

# Final Assessment Report

## Civil Engineering (BASc), Environmental Engineering (BASc, Option), Geological Engineering (BASc), Water Resources (Option)

### September 2022

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#### Executive Summary

External reviewers found that the Civil Engineering (BASc), Environmental Engineering (BASc, Option), Geological Engineering (BASc), Water Resources (Option) delivered by the Department of Civil and Environmental Engineering were in good standing.

*The undergraduate Civil, Environmental and Geological Engineering programs are strong programs taught by a group of high-quality faculty, supported by highly qualified technical and administrative staff. The programs offer solid training to students, both broad and deep, are student-centered and highly regarded.*

A total of five recommendations were provided by the reviewers, regarding curriculum review, EDI and flexible and innovative approaches to teaching and learning. 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 2027-2028.

#### Enrollment over the past three years

	Civil Engineering	Environmental Engineering	Environmental Engineering Option	Geological Engineering	Water Resources Option
2021-2022	586	275	7	61	1
2020-2021	636	277	6	67	9
2019-2020	613	290	9	90	17

Based on Active Students Extract in Quest, accesses September 20, 2022.

## **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 Civil Engineering (BASc), Environmental Engineering (BASc, Option), Geological Engineering (BASc), Water Resources (Option) delivered by the Department of Civil and Environmental Engineering (CEE). A self-study (Volume I, II, III) was submitted to the Associate Vice-President, Academic on August 16, 2021. 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: Dr. Jocelyn Hayley, Professor of Civil Engineering, University of Calgary, and Dr. Mamadou Fall, Professor of Environmental Engineering, University of Ottawa.

Reviewers appraised the self-study documentation and conducted a virtual site visit to the University between January 10 and January 14, 2022. An internal reviewer from the University of Waterloo, Dr. Bruce Taylor, Professor of Fine Arts, was selected to accompany the external reviewers. The visit included interviews with the Associate Vice-President, Academic; Dean of the Faculty of Engineering; Chair of the Department, as well as faculty members, staff and current undergraduate. The Review Team also had an opportunity to view the undergraduate laboratories 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. Subsequently, 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

The following programs and options were reviewed:

- [Bachelor of Applied Science, Honours Civil Engineering, Co-operative Program](#)
- [Bachelor of Applied Science, Honours Environmental Engineering, Co-operative Program](#)
- [Bachelor of Applied Science, Honours Geological Engineering, Co-operative Program](#)
- Water Resources Option (see [2018-19 Archived Calendar](#) > Faculty of Engineering > Bachelor of Applied Science ... Degree Requirements > Option in Water Resources)
- [Environmental Engineering Option](#)

Civil engineers design and maintain the massive infrastructure on which society depends, including roads, buildings, bridges, dams, tunnels, levees, sewer systems, and water treatment plants. Given this strong interaction with society, civil engineers often deal with the human impact of engineering, including social, moral, and legal issues.

Geological engineers apply geological knowledge to the siting, design, construction, operation and maintenance of civil engineering structures and facilities. They also provide the expertise to develop mines, petroleum reservoirs, hydroelectric dams and reservoirs, groundwater and surface water resources, as well as building and managing the necessary infrastructure to bring the resulting commodities to market. It is a niche program that continues to draw students interested in the physical mechanics of the earth's surface and subsurface, sustainable resource management, environmental stewardship, and reducing the risk of geological hazards to create a safer world.

Environmental engineers are charged with managing the residual waste streams of civilization. This responsibility includes cleaning up existing pollution from our water and soils, developing technological solutions to reduce the presence or risk of pollutants from future human activities, and providing a safe supply of water for domestic, industrial, and agricultural use. This work is necessarily interdisciplinary, and environmental engineers work with planners, industry, environmental advocacy groups, government regulators, and others.

All engineering programs, including Civil Engineering (CIVE), Environmental Engineering (ENVE), and Geological Engineering (GEOE) are co-op programs requiring students to alternate study terms with work terms and graduate with up to two years of relevant, paid work experience. This means two years of experience learning how to navigate the hiring process, applying skills to real-life problems and learning about oneself along the way.

