified Technology, Energy and Water among top objectives under its themes and priorities of a) top-tier research university, b) sustainable prosperity in the community, region and beyond, c) academic planning, d) successful students: recruitment, retention, and remediation, e) financially sustained university, f) technology, g) physical aspects of campus, h) internationalization, i) faculty and staff attraction, development and retention, and j) community engagement. The program also fits the CEAS Strategic Goals of a) Creating a dynamic environment and infrastructure to enhance innovative research, b) Anticipating and responding to market demands in order to produce graduates who are prepared to address and adapt to the changing needs of the marketplace and society, and c) Building partnerships with stakeholders and enhance awareness of CEAS strengths and accomplishments.

### **Need as Suggested by Current Student Demand**

Many students are aware of potential growth of environmental engineering area. As a result, institutions with this program have exceptionally high enrollments. We have received enquiries from prospective students for quite some time about the availability of environmental engineering program at UWM. Since our intent to plan was circulated, student requests for the date of availability of this program have been continuous, including many enquiries from students belonging to underrepresented groups. Additionally, recently graduated students also provide important feedback regarding the needs of environmental engineering program based on the exit survey, such as “make environmental engineering an undergraduate degree, rather than a part of civil engineering”, “the environmental engineering courses are very limited”, and “having a course on air emissions for environmental people would be good”.

### **Need as Suggested by Market Demand**

According to the Bureau of Labor Statistics, environmental engineering is projected to grow by 8% from 2016 to 2026. Many students are aware of potential growth of environmental engineering area. As a result, institutions with this program have high enrollments, particularly from female and minority Engineering students. We have received enquiries from prospective students for quite some time about the availability of environmental engineering program at UWM.

According to Labor Insight Jobs (Burning Glass Technologies), during the last 12 months (Aug. 01, 2017 - Jul. 31, 2018) there were 5,607 postings nationwide for candidates with a Bachelor's degree in Environmental Engineering. Of those opportunities, 58 were posted in Wisconsin, and over 600 in neighboring states. Meanwhile, the total number of degrees conferred during the same period by UW-Platteville and Marquette University was 28.

The most frequent locations of Wisconsin employers seeking environmental engineers were Milwaukee-Waukesha-West Allis (29 postings), Madison (15 postings), and Green Bay (6 postings). Some of the main nationwide employers seeking environmental engineers included Arcadis, AECOM Technology Corporation, Tetra Tech, CH2M Hill, Ghd Incorporated, Amec, CDM Smith, Fieldcore, US Air Force, and The Kleinfelder Group, Inc.

The 2016- 2026 National Change in Employment for environmental engineers projected by Burning Glass Technologies was 15.9%. Furthermore, nationwide there were an additional 1,909 and 209 postings for candidates with Master's and Doctoral degree in Environmental Engineering, respectively.

The UWM School of Freshwater Sciences conducted a survey designed to evaluate how undergraduate programs in freshwater sciences might best serve private and public needs in the water sector. There were 182 responses to the survey, and respondents described the area of the water sector in which their organizations operate as government agency, manufacturing, environmental consulting and civil engineering, utilities, agriculture, food and beverage, water technology, hospitals and health care, and non-profit organizations.

The survey asked what content, subject matter, and training would their future workforce most benefit from having in the engineering and technology area. The most frequent responses included a) quality management, water processing, industrial treatment systems, chemical engineering, quality and performance standards; civil infrastructure, water supply and treatment, urban systems; c) sensors, monitoring systems, industrial systems and controls; d) hydrodynamics, hydraulics and fluid dynamics; e) material science and nanotechnology; f) product development and realization; and g) mechatronics and robotics. The proposed program will collaborate with the School of Freshwater Sciences by providing training on most of the aforementioned subject matters.

### **Emerging Knowledge and Advancing New Directions**

Environmental engineering is an interdisciplinary program that prepares students to apply basic science and engineering analysis and design techniques to the environmental field. This requires fundamental understanding of the environmental systems functions to develop engineered solutions to solve the complex environmental issues. Thus, this brings a diverse group of professionals (from natural sciences, social sciences, and mathematics) together that in turn benefits engineering design. Numerous environmentally related grand challenges have been identified across the globe, such as energy, water resources, climate change, and environmental degradation. Environmental engineering is emerging as a field of significant potential to address these challenges to promote a sustainable and resilient society.

