

## COLLEGE OF NATURAL AND APPLIED SCIENCES

### MASTER OF SCIENCE IN ENVIRONMENTAL SCIENCE

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#### OVERVIEW

#### OBJECTIVES

The Environmental Science Graduate Program prepares students for professional employment, teaching, or advanced studies in environmental science and related disciplines. Courses are offered by faculty from the Water & Environmental Research Institute of the Western Pacific, the Marine Laboratory, College of Natural & Applied Sciences, Micronesia Area Research Center, and the College of Liberal Arts & Social Sciences.

Specific objectives of the program include directly addressing pressing environmental questions, especially those arising in the small developing island nations of the Pacific; promoting needed educational and service projects in Western Pacific island communities; equipping graduates with the knowledge and skills needed for sound scientific inquiry and professional practice; and ingraining a solid understanding and commitment to academic ethics.

#### PROGRAM LEARNING OUTCOMES

**A. Knowledge-Based Outcomes.** Students completing this program will understand the defining attributes of science, the roles and responsibilities of scientists in addressing environmental problems, and the essential elements of the defining subdisciplines of environmental science. Specifically, they will:

A-1. Understand the attributes and limitations of scientific thought, culture, method, and practice — along with acknowledged principles for ethical conduct — in the search for truth and in the effective and humane application of science to the resolution of local, regional, and global environmental problems. (EV-508)

A-2. Understand basic principles and components of earth science and engineering, biology and ecology, and economics and management that are requisite to the

exploration and resolution of environmental problems. (EV-510, EV-511, EV-512)

**B. Skills-Based Outcomes.** Students completing this program will demonstrate the abilities to conceive, conduct, and report original research. Specifically, they will:

B-1. Demonstrate the abilities to frame research questions, make observations and collect data, and — as applicable to her or his discipline — design and conduct experiments, operate analytical instruments, or employ statistical, numerical, or geospatial tools to test either new hypotheses or prevailing theories. (EV-507, EV-558, EV-695)

B-2. Demonstrate the ability to conceive, critically examine, and systematically develop integral approaches to multidisciplinary research questions and broadly based solutions to public issues and policy problems that span the environmental subdisciplines of earth science, biology, ecology, economics, management, and engineering. (EV-508, EV-510, EV-511, EV-512, EV-695)

B-3. Demonstrate the ability to write rigorous, critical, clear, informative, and concise technical reports and articles. (EV-508, BI- 503)

#### VALUES

The Environmental Science Program faculty is committed to the search for objective truth; impartial, honest, and thorough scientific debate; and excellence in all endeavors. We hold that scientists must have the integrity to not compromise research or other work in response to political, ideological, social, or financial pressures. Scientific integrity also includes a commitment to share data and cooperate with others in their attempts to advance scientific understanding and replicate or verify the quality of previous work. We seek to instill these



values in our students through personal example as well as thoughtful academic instruction.

## **ADMISSION**

### **ADMISSION REQUIREMENTS**

#### **GENERAL ADMISSION REQUIREMENTS**

Applicants must first meet the Graduate Admission Standards for pre-candidacy as described in this Graduate Bulletin. Once admitted for pre-candidacy by the University Graduate Admissions office, they may then apply for admission to the Environmental Science Program. In addition to the materials submitted for admission to pre-candidacy, applicants must submit the following to the Environmental Science Graduate Program Recruiting and Admission Committee:

1. three letters of recommendation,
2. a comprehensive statement of academic achievements, interests, professional goals, and specific reasons for pursuing a master's degree in environmental science.

Application packages are first evaluated by the Recruiting and Admission Committee, based on the submitted materials and the Background and Performance Requirements specified below. The Recruiting and Admission Committee recommends acceptance, provisional acceptance, or rejection of the application to the program chair. Upon approval by the chair, the applicant is admitted to the program.

