

Final Assessment Report

Earth Sciences (BSc, Minor, MSc, PhD) and Environmental Science (BSc)

November 2020

Executive Summary

External reviewers found that the Earth Sciences (BSc, Minor, MSc, PhD) and Environmental Science (BSc) programs delivered by the Department of Earth and Environmental Sciences were in good standing.

“Overall, we were impressed by the Earth and Environmental Sciences Department and compared to other Canadian earth science departments, we felt the department is ranked strongly”; “Students, faculty, and staff over all are happy and collegial. The complete lack of complaints or concerns regarding the EES leadership during our interviews with students, staff, and faculty suggests a high level of satisfaction in this regard”.

A total of 10 recommendations were provided by the reviewers, regarding minor curricular changes (including online course offerings), promotion and recruitment of students and Faculty members, and strategic planning. In response, the program created a plan outlining the specific actions proposed to address each recommendation as well as a timeline for implementation. The next cyclical review for this program is scheduled for 2025-2026.

Total Enrollment (All Years)

	Earth Sciences BSc		Environmental Science BSc		Earth Sciences Minor	Earth Sciences MSc	Earth Sciences PhD
	H	HC	H	HC			
Fall 2020	48	51	63	63	27	64	42
Fall 2019	53	55	22	54	21	54	35
Fall 2018	60	54	20	48	12	62	44

*based on Active Students Extract retrieved from Quest November 11, 2020

Background

In accordance with the University of Waterloo’s Institutional Quality Assurance Process (IQAP), this final assessment report provides a synthesis of the external evaluation and the internal response of the Earth Sciences (BSc, Minor, MSc, PhD) and Environmental Science (BSc) programs delivered by the Department of Earth and Environmental Sciences. A self-study (Volume I, II, III)

was submitted to the Associate Vice-President, Academic and Associate Vice-President, Graduate Studies and Postdoctoral Affairs on May 8, 2019. The self-study (Volume I) presented the program descriptions and learning outcomes, an analytical assessment of the programs, including the data collected from a student survey, along with the standard data package prepared by the Office of Institutional Analysis & Planning (IAP). The CVs for each faculty member with a key role in the delivery of the program(s) were included in Volume II of the self-study.

From Volume III, two arm's-length external reviewers were selected by the Associate Vice-President, Academic and Associate Vice-President, Graduate Studies and Postdoctoral Affairs: Dr. Jeffrey McKenzie, Associate Professor of Earth and Planetary Sciences, McGill University, and Dr. Janok Bhattacharya, Professor of Geography and Earth Sciences, McMaster University.

Reviewers appraised the self-study documentation and conducted a site visit to the University on November 26-27, 2019. An internal reviewer from the University of Waterloo, Dr. Shannon Dea, Professor of Philosophy, was selected to accompany the external reviewers. The visit included interviews with the Vice-President, Academic & Provost; Associate Vice-President, Academic and Associate Vice-President, Graduate Studies and Postdoctoral Affairs; Science Associate Deans of Undergraduate and Graduate Studies; Chair of the Department of Earth and Environmental Sciences, as well as faculty members, staff and current undergraduate and graduate students. The Review Team also had an opportunity to visit the program's facilities and meet with representatives from the Library and Co-operative Education.

Following the site visit, the external reviewers submitted a report on their findings, with recommendations. In response, the program responded to each recommendation and outlined a plan for implementation of the recommendations. Finally, the Dean responded to the external reviewers' recommendations, and endorsed the plans outlined by the program.

This final assessment report is based on information extracted, in many cases verbatim, from the self-study, the external reviewers' report, the program response and the Dean's response.

Program Characteristics

Earth Sciences (BSc): Students enrolled in the Earth Science program must choose a specialization to study. Their choices are Geology, Hydrogeology, or Geophysics. Each of the three specializations is available to study in the regular or co-op stream. All three also have the same minimum academic average requirements. In order for students to progress through the program, they need to maintain an overall cumulative average of 60% as well as an average of 60% in all their EARTH courses.

Environmental Science (BSc): Students who are studying Environmental Science must choose from three available specializations: Ecology, Geoscience, and Water Science (as of 2018), which are all available in both co-op and regular streams. As with the Earth Science specializations,

students studying in Environmental Science need to maintain an overall cumulative average of 60% as well as an average of 60% in all Science (Ecology and Water Science) or EARTH courses (Geoscience).

Earth Science (Minor): Waterloo students from outside the Department are able to take courses offered through the Department that can be used towards an Earth Sciences Minor. Students must take a minimum of 10 EARTH courses including two first year courses plus their labs and a minimum of 4 courses that are at the 300 or 400 level. A total of 76 students graduated with the Earth Sciences Minor between 2011 and 2017. All of these students studied within the Faculty of Science (84%) or Faculty of Environment (16%).

Earth Science (MSc): MSc Earth Sciences graduates are prepared for professional geoscience employment or further study at the doctoral level. Two options are available within the MSc Earth Sciences program: (1) Research Paper Option, consisting of six 0.5 credit (CR) courses and a research paper; and (2) Thesis Option, consisting of four 0.5 CR courses and a research thesis. Students may study in one of five research areas: Solid Earth Sciences (SES), Hydrogeology (HYD), Aqueous and Organic Hydrogeochemistry (AOG), Isotope Hydrology and Geochemistry (IHG), and Water Cycle Modelling (WCM).