## **DESCRIPTION OF PROGRAM**

### **General Structure**

#### **Institutional Program Array**

The program is interdisciplinary and combines several disciplines of the College of Engineering and Applied Science, School of Freshwater Sciences, College of Letters and Sciences, and School of Public Health. The proposed program is designed on the basis of selected courses from engineering, biological sciences and other basic sciences. A limited number of new courses will be developed for this program, as detailed below. The program will be administered within the Department of Civil and Environmental Engineering of the College of Engineering and Applied Science. That department currently offers a Bachelor of Science in Civil Engineering with four areas of concentration: geotechnical, structural, transportation, and water resources and environmental engineering. The Bachelor of Science in Environmental Engineering program will have a significantly different curriculum from the existing Bachelor of Science in Civil Engineering, with changes in the engineering core courses, environmental engineering major courses, and technical electives. The core curriculum of the program will include courses in mathematics through differential equations, probability and statistics, calculus based physics, chemistry, earth science, biology and fluid mechanics. The curriculum will prepare graduates to formulate material and energy balances, analyze the fate and transport of substances in and between air, water and soil phases; conduct laboratory experiments, and analyze and interpret the resulting data in more than just one environmental engineering focus area, e.g., air, water land, environmental health; design environmental systems that include considerations of risk, uncertainty, sustainability, life-cycle principles, and environmental impacts; and apply advanced principles and practice relevant to the program objectives.

### **Other Programs in the University of Wisconsin System**

The UW System offers programs in Environmental Engineering and Civil Engineering with option or emphasis in Environmental Engineering at UW-Madison and UW-Platteville. A program located in the UW System urban university that emphasizes topics relevant to southeastern Wisconsin and the Great Lakes watershed will complement the existing programs. UW-Madison offers an Environmental Engineering option within the Bachelor of Science in Civil Engineering program. Students who complete the Environmental Engineering option still receive an accredited BS degree in Civil Engineering and only the transcript will show that the student has complete the option. According to its Vice Provost for Academic Affairs, UW-Madison sees no problem with both Madison and Milwaukee offering such degrees, as the student interest and demand for graduates is sufficient to support both. UW-Platteville is the only campus that offers an ABET accredited Bachelor of Science in Environmental Engineering in Wisconsin. UWM is an urban university primarily serving the needs of SE Wisconsin. The majority of our students come from the greater Milwaukee area. These students either want or need to stay in Milwaukee. UWM not only serves new freshmen but many transfer students and working adults who are place bound in Milwaukee. These students cannot go other campuses. So even if other campuses have capacity to serve these students, it is not an option for these place bound students.

### **Collaborative Nature of the Program**

The proposed program will be built upon the strong existing interdepartmental collaborations within the College of Engineering and Applied Science, as well as with other departments/colleges across UWM (e.g., School of Freshwater Sciences, Department of Geoscience, Department of Geography, School of Public Health). We have also established strong relationships with water-related industries and organizations (e.g., A.O. Smith, Badger Meter, Wisconsin Department of Natural Resources, Milwaukee Metropolitan Sewage District, Water Quality Association, etc.) through Milwaukee Water Council and a NSF-funded Water Equipment and Policy Research Center. The Global Water Center and newly built Innovation Campus also serve as a catalyst to facilitate collaborative activities with the water companies/organizations.

### **Diversity**

Diversity and quality of student are crucial to the success of the proposed Environmental Engineering program. The mission statement of the University of Wisconsin-Milwaukee includes furthering academic and professional opportunities for women and minority students. National trends indicate that Environmental Engineering is more attractive among the under-represented groups. Women are attracted to engineering disciplines that are more socially meaningful. According to ASEE, 50% of BS in Environmental Engineering were awarded to female students in 2014-2015, the highest among all engineering disciplines. The average female BS graduation in Civil Engineering was 22% and 20% among all engineering in the same year.