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

### Strengths

- Co-operative education: Waterloo's world leading co-operative education is mandatory for all engineering programs. Co-op is a key aspect of undergraduate training. During their work-terms, students learn to function and communicate in a professional workplace and to solve real-world engineering problems. Co-operative education also makes employers active participants in the undergraduate pedagogical process. Not only do the employers directly train students during their co-op placements, but they also provide feedback to the Department about strength and weaknesses in the preparation of the students, information that is incorporated into our continual improvement process. Ultimately, many of the employers hire co-op students into full-time, permanent positions.
- Rankings and reputation: The CIVE, ENVE and GEOE programs contribute to and benefit from the high world academic rankings (e.g., Shanghai Ranking's 11<sup>th</sup> in Transportation Science and Technology, 33<sup>rd</sup> in Water Resources, Top 75 in CIVE, Top 100 ENVE and Top 200 in Earth Science) and a strong Canadian reputation (e.g., Maclean's survey of comprehensive universities place Waterloo in the top three of Best Overall (2), Highest Quality (3) and Most Innovative (1)).
- Satisfied and successful graduates: National, provincial and exit survey results demonstrate that CEE graduates are satisfied with their programs and educational experiences, would do the same program again if starting over, and find work within 6 months of graduation in areas that are related to their program of study.
- Faculty and staff: CEE faculty and staff are talented, experienced and dedicated. The CEE age demographic is well-balanced, with low risk of losing many members. CEE has an excellent work environment that leads to high retention of faculty and staff. This collegial culture enhances and allows for healthy communication and relationships between faculty, staff and students.
- Quality of students: CEE programs attract outstanding students from high school, and other engineering and science programs. High school grades for first-year students were at least 90% for 80% of CIVE, 60% of ENVE and 50% of GEOE. Students who start in CEE are highly retained by the faculty and university. CIVE, ENVE and GEOE students were on average retained in their original program 94%, 86% and 80% of the time, and retained at UW 97%, 99% and 98% of the time.

- Teaching quality: CEE has a rich history and culture of teaching excellence with instructor and course evaluations consistent with the faculty average. The CEE teaching assessment scores are at least 2% higher than the faculty averages with less variance and higher modes.
- Physical resources: CEE students have access to outstanding services and resources, including the UW Library services, Rapid Prototyping Centre, Engineering Machine Shops, faculty and department computer labs and specialized engineering software. CEE students have access to the CEE Structures, Environmental, Geotechnical and Hydraulics and Hydrology Labs, most of which were updated in 2013.
- Process to measure learning outcomes: CEE has developed a comprehensive process of mapping and reviewing graduate attributes (GAs) by measuring performance indicators (PIs) or learning outcomes across the curricula. The process is continual and used to improve the programs.
- Program specialization: CEE programs include 9 to 11 elective courses within and outside of the department. The curricula were recently revised to include specializations which focus technical elective choices into theme areas. These came into effect in 2020/21.
- Environmental Engineering Option: the ENVE Option is well subscribed in terms of numbers of graduates with an option, ranking 4<sup>th</sup> across the faculty options. It is also broadly subscribed across the Chemical, Civil, Mechanical and Systems Design Engineering programs.

### **Challenges**

- Graduate attribute data collection and decision making: CEE is measuring PIs across all courses in all programs. It is a large effort to collect, organize, analyze and review the GA data, and it can be challenging to engage all teaching teams. CEE strives to increase efficiencies in the process so that meaningful and necessary data are collected to continually improve the programs.
- Outreach and recruitment: CEE programs attract strong students; however, the number of high school applicants and registrants in the ENVE and GEOE programs has decreased. CEE is currently working on promotional and outreach materials to promote ENVE and GEOE, especially with high school guidance counsellors.
- Academic integrity: New communication technologies and the proliferation of internet-banked assignments and lab reports present new challenges to academic integrity that must be overcome.

- Student wellness/resiliency: The CEE programs are challenging experiences for undergraduate students, and often involve long working hours under intense pressure. While these conditions are formative, and help students develop organizational and time management skills, there is an increasing appreciation that they can also adversely affect mental and emotional wellbeing. Waterloo Engineering is known for hard work and rigor, but these need to be better balanced with wellness so that the students find more enjoyment and satisfaction.

### **Weaknesses**

- Additional GA measurements are needed in three areas: CEE has targeted GA8: Professionalism, GA9: Impact of Engineering, and GA11: Economics & Project Management for more aggressive data collection.