#### **BACKGROUND AND PERFORMANCE GUIDELINES**

The Environmental Science Program is built around three component disciplines:

1. Biology-Ecology
2. Geoscience-Engineering
3. Economics-Management

Applicants are expected to have backgrounds related to at least one of these three disciplines. Related backgrounds are broadly defined. For example, disciplines related to Biology-Ecology include all the sub-disciplines of biology and other life sciences, such as physiology, biochemistry, or genetics; the health sciences; and

agricultural, animal, and plant sciences. Disciplines related to Geosciences-Engineering include the physical and natural sciences, particularly physics, chemistry, biogeochemistry, and the earth sciences (geological, oceanic, atmospheric). Relevant disciplines also include engineering and applied sciences, particularly civil or mechanical engineering, applied mathematics, statistics, geographic information systems, remote sensing, and computer science. Economics-Management backgrounds include economics, business, natural resource management, law, public administration, political science, and human, economic, or political geography. Applicants with other backgrounds, especially with interdisciplinary training or experience, who have completed the prerequisites listed below or can provide other evidence of their ability to successfully complete the core course requirement will be considered as well.

The recommended prerequisites listed below represent the ideal background preparation for each component discipline. It is acknowledged, however, that capable students from any given undergraduate major may not necessarily have completed the full suite of courses listed. Any of the listed prerequisites, with the exception of Calculus I, may therefore be waived by the program chair on the recommendation of the Recruiting & Admission Committee, based on its confidence that the applicant will nevertheless be able to successfully complete the core requirements (described in the "Degree Requirements" section below). Applicants who have taken the prerequisite courses listed below, however, should have earned no grade lower than a "C" in any of the courses listed for their discipline of interest, or alternatively, have earned a score of 4 or 5 in an Advanced Placement Exam for calculus, physics, biology, chemistry, economics). An applicant who does not meet these grade criteria may be admitted to the program on a provisional basis, if a faculty member agrees to serve as his or her advisor. Full admission may be granted by the program chair on the recommendation of the Recruiting & Admission Committee after such a student has completed 12 credit hours of Environmental Science courses approved in advance by the student's advisor, with grades of "B" or higher in each of them, and has demonstrated to the satisfaction of the Recruiting & Admission Committee and the program chair that the student has remedied any deficiencies identified when granted provisional acceptance.

## REQUIRED AND RECOMMENDED PREREQUISITES

### All Disciplines

- Methods: Statistics and geographic information systems (upper level, i.e., 300-400 level)
- Math: 2 semesters calculus (Calculus I is required; Calculus II is recommended for all and may be required in specific cases at the discretion of the thesis advisor/project supervisor based upon the nature of the research.)

### Biology-Ecology

- Physics: 1 semester general physics with lab
- Chemistry: 2 semesters inorganic chemistry with lab and 2 semesters organic chemistry with lab
- Biology: 2 semesters of general biology with lab

### Geosciences-Engineering

- Physics: 2 semesters general physics with lab
- Chemistry: 2 semesters general chemistry with lab
- Biology: 1 semester biological/life science with lab

### Economics-Management

- Physics: 1 semester general physics with lab
- Chemistry: 1 semester general chemistry with lab
- Biology: 1 semester biological/life science with lab
- Economics & Business: 1 semester microeconomics and 1 semester intro to business or public administration

## DEGREE REQUIREMENTS

### COURSE REQUIREMENTS (33-36 CREDIT HOURS)

#### Core Courses (18 Credit Hours)

The University of Guam's graduate Environmental Science Program is a rigorous and challenging program, designed to produce graduates of the highest caliber equipped with essential knowledge and skills and committed to the highest standards of professional integrity in research and application of environmental science to matters of public

interest. The core curriculum thus contains consists of six courses totaling 18 credit hours.

#### INNER CORE:

#### Fundamentals of Scientific Practice and Tools of Environmental Science

| 9 credit hours

The "inner core" is three courses totalling nine credit hours, centered on the essential skills of scientific thought and practice and advanced methods of applied environmental science. Students should take these courses in the first year of their program.