### **Student Learning Outcomes**

Upon the completion of the program, students are expected to have:

- a. an ability to apply knowledge of mathematics, science, and engineering,

- b. an ability to design and conduct experiments, as well as to analyze and interpret data,
- c. an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability,
- d. an ability to function on multidisciplinary teams,
- e. an ability to identify, formulate, and solve (environmental) engineering problems,
- f. an understanding of professional and ethical responsibility,
- g. an ability to communicate effectively (both orally and in writing),
- h. the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context,
- i. a recognition of the need for, and an ability to engage in life-long learning,
- j. a knowledge of contemporary issues (within environmental engineering profession), and
- k. an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

### Assessment of Objectives

Accreditation of engineering program requires a continuous assessment of the learning outcomes. Similar to existing engineering programs, this program will also be assessed in order to receive accreditation.

### Program Curriculum (119~126 credits)

Students will be required to take at least 125 credits to fulfill the requirements of the program. As indicated in the table below, this includes 29 credits in engineering core courses, 26 credits in the environmental engineering major, 14 -16 credits in mathematics, 5 -10 credits in chemistry 8 credits in physics, 7 credits in other natural sciences and 15 in GER courses. Remaining 15 credits are assigned to five specialized tracks that students may select according to their interests. Some of these students may select a track in higher education while some other may select a broader spectrum and tracks in industrial applications. There will be more courses added to this group as the program expands.

Engineering Core Courses  
(29 credits)

EAS 200 Professional Seminar (1) (*Pre: none*)  
Ind Eng 111 Introduction to Engineering (3) (*Pre: Math 116 (c)*)  
Ind Eng 112 Engineering Drawing & Computer Aided Design/Drafting (3) (*Pre: Math 116*)  
Ind Eng 360 Engineering Economic Analysis (3) (*Pre: Jr St*)  
Civ Eng 280 Computer-Based Engineering Analysis (3) (*Pre: math 226 or 231, compsci 132 or equivalent*)  
Comp Sci 240 Introduction to Engineering Programming (3) (*Pre: Math Placement Code of 40 or Math 116 (P)*)  
Civ Eng 2XX Engineering Mechanics (3) (Note: new course that combines CivEng 201 and 202)

	MatlEng 201 Engineering Materials (4) ( <u>Pre:chem 105 or 102 or 117</u> )
	MechEng 301 Basic Engineering Thermodynamics (3) ( <u>Pre: Math 233, Physics 209</u> )
	MechEng 320 Introduction to Fluid Mechanics (3) ( <u>Pre: MechEng 301(c), ElecEng 234, CivEng 2XX</u> )
Environmental Engineering Major (26 credits)	Civ Eng 311 Introduction to Energy, Environment and Sustainability (3) ( <u>Pre: Jr St</u> )
	Civ Eng 411 Engineering Principles of Water Resources Design (3) ( <u>Pre: Jr St, MechEng 320</u> )
	Civ Eng 413 Environmental Engineering (3) ( <u>Pre:MechEng 320</u> )
	Civ Eng 412 Applied Hydrology (3) ( <u>Pre: Jr St, MechEng 320, Math 233</u> )
	Civ Eng 511 Water Supply and Sewage (3) ( <u>Pre: Jr St, CivEng 411</u> )
	Civ Eng 521 Water Quality Analysis (4) (Note: 1 more credit due to additional lab sessions) ( <u>Pre: Jr St, CivEng 411</u> )
	Civ Eng XXX Air Quality (3) (New faculty needed)
	Civ Eng 495 Environmental Senior Design (4) ( <u>Pre: CivEng 411, 413</u> )
Mathematics (14~16 credits)	One of the following Calculus sequences must be completed Math 231-232-233 (12) OR Math 221-222(Honors) (10), ( <u>Pre: Math placement score, or previous course with "C" grade</u> )
	ElecEng 234 Analytical Methods in Engineering (4) ( <u>Pre: Math 233 (P)</u> )
	Or 205 & 211
Chemistry (5-10 credits)	Chem 102&104 or 105 (suggested) ( <u>Pre: Chemistry placement test</u> )
Physics (8 credits)	Physics 209-210
Other Natural Sciences (7 credits)	Bio Sci 150-level (4) (required)
	Bio Sci 150-level or above (3)
	Any Geo Sci course 300-level or above (3)
	Atm Sci 330 (3)
General Education Requirements (15 credits)	Art (3)
	Humanities (3)