### **Summary of Key Findings from the External Reviewers**

The undergraduate Civil, Environmental and Geological Engineering programs are strong programs taught by a group of high-quality faculty, supported by highly qualified technical and administrative staff. The programs offer solid training to students, both broad and deep, are student-centered and highly regarded. The programs meet the academic goals of the University and support the University of Waterloo's mission and academic strategic plans. The programs include a Co-op and the employment prospects of graduates are good. The presence of a co-op option adds a dimension of experiential learning to an already rich program of study and attracts high quality students.

All recommendations should be viewed through the lens of a virtual visit, understanding that limited interactions may lead to gaps in our understanding. A summary of program strengths along with five recommendations for improvements are provided, with further commentary on each. In summary, the recommendations are: 1) conduct a curriculum review with the guiding question of how to educate the engineer of the future; 2) bring attention, awareness and best practices around equity, diversity and inclusion to all aspects of the programs and department; 3) enable, encourage and support flexible and innovative approaches to teaching and learning; 4) consider how design is integrated throughout and between the programs and culminates in the capstone design experience; and 5) consider combined undergraduate and graduate program reviews.

## Program Response to External Reviewers' Recommendations

- 1. Recommendation 1: Each program conduct a review and self-assessment of their curriculum to understand how they are, and will be, educating the engineer of the future with attention to integration between the programs, balancing STEM and non-STEM content, and incorporating flexibility.**

We recommend each program, coordinated by the department, conduct a self-assessment of their curriculum with the guiding question of how the program is meeting the needs of the engineer of the future. In particular, the programs may want to consider:

- a. Integration across the programs and between the years. Leveraging on the strength of being housed in one department, the programs have the opportunity to integrate between the four different programs, with potential mechanisms such as integrated capstone design. In addition, although operationally challenging with student on campus at different times, we suggest more integration between the years/cohorts would be highly beneficial for the student experience.
- b. Balancing content. Consider the balance of technical content within traditional science and engineering with content outside of traditional STEM (e.g. creativity, sustainability, human behaviour, socio-economics, entrepreneurship, etc.).
- c. Content continuity. Consider the continuity of content such as design, digital/computing, sustainability, or other key forward looking topics/skills between the years and across the programs (e.g. design spines, digital tools and technologies, etc.)
- d. Program flexibility. Consider added flexibility in the programs enabling students to have more flexibility between the four programs and outside of traditional STEM. Consider incorporating flexibility into the programs earlier (i.e., years 2 or 3).

### Program Response

The last major curriculum changes to the CIVE, ENVE and GEOE programs were implemented in 2015, and the new AE program is undergoing accreditation in 2022 and graduates its first class in 2023. It is an opportune time to review all curricula together.

The suggested focus of educating the “engineer of the future” is appreciated, as are the proposed considerations of a) integration within and across courses, levels, and programs, b)

balance of STEM and non-STEM content, c) continuity of important content themes, and d) increasing student flexibility.

CEE commits to the curriculum review of all programs. Additional curriculum considerations will be developed, including important feedback from the accreditation continual improvement process. This work has already commenced (as of Spring 2023) for the ENVE program, with a major review now underway and a draft of proposed revisions discussed at several recent department meetings. The committee doing this work is aiming to start the approval process for implementing these revisions in 2024. For the other programs, it is expected that curriculum review will begin in 2024 and leverage ideas generated in the current strategic planning cycle, which has just begun and will wrap up at the department level in Spring 2024. The results of this review will follow the ENVE revisions through the approval process in 2025.

### **Dean's Response**

I have asked our Associate Dean Undergraduate to work with all the Associate Chairs on a curriculum diet to provide more flexibility to our students and open up room in our curriculum so that students can choose to customize their academic journey depending on their interests and passions.

- 2. Recommendation 2: The programs bring attention to equity, diversity, and inclusion, which could include seeking to understand the state of EDI in the programs, faculty, and spaces, setting goals and deliverables, and tracking progress in a way that brings EDI awareness to all faculty and staff.**

We recommend attention be brought to issues of equity, diversity and inclusion as a whole. In particular, the programs could seek to understand EDI issues, set goals/milestones, track and monitor progress through deliverables. There are a variety of ways the programs can bring EDI to the forefront, including but not limited to, more awareness about EDI through consistent widespread programming/discussions, opting in to faculty level programs or initiatives with subsequent broad discussion, and clear, consistent and forward looking best practices for diversity in faculty hiring.