Earth Science (PhD): PhD Earth Sciences graduates are prepared for professional geoscience employment or academic careers. The PhD Earth Sciences program typically consists of two 0.5 CR courses and a research thesis for candidates already possessing a Master's degree in a relevant field. Five research areas are offered: Solid Earth Sciences (SES), Hydrogeology (HYD), Aqueous and Organic Hydrogeochemistry (AOG), Isotope Hydrology and Geochemistry (IHG), and Water Cycle Modelling (WCM).

Summary of Strengths, Challenges and Weaknesses based on Self-Study

Strengths – Undergraduate Programs

- One of the particular strengths of the current undergraduate curriculum is the emphasis on and availability of **experiential learning** related to laboratory and field courses. The faculty are fully committed to including hands-on training opportunities in many of the core courses within each of the different programs. Efforts are made to expose students to both field and laboratory experience early in their academic careers (e.g., EARTH 121L, 122L, 123L and 231).
- A unique aspect of the undergraduate Environmental Science program, which is one of its key strengths, is the overall **diversity of the major program fields** that are offered including Geology, Hydrogeology, Geophysics, and Environmental Geoscience. The program is able to offer this high degree of diversity in training due to the breadth of expertise provided by their regular faculty complement, including the instructors and the additional capacity associated with the Research Professors.

- One of the most recognized strengths of the Earth Sciences and Environmental Science programs is the opportunity for the students to participate in the **Co-op program** at UW. The emphasis on hands-on, practical training within the curriculum provides the Co-op students with unique skills that are attractive to employers, particularly in the early work terms. In addition, the curriculum is designed to ensure that the graduates are immediately eligible for Professional Geoscientist designation within the Association of Professional Geoscientists of Ontario.
- On a final note, one of the key strengths of EES's existing program, based on the feedback provided by the graduating cohorts and 3rd and 4th year students' surveys, is the solidarity and **sense of community** that is developed and encouraged within the student body in the various programs. Part of this is due to the small size of the classes, but also reflects the camaraderie that is developed through the field excursions and the team project work.

Strengths – Graduate Programs

- A valuable aspect of the graduate programs has been the ability of the faculty to **adapt to changes in research direction** and to remain relevant to a wide range of stakeholders who represent sources of student support. The program has averaged over 100 graduate students across the various fields, and employment following the completion of the graduate program remains very strong in a wide range of areas including industry, government and academia. An average of 22 faculty members supports the graduate student population within EES. The overall opportunities for exciting and fully funded research projects are excellent and continue to evolve, as scientific questions change, and as societal priorities adjust.
- As the program maintains a very **extensive collaborative network with industrial partners** from many disciplines, there is an excellent opportunity to ensure that the research directions are influenced by modern, evolving challenges. This strong interaction with industry provides unique funding opportunities that have been a significant component of the research support over the lifetime of the department and is continuing to increase with time.
- The University of Waterloo has made a significant **commitment to supporting water research** including water geoscience, which is an indication of the institutional value of these academic programs. For example, in 2009 the Water Institute was established at the University of Waterloo. The Department of Earth and Environmental Sciences played a significant part of this initiative including the contribution of the founding Executive Director, Dr. David Rudolph.

Challenges / Weaknesses – Undergraduate Programs

- Due to the relatively high cost of running and modernizing the laboratory and field courses, one of the challenges moving forward will be to **maintain the financial support** that will be required to permit the courses to be offered. As one of the most significant

aspects of training in the diverse fields of Earth and Environmental Sciences is the hands-on experience of working in the laboratories and in the field, there is a need to maintain appropriate financial support for these activities to be a high priority and a challenge moving forward.

- Historically, students have enjoyed excellent employment opportunities upon graduation. However, even considering these key benefits to the EES program, it is constantly a **challenge to attract a large number of new students**, and **relatively low enrollment represents a chronic issue in most Geoscience programs**. Part of this problem is related to the difficulty in distinguishing the EES program from other environmentally oriented programs. The confusion arises as a result of similarities in program names and brief descriptions, which do not clearly reflect the differences between the program offerings. This will require innovation and aggression in branding and promotion within a wide range of different media and is a major priority for their administration moving forward.
- Finally, a major challenge at the undergraduate level is **maintaining a current and relevant curriculum** to ensure that students are graduating with the skills and knowledge required for the evolving area of Geoscience. This is a constant topic of conversation among faculty members within EES. This topic is also shared with a wide range of employers who are solicited for their opinions on the skill requirements they are seeking in new graduates.

Challenges / Weaknesses – Graduate Programs

- A major challenge within the graduate studies program, as noted for the undergraduate program, relates to ensuring that the **course curriculum** evolves in such a way that the students receive as modern a training regime as possible with the most relevant and modern resources. As funding and employment opportunities continue to evolve, it is necessary that EES faculty and staff remain current and flexible enough to react to new opportunities.
- As is the case within the Department faculty complement, there is always a challenge to **encourage and maintain gender equity** within the graduate program. It is critical that the opportunities offered for graduate studies within EES be perceived by potential students as being open and available to all and continued efforts to ensure that every potential applicant is encouraged and supported within all of the major fields is a high priority.
- Within all of EES research operations that involve laboratory and field experimentation, it is a considerable **challenge to attract sufficient funding** to purchase and maintain modern analytical and experimental equipment that is required to remain at the cutting edge of science. The Faculty of Science in concert with EES faculty members are continually exploring new opportunities to attract funding to support the research facilities and infrastructure.