Social Science (6)  
English 310 (3)

### Technical Electives (15)

- Civ Eng 303 Strength of Materials (*Pre: CivEng 201, Math 233*)
- Civ Eng 335 Soil mechanics (*Pre: CivEng 303*)
- Civ Eng 490 Transportation engineering (*Pre: CivEng 280, Jr. St*)
- Civ Eng 492 Environmental Impact Assessment (*Pre: Sr St*)
- Civ Eng 555 Sustainable Construction Materials and Technology (*Pre: Jr St*)
- Civ Eng 480 Software Applications for Civil Engineering (*Pre: Jr St*)
- Civ Eng 610 Introduction to Water and Sewage Treatment (*Pre: Sr St, CivEng 413*)
- Civ Eng 614 Hazardous Waste Management (*Pre: jr st; CivEng 413*)
- Civ Eng 616 Computational Hydraulics and Environmental Flows (*Pre: Jr St, CivEng 411*)
- GEOG 215 Introduction to geographic information systems (*Pre: None*)
- Urb Plan 591 Introduction to Urban Geographic Information Systems (*Pre: Jr St, CivEng 411*)
- GEOSCI 400 Water quality (*Pre: jr st; Chem 102(P); Math 232(P); or cons instr.*)
- GEOG 403 Remote sensing (focus on hydrology?) (*Pre: Jr St & Geog 215*)
- GEOSCI 464/FRSHWTR 464 Chemical hydrogeology (*Pre: jr st; Chem 102(P).*)
- GEOSCI 562 Environmental Surface Hydrology (*Pre: jr st; Math 232(P); or cons instr.*)
- FRSHWTR 502 Aquatic ecosystem dynamics (*Pre: jr st; 1 sem calculus or algebra; 2 sem Physics, Chem, or Bio Sci; or cons instr.*)
- FRSHWTR 504 Quantitative freshwater analysis (*Pre: jr st; 1 sem calculus, Physics, Chem, & Bio Sci; or cons instr.*)
- FRSHWTR 506 Environmental health of freshwater ecosystems (*Pre: jr st*)
- FRSHWTR 510 Economics, Policy & Management of Water (*Pre: jr st*)
- ElecEng 430/Mech Eng 430 Energy Modeling (*Pre: jr st or cons instr*)
- Ind Eng 455 Operations research (*Pre: jr st; Math 233(P)*)
- Matl Eng 460 Nanomaterials and Nanomanufacturing (*Pre: jr st; MatlEng 201(P)*)
- Mech Eng 321 Basic Heat Transfer (*Pre: jr st; MechEng 301(P)*)
- Mech Eng 436 Solar Engineering (*Pre: jr st; MechEng 301 (P)*)
- PH 303: Climate Change, the Environment, and Human Health (*Pre: Sophomore standing*)

### (New Courses)

- Civ Eng XXX Environmental fluid mechanics
- Civ Eng XXX Water resources management
- Civ Eng XXX Built environment



### **Time to Degree**

Students taking 15 credits per semester can finish the requirements in eight semesters. Students taking 12 credits per semester can finish the requirements in 10 semesters. Since engineering students are encouraged to co-op, this may add another year to their graduation time.

### **Program Review Process**

#### **Institutional Review**

Academic Planning and Curriculum Committee reviews all undergraduate programs at the University of Wisconsin-Milwaukee. The details may be found at the following site. <https://uwm.edu/secu/wp-content/uploads/sites/122/2017/02/UWM-Program-Review-Schedule-2030.pdf>

#### **Accreditation**

Also, all existing engineering programs are accredited by ABET (Accreditation Board for Engineering and Technology). They have set eight criteria for such reviews: students, program educational objectives, student outcomes, continuous improvement, curriculum, faculty, facility and institutional support. The requirements include monitoring of student progress in attaining 11 outcomes, documenting processes for assessing and evaluating the extent to which student outcomes are being attained, and using this evaluation for continuous improvement. Students, alumni, and employers are included in the assessment process. An industrial advisory committee is involved for each engineering program. The proposed program will also have these assessments in order to have ABET accreditation.