

Fiscal Unit/Academic Org	School of Earth Sciences - D0656
Administering College/Academic Group	Arts and Sciences
Co-administering College/Academic Group	
Semester Conversion Designation	New Program/Plan
Proposed Program/Plan Name	Hydrogeology Certificate
Type of Program/Plan	Undergraduate certificate program
Program/Plan Code Abbreviation	HYDRGEO
Proposed Degree Title	Certificate in Hydrogeology

Credit Hour Explanation

Program credit hour requirements		A) Number of credit hours in current program (Quarter credit hours)	B) Calculated result for 2/3rds of current (Semester credit hours)	C) Number of credit hours required for proposed program (Semester credit hours)	D) Change in credit hours
Total minimum credit hours required for completion of program				12	
Required credit hours offered by the unit	Minimum			4	
	Maximum			15	
Required credit hours offered outside of the unit	Minimum			0	
	Maximum			8	
Required prerequisite credit hours not included above	Minimum			12	
	Maximum			15	

Program Learning Goals

Note: these are required for all undergraduate degree programs and majors now, and will be required for all graduate and professional degree programs in 2012. Nonetheless, all programs are encouraged to complete these now.

Program Learning Goals

- Upon completion of the academic certificate in Hydrogeology, students will be prepared to
 - (1) Solve natural and human-caused problems in water resources and water contamination.
 - (2) Enter the workforce as a practicing hydrologist or hydrogeologist in government agencies, geotechnical firms, and environmental consulting firms in the private section.
 - (3) seek certification as a hydrologist by the American Institute of Hydrology, meeting the requirements if also completing an undergraduate degree in civil engineering or earth sciences.

Assessment

Assessment plan includes student learning goals, how those goals are evaluated, and how the information collected is used to improve student learning. An assessment plan is required for undergraduate majors and degrees. Graduate and professional degree programs are encouraged to complete this now, but will not be required to do so until 2012.

Is this a degree program (undergraduate, graduate, or professional) or major proposal? No

Program Specializations/Sub-Plans

If you do not specify a program specialization/sub-plan it will be assumed you are submitting this program for all program specializations/sub-plans.

Pre-Major

Does this Program have a Pre-Major? No

Attachments

- Completion Sheet for Hydrogeology Certificates.pdf: Completion sheet
(Other Supporting Documentation. Owner: Vankeerbergen,Bernadette Chantal)
- revisions to Certificate in Hydrogeology.docx: revisions to proposal
(Other Supporting Documentation. Owner: Panero,Wendy R)
- Certificate Proposal Hydrogeology.pdf: proposal
(Program Proposal. Owner: Panero,Wendy R)

Comments

- See 9-27-19 email to W. Panero *(by Oldroyd,Shelby Quinn on 09/27/2019 04:09 PM)*
- This is a certificate program, to be open to undergraduate and graduate students. See details in the proposal. *(by Panero,Wendy R on 08/30/2019 03:43 PM)*

Workflow Information

Status	User(s)	Date/Time	Step
Submitted	Panero,Wendy R	08/30/2019 03:43 PM	Submitted for Approval
Approved	Panero,Wendy R	08/30/2019 03:44 PM	Unit Approval
Approved	Haddad,Deborah Moore	08/30/2019 03:51 PM	College Approval
Revision Requested	Oldroyd,Shelby Quinn	09/27/2019 04:09 PM	ASCCAO Approval
Submitted	Panero,Wendy R	09/30/2019 11:52 AM	Submitted for Approval
Approved	Panero,Wendy R	09/30/2019 11:54 AM	Unit Approval
Approved	Haddad,Deborah Moore	09/30/2019 01:14 PM	College Approval
Revision Requested	Oldroyd,Shelby Quinn	10/01/2019 10:48 AM	ASCCAO Approval
Submitted	Panero,Wendy R	10/01/2019 10:58 AM	Submitted for Approval
Approved	Panero,Wendy R	10/01/2019 10:59 AM	Unit Approval
Approved	Haddad,Deborah Moore	10/01/2019 11:34 AM	College Approval
Pending Approval	Jenkins,Mary Ellen Bigler Hanlin,Deborah Kay Oldroyd,Shelby Quinn Vankeerbergen,Bernadette Chantal	10/01/2019 11:34 AM	ASCCAO Approval

Proposal Submission Guidelines for Establishing a New Certificate

1. Required Information

- Name of proposed certificate. Identify certificate type from certificate grid (e.g., Type 2, standalone post-bachelor undergraduate certificate).