Summary of Key Findings from the External Reviewers

“Overall, we were impressed by the Earth and Environmental Sciences Department and compared to other Canadian earth science departments, we felt the department is ranked strongly.

- With approximately 200 undergraduate students and 100 graduate students, and given the number of faculty, the department seems to be above average in terms of enrolment for department size in Canada.
- Further, the overall research profile of EES is very strong in terms of research output, grantsmanship, and success in large funding initiatives (programs such as CERC, GWF, CREATE, and the Water Institute).
- The department also provides adequate facilities, and the Environmental Isotope Laboratory is a fantastic resource.
- Students, faculty, and staff overall are happy and collegial. The complete lack of complaints or concerns regarding the EES leadership during our interviews with students, staff, and faculty suggests a high level of satisfaction in this regard.
- We were very encouraged with the focus and energy of the junior faculty and lecturers that we met. There is evidence that the teaching faculty will enhance the recruitment of majors through their focus on pedagogical initiatives, as well as introduction of online courses, the experiential focus with field trips, lab research and especially the co-op programs and the requirements that all BSc students complete a research thesis. We believe this demonstrates the value of judicious balance of teaching and research faculty.”

Response to External Reviewers’ Recommendations

1. *Overall the curriculum is consistent with other Canadian and international geoscience and environmental programs and meets professional accreditation standards. Some small tweaks are possible; both identified in the self-study report and in this evaluation. In other words, we do not feel that a major overhaul is needed. Course descriptions should be updated in describing content, and could include major themes in Earth and Environmental Sciences such as tectonics, climate change, sustainability, etc.*

Program Response

Unlike Canadian Engineering programs, Earth Sciences programs are not accredited. The curriculum is structured so that the graduating students are eligible to apply for Professional Licensing (P. Geo.). The Professional Geoscience Associations in the different provinces provide curriculum guidelines that must be followed to be eligible for a Professional License. The Undergraduate Committee has recently started a full curriculum review of all EES programs and specializations. The first part of this task was to take a close look at all 38 EARTH courses that are currently offered to determine if changes and updates are needed to:

- a. Course titles
- b. Course descriptions
- c. Prerequisites

The Undergraduate Committee has highlighted courses that need updating and are working with course instructors to expedite these changes. The Undergraduate Committee and course instructors will ensure that course descriptions properly emphasize major themes throughout. This is still an ongoing activity.

They are also reviewing each specific program within Earth and Environmental Sciences (EES) with the objective of streamlining the offerings to better reflect the current Geoscience focus and the backgrounds of EES faculty members. The intention here is to ensure that undergraduate students interested in obtaining a P. Geo. have the necessary courses and knowledge, and to improve clarity for student entrance into the Department of Earth and Environmental Sciences moving forward. This is a very significant task and it is critical that as the review of the curriculum and specific courses proceeds, EES ensures that courses ladder students appropriately through the curriculum and that there is an eye toward eliminating redundancies/ overlaps and identify any gaps (including what needs to be part of a current and rapidly evolving Geoscience education).

In May 2020, the Department faculty voted to terminate the Geochemistry Option that was jointly shared with the Department of Chemistry because of very low student uptake. Efforts are being made to streamline the program offerings to ensure that they emphasize Geoscience topics of critical importance to society; maximize their appeal to prospective students; and align with the major technical themes of: 1) Surface and groundwater resources: planning for the future; 2) Biogeochemical cycles in the Anthropocene; 3) Geosciences for responsible exploration and development of natural resources; 4) Earth processes and evolution; and 5) Geohazards, risks, and prevention.

Course and curriculum changes have already been brought forward to the Earth and Environmental Sciences Department for consideration and approval and were subsequently brought to the Science Undergraduate Committee in June 2020 for inclusion in the 2021 Undergraduate Calendar.

Dean's Response

Current program review and streamlining undertaken by EES is entirely appropriate and addresses the reviewers' comments.

2. *The department can and needs to continue to increase the number of undergraduate students. In discussions with faculty it was felt there is still room for additional undergraduate*

student capacity. That said, the department needs to be very careful with regards to limits of faculty and lecturer time and departmental resources.

Program Response

The Faculty of Science recruitment team has identified Earth and Environmental Sciences as a key area for recruitment focus during the 2020-2021 cycle. Along with the normal efforts from the recruitment team, the following are initiatives that have been taken specifically for the recruitment of prospective Earth and Environmental Sciences students:

- a. Earth and Environmental Sciences Day, which was a single day for prospective Earth Sciences and Environmental Sciences students (those who have applied into the two programs) to visit campus, attend a lecture, receive a tour, attend labs, speak with current students, and have the opportunity to talk with faculty.
- b. The development of a 3-minute video using faculty members that teach EARTH courses. The goal of this video is to highlight the importance of studying Earth and Environmental Sciences along with some exposure to the great facilities at UW and research that is being done within EES. This video has been posted on the Faculty of Science social media pages and is sent to all accepted applicants into the program.
- c. Increased efforts have been made by faculty members and the Earth Science Museum personnel to develop outreach activities involving high school students to get them interested in Geoscience and promote awareness of programs offered by the Department.
- d. Several new undergraduate course offerings are being added to the EES curriculum in very topical areas (e.g., Geomicrobiology, Ecohydrology, Data to Decisions), which reflect the background of the current faculty complement and which address the evolving, multidisciplinary nature of modern Geosciences. EES anticipates that these courses will attract new students into EES programs from a wide range of disciplines including Biology, Computer Science, Geography and Environmental Engineering.
- e. Development of new social media strategies to promote EES using a variety of the most effective social media platforms (e.g., YouTube, Instagram, etc.). This activity will be directed through the Undergraduate Committee in connection with Science Advancement and the EES Administration and will be carefully monitored to assess the degree of success in outreach.
- f. Promotion of the unique and exciting educational opportunities related to the skill set of the new faculty complement that will be available to the current generation of students entering the EES programs at all levels.
- g. Working in concert with the Department of Civil and Environmental Engineering, targeted promotion of the Geological Engineering Program (co-operated by EES) is also underway and is an ongoing activity.