Course	Course Title	Credits	Term Offered
EV508	SCIENTIFIC COMPETENCE AND INTEGRITY	3	FALL ONLY/ ALL YEARS
EV503	BIOLOGICAL LITERATURE AND SCIENTIFIC WRITING	2	SPRING ONLY/ ALL YEARS

Choose one of the following:

Course	Course Title	Credits	Term Offered
EV507	ADVANCED STATISTICAL METHODS	4	FALL ONLY/ ALL YEARS
EV558	ADVANCED GEOSPATIAL METHODS	4	SPRING ONLY/ ALL YEARS

**Note:** The course not chosen to meet the core requirement may, of course, be taken as an elective.

#### OUTER CORE:

#### Component Disciplines

| 9 credit hours



Building on these central courses, is an “outer core” of three three-credit hour courses in each of the respective sub-disciplines of environmental science:

Course	Course Title	Credits	Term Offered
EV510	ENVIRONMENTAL SCIENCE: BIOLOGY/ ECOLOGY	3	FALL ONLY
EV511	ENVIRONMENTAL SCIENCE: GEOSCIENCES/ ENGINEERING	3	SPRING ONLY/ ALL YEARS
EV512	ENVIRONMENTAL SCIENCE: ECONOMICS-MANAGEMENT-LAW	3	SPRING ONLY/ ALL YEARS

This second suite of core courses thus equips each student with the essential knowledge and skills from each of the three sub-disciplines that define environmental science.

### Elective Courses (9-18 credit hours)

Beyond the core, each student must complete at least three elective courses for a total of at least nine credit hours related to his or her selected area of concentration and agreed upon by his or her advisor. Elective courses should support the student’s proposed capstone requirement within either the research or professional track, as described below. Students who desire to take additional electives (i.e., beyond the requirement) may do so with the consent of their advisor, but students need take no more than three elective courses to meet the degree requirement. Students may include no more than one 400G-level course among their electives, nor may they include 400G-level courses in statistics, geographic information systems, or any other subject that is a prerequisite for admission to the program.

#### RESEARCH TRACK: Research Thesis

| 9 credit hours

Electives may not include 400G-level courses in statistics or GIS, or other program prerequisites.

#### PROFESSIONAL TRACK: Professional Thesis or Internship

| 9 credit hours

Electives may not include 400G-level courses in statistics or GIS, or other program prerequisites.

#### Coursework Option

| 18 credit hours

Students selecting the Coursework Option within the Professional Track must take an additional nine hours of electives, for a total of 18 elective credit hours, and submit and defend a research paper. Electives may not include 400G-level courses in statistics or GIS, or other program prerequisites.

### Capstone Courses (6 credit hours)

#### RESEARCH TRACK: Research Thesis

| 6 credit hours

The purpose of the research track is to prepare students for advanced (doctoral level) studies in environmental science and related disciplines, or careers in scientific or professional work for which a research background is necessary or desirable. The capstone requirement for the research track is thus a traditional research thesis, for which the student earns six hours of academic credit. Research theses in Environmental Science are expected to make an original contribution to the selected sub-discipline and reflect mastery of the knowledge and skills required to successfully pursue advanced study and research in environmental science.

Students may choose one the following:

Course	Course Title	Credits	Term Offered
EV695	ENVIRONMENTAL SCIENCE THESIS	1 - 6	FALL/SPRING/ ALL YEARS

## PROFESSIONAL TRACK: Professional Thesis

Six credit hours of the following are needed:

Course	Course Title	Credits	Term Offered
EV695	ENVIRONMENTAL SCIENCE THESIS	1 - 6	FALL/SPRING/ ALL YEARS

## Professional Internship

Six credit hours of the following are needed:

Course	Course Title	Credits	Term Offered
EV698	ENVIRONMENTAL SCIENCE THESIS	1 - 6	FALL/SPRING

## Coursework Option

No capstone credits are required for the coursework option.

## PERFORMANCE REQUIREMENTS

Students must maintain at least a B (3.00) average, with no more than one grade of C or lower in all courses taken for credit. Students may retake any course for which they have received a grade of C or lower. However, any student who fails to improve his or her grade to at least a B after re-taking the course and whose record shows two unimproved C grades as a result, will be dismissed from the program.

Upon admission to the program, students must choose and be accepted by a faculty advisor with expertise in their selected sub-discipline. Subsequently, the student's

individual program is developed by the student and his or her advisor; and monitored by the advisor and the student's advisory committee. Final program approval requires endorsement by the chair of the Environmental Science Program, with subsequent approval by the director of Graduate Studies.

In consultation with his or her advisor, each student must select which of the two tracks he or she will follow for the capstone experience: research or professional. For the research track, the capstone experience is a research thesis. For the professional track there are three options: a professional thesis, an internship, or additional coursework with a related research paper. Students may only apply for degree candidacy and register for capstone credits after their proposal has been presented to and approved by their advisory committee, as described below.

## TRACKS

### RESEARCH TRACK

The purpose of the research track is to prepare students for advanced (doctoral level) studies in environmental science and related disciplines, or careers in scientific or professional work for which a research background is necessary or desirable. The capstone requirement for the research track is thus a traditional research thesis, for which the student earns six hours of academic credit. General requirements for research theses are described on page 11 of the Graduate Bulletin. Research theses in Environmental Science are expected to make an original contribution to the selected sub-discipline and reflect mastery of the knowledge and skills required to successfully pursue advanced study and research in environmental science.

### PROFESSIONAL TRACK

The purpose of the professional track is to produce competent and credentialed professionals prepared especially for employment in industry, education, or government. Students following the professional track may select one of the three options described below: professional thesis, internship, or additional coursework/research paper. The professional track options demand the same mastery of basic knowledge and skills required of the research-track students, including writing skills.

These options, however, accommodate students planning professional careers in industry, education, or government rather than scientific research careers.

The professional thesis option requires submission of a professional thesis, which requires the same standards as for a research thesis. The internship option requires a report, which must be worthy of a typical consultant's report from major (year-long) project or substantive agency publication (such as a comprehensive regulatory guideline), and requires the same level of effort as a research or professional thesis. The research paper for the coursework option must be derived from the current relevant professional literature and comprise no fewer than 20 pages, double-spaced, 12-point Times Roman font, inclusive of figures and references. The thesis or paper should be worthy, in accordance with the topic, of local and/or on-line publication as a technical report, user's manual, review paper, or educational pamphlet. Each option also requires a comprehensive oral defense presentation following submission of the thesis or paper. Following the defense, the student corrects or revises the thesis or paper, based on the committee's review of it. The grade (Pass or Fail) is based on the committee's evaluation of the final report or paper and the outcome of the oral examination. General requirements for capstone documents are contained in the Graduate Bulletin.

## PROFESSIONAL TRACK OPTIONS

### Professional Thesis Option

This option consists of a 6-hr professional thesis EV-695 agreed upon by the student and committee and approved by the Program Chair. An example might be the development of a major database, solution of a practical environmental engineering problem, of construction of an educational website containing animations, databases, and informative or instructional material on a selected local or regional environmental problem. The student prepares a proposal agreed upon by the student and committee and approved by the Program Chair. At the completion of the project, the student prepares and presents a written thesis, as specified above, and stands for a comprehensive oral examination (thesis defense) before his or her committee.

**Example:** The student was employed as a WERI Research Assistant. Her coursework focused on groundwater hydrology, and she designed, developed,

and documented a comprehensive database of historical and current water wells drilled on northern Guam. The Northern Guam Lens Aquifer Database consists of a spreadsheet that contains basic information on 525 wells, including locations, depth, use, custodial agency, with each cell linked to digital appendices that contain all of the historical records that could be located for the well, including drilling and pump test logs, and design and construction records. The database is published at WERI Technical Report 141 and is now a permanent on-line water resource management tool for water managers, educators, scientists, and engineers.

### Internship Option

This option consists of a semester-length six-credit-hour internship (EV-698) with an environmental firm (profit or non-profit) or government agency, under collaborative supervision of an academic advisor and workplace supervisor. The internship must include work on a specific project, product, or set of projects and products. These are agreed upon in advance by the student and his or her advisory committee (which includes the workplace supervisor), and approved by the Program Chair. At the completion of the internship, the student prepares and presents a written report, as specified above, on the project or projects undertaken during the internship, with the purpose and content of the report agreed on in advance by the student and the committee. The model for the internship product is a report or document such as typically results from a major project at private firm or government agency. Following review of the report by the advisory committee, the student stands for a comprehensive oral defense.

**Example:** The student is employed with the environmental office of the local US Navy Facilities Engineering Command. As part of his work he is required to coordinate the production of an Environmental Impact Assessment in conjunction with the relocation of some wetlands on DOD property. In consultation with his academic and professional supervisors, he prepares a formal report, which meets the requirements of the command, and which he presents to his committee.

### Coursework Option

This option requires nine hours of additional coursework equivalent to a second, and separate, major sub-discipline. The student may select the second



concentration from among the three sub-disciplines (Biology-Ecology, Geosciences-Engineering, or Economics-Management) or a second concentration in a relevant inter-disciplinary field, such as Mathematics, Micronesian Studies, or Business Administration. Thus, in addition to selecting 9 hours for his or her first sub-discipline concentration, the student selects courses comprising 9 additional hours in another appropriate field. Examples of appropriate courses include probability, statistics, and numerical analysis, from Mathematics; physical geography, health and human adaptation, or economic development in Micronesia, from Micronesian Studies; or management and economics courses from Business Administration. These courses may include no more than one special topic or reading and conference course. The committee must include members with expertise in the two concentrations selected and agree on the curriculum proposed by the student. The student also prepares a proposal for a research paper that must address a topic related to one or both of the two selected concentration areas of coursework and offer some judgment or present an argument, drawing on a comprehensive review of the current scientific literature. The topic must be agreed upon by the committee and approved by the Program Chair. The paper does not require original research but must draw from the appropriate works from the current professional literature, based on a comprehensive review of the literature. On completion of the coursework, the student prepares and submits the paper to the advisory committee and stands for a comprehensive oral defense. Again, the research paper for the coursework option must be derived from the current relevant professional literature and comprise no fewer than 20 pages, double-spaced, 12-point Times Roman font, inclusive of figures and references. The thesis or paper should be worthy, in accordance with the topic, of local and/or online publication as a technical report, user's manual, review paper, or educational pamphlet. Each option also requires a comprehensive oral defense presentation following submission of the thesis or paper. Following the defense, the student corrects or revises the thesis or paper, based on the committee's review of it. The grade (Pass or Fail) is based on the committee's evaluation of the final report or paper and the outcome of the oral examination. General requirements for capstone documents are contained in the Graduate Bulletin.

**Example:** The student is employed as an instructor at the College of Micronesia. For the research paper, the student conducts a comprehensive literature search on

the historical incidence of El Nino-related droughts in Micronesia and prepares a summary paper describing its effects, and the human responses to them in Micronesia. He selects Geology/ Engineering as his first major sub-discipline concentration, comprised of Hydrology (EV-542), Hydrogeology (EV-543) and Tropical Climate and Climate Variability (EV-535). For the second sub-discipline concentration field he selects Micronesian Studies, with Physical Geography of Micronesia (EV/MI-506), Health and Human Adaptation in Micronesia (EV-514), and Economic Development and Change in Micronesia (EV-520) in which he will search, read and study the literature pertaining to water resources on Micronesia and similar islands.

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