Hydrogeology, type 1 (undergraduate academic certificate, embedded), type 2 (Undergraduate academic certificate, post-bachelor degree) and 3 (graduate academic certificate, stand alone (3a) or embedded (3b))

- Indicate whether the certificate will be delivered wholly on-line, wholly in-person, a combination, or with all hybrid courses.

In person delivery.

- Proposed implementation date.

Spring 2020

- Academic units (e.g., department, college) responsible for administering the certificate program.

Earth Sciences, College of Arts and Sciences

2. Rationale

- Describe the rationale/purpose of the certificate.

Ohio State has a significant strength in hydrogeologic sciences, with additional strengths in environmental engineering, environmental sciences, soil science, and contaminant transport. These strengths are found across the university, including the College of Engineering and College of Food, Agriculture, and Environmental Science. This new certificate will clarify to students, graduate schools, and employers that the student engaged in a coherent set of undergraduate coursework to prepare the student to work or do research in the area of hydrogeology. The certificate also includes the course work for students to meet the educational criteria for certification by the American Institute of Hydrology.

The American Institute of Hydrology certifies individuals with appropriate educational background, work experience, and passing score on a qualifying exam under the categories of: Professional Hydrologist-Surface Water, Hydrologist-Groundwater, and Hydrologist-Water Quality. These certifications require

Five semester ... hours in Chemistry and Physics and Calculus. An additional 25 semester ... hours in Hydrology coursework of which at least 10 semester ... hours come from Hydrology courses; 10 semester ... hours come from Hydrology Allied courses; and 5 semester ... hours come from Hydrology Supplemental courses.

A student completing this certificate along with an undergraduate degree in either Earth Science or Civil Engineering will provide students with the necessary courses for both surface water and groundwater certification.

- Identify a likely source of student demand for the proposed certificate, and provide one or two examples.

Students majoring in or pursuing a graduate degree the Earth Sciences, Environmental Sciences, and Civil or Environmental Engineering will be able to indicate their focus on the hydrogeologic sciences with such a certificate.

For example, students majoring in Earth Sciences on the Earth System Science track (or the proposed Climate, Water, and Environment revised track) will be able to combine their major coursework with this certificate with two additional classes in SES, CFAES, or CEGE.

Complementary to this population, students in Environmental Engineering (CEGE) and Environmental Science (CFAES) in the specializations of Environmental Molecular Sciences, Soil Resources and Environmental Sustainability, or Water Sciences will be able to combine this certificate with their program of study, in which 4-7 credit hours will overlap, enabling these students to be prepared to enter the workforce in the area of hydrogeology.

- Provide the following statement: *Upon completion of the academic certificate in <specify title>, learners will be prepared to. . .” <list a maximum of 3 outcomes>.*

Upon completion of the academic certificate in Hydrogeology, students will be prepared to

(1) Solve natural and human-caused problems in water resources and water contamination.

(2) Enter the workforce as a practicing hydrologist or hydrogeologist in government agencies, geotechnical firms, and environmental consulting firms in the private section.

(3) seek certification as a hydrologist by the American Institute of Hydrology, meeting the requirements if also completing an undergraduate degree in civil engineering or earth sciences.

3. Relationship to Other Programs / Benchmarking

- Identify any overlaps with other programs or departments within the university. Append letters of concurrence or objection from related units.

The certificate can be earned primarily through courses offered in the School of Earth Sciences. Additional course options are available to students in Civil Engineering and SENR and some of the courses required for the undergraduate majors in those units are included as required or as options for this certificate.

- Indicate whether this certificate or a similar certificate was submitted for approval previously.
This is a new proposal, no such certificate proposal has been submitted for approval previously.

Explain at what stage and why that proposal was not approved or was withdrawn.

- Identify similar programs at other universities in Ohio or in the United States and their levels of

success.

We can identify no other similar programs in Ohio. Elsewhere in the US, only the University Nevada, Reno offers a MS degree in hydrogeology, while University of Colorado offers an undergraduate concentration in this field, and Western Michigan University offers a 15-credit hour certificate.

4. Student Enrollment

- Indicate the number of students you anticipate will choose to pursue this certificate.
Annual enrollment in the required SES classes are ~20 students, up to half of whom come from the College of Engineering and CFAES, taking the classes to satisfy distribution requirements in the BS major or MS degree. We expect about half of the SES students who already take ES 5651 and 5655 to complete the certificate (taking 2 additional classes), and up to 25% of the students from other colleges (taking 2-3 additional classes) to pursue the certificate, for an estimated 20-30 students pursuing such a certificate annually. Growth will be facilitated with outreach to the relevant populations. The Undergraduate Studies Committee will advertise the certificate during student visit days, communicate the opportunity to advisors and the career center. The School of Earth Sciences will work with ASC communications to ensure that those employed in the region are aware of the opportunity.