Related to new faculty members, the Department had realized the limitations on student growth and its ability to completely and effectively deliver its evolving program offerings.

Hence, over the last 3 years they added 4 Lecturers and 5 Regular and Research Faculty members to further support and improve all EES undergraduate programs. EES is convinced that the Department can now continue to grow without undue stress on instructor and general Departmental Resources. However, with changes to program delivery and the challenges for students entering the university as a result of COVID-19, they will need to carefully consider how each of these proposed outreach activities is best delivered.

Dean's Response

EES has been the most active of our four departments in developing outreach activities aimed at increasing their undergrad enrolment. I have no doubt these efforts will bear fruit over the next few years.

3. *An issue at many universities, including Waterloo, is confusion around environment programs on campus. As discussed, having a Faculty of Environment (without a BSc program) and a Department of Earth and Environmental Sciences (in the Faculty of Science) is leading to confusion. Many interviewees specifically mentioned the development of a Geography BSc. While it seemed that no-one had seen the proposed curriculum, it is assumed that there will be some overlap with the EES environment program. The integration and overlap of these two programs should be addressed.*

Program Response

There is a current initiative in the Department of Geography and Environmental Management (GEM) within the Faculty of Environment to develop a **BSc** in Climate and Environmental Change. A draft curriculum has been developed and circulated to EES for consideration and discussion between the Department Chairs. Several issues related to the establishment of the Climate and Environmental Change BSc program include the following:

- a. Considering the limited pool of students within the Environmental/Geosciences, yet another program offering may further dilute the student pool and confuse to an even greater extent, the entrance options for first year students. This is under discussion with GEM.
- b. The current Environmental Science Ecology, Geoscience and Water options are relatively close in scope to the proposed new Geography program, again potentially deflecting students from the Science programs.
- c. As noted above, it is critical that EES and Science actively explain and promote the differences between their programs and other (apparently) similar programs on campus. EES anticipates that this new Climate and Environmental Change program will indeed receive approval but there still may be an opportunity to influence the final curriculum to minimize program competition and embed more Science and EES courses into this proposed Bachelor of Science program.

- d. The Climate and Environmental Change BSc program does not provide the course/knowledge requirements to attain P. Geo. registration and this detail may not be known to applicants ahead of time.
- e. A significant effort is underway to enhance information available to students to more clearly understand the distinction and value of the EES programs as compared to other programs on campus that include environmental sciences as part of their curriculum (e.g., Geography, other Faculty of Environment Programs, Civil and Environmental Engineering).

Dean's Response

I was recently advised by the Dean of Environment that the new program will be named *BSc in Climate and Environmental Change* and that students will have to take one additional Science elective as one of their choices in the plan. I am confident that EES and Geography will continue to work together to ensure that the new program is differentiated from EES programs.

- 4. *We felt there was potential scope for more online courses. In the Canadian university earth science departments, we do not know of many other online course offerings. In particular, courses that would be for degree credit have potential (as opposed to MOOCs or general interest courses).*

Program Response

Over the last 3 years, EES has experimented with a fully on-line course offering, EARTH 121, which still has a very active regular in-person classroom offering. The course was developed with EES faculty and with the help of Waterloo's Centre for Extended Learning (CEL). This online course has been extremely successful to date with enrolment caps needing to be increased for each subsequent offering.

As a result of the rapid pivoting of many regular, in-person courses, to a remote, asynchronous offering due to the restrictions associated with the COVID-19 situation, many of the EES core and elective courses have undergone initial development towards a formal online format. Specifically, EARTH 122, 122L and 123 have been advanced towards online delivery and there are plans to solicit CEL support to fully develop these courses.

In the long term, EES proposes to develop a slate of 5 – 6 undergraduate courses (examples are EARTH 221, 281, 438, and 458) that would be especially attractive to students wanting to explore options within the EES scope and for professionals who may require additional course training to obtain a Professional Geoscience license. EES feels that there is tremendous opportunity within the Department to establish a significant presence in the online market and this will be an immediate priority over the coming years.

Dean's Response

I fully agree with the program response that there is significant potential for EES to establish a strong presence in the professional development online market.

5. *There is potential scope for a Professional MSc in Hydrogeology or a related field. The first step is for EES to develop a business plan that clearly lays out the potential risks and benefits of such a program.*

Program Response

The Department currently has a research paper MSc program that has been part of their offerings since the 1980's. The program has a higher course requirement than the thesis MSc option. This program has been taken by students who are intending to return to industry following their graduate studies and by industrial/practicing geoscientists who are able to take leave from their employment on a full-time or part-time basis to complete the project MSc program. This program currently represents about 15% of the MSc population and it is designed to be completed within a 1.5-year time frame. As part of this program, students are required to complete a research project that is designed in scope to be completed within the shorter time frame than is available for the MSc thesis option. There has been an increase in uptake of this program from returning professionals who are looking to upgrade skills and complete courses required for professional designation over the last 5 years.