### **Program Response**

Increasing attention on issues of equity, diversity and inclusion is a vital recommendation. Seeking to understand the issues within our department, faculty and university is an important step. The Office of Equity, Diversity, Inclusion and Anti-racism will soon release the 2022-2025



Strategic Plan Framework (targeted release was May 2022), which will help CEE leadership better understand the issues and proposed methods to work towards removing barriers, making safe spaces and transforming culture. This framework follows the President's Anti-Racism Taskforce (PART) Report published in April 2022.

The recommendation to set goals and measure progress on bringing attention to EDI issues is warranted. To start, CEE commits to adding EDI content to UG seminars in addition to the current content on wellness each term. CEE commits to presenting and discussing an EDI issue in a department meeting each term.

CEE will continue to follow best practices for diversity in faculty hiring. CEE has hired five female faculty members since 2019, such that in Sept 2022 regular faculty members (tenure track or lecturers) will be 20% female (headcounts). CEE participated in the University's cluster hiring initiatives for indigenous and black faculty, resulting in an offer to an established professor who identifies as black.

CEE will work with Engineering Outreach and Admissions on recruiting and admission practices that increase the diversity of applicants and admitted students. The Ontario University Application Centre (OUAC) will be collecting self-reported EDI data for the first time in the upcoming admissions cycle. These data will help Waterloo Engineering move towards the goal of a student body that represents the diversity of Canada.

EDI issues need careful consideration when reviewing the curriculum for all programs (Recommendation 1). These issues are connected to many desired engineering graduate attributes such as teamwork, professionalism, and ethics and equity.

### **Dean's Response**

Addressing issues of equity, diversity, and inclusivity is of paramount importance to the Faculty. In 2021, I appointed Prof. Mary Robinson to be the 1<sup>st</sup> Associate Dean, Outreach, Equity, and Diversity. In that role, and with full support of the Engineering Departments, Prof. Robinson has put forward several EDI initiatives, and facilitated Engineering's participation in several existing initiatives. These include:

- The creation of a new EDI Website
- Participation in the PALs program to promote EDI-R training across the campus

- The creation of the Equity Champion role within each department
- Activities that draw attention to gender-based violence
- Work to improve washroom accessibility on campus, and to provide free menstrual products
- Participation in the IBET PhD Project which provided scholarships and mentoring to black and indigenous students
- Creation of the Elder in Residence and Indigenous spaces within the Engineering Faculty.

**3. Recommendation 3: The programs are recommended to consider and support flexible and novel approaches to teaching and student learning.**

We recommend the programs reflect on elements, methodologies, and/or technologies which were successfully implemented during covid to consider bringing these innovations into ongoing teaching practices. This may involve promoting novel teaching methods through capitalizing on university level programs and supporting faculty who are exploring non-traditional teaching methods. Overall, the programs are encouraged to consider, support, and promote flexibility in approaches to teaching and student learning.

**Program Response**

CEE students, staff and faculty are transitioning from online to in-person focused teaching and learning. During the transition CEE has encouraged teaching teams to use successful online practices with in-person delivery, such as digital submission of coursework and providing asynchronous recorded materials to supplement live in-person activities. CEE will continue to encourage and support individual instructors with non-traditional teaching methods, in addition to the encouragement and support provided by Centre for Teaching Excellence.

CEE will consider how teaching and learning practices enhance curricula and student experience during the program curriculum review (Recommendation 1). For example, there may be specific courses or parts of courses that can be delivered more effectively using online practices at specific locations in the programs (just in time delivery). In addition, CEE is interested in developing MEng curricula for primarily online delivery.

**Dean's Response**

I support the department's proposed actions to address this recommendation.

**4. Recommendation 4: The programs consider how design is developed throughout the curriculum and culminates in the capstone project, with consideration of cross-program capstone groups with industrial (and academic) advisors.**

The capstone design experience is an integral component of the engineering experience and the programs have done well leveraging the capstone with the Co-op and integrated learning experience. We recommend further improvements could be considered with capstone and design elements throughout the curriculum. In particular, the programs may consider: a) how design is introduced into the curriculum and how students are prepared for capstone design; b) further leveraging the programs industry relations to obtain capstone projects from industry with industry advisors; and c) increasing interactions between capstone groups (within and across programs), to further student learning and potentially provide a broader design perspective/experience. For example, the programs may consider and encourage an inter-departmental capstone that brings student from the four different programs together into one design team, thus further leveraging the strength of one department housing these different programs.

**Program Response**

The recommendation to further improve the capstone design experience is appreciated. How design is introduced, developed and practiced will be considered in the curriculum review of each program (Recommendation 1).