5. Curricular Requirements

- Provide ASC certificate advising sheet (see Appendix 5).
- List the courses (department, title, credit hours, description) which constitute the requirements and other components of the certificate. If any courses have prerequisites, please indicate so. Indicate which courses are currently offered and which will be new. When new course requests are submitted through curriculum.osu.edu, indicate that those course requests are being submitted as part of a new certificate proposal. As much as possible, the curriculum committees will review the course requests in conjunction with the certificate proposal.

Course Number	Course Name	Credit Hours	Prereqs.
Required groundwater course:			
EARTHSC 5651	<i>Hydrogeology</i> : Geologic and hydrologic factors controlling the occurrence, movement, storage, and chemical quality of surface water and ground water; exploration, evaluation, development and management of water resources.	4	EARTHSC 1100, 1105, 1108, 1121, 1151, 2203, OR 2205; and Math 1152 or above
Complete one of the following surface water courses:			
EARTHSC 5655	<i>Land Surface Hydrology</i> : Physical processes of land surface hydrology in the context of the global hydrologic cycle. Consideration of the processes and mechanisms responsible for water and energy fluxes, with examples from various river basins.	3	Math 1152 or above, and Physics 1250 or above.

ENR 4285	<i>Watershed Hydrology:</i> Covers hydrologic processes in watersheds, including precipitation, evapotranspiration, infiltration, runoff, and streamflow. We will evaluate how watershed characteristics, climate, and land use control these processes. In addition, we will discuss and practice current physical, chemical, and computational techniques for characterizing the hydrologic functioning of watersheds.	3	Chem 1210, Math 1151 or 1156
CIVILEN 5130	<i>Applied Hydrology:</i> Hydrologic cycle, meteorology, streamflow, evapotranspiration, hydrographs, runoff relations, runoff hydrographs, groundwater, unit hydrographs, flood routing, frequency and duration studies, and application of hydrologic techniques.	3	CIVILEN 3160
Complete at least 5 credit hours of electives from the following:			
EARTHSC 5751	<i>Quantitative Reservoir Modeling:</i> Principles of analytical and numerical techniques in modeling single- and multiphase flow in gas, oil, and water (aquifer) reservoirs. Development of Matlab code for two- and three-dimensional flow in porous media.	4	EARTHSC 2245, Math 1152
EARTHSC 4450	<i>Water, Ice, and Energy in the Earth System:</i> Earth's energy budget and the transfer of water between reservoirs. Processes that regulate water transfer, common measurement approaches, and the importance of water in geological processes, global change, and as a resource.	3	EARTHSC 1100, 1105, 1108, 1121, 1151, 2203, 2204, 2205, GEOG 3901, OR GEOG 5900; or permission of instructor
EARTHSC 5203	<i>Geo-environment and Human Health:</i> Examine geo-environmental processes that are contributing to human health degradation and the resultant societal impacts.	3	EarthSci 2245, or GE data only course, or equiv; and Soph standing or above; or permission of instructor
EARTHSC 5621	<i>Introduction to Geochemistry:</i> Introduction to the chemistry of the solid Earth and hydrosphere describing the processes controlling the distribution of elements.	3	Chem 1220 or above
EARTHSC 5550	<i>Geomorphology:</i> Investigation of the mechanics and chemistry of landscape development; interpretation of materials, processes, types, and evolution of landforms produced under diverse climates.	4	EARTHSC 1100, 1121, OR 1200; AND EARTHSC 1122 or 2122; or permission of instructor
ENR 5268	<i>Soils and Climate Change:</i> Soil processes, abrupt climate change, trace gases and their properties, global C cycle, gaseous emissions, C-neutral fuels, carbon sequestration, Kyoto Treaty, trading of C credits.	2	-