The option to develop an additional, 1-year program that is fully course-based and intended to provide an opportunity for returning professionals to enhance their training and skill set is also under consideration. This could be considered a professional degree or diploma program that would not involve a research component. The plan would be to ensure that the program could be completed within one year and would likely be a mix of in-person and online courses that could include a mix of graduate and undergraduate level courses. The priority topic(s) for this program are under consideration and could include Geoscience Data Management or Hydrogeology for example. It is not yet clear what the strongest business plan option would be for such a program and it is considered a priority for discussion and development in the short term. EES is currently planning to survey students in the existing course-based MSc program to get some feedback. They are also considering surveying alumni in industry to get feedback and advice on a potential new "Professional" course-based program/diploma.

Dean's Response

The creation of new professional development programs such as the one envisioned herein is consistent with the UW Strategic Plan and fully supported by the Faculty of Science.

6. *At the undergraduate level, the students are overall satisfied and feel a close sense of community within EES. It was clear that the undergraduate thesis course requires additional*

clarification in terms of guidelines, student feedback, and engagement, but the focus on a thesis is certainly a valuable component of their training and professional development.

Program Response

EES is particularly proud of their students and the sense of belonging they have developed while undertaking their undergraduate studies. Students have a strong connection to the department, which is reflected by the long-term relationships EES has developed with a large number of their alumni. This connection is often reinforced with students that completed an Honours thesis because this experience represents a key highlight of their undergraduate program and often their first exposure to research. Nonetheless, EES acknowledges that there is room for improvement regarding the undergraduate thesis course. This issue has already been recognized by the Department and they have been revising the structure and administration of the undergraduate thesis course (EARTH 436A & 436B). First, the course format has been changed from what was essentially a single two-term course to a sequential set of two one-term courses where EARTH 436A focuses on the preparation and presentation of a research proposal and EARTH 436B involves the execution of the proposed research project and the production of the resulting thesis. The rationale for this format change was to improve the successful completion of course milestones in a timely fashion by both the students and their research supervisors. In addition, students must now achieve a minimum grade of 75% in EARTH 436A to proceed to EARTH 436B. This requirement was implemented to ensure that students who demonstrated the necessary skill set were allowed to advance to the thesis portion of the course sequence.

The course administrator is taking an explicit role in these thesis courses in terms of instruction concerning the necessary elements of the thesis process (i.e., definition of the problem, formulation of research hypotheses, literature review, role and format of research proposal, structure and format of the thesis). In addition, the course administrator has made a significant effort to clearly communicate the course expectations, milestones and deadlines to both the students and their supervisors. Further, the course supervisor has been encouraged to closely monitor both student and supervisor activities to assist in the successful and timely completion of course milestones.

The first year of the new EARTH 436A & B course format was completed during the 2019-2020 academic year. The Departmental Associate Chair, Undergraduate Studies and the Undergraduate Committee have been monitoring the progress and results from the first year. They will confer with the course administrator to discuss these outcomes and develop plans to refine and improve the course. It is anticipated that this feedback procedure will continue into the future as EES strives to produce the best possible outcome for the students and supervisors.

Dean's Response

Satisfied with the proposed changes.

7. *The graduate students would benefit from a formalized 'new graduate student' orientation. While the staff and faculty are easily available for answering graduate student inquiries, the students we spoke with identified initial struggles with understanding the bureaucracy and steps required to commence their graduate degrees (especially for those who did not do their undergraduate degree in EES or at Waterloo). A new graduate student orientation session, mentoring program, and/or an EES graduate student handbook would assist alleviate this issue.*

Program Response

The Department has a Graduate Student Handbook (on the EES web site) which is sent to all incoming Graduate students upon arrival and is available to all instructors and students. The document is updated every year. The document is intended to provide all the information that should be required to get through the program as well as the most important and useful web links to specific GSPA webpages. The Department also provides MSc thesis students and their research supervisors with a separate document that outlines the expectations and format regarding the MSc thesis proposal; there is a plan to develop a similar document for the PhD thesis proposal. The departmental webpage will be revised to have a highly visible link that leads to a page containing all important documents and relevant links to important university, Faculty of Science, and Graduate Studies and Postdoctoral Affairs resources for graduate students. Enhanced communication with the incoming students to ensure they are aware of the available resources will be undertaken. Graduate student orientation has been attempted on several occasions in the past, however, the attendance has been very low. This idea is being reconsidered now. The initial struggles related with the "bureaucracy" of the system has been handled by direct communication with the Graduate Administrator and the Associate Chair of Graduate Studies. Live info and Q&A sessions in a new format are being considered, which could be more successful and better help address this issue for new students. We intend to reach out to GSPA for support in this endeavor.

Dean's Response

Program response is appropriate.