The CEE Capstone Coordinator, Nadine Ibrahim, created the CEE Capstone Design Portal to collect capstone project ideas and volunteer technical advisors from industry. Though students have preferred to pursue their own project ideas to date, CEE will continue to develop capstone ties with industry and promote their opportunities with our students.

The CEE programs have different streams of academic and co-op work terms. The AE and CIVE programs take the first capstone design course together in the same term, whereas the ENVE and GEOE programs take the first capstone together in another term. This means it is not possible to combine all programs for a common capstone design course delivery. However, it is easy for AE and CIVE students or ENVE and GEOE students to form mixed groups since they are on the same stream for capstone. It is also possible for students from other engineering programs on the same stream to join our capstone courses, or a group of students from different programs to all join an interdisciplinary capstone course available in the faculty.

The AE program has a studio course each term which exposes students to group open-ended design activities. Technical advisement and criticism are given during weekly studio sessions. This exposes groups to many experts and allows the experts to interact with many groups. This model of technical capstone advisement will be considered for all programs as it broadens the design perspective and exposure.

CEE will allow some mixed groups of AE and CIVE students (mixed groups of ENVE and GEOE students are already permitted) starting in the 2023-24 capstone sequence. CEE will also consider implementing a studio model for technical advisement.

#### **Dean's Response**

I support the department's proposed actions to address this recommendation.

#### **5. Recommendation 5: The program consider combined undergraduate and graduate program reviews.**

The overlap of program review with considerations such as faculty contingent, EDI, space, resources, could be optimized by a combined review of the undergraduate and graduate programs in one process. Although incrementally more work, it may optimize the process for both the department and the review teams.

#### **Program Response**

CEE will work with the Quality Assurance Office to combine future undergraduate and graduate program reviews.

#### **Dean's Response**

I support the department's proposed actions to address this recommendation.

#### **Recommendations Not Selected for Implementation**

N/A

**Implementation Plan**

	<b>Recommendations</b>	<b>Proposed Actions</b>	<b>Responsibility for Leading and Resourcing (if applicable) the Actions</b>	<b>Timeline for addressing Recommendations</b>
1.	Each program conduct a review and self-assessment of their curriculum to understand how they are, and will be, educating the engineer of the future with attention to integration between the programs, balancing STEM and non-STEM content, and incorporating flexibility.	CEE will review curriculum for each program.	Curriculum Review Committee to be formed, including UG Associate Chair, AE Director, GEOE Director	current to 2024
2.	The programs bring attention to equity, diversity, and inclusion, which could include seeking to understand the state of EDI in the programs, faculty, and spaces, setting goals and deliverables, and tracking progress in a way that brings EDI awareness to all faculty and staff.	CEE will review the Strategic Plan Framework by the Office of Equity, Diversity, Inclusion and Anti-racism (EDI-R). CEE will partner with EDI-R and Engineering EDI to better understand and address EDI issues in the department. CEE will present and discuss EDI issues in one UG seminar and departmental meeting each term.	Chair, UG Associate Chair, and Chair's Advisory Committee	current to 2023
3.	The programs are recommended to consider and support flexible and novel approaches to teaching and student learning.	CEE will continue to support flexible and novel teaching and learning. CEE will consider teaching and learning methodologies in the curriculum review for each program.	Curriculum Review Committee, UG Associate Chair, Grad Associate Chair	current to 2023

4.	The programs consider how design is developed throughout the curriculum and culminates in the capstone	CEE will review curriculum for each program, including how design is developed. CEE will allow more mixed capstone groups in next	Curriculum Review Committee, Capstone Coordinator	current to 2023
	project, with consideration of cross- program capstone groups with industrial (and academic) advisors.	capstone cycle. Capstone Coordinator will continue to solicit and promote industrial projects and will explore the studio model for technical advisement.		
5.	The program consider combined undergraduate and graduate program reviews.	CEE will work with the Quality Assurance Office to combine future undergraduate and graduate program reviews.	Chair and QA Director	After CEE grad and AE UG program reviews

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

Date of next program review \_\_\_\_\_ **2027-2028**  
Date

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**Signatures of Approval**



September 28, 2023

Chair/Director \_\_\_\_\_ Date


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AFIW Administrative Dean/Head (*For AFIW programs only*) \_\_\_\_\_ Date

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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.



July 11, 2023

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