ENR 5261	<i>Environmental Soil Physics</i> : Principally involves the state and transport of water, heat and gas within soil, and the associated soil physical properties.	3	-
ENR 5273	<i>Environmental Fate and Impact of Contaminants in Soil and Water</i> : An overview of contaminant sources, transport through soil and water, and environmental fate and impact to human and ecosystem receptors.	3	Grad standing or two semesters of chemistry
CIVILEN 5220	<i>Open Channel Hydraulics</i> : Flow classifications, channel properties, energy and momentum principles, critical flow, uniform flow formulas, erodible and nonerodible channel design, and gradually-varied profile computations.	3	Civil Eng 3160, Math 2177 or 2415 and 2568
AgSysMt 4575	<i>Applied Agricultural Water Management</i> : Planning and managing the drainage, irrigation, erosion and sediment control, water harvesting and storage systems and agricultural constructed wetlands for the agricultural landscape.	2	AgSysMt 2370 and 2371, ENR 3000 or permission of instructor
GEOG 5210	<i>Fundamentals of GIS</i> : Basic principles of geographic and land information systems and their use in spatial analysis and information management.	3	Not open to students with credit for Geog 5220 (607), CRPlan 5001 (607), or CivilEn 5001 (607)

- State the minimum number of credits required for completion of the certificate.

Total 12-15 hours, where the range is a result of the variable credit hours fulfilling the electives.

- Indicate the number of semesters expected to complete the certificate. Confirm that courses are offered frequently enough and have the capacity to meet this expectation.

While intended to be completed in 4 semesters, due to the annual offering of the required classes and the number of options for electives, the certificate can be completed in as few as 2 semesters for those students who have already completed the necessary prerequisites.

- If applicable, describe existing facilities, equipment, and off-campus field experience and clinical sites to be used. Indicate how the use of these facilities, equipment, etc., will impact other existing programs.

None.

- For interdisciplinary certificates, describe the way in which advising and other student support will be provided.

Advising and students support services are available through the department, college, and university, as is available to any student pursuing a program.

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- If applicable, describe additional university resources (including advisors and libraries) that will be required for the new certificate.

Not Applicable

- Provide ASC completion sheet for certificates.
- Provide semester-by-semester sample program.

Plan to complete in two years

Year 1:

EarthSc 5651 (Autumn, offered annually)

EarthSc 5655 (Spring, offered annually)

Year 2:

elective (Autumn)

elective (Spring)

Plan to complete in one year

Year 1:

EarthSc 5651 (Autumn, offered annually)

elective (Autumn)

EarthSc 5655 (Spring, offered annually)

elective (Spring)

Additional Graduate School Guidelines

- Students must be admitted into a graduate certificate program.
- Admitted students must meet the minimum admission requirements of the Graduate School.
- Certificates are administered by a graduate studies chair and committee that are responsible for admission decisions.
- Proposals originate in a TIU following the TIU's curricular approval process. Once submitted in curriculum.osu.edu and approval by the college, proposals will be routed automatically to the Graduate School for review. Once approved by the Graduate School, proposals are review by the Council on Academic Affairs (CAA).
- A letter of support from the college dean or associate executive dean must accompany the proposal.
- If a graduate non-degree student is admitted to a graduate certificate program, no more than four hours of semester graduate credit accumulated while in this non-degree classification may be counted toward the certificate.

COLLEGE OF ARTS AND SCIENCES
THE OHIO STATE UNIVERSITY

TYPE 1B, 2, 3 HYDROGEOLOGY CERTIFICATE (HYDRGEO-CT)

Coordinating Advisor: Professor Ashley Griffith, 381 Mendenhall Labs, Columbus, OH 43210; griffith.233@osu.edu

The 12-15 credit hour Hydrogeology Certificate will provide students with a competitive advantage in beginning a career in the hydrogeological fields or pursuing entrance into a graduate degree program in fields related to hydrogeology. The certificate is designed to enhance both critical thinking and the technical skills for practicing hydrogeology.

One groundwater course (4 credits):

- **EARTHSC 5651:** Hydrogeology (4)

One surface water course (3 credits):

- **EARTHSC 5665:** Land surface hydrology (3)
- **ENR 4285:** Watershed hydrology (3)
- **CIVILEN 5130:** Applied Hydrology (3)

Electives (at least 5 credit hours):

- **EARTHSC 5751:** Quantitative Reservoir Modeling (4)
- **EARTHSC 4450:** Water, Ice and Energy in the Earth System (3)
- **EARTHSC 5203:** Geo-environment and Human Health (3)
- **EARTHSC 5621:** Introduction to Geochemistry (3)
- **EARTHSC 5550:** Geomorphology (4)
- **ENR 5268:** Soils and Climate Change (2)
- **ENR 5261:** Environmental Soil Physics (3)
- **ENR 5273:** Environmental Fate and Impact of Contaminants in Soil and Water (3)
- **CIVILEN 5220:** Open Channel Hydraulics (3)
- **AGSYSMT 4575:** Applied Agricultural Water Management (2)
- **GEOG 5210:** Fundamentals of GIS (3)

Hydrogeology Certificate program guidelines

The following guidelines govern the Hydrogeology Certificate. Required for certificate:

Credit hours required: 12-15 credit hours.