8. *We were impressed with Environmental Isotope Laboratory (EIL) as a global recognized core facility that serves both outer and inner users. Budget revenue should be shared with the department versus merely sustainment. Should this be a pan-university centre or institute for isotope analysis?*

Program Response

The Environmental Isotope Laboratory (EIL) continues to expand its scope of analytical offerings related to environmental isotopes and supports a large number of researchers and students within EES (including experiential educational opportunities for undergraduate students), across the UW campus and external to UW. The demand for the services of the EIL continues to grow and there is the potential for the overall facility to expand beyond its current scale and capacity. The facility has proven not only to be completely self-sustainable, but also to progressively support a revenue excess beyond annual expenses most years. This excess has been used to repair and replace the highly expensive analytical instruments that make up the core infrastructure. As required, the facility has hired casual and permanent staff to ensure timely delivery of the analytical data. Requests for analyses are received from all around the world.

The EIL is an EES facility, and is not driven by any individual faculty member's research program, as many other laboratory facilities are within Science. There is the potential to consider a different administrative model as noted above to establish a formal Center or Institute in Environmental Isotope Research. EES has a very strong core of faculty conducting world-leading research in this area. It is unclear what the specific advantages of such an administrative structure would be but the Department will consider various options in the near future.

There has recently been a change in senior management within the EIL and considering the relevant expertise of several of the most recent faculty hires, this is an ideal time to assess options for optimizing the impact and value of the EIL to the Department and to the University as a whole.

Dean's Response

There are ongoing discussions at the VPRI level to develop a network of University core facilities and future developments of EIL will be considered within this framework. The Faculty of Science is fully supportive of EIL in its current form, but sees significant potential for future growth.

- 9. Based on our discussions, we feel that the Department should develop a strategic plan, specifically in the area of hiring priorities. As discussed in meetings and in the self-study report, there are upcoming potential retirements. With the recent cluster of water related hires, the Department must now develop a plan for the next hires. The department's strategic plan should also rationalize its specialized programs with respect to faculty who can teach the courses. For example, it is our understanding that in the area of geophysics, there is only one faculty member and one definite term lecturer in EES. This creates an inequitable teaching and resource distribution that is not sustainable in the long term and can be dealt with by either closing or broadening the geophysics program and/or hiring additional faculty in this*

research area. Ensure utmost attention to improving gender diversity in faculty, via future hires.

Program Response

Following the completion of a very major period of retirements and new hires, which occurred between 2017 and 2020, the scope of expertise within EES has evolved considerably. The majority of the new hires are working within some aspect of water research, although this is highly diverse (Geomicrobiology, Near Surface Geophysics, Isotope Hydrology and Geochemistry, Hydrogeology, Geochemistry, Critical Zone Hydrology and Numerical Modeling). A conscious and faculty-supported decision was made to wait until all of the hires had been complete so that the new faculty would be able to participate directly in the strategic planning process and the full expertise within the Department could be clearly established.

It is unclear what the intentions are of several EES senior faculty members with respect to retirement so that specific planning based on pending retirements will likely be difficult. However, the Department is highly motivated now to undertake strategic planning initiatives and some of the central themes will include:

- Rationalization and optimization of the undergraduate programs and curricula, reflecting the new faculty expertise base, anticipated areas of strength and interest that will attract the next generation of Geoscientists.
- Strengthening and ensuring the resilience of core Earth Sciences offerings in areas including Field Techniques, Mineralogy & Petrology, Sedimentation & Stratigraphy, Engineering Geology and Structural Geology
- Consider which areas of research specialization must be expanded or rejuvenated in order to ensure delivery of new programs. As part of this effort, the area of Geophysics will be re-evaluated. These efforts will help to focus priorities for new hires.
- Develop aggressive and innovative approaches to promote the EES undergraduate and Graduate Programs with the goal of increasing enrolment. Expand the use of many social media platforms.
- Consider approaches to further strengthen the Geological Engineering program from the EES stand point by appointing the Director of the program from the ranks of EES faculty and establishing a Geological Engineering Committee within EES to work with the Director on matters of interest. A major priority will be to continue to work at increasing annual enrolment.
- Develop aggressive strategies for outreach, advancement and building EES endowment funds, including the Earth 2020 endowment in support of student training and research support.

- Discuss and focus on the “*new frontiers*” within the technical specialties associated with EES and proactively develop a strategic plan to become international leaders in these emerging areas, both from a research and training standpoint.

The Department is well aware of the need to diversify the faculty composition and specifically to enhance gender diversity. During the recent hiring campaign, a very conscious effort was made to attract excellent female candidates to apply for the advertised positions. This initiative proved to be highly successful as four new female faculty members have now joined the Department, which will significantly improve the level of gender diversity within EES. We believe, however, that there is still more progress that can be made in this regard, but are encouraged by these recent changes and additions. The Department also recognizes the importance of further efforts to diversify with respect to other designated groups (persons with disabilities, Indigenous peoples, and members of visible minorities).

Dean’s Response

The program response is appropriate and fully supported by the Dean. There is tremendous potential for EES to distinguish itself as a world-class unit.

10. We understand that introduction of the activities-based budget model has put the Faculty of Science and EES under stress. The university should develop clear metrics for reconciliation of budgets and appropriate scale of EES (numbers of students, budgets, outcomes). This should include efforts by senior administration to reconcile the broader value of EES as a key component of the “environmental” theme at Waterloo to ensure continued health and success of EES and the Faculty of Science.

Program Response

Even though the COVID-19 situation has impacted the nature of the University budgetary framework, EES is very aware that the Department’s overall value within the Faculty of Science and the University of Waterloo overall, needs to be clearly expressed and demonstrated moving forward.

The Department is moving into a period of remarkable opportunity and the rejuvenated faculty and staff are poised to raise EES to an even higher level at UW and internationally. EES is committed to work with all Departments and Schools within Science to help ensure strong growth and sustainable operations both within the Department and within Science overall.

Recent efforts to generate Departmental revenue through Advancement in order to enhance EES’s ability to offer continually improving academic programs will help in this regard. EES looks forward to continually working with senior Faculty of Science Administration to explore ways to continue to grow their programs and to contribute to the strength and viability of the Faculty overall.

Dean's Response
Agreed.

Implementation Plan

	Recommendations	Proposed Actions	Responsibility for Leading and Resourcing (if applicable) the Actions	Timeline for addressing Recommendations
1.	Overall the curriculum is consistent with other Canadian and international geoscience and environmental programs and meets professional accreditation standards. Some small tweaks are possible; both identified in the self-study report and in this evaluation. In other words, we do not feel that a major overhaul is needed. Course descriptions should be updated in describing content, and could include major themes in Earth and Environmental Science such as tectonics, climate change, sustainability, etc.	<ul style="list-style-type: none"> • Review of all 38 current EARTH, GEOE and SCI courses related to EES programs to recommend changes/updates. • Review and streamlining of each specific EES program offering to best reflect the current faculty complement and training priorities. 	<ul style="list-style-type: none"> • Undergraduate committee • Executive Committee • Support for the promotion of the updated programs and EES overall. 	May 2022
2.	The Department can and needs to continue to increase the number of undergraduate students. In discussions with faculty it was felt there is still room for additional undergraduate student capacity. That said, the department needs to be very careful with regards to limits of faculty and lecturer time and departmental resources.	<ul style="list-style-type: none"> • New Faculty Members and Lecturers have been added to the faculty to help modernize the undergraduate program and to expose potential transfer students to motivational instructors in early years. • Enhanced promotional activities on campus and through the use of modern social media platforms. • Inclusion of new undergraduate course offerings in topical areas designed to attract the next generation of Geoscientists. 	<ul style="list-style-type: none"> • Department Chair • Undergraduate committee • Science outreach personnel • EES Lecturer and Instructor personnel • Additional resources to support the development of multimedia promotional materials. 	December 2021
3.	An issue at many universities, including Waterloo, is confusion around environment	<ul style="list-style-type: none"> • EES will actively develop promotional and outreach content that will help to clarify 	<ul style="list-style-type: none"> • Executive Committee 	<ul style="list-style-type: none"> • Immediate response to the

	<p>programs on campus. As discussed, having a Faculty of Environment (without a BSc program) and a Department of Earth and Environmental Science (in the Faculty of Science) is leading to confusion. Many interviewees specifically mentioned the development of a Geography BSc. While it seemed that no-one had seen the proposed curriculum, it is assumed that there will be some overlap with the EES environment program. The integration and overlap of these two programs should be addressed.</p>	<p>the distinct opportunities available through the EES set of programs relative to other similar programs on campus (e.g., Geography, other Faculty of Environment Programs, Civil and Environmental Engineering).</p> <ul style="list-style-type: none"> • Emphasis on the professional nature of the EES programs will be a promotional feature. 	<ul style="list-style-type: none"> • Undergraduate committee • Science outreach personnel. • Support from Faculty of Science in further development of outreach and approaches to emphasize the distinct aspects of the EES program 	<p>proposed BSc program in Geography</p> <ul style="list-style-type: none"> • September, 2021 for completion of new outreach materials
4.	<p>We felt there was potential scope for more online courses. In the Canadian university earth science departments, we do not know of many other online course offerings. In particular, courses that would be for degree credit have potential (as opposed to MOOCs or general interest courses).</p>	<ul style="list-style-type: none"> • Following the development of new remote offerings of most of the EES courses as a result of the requirement to deliver most courses on line due to COVID-19, online versions of several priority courses are being considered. The highest priorities include EARTH 122, 122L and 123. • Other potential courses under consideration for full online development, with specific emphasis on requirements for professional registration include EARTH 221, 281 and 458. 	<ul style="list-style-type: none"> • Lectures and Instructors are the main faculty members engaged in this along with the specific course instructors • Undergraduate committee • There will likely be expenses associated with the development of the fully online version of these courses. 	<ul style="list-style-type: none"> • May 2022 for first additional online courses (EARTH 122, 122L and 123) • Ongoing online course developments
5.	<p>There is potential scope for a Professional MSc in Hydrogeology or a related field. The first step is for EES to develop a business plan that</p>	<ul style="list-style-type: none"> • A new 1-year Professional/Diploma MSc program is under consideration. 	<ul style="list-style-type: none"> • Executive Committee • Graduate Committee • Support to hire a co-op student in Science and 	<ul style="list-style-type: none"> • December 2021 for Business plan



	clearly lays out the potential risks and benefits of such a program.	<ul style="list-style-type: none"> • Business plans for specific focusses within this new program are under discussion now. 	<p>Business to develop a business plan in collaboration with a co-op student in EES to provide technical guidance.</p> <ul style="list-style-type: none"> • Potential faculty course buyout to direct the development of this new graduate program offering. 	<ul style="list-style-type: none"> • September 2022 for initial program offering
6.	At the undergraduate level, the students are overall satisfied and feel a close sense of community within EES. It was clear that the undergraduate thesis course requires additional clarification in terms of guidelines, student feedback, and engagement, but the focus on a thesis is certainly a valuable component of their training and professional development.	<ul style="list-style-type: none"> • The thesis course(s) have been significantly overhauled over the last 2 years. As a result, detailed instructions for the students have been in development and are now available in a more complete format and is being shared with the current student cohort. • Feedback from the students who have been enrolled in the new version of the course is being collected and has been invaluable in modifying the new approach and in ensuring appropriate guidance is communicated with the students going forward. 	<ul style="list-style-type: none"> • Instructor of EARTH 436A and 436B • Undergraduate committee • Undergraduate Administrator 	<ul style="list-style-type: none"> • On going
7.	The graduate students would benefit from a formalized 'new graduate student' orientation. While the staff and faculty are easily available for answering graduate student inquiries, the students we spoke with identified initial struggles with understanding the bureaucracy and steps required to	<ul style="list-style-type: none"> • The Department has a Graduate Student Handbook, updated annually, which is sent to all incoming Graduate students upon arrival and is available to all. • Enhanced communication is planned with the incoming students to ensure they are aware of this resource. 	<ul style="list-style-type: none"> • Graduate Committee • Senior Graduate Administrator 	<ul style="list-style-type: none"> • April 2022

	commence their graduate degrees (especially for those who did not do their undergraduate degree in EES or at Waterloo). A new graduate student orientation session, mentoring program, and/or an EES graduate student handbook would assist alleviate this issue.	<ul style="list-style-type: none"> • Potential for additional outreach to new graduate students in the form of in-person meetings and Q & A sessions are being considered. 		
8.	We were impressed with Environmental Isotope Laboratory (EIL) as a global recognized core facility that serves both outer and inner users. Budget revenue should be shared with the department versus merely sustainment. Should this be a pan-university centre or institute for isotope analysis?	<ul style="list-style-type: none"> • The administrative structure, including financial management and direction are currently under revision. • There is an opportunity to expand the EIL and extend its capacity as the market for these types of analyses continues to grow from a research and industrial point of view. 	<ul style="list-style-type: none"> • Department Chair • EIL Manager • Executive Committee • EIL Management Board. 	<ul style="list-style-type: none"> • July 2021
9.	Based on our discussions, we feel that the Department should develop a strategic plan, specifically in the area of hiring priorities. As discussed in meetings and in the self-study report, there are upcoming potential retirements. With the recent cluster of water related hires, the Department must now develop a plan for the next hires. The department's strategic plan should also rationalize its specialized programs with respect to faculty who can teach the courses. For example, it is our understanding that in the area of geophysics, there is only one faculty member and one definite term lecturer in EES. This creates an inequitable	<ul style="list-style-type: none"> • Although plans for a Department Retreat to initiate discussions around a Strategic Planning exercise has been under consideration for several years, it was decided that it would be best to wait until all of the new hires had arrived and become somewhat settled before arranging the retreat. • With the hiring process complete for the time being, plans for the development of formal Strategic Plan are underway. • As noted above, significant streamlining and modernization of the specific programs is underway and a specific priority in the short term. 	<ul style="list-style-type: none"> • Executive Committee • Undergraduate committee • Ultimately the entire, newly constituted faculty and staff! 	<ul style="list-style-type: none"> • On going • Potential retreat date Spring 2022



	teaching and resource distribution that is not sustainable in the long term and can be dealt with by either closing or broadening the geophysics program and/or hiring additional faculty in this research area. Ensure utmost attention to improving gender diversity in faculty, via future hires.	<ul style="list-style-type: none"> As part of the hiring process over the last 4 years, there has been a significant improvement in gender balance within the Department, although there is still some growth in gender diversity that is required. 		
10.	We understand that introduction of the activities-based budget model has put the Faculty of Science and EES under stress. The university should develop clear metrics for reconciliation of budgets and appropriate scale of EES (numbers of students, budgets, outcomes). This should include efforts by senior administration to reconcile the broader value of EES as a key component of the “environmental” theme at Waterloo to ensure continued health and success of EES and the Faculty of Science.	<ul style="list-style-type: none"> Through the efforts to gradually increase undergraduate enrolment, expansion of both the scope and magnitude of the research activities within EES and the development of endowment funds to support new initiatives, the Department intends to demonstrate and enhance its value both within the Faculty of Science and the University overall. Within the budgetary uncertainty related to the COVID-19 crisis, the Department will be considering novel ways to grow in diverse sources of revenue including increasing enrolments, potential new graduate study options, alumni engagement and facilities management. 	<ul style="list-style-type: none"> Executive Committee Undergraduate committee Graduate Committee Science Outreach and Advancement personnel. 	<ul style="list-style-type: none"> On going

The Department Chair/Director, in consultation with the Dean of the Faculty shall be responsible for the Implementation Plan.



Date of next program review

2025-2026

Date

Signatures of Approval

AL Rudolph

June 1, 2021

Chair/Director

Date

AFIW Administrative Dean/Head (*For AFIW programs only*)

Date

**Robert P.
Lemieux**

Digitally signed by Robert P.
Lemieux
Date: 2021.06.09 14:34:50 -04'00'

Faculty Dean

Date

Note: AFIW programs fall under the Faculty of ARTS; however, the Dean does not have fiscal control nor authority over staffing and administration of the program.

Dan DeVida

January 7, 2021

Associate Vice-President, Academic
(For undergraduate and augmented programs)

Date

Jeffrey M. Cauley

January 7, 2021

Associate Vice-President, Graduate Studies and Postdoctoral Affairs

Date



(For graduate and augmented programs)