Overlap with a major

- Max 50% overlap with major program courses.

Grades required

- Minimum C- for a course to be listed on the certificate.
- Minimum 2.00 cumulative point-hour ratio required for the certificate.

X193 credits: Not permitted.

Certificate Completion: If the certificate is not complete on the DAR, the student must consult with the College of Arts and Sciences Coordinating Advisor.

Filing the certificate program form: The certificate program form must be filed at least by the time the graduation application is submitted to a college/school counselor.

Changing the certificate: Once the certificate program is filed in the college office, any changes must be approved by the College of Arts and Sciences Coordinating Advisor.

School of Earth Sciences undergraduate advisor
Dr. Karen Royce royce.6@osu.edu 614-292-6961

School of Earth Sciences graduate advisor
Professor Steve Lower, 084 Orton Hall, lower.9@osu.edu; 614-292-1571

**COLLEGE OF ARTS AND SCIENCES
THE OHIO STATE UNIVERSITY**

TYPE 1B, 2, 3 HYDROGEOLOGY CERTIFICATE (HYDRGEO-CT)

Student: _____

Course	Credit Hours	Semester Completed	Overlap with major?
<i>One groundwater class</i>			
EARTHSC 5651	4		
<i>One surface water course</i>			
	3		
<i>Electives (minimum 5 credit hours)</i>			

Total Credit hours: _____ (minimum 12)

Credits double counted with major: _____ (maximum 50%)

Advisor's signature _____

One groundwater course (4 credits):

- **EARTHSC 5651:** Hydrogeology (4)

One surface water course (3 credits):

- **EARTHSC 5665:** Land surface hydrology (3)
- **ENR 4285:** Watershed hydrology (3)
- **CIVILEN 5130:** Applied Hydrology (3)

Electives (at least 5 credit hours):

- **EARTHSC 5751:** Quantitative Reservoir Modeling (4)
- **EARTHSC 4450:** Water, Ice and Energy in the Earth System (3)
- **EARTHSC 5203:** Geo-environment and Human Health (3)
- **EARTHSC 5621:** Introduction to Geochemistry (3)
- **EARTHSC 5550:** Geomorphology (4)
- **ENR 5268:** Soils and Climate Change (2)
- **ENR 5261:** Environmental Soil Physics (3)
- **ENR 5273:** Environmental Fate and Impact of Contaminants in Soil and Water (3)
- **CIVILEN 5220:** Open Chanel Hydraulics (3)
- **AGSYSMT 4575:** Applied Agricultural Water Management (2)
- **GEOG 5210:** Fundamentals of GIS (3)



August 29, 2019

To ASCC and CAA members:

I am writing to document the College of Arts and Sciences' strong endorsement of four new certificate programs coming out of the School of Earth Sciences as part of their substantial revision of the Earth Sciences BS program:

- Certificate in Natural History Museum Curation (certificate types 1, 2, and 3: embedded undergraduate; post-bachelor undergraduate; and graduate certificate (both embedded and stand-alone)).
- Certificate in Petroleum Geology (certificate types 1, 2, and 3, as above).
- Certificate in Hydrogeology (certificate types 1, 2, and 3, as above).
- Certificate in Marine Science (certificate types 1 and 3, as identified above).

All four of these certificates have been designed for in-person delivery at this time. Each certificate proposal (as well as the redesign of the Earth Sciences BS program) is the result of thoughtful and extensive assessment of the curriculum, student interest, and market appeal. These certificates should complement a number of existing natural science programs (both graduate and undergraduate—so they utilize 5000-level dual-career courses), and they should also, in distinct ways, appeal to individuals who are in the workforce and have already earned Bachelor's degrees, to advance their careers and expand career opportunities.

The college of Arts and Sciences—as well as the Ohio Department of Higher Education and the State legislature—have been encouraging our departments to explore opportunities to develop certificate programs, and the School of Earth Sciences' proposals are exemplary. They address both our college's enrollment goals and our state's workforce enhancement goals.

Sincerely,



THE OHIO STATE UNIVERSITY

Steven Fink

Associate Executive Dean, College of Arts and Sciences

114 University Hall, 234 North Oval Mall, Columbus, OH 43210
614.292.6868 Office / 614.247.7498 Fax

Fink.5@osu.edu



October 1, 2019

To ASCC and CAA members:

I am writing to document the School of Earth Science's strong endorsement of five new certificate programs proposed as part of their substantial revision of the Earth Sciences BS program:

- Certificate in Natural History Museum Curation (certificate types 1, 2, and 3: embedded undergraduate; post-bachelor undergraduate; and graduate certificate (both embedded and stand-alone)).
- Certificate in Petroleum Geology (certificate types 1, 2, and 3, as above).
- Certificate in Hydrogeology (certificate types 1, 2, and 3, as above).
- Certificate in Marine Science (certificate types 1 and 3, as identified above).
- Certificate in Planetary Science (certificate type 1, as identified above).

All five of these certificates have been designed for in-person delivery at this time. Each certificate proposal (as well as the redesign of the Earth Sciences BS program) is the result of thoughtful and extensive assessment of the curriculum, student interest, and market appeal. These certificates are designed to complement a number of existing natural science programs (both graduate and undergraduate—so they utilize 5000-level dual-career courses), and they should also, in distinct ways, appeal to individuals who are in the workforce and have already earned Bachelor's degrees, to advance their careers and expand career opportunities.

Please feel free to contact me if you have any additional questions.

Sincerely,

Matthew R. Saltzman
Professor and Director
School of Earth Sciences

2. Certificate in Hydrogeology (new) approved with one contingency and six recommendations:
- Contingency: Correct both letters of support that say “Certificate in Hydrology” rather than “Certificate in Hydrogeology.”

Done

- Recommendation: Statements about what portion of the American Institute of Hydrology certificate is covered are inconsistent. Make the statements consistent throughout the proposal.

Done. The statements are clarified in terms of what is actually required.

- Recommendation: Correct the third program learning goal in the proposal and on curriculum.osu.edu that currently states “have completed the much of...”

Done

- Recommendation: Remove “better” from the program goals to say, “students will be prepared to...”

Done

- Recommendation: The program consists of 12 to 15 credit hours.

This was correct on the proposal, incorrect on the advising sheet, which has now been fixed

- Recommendation: Corrections to prerequisites and exclusions:
 - Geography 5210 – clarify that the exclusion is Geography 5220, as Civil Engineering 5220 is also on the list of course options.
 - AgSysMt 4575 – exclusion of ENR 3000, not 300
 - Earth Science 5550 – 3 credit hours
Done, except for 5550, which is 4 hours.
- Recommendation: Include the following statement on advising for interdisciplinary programs: Advising and students support services are available through the department, college, and university, as is available to any student pursuing a program.

**COLLEGE OF ARTS AND SCIENCES
THE OHIO STATE UNIVERSITY**

TYPE 1B, 2, 3 HYDROGEOLOGY CERTIFICATE (HYDRGEO-CT)

Student: _____

Course	Credit Hours	Semester Completed	Overlap with major?
<i>One groundwater class</i>			
EARTHSC 5651	4		
<i>One surface water course</i>			
	3		
<i>Electives (minimum 5 credit hours)</i>			

Total Credit hours: _____ (minimum 12)

Credits double counted with major: _____ (maximum 50%)

Advisor's signature _____

One groundwater course (4 credits):

- **EARTHSC 5651:** Hydrogeology (4)

One surface water course (3 credits):

- **EARTHSC 5665:** Land surface hydrology (3)
- **ENR 4285:** Watershed hydrology (3)
- **CIVILEN 5130:** Applied Hydrology (3)

Electives (at least 5 credit hours):

- **EARTHSC 5751:** Quantitative Reservoir Modeling (4)
- **EARTHSC 4450:** Water, Ice and Energy in the Earth System (3)
- **EARTHSC 5203:** Geo-environment and Human Health (3)
- **EARTHSC 5621:** Introduction to Geochemistry (3)
- **EARTHSC 5550:** Geomorphology (3)
- **ENR 5268:** Soils and Climate Change (2)
- **ENR 5261:** Environmental Soil Physics (3)
- **ENR 5273:** Environmental Fate and Impact of Contaminants in Soil and Water (3)
- **CIVILEN 5220:** Open Chanel Hydraulics (3)
- **AGSYSMT 4575:** Applied Agricultural Water Management (2)
- **GEOG 5210:** Fundamentals of GIS